Overnight glucose control in people with type 1 diabetes

This paper presents an individualized model predictive control (MPC) algorithm for overnight blood glucose stabilization in people with type 1 diabetes (T1D). The MPC formulation uses an asymmetric objective function that penalizes low glucose levels more heavily. We compute the model parameters in the MPC in a systematic way based on a priori available patient information. The model used by the MPC algorithm for filtering and prediction is an autoregressive integrated moving average with exogenous input (ARIMAX) model implemented as a linear state space model in innovation form. The control algorithm uses frequent glucose measurements from a continuous glucose monitor (CGM) and its decisions are implemented by a continuous subcutaneous insulin infusion (CSII) pump. We provide guidelines for tuning the control algorithm and computing the Kalman gain in the linear state space model in innovation form. We test the controller on a cohort of 100 randomly generated virtual patients with a representative inter-subject variability. We use the same control algorithm for a feasibility overnight study using 5 real patients. In this study, we compare the performance of this control algorithm with the patient’s usual pump setting. We discuss the results of the numerical simulations and the in vivo clinical study from a control engineering perspective. The results demonstrate that the proposed control strategy increases the time spent in euglycemia.
Online short-term forecast of greenhouse heat load using a weather forecast service

In some district heating systems, greenhouses represent a significant share of the total load, and can lead to operational challenges. Short term load forecast of such consumers has a strong potential to contribute to the improvement of the overall system efficiency. This work investigates the performance of recursive least squares for predicting the heat load of individual greenhouses in an online manner. Predictor inputs (weekly curves terms and weather forecast inputs) are selected in an automated manner using a forward selection approach. Historical load measurements from 5 Danish greenhouses with different operational characteristics were used, together with weather measurements and a weather forecast service. It was found that these predictors of reduced complexity and computational load performed well at capturing recurring load profiles, but not fast frequency random changes. Overall, the root mean square error of the prediction was within 8–20% of the peak load for the set of consumers over the 8 months period considered.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Aalborg University
Authors: Vogler-Finck, P. J. (Ekstern), Bacher, P. (Intern), Madsen, H. (Intern)
Pages: 1298-1310
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Main Research Area: Technical/natural sciences

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Journal: Applied Energy
Volume: 205
ISSN (Print): 0306-2619
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BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Effective mathematical modelling of continuous subcutaneous infusion pharmacokinetics should aid understanding and control in insulin therapy. Thorough analysis of candidate model performance is important for selecting the appropriate models. Eight candidate models for insulin pharmacokinetics included a range of modelled behaviours, parameters and complexity. The models were compared using clinical data from subjects with type 1 diabetes with continuous subcutaneous insulin infusion. Performance of the models was compared through several analyses: $R^2$ for goodness of fit;
the Akaike Information Criterion; a bootstrap analysis for practical identifiability; a simulation exercise for predictability. The simplest model fit poorly to the data ($R^2 = 0.53$), had the highest Akaike score, and worst prediction. Goodness of fit improved with increasing model complexity ($R^2 = 0.85–0.92$) but Akaike scores were similar for these models. Complexity increased practical non-identifiability, where small changes in the dataset caused large variation (CV > 10%) in identified parameters in the most complex models. Best prediction was achieved in a relatively simple model. Some model complexity was necessary to achieve good data fit but further complexity introduced practical non-identifiability and worsened prediction capability. The best model used two linear subcutaneous compartments, an interstitial and plasma compartment, and two identified variables for interstitial clearance and subcutaneous transfer rate. This model had optimal performance trade-off with reasonable fit ($R^2 = 0.85$) and parameterisation, and best prediction and practical identifiability (CV < 2%).

**General information**

State: Published
Organisations: Department of Applied Mathematics and Computer Science, Scientific Computing, Dynamical Systems, University of Canterbury, University of Copenhagen
Authors: Mansell, E. J. (Ekstern), Schmidt, S. (Ekstern), Docherty, P. D. (Ekstern), Nørgaard, K. (Ekstern), Jørgensen, J. B. (Intern), Madsen, H. (Intern)
Pages: 477-489
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BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.8 SJR 0.696 SNIP 0.801
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.709 SNIP 0.953 CiteScore 1.77
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.696 SNIP 0.851 CiteScore 1.82
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.561 SNIP 0.802 CiteScore 1.7
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.974 SNIP 1.179 CiteScore 2.07
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.955 SNIP 1.109 CiteScore 2.2
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.884 SNIP 0.79
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.072 SNIP 1.226
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.024 SNIP 0.993
Scopus rating (2007): SJR 0.579 SNIP 0.938
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.452 SNIP 0.758
Scopus rating (2005): SJR 0.577 SNIP 1.109
Web of Science (2005): Indexed yes
Adaptive control in an artificial pancreas for people with type 1 diabetes

In this paper, we discuss overnight blood glucose stabilization in patients with type 1 diabetes using a Model Predictive Controller (MPC). We compute the model parameters in the MPC using a simple and systematic method based on a priori available patient information. We describe and compare 3 different model structures. The first model structure is an autoregressive integrated moving average with exogenous input (ARIMAX) structure. The second model structure is an autoregressive moving average with exogenous input (ARMAX) model, i.e. a model without an integrator. The third model structure is an adaptive ARMAX model in which we use a recursive extended least squares (RELS) method to estimate parameters of the stochastic part. In addition, we describe some safety layers in the control algorithm that improve the controller robustness and reduce the risk of hypoglycemia. We test and compare our control strategies using a virtual clinic of 100 randomly generated patients with a representative inter-subject variability. This virtual clinic is based on the Hovorka model. We consider the case where only half of the meal bolus is administered at mealtime, and the case where the insulin sensitivity increases during the night. The numerical results suggest that the use of an integrator leads to higher occurrence of hypoglycemia than for the controllers without the integrator. Compared to other control strategies, the adaptive MPC reduces both the time spent in hypoglycemia and the time spent in hyperglycemia.
Adaptive Unscented Kalman Filter using Maximum Likelihood Estimation

The purpose of this study is to develop an adaptive unscented Kalman filter (UKF) by tuning the measurement noise covariance. We use the maximum likelihood estimation (MLE) and the covariance matching (CM) method to estimate the noise covariance. The multi-step prediction errors generated by the UKF are used for covariance estimation by MLE and CM. Then we apply the two covariance estimation methods on an example application. In the example, we identify the covariance of the measurement noise for a continuous glucose monitoring (CGM) sensor. The sensor measures the subcutaneous glucose concentration for a type 1 diabetes patient. The root-mean square (RMS) error and the computation time are used to compare the performance of the two covariance estimation methods. The results indicate that as the prediction horizon expands, the RMS error for the MLE declines, while the error remains relatively large for the CM method. For larger prediction horizons, the MLE provides an estimate of the noise covariance that is less biased than the estimate by the CM method. The CM method is computationally less expensive though.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Scientific Computing, Dynamical Systems
Authors: Mahmoudi, Z. (Intern), Poulsen, N. K. (Intern), Madsen, H. (Intern), Jørgensen, J. B. (Intern)
Number of pages: 6
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Main Research Area: Technical/natural sciences
Publication information
Journal: IFAC-PapersOnLine
A Dynamic Characterization of Energy Flexibility

**General information**

State: Published
Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Universidade Nova de Lisboa
Authors: Junker, R. G. (Intern), Relan, R. (Intern), Azar, A. G. (Intern), Lopes, R. A. (Ekstern), Madsen, H. (Intern)
Number of pages: 1
Publication date: 2017

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Publisher: Technical University of Denmark (DTU)
Article number: S-2
Main Research Area: Technical/natural sciences
Conference: Sustain 2017, Kgs. Lyngby, Denmark, 06/12/2017 - 06/12/2017

Electronic versions:
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Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2017

An Adaptive Nonlinear Basal-Bolus Calculator for Patients With Type 1 Diabetes

**Background:** Bolus calculators help patients with type 1 diabetes to mitigate the effect of meals on their blood glucose by administering a large amount of insulin at mealtime. Intraindividual changes in patients physiology and nonlinearity in insulin-glucose dynamics pose a challenge to the accuracy of such calculators.

**Method:** We propose a method based on a continuous-discrete unscented Kalman filter to continuously track the postprandial glucose dynamics and the insulin sensitivity. We augment the Medtronic Virtual Patient (MVP) model to simulate noise-corrupted data from a continuous glucose monitor (CGM). The basal rate is determined by calculating the steady state of the model and is adjusted once a day before breakfast. The bolus size is determined by optimizing the postprandial glucose values based on an estimate of the insulin sensitivity and states, as well as the announced meal size. Following meal announcements, the meal compartment and the meal time constant are estimated, otherwise insulin sensitivity is estimated.
**Results:** We compare the performance of a conventional linear bolus calculator with the proposed bolus calculator. The proposed basal-bolus calculator significantly improves the time spent in glucose target ($P < .01$) compared to the conventional bolus calculator.

**Conclusion:** An adaptive nonlinear basal-bolus calculator can efficiently compensate for physiological changes. Further clinical studies will be needed to validate the results.

**General information**

State: Published

Organisations: Department of Applied Mathematics and Computer Science, Scientific Computing, Dynamical Systems, Copenhagen University Hospital

Authors: Boiroux, D. (Intern), Aradóttir, T. B. (Intern), Nørgaard, K. (Ekstern), Poulsen, N. K. (Intern), Madsen, H. (Intern), Jørgensen, J. B. (Intern)

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Main Research Area: Technical/natural sciences

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Scopus rating (2016): CiteScore 2.14 SJR 0.804 SNIP 1.124

BFI (2015): BFI-level 1

Scopus rating (2015): SJR 0.855 SNIP 0.897 CiteScore 1.99

BFI (2014): BFI-level 1

Scopus rating (2014): SJR 0.871 SNIP 0.971 CiteScore 1.84

BFI (2013): BFI-level 1

Scopus rating (2013): SJR 0.78 SNIP 0.918 CiteScore 2.19

ISI indexed (2013): ISI indexed no

BFI (2012): BFI-level 1

Scopus rating (2012): SJR 0.69 SNIP 0.972 CiteScore 1.33

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BFI (2011): BFI-level 1

Scopus rating (2011): SJR 0.687 SNIP 0.916 CiteScore 0.6

ISI indexed (2011): ISI indexed no

BFI (2010): BFI-level 1

Scopus rating (2010): SJR 0.452 SNIP 0.683

BFI (2009): BFI-level 1

Scopus rating (2009): SJR 0.24 SNIP 0.539

BFI (2008): BFI-level 1

Scopus rating (2008): SJR 0.228 SNIP 0.422

Original language: English

Bolus calculator, Diabetes technology, Type 1 diabetes, Unscented Kalman filter

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Source: PublicationPreSubmission

Source-ID: 126153779

Publication: Research - peer-review › Journal article – Annual report year: 2016
A Stochastic Method to Manage Delay and Missing Values for In-Situ Sensors in an Alternating Activated Sludge Process

In the alternating activated sludge process with rule-based control, online N-measurements are of great importance for maintaining good control. These measurements can be delayed due to sensor processing time, turbulence at the location in the aeration tank where the sensor is placed, etc. The measurements may also be temporarily unavailable because of recalibration, communication faults or other errors. Here we present a method that handles such delay and missing observations. The model is based on zero order hold stochastic differential equations which use binary signals for influent flow and aeration to determine the state of the alternating process. It also uses measured ammonium and nitrate concentrations, which are shifted to account for delay. The method is developed and tested with data from a WWTP located in Kolding, Denmark. Results indicate that even though the model is simple, the model residuals and parameters are uncorrelated and the model predictions are 60% closer to the true values (measurements shifted to account for delay) than the delayed measurements are.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Department of Environmental Engineering, Urban Water Systems, Krüger A/S
Authors: Stentoft, P. A. (Intern), Munk-Nielsen, T. (Ekstern), Mikkelsen, P. S. (Intern), Madsen, H. (Intern)
Number of pages: 10
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Conference: 12th IWA Specialized Conference on Instrumentation, Control & Automation, Québec, Canada, 11/06/2017 - 11/06/2017
Grey box, WWTP, Stochastic, Sensor delay, Alternating, ASP, Online control, In-situ sensor, Rule-based control
Source: PublicationPreSubmission
Source-ID: 140797706
Publication: Research - peer-review › Article in proceedings – Annual report year: 2017

Biomass Supply Planning for Combined Heat and Power Plants using Stochastic Programming

During the last years, the consumption of biomass to produce power and heat has increased due to the new carbon neutral policies. Nowadays, many district heating systems operate their combined heat and power (CHP) plants using different types of biomass instead of fossil fuel, especially to produce heat. Since biomass is transported from the supplier to the consumption sites and the contracts with the suppliers are negotiated months in advance, the negotiation process involves many uncertainties from the energy producer’s side. The demand for biomass is uncertain at the time of negotiation, and heat demand and electricity prices vary drastically during the planning period. Furthermore, the optimal operation of combined heat and power plants has to consider the existing synergies between the power and heating systems while always fulfilling the heat demand of the system. We propose a solution method using stochastic optimization to support the biomass supply planning for combined heat and power plants. Our two-phase approach combines mid-term decisions about biomass supply contracts with the short-term decisions regarding the optimal market participation of the producer to ensure profitability and feasibility. The risk of major deficits in biomass supply is reduced by including appropriate risk measures to the models. We present numerical results and an economic analysis based on a realistic test case.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Centre for IT-Intelligent Energy Systems in Cities
Authors: Guericke, D. (Intern), Blanco, I. (Intern), Morales González, J. M. (Intern), Madsen, H. (Intern)
Number of pages: 1
Publication date: 2017
Main Research Area: Technical/natural sciences
Electronic versions:
Source: PublicationPreSubmission
Source-ID: 139979417
Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2017

Cross-Validation of a Glucose-Insulin-Glucagon Pharmacodynamics Model for Simulation using Data from Patients with Type 1 Diabetes

Background:
Currently, no consensus exists on a model describing endogenous glucose production (EGP) as a function of glucagon concentrations. Reliable simulations to determine the glucagon dose preventing or treating hypoglycemia or to tune a dual-hormone artificial pancreas control algorithm need a validated glucoregulatory model including the effect of glucagon.
Methods:
Eight type 1 diabetes (T1D) patients each received a subcutaneous (SC) bolus of insulin on four study days to induce mild hypoglycemia followed by a SC bolus of saline or 100, 200, or 300 µg of glucagon. Blood samples were analyzed for concentrations of glucagon, insulin, and glucose. We fitted pharmacokinetic (PK) models to insulin and glucagon data using maximum likelihood and maximum a posteriori estimation methods. Similarly, we fitted a pharmacodynamic (PD) model to glucose data. The PD model included multiplicative effects of insulin and glucagon on EGP. Bias and precision of PD model test fits were assessed by mean predictive error (MPE) and mean absolute predictive error (MAPE).

Results:
Assuming constant variables in a subject across nonoutlier visits and using thresholds of ±15% MPE and 20% MAPE, we accepted at least one and at most three PD model test fits in each of the seven subjects. Thus, we successfully validated the PD model by leave-one-out cross-validation in seven out of eight T1D patients.

Conclusions:
The PD model accurately simulates glucose excursions based on plasma insulin and glucagon concentrations. The reported PK/PD model including equations and fitted parameters allows for in silico experiments that may help improve diabetes treatment involving glucagon for prevention of hypoglycemia.
Dynamic Asset Allocation - Identifying Regime Shifts in Financial Time Series to Build Robust Portfolios

Long-term investors can often bear the risk of outsized market movements or tail events more easily than the average investor; for bearing this risk, they hope to earn significant excess returns. Rebalancing periodically to a fixed benchmark allocation, however, is not the way to do this. In the presence of time-varying investment opportunities, portfolio weights should be adjusted as new information arrives to take advantage of favorable regimes and reduce potential drawdowns. This thesis contributes to a better understanding of financial markets’ behavior in the form of a model-based framework for dynamic asset allocation. Regime-switching models can match financial markets’ tendency to change their behavior abruptly and the phenomenon that the new behavior often persists for several periods after a change. Regime shifts lead to time-varying parameters and, in addition, the parameters within the regimes and the transition probabilities change over time. Using recursive and adaptive estimation techniques to capture this, we are able to better reproduce the volatility persistence that dynamic asset allocation benefits from. With this approach it is sufficient to distinguish between two regimes in stock returns in order for it to be profitable to change asset allocation based solely on the inferred regimes, both in a single- and multiasset universe. We advocate the use of model predictive control for translating forecasts into a dynamic strategy and controlling drawdowns by solving a multi-period optimization problem. We implement this based on forecasts from a multivariate hidden Markov model with time-varying parameters. Our results show that a substantial amount of value can be added by adjusting the asset allocation to the current market conditions, rather than rebalancing periodically to a static benchmark. By proposing a practical approach to drawdown control, we demonstrate the theoretical link to dynamic asset allocation and the importance of identifying and acting on regime shifts in order to limit losses and build robust portfolios.

General information
State: Submitted
Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems
Authors: Nystrup, P. (Intern), Madsen, H. (Intern), Hansen, B. W. (Ekstern), Larsen, H. O. (Forskerdatabase), Lindstrøm, K. J. E. L. (Ekstern)
Number of pages: 317
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Risk management, Regime switching, Adaptive estimation, Forecasting, Model predictive control, Portfolio optimization, Drawdown control

Relations
Projects:
Dynamic Asset Allocation - Identifying Regime Shifts in Financial Time Series to Build Robust Portfolios
Publication: Research › Ph.D. thesis – Annual report year: 2017

Dynamic portfolio optimization across hidden market regimes
Regime-based asset allocation has been shown to add value over rebalancing to static weights and, in particular, reduce potential drawdowns by reacting to changes in market conditions. The predominant approach in previous studies has been to specify in advance a static decision rule for changing the allocation based on the state of financial markets or the economy. In this article, model predictive control (MPC) is used to dynamically optimize a portfolio based on forecasts of the mean and variance of financial returns from a hidden Markov model with time-varying parameters. There are computational advantages to using MPC when estimates of future returns are updated every time a new observation becomes available, since the optimal control actions are reconsidered anyway. MPC outperforms a static decision rule for changing the allocation and realizes both a higher return and a significantly lower risk than a buy-and-hold investment in various major stock market indices. This is after accounting for transaction costs, with a one-day delay in the
implementation of allocation changes, and with zero-interest cash as the only alternative to the stock indices. Imposing a trading penalty that reduces the number of trades is found to increase the robustness of the approach.

**General information**

State: Published
Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Lund University
Authors: Nystrup, P. (Intern), Madsen, H. (Intern), Lindström, E. (Ekstern)
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- Web of Science (2017): Indexed Yes
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- Scopus rating (2016): CiteScore 1 SJR 0.608 SNIP 0.925
- Web of Science (2016): Indexed yes
- BFI (2015): BFI-level 2
- Scopus rating (2015): SJR 0.588 SNIP 0.872 CiteScore 0.82
- Web of Science (2015): Indexed yes
- BFI (2014): BFI-level 2
- Scopus rating (2014): SJR 0.632 SNIP 1.056 CiteScore 0.91
- BFI (2013): BFI-level 2
- Scopus rating (2013): SJR 0.77 SNIP 1.094 CiteScore 0.98
- ISI indexed (2013): ISI indexed yes
- BFI (2012): BFI-level 2
- Scopus rating (2012): SJR 0.778 SNIP 1.16 CiteScore 0.89
- ISI indexed (2012): ISI indexed yes
- BFI (2011): BFI-level 2
- Scopus rating (2011): SJR 0.666 SNIP 1.27 CiteScore 0.74
- ISI indexed (2011): ISI indexed yes
- BFI (2010): BFI-level 2
- Scopus rating (2010): SJR 0.615 SNIP 0.832
- BFI (2009): BFI-level 2
- Scopus rating (2009): SJR 0.532 SNIP 0.97
- BFI (2008): BFI-level 2
- Scopus rating (2008): SJR 0.66 SNIP 0.936
- Web of Science (2008): Indexed yes
- Scopus rating (2007): SJR 0.734 SNIP 1.158
- Scopus rating (2006): SJR 0.692 SNIP 0.966
- Scopus rating (2005): SJR 0.327 SNIP 0.651
- Scopus rating (2004): SJR 0.231 SNIP 0.297
- Scopus rating (2003): SJR 0.108 SNIP 0.038
- Scopus rating (2002): SJR 0.126 SNIP 0

Original language: English
Multi-period portfolio selection, Meanvariance optimization, Model predictive control, Hidden Markov model, Adaptive estimation, Forecasting

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Source: PublicationPreSubmission
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Economic MPC based on LPV model for thermostatically controlled loads

Rapid increase of the renewable energy share in electricity production requires optimization and flexibility of the power consumption side. Thermostatically controlled loads (TCLs) have a large potential for regulation service provision. Economic model predictive control (MPC) is an advanced control method which can be used to synchronize the power consumption with undispatchable renewable electricity production. Thermal behavior of TCLs can be described by linear models based on energy balance of the system. In some cases, parameters of the model may be time-varying. In this work, we present a modified economic MPC based on linear parameter-varying model. In particular, we provide an exact transformation from a standard economic MPC formulation to a linear program. We assume that the variables influencing the model parameters are known (predictable) for the prediction horizon of the controller. As a case study, we present control system that minimizes operational cost of swimming pool heating system, where parameters of the model depend on the weather forecast. Simulation results demonstrate that the proposed method is able to deal with this kind of systems.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Scientific Computing, Technical University of Liberec, Novosibirsk State Technical University
Authors: Zemtsov, N. (Ekstern), Hlava, J. (Ekstern), Frantsuzova, G. (Ekstern), Madsen, H. (Intern), Junker, R. G. (Intern), Jørgensen, J. B. (Intern)
Number of pages: 5
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Main Research Area: Technical/natural sciences
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Economic model predictive control, Linear time-varying model, Smart energy grid, Thermostatically controlled loads
DOI: 10.1109/SIBCON.2017.7998560
Source: FindIt
Source-ID: 2372744332
Publication: Research - peer-review › Article in proceedings – Annual report year: 2017

Fault and meal detection by redundant continuous glucose monitors and the unscented Kalman filter

The purpose of this study is to develop a method for detecting and compensating the anomalies of continuous glucose monitoring (CGM) sensors as well as detecting unannounced meals. Both features, sensor fault detection/correction and meal detection, are necessary to have a reliable artificial pancreas. The aim is to investigate the best detection results achievable with the proposed detection configuration in a perfect situation, and to have the results as a benchmark against which the imperfect scenarios of the proposed fault detection can be compared. The perfect situation that we set up here is in terms of a patient simulation model, where the model in the detector is the same as the patient simulation model used for evaluation of the detector. The detection module consists of two CGM sensors, two fault detectors, a fault isolator, and an adaptive unscented Kalman filter (UKF). Two types of sensor faults, i.e., drift and pressure-induced sensor attenuation (PISA), are simulated by a Gaussian random walk model. Each of the fault detectors has a local UKF that receives the signal from the associated sensor, detects faults, and finally tunes the adaptive UKF. A fault isolator that accepts data from the two fault detectors differentiates between a sensor fault and an unannounced meal appearing as an anomaly in the CGM data. If the fault isolator indicates a sensor fault, a method based on the covariance matching technique tunes the covariance of the measurement noise associated with the faulty sensor. The main UKF uses the tuned noise covariances and fuses the CGM data from the two sensors. The drift detection sensitivity and specificity are 80.9% and 92.6%, respectively. The sensitivity and specificity of PISA detection are 78.1% and 82.7%, respectively. The fault detectors can detect 100 out of 100 simulated drifts and 485 out of 500 simulated PISA events. Compared to a nonadaptive UKF, the adaptive UKF reduces the deviation of the CGM measurements from their paired blood glucose concentrations from 72.0% to 12.5% when CGM is corrupted by drift, and from 10.7% to 6.8% when CGM is corrupted by PISA. The fault isolator can detect 199 out of 200 unannounced meals. The average change in the glucose concentrations between the meals and the detection time points is 46.3Â± mg/dL.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Scientific Computing, Dynamical Systems, University of Copenhagen
Harnessing Flexibility from Hot and Cold

As has been often reported, electricity systems with high levels of variable wind and solar power generation would benefit from demand flexibility. What is not as often mentioned is that electrification of the transport and heat sectors could exacerbate the need for flexibility, if they are implemented as inflexible loads. This demand could also be made more flexible, but it comes with a cost. The main issue is to identify the cases in which the benefits will outweigh those costs, a matter that will naturally depend on the evolution of specific energy systems. In this article, we lay out some generic principles and characteristics related to heat sector flexibility and demonstrate its possibilities using specific examples. While we generally use the word heat here, most of the discussions also apply to cool, which, after all, is just another form of temperature difference. A major potential for flexibility in the heat sector results from the low cost of storing heat, which allows opportunities to shift electricity demand. Another possibility is to utilize hybrid systems in which either electricity or fuel can be used to produce heat depending on price variations between the two options.
Heating of indoor swimming pools by solar thermal collectors in summerhouses in Denmark

General information
State: Published
Organisations: Department of Civil Engineering, Section for Building Energy, Department of Applied Mathematics and Computer Science, Dynamical Systems, Centre for IT-Intelligent Energy Systems in Cities, Eurisco Aps.
Authors: Dannemand, M. (Intern), Furbo, S. (Intern), Andersen, C. A. (Ekstern), Heller, A. (Intern), Madsen, H. (Intern)
Number of pages: 38
Publication date: 2017

Publication information
Publisher: Technical University of Denmark, Department of Civil Engineering
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Number: R-366
Main Research Area: Technical/natural sciences
Electronic versions: Untitled_32.pdf
Source: PublicationPreSubmission
Source-ID: 128931966
Publication: Research › Report – Annual report year: 2017

Inverse Optimization and Forecasting Techniques Applied to Decision-making in Electricity Markets

This thesis deals with the development of new mathematical models that support the decision-making processes of market players. It addresses the problems of demand-side bidding, price-responsive load forecasting and reserve determination. From a methodological point of view, we investigate a novel approach to model the response of aggregate price-responsive load as a constrained optimization model, whose parameters are estimated from data by using inverse optimization techniques.

The problems tackled in this dissertation are motivated, on one hand, by the increasing penetration of renewable energy production and smart grid technologies in power systems, that is expected to continue growing in the coming years. Non-dispatchable electricity generation cannot ensure a certain production at all times, since it depends on meteorological factors. Also, smart grid technologies are affecting the consumption patterns that the load traditionally exhibited. On the other hand, this thesis is motivated by the decision-making processes of market players. In response to these challenges, this thesis provides mathematical models for decision-making under uncertainty in electricity markets.

Demand-side bidding refers to the participation of consumers, often through a retailer, in energy trading. Under the smart-grid paradigm, the demand bids must reflect the elasticity of the consumers to changes in electricity price. Traditional forecasting models are typically not able to reflect this elasticity, hence we propose two novel approaches to estimate market bids. Both approaches are data-driven and take into account the uncertainty of future factors, as, for example, price. In both cases, demand-side bids that comprise a price-energy term decrease the expected imbalances and also increase the profit of retailers participating in electricity markets.

In the field of load forecasting, this thesis provides a novel approach to model time series and forecast loads under the real-time pricing setup. The relationship between price and aggregate response of the load is characterized by an optimization problem, which is shaped by a set of unknown parameters. Such parameters are estimated from data by using an inverse optimization framework. The usability of the proposed method is studied and we conclude that inverseoptimization-based modeling is a computationally attractive method that outperforms the forecasting capabilities of traditional time series models. Regarding the reserve determination, the special characteristics of the Danish power system do not allow for co-optimizing the unit commitment and reserve requirements. Hence, we propose a probabilistic framework, where the reserve requirements are computed based on scenarios of wind power and load forecast errors and power plant outages. The solution of the stochastic optimization models increases the safety of the overall system while decreases the associated reserve costs, with respect to the method currently used by the Danish TSO.

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Leveraging stochastic differential equations for probabilistic forecasting of wind power using a dynamic power curve

Short-term (hours to days) probabilistic forecasts of wind power generation provide useful information about the associated uncertainty of these forecasts. Standard probabilistic forecasts are usually issued on a per-horizon-basis, meaning that they lack information about the development of the uncertainty over time or the inter-temporal correlation of forecast errors for different horizons. This information is very important for forecast end-users optimizing time-dependent variables or dealing with multi-period decision-making problems, such as the management and operation of power systems with a high penetration of renewable generation. This paper provides input to these problems by proposing a model based on stochastic differential equations that allows generating predictive densities as well as scenarios for wind power. We build upon a probabilistic model for wind speed and introduce a dynamic power curve. The model thus decomposes the dynamics of wind power prediction errors into wind speed forecast errors and errors related to the conversion from wind speed to wind power. We test the proposed model on an out-of-sample period of 1 year for a wind farm with a rated capacity of 21 MW. The model outperforms simple as well as advanced benchmarks on horizons ranging from 1 to 24 h.
Modeling Pharmacokinetics and Pharmacodynamics of Glucagon for Simulation of the Gluoregulatory System in Patients with Type 1 Diabetes.

The goal of this thesis was to develop a pharmacokinetics/pharmacodynamics (PK/PD) model for glucagon. The proposed PD model included multiplication of the stimulating glucagon effect and inhibiting insulin effect on the endogenous glucose production (EGP). Moreover, the concentration-response relationship of glucagon and EGP was characterized by a non-linear function, where the response saturated for high concentrations of glucagon. The novel EGP model extended Hovorka’s glucoregulatory model to include the effect of glucagon. The PK/PD model described both regular glucagon and a novel glucagon analogue in healthy dogs. The extended glucoregulatory model translated to the human species and described glucose-insulin-glucagon dynamics in healthy subjects and patients with type 1 diabetes (T1D). The extended glucoregulatory model was successfully validated by leave-one-out cross-validation in seven T1D patients which justified its use for simulations. The final model parameters were estimated from three to four datasets from each patient. The validated extended glucoregulatory model was used for in silico studies. The model replicated a clinical study of the effect of glucagon at varying insulin levels. The simulations also suggested new glucagon doses to be tested in a similar in vivo study to provide new insight to the relationship between insulin, glucagon, and EGP. Finally, the model was used to conduct a large original simulation study investigating an insulin dependent glucagon dosing regimen for treatment of insulin-induced mild hypoglycemia.

General information
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Multi-site solar power forecasting using gradient boosted regression trees

The challenges to optimally utilize weather dependent renewable energy sources call for powerful tools for forecasting. This paper presents a non-parametric machine learning approach used for multi-site prediction of solar power generation on a forecast horizon of one to six hours. Historical power generation and relevant meteorological variables related to 42 individual PV rooftop installations are used to train a gradient boosted regression tree (GBRT) model. When compared to single-site linear autoregressive and variations of GBRT models the multi-site model shows competitive results in terms of root mean squared error on all forecast horizons. The predictive performance and the simplicity of the model setup make the boosted tree model a simple and attractive compliment to conventional forecasting techniques. (C) 2017 Elsevier Ltd. All rights reserved.

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On site characterisation of the overall heat loss coefficient: comparison of different assessment methods by a blind validation exercise on a round robin test box

Several studies have shown that the actual thermal performance of buildings after construction may deviate significantly from its performance anticipated at design stage. As a result, there is growing interest in on site testing as a means to assess real performance. The IEA EBC Annex 58-project ‘Reliable Building Energy Performance Characterisation Based on Full Scale Dynamic Measurements’ focused on on site testing and dynamic data analysis methods that can be used to characterise the actual thermal performance and energy efficiency of building components and whole buildings. The research within this project was driven by case studies. The current paper describes one of them: the thermal characterisation of a round robin test box. This test box can be seen as a scale model of a building, and was built by one of the participants. During the project, its fabric properties remained unknown to all other participants. Full scale measurements have been performed on the test box in different countries under real climatic conditions. The obtained dynamic data has been distributed to all participants who had to characterise the thermal performance of the test box’s fabric based on the provided data. The paper compares the result of different techniques, ranging from a simple quasi-stationary analysis to advanced dynamic data analysis methods, which can be used to characterise the thermal performance based on on-site collected data.

General information
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Relationship between Optimum Mini-doses of Glucagon and Insulin Levels when Treating Mild Hypoglycaemia in Patients with Type 1 Diabetes - A Simulation Study

Hypoglycaemia remains the main limiting factor in type 1 diabetes management. We developed an insulin-dependent glucagon dosing regimen for treatment of mild hypoglycaemia based on simulations. A validated glucose-insulin-glucagon model was used to describe seven virtual patients with insulin pump-treated type 1 diabetes. In each simulation, one of ten different and individualized subcutaneous insulin boluses was administered to decrease plasma glucose (PG) from 7.0 to ≤3.9 mmol/l. Insulin levels were estimated as ratio of actual to baseline serum insulin concentration (se/ba-insulin), insulin on board (IOB) or percentage of IOB to total daily insulin dose (IOB/TDD). Insulin bolus sizes were chosen to provide pre-defined insulin levels when PG reached 3.9 mmol/l, where one of 17 subcutaneous glucagon boluses was administered. Optimum glucagon bolus to treat mild hypoglycaemia at varying insulin levels was the lowest dose that in most patients caused PG peak between 5.0 and 10.0 mmol/l and sustained PG ≥ 3.9 mmol/l for 2 hr after the bolus. PG response to glucagon declined with increasing insulin levels. The glucagon dose to optimally treat mild hypoglycaemia depended exponentially on insulin levels, regardless of how insulin was estimated. A 125-μg glucagon dose was needed to optimally treat mild hypoglycaemia when insulin levels were equal to baseline levels. In contrast, glucagon doses >500 μg were needed when se/ba-insulin >2.5, IOB >2.0 U or IOB/TDD >6%. Although the proposed model-based glucagon regimen needs confirmation in clinical trials, this is the first attempt to develop an insulin-dependent glucagon dosing regimen for treatment of insulin-induced mild hypoglycaemia in patients with type 1 diabetes.
Simulating clinical studies of the glucoregulatory system: in vivo meets in silico

In this report we use a validated model of the glucoregulatory system including effects of insulin and glucagon for simulation studies in seven type 1 diabetes patients. Using simulations, we replicate the results from a clinical study investigating the effect of micro-doses of glucagon on glucose metabolism at varying ambient insulin levels. The report compares in vivo and in silico results head-to-head, and discusses similarities and differences. We design and simulate simple studies to emphasize the implications of some glucoregulatory dynamics which are ignored in most previous clinical studies: the effect of discontinuing insulin and glucose infusions prior to glucagon administration, the delayed effect of insulin, timing of data sampling, and carryover effects from multiple subcutaneous doses of glucagon. We also use simulations to discuss two hypotheses of how insulin and glucagon might interact in influencing the glucose response. Following the simulations we propose a study design that potentially could explore if the hypotheses are true or false.

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skoleklima.dk – A platform to monitor air quality and thermal comfort in classrooms, developed for teachers and students

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Spatial bias and uncertainty in numerical weather predictions for urban runoff forecasts with long time horizons
Numerical Weather Predictions (NWP) can be used to forecast urban runoff with long lead times. However, NWP exhibit large spatial uncertainties and using forecasted precipitation directly above the catchment might therefore not be an ideal approach in an online setup. We use the Danish Meteorological Institute’s NWP ensemble and investigate a large spatial neighborhood around the catchment over a two-year period. When compared against in-sewer observations, runoff forecasts forced with precipitation from north-east of the catchment are most skillful. This highlights spatial biases in the coupled hydro-meteorological setup, which a forecaster should be aware of.

Stochastic Greybox Modeling for Control of an Alternating Activated Sludge Process
We present a stochastic greybox model of a BioDenitro WWTP that can be used for short time horizon Model Predictive Control. The model is based on a simplified ASM1 model and takes model uncertainty in to account. It estimates unmeasured state variables in the system, e.g. the inlet concentration or the sensor measurements in case of temporary sensor faults. This improves control performance without adding additional or redundant sensors. We fitted the parameters of the model to actual plant data and demonstrate the state estimation capabilities with this data set. The model now runs online at a WWTP in Denmark.
Stochastic model of wind-fuel cell for a semi-dispatchable power generation

Hybrid systems are implemented to improve the efficiency of individual generation technologies by complementing each other. Intermittence is a challenge to overcome especially for renewable energy sources for electric generation, as in the case of wind power. This paper proposes a hybrid system as an approach for reducing and overcoming the volatility of wind power, by implementing storage technology, forecasts and predictive control. The proposed hybrid system, which is suitable for the distributed generation level, consists of a wind generator, an electrolyzer, hydrogen storage and a polymer electrolyte membrane fuel cell, which are embedded in one complete system with the wind power. This study uses historic wind speed data from Mexico; the forecasts are obtained using the recursive least square algorithm with a forgetting factor. The proposed approach provides probabilistic information for short-term wind power generation and electric generation as the outcome of the hybrid system. A method for a semi-dispatchable electric generation based on time series analysis is presented, and the implementation of wind power and polymer electrolyte membrane fuel cell models controlled by a model predictive control approach is developed.

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Stochastic Programming for Fuel Supply Planning of Combined Heat and Power Plants
The consumption of biomass to produce power and heat has increased due to the carbon neutral policies. Combined heat and power (CHP) plants often combine biomass with other fuels, e.g., natural gas. The negotiation process for supply contracts involves many uncertainties due to the long planning horizon. The demand for biomass is uncertain, and heat demand and electricity prices vary during the planning period. We propose a method using stochastic optimization to support the biomass and natural gas supply planning for CHP plants including short-term decisions for optimal market participation.

Stochastic Programming for Fuel Supply Planning of Combined Heat and Power Plants
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Authors: Guericke, D. (Intern), Blanco, I. (Intern), Morales González, J. M. (Intern), Madsen, H. (Intern)
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Urban runoff forecasting with ensemble weather predictions
This research shows how ensemble weather forecasts can be used to generate urban runoff forecasts up to 53 hours into the future. The results highlight systematic differences between ensemble members that needs to be accounted for when these forecasts are used in practice.
Validation of a Simulation Model Describing the Glucose-Insulin-Glucagon Pharmacodynamics in Patients with Type 1 Diabetes

Currently, no consensus exists on a model describing endogenous glucose production (EGP) as a function of glucagon concentrations. Reliable simulations to determine the glucagon dose preventing or treating hypoglycemia or to tune a dual-hormone artificial pancreas control algorithm need a validated glucoregulatory model including the effect of glucagon.

Validation of the dynamic wake meander model with focus on tower loads: Paper

This paper presents a comparison between measured and simulated tower loads for the Danish offshore wind farm Nysted 2. Previously, only limited full scale experimental data containing tower load measurements have been published, and in many cases the measurements include only a limited range of wind speeds. In general, tower loads in wake conditions are very challenging to predict correctly in simulations. The Nysted project offers an improved insight to this field as six wind turbines located in the Nysted II wind farm have been instrumented to measure tower top and tower bottom moments. All recorded structural data have been organized in a database, which in addition contains relevant wind turbine SCADA data as well as relevant meteorological data - e.g. wind speed and wind direction - from an offshore mast located in the immediate vicinity of the wind farm. The database contains data from a period extending over a time span of more than 3 years. Based on the recorded data basic mechanisms driving the increased loading experienced by wind turbines operating in offshore wind farm conditions have been identified, characterized and modeled. The modeling is based on the Dynamic Wake Meandering (DWM) approach in combination with the state-of-the-art aeroelastic model HAWC2, and has previously as well as in this study shown good agreement with the measurements. The conclusions from the study have several parts. In general the tower bending and yaw loads show a good agreement between measurements and simulations. However, there are situations that are still difficult to match. One is tower loads of single-wake operation near rated ambient wind speed for single wake situations for spacing’s around 7-8D. A specific target of the study was to investigate whether the largest tower fatigue loads are associated with a certain downstream distance. This has been identified in both simulations and measurements, though a rather flat optimum is seen in the measurements.
A Data-Driven Bidding Model for a Cluster of Price-Responsive Consumers of Electricity

This paper deals with the market-bidding problem of a cluster of price-responsive consumers of electricity. We develop an inverse optimization scheme that, recast as a bilevel programming problem, uses price-consumption data to estimate the complex market bid that best captures the price-response of the cluster. The complex market bid is defined as a series of marginal utility functions plus some constraints on demand, such as maximum pick-up and drop-off rates. The proposed modeling approach also leverages information on exogenous factors that may influence the consumption behavior of the cluster, e.g., weather conditions and calendar effects. We test the proposed methodology for a particular application: forecasting the power consumption of a small aggregation of households that took part in the Olympic Peninsula project. Results show that the price-sensitive consumption of the cluster of flexible loads can be largely captured in the form of a complex market bid, so that this could be ultimately used for the cluster to participate in the wholesale electricity market.
An Efficient UD-Based Algorithm for the Computation of Maximum Likelihood Sensitivity of Continuous-Discrete Systems

This paper addresses maximum likelihood parameter estimation of continuous-time nonlinear systems with discrete-time measurements. We derive an efficient algorithm for the computation of the log-likelihood function and its gradient, which can be used in gradient-based optimization algorithms. This algorithm uses UD decomposition of symmetric matrices and the array algorithm for covariance update and gradient computation. We test our algorithm on the Lotka-Volterra equations. Compared to the maximum likelihood estimation based on finite difference gradient computation, we get a significant speedup without compromising the numerical accuracy.

General information
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An Ensemble Nonlinear Model Predictive Control Algorithm in an Artificial Pancreas for People with Type 1 Diabetes

This paper presents a novel ensemble nonlinear model predictive control (NMPC) algorithm for glucose regulation in type 1 diabetes. In this approach, we consider a number of scenarios describing different uncertainties, for instance meals or metabolic variations. We simulate a population of 9 patients with different physiological parameters and a time-varying insulin sensitivity using the Medtronic Virtual Patient (MVP) model. We augment the MVP model with stochastic diffusion terms, time-varying insulin sensitivity and noise-corrupted CGM measurements. We consider meal challenges where the uncertainty in meal size is ±50%. Numerical results show that the ensemble NMPC reduces the risk of hypoglycemia compared to standard NMPC in the case where the meal size is overestimated or correctly estimated at the expense of a slightly increased number of hyperglycemia. Therefore, ensemble MPC-based algorithms can improve the safety of the AP compared to the classical MPC-based algorithms.

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Application of the Continuous-Discrete Extended Kalman Filter for Fault Detection in Continuous Glucose Monitors for Type 1 Diabetes

The purpose of this study is the online detection of faults and anomalies of a continuous glucose monitor (CGM). We simulated a type 1 diabetes patient using the Medtronic virtual patient model. The model is a system of stochastic differential equations and includes insulin pharmacokinetics, insulin-glucose interaction, and carbohydrate absorption. We simulated and detected two types of CGM faults, i.e., spike and drift. A fault was defined as a CGM value in any of the zones C, D, and E of the Clarke error grid analysis classification. Spike was modelled by a binomial distribution, and drift was modelled by a Gaussian random walk. We used a continuous-discrete extended Kalman filter for the fault detection, based on the statistical tests of the filter innovation and the 90-min prediction residuals of the sensor measurements. The spike detection had a sensitivity of 93% and a specificity of 100%. Also, the drift detection had a sensitivity of 80% and a specificity of 85%. Furthermore, with 100% sensitivity the proposed method was able to detect if the drift overestimates or underestimates the interstitial glucose concentration.

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Approaches for Accommodating Demand Response in Operational Problems and Assessing its Value
This thesis deals with the development of operational models of demand response and the evaluation of this novel resource within existing frameworks for power system dispatch and market clearing.

Increasing shares of power generation from variable renewable sources, and climate change policies that discourage the use of fossil fuel intensive power plants, are among the factors that are currently driving the evolution of power systems towards greater flexibility. Activating the latent flexibility of electricity consumption through demand response can contribute towards facilitating this evolution. However, before the necessary investments can be made to establish and operate this novel resource, its value must be determined.

As with all current power system resources, if distributed demand response is deployed on a large scale it will be required to interface with the power system and market operators through established frameworks. Such frameworks are not suited to interact with large numbers of individual flexible loads, so it is necessary to establish a representation of their aggregated flexibility that can be effectively communicated to system and market operators. In this thesis we introduce the concept of a saturation curve, which represents the flexibility offered by a broad class of flexible loads capable of providing load shifting demand response: thermal-electric loads such as refrigeration and heating. From this saturation curve we extract dispatch and market offering structures for demand response that respect the physical characteristics and constraints of the individual flexible loads within an aggregate population, while being limited in complexity to that allowable within current operational power system frameworks.

An evaluation of demand response must consider both the social welfare value it generates by reducing overall power system operation costs, and the commercial value it can accrue by participating in competitive electricity markets. Social welfare value provides an indicator of the viability of any new power system resource, but does not guarantee that the necessary investments will be made to establish and operate the resource. A positive commercial assessment will signal to investors that the resource can offer a return on their investment, and that it can thrive in a competitive environment. We consider both the social welfare and commercial value of demand response in this thesis, by simulating the deployment of our specialised operational models of demand response within power system dispatch frameworks and by developing innovative trading strategies for demand response on the day-ahead and intraday markets.

We find through the combined modelling and analysis contained in this thesis that the value offered by demand response is very low under current power system conditions, and when it is restricted to operating within existing operational frameworks. Prices and costs on the studied power systems are insufficient to allow demand response to generate significant value or revenue through energy arbitrage or load curtailment. This does not rule out that there may be certain power systems, or sections thereof, that are currently experiencing sufficient resource scarcity to result in a favourable environment for the successful implementation of demand response. At the current time however, our research finds that the outlook for the widespread deployment of demand response is poor.
Commitment and dispatch of heat and power units via affinely adjustable robust optimization

The joint management of heat and power systems is believed to be key to the integration of renewables into energy systems with a large penetration of district heating. Determining the day-ahead unit commitment and production schedules for these systems is an optimization problem subject to uncertainty stemming from the unpredictability of demand and prices for heat and electricity. Furthermore, owing to the dynamic features of production and heat storage units as well as to the length and granularity of the optimization horizon (e.g., one whole day with hourly resolution), this problem is in essence a multi-stage one. We propose a formulation based on robust optimization where recourse decisions are approximated as linear or piecewise-linear functions of the uncertain parameters. This approach allows for a rigorous modeling of the uncertainty in multi-stage decision-making without compromising computational tractability. We perform an extensive numerical study based on data from the Copenhagen area in Denmark, which highlights important features of the proposed model. Firstly, we illustrate commitment and dispatch choices that increase conservativeness in the robust optimization approach. Secondly, we appraise the gain obtained by switching from linear to piecewise-linear decision rules within robust optimization. Furthermore, we give directions for selecting the parameters defining the uncertainty set (size, budget) and assess the resulting trade-off between average profit and conservativeness of the solution. Finally, we perform a thorough comparison with competing models based on deterministic optimization and stochastic programming.

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Scopus rating (2011): SJR 2.472 SNIP 2.495 CiteScore 3.05
ISI indexed (2011): ISI indexed yes
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BFI (2010): BFI-level 1
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BFI (2009): BFI-level 1
Scopus rating (2009): SJR 2.386 SNIP 2.405
Comparison of Three Nonlinear Filters for Fault Detection in Continuous Glucose Monitors

The purpose of this study is to compare the performance of three nonlinear filters in online drift detection of continuous glucose monitors. The nonlinear filters are the extended Kalman filter (EKF), the unscented Kalman filter (UKF), and the particle filter (PF). They are all based on a nonlinear model of the glucose-insulin dynamics in people with type 1 diabetes. Drift is modelled by a Gaussian random walk and is detected based on the statistical tests of the 90-min prediction residuals of the filters. The unscented Kalman filter had the highest average F score of 85.9%, and the smallest average detection delay of 84.1%, with the average detection sensitivity of 82.6%, and average specificity of 91.0%.

Detecting change points in VIX and S&P 500: A new approach to dynamic asset allocation

The purpose of dynamic asset allocation (DAA) is to overcome the challenge that changing market conditions present to traditional strategic asset allocation by adjusting portfolio weights to take advantage of favorable conditions and reduce potential drawdowns. This article proposes a new approach to DAA that is based on detection of change points without fitting a model with a fixed number of regimes to the data, without estimating any parameters and without assuming a specific distribution of the data. It is examined whether DAA is most profitable when based on changes in the Chicago Board Options Exchange Volatility Index or change points detected in daily returns of the S&P 500 index. In an asset universe consisting of the S&P 500 index and cash, it is shown that a dynamic strategy based on detected change points
significantly improves the Sharpe ratio and reduces the drawdown risk when compared with a static, fixed-weight benchmark.

**General information**

State: Published

Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Sampension, Lund University

Authors: Nystrup, P. (Intern), Hansen, B. W. (Ekstern), Madsen, H. (Intern), Lindström, E. (Ekstern)

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- BFI (2015): BFI-level 1
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**Distributed Model Predictive Control for Smart Energy Systems**

Integration of a large number of flexible consumers in a smart grid requires a scalable power balancing strategy. We formulate the control problem as an optimization problem to be solved repeatedly by the aggregator in a model predictive control framework. To solve the large-scale control problem in real-time requires decomposition methods. We propose a decomposition method based on Douglas–Rachford splitting to solve this large-scale control problem. The method decomposes the problem into smaller subproblems that can be solved in parallel, e.g., locally by each unit connected to an aggregator. The total power consumption is controlled through a negotiation procedure between all cooperating units and an aggregator that coordinates the overall objective. For large-scale systems, this method is faster than solving the original problem and can be distributed to include an arbitrary number of units. We show how different aggregator objectives are implemented and provide simulations of the controller including the computational performance.

**General information**

State: Published
This paper summarizes comprehensively the work in four recent PhD theses from the Technical University of Denmark related to Economic MPC of future power systems. Future power systems will consist of a large number of decentralized power producers and a large number of controllable power consumers in addition to stochastic power producers such as wind turbines and solar power plants. Control of such large scale systems requires new control algorithms. In this paper, we formulate the control of such a system as an Economic Model Predictive Control (MPC) problem. When the power producers and controllable power consumers have linear dynamics, the Economic MPC may be expressed as a linear program. We provide linear models for a number of energy units in an energy system, formulate an Economic MPC for coordination of such a system. We indicate how advances in computational MPC makes the solutions of such large-scale models feasible in real-time. The system presented may serve as a benchmark for simulation and control of smart energy systems and we indicate how advances in computational MPC.
Economic valuation of heat pumps and electric boilers in the Danish energy system

Heat pumps (HP) and electric immersion boilers (EB) have great potential to increase flexibility in energy systems. In parallel, decreasing taxes on electricity-based heat production are creating a more favorable economic environment for the deployment of these units in Denmark. In this paper, the economic value of heat pumps and electric boilers is assessed by simulating their day-to-day market performance using a novel operational strategy based on two-stage stochastic programming. This stochastic model is employed to optimize jointly the daily operation of HPs and EBs along with the Combined Heat and Power (CHP) units in the system. Uncertainty in the heat demand and power price is modeled via scenarios representing different plausible paths for their future evolution. A series of case-studies are performed using real-world data for the heat and power systems in the Copenhagen area during four representative weeks of 2013. We show that the use of stochastic operational models is critical, as standard deterministic models provide an overestimation of the added benefits from the installation of HPs and EBs, thus leading to over-investment in capacity. Furthermore, we perform sensitivity studies to investigate the effect on market performance of varying capacity and efficiency for these units, as well as of different levels of prices in the electricity market. We find that these parameters substantially affect the profitability of heat pumps and electric boilers, hence, they must be carefully assessed by potential investors.
Hidden Markov Models for indirect classification of occupant behaviour

Even for similar residential buildings, a huge variability in the energy consumption can be observed. This variability is mainly due to the different behaviours of the occupants and this impacts the thermal (temperature setting, window opening, etc.) as well as the electrical (appliances, TV, computer, etc.) consumption.

It is very seldom to find direct observations of occupant presence and behaviour in residential buildings. However, given the increasing use of smart metering, the opportunity and potential for indirect observation and classification of occupants' behaviour is possible. This paper focuses on the use of Hidden Markov Models (HMMs) to create methods for indirect observations and characterisation of occupant behaviour.

By applying homogeneous HMMs on the electricity consumption of fourteen apartments, three states describing the data were found suitable. The most likely sequence of states was determined (global decoding). From reconstruction of the states, dependencies like ambient air temperature were investigated. Combined with an occupant survey, this was used to classify/interpret the states as (1) absent or asleep, (2) home, medium consumption and (3) home, high consumption. From the global decoding, the average probability profiles with respect to time of day were investigated, and four distinct patterns of occupant behaviour were observed. Based on the initial results of the homogeneous HMMs and with the observed dependencies, time dependent HMMs (inhomogeneous HMMs) were developed, which improved forecasting.
For both the homogeneous and inhomogeneous HMMs, indications of common parameters were observed, which suggests further development of the HMMs as population models.

General information
State: Published
Authors: Lisberg, J. A. R. (Intern), Møller, J. K. (Intern), Bloem, H. (Ekstern), Cipriano, J. (Ekstern), Mor, G. (Ekstern), Madsen, H. (Intern)
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Web of Science (2016): Indexed yes
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Scopus rating (2014): SJR 0.885 SNIP 1.558 CiteScore 2.3
BFI (2013): BFI-level 1
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Scopus rating (2012): SJR 0.744 SNIP 0.535 CiteScore 1.43
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Impacts of urban development and climate change in exposing cities to pluvial flooding
Urban areas are characterized by very high concentrations of people and economic activities and are thus particularly vulnerable to flooding due to extreme precipitation. Urban development and climate change are among the key drivers of changes in the exposure of cities to the occurrence and impacts of pluvial flooding. Cities are often dominated by large areas of impervious surfaces, that is, man-made sealed surfaces which water cannot penetrate, and increases in these – for example, as a consequence of urban development – can cause elevated run-off volumes and flood levels during precipitation. Climate change is expected to affect the intensity and frequency of extreme precipitation, with increases projected for many regions, including most parts of Europe.

General information
State: Published
Organisations: Department of Management Engineering, Systems Analysis, Department of Environmental Engineering, Urban Water Systems, Department of Applied Mathematics and Computer Science, Dynamical Systems
Authors: Kaspersen, P. S. (Intern), Drews, M. (Intern), Ambjerg-Nielsen, K. (Intern), Madsen, H. (Intern)
Number of pages: 48
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Publisher: Technical University of Denmark (DTU)
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Learning from nature: Nature-inspired algorithms

During last decade, the nature has inspired researchers to develop new algorithms. The largest collection of nature-inspired algorithms is biology-inspired: swarm intelligence (particle swarm optimization, ant colony optimization, cuckoo search, bees’ algorithm, bat algorithm, firefly algorithm etc.), genetic and evolutionary strategies, artificial immune systems etc. Well-known examples of applications include: aircraft wing design, wind turbine design, bionic car, bullet train, optimal decisions related to traffic, appropriate strategies to survive under a well-adapted immune system etc. Based on collective social behaviour of organisms, researchers have developed optimization strategies taking into account not only the individuals, but also groups and environment. However, learning from nature, new classes of approaches can be identified, tested and compared against already available algorithms. This work reviews the most effective nature-inspired algorithms and describes learning strategies based on nature oriented thinking. Examples and the benefits obtained from applying nature-inspired strategies in test generation, learners group optimization, and artificial immune systems for learning are given.

Load forecasting of supermarket refrigeration

This paper presents a novel study of models for forecasting the electrical load for supermarket refrigeration. The data used for building the models consists of load measurements, local climate measurements and weather forecasts. The load measurements are from a supermarket located in a village in Denmark. Every hour the hourly electrical load for refrigeration is forecasted for the following 42 h. The forecast models are adaptive linear time series models. The model has two regimes; one for opening hours and one for closing hours, this is modeled by a regime switching model and two different methods for predicting the regimes are tested. The dynamic relation between the weather and the load is modeled by simple transfer functions and the non-linearities are described using spline functions. The results are thoroughly evaluated and it is shown that the spline functions are suitable for handling the non-linear relations and that after applying an auto-regressive noise model the one-step ahead residuals do not contain further significant information.
Refrigeration, Load forecasting, Numerical weather predictions, Adaptive models, Base splines, Time series analysis

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Long Memory of Financial Time Series and Hidden Markov Models with Time-Varying Parameters

Hidden Markov models are often used to model daily returns and to infer the hidden state of financial markets. Previous studies have found that the estimated models change over time, but the implications of the time-varying behavior have not been thoroughly examined. This paper presents an adaptive estimation approach that allows for the parameters of the estimated models to be time varying. It is shown that a two-state Gaussian hidden Markov model with time-varying parameters is able to reproduce the long memory of squared daily returns that was previously believed to be the most difficult fact to reproduce with a hidden Markov model. Capturing the time-varying behavior of the parameters also leads to improved one-step density forecasts. Finally, it is shown that the forecasting performance of the estimated models can be further improved using local smoothing to forecast the parameter variations.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Sampension, Lund University
Authors: Nystrup, P. (Intern), Madsen, H. (Intern), Lindström, E. (Ekstern)
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Main Research Area: Technical/natural sciences

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BFI (2014): BFI-level 1
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BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.033 SNIP 1.026 CiteScore 1.19
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.66 SNIP 0.83
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.506 SNIP 1.046
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.485 SNIP 1.117
Methods and Algorithms for Economic MPC in Power Production Planning

This thesis concerns methods and algorithms for power production planning in contemporary and future power systems. Power production planning is a task that involves decisions across different time scales and planning horizons. Hours-ahead to days-ahead planning is handled by solving a mixed-integer linear program for unit commitment and economic dispatch of the system power generators. We focus on a minutes-ahead planning horizon, where unit commitment decisions are fixed. Economic model predictive control (EMPC) is employed to determine an optimal dispatch for a portfolio of power generators in real-time. A generator can represent a producer of electricity, a consumer of electricity, or possibly both. Examples of generators are heat pumps, electric vehicles, wind turbines, virtual power plants, solar cells, and conventional fuel-fired thermal power plants. Although this thesis is mainly concerned with EMPC for minutes-ahead production planning, we show that the proposed EMPC scheme can be extended to days-ahead planning (including unit commitment) as well.

The power generation from renewable energy sources such as wind and solar power is inherently uncertain and variable. A portfolio with a high penetration of renewable energy is therefore a stochastic system. To accommodate the need for EMPC of stochastic systems, we generalize certainty-equivalent EMPC (CEEMPC) to mean-variance EMPC (MV-EMPC). In MV-EMPC, the objective function is a trade-off between the expected cost and the cost variance. Simulations show that MV-EMPC reduces cost and risk compared to CE-EMPC. The simulations also show that the economic performance of CE-EMPC can be much improved using a constraint back-off heuristic.

Efficient solution of the optimal control problems (OCPs) that arise in EMPC is important, as the OCPs are solved online. We present special-purpose algorithms for EMPC of linear systems that exploit the high degree of structure in the OCPs. A Riccati-based homogeneous and self-dual interior-point method is developed for the special case, where the OCP
objective function is a linear function. We design an algorithm based on the alternating direction method of multipliers (ADMM) to solve input-constrained OCPs with convex objective functions. The OCPs that occur in EMPC of dynamically decoupled subsystems, e.g., power generators, have a block-angular structure. Subsystem decomposition algorithms based on ADMM and Dantzig-Wolfe decomposition are proposed to solve these OCPs. Subproblems that arise in the decomposition algorithms are solved using structure-exploiting algorithms. To reduce computation time of the EMPC algorithms further, warm-start and early-termination strategies are employed. Benchmarks show that the special-purpose algorithms are significantly faster than current state-of-the-art solvers.

As a potential application area of EMPC, we study power production planning in small isolated power systems. A critical part of power production planning in small isolated power systems is operational reserve planning. The operational reserves are activated to balance production and consumption in real-time. An EMPC scheme is presented for activation of operational reserves. Simulations based on a Faroe Islands case study show that significant cost savings can be achieved using this strategy. For efficient planning of the operational reserves, we present an optimal reserve planning problem (ORPP). The ORPP is a contingency-constrained unit commitment problem that addresses low inertia challenges in small isolated power systems.

In summary, the main contributions of this thesis are:
- A mean-variance optimization strategy for EMPC of linear stochastic systems.
- Tailored algorithms for solution of the OCPs that arise in EMPC of linear stochastic systems.
- Methods for power production planning in small isolated power; the ORPP for unit commitment and economic dispatch, and an EMPC scheme for activation of operational reserves.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Scientific Computing, Center for Energy Resources Engineering, Dynamical Systems
Authors: Sokoler, L. E. (Intern), Jørgensen, J. B. (Intern), Madsen, H. (Intern), Poulsen, N. K. (Intern)
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Model Identification using Continuous Glucose Monitoring Data for Type 1 Diabetes
This paper addresses model identification of continuous-discrete nonlinear models for people with type 1 diabetes using sampled data from a continuous glucose monitor (CGM). We compare five identification techniques: least squares, weighted least squares, Huber regression, maximum likelihood with extended Kalman filter and maximum likelihood with unscented Kalman filter. We perform the identification on a 24-hour simulation of a stochastic differential equation (SDE) version of the Medtronic Virtual Patient (MVP) model including process and output noise. We compare the fits with the actual CGM signal, as well as the short- and long-term predictions for each identified model. The numerical results show that the maximum likelihood-based identification techniques offer the best performance in terms of fitting and prediction. Moreover, they have other advantages compared to ODE-based modeling, such as parameter tracking, population modeling and handling of outliers.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Scientific Computing, Dynamical Systems
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Main Research Area: Technical/natural sciences

Publication information
Modeling and Control for Price Responsive Electricity Loads

This thesis deals with the development of model-based control architectures to facilitate renewable sources integration in the power system, focusing on residential buildings. Energy use in buildings in developed countries is increasing rapidly, and advanced model based techniques for control of thermal storages are becoming popular due to the high demand for solutions that improve energy efficiency and reduce operating costs.

This presents new challenges on how to integrate uncertain and intermittent energy sources. This work proposes methods for control of price responsive electricity loads in future energy systems and methods for handling stochasticity of, e.g., wind and solar power production. Hierarchies of aggregators and predictive controllers, in flexible demand side response, are implemented to achieve a balance with the non-dispatchable energy production.

Particular focus is given on producing models for control that facilitate better planning for an efficient integration of renewable energy into the power generation. Combining both data and statistical expertise, opens up new possibilities for designing models that describe thermal storages flexibility.

Finally, focus is also put on the problem of managing a virtual power plant equipped with stochastic energy sources and flexible consumers. Two distinct control approaches are described: direct control of the load consumption and indirect control by broadcasting a price signal. The advantages and challenges of these two approaches are discussed providing examples for suggested techniques.

General information
State: Submitted
Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Scientific Computing
Authors: Parvizi, J. (Intern), Madsen, H. (Intern), Jørgensen, J. B. (Intern)
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Original language: English
Modeling and Prediction Using Stochastic Differential Equations

Pharmacokinetic/pharmacodynamic (PK/PD) modeling for a single subject is most often performed using nonlinear models based on deterministic ordinary differential equations (ODEs), and the variation between subjects in a population of subjects is described using a population (mixed effects) setup that describes the variation between subjects. The ODE setup implies that the variation for a single subject is described by a single parameter (or vector), namely the variance (covariance) of the residuals. Furthermore the prediction of the states is given as the solution to the ODEs and hence assumed deterministic and can predict the future perfectly. A more realistic approach would be to allow for randomness in the model due to e.g., the model be too simple or errors in input. We describe a modeling and prediction setup which better reflects reality and suggests stochastic differential equations (SDEs) for modeling and forecasting. It is argued that this gives models and predictions which better reflect reality. The SDE approach also offers a more adequate framework for modeling and a number of efficient tools for model building. A software package (CTSM-R) for SDE-based modeling is briefly described.

Modelling of glucose-insulin-glucagon pharmacodynamics in man

The purpose is to build a simulation model of the glucoregulatory system in man. We estimate individual human parameters of a physiological glucose-insulin-glucagon model. We report posterior probability distributions and correlations of model parameters.

Modelling and Control for Price Responsive Electricity Loads

Publication: Research › Ph.D. thesis – Annual report year: 2016

Modeling and Prediction Using Stochastic Differential Equations

Pharmacokinetic/pharmacodynamic (PK/PD) modeling for a single subject is most often performed using nonlinear models based on deterministic ordinary differential equations (ODEs), and the variation between subjects in a population of subjects is described using a population (mixed effects) setup that describes the variation between subjects. The ODE setup implies that the variation for a single subject is described by a single parameter (or vector), namely the variance (covariance) of the residuals. Furthermore the prediction of the states is given as the solution to the ODEs and hence assumed deterministic and can predict the future perfectly. A more realistic approach would be to allow for randomness in the model due to e.g., the model be too simple or errors in input. We describe a modeling and prediction setup which better reflects reality and suggests stochastic differential equations (SDEs) for modeling and forecasting. It is argued that this gives models and predictions which better reflect reality. The SDE approach also offers a more adequate framework for modeling and a number of efficient tools for model building. A software package (CTSM-R) for SDE-based modeling is briefly described.
Modelling the glucose-insulin-glucagon dynamics after subcutaneous administration of native glucagon and a novel glucagon analogue in dogs
Zealand Pharma has invented a glucagon analogue, ZP-GA-1, with increased stability in liquid formulation for treatment of hypoglycemia. A pharmacodynamic (PD) model is needed to compare ZP-GA-1 with marketed glucagon. We aim to develop a model of the complex glucose-insulin-glucagon dynamics based on physiology and data.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Scientific Computing, Copenhagen Center for Health Technology, Center for Energy Resources Engineering, Dynamical Systems, Zealand Pharma A/S, McGill University
Authors: Wendt, S. L. (Intern), Boye Knudsen, C. (Ekstern), Jørgensen, J. B. (Intern), Madsen, H. (Intern), Haidar, A. (Ekstern)
Number of pages: 1
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Model of the Glucose-Insulin-Glucagon Dynamics after Subcutaneous Administration of a Glucagon Rescue Bolus in Healthy Humans
In healthy individuals, insulin and glucagon work in a complex fashion to maintain blood glucose levels within a narrow range. This regulation is distorted in patients with diabetes. The hepatic glucose response due to an elevated glucagon level depends on the current insulin concentration and thus endogenous glucose production (EGP) can not be modelled without knowledge of the concentration of both hormones in plasma. Furthermore, literature suggests an upper limit to EGP irrespective of glucagon
levels. We build a simulation model of the glucose-insulin-glucagon dynamics in man including saturation effect of EGP.

Ten healthy subjects received a 1 mg subcutaneous (SC) glucagon bolus (GlucaGen®). Plasma samples were collected until 300 minutes post dose and analyzed for glucagon, insulin, and glucose concentrations. All observations were used to fit a physiological model of the glucose-insulin-glucagon dynamics using the Hovorka model with a novel multiplicative description of the effects of insulin and of glucagon on EGP.

Bayesian estimation by Maximum a Posteriori using prior knowledge reported in literature was used to estimate the model parameters for each subject. Profile likelihood plots were used to investigate parameter identifiability. Unidentifiable parameters were fixed at their prior mean values.

The new model enables simulations of the glucose-insulin-glucagon dynamics in humans at both low and high glucagon concentrations (180-8000 pg/mL) and physiologic insulin concentrations (1.2-81.9 mIU/L). The model can be used for simulation of glucagon bolus strategies for treatment of hypoglycemia and for in silico simulation of dual-hormone artificial pancreas algorithms.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Scientific Computing, Dynamical Systems, Copenhagen Center for Health Technology, Center for Energy Resources Engineering, Zealand Pharma A/S, McGill University
Authors: Wendt, S. L. (Intern), Møller, J. K. (Intern), Haidar, A. (Ekstern), Bysted, B. V. (Ekstern), Knudsen, C. B. (Ekstern), Madsen, H. (Intern), Jørgensen, J. B. (Intern)
Number of pages: 1
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Non-parametric method for separating domestic hot water heating spikes and space heating

In this paper a method for separating spikes from a noisy data series, where the data change and evolve over time, is presented. The method is applied on measurements of the total heat load for a single family house. It relies on the fact that the domestic hot water heating is a process generating short-lived spikes in the time series, while the space heating changes in slower patterns during the day dependent on the climate and user behavior. The challenge is to separate the domestic hot water heating spikes from the space heating without affecting the natural noise in the space heating measurements. The assumption behind the developed method is that the space heating can be estimated by a non-parametric kernel smoother, such that every value significantly above this kernel smoother estimate is identified as a domestic hot water heating spike. First, it is showed how a basic kernel smoothing approach is too simple to deliver reliable results. Therefore the problem is generalized to a local least squares problem, which makes it possible to design a robust kernel smoother, which estimate is not affected by the spikes. Furthermore, the generalized model makes it possible to estimate higher order local polynomials. Finally, the results are evaluated and it is found that the method is capable of calculating a reliable separation of the total heat load into the two components.
Objective Classification of Rainfall in Northern Europe for Online Operation of Urban Water Systems Based on Clustering Techniques

This study evaluated methods for automated classification of rain events into groups of "high" and "low" spatial and temporal variability in offline and online situations. The applied classification techniques are fast and based on rainfall data only, and can thus be applied by, e.g., water system operators to change modes of control of their facilities. A k-means clustering technique was applied to group events retrospectively and was able to distinguish events with clearly different temporal and spatial correlation properties. For online applications, techniques based on k-means clustering and quadratic discriminant analysis both provided a fast and reliable identification of rain events of "high" variability, while the k-means provided the smallest number of rain events falsely identified as being of "high" variability (false hits). A simple classification method based on a threshold for the observed rainfall intensity yielded a large number of false hits and was thus outperformed by the other two methods.

General information
State: Published
Organisations: Department of Environmental Engineering, Urban Water Systems, Department of Applied Mathematics and Computer Science, Dynamical Systems, University of Oxford
Authors: Löwe, R. (Intern), Madsen, H. (Intern), McSharry, P. (Ekstern)
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On the significance of the noise model for the performance of a linear MPC in closed-loop operation

This paper discusses the significance of the noise model for the performance of a Model Predictive Controller when operating in closed-loop. The process model is parametrized as a continuous-time (CT) model and the relevant sampled-data filtering and control algorithms are developed. Using CT models typically means less parameters to identify. Systematic tuning of such controllers is discussed. Simulation studies are conducted for linear time-invariant systems showing that choosing a noise model of low order is beneficial for closed-loop performance. (C) 2016, IFAC (International Federation of Automatic Control) Hosting by Elsevier Ltd. All rights reserved.
PK/PD modelling of glucose-insulin-glucagon dynamics in healthy dogs after a subcutaneous bolus administration of native glucagon or a novel glucagon analogue

**Objective** We aim to develop a simulation model of the complex glucose-insulin-glucagon dynamics based on physiology and data. Furthermore, we compare pharmacokinetic (PK) and pharmacodynamic (PD) characteristics of marketed reconstituted glucagon with a stable liquid glucagon analogue invented by Zealand Pharma A/S.

**Research Design and Methods** We expanded a physiological model of endogenous glucose production with multiplicative effects of insulin and glucagon and combined it with the Hovorka glucoregulatory model. We used a Bayesian framework to perform multidimensional MAP estimation of model parameters given priors reported in the literature. We used profile likelihood analysis to investigate parameter identifiability and reduce the number of model variables. We estimated model parameters in pre-clinical data from one cross-over study with a total of 20 experiments in five dogs. The dogs received two subcutaneous (SC) bolus injections of low and high doses of glucagon and ZP-GA-1 (20 and 120 nmol/kg).

**Results** We report posterior probability distributions and correlations for all identifiable model parameters. Based on visual inspection and residual analysis, the PD model described data satisfactorily for both glucagon and the analogue. Parameter estimates of the PD model were not significantly different between the two compounds.

**Conclusions** The new PK/PD model enables simulations of the glucose-insulin-glucagon dynamics after a SC bolus of glucagon or glucagon analogue. The novel glucagon analogue by Zealand Pharma A/S shows PK and PD characteristics similar to marketed glucagon.
operator is concerned with minimizing system failures and is aided by wind power forecasts, to the end user of energy where power price forecasts are useful for users with flexible power demand.

The main contributions of this thesis lie in the realm of using gray box models to produce forecasts for energy systems. Gray box models can be defined as a crossover between physical models (or white box models), that base their model on a physical understanding of the system at hand, and data driven models (or black box models) that focus on accurately describing the data without considering physical limitations of the system. Integrating these physical structures into a data driven approach allows for producing better forecasts with more accurate predictions. In this thesis we have developed and applied methodologies for gray box modeling to produce forecasts for vehicle driving patterns, solar irradiance, wind speeds, wind power, and solar power. The model for driving patterns has subsequently been used as input into an optimization algorithm for charging a single electric vehicle. In a subsequent study the behavior of a fleet of electric vehicles has been studied.

In the thesis we go through various examples of forecasts products and their applications. We emphasize that forecasting can not stand alone and should be complimented by optimization and decision making tools for an efficient integration of renewable energy. Thus forecast products should be developed in unison with the decision making tool as they are two sides of the same overall challenge.
Probabilistic runoff volume forecasting in risk-based optimization for RTC of urban drainage systems
This article demonstrates the incorporation of stochastic grey-box models for urban runoff forecasting into a full-scale, system-wide control setup where setpoints are dynamically optimized considering forecast uncertainty and sensitivity of overflow locations in order to reduce combined sewer overflow risk. The stochastic control framework and the performance of the runoff forecasting models are tested in a case study in Copenhagen (76 km2 with 6 sub-catchments and 7 control points) using 2-h radar rainfall forecasts and inlet flows to control points computed from a variety of noisy/oscillating in-sewer measurements. Radar rainfall forecasts as model inputs yield considerably lower runoff forecast skills than “perfect” gauge-based rainfall observations (ex-post hindcasting). Nevertheless, the stochastic grey-box models clearly outperform benchmark forecast models based on exponential smoothing. Simulations demonstrate notable improvements of the control efficiency when considering forecast information and additionally when considering forecast uncertainty, compared with optimization based on current basin fillings only.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Urban Water Systems, Department of Environmental Engineering, Dynamical Systems, Krüger A/S
Authors: Löwe, R. (Intern), Vezzaro, L. (Intern), Mikkelsen, P. S. (Intern), Grum, M. (Ekstern), Madsen, H. (Intern)
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Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
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BFI (2012): BFI-level 1
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BFI (2011): BFI-level 1
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Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.684 SNIP 2.221
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.33 SNIP 1.965
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.131 SNIP 1.892
Scopus rating (2007): SJR 1.125 SNIP 1.907
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.962 SNIP 1.743
Scopus rating (2005): SJR 0.927 SNIP 1.595
Scopus rating (2004): SJR 0.49 SNIP 1.162
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.471 SNIP 1.076
Scopus rating (2002): SJR 0.421 SNIP 0.829
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Stochastic grey-box model, Probabilistic forecasting, Real-time control, Urban hydrology, Radar rainfall, Storm water management
Short-term Probabilistic Forecasting of Wind Speed Using Stochastic Differential Equations

It is widely accepted today that probabilistic forecasts of wind power production constitute valuable information for both wind power producers and power system operators to economically exploit this form of renewable energy, while mitigating the potential adverse effects related to its variable and uncertain nature. In this paper, we propose a modeling framework for wind speed that is based on stochastic differential equations. We show that stochastic differential equations allow us to naturally capture the time dependence structure of wind speed prediction errors (from 1 up to 24 hours ahead) and, most importantly, to derive point and quantile forecasts, predictive distributions, and time-path trajectories (also referred to as scenarios or ensemble forecasts), all by one single stochastic differential equation model characterized by a few parameters.

The Smart-Energy Operating-System (SE-OS) framework has been developed within the CITIES research project (www.smart-cities-centre.org). This framework enables a systematic approach for implementing flexible electric energy systems in smart cities. The SE-OS methodologies are based on methods for data analytics, cyber physical modelling, forecasting, control, optimization, IoT, IoS, and cloud computing. The SE-OS concept has being used for enabling flexibility and demand response in smart cities in a large number of demo project. Finally it is shown that SE-OS in combination with methods for energy systems (gas, thermal, power, biomass, fuel) integration can provide virtual energy storage solutions on all relevant time scales, ie. from minutes to seasonal storage.

The Smart-Energy Operating-System (SE-OS) is used to develop, implement and test of solutions (layers: data, models, optimization, control, communication) for operating flexible electrical energy systems at all scales.

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Authors: Madsen, H. (Intern), Parvizi, J. (Intern), Bacher, P. (Intern)
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Links:
http://www.sustain.dtu.dk/

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Statistical modelling using CTSM-R

The ability to forecast the future of a system is more important than ever. Countless of applications require precise forecasting models to make smarter decisions in real time. Practitioners need software tools allowing an easy, quick and accurate implementation of their ideas. This thesis shows our software CTSM-R, which means: Continuous Time Stochastic Modelling in R. CTSMR provides the ability to implement statistical models and estimate unknown parameters. Thus allows modellers to model and understand the physical system of interest.

The main contributions of this thesis are the development of a generic software tool for grey box modelling. Grey box models use knowledge about the physical system of interest in combination with data to create models that accurately explain the data. The thesis will demonstrate how to implement linear and nonlinear models. These two model classes then serve as a building block for population models and spatiotemporal models. Population models known from the pharmaceutical industry where nonlinear population modelling has been long used in the industry to analyse trial data from many subjects. Spatiotemporal modelling extends CTSM-R to model complex correlations in space and time. This thesis demonstrates how to use spatio-temporal models for solar power forecasting.

CTSM-R is built in R using fast computations in Fortran when needed. CTSMR provides a simple interface which is quickly learned through our examples on our website http://ctsm.info.

Finally, this thesis demonstrates the importance of identifiability. A model is just a representation of the physical reality and such a representation is not guaranteed to be unique. Identifiability and the use of profile likelihood figures should be
A Bolus Calculator Based on Continuous-Discrete Unscented Kalman Filtering for Type 1 Diabetics

In patients with type 1 diabetes, the effects of meals intake on blood glucose level are usually mitigated by administering a large amount of insulin (bolus) at mealtime or even slightly before. This strategy assumes, among other things, a prior knowledge of the meal size and the postprandial glucose dynamics. On the other hand, administering the meal bolus during or after mealtime could benefit from the information provided by the postprandial meal dynamics at the expense of a delayed meal bolus. The present paper investigates different bolus administration strategies (at mealtime, 15 minutes after or 30 minutes after the beginning of the meal). We implement a continuous-discrete unscented Kalman filter to estimate the states and insulin sensitivity. These estimates are used in a bolus calculator. The numerical results demonstrate that administering the meal bolus 15 minutes after mealtime both reduces the risk of hypoglycemia in case of an overestimated meal and the time spent in hyperglycemia if the meal size is underestimated. Faster insulin and the use of glucagon will have the potential to encourage postprandial meal bolus administration and hence will not require to accurately estimate the meal size.
A Continuous-Discrete Extended Kalman Filter for State and Parameter Estimation in People with Type 1 Diabetes

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An artificial pancreas for automated blood glucose control in patients with Type 1 diabetes

Automated glucose control in patients with Type 1 diabetes is much-coveted by patients, relatives and healthcare professionals. It is the expectation that a system for automated control, also known as an artificial pancreas, will improve glucose control, reduce the risk of diabetes complications and markedly improve patient quality of life. An artificial pancreas consists of portable devices for glucose sensing and insulin delivery which are controlled by an algorithm residing on a computer. The technology is still under development and currently no artificial pancreas is commercially available. This review gives an introduction to recent progress, challenges and future prospects within the field of artificial pancreas research.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Scientific Computing, Dynamical Systems, Copenhagen University Hospital
A Non-linear Stochastic Model for an Office Building with Air Infiltration

This paper presents a non-linear heat dynamic model for a multi-room office building with air infiltration. Several linear and non-linear models, with and without air infiltration, are investigated and compared. The models are formulated using stochastic differential equations and the model parameters are estimated using a maximum likelihood technique. Based on the maximum likelihood value, the different models are statistically compared to each other using Wilk's likelihood ratio test. The model showing the best performance is finally verified in both the time domain and the frequency domain using the auto-correlation function and cumulated periodogram. The proposed model which includes air-infiltration shows a significant improvement compared to previously proposed linear models. The model has subsequently been used in applications for provision of power system services, e.g. by providing heat load reduction during peak load hours, control of indoor air temperature and for generating forecasts of power consumption from space heating.

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Organisations: Department of Electrical Engineering, Center for Electric Power and Energy, Energy system operation and management , Department of Applied Mathematics and Computer Science , Dynamical Systems
Authors: Thavlov, A. (Intern), Madsen, H. (Intern)
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Bi-hormonal Closed-loop Control of Blood Glucose for People With Type 1 Diabetes - the Diacon Project

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BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.223 SNIP 1.035 CiteScore 1.52
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.315 SNIP 1.14 CiteScore 2.09
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.153 SNIP 1.058 CiteScore 2.74
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.962 SNIP 1.103 CiteScore 2.5
ISI indexed (2012): ISI indexed yes
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BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.029 SNIP 1.1 CiteScore 2.17
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.997 SNIP 1.187
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.936 SNIP 0.97
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.727 SNIP 0.889
Scopus rating (2007): SJR 0.6 SNIP 0.789
Scopus rating (2006): SJR 0.817 SNIP 0.891
Scopus rating (2005): SJR 0.763 SNIP 0.963
Bihormonal control of blood glucose in people with type 1 diabetes

This paper presents a bihormonal artificial pancreas (AP) for people with type 1 diabetes (T1D) designed to provide a safe blood glucose control with minimal use of glucagon. The control algorithm uses insulin as well as glucagon to prevent hyper- and hypoglycemia. We employ a novel prediction-based activation of glucagon administration. The control algorithm consists of a Kalman filter, an insulin infusion model predictive controller (MPC), a proportional-derivative (PD) controller for glucagon infusion, and a meal time insulin bolus calculator. The PD controller is activated if the Kalman filter predicts hypoglycemia. Predictions utilize an ARMAX model describing glucose-insulin and glucose-glucagon dynamics. The model parameters are estimated from basic patient-specific data. A continuous glucose monitor provides feedback. We test the control algorithm using a simulation model with time-varying parameters available for 3 patients. We consider a simulation scenario where meals are estimated correctly as well as overestimated by 30%. The simulation results demonstrate that during normal operation, the controller only needs insulin and does not need glucagon. During unexpected events, such as insulin overdose due to an overestimated meal, the control algorithm uses glucagon efficiently to avoid severe hypoglycemia.

Characterising the Actual Thermal Performance of Buildings: Current Results of Common Exercises Performed in the Framework of the IEA EBC Annex 58-Project

Several studies have shown that actual thermal performance of buildings after construction may deviate significantly from that anticipated at design stage. As a result, there is growing interest in full scale testing of components and whole buildings. The IEA EBC Annex 58-project 'Reliable Building Energy Performance Characterisation Based on Full Scale Dynamic Measurements' is developing the necessary knowledge and tools to achieve reliable in-situ dynamic testing and data analysis methods that can be used to characterise the actual thermal performance and energy efficiency of building components and whole buildings. The research within this project is driven by case studies. As a first simple case, an experiment on testing and data analysis is performed on a round robin test box. This test box can be seen as a scale model of a building, built by one of the participants, with fabric properties unknown to all other participants. Full scale measurements have been performed on the test box in different countries under real climatic conditions. The obtained dynamic data are distributed to all participants who have to try to characterise the thermal performance of the test box's fabric based on the provided data.

This paper presents the first results obtained on the round robin experiment. It is shown how different techniques can be used to characterise the thermal performance of the test box, ranging from a simple stationary analysis to advanced dynamic data analysis methods.
Comparison of Prediction Models for a Dual-Hormone Artificial Pancreas

In this paper we compare the performance of five different continuous time transfer function models used in closed-loop model predictive control (MPC). These models describe the glucose-insulin and glucose-glucagon dynamics. They are discretized into a state-space description and used as prediction models in the MPC algorithm. We simulate a scenario including meals and daily variations in the model parameters. The numerical results do not show significant changes in the glucose traces for any of the models, excepted for the first order model. From the present study, we can conclude that the second order model without delay should provide the best trade-off between sensitivity to uncertainties and practical usability for in vivo clinical studies.
Comparison of two stochastic techniques for reliable urban runoff prediction by modeling systematic errors

In urban rainfall-runoff, commonly applied statistical techniques for uncertainty quantification mostly ignore systematic output errors originating from simplified models and erroneous inputs. Consequently, the resulting predictive uncertainty is often unreliable. Our objective is to present two approaches which use stochastic processes to describe systematic deviations and to discuss their advantages and drawbacks for urban drainage modeling. The two methodologies are an external bias description (EBD) and an internal noise description (IND, also known as stochastic gray-box modeling). They emerge from different fields and have not yet been compared in environmental modeling. To compare the two approaches, we develop a unifying terminology, evaluate them theoretically, and apply them to conceptual rainfall-runoff modeling in the same drainage system. Our results show that both approaches can provide probabilistic predictions of wastewater discharge in a similarly reliable way, both for periods ranging from a few hours up to more than 1 week ahead.
of time. The EBD produces more accurate predictions on long horizons but relies on computationally heavy MCMC routines for parameter inferences. These properties make it more suitable for off-line applications. The IND can help in diagnosing the causes of output errors and is computationally inexpensive. It produces best results on short forecast horizons that are typical for online applications.

**General information**

*State:* Published

*Organisations:* Department of Applied Mathematics and Computer Science, Department of Environmental Engineering, Urban Water Engineering, Dynamical Systems, Swiss Federal Institute of Technology, Swiss Federal Institute of Aquatic Science and Technology

*Authors:* Del Giudice, D. (Ekstern), Löwe, R. (Intern), Madsen, H. (Intern), Mikkelsen, P. S. (Intern), Rieckermann, J. (Ekstern)

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- Web of Science (2016): Indexed yes
- BFI (2015): BFI-level 2
- Scopus rating (2015): SJR 2.58 SNIP 1.617 CiteScore 4.06
- Web of Science (2015): Indexed yes
- BFI (2014): BFI-level 2
- Scopus rating (2014): SJR 2.44 SNIP 1.643 CiteScore 3.75
- Web of Science (2014): Indexed yes
- BFI (2013): BFI-level 2
- Scopus rating (2013): SJR 2.205 SNIP 1.748 CiteScore 3.65
- ISI indexed (2013): ISI indexed yes
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- BFI (2012): BFI-level 2
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- ISI indexed (2012): ISI indexed yes
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- BFI (2011): BFI-level 2
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- ISI indexed (2011): ISI indexed yes
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- BFI (2010): BFI-level 2
- Scopus rating (2010): SJR 2.051 SNIP 1.433
- Web of Science (2010): Indexed yes
- BFI (2009): BFI-level 2
- Scopus rating (2009): SJR 2.132 SNIP 1.524
- BFI (2008): BFI-level 2
- Scopus rating (2008): SJR 1.753 SNIP 1.522
- Web of Science (2008): Indexed yes
- Scopus rating (2007): SJR 1.619 SNIP 1.401
- Web of Science (2007): Indexed yes
- Scopus rating (2006): SJR 1.663 SNIP 1.589
Consumption management in the Nord Pool region: A stability analysis
Integration of fluctuating renewables like wind and solar power is nowadays a hot topic, but this comes at a cost of decreased stability of the power system. The deterioration often translates into so-called spikes and drops in the electricity spot price, very large (even extreme) deviations from the regular spot price, followed by a reversion to roughly the original level a few days later. We use the spikes and drops as a strong indication that there is an imbalance in the physical power system in this paper.

Independent Spike Models (ISM) is a popular class of models for the electricity spot price that uses regime switching, typically having three regimes (base regime, spikes and drops). We fit a such model to Nord Pool spot data to characterize the size and intensity of these deviations, and proceed by augmenting the standard second generation, three factor Independent Spike Model by relating the spike and drop intensity to several factors and find strong statistical support for relating the consumption to the spike and drop intensity.

The model is then used to quantitatively evaluate the effects when modifying the consumption in order to mimic how additional renewables are integrated into the power system or conversely the effects when smoothing consumption using strategies that can be implemented in smart grids. We use this tool to obtain a direct measure of how much the spike and drop intensity can be reduced by smoothing the consumption and see that even a small increase in the variability of the consumption translates into decreased stability (more spikes and/or drops) of the power system.

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State: Published
Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Centre for IT-Intelligent Energy Systems in Cities, Lund University, Center on Renewable Energy
Authors: Lindström, E. (Ekstern), Madsen, H. (Intern), Norén, V. (Ekstern)
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Independent Spike Model, Electricity spot price, Nord Pool, Consumption management

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Control of Electricity Load in Future Smart Cities

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Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Scientific Computing
Authors: Madsen, H. (Intern), Parvizi, J. (Intern), Halvgaard, R. (Intern), Jørgensen, J. B. (Intern)
Control of Electricity Loads in Future Electric Energy Systems

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Decision Support Tools for Electricity Retailers, Wind Power and CHP Plants Using Probabilistic Forecasts

This paper reviews a number of applications of optimization under uncertainty in energy markets resulting from the research project ENSYMORA. A general mathematical formulation applicable to problems of optimization under uncertainty in energy markets is presented. This formulation can be effortlessly adapted to describe different approaches: the deterministic one (usable within a rolling horizon scheme), stochastic programming and robust optimization. The different features of this mathematical formulation are duly interpreted with a view to the energy applications reviewed in this paper: trading for a price-maker wind power producer, management of heat and power systems, operation for retailers in a dynamic-price market. A selection of results shows the viability and appropriateness of the presented stochastic optimization approaches for managing energy systems under uncertainty.

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Organisations: Department of Applied Mathematics and Computer Science , Dynamical Systems
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Ratings:
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BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.302 SNIP 0.039
Web of Science (2015): Indexed yes
Economic Dispatch of Demand Response Balancing through Asymmetric Block Offers

This paper proposes a method of describing the load shifting ability of flexible electrical loads in a manner suitable for existing power system dispatch frameworks. The concept of an asymmetric block offer for flexible loads is introduced. This offer structure describes the ability of a flexible load to provide a response to the power system and the subsequent need to recover. The conventional system dispatch algorithm is altered to facilitate the dispatch of demand response units alongside generating units using the proposed offer structure. The value of demand response is assessed through case studies that dispatch flexible supermarket refrigeration loads for the provision of regulating power. The demand resource is described by a set of asymmetric blocks, and a set of four blocks offers is shown to offer cost savings for the procurement of regulating power in excess of 20%. For comparative purposes, the cost savings achievable with a fully observable and controllable demand response resource are evaluated, using a time series model of the refrigeration loads. The fully modeled resource offers greater savings; however, the difference is small and potentially insufficient to justify the investment required to fully model and control individual flexible loads.

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Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Department of Electrical Engineering, Center for Electric Power and Energy, Electricity markets and energy analytics, Centre for IT-Intelligent Energy Systems in Cities, University College Dublin
Authors: O'Connell, N. (Intern), Pinson, P. (Intern), Madsen, H. (Intern), O'Malley, M. (Ekstern)
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Web of Science (2016): Indexed yes
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Scopus rating (2015): SJR 3.602 SNIP 3.486 CiteScore 6.6
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.831 SNIP 3.577 CiteScore 5.31
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.939 SNIP 4.35 CiteScore 6.33
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.177 SNIP 3.516 CiteScore 5.84
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Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Department of Wind Energy, Meteorology, Department of Electrical Engineering, Center for Electric Power and Energy, Energy system operation and management, Centre for IT-Intelligent Energy Systems in Cities, Durham University, Fraunhofer Institute for Wind Energy and Energy System Technology
Authors: Madsen, H. (Intern), Parvizi, J. (Intern), Sempreviva, A. M. (Intern), Bindner, H. W. (Intern), Dent, C. (Ekstern), Mackensen, R. (Ekstern)
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Integrated energy systems modelling
Limited area forecasting for wind energy scheduling

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Authors: Rosgaard, M. H. (Intern), Hahmann, A. N. (Intern), Madsen, H. (Intern), Giebel, G. (Intern), Sørensen, P. E. (Intern), Nielsen, H. A. (Ekstern), Nielsen, T. S. (Ekstern)
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Long memory of financial time series and hidden Markov models with time-varying parameters

Hidden Markov models are often used to capture stylized facts of daily returns and to infer the hidden state of financial markets. Previous studies have found that the estimated models change over time, but the implications of the time-varying behavior for the ability to reproduce the stylized facts have not been thoroughly examined. This paper presents an adaptive estimation approach that allows for the parameters of the estimated models to be time-varying. It is shown that a two-state Gaussian hidden Markov model with time-varying parameters is able to reproduce the long memory of squared daily returns that was previously believed to be the most difficult fact to reproduce with a hidden Markov model. Capturing the time-varying behavior of the parameters also leads to improved one-step predictions.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems
Authors: Nystrup, P. (Intern), Madsen, H. (Intern), Lindström, E. (Ekstern)
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Publication: Research › Paper – Annual report year: 2015
Methodology and forecast products for the optimal offering of ancillary services from wind in a market environment

In this report models for extreme negative wind power forecast errors are presented. The models can be applied to estimate levels below which the wind power rarely drops. Such levels could be called “certain-levels” or “guaranteed levels” of wind power, well knowing that full guarantee never can be given. The estimated levels are obtained by modelling the error from already existing wind power forecasting software, this is accomplished by modelling the residuals with statistical extreme value techniques.

The forecasts can be used in the operation of power systems with significant amounts of wind power for example in the planning of ancillary power services, where the level of available wind power with a high degree of certainty is important to know.

The presented extreme value models are applied to negative forecast residuals from state-of-the-art wind power forecast software. This enables the estimation of return levels below which the extreme wind power forecast error events occur only at a specified rate, e.g. once a month or once every year. The techniques allows extrapolation beyond the available data period. In the study data from 1.5 years is used. It consists of hourly wind power production in the two regions of Denmark (DK1 and DK2) and corresponding wind power forecasts. The wind power forecasts are generated using the software WPPT and are based on the outcome of three numerical weather prediction models. They cover horizons from 1 to 42 hours ahead in time and are updated each hour.

In the report a range of extreme value models are suggested. They are of increasing complexity and a model selection is carried using statistical measures and test. A normal procedure when building forecasting models is to divide the data into a learning and a test set to cross-validate the results in order to avoid over-fitting the models. This is hardly ever possible for extreme value analysis, instead the model selection and evaluation sole rely on statistical techniques such as correlation measures, likelihood ratio-tests and information about uncertainty, for example in the form of confidence bands on parameter estimates and predictions.

The foundation to statistical extreme value theory was set by Fisher and Tippett in 1928 and later developed by Gumbel (1958). Since then it has been used for modelling extremes in a wide range of applications. Typical applications are for estimation of extreme weather induced phenomena, for example extreme water levels in a river, wind levels or at sea for design of dykes (de Haan and de Ronde, 1998). In insurance and finance the extreme value modelling is widespread (Embrechts et al., 1997). Extreme value statistics for energy and power applications is also widely used, for example for planning in wind power operation (Horvat et al., 2013) and peak wind prediction (Cook, 1982) and (Friederichs and Thorarinsdottir, 2012). Several books provide comprehensive introductions to extreme value theory, for example Coles (2001) and Beirlant et al. (2006). A really good overview of available extreme value analysis software is given by Stephenson and Gilleland (2005). In the present study the R R Core Team (2013) package extRemes Gilleland and Katz (2011) is used.

Pharmacokinetics Modeling of Glucagon and a Novel Glucagon Analogue after Subcutaneous Administration in Dogs

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Scientific Computing, Dynamical Systems, Zealand Pharma A/S
Authors: Bacher, P. (Intern), Madsen, H. (Intern), Pinson, P. (Intern), Mortensen, S. B. (Ekstern), Nielsen, H. A. (Ekstern)
Number of pages: 73
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Regime-Based Versus Static Asset Allocation: Letting the Data Speak

Regime shifts present a big challenge to traditional strategic asset allocation. This article investigates whether regime-based asset allocation can effectively respond to changes in financial regimes at the portfolio level, in an effort to provide better long-term results than more static approaches can offer. The authors center their regime-based approach around a regime-switching model with time-varying parameters that can match financial markets' tendency to change behavior abruptly and the fact that the new behavior often persists for several periods after a change. In an asset universe consisting of a global stock index and a global government bond index, they show that, even without any level of forecasting skill, holding a static portfolio may not be optimal.
Space-time trajectories of wind power generation: Parameterized precision matrices under a Gaussian copula approach

Emphasis is placed on generating space-time trajectories of wind power generation, consisting of paths sampled from high-dimensional joint predictive densities, describing wind power generation at a number of contiguous locations and successive lead times. A modelling approach taking advantage of the sparsity of precision matrices is introduced for the description of the underlying space-time dependence structure. The proposed parametrization of the dependence structure accounts for important process characteristics such as lead-time-dependent conditional precisions and direction-dependent cross-correlations. Estimation is performed in a maximum likelihood framework. Based on a test case application in Denmark, with spatial dependencies over 15 areas and temporal ones for 43 hourly lead times (hence, for a dimension of \( n = 645 \)), it is shown that accounting for space-time effects is crucial for generating skilful trajectories.

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Organisations: Department of Electrical Engineering, Department of Applied Mathematics and Computer Science, Dynamical Systems, Centre for IT-Intelligent Energy Systems in Cities, Siemens Wind Power A/S
Authors: Tastu, J. (Ekstern), Pinson, P. (Intern), Madsen, H. (Intern)
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Statistics for Finance
Statistics for Finance develops students' professional skills in statistics with applications in finance. Developed from the authors' courses at the Technical University of Denmark and Lund University, the text bridges the gap between classical, rigorous treatments of financial mathematics that rarely connect concepts to data and books on econometrics and time series analysis that do not cover specific problems related to option valuation.

The book discusses applications of financial derivatives pertaining to risk assessment and elimination. The authors cover various statistical and mathematical techniques, including linear and nonlinear time series analysis, stochastic calculus models, stochastic differential equations, Ito's formula, the Black–Scholes model, the generalized method-of-moments, and the Kalman filter. They explain how these tools are used to price financial derivatives, identify interest rate models, value bonds, estimate parameters, and much more.

This textbook will help students understand and manage empirical research in financial engineering. It includes examples of how the statistical tools can be used to improve value-at-risk calculations and other issues. In addition, end-of-chapter
exercises develop students' financial reasoning skills.

**General information**
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Netcompany IT and business consulting A/S, Lund University
Authors: Lindström, E. (Ekstern), Madsen, H. (Intern), Nielsen, J. N. (Intern)
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**Stochastic Greybox Modeling of an Alternating Activated Sludge Process**
Summary of key findings
We found a greybox model for state estimation and control of the BioDenitro process based on a reduced ASM1. We then applied Maximum Likelihood Estimation on measurements from a real full-scale waste water treatment plant to estimate the model parameters. The estimation method also incorporates the Extended Kalman Filter that provides estimates of any unmeasured states, e.g. the NH4 and NO3 concentrations in both aeration tanks, and more importantly, the NH4 inlet concentration. This will improve control performance without the need for extra sensors and improve forecasts of the load.

**General information**
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Krüger A/S
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**Stylised facts of financial time series and hidden Markov models in continuous time**
Hidden Markov models are often applied in quantitative finance to capture the stylised facts of financial returns. They are usually discrete-time models and the number of states rarely exceeds two because of the quadratic increase in the number of parameters with the number of states. This paper presents an extension to continuous time where it is possible to increase the number of states with a linear rather than quadratic growth in the number of parameters. The possibility of increasing the number of states leads to a better fit to both the distributional and temporal properties of daily returns.

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State: Published
Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Lund University
Authors: Nystrup, P. (Intern), Madsen, H. (Intern), Lindström, E. (Ekstern)
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Main Research Area: Technical/natural sciences

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Temporal knowledge discovery in big BAS data for building energy management

With the advances of information technologies, today's building automation systems (BASs) are capable of managing building operational performance in an efficient and convenient way. Meanwhile, the amount of real-time monitoring and control data in BASs grows continually in the building lifecycle, which stimulates an intense demand for powerful big data analysis tools in BASs. Existing big data analytics adopted in the building automation industry focus on mining cross-sectional relationships, whereas the temporal relationships, i.e., the relationships over time, are usually overlooked. However, building operations are typically dynamic and BAS data are essentially multivariate time series data. This paper presents a time series data mining methodology for temporal knowledge discovery in big BAS data. A number of time series data mining techniques are explored and carefully assembled, including the Symbolic Aggregate approximAtion (SAX), motif discovery, and temporal association rule mining. This study also develops two methods for the efficient post-processing of knowledge discovered. The methodology has been applied to analyze the BAS data retrieved from a real building. The temporal knowledge discovered is valuable to identify dynamics, patterns and anomalies in building operations, derive temporal association rules within and between subsystems, assess building system performance and
spot opportunities in energy conservation.

**General information**

**State:** Published

**Organisations:** Department of Applied Mathematics and Computer Science, Dynamical Systems, Centre for IT-Intelligent Energy Systems in Cities, Hong Kong Polytechnic University

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Scopus rating (2014): SJR 2.123 SNIP 2.936 CiteScore 4.21  
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Scopus rating (2013): SJR 1.897 SNIP 2.433 CiteScore 3.79  
ISI indexed (2013): ISI indexed yes  
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ISI indexed (2011): ISI indexed yes  
Web of Science (2011): Indexed yes  
BFI (2010): BFI-level 2  
Scopus rating (2010): SJR 1.631 SNIP 2.081  
Web of Science (2010): Indexed yes  
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Temporal knowledge discovery, Time series data mining, Big Data, Building automation system, Energy and Buildings 109 (2015) 75–89 Contents lists available at ScienceDirect Energy and Buildings journal home page: www.elsevier.com/locate/enbuild Temporal knowledge discovery in big BAS data for building energy management Cheng Fan a, Fu Xiao a, *, Henrik Madsen b, Dan Wang c a Department of Building Services Engineering, The Hong Kong Polytechnic University, Hong Kong b Department of Applied Mathematics and Computer Science, Technical University of Denmark, Denmark c Department of Computing, The Hong Kong Polytechnic University, Hong Kong article info Article history: Received 6 August 2015 Received in revised form 16 September 2015 Accepted 23 September 2015 Available online 26 September 2015 Keywords: Temporal knowledge discovery Time series data mining Big data Building automation system DOIs: 10.1016/j.enbuild.2015.09.060 Source: FindIt Source-ID: 2281836300 Publication: Research - peer-review › Journal article – Annual report year: 2015

The contribution of glucagon in an Artificial Pancreas for people with type 1 diabetes
The risk of hypoglycemia is one of the main concerns in treatment of type 1 diabetes (T1D). In this paper we present a head-to-head comparison of a currently used insulin-only controller and a prospective bihormonal controller for blood glucose in people with T1D. The bihormonal strategy uses insulin to treat hyperglycemia as well as glucagon to ensure fast recovery from hypoglycemic episodes. Two separate model predictive controllers (MPC) based on patient-specific models handle insulin and glucagon infusion. In addition, the control algorithm consists of a Kalman filter and a meal time insulin bolus calculator. The feedback is obtained from a continuous glucose monitor (CGM). We implement a bihormonal simulation model with time-varying parameters available for 3 subjects to compare the strategies. We consider a protocol with 3 events - a correct mealtime insulin bolus, a missed bolus and a bolus overestimated by 60%. During normal operation both strategies provide similar results. The contribution of glucagon becomes evident after administration of the overestimated insulin bolus. In a 10h period following an overbolused meal, the bihormonal strategy reduces time spent in hypoglycemia in the most severe case by almost 15% (1.5h), outperforming the insulin-only control. Therefore, glucagon contributes to the safety of an Artificial Pancreas.

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Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Scientific Computing, Center for Energy Resources Engineering, Slovak University of Technology, Copenhagen University Hospital
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Thermal Performance Characterization using Time Series Data - IEA EBC Annex 58 Guidelines
This document presents guidelines for using time series analysis methods, models and tools for estimating the thermal performance of buildings and building components. The thermal performance is measured as estimated parameters of a model, or parameters derived from estimated parameters of a model. A special focus will be on estimating the Heat Loss Coefficient (HLC) and gA-value. Provided in the guidelines are modelling procedures with which consistent results for
estimation of energy performance of buildings and building components can be achieved.

These guidelines start with simple (non-dynamical) steady state models where the parameters are found using classical methods for linear regression. Such steady state techniques provide sub-optimal use of the information embedded in the data and provides information only about the HLC and gA-values.

Next the guidelines consider dynamical models. Firstly, linear input-output models are considered. More specifically we will consider the class of AutoRegressive with eXogenous input (ARX) (p) models. These models provides information about the HLC and gA-values, and information about the dynamics (most frequently described as time-constants for the system).

Finally, grey-box models are considered. This class of models is formulated as state space models which are able to provide rather detailed information about the internal physical parameters of a construction. This class of models bridges the gap between physical and statistical modelling. A grey-box model is formulated as a continuous time model for the states of the system, together with a discrete set of equations describing how the measurements are linked to the states. The frequently used so-called RC-network models belongs to the class of linear greybox models. However, advanced constructions, like a wall with PV-integration or a complex building with a lot of glass, often calls for a description of nonlinear phenomena. This can be facilitated by the class of non-linear grey-box models.

It is assumed that data is available as time series of measurements. Hence it should be noticed that the important steps of experimental design and setting up the experiment have been conducted.
A Decomposition Algorithm for Mean-Variance Economic Model Predictive Control of Stochastic Linear Systems

This paper presents a decomposition algorithm for solving the optimal control problem (OCP) that arises in Mean-Variance Economic Model Predictive Control of stochastic linear systems. The algorithm applies the alternating direction method of multipliers to a reformulation of the OCP that decomposes into small independent subproblems. We test the decomposition algorithm using a simple power management case study, in which the OCP is formulated as a convex quadratic program. Simulations show that the decomposition algorithm scales linearly in the number of uncertainty scenarios. Moreover, a parallel implementation of the algorithm is several orders of magnitude faster than state-of-the-art convex quadratic programming algorithms, provided that the number of uncertainty scenarios is large.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Scientific Computing, Dynamical Systems, Center for Energy Resources Engineering, Centre for IT-Intelligent Energy Systems in Cities
Authors: Sokoler, L. E. (Intern), Dammann, B. (Intern), Madsen, H. (Intern), Jørgensen, J. B. (Intern)
Pages: 1086-1093
Publication date: 2014

A Mean-Variance Criterion for Economic Model Predictive Control of Stochastic Linear Systems

Stochastic linear systems arise in a large number of control applications. This paper presents a mean-variance criterion for economic model predictive control (EMPC) of such systems. The system operating cost and its variance is approximated based on a Monte-Carlo approach. Using convex relaxation, the tractability of the resulting optimal control problem is addressed. We use a power management case study to compare different variations of the mean-variance strategy with EMPC based on the certainty equivalence principle. We use a power management case study to compare different variations of the mean-variance strategy with EMPC based on the certainty equivalence principle. The certainty equivalence strategy is much more computationally efficient than the mean-variance strategies, but it does not account for the variance of the uncertain parameters. Openloop simulations suggest that a single-stage mean-variance approach yields a significantly lower operating cost than the certainty equivalence strategy. In closed-loop, the single-stage formulation is overly conservative, which results in a high operating cost. For this case, a two-stage extension of the mean-variance approach provides the best trade-off between the expected cost and its variance. It is demonstrated that by using a constraint back-off technique in the specific case study, certainty equivalence EMPC can be modified to perform almost as well as the two-stage mean-variance formulation. Nevertheless, we argue that the mean-variance approach can be used both as a strategy for evaluating less computational demanding methods such as the certainty equivalence method, and as an individual control strategy when heuristics such as constraint back-off do not perform well.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Scientific Computing, Dynamical Systems, Center for Energy Resources Engineering, Centre for IT-Intelligent Energy Systems in Cities
Authors: Sokoler, L. E. (Intern), Dammann, B. (Intern), Madsen, H. (Intern), Jørgensen, J. B. (Intern)
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A model predictive control strategy for the space heating of a smart building including cogeneration of a fuel cell-electrolyzer system

The objective of this paper is to analyze the value of energy replacement in the context of demand response. Energy replacement is defined as the possibility of the consumer to choose the most convenient source for providing space heating to a smart building according to a dynamic electricity price. In the proposed setup, heat is provided by conventional electric radiators and a combined heat and power generation system, composed by a fuel cell and an electrolyzer. The energy replacement strategy is formulated using model predictive control and mathematical models of the components involved. Simulations show that the predictive energy replacement strategy reduces the operating costs of the system and is able to provide a larger amount of regulating power to the grid. In the paper, we also develop a novel dynamic model of a PEM fuel cell suitable for micro-grid applications. The model is realized applying a grey-box methodology to the experimental proton exchange membrane fuel cell of the EPFL-DESL micro-grid.

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Organisations: Department of Electrical Engineering, Center for Electric Power and Energy, Department of Applied Mathematics and Computer Science, Dynamical Systems, Ecole Polytechnique Federale de Lausanne (EPFL)
Authors: Sossan, F. (Intern), Bindner, H. W. (Intern), Madsen, H. (Intern), Torregrossa, D. (Ekstern), Reyes Chamorro, L. (Ekstern), Paolone, M. (Ekstern)
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ISI indexed (2011): ISI indexed yes
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BFI (2009): BFI-level 1
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BFI (2008): BFI-level 1
Assessment of Model Predictive and Adaptive Glucose Control Strategies for People with Type 1 Diabetes

This paper addresses overnight blood glucose stabilization in people with type 1 diabetes using a Model Predictive Controller (MPC). We use a control strategy based on an adaptive ARMAX model in which we use a Recursive Extended Least Squares (RELS) method to estimate parameters of the stochastic part. We compare this model structure with an autoregressive integrated moving average with exogenous input (ARIMAX) structure, and with an autoregressive moving average with exogenous input (ARMAX) model, i.e. without an integrator. Additionally, safety layers improve the controller robustness and reduce the risk of hypoglycemia. We test our control strategies on a virtual clinic of 100 randomly generated patients with a representative inter-subject variability. This virtual clinic is based on the Hovorka model. We consider the case where only half of the meal bolus is administered at mealtime, and the case where the insulin sensitivity varies during the night. The simulation results demonstrate that the adaptive control strategy can reduce the risks of hypoglycemia and hyperglycemia during the night.

Automatic Classification of Offshore Wind Regimes With Weather Radar Observations

Weather radar observations are called to play an important role in offshore wind energy. In particular, they can enable the monitoring of weather conditions in the vicinity of large-scale offshore wind farms and thereby notify the arrival of precipitation systems associated with severe wind fluctuations. The information they provide could then be integrated into
an advanced prediction system for improving offshore wind power predictability and controllability. In this paper, we address the automatic classification of offshore wind regimes (i.e., wind fluctuations with specific frequency and amplitude) using reflectivity observations from a single weather radar system. A categorical sequence of most likely wind regimes is estimated from a wind speed time series by combining a Markov-Switching model and a global decoding technique, the Viterbi algorithm. In parallel, attributes of precipitation systems are extracted from weather radar images. These attributes describe the global intensity, spatial continuity and motion of precipitation echoes on the images. Finally, a CART classification tree is used to find the broad relationships between precipitation attributes and wind regimes.

**General information**

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Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Center for Electric Power and Energy
Authors: Trombe, P. (Intern), Pinson, P. (Intern), Madsen, H. (Intern)
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Scopus rating (2014): SJR 1.682 SNIP 2.462 CiteScore 3.77
Web of Science (2014): Indexed yes
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Scopus rating (2012): SJR 1.319 SNIP 2.084 CiteScore 2.97
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BFI (2010): BFI-level 1
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**Source-ID:** u::9626
Benefits and challenges of electrical demand response: A critical review
Advances in IT, control and forecasting capabilities have made demand response a viable, and potentially attractive, option to increase power system flexibility. This paper presents a critical review of the literature in the field of demand response, providing an overview of the benefits and challenges of demand response. These benefits include the ability to balance fluctuations in renewable generation and consequently facilitate higher penetrations of renewable resources on the power system, an increase in economic efficiency through the implementation of real-time pricing, and a reduction in generation capacity requirements. Nevertheless, demand response is not without its challenges. The key challenges for demand response centre around establishing reliable control strategies and market frameworks so that the demand response resource can be used optimally. One of the greatest challenges for demand response is the lack of experience, and the consequent need to employ extensive assumptions when modelling and evaluating this resource. This paper concludes with an examination of these assumptions, which range from assuming a fixed linear price–demand relationship for price responsive demand, to modelling the highly diverse, distributed and uncertain demand response resource as a single, centralised negative generator, adopting fixed characteristics and constraints.

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Bihormonal model predictive control of blood glucose in people with type 1 diabetes

In this paper we present a bihormonal control system that controls blood glucose in people with type 1 diabetes (T1D). We use insulin together with glucagon to mitigate the negative effects of hyper- and hypoglycemia. The system consists of a Kalman filter, a micro-bolus insulin and glucagon infusion MPC, a mealtime bolus calculator and a CGM providing feedback to the controller. The controller employs a patient data-based prediction model with ARMAX structure. We test the controller using a bihormonal model with time-varying parameters for 3 subjects and compare its performance to a system with an identical insulin MPC, but a glucagon PD controller. The key contribution of the bihormonal MPC is the efficiency of glucagon use. We consider scenarios where the meals are estimated correctly or overestimated and where the insulin sensitivity increases. Both solutions provide tight glucose control. According to the simulations, the bihormonal MPC requires on average 30% less glucagon than the system with a PD controller.

Bio Inspired Algorithms in Single and Multiojective Reliability Optimization

Non-traditional search and optimization methods based on natural phenomena have been proposed recently in order to avoid local or unstable behavior when run towards an optimum state. This paper describes the principles of bio inspired algorithms and reports on Migration Algorithms and Bees Algorithms as good candidates to solve multiobjective optimization problems. A general framework for reliability optimization is formulated and applied to investigate classical and intuitionistic-fuzzy reliability optimization problems. The meta-algorithm proved good performance for large size problems with a reasonable time for tuning of initial parameters.
Characterization of heat dynamics of an arctic low-energy house with floor heating

This paper presents grey-box modeling of the heat dynamics of an apartment in a highly insulated test building located in the Arctic. Data from a 16-day-long experiment is analyzed and used to fit lumped parameter models formulated as coupled stochastic differential equations. The output of the models is the measured indoor air temperature, and the models are fitted using maximum likelihood techniques with the software CTSM-R. Models are compared using likelihood-ratio tests and validated considering autocorrelation and periodograms of residuals. The fitted models facilitate description of both the fast responses to mechanical ventilation and solar radiation through a large window facade, and the slow responses to floor heating and outdoor temperature. To successfully describe the dynamics of the system, solar radiation is given special attention in modeling of both the physical system and the observational noise. The estimated physical parameters which include UA-value, total heat capacity, and time constants for the apartment are discussed. Simulations are performed to illustrate step and impulse responses of inputs.
CITIES: Centre for IT-Intelligent Energy Systems in Cities

This extended abstract provides an introduction to an interdisciplinary strategic research project, CITIES which has been funded with an excess of € 7 million from a wide range of industrial and academic partners, and the Danish Council for Strategic Research. CITIES was launched January 1, 2014 and aims at developing methodologies and ICT solutions for the analysis, operation, planning and development of fully integrated urban energy systems. A holistic research approach will be developed, to provide solutions at all levels between the appliance and the overall system, and at all-time scales between operations and planning. This extended abstract outlines the challenges to be met by city and energy planning bodies in an energy efficient future. The necessity of novel, data driven and IT intelligent solutions is stressed. A focus is placed on energy system planning in systems with high penetrations of renewable energy, or those entirely independent of fossil fuels.

Determining reserve requirements in DK1 area of Nord Pool using a probabilistic approach

Allocation of electricity reserves is the main tool for transmission system operators to guarantee a reliable and safe real-time operation of the power system. Traditionally, a deterministic criterion is used to establish the level of reserve. Alternative criteria are given in this paper by using a probabilistic framework where the reserve requirements are computed based on scenarios of wind power forecast error, load forecast errors and power plant outages. Our approach is first motivated by the increasing wind power penetration in power systems worldwide as well as the current market design of the DK1 area of Nord Pool, where reserves are scheduled prior to the closure of the day-ahead market. The risk of the solution under the resulting reserve schedule is controlled by two measures: the LOLP (Loss-of-Load Probability) and the CVaR (Conditional Value at Risk). Results show that during the case study period, the LOLP methodology produces more costly and less reliable reserve schedules, whereas the solution from the CVaR-method increases the safety of the overall system while decreasing the associated reserve costs, with respect to the method currently used by the Danish TSO (Transmission System Operator).

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Dynamic modeling of presence of occupants using inhomogeneous Markov chains

Occupancy modeling is a necessary step towards reliable simulation of energy consumption in buildings. This paper outlines a method for fitting recordings of presence of occupants and simulation of single-person to multiple-persons office environments. The method includes modeling of dependence on time of day, and by use of a filter of the observations it is able to capture per-employee sequence dynamics. Simulations using this method are compared with simulations using homogeneous Markov chains and show far better ability to reproduce key properties of the data. The method is based on inhomogeneous Markov chains with where the transition probabilities are estimated using generalized linear models with polynomials, B-splines, and a filter of passed observations as inputs. For treating the dispersion of the data series, a hierarchical model structure is used where one model is for low presence rate, and another is for high presence rate.

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Evaluation of Dynamical Downscaling Resolution Effect on Wind Energy Forecast Value for a Wind Farm in Central Sweden

For any energy system relying on wind power, accurate forecasts of wind fluctuations are essential for efficient integration into the power grid. Increased forecast precision allows end-users to plan day-ahead operation with reduced risk of penalties which in turn supports the feasibility of wind energy. The present study aims to quantify value added to wind energy forecasts in the 12-48 hour leadtime by downscaling global numerical weather prediction (NWP) data from the National Centers for Environmental Prediction Global Forecast System (GFS) using the limited-area NWP model described in Skamarock et al. (2008).

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Evaluation of Dynamical Downscaling Resolution Effect on Wind Energy Forecast Value for a Wind Farm in Central Sweden

For any energy system relying on wind power, accurate forecasts of wind fluctuations are essential for efficient utilisation in the power grid. Statistical wind power prediction tools [1] use numerical weather prediction (NWP) model data along with measurements and can correct magnitude errors operationally. It is, however, entirely up to the NWP input to describe the timing of fluctuations correctly.

Wind power is nonlinearly transformed wind speed, and the two are monotonically dependent up till wind speeds of ~25m/s, which is the typical wind farm cut-out. Thus, an improvement in the correlation accuracy metric evaluated for wind speed data consistently translates to an improvement for wind power. For two time series describing the temporal development of the same variable, though by different means, it is assumed that phase errors account for most of the departure from perfect correlation between the two time series.

Results on limited-area NWP model performance, with focus on the 12th to 48th forecast hour horizon relevant for Elspot auction bidding on the Nord Pool Spot market [2], are presented.
Exponential smoothing approaches for prediction in real-time electricity markets

The optimal design of offering strategies for wind power producers is commonly based on unconditional (and, hence, constant) expectation values for prices in real-time markets, directly defining their loss function in a stochastic optimization framework. This is why it may certainly be advantageous to account for the seasonal and dynamic behavior of such prices, hence translating to time-varying loss functions. With that objective in mind, forecasting approaches relying on simple models that accommodate the seasonal and dynamic nature of real-time prices are derived and analyzed. These are all based on the well-known Holt–Winters model with a daily seasonal cycle, either in its conventional form or conditioned upon exogenous variables, such as: (i) day-ahead price; (ii) system load; and (iii) wind power penetration. The superiority of the proposed approach over a number of common benchmarks is subsequently demonstrated through an empirical investigation for the Nord Pool, mimicking practical forecasting for a three-year period over 2008–2011.

General information

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Integrating Renewables in Electricity Markets: Operational Problems

This addition to the ISOR series addresses the analytics of the operations of electric energy systems with increasing penetration of stochastic renewable production facilities, such as wind- and solar-based generation units.

As stochastic renewable production units become ubiquitous throughout electric energy systems, an increasing level of flexible backup provided by non-stochastic units and other system agents is needed if supply security and quality are to be maintained.

Within the context above, this book provides up-to-date analytical tools to address challenging operational problems such as:

- The modeling and forecasting of stochastic renewable power production.
- The characterization of the impact of renewable production on market outcomes.
- The clearing of electricity markets with high penetration of stochastic renewable units.
- The development of mechanisms to counteract the variability and unpredictability of stochastic renewable units so that supply security is not at risk.
- The trading of the electric energy produced by stochastic renewable producers.
- The association of a number of electricity production facilities, stochastic and others, to increase their competitive edge in the electricity market.
- The development of procedures to enable demand response and to facilitate the integration of stochastic renewable units.

This book is written in a modular and tutorial manner and includes many illustrative examples to facilitate its comprehension. It is intended for advanced undergraduate and graduate students in the fields of electric energy systems, applied mathematics and economics. Practitioners in the electric energy sector will benefit as well from the concepts and techniques explained in this book.

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Model Identification for Control of Display Units in Supermarket Refrigeration Systems

In this paper we propose a method for identifying and validating a model of the heat dynamics of a supermarket refrigeration display case for the purpose of advanced control. The model is established to facilitate the development of novel model-based control techniques for individual display units in a supermarket refrigeration system. The grey-box modelling approach is adopted, using stochastic differential equations to define the dynamics of the model, combining prior knowledge of the physical system with data-driven modelling. Model identification is performed using the forward selection method, and the performance of candidate models is evaluated through cross-validation. The model developed in this work uses operational data from a small Danish supermarket. A three-state model is determined to be most appropriate for describing the dynamics of this system. Advanced local control employing the identified model can contribute to the extension of the control capabilities of the entire supermarket refrigeration system.

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Modelling and Assessment of the Capabilities of a Supermarket Refrigeration System for the Provision of Regulating Power

This report presents an analysis of the demand response capabilities of a supermarket refrigeration system, with a particular focus on the suitability of this resource for participation in the regulating power market. An ARMAX model of the system is identified from experimental data, and the model is found to have time constants at 10 and 0.12 hours, indicating the potential for the system to provide exibility in both the long- and short-term. Direct- and indirect-control architectures are employed to simulate the demand response attainable from the refrigeration system. A number of complexities are revealed that would complicate the task of devising bids on a conventional power market. These complexities are incurred due to the physical characteristics and constraints of the system as well as the particular characteristics of the control frameworks employed. Simulations considering the provision of up- and down-regulation reveal that allowing the system to occupy any state within its feasible region results in a complex behaviour. This would require intensive monitoring and control and would be excessively complicated to communicate to a market operator. By restricting the operating region of the system this behaviour can be simplified. These restrictions result in a loss of optimality, but a result in a resource that can be communicated to the market operator in the form of a bid containing a quantity of power for up- or down-regulation and the duration for which the service can be provided.

General information
Model Predictive Control for Smart Energy Systems

In this thesis, we consider control strategies for flexible distributed energy resources in the future intelligent energy system – the Smart Grid. The energy system is a large-scale complex network with many actors and objectives in different hierarchical layers. Specifically, the power system must supply electricity reliably to both residential and industrial consumers around the clock. More and more fluctuating renewable energy sources, like wind and solar, are integrated in the power system. Consequently, uncertainty in production starts to affect an otherwise controllable power production significantly. A Smart Grid calls for flexible consumers that can adjust their consumption based on the amount of green energy in the grid. This requires coordination through new large-scale control and optimization algorithms. Trading of flexibility is key to drive power consumption in a sustainable direction. In Denmark, we expect that distributed energy resources such as heat pumps, and batteries in electric vehicles will mobilize part of the needed flexibility.

Our primary objectives in the thesis were threefold:

1. Simulate the components in the power system based on simple models from literature (e.g. heat pumps, heat tanks, electrical vehicle battery charging/discharging, wind farms, power plants).

2. Embed forecasting methodologies for the weather (e.g. temperature, solar radiation), the electricity consumption, and the electricity price in a predictive control system.

3. Develop optimization algorithms for large-scale dynamic systems. This includes decentralized optimization and simulation on realistic large-scale dynamic systems.

Chapter 1 introduces the power system, the markets, and the main actors. The objectives and control hierarchy is outlined while Aggregators are introduced as new actors.

Chapter 2 provides linear dynamical models of Smart Grid units: Electric Vehicles, buildings with heat pumps, refrigeration systems, solar collectors, heat storage tanks, power plants, and wind farms. The models can be realized as discrete time state space models that fit into a predictive control system.

Chapter 3 introduces Model Predictive Control (MPC) including state estimation, filtering and prediction for linear models.

Chapter 4 simulates the models from Chapter 2 with the certainty equivalent MPC from Chapter 3. An economic MPC minimizes the costs of consumption based on real electricity prices that determined the flexibility of the units. A predictive control system easily handles constraints, e.g. limitations in power consumption, and predicts the future behavior of a unit by integrating predictions of electricity prices, consumption, and weather variables. The simulations demonstrate the expected load shifting capabilities of the units that adapts to the given price predictions. We furthermore evaluated control performance in terms of economic savings for different control strategies and forecasts.

Chapter 5 describes and compares the proposed large-scale Aggregator control strategies. Aggregators are assumed to play an important role in the future Smart Grid and coordinate a large portfolio of units. The developed economic MPC controllers interfaces each unit directly to an Aggregator. We developed several MPC-based aggregation strategies that coordinates the global behavior of a portfolio of units by solving a large-scale optimization and control problem. We applied decomposition methods based on convex optimization, such as dual decomposition and operator splitting, and developed price-based aggregator strategies.
Chapter 6 provides conclusions, contributions and future work.

The main scientific contributions can be summarized to:

- Linear dynamical models of flexible Smart Grid units: heat pumps in buildings, heat storage tanks, and electric vehicle batteries.
- Economic MPC that integrates forecasts in the control of these flexible units.
- Large-scale distributed control strategies based on economic MPC, convex optimization, and decomposition methods.
- A Matlab toolbox including the modeled units for simulating a Smart Energy System with MPC.

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**Neutrosophic Logic Applied to Decision Making**

Decision making addresses the usage of various methods to select "the best", in some way, alternative strategy (from many available) when a problem is given for solving. The authors propose the usage of neutrosophic way of thinking, called also Smarandache's logic, to select a model by experts when degrees of trustability, ultrastability (falsehood), and indeterminacy are used to decide. The procedures deal with multi-attribute neutrosophic decision making and a case study on e-learning software objects is presented.

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Optimal charging of an electric vehicle using a Markov decision process

The combination of electric vehicles and renewable energy is taking shape as a potential driver for a future free of fossil fuels. However, the efficient management of the electric vehicle fleet is not exempt from challenges. It calls for the involvement of all actors directly or indirectly related to the energy and transportation sectors, ranging from governments, automakers and transmission system operators, to the ultimate beneficiary of the change: the end-user. An electric vehicle is primarily to be used to satisfy driving needs, and accordingly charging policies must be designed primarily for this purpose. The charging models presented in the technical literature, however, overlook the stochastic nature of driving patterns. Here we introduce an efficient stochastic dynamic programming model to optimally charge an electric vehicle while accounting for the uncertainty inherent to its use. With this aim in mind, driving patterns are described by an inhomogeneous Markov model that is fitted using data collected from the utilization of an electric vehicle. We show that the randomness intrinsic to driving needs has a substantial impact on the charging strategy to be implemented.

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Predicting Plasma Glucose From Interstitial Glucose Observations Using Bayesian Methods

One way of constructing a control algorithm for an artificial pancreas is to identify a model capable of predicting plasma glucose (PG) from interstitial glucose (IG) observations. Stochastic differential equations (SDEs) make it possible to account both for the unknown influence of the continuous glucose monitor (CGM) and for unknown physiological influences. Combined with prior knowledge about the measurement devices, this approach can be used to obtain a robust predictive model. A stochastic-differential-equation-based gray box (SDE-GB) model is formulated on the basis of an identifiable physiological model of the glucoregulatory system for type 1 diabetes mellitus (T1DM) patients. A Bayesian method is used to estimate robust parameters from clinical data. The models are then used to predict PG from IG observations from 2 separate study occasions on the same patient. First, all statistically significant diffusion terms of the model are identified using likelihood ratio tests, yielding inclusion of $\sigma_{esc}$, $\sigma_{Gp}$, and $\sigma_{Gsc}$. Second, estimates using maximum likelihood are obtained, but prediction capability is poor. Finally, a Bayesian method is implemented. Using this method the identified models are able to predict PG using only IG observations. These predictions are assessed visually. We are also able to validate these estimates on a separate data set from the same patient. This study shows that SDE-GBs and a Bayesian method can be used to identify a reliable model for prediction of PG using IG observations obtained with a CGM. The model could eventually be used in an artificial pancreas.
Predictive densities for day-ahead electricity prices using time-adaptive quantile regression

A large part of the decision-making problems actors of the power system are facing on a daily basis requires scenarios for day-ahead electricity market prices. These scenarios are most likely to be generated based on marginal predictive densities for such prices, then enhanced with a temporal dependence structure. A semi-parametric methodology for generating such densities is presented: it includes: (i) a time-adaptive quantile regression model for the 5%–95% quantiles; and (ii) a description of the distribution tails with exponential distributions. The forecasting skill of the proposed model is compared to that of four benchmark approaches and the well-known the generalist autoregressive conditional heteroskedasticity (GARCH) model over a three-year evaluation period. While all benchmarks are outperformed in terms of forecasting skill overall, the superiority of the semi-parametric model over the GARCH model lies in the former’s ability to generate reliable quantile estimates.
Probabilistic Forecasting for On-line Operation of Urban Drainage Systems

This thesis deals with the generation of probabilistic forecasts in urban hydrology. In particular, we focus on the case of runoff forecasting for real-time control (RTC) on horizons of up to two hours.

For the generation of probabilistic on-line runoff forecasts, we apply the stochastic grey-box model approach. Building on previous work concerning the development of conceptual stochastic rainfall-runoff model structures, we

- investigate approaches for the calibration of model parameters that tune the models for multistep predictions,
- develop an approach for generating probabilistic multistep predictions of runoff volume in an on-line setting,
- develop a new approach for dynamically modelling runoff forecast uncertainty.

We investigate how rainfall inputs can be optimally combined for runoff forecasting with stochastic grey-box models and what effect different types of radar rainfall measurements and forecasts have on on-line runoff forecast quality.

Finally, we implement the stochastic grey-box model approach in a real-world real-time control (RTC) setup and study how RTC can benefit from a dynamic quantification of runoff forecast uncertainty.

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Probabilistic Forecasts of Solar Irradiance by Stochastic Differential Equations

Probabilistic forecasts of renewable energy production provide users with valuable information about the uncertainty associated with the expected generation. Current state-of-the-art forecasts for solar irradiance have focused on producing reliable point forecasts. The additional information included in probabilistic forecasts may be paramount for decision makers to efficiently make use of this uncertain and variable generation. In this paper, a stochastic differential equation framework for modeling the uncertainty associated with the solar irradiance point forecast is proposed. This modeling approach allows for characterizing both the interdependence structure of prediction errors of short-term solar irradiance and their predictive distribution. Three different stochastic differential equation models are first fitted to a training data set and subsequently evaluated on a one-year test set. The final model proposed is defined on a bounded and time-varying state space with zero probability almost surely of events outside this space.

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Scopus rating (2016): SJR 0.944 SNIP 1.045 CiteScore 1.59
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Scopus rating (2015): SJR 1.014 SNIP 0.892 CiteScore 1.48
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.061 SNIP 1.178 CiteScore 1.64
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.073 SNIP 1.228 CiteScore 1.65
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.563 SNIP 0.897 CiteScore 1.12
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.537 SNIP 1.015 CiteScore 1.3
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.684 SNIP 0.811
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.467 SNIP 0.912
Web of Science (2009): Indexed yes
Probabilistic forecasts of wind power generation accounting for geographically dispersed information

Forecasts of wind power generation in their probabilistic form are a necessary input to decision-making problems for reliable and economic power systems operations in a smart grid context. Thanks to the wealth of spatially distributed data, also of high temporal resolution, such forecasts may be optimized by accounting for spatio-temporal effects that are so far merely considered. The way these effects may be included in relevant models is described for the case of both parametric and nonparametric approaches to generating probabilistic forecasts. The resulting predictions are evaluated on the real-world test case of a large offshore wind farm in Denmark (Nysted, 165 MW), where a portfolio of 19 other wind farms is seen as a set of geographically distributed sensors, for lead times between 15 minutes and 8 hours. Forecast improvements are shown to mainly come from the spatio-temporal correction of the first order moments of predictive densities. The best performing approach, based on adaptive quantile regression, using spatially corrected point forecasts as input, consistently outperforms the state-of-the-art benchmark based on local information only, by 1.5%-4.6%, depending upon the lead time.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Department of Electrical Engineering, Center for Electric Power and Energy
Authors: Tastu, J. (Intern), Pinson, P. (Intern), Trombe, P. (Intern), Madsen, H. (Intern)
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Volume: 5
Issue number: 1
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Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 7.73 SJR 2.851 SNIP 2.58
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Probabilistic modelling in urban drainage – two approaches that explicitly account for temporal variation of model errors

This article presents and compares two approaches that consider temporal variations of model errors during stochastic modelling and uncertainty analysis. Time-dynamic error variations should be considered especially in urban drainage modelling because of model structure deficits and the sources of input uncertainties observed in the models. The explicit inclusion of such variations in the modelling process will lead to a better fulfilment of the assumptions made in formal statistical frameworks, thus reducing the need to resolve to informal methods. The two approaches presented here are the external bias description (EBD) and the internal noise description (IND, also known as stochastic grey-box model). The former approach can add a bias with time-varying mean and variance to the output of any model, while the latter approach uses stochastic model equations and continuously updates the model to observations. After a brief discussion of the assumptions made for likelihood-based parameter inference, we illustrated the basic principles of both approaches on the example of sewer flow modelling with a conceptual rainfall-runoff model. The results from a real-world case study suggested that both approaches can yield reliable simulations and forecasts. The EBD approach had performed stronger in simulation but was computationally more expensive while the IND approach was suitable for online applications.

Probabilistic online runoff forecasting for urban catchments using inputs from rain gauges as well as statically and dynamically adjusted weather radar

We investigate the application of rainfall observations and forecasts from rain gauges and weather radar as input to operational urban runoff forecasting models. We apply lumped rainfall runoff models implemented in a stochastic grey-box modelling framework. Different model structures are considered that account for the spatial distribution of rainfall in different degrees of detail.
Considering two urban example catchments, we show that statically adjusted radar rainfall input improves the quality of probabilistic runoff forecasts as compared to input based on rain gauge observations, although the characteristics of these radar measurements are rather different from those on the ground. Data driven runoff forecasting models can to some extent adapt to bias of the rainfall input by model parameter calibration and state-updating. More detailed structures in these models provide improved runoff forecasts compared to the structures considering mean areal rainfall only.

A time-dynamic adjustment of the radar data to rain gauge data provides improved rainfall forecasts when compared with rainfall observations on the ground. However, dynamic adjustment reduces the potential for creating runoff forecasts and in fact also leads to reduced cross correlation between radar rainfall and runoff measurements. We conclude that evaluating the performance of radar rainfall adjustment against rain gauges may not always be adequate and that adjustment procedure and online runoff forecasting should ideally be considered as one unit.

**General information**
- **State:** Published
- **Organisations:** Department of Applied Mathematics and Computer Science, Dynamical Systems, Department of Environmental Engineering, Urban Water Engineering, Aalborg University
- **Authors:** Löwe, R. (Intern), Thordahl, S. (Ekstern), Mikkelsen, P. S. (Intern), Rasmussen, M. R. (Ekstern), Madsen, H. (Intern)
- **Pages:** 397–407
- **Publication date:** 2014
- **Main Research Area:** Technical/natural sciences

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- **Journal:** Journal of Hydrology
- **Volume:** 512
- **ISSN (Print):** 0022-1694
- **Ratings:**
  - BFI (2018): BFI-level 2
  - BFI (2017): BFI-level 2
  - Web of Science (2017): Indexed yes
  - BFI (2016): BFI-level 2
  - Scopus rating (2016): CiteScore 3.89 SJR 1.745 SNIP 1.759
  - Web of Science (2016): Indexed yes
  - BFI (2015): BFI-level 2
  - Scopus rating (2015): SJR 1.708 SNIP 1.771 CiteScore 3.54
  - Web of Science (2015): Indexed yes
  - BFI (2014): BFI-level 2
  - Scopus rating (2014): SJR 1.679 SNIP 2.005 CiteScore 3.45
  - Web of Science (2014): Indexed yes
  - BFI (2013): BFI-level 2
  - Scopus rating (2013): SJR 1.71 SNIP 1.997 CiteScore 3.36
  - ISI indexed (2013): ISI indexed yes
  - Web of Science (2013): Indexed yes
  - BFI (2012): BFI-level 2
  - Scopus rating (2012): SJR 1.924 SNIP 2.016 CiteScore 3.38
  - ISI indexed (2012): ISI indexed yes
  - Web of Science (2012): Indexed yes
  - BFI (2011): BFI-level 2
  - Scopus rating (2011): SJR 1.753 SNIP 1.858 CiteScore 3.16
  - ISI indexed (2011): ISI indexed yes
  - Web of Science (2011): Indexed yes
  - BFI (2010): BFI-level 2
  - Scopus rating (2010): SJR 1.784 SNIP 1.714
    - Web of Science (2010): Indexed yes
  - BFI (2009): BFI-level 2
  - Scopus rating (2009): SJR 2.018 SNIP 1.835
    - Web of Science (2009): Indexed yes
  - BFI (2008): BFI-level 2
Regulating Power from Supermarket Refrigeration

This paper presents an analysis of the demand response capabilities of a supermarket refrigeration system, with a particular focus on the suitability for participation in the regulating power market. An ARMAX model of a supermarket refrigeration system is identified using experimental data from the Danfoss refrigeration test centre. The complexities of modelling demand response are demonstrated through simulation. Simulations are conducted by placing the identified model in a direct-control demand response architecture, with power reference tracking using model predictive control. The energy-limited nature of demand response from refrigeration is identified as the key consideration when considering participation in the regulating power market. It is demonstrated that by restricting the operating regions of the supermarket refrigeration system, a simple relationship can be found between the available up- or down-regulation power, and the duration for which the service can be sustained. The available demand response resource within these operational restrictions is reduced from the optimised physical capabilities. The benefit of these restrictions is that the available demand response can be represented in a manner that is sufficiently simple to communicate to a market operator in the form of a bid for the provision of regulating power.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Department of Electrical Engineering, Center for Electric Power and Energy, Electricity markets and energy analytics, University College Dublin, Danfoss A/S
Authors: O’Connell, N. (Intern), Madsen, H. (Intern), Pinson, P. (Intern), O’Malley, M. (Ekstern), Green, T. (Ekstern)
Number of pages: 6
Publication date: 2014
Risk-Based Model Predictive Control of Urban Drainage Networks: When Uncertainty matters

General information
State: Published
Organisations: Department of Environmental Engineering, Urban Water Engineering, Department of Applied Mathematics and Computer Science, Dynamical Systems, Krüger A/S
Authors: Vezzaro, L. (Intern), Löwe, R. (Intern), Madsen, H. (Intern), Grum, M. (Ekstern), Mikkelsen, P. S. (Intern)
Number of pages: 9
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Main Research Area: Technical/natural sciences
Combined sewer overflow, Integratrd real-time control, Risk-based control, Weather radar forecasts
Source: PublicationPreSubmission
Source-ID: 100371480
Publication: Research - peer-review › Article in proceedings – Annual report year: 2014

Robust Management of Combined Heat and Power Systems via Linear Decision Rules
The heat and power outputs of Combined Heat and Power (CHP) units are jointly constrained. Hence, the optimal management of systems including CHP units is a multicommodity optimization problem. Problems of this type are stochastic, owing to the uncertainty inherent both in the demand for heat and in the electricity prices that owners of CHP units receive for the power they sell in the market. In this work, we model the management problem for a coupled heat-and-power system comprising CHP plants, units solely producing heat as well as heat storages. We propose a robust optimization model including unit commitment, day-ahead power and heat dispatch as well as real-time re-dispatch (recourse) variables. This model yields a solution that is feasible under any realization of the heat demand within a given uncertainty set. Optimal recourse functions for the real-time operation of the units are approximated via linear decision rules to guarantee both tractability and a correct representation of the dynamic aspects of the problem. Numerical results from an illustrative example confirm the value of the proposed approach.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Centre for IT-Intelligent Energy Systems in Cities
Authors: Zugno, M. (Intern), Morales González, J. M. (Intern), Madsen, H. (Intern)
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Conference: 2014 IEEE International Energy Conference (ENERGYCON), Dubrovnik, Croatia, 13/05/2014 - 13/05/2014
Source: PublicationPreSubmission
Source-ID: 100812423
Publication: Research - peer-review › Article in proceedings – Annual report year: 2014

Setting up and validating a complex model for a simple homogeneous wall
The present paper describes modelling of the thermal dynamics of a real wall tested in dynamic outdoor weather conditions, to identify all the parameters needed for its characterisation. Specifically, the U value, absorptance and effective heat capacity are estimated for the wall using grey-box modelling based on statistical methods and known physical dynamic energy balance equations, related to the heat flux density through a simple and homogeneous wall. The experimental test was carried out in a hot-temperature climate for nine months. This study aims at proposing a dynamic method improving the regression averages method for estimation of parameters which describe the thermal behaviour of the wall. Solar irradiance and long-wave radiation balance terms are added in the heat balance equation besides modelling of wind speed effect to achieve a complete description of the relevant phenomena which affect the thermal dynamics of the wall. The method is applied using different frequency data samples looking for the best to study this wall. The U value obtained characterising the wall is consistent with the one given by the regression averages method.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Centro de Investigaciones Energéticas, MedioAmbientales y Tecnolóögicas, University of Granada
Stochastic rainfall-runoff forecasting: parameter estimation, multi-step prediction, and evaluation of overflow risk

Probabilistic runoff forecasts generated by stochastic greybox models can be notably useful for the improvement of the decision-making process in real-time control setups for urban drainage systems because the prediction risk relationships in these systems are often highly nonlinear. To date, research has primarily focused on one-step-ahead flow predictions for identifying, estimating, and evaluating greybox models. For control purposes, however, stochastic predictions are required for longer forecast horizons and for the prediction of runoff volumes, rather than flows. This article therefore analyzes the quality of multistep ahead forecasts of runoff volume and considers new estimation methods based on scoring rules for k-step-ahead predictions. The study shows that the score-based methods are, in principle, suitable for the estimation of model parameters and can therefore help the identification of models for cases with noisy in-sewer observations. For the prediction of the overflow risk, no improvement was demonstrated through the application of stochastic forecasts instead of point predictions, although this result is thought to be caused by the notably simplified setup used in this analysis. In conclusion, further research must focus on the development of model structures that allow the proper separation of dry and wet weather uncertainties and simulate runoff uncertainties depending on the rainfall input.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Department of Environmental Engineering
Authors: Löwe, R. (Intern), Mikkelsen, P. S. (Intern), Madsen, H. (Intern)
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Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 1.149 SNIP 1.381 CiteScore 2.54
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.999 SNIP 1.015 CiteScore 1.74
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.008 SNIP 1.429 CiteScore 2.3
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.145 SNIP 1.607 CiteScore 2.49
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.343 SNIP 1.452 CiteScore 2.08
ISI indexed (2012): ISI indexed yes
Waste Water Treatment Plants and the Smart Grid

Denmark's political ambitions of a fossil fuel free energy system by 2050 calls for more renewable energy sources such as wind and solar. These green energy resources fluctuate and the transition to a green energy system requires a Smart Grid with flexible consumers that balance the fluctuating power production. The energy-heavy processes for waste water transport and treatment could potentially provide a flexible operation with storage capabilities and be a valuable asset to a Smart Grid. In order to enable Waste Water Treatment Plants (WWTPs) as flexible prosumers in the future Smart Grid, we must update their process control system to model based predictive control that monitors the changed flexible operation and plans ahead. The primary aim of a WWTP is to treat the incoming waste water as much as possible to ensure a sufficient effluent water quality and protect the environment of the recipient. The secondary aim is to treat the waste water using as little energy as possible. In the future waste water will be considered an energy resource, that contains valuable nutrients convertible to green biogas and in turn electricity and heat. In a Smart Grid consuming or producing energy at the right time is key to both lower plant electricity costs and actively help to balance the energy system. Predictions of the WWTP and sewer system operation could help a model based controller to adapt power consumption and production according to the energy system flexibility needs; incentivized through energy markets and prices. We are in the process of upgrading the current control system to prepare a flexible operation and Smart Grid market integration. The prototype system will be tested online at a plant in Denmark, that in the current market could save up to 300.000 DKK/year in electricity costs. The solution is based on existing available online plant sensors and is expected to be part of Krüger’s advanced process control software STAR control® already used at plants worldwide.
Weather radars – the new eyes for offshore wind farms?

Offshore wind fluctuations are such that dedicated prediction and control systems are needed for optimizing the management of wind farms in real-time. In this paper, we present a pioneer experiment – Radar@Sea – in which weather radars are used for monitoring the weather at the Horns Rev offshore wind farm, in the North Sea. First, they enable the collection of meteorological observations at high spatio-temporal resolutions for enhancing the understanding of meteorological phenomena that drive wind fluctuations. And second, with the extended visibility they offer, they can provide relevant inputs to prediction systems for anticipating changes in the wind fluctuation dynamics, generating improved wind power forecasts and developing specific control strategies. However, integrating weather radar observations into automated decision support systems is not a plug-and-play task, and it is important to develop a multi-disciplinary approach linking meteorology and statistics. Here, (i) we describe the settings of the Radar@Sea experiment, (ii) we report the experience gained with these new remote sensing tools, (iii) we illustrate their capabilities with some concrete meteorological events observed at Horns Rev and (iv) we discuss the future perspectives for weather radars in wind energy. Copyright © 2013 John Wiley & Sons, Ltd.
A bilevel model for electricity retailers’ participation in a demand response market environment

Demand response programmes are seen as one of the contributing solutions to the challenges posed to power systems by the large-scale integration of renewable power sources, mostly due to their intermittent and stochastic nature. Among demand response programmes, real-time pricing schemes for small consumers are believed to have significant potential for peak-shaving and load-shifting, thus relieving the power system while reducing costs and risk for energy retailers. This
paper proposes a game theoretical model accounting for the Stackelberg relationship between retailers (leaders) and consumers (followers) in a dynamic price environment. Both players in the game solve an economic optimisation problem subject to stochasticity in prices, weather-related variables and must-serve load. The model allows the determination of the dynamic price-signal delivering maximum retailer profit, and the optimal load pattern for consumers under this pricing. The bilevel programme is reformulated as a single-level MILP, which can be solved using commercial off-the-shelf optimisation software. In an illustrative example, we simulate and compare the dynamic pricing scheme with fixed and time-of-use pricing. We find that the dynamic pricing scheme is the most effective in achieving load-shifting, thus reducing retailer costs for energy procurement and regulation in the wholesale market. Additionally, the redistribution of the saved costs between retailers and consumers is investigated, showing that real-time pricing is less convenient than fixed and time-of-use price for consumers. This implies that careful design of the retail market is needed. Finally, we carry out a sensitivity analysis to analyse the effect of different levels of consumer flexibility.

**General information**

State: Published  
Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems  
Authors: Zugno, M. (Intern), Morales González, J. M. (Intern), Pinson, P. (Intern), Madsen, H. (Intern)  
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BFI (2018): BFI-level 2  
BFI (2017): BFI-level 2  
Web of Science (2017): Indexed yes  
BFI (2016): BFI-level 2  
Scopus rating (2016): CiteScore 3.89 SJR 2.387 SNIP 1.951  
BFI (2015): BFI-level 2  
Scopus rating (2015): SJR 2.865 SNIP 1.941 CiteScore 3.74  
BFI (2014): BFI-level 2  
Scopus rating (2014): SJR 2.875 SNIP 2.169 CiteScore 3.63  
BFI (2013): BFI-level 1  
Scopus rating (2013): SJR 1.974 SNIP 2.102 CiteScore 3.45  
ISI indexed (2013): ISI indexed yes  
Web of Science (2013): Indexed yes  
BFI (2012): BFI-level 1  
Scopus rating (2012): SJR 2.142 SNIP 2.023 CiteScore 3.17  
ISI indexed (2012): ISI indexed yes  
BFI (2011): BFI-level 1  
Scopus rating (2011): SJR 2.43 SNIP 2.115 CiteScore 3.29  
ISI indexed (2011): ISI indexed yes  
BFI (2010): BFI-level 1  
Scopus rating (2010): SJR 2.053 SNIP 1.989  
Web of Science (2010): Indexed yes  
BFI (2009): BFI-level 1  
Scopus rating (2009): SJR 2.425 SNIP 1.742  
BFI (2008): BFI-level 2  
Scopus rating (2008): SJR 1.579 SNIP 2.324  
Scopus rating (2007): SJR 2.118 SNIP 2.237  
Scopus rating (2006): SJR 1.102 SNIP 1.647  
Scopus rating (2005): SJR 0.629 SNIP 1.104  
Scopus rating (2004): SJR 0.822 SNIP 1.244  
Scopus rating (2003): SJR 0.764 SNIP 0.916  
Web of Science (2003): Indexed yes  
Scopus rating (2002): SJR 0.564 SNIP 1.088
A Coordination Scheme for Distributed Model Predictive Control: Integration of Flexible DERs

This paper presents a control scheme based on distributed model predictive control (DMPC) for coordinating flexible distributed energy resources (DER) of heterogeneous type in the Smart Grid with minimum system integration effort. This approach can be used for reducing the peak power exchange between the grid and a cluster of units in the same feeder in price-driven demand response applications. Preliminary simulations prove that the proposed coordination scheme for DMPC succeeds in coordinating flexible DER unit, achieving significant peak shaving when required. The rationale of this approach consists in coordinating independent units equipped with local MPC controller via simple information passing and hiding in the local controllers the units’ dynamics.

General information
State: Published
Organisations: Department of Electrical Engineering, Center for Electric Power and Energy, Department of Applied Mathematics and Computer Science, Dynamical Systems
Number of pages: 5
Publication date: 2013

Electronic versions:
ISGT0668.pdf
DOIs:
10.1109/ISGTEurope.2013.6695474
Source: dtu
Source-ID: u::9152
Publication: Research - peer-review › Article in proceedings – Annual report year: 2013

An arctic low-energy house as experimental setup for studies of heat dynamics of buildings

This paper addresses the difficulties in pinpointing reasons for unexpectedly high energy consumption in construction, and in low-energy houses especially. Statistical methods are applied to improve the insight into the energy performance and heat dynamics of a building based on consumption records and weather data. Dynamical methods separate influences from outdoor temperature, solar radiation, and wind on the energy consumption in the building. The studied building is a low-energy house in Sisimiut, Greenland. Weather conditions like large temperature differences between indoors and outdoors throughout long winters, strong winds, and very different circumstances regarding solar radiation compared to areas where low-energy houses are usually built, make the location very interesting for modeling and testing purposes. In 2011 new measurement equipment was installed in the house, which will be used to develop more detailed models of the heat dynamics and energy performance in relation to different meteorological variables, heating systems, and user behavior. This type of models is known as a graybox model and is been introduced in this paper.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Department of Civil Engineering, Section for Building Physics and Services
Authors: Andersen, P. H. D. (Intern), Rode, C. (Intern), Madsen, H. (Intern)
Pages: 488-499
Publication date: 2013
Main Research Area: Technical/natural sciences
A non-parametric method for correction of global radiation observations

This paper presents a method for correction and alignment of global radiation observations based on information obtained from calculated global radiation, in the present study one-hour forecast of global radiation from a numerical weather prediction (NWP) model is used. Systematical errors detected in the observations are corrected. These are errors such as: tilt in the leveling of the sensor, shadowing from surrounding objects, clipping and saturation in the signal processing, and errors from dirt and wear. The method is based on a statistical non-parametric clear-sky model which is applied to both the observed and the calculated radiation in order to find systematic deviations between them. The method is applied to correct global radiation observations from a climate station located at a district heating plant in Denmark. The results are compared to observations recorded at the Danish Technical University. The method can be useful for optimized use of solar radiation observations for forecasting, monitoring, and modeling of energy production and load which are affected by solar radiation.
Household-based demand response is expected to play an increasing role in supporting the large scale integration of renewable energy generation in existing power systems and electricity markets. While the direct control of the consumption level of households is envisaged as a possibility, a credible alternative is that of indirect control based on price signals to be sent to these end-consumers. A methodology is described here allowing to estimate in advance the potential response of flexible end-consumers to price variations, subsequently embedded in an optimal price-signal generator. In contrast to some real-time pricing proposals in the literature, here prices are estimated and broadcast once a day for the following one, for households to optimally schedule their consumption. The price-response is modeled using stochastic finite impulse response (FIR) models. Parameters are estimated within a recursive least squares (RLS) framework using data measurable at the grid level, in an adaptive fashion. Optimal price signals are generated by embedding the FIR models within a chance-constrained optimization framework. The objective is to keep the price signal as unchanged as possible from the reference market price, whilst keeping consumption below a pre-defined acceptable level.
Clinical Data for Advanced Glucose Modeling

**General information**
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Copenhagen University Hospital
Authors: Duun-Henriksen, A. K. (Intern), Schmidt, S. (Ekstern), Nøgaard, K. (Ekstern), Madsen, H. (Intern)
Number of pages: 33
Publication date: 2013

**Publication information**
Place of publication: Kgs. Lyngby
Publisher: Technical University of Denmark (DTU)
Controlling Electricity Consumption by Forecasting Its Response to Varying Prices

In a real-time electricity pricing context where consumers are sensitive to varying prices, having the ability to anticipate their response to a price change is valuable. This paper proposes models for the dynamics of such price-response, and shows how these dynamics can be used to control electricity consumption using a one-way price signal. Estimation of the price-response is based on data measurable at grid level, removing the need to install sensors and communication devices between each individual consumer and the price-generating entity. An application for price-responsive heating systems is studied based on real data, before conducting a control by price experiment using a mixture of real and synthetic data. With the control objective of following a constant consumption reference, peak heating consumption is reduced by nearly 5%, and 11% of the mean daily heating consumption is shifted.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems
Authors: Corradi, O. (Intern), Ochsenfeld, H. P. (Intern), Madsen, H. (Intern), Pinson, P. (Intern)
Number of pages: 9
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BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 8.17 SJR 3.757 SNIP 3.624
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 3.602 SNIP 3.486 CiteScore 6.6
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.831 SNIP 3.577 CiteScore 5.31
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.939 SNIP 4.35 CiteScore 6.33
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.177 SNIP 3.516 CiteScore 5.84
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.725 SNIP 3.254 CiteScore 5.34
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
Decentralized Large-Scale Power Balancing

A power balancing strategy based on Douglas-Rachford splitting is proposed as a control method for large-scale integration of flexible consumers in a Smart Grid. The total power consumption is controlled through a negotiation procedure between all units and a coordinating system level. The balancing problem is formulated as a centralized large-scale optimization problem but is then decomposed into smaller subproblems that are solved locally by each unit connected to an aggregator. For large-scale systems the method is faster than solving the full problem and can be distributed to include an arbitrary number of units.

General information

State: Published
Organisations: Department of Applied Mathematics and Computer Science, Scientific Computing, Dynamical Systems
Authors: Halvgaard, R. (Intern), Jørgensen, J. B. (Intern), Poulsen, N. K. (Intern), Madsen, H. (Intern), Vandenberghe, L. (Intern)
Number of pages: 5
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Main Research Area: Technical/natural sciences
Conference: 2013 4th IEEE PES Innovative Smart Grid Technologies Europe, Lyngby, Denmark, 06/10/2013 - 06/10/2013
DOIs: 10.1109/ISGTEurope.2013.6695323
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Energy Comes Together in Denmark: The Key to a Future Fossil-Free Danish Power System

The transition of the Danish energy system to a system based only on renewable energy in 2050 carries many challenges. For Denmark to become independent of fossil energy sources, wind power and biomass are expected to become the main sources of energy. Onshore and offshore wind farms are expected to provide the majority of electricity, and biomass and
electricity are expected to become the major sources of heating. On the way toward the 100% renewable goal in 2050, the Danish government has proposed a 2035 midterm goal to cover the energy consumption for power and heat with renewables.
Exercise effects in a virtual type 1 diabetes patient: Using stochastic differential equations for model extension

The use of virtual patients for in silico testing of control algorithms for an artificial pancreas is growing. It is an easy, fast and low-cost alternative to pre-clinical testing. To simulate the everyday life of a type 1 diabetes (T1D) patient a simulator must be able to take into account physical activity. Exercise constitutes a substantial challenge to closed-loop control of T1D. The effects are many and depend on intensity and duration and may be delayed by several hours. In this study, we use a model for the glucoregulatory system based on the minimal model and a previously published extension incorporating exercise effects on insulin and glucose dynamics. Our model is constructed as a stochastic state space model consisting of a set of stochastic differential equations (SDEs). In a stochastic state space model, the residual error is split into random measurement error and misspecification noise. The latter of the two can be used to pinpoint model deficiencies or unknown influential factors during the development of the model. The model is thus built on the basis of physiological knowledge of the system combined with information from observed data. Model parameters are estimated on clinical data from a study including exercise bouts of 20 minutes performed on 12 T1D patients treated with continuous subcutaneous insulin infusion. The predictive abilities of the model are investigated. In conclusion, this study illustrates the advantages of using SDEs in the development of an extended glucoregulatory model including effects of exercise suited for in silico testing.

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Following a drop of water from the cloud, throughout the sewer system, into the receiving water - Model predictive control of integrated sewer-wastewater treatment systems

This article presents selected examples of model-based prediction and control of integrated sewer-wastewater treatment systems, developed within the framework of the Storm- and Wastewater Informatics project (SWI). By exploiting all the available on-line information (e.g. radar based rainfall measurements, flow and water levels, operational parameters at treatment plants) it is possible to dynamically optimize the integrated storm- and wastewater systems according to different criteria (e.g. utilizing the system fully at all times and reducing volumes of combined sewer overflows, loads of pollutants discharged from treatment plants, etc.). The tools developed in the SWI project include (but are not limited to (i) rainfall nowcasting based on radar measurements, (ii) probabilistic flow forecasting based on data assimilation and stochastic models, (iii) prediction and optimization of wet-weather performance of wastewater treatment plants, and (iv) integrated control of the different elements of the integrated wastewater systems. Full-scale testing of these tools in different catchment located in Denmark ensure that the developed tools can represent an important step forwards for on-line operation of combined sewer networks and wastewater treatment plants.
Forecasting the conditional dynamic elasticity of electricity consumers

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Grey-box Modeling for System Identification of Household Refrigerators: a Step Toward Smart Appliances

This paper presents the grey-box modeling of a vapor-compression refrigeration system for residential applications based on maximum likelihood estimation of parameters in stochastic differential equations. Models obtained are useful in the view of controlling refrigerators as flexible consumption units, which operation can be shifted within temperature and operational constraints. Even if the refrigerators are not intended to be used as smart loads, validated models are useful in predicting units consumption. This information can increase the optimality of the management of other flexible units, such as heat pumps for space heating, in order to smooth the load factor during peak hours, enhance reliability and efficiency in power networks and reduce operational costs.

Impact of Wind Power Generation on European Cross-Border Power Flows

A statistical analysis is performed in order to investigate the relationship between wind power production and cross-border power transmission in Europe. A dataset including physical hourly cross-border power exchanges between European countries as dependent variables is used. Principal component analysis is employed in order to reduce the problem dimension. Then, nonlinear relationships between forecast wind power production as well as spot price in Germany, by far the largest wind power producer in Europe, and power flows are modeled using local polynomial regression. We find that both forecast wind power production and spot price in Germany have substantial nonlinear effects on power transmission on a European scale.
Informal uncertainty analysis (GLUE) of continuous flow simulation in a hybrid sewer system with infiltration inflow - Consistency of containment ratios in calibration and validation?

Monitoring of flows in sewer systems is increasingly applied to calibrate urban drainage models used for long-term simulation. However, most often models are calibrated without considering the uncertainties. The generalized likelihood uncertainty estimation (GLUE) methodology is here applied to assess parameter and flow simulation uncertainty using a simplified lumped sewer model that accounts for three separate flow contributions: wastewater, fast runoff from paved areas, and slow infiltrating water from permeable areas. Recently GLUE methodology has been criticized for generating prediction limits without statistical coherence and consistency and for the subjectivity in the choice of a threshold value to distinguish "behavioural" from "non-behavioural" parameter sets. In this paper we examine how well the GLUE methodology performs when the behavioural parameter sets deduced from a calibration period are applied to generate prediction bounds in validation periods. By retaining an increasing number of parameter sets we aim at obtaining consistency between the GLUE generated 90% prediction limits and the actual containment ratio (CR) in calibration. Due to the large uncertainties related to spatio-temporal rain variability during heavy convective rain events, flow measurement errors, possible model deficiencies as well as epistemic uncertainties, it was not possible to obtain an overall CR of more than 80%. However, the GLUE generated prediction limits still proved rather consistent, since the overall CRs obtained in calibration corresponded well with the overall CRs obtained in validation periods for all proportions of retained parameter sets evaluated. When focusing on wet and dry weather periods separately, some inconsistencies were however found between calibration and validation and we address here some of the reasons why we should not expect the coverage of the prediction limits to be identical in calibration and validation periods in real-world applications. The large uncertainties result in wide posterior parameter limits, that cannot be used for interpretation of, for example, the relative size of paved area vs. the size of infiltrating area. We should therefore try to learn from the significant discrepancies between model and observations from this study, possibly by using some form of non-stationary error correction procedure, but it seems crucial to obtain more representative rain inputs and more accurate flow observations to reduce parameter and model simulation uncertainty. © Author(s) 2013.

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Inhomogeneous Markov Models for Describing Driving Patterns

It has been predicted that electric vehicles will play a crucial role in incorporating a large renewable component in the energy sector. If electric vehicles are integrated in a naive way, they may exacerbate issues related to peak demand and transmission capacity limits while not reducing polluting emissions.

Optimizing the charging of electric vehicles is paramount for their successful integration. This paper presents a model to describe the driving patterns of electric vehicles, in order to provide primary input information to any mathematical programming model for optimal charging. Specifically, an inhomogeneous Markov model that captures the diurnal variation in the use of a vehicle is presented. The model is dened by the time-varying probabilities of starting and ending a trip and is justied due to the uncertainty associated with the use of the vehicle. The model is tied to data collected from the actual utilization of a vehicle. Inhomogeneous Markov models imply a large number of parameters. The number of parameters in the proposed model is reduced using B-splines.

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Investigating the use of stochastic forecast for RTC of urban drainage systems

Real time control is considered a mean to efficiently improve the performance of urban drainage systems. A globally optimal utilisation of e.g. storage volume in basins can best be achieved by considering runoff forecasts in the decision setup. These forecasts, however, are subject to significant uncertainty. This uncertainty should be considered in the decision making. An approach that incorporates stochastic multistep runoff predictions from so-called greybox models into a real time control setup is presented. These models provide a dynamic description of forecast uncertainties and they simultaneously allow a continuous adaption of the model states to observed runoff. Methods for generating stochastic forecasts and incorporating these into the decision making framework are described. Using two sample events, the forecast quality is compared to state-of-the-art deterministic forecasting models and the effect on control decisions and the resulting overflow volume is evaluated. We can demonstrate potential of the stochastic models but identify a need for model adaptivity and modified model structures that allow for a more general modelling of forecast uncertainties.
Activities:

Investigating the use of stochastic forecast for RTC of urban drainage systems
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Load forecasting for supermarket refrigeration
This report presents a study of models for forecasting the load for supermarket refrigeration. The data used for building the forecasting models consists of load measurements, local climate measurements and weather forecasts. The load measurements are from a supermarket located in a village in Denmark. The load for refrigeration is the sum of all cabinets in the supermarket, both low and medium temperature cabinets, and spans a period of one year. As input to the forecasting models the ambient temperature observed near the supermarket together with weather forecasts are used. Every hour the hourly load for refrigeration for the following 42 hours is forecasted. The forecast models are adaptive linear time-series models which are fitted with a computationally efficient recursive least squares scheme. The dynamic relations between the inputs and the load is modeled by simple transfer functions. The system operates in two regimes: one in the closing hours during night and one in the opening hours during the day. This is modeled by a regime switching model in which some of the coefficients in the model depends on the regime. The results show that the one-step ahead residuals are close to white noise, however some dependence on the ambient temperature remains, which is caused by non-linearities in the relation between the load and the ambient temperature. Suggestions for including these non-linearities are given in the discussion of the results.

The report starts with a section in which the data and the NWPs are described. This is followed by a presentation of the modeling approach and the model identification, where a suitable forecasting model is found. Finally, the results are presented, and the method is discussed and conclusions are drawn.

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Low-energy house in Sisimiut - Data overview
Experiments with persistently exciting heat inputs are a fundamental tool in identification of heat dynamics in buildings. The Low-energy house in Sisimiut, Greenland, provides an advanced experimental setup with frequent measurements of temperatures, heat inputs, and much more. This paper presents an overview of data collected since the installation of the new measurement and control system. Focus is on heat dynamics so only data related to that will be shown. 5 experiments have been conducted. They are described, and resulting data is shown.

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Low-energy house in Sisimiut - Measurement equipment
This paper documents the measurement equipment in a low-energy house in Sisimiut, Greenland. Detailed measurements are being taken on energy consumption, indoor temperatures, floor heating, ventilation, open/closed state of doors and windows, and indoors climate. Equipped with a central control unit, experiments can be designed in order to study heat dynamics of the building. It is described how to plan and execute such experiments in one apartment in the building. The building also features both a solar thermal system and extra buffer tank facilitating testing of storage strategies on the power generated by the solar thermal system. A weather station equipped with thermometer, pyranometer and anemometer is installed on the building as well. Finally, it is described how to retrieve data from an SQL server which is configured to take monthly backups. R functions have been implemented to fetch and prepare the data for time series analysis. Examples are given on the use of these.

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Model-Based Closed-Loop Glucose Control in Type 1 Diabetes: The DiaCon Experience
Background:
To improve type 1 diabetes mellitus (T1DM) management, we developed a model predictive control (MPC) algorithm for closed-loop (CL) glucose control based on a linear second-order deterministic-stochastic model. The deterministic part of the model is specified by three patient-specific parameters: insulin sensitivity factor, insulin action time, and basal insulin infusion rate. The stochastic part is identical for all patients but identified from data from a single patient. Results of the first clinical feasibility test of the algorithm are presented.

Methods:
We conducted two randomized crossover studies. Study 1 compared CL with open-loop (OL) control. Study 2 compared glucose control after CL initiation in the euglycemic (CL-Eu) and hyperglycemic (CL-Hyper) ranges, respectively. Patients were studied from 22:00–07:00 on two separate nights.

Results:
Each study included six T1DM patients (hemoglobin A1c 7.2% ± 0.4%). In study 1, hypoglycemic events (plasma glucose < 54 mg/dl) occurred on two OL and one CL nights. Average glucose from 22:00–07:00 was 90 mg/dl [74–146 mg/dl; median (interquartile range)] during OL and 108 mg/dl (101–128 mg/dl) during CL (determined by continuous glucose monitoring). However, median time spent in the range 70–144 mg/dl was 67.9% (3.0–73.3%) during OL and 80.8% (70.5–89.7%) during CL. In study 2, there was one episode of hypoglycemia with plasma glucose <54 mg/dl in a CL-Eu night. Mean glucose from 22:00–07:00 and time spent in the range 70–144 mg/dl were 121 mg/dl (117–133 mg/dl) and 69.0% (30.7–77.9%) in CL-Eu and 149 mg/dl (140–193 mg/dl) and 48.2% (34.9–72.5%) in CL-Hyper, respectively.

Conclusions:
This study suggests that our novel MPC algorithm can safely and effectively control glucose overnight, also when CL control is initiated during hyperglycemia.
Model Identification Using Stochastic Differential Equation Grey-Box Models in Diabetes

BACKGROUND:
The acceptance of virtual preclinical testing of control algorithms is growing and thus also the need for robust and reliable models. Models based on ordinary differential equations (ODEs) can rarely be validated with standard statistical tools. Stochastic differential equations (SDEs) offer the possibility of building models that can be validated statistically and that are capable of predicting not only a realistic trajectory, but also the uncertainty of the prediction. In an SDE, the prediction error is split into two noise terms. This separation ensures that the errors are uncorrelated and provides the possibility to pinpoint model deficiencies.

METHODS:
An identifiable model of the glucoregulatory system in a type 1 diabetes mellitus (T1DM) patient is used as the basis for development of a stochastic-differential-equation-based grey-box model (SDE-GB). The parameters are estimated on
clinical data from four T1DM patients. The optimal SDE-GB is determined from likelihood-ratio tests. Finally, parameter tracking is used to track the variation in the "time to peak of meal response" parameter.

RESULTS:
We found that the transformation of the ODE model into an SDE-GB resulted in a significant improvement in the prediction and uncorrelated errors. Tracking of the "peak time of meal absorption" parameter showed that the absorption rate varied according to meal type.

CONCLUSION:
This study shows the potential of using SDE-GBs in diabetes modeling. Improved model predictions were obtained due to the separation of the prediction error. SDE-GBs offer a solid framework for using statistical tools for model validation and model development.
Modeling and forecasting of wind power generation - Regime-switching approaches

The present thesis addresses a number of challenges emerging from the increasing penetration of renewable energy sources into power systems. Focus is placed on wind energy and large-scale offshore wind farms. Indeed, offshore wind power variability is becoming a serious obstacle to the integration of more renewable energy into power systems since these systems are subjected to maintain a strict balance between electricity consumption and production, at any time. For this purpose, wind power forecasts offer an essential support to power system operators. In particular, there is a growing demand for improved forecasts over very short lead times, from a few minutes up to a few hours, because these forecasts, when generated with traditional approaches, are characterized by large uncertainty. In this thesis, this issue is considered from a statistical perspective, with time series models. The primary case study is the Horns Rev wind farm located in the North Sea. Regime-switching aspects of offshore wind power fluctuations are investigated. Several formulations of Markov-Switching models are proposed in order to better characterize the stochastic behavior of the underlying process and improve its predictability. These models assume the existence of a hidden or unobservable regime sequence. Estimation methods are presented in both Bayesian and Frequentist frameworks. Markov-Switching models enable to highlight structural breaks in the dynamics of offshore wind power generation, with alternating periods of high and low variability. They also yield substantial gains in probabilistic forecast accuracy for lead times of a few minutes. However, these models only integrate historical and local measurements of wind power and thus have a limited ability for notifying regime changes for larger lead times. For that purpose, there is a long tradition in using meteorological forecasts of wind speed and direction that are converted into wind power forecasts. Nevertheless, meteorological forecasts are not informative on the intra-hour wind variability and thus cannot be used in the present context focusing on temporal resolutions of a few minutes. Instead, this thesis investigates the use of weather radar observations for monitoring weather conditions in the vicinity of offshore wind farms, with the ambition of establishing a link between the passage of precipitation systems and high wind variability. The underlying motivation of this approach is twofold. First, it aims at providing a meteorological interpretation of the hidden regimes as estimated by regime-switching models. Second, it aims at determining an observed sequence of regimes based on the information extracted from the observations supplied weather radar observations. This approach, combining both meteorological and statistical expertise, opens up new possibilities for designing prediction systems in wind energy.

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Modelling the Effect of Exercise on Insulin Pharmacokinetics in "Continuous Subcutaneous Insulin Infusion" Treated Type 1 Diabetes Patients

Introduction: The artificial pancreas is believed to ease the burden of constant management of type 1 diabetes for the patients substantially. An important aspect of the artificial pancreas development is the mathematical models used for control, prediction or simulation. A major challenge to the realization of the artificial pancreas is the effect of exercise on the insulin and plasma glucose dynamics. In this report, we take the first step towards a population model of exercise effects in type 1 diabetes. We focus on the effect on the insulin pharmacokinetics in continuous subcutaneous insulin infusion (CSII) treated patients by modelling the absorption rate as a function of exercise.

Methods: Three models are estimated from 17 data sequences. All of them are based on a linear three-compartment base model. The models are based on stochastic differential equations to allow noise to enter the dynamics. In the first model, the insulin absorption rate parameter is replaced by a random walk. In the second model, the relationship between the absorption rate and exercise is modelled as a linear dependency, while in the third model this linear relationship depends on the intensity. A Lamperti transformation is used to ensure non-negative state values. A special focus is put on the structural identifiability of the base model, while the posterior identifiability is checked for all models from the conditional likelihood profiles.

Results: The first model is disregarded due to the small number of observations during the exercise bout. From likelihood-
ratio tests and information criteria, the third model is appointed as the best model to model the relationship between exercise and the insulin absorption. The posterior identifiability check showed that it was not possible to identify the variance of the measurement variance.

Conclusion: A model to predict the insulin appearance in plasma during exercise in CSII treated patients is identified. Further clinical studies are needed to confirm the increase in insulin plasma concentration during exercise in type 1 diabetes patients. These studies should include dense sampling to allow for a fully data driven identification of an appropriate model.

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Models for the energy performance of low-energy houses
The aim of this thesis is data-driven modeling of heat dynamics of buildings. Traditionally, thermal modeling of buildings is done using simulation tools which take information about the construction, weather data, occupancy etc. as inputs and generate deterministic energy profiles of the buildings. This approach often fails in predicting the actual heat consumption of buildings once they are constructed. The approach taken in this work is deriving models from observations collected after the construction, aiming at describing the actual characteristics of the building.

Identification of heat dynamics of buildings is needed both in order to assess energy-efficiency and to operate modern buildings economically. Energy signatures are a central tool in both energy performance assessment and decision making related to refurbishment of buildings. Also for operation of modern buildings with installations such as mechanical ventilation, floor heating, and control of the lighting effect, the heat dynamics must be taken into account. Hence, this thesis provides methods for data-driven modeling of heat dynamics of modern buildings.

While most of the work in this thesis is related to characterization of heat dynamics of buildings, the first topic analyzed is the variation of presence of occupants. As buildings get more energy-efficient, internal loads and user-behavior increasingly influence the energy consumption. Most simulation tools use deterministic occupancy profiles to simulate internal loads. However, such occupancy patterns will largely depend on the specific use of the building, and hence the profiles must be empirically based. A probabilistic method for modeling timedependence and dynamics of presence of occupants is developed and applied by estimation and model validation on data from an office building. The approach to modeling occupants’ presence provides a flexible method where no assumptions in the application.

The rest of the thesis deals with statistical modeling of heat dynamics of buildings. First, discrete-time models are applied. Discrete-time models are computationally relatively simple and provide a flexible framework for dynamical modeling as a natural extension of the often-used static energy-balance models. The importance of applying dynamical models, even for deriving thermostatic or steady-state properties, is stressed, and methods for doing so are outlined.

Since heat transfer is fundamentally described by partial differential equations, modeling of heat dynamics using differential equations is an obvious approach. A quasi-Gaussian maximum likelihood estimation technique, where the likelihood function is evaluated using the extended Kalman filter on state-space models, is used. In this framework - referred to as “grey-box” modeling - one-step predictions can be generated and used for model validation by testing statistically whether the model describes all variation and dynamics observed in the data. The possibility of validating the model dynamics is a great advantage from the use of stochastic differential equations compared to ordinary differential equations.
The strengths of the discrete-time and the continuous-time approach are discussed. Besides the parametrization, which is directly physically interpretable, grey-box models intrinsically provide variable prediction uncertainty, which is important in relation to design of controllers and decision making for comfort requirements. In the framework of stochastic differential equations, there are normally more parameters related to noise processes than in discrete-time models which increases the complexity of the estimation. Here, the state space formulation is often used. Since there is normally infinitely many state space representations corresponding to a transfer function model, structural identifiability is important in relation to state space modeling.

A low-energy building in Sisimiut, Greenland is used as a test-building. The building is well-insulated and features large modern energy-efficient windows and floor heating. These features lead to increased non-linear responses to solar radiation and longer time constants. The building is equipped with advanced control and measuring equipment. Experiments are designed and performed in order to identify important dynamical properties of the building, and the collected data is used for modeling.

The thesis emphasizes the statistical model building and validation needed to identify dynamical systems. It distinguishes from earlier work by focusing on modern low-energy construction and going further into studying and characterizing the dynamical properties of the fitted models.
Online short-term heat load forecasting for single family houses

This paper presents a method for forecasting the load for heating in a single-family house. Both space and hot tap water heating are forecasted. The forecasting model is built using data from sixteen houses in Sønderborg, Denmark, combined with local climate measurements and weather forecasts. Every hour the hourly heat load for each house the following two days is forecasted. The forecast models are adaptive linear time-series models and the climate inputs used are: ambient temperature, global radiation, and wind speed. A computationally efficient recursive least squares scheme is used. The models are optimized to fit the level of optimal adaptivity and the thermal dynamical response of the building. Identification of a model, which is suitable for application to all the houses, is carried out. The results show that the forecasting errors mainly are related to: unpredictable high frequency variations in the heat load signal (predominant only for some houses), peaks presumably from showers, shifts in resident behavior, and uncertainty of the weather forecasts for longer horizons, especially for the solar radiation.

On the best learning algorithm for web services response time prediction

In this article we will examine the effect of different learning algorithms, while training the MLP (Multilayer Perceptron) with the intention of predicting web services response time. Web services do not necessitate a user interface. This may seem contradictory to most people's concept of what an application is. A Web service is better imagined as an application "segment," or better as a program enabler. Performance is an important quality aspect of Web services because of their distributed nature. Predicting the response of web services during their operation is very important.
Optimization Under Uncertainty for Management of Renewables in Electricity Markets

This thesis deals with the development and application of models for decision-making under uncertainty to support the participation of renewables in electricity markets.

The output of most renewable sources, e.g., wind, is intermittent and, furthermore, it can only be predicted with a limited accuracy. As a result of their non-dispatchable and stochastic nature, the management of renewables poses new challenges as compared to conventional sources of electricity. Focusing in particular on short-term electricity markets, both the trading activities of market participants (producers, retailers and consumers) and the decision-making processes of system and market operators are challenged.

As far as producers are concerned, participation in electricity markets imposes them to make their trading decisions with a certain advance in time as compared to energy delivery. Since their actual output is uncertain at the time of bidding, the trading problem for a renewable power producer translates into a stochastic optimization problem, whose objective is the maximization of the expected revenues. In this thesis, we consider the trading problem for a wind power producer both in markets with low penetration of renewables, where the producer is a price-taker, and in markets where the producer acts as a price-maker.

Owing to the demand response initiatives to be undertaken in future power systems, the operation of electricity retailers and the behavior of consumers are also going to be influenced by renewable power production. Another focus of this thesis is on time-varying price mechanisms to make the most of end consumers' flexibility. In particular, the problem of managing optimally a virtual power plant equipped with renewable production facilities and flexible consumers is addressed through control-by-price. In a similar setup, the optimal trading (and pricing) problem for a retailer connected to flexible consumers is considered.

Finally, market and system operators are challenged by the increasing penetration of renewables, which put stress on markets that were designed to accommodate a generation mix largely dominated by conventional sources. Indeed, the traditional market design, based on the sequential clearing of successive market floors and on deterministic rules and criteria, is characterized by higher and higher degrees of suboptimality and lower reliability as the penetration of renewables increases. This work contributes to the state-of-the-art by proposing new mechanisms for day-ahead dispatch and reserve determination in markets with high penetration of renewables, on the basis of stochastic criteria.

Pool Strategy of a Price-Maker Wind Power Producer

We consider the problem of a wind power producer trading energy in short-term electricity markets. The producer is a price-taker in the day-ahead market, but a price-maker in the balancing market, and aims at optimizing its expected revenues from these market floors. The problem is formulated as a mathematical program with equilibrium constraints (MPEC) and cast as a mixed-integer linear program (MILP), which can be solved employing off-the-shelf optimization software. The optimal bid is shown to deliver significantly improved performance compared to traditional bids such as the conditional mean or median forecast of wind power distribution. Finally, sensitivity analyses are carried out to assess the impact on the offering strategy of the producer's penetration in the market, of the correlation between wind power...
production and residual system deviation, and of the shape of the forecast distribution of wind power production.

**General information**

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Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Department of Electrical Engineering, Center for Electric Power and Energy
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Scopus rating (2004): SJR 1.036 SNIP 2.843
Reliability in the utility computing era: Towards reliable Fog computing

This paper considers current paradigms in computing and outlines the most important aspects concerning their reliability. The Fog computing paradigm as a non-trivial extension of the Cloud is considered and the reliability of the networks of smart devices are discussed. Combining the reliability requirements of grid and cloud paradigms with the reliability requirements of networks of sensor and actuators it follows that designing a reliable Fog computing platform is feasible.

Short-term heat load forecasting for single family houses

This paper presents a method for forecasting the load for space heating in a single-family house. The forecasting model is built using data from sixteen houses located in Sønderborg, Denmark, combined with local climate measurements and weather forecasts. Every hour the hourly heat load for each house the following two days is forecasted. The forecast models are adaptive linear time-series models and the climate inputs used are: ambient temperature, global radiation and wind speed. A computationally efficient recursive least squares scheme is used. The models are optimized to fit the individual characteristics for each house, such as the level of adaptivity and the thermal dynamical response of the building, which is modeled with simple transfer functions. Identification of a model, which is suitable for all the houses, is carried out. The results show that the one-step ahead errors are close to white noise and that practically all correlation to the climate variables are removed. Furthermore, the results show that the forecasting errors mainly are related to: unpredictable high frequency variations in the heat load signal (predominant only for some houses), shifts in resident behavior patterns and uncertainty of the weather forecasts for longer horizons, especially for solar radiation.
Heat load, Single-family house, Building heat dynamics, Forecasting, Numerical weather predictions, Thermal, Cooling

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Short-term wind power forecasting: probabilistic and space-time aspects
Optimal integration of wind energy into power systems calls for high quality wind power predictions. State-of-the-art forecasting systems typically provide forecasts for every location individually, without taking into account information coming from the neighbouring territories. It is however intuitively expected that owing to the inertia in meteorological systems such local approach to power forecasting is sub-optimal. Indeed, errors in meteorological forecasts might translate to fronts of imbalances, i.e. taking the form of a band of forecast errors propagating across entire regions.

My research work deals with the proposal and evaluation of new mathematical models and forecasting methods for short-term wind power forecasting, accounting for space-time dynamics based on geographically distributed information. Different forms of power predictions are considered, starting from traditional point forecasts, then extending to marginal predictive densities and, finally, considering multivariate space-time trajectories.

Point predictions is the most classical approach to wind power forecasting, only providing single-valued estimates of the expected future power generation. The objective is to introduce a statistical model which would improve the quality of state-of-the-art prediction methods by accounting for the fact that forecasts errors made by such locally-optimized forecasting methods propagate in space and in time under the influence of prevailing weather conditions.

Subsequently, the extension from point to probabilistic forecasts is dealt with, hence requiring to describe the uncertainty associated with the point predictions previously generated. Both parametric and non-parametric approaches to forming predictive densities are considered, while ways to include space-time effects into the corresponding models are analysed.

As a final step, emphasis is placed on generating space-time trajectories: this calls for the prediction of joint multivariate predictive densities describing wind power generation at a number of distributed locations and for a number of successive lead times.

In addition to new improved approaches to wind power forecasting, a part of the research is devoted to problems related to the assessment of high-dimensional (multivariate) probabilistic forecasts.

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Solar/electric heating systems for the future energy system
The project “Solar/electric heating systems in the future energy system” was carried out in the period 2008-2013. The project partners were DTU Byg, DTU Informatics (now DTU Compute), DMI, ENFOR A/S and COWI A/S. The companies Ajva ApS, Ohmatex ApS and Innogie ApS worked together with the project partners in two connected projects in order to develop solar/electric heating systems for laboratory tests. The project was financed by the Danish Agency for Science, Technology and Innovation under the Danish Council for Strategic Research in the program Sustainable Energy and Environment. The DSF number of the project is 2104-07-0021/09-063201/DSF. This report is the final report of the project.
The aim of the project is to elucidate how individual heating units for single family houses are best designed in order to fit into the future energy system. The units are based on solar energy, electrical heating elements/heat pump, advanced heat storage tanks and advanced control systems.

Heat is produced by solar collectors in sunny periods and by electrical heating elements/heat pump. The electrical heating elements/heat pump will be in operation in periods where the heat demand cannot be covered by solar energy. The aim is to use the auxiliary heating units when the electricity price is low, e.g. due to large electricity production by wind turbines.

The unit is equipped with an advanced control system where the control of the auxiliary heating is based on forecasts of the electricity price, the heat demand and the solar energy production. Consequently, the control is based on weather forecasts.

Three differently designed heating units are tested in a laboratory test facility. The systems are compared on the basis of:
- energy consumption for the auxiliary heating
- energy cost for the auxiliary heating
- net utilized solar energy

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State-space adjustment of radar rainfall and skill score evaluation of stochastic volume forecasts in urban drainage systems

Merging of radar rainfall data with rain gauge measurements is a common approach to overcome problems in deriving rain intensities from radar measurements. We extend an existing approach for adjustment of C-band radar data using state-space models and use the resulting rainfall intensities as input for forecasting outflow from two catchments in the Copenhagen area. Stochastic grey-box models are applied to create the runoff forecasts, providing us with not only a point forecast but also a quantification of the forecast uncertainty. Evaluating the results, we can show that using the adjusted radar data improves runoff forecasts compared with using the original radar data and that rain gauge measurements as forecast input are also outperformed. Combining the data merging approach with short-term rainfall forecasting algorithms may result in further improved runoff forecasts that can be used in real time control.
Statistical aspects of fish stock assessment

Fish stock assessments are conducted for two main purposes: 1) To estimate past and present fish abundances and their commercial exploitation rates. 2) To predict the consequences of different management strategies in order to ensure a sustainable fishery in the future.

This thesis concerns statistical aspects of fish stocks assessment, which includes topics such as time series analysis, generalized additive models (GAMs), and non-linear state-space/mixed models capable of handling missing data and a high number of latent states and parameters. The aim is to improve the existing methods for stock assessment by application of state-of-the-art statistical methodology. The main contributions are presented in the form of six research papers.

The major part of the thesis deals with age-structured assessment models, which is the most common approach. Conversion from length to age distributions in the catches is a necessary step in age-based stock assessment models. For this purpose, GAMs and continuation ratio logits are combined to model the probability of age as a smooth function of length and spatial coordinates, which constitutes an improvement over traditional methods based on area-stratification. GAMs and delta-distributions are applied for the calculation of indices of abundance from trawl survey data, and different error structures for these are investigated.

Two extensions to the state-space approach to age-structured stock assessment modelling are presented. The first extension introduces multivariate error distributions on survey catch-at-age data. The second extension is an integrated assessment model for overlapping sub-stocks subject to joint exploitation in the area of overlap. Estimation and inference is carried out using maximum likelihood.

Finally, a biomass dynamic model based on stochastic differential equations is presented. This work extends the classical approaches to biomass modelling by incorporating observation errors on the catches, and allowing for missing and non-equidistant samples in time.
Stochastic Differential Equations in Artificial Pancreas Modelling

Type 1 diabetes accounts for approximately 5% of the total diabetes population. It is caused by the destruction of insulin producing β-cells in the pancreas. Various treatment strategies are available today, some of which include advanced technological devices such as an insulin pump and a continuous glucose monitor (CGM). Despite these technological advances in the treatment of type 1 diabetes, the disease still poses an enormous and constant challenge for the patients. To obtain tight glucose control the patients are required to assess how much they will eat prior to the meal. They have to assess the timing, intensity and duration of physical exercise in advance, to adjust the insulin dose accordingly. Additionally, several uncontrollable and unpredictable factors such as stress, hormonal cycles and sickness changing the metabolic state make this task even more difficult.

The development of the insulin pump and the CGM has paved the way for a fully automatic treatment regime, the artificial pancreas. The idea is to connect the CGM with the insulin pump via a control algorithm running on e.g. the patients smart phone. The CGM observations are sent to the smart phone and based on this information, the control algorithm computes the optimal dose adjustment and sends instructions to the insulin pump.

To develop control algorithms, mathematical models of the physiological dynamics are needed. They attempt to describe the significant dynamics of the system and hence they approximate the system behavior. However, uncertainty in the model occurs due to the nature of physiological systems and due to the presence of unknown disturbances. An attractive approach to deal with this uncertainty is to use stochastic differential equations (SDEs). In a model based on SDEs, the noise is separated into two terms: 1) a diffusion term occurring from model misspecifications, effects of unknown disturbances, or just true stochastic behavior of the system and 2) a measurement noise term representing the serially uncorrelated error occurring due to the imperfect analysing equipment. The diffusion term affects the evolution of the system directly.

The purpose of this PhD-project was to investigate the potential of SDEs in the artificial pancreas development. Especially, the emerging continuous monitoring of glucose levels makes SDEs highly applicable to this field. The current thesis aims at demonstrating and discussing the benefits and challenges by using SDEs compared to traditional methods on the basis of the results of the project.

First of all, we designed a clinical study to obtain high quality data from type 1 diabetes patients to identify the models from. The study included the main factors influencing the glucose level: insulin boluses, meals, and exercise. A modelling study showed that using SDEs in model development can be advantageous in several ways. We were able to pinpoint model deficiencies in a well-known model and to track parameter variation probably caused by a differences in meal type. This information could be added to the model to improve the fit. The study was limited by the lack of a software capable of handling SDE models of population effects instead of single-subject effects. A prototype of this type of software was developed parallel to the end of the project. Thus, we could finally identify a population model of the effect of exercise on the insulin absorption rate. The small amount of observations made it impossible to use SDEs to track parameter variation. Instead, we formulated a model structure with showed to be significantly better than the base model with a constant rate.

Two studies specifically related to the CGM observations were performed during the project. In the first study, we showed that SDEs could be used to tune a control algorithm for overnight glucose control on the basis of CGM observations. The tuned algorithm improved the controller performance in a subsequent clinical study. Further attempts to deal with the problems related to the CGM included a Bayesian estimation scheme. By incorporating prior knowledge about the uncertainty in the CGM observations into the estimation method, we succeeded in predicting the plasma glucose level with acceptable confidence from the CGM observations only.

Overall, the project confirms that SDEs have a large potential within this field. However, future modeling requires a robust
software capable of handling the nonlinear population SDE models. When this is available, larger modeling studies can be
initiated and the impact of SDEs would be expected to increase.

General information
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Stochastic runoff forecasting and real time control of urban drainage systems

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Thermal Storage Power Balancing with Model Predictive Control
The method described in this paper balances power production and consumption with a large number of thermal loads. Linear controllers are used for the loads to track a temperature set point, while Model Predictive Control (MPC) and model estimation of the load behavior are used for coordination. The total power consumption of all loads is controlled indirectly through a real-time price. The MPC incorporates forecasts of the power production and disturbances that influence the loads, e.g. time-varying weather forecasts, in order to react ahead of time. A simulation scenario demonstrates that the method allows for the integration of flexible thermal loads in a smart energy system in which consumption follows the changing production.
The smart grid research network: Road map for Smart Grid research, development and demonstration up to 2020

This road map is a result of part-recommendation no. 25 in ‘MAIN REPORT – The Smart Grid Network’s recommendations’, written by the Smart Grid Network for the Danish Ministry of Climate, Energy and Building in October 2011. This part-recommendation states:

“Part-recommendation 25 – A road map for Smart Grid research, development and demonstration

It is recommended that the electricity sector invite the Ministry to participate in the creation of a road map to ensure that solutions are implemented and coordinated with related policy areas. The sector should also establish a fast-acting working group with representatives from universities, distribution companies and the electric industry, in order to produce a mutual, binding schedule for the RDD of the Smart Grid in Denmark.

Time prioritisation of part-recommendation: 2011-2012

Responsibility for implementation of part-recommendation: Universities, along with relevant electric-industry actors, should establish a working group for the completion of a consolidated road map by the end of 2012.”

In its work on this report, the Smart Grid Research Network has focused particularly on part-recommendations 26, 27 and 28 in ‘MAIN REPORT – The Smart Grid Network’s recommendations’, which relate to strengthening and marketing the research infrastructure that will position Denmark as the global hub for Smart Grid development; strengthening basic research into the complex relationships in electric systems with large quantities of independent parties; and improved understanding of consumer behaviour and social economics. Naturally the work has spread to related areas along the way. The work has been conducted by the Smart Grid Research Network.
Weather radars for wind energy applications

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Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Department of Electrical Engineering, Center for Electric Power and Energy, Department of Wind Energy, Wind Energy Systems, Danish Meteorological Institute
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Wind Power Forecasting with a Focus on Risk and Uncertainties

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A convex programming framework for optimal and bounded suboptimal well field management

This paper presents a groundwater management model, considering the interaction between a confined aquifer and an unlooped Water Distribution Network (WDN), conveying the groundwater into the Water Works distribution mains. The pumps are controlled by regulating the characteristic curves. The objective of the management is to minimize the total cost of pump operations over a multistep time horizon, while fulfilling a set of time-varying management constraints. Optimization in groundwater management and pressurized WDNs have been widely investigated in the literature. Problem formulations are often convex, hence global optimality can be attained by a wealth of algorithms. Among these, the Interior Point methods are extensively employed for practical applications, as they are capable of efficiently solving large-scale problems. Despite this, management models explicitly embedding both systems without simplifications are rare, and they usually involve heuristic techniques. The main limitation with heuristics is that neither optimality nor suboptimality bounds can be guaranteed. This paper extends the proof of convexity to mixed management models, enabling the use of Interior Point techniques to compute globally optimal management solutions. If convexity is not achieved, it is shown how suboptimal solutions can be computed, and how to bound their deviation from the optimality. Experimental results obtained by testing the methodology in a well field located nearby Copenhagen (DK), show that management solutions can consistently perform within the 99.9% of the true optimum. Furthermore it is shown how not considering the Water Distribution Network in optimization is likely to result in unfeasible management solutions.

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Adaptive modelling and forecasting of offshore wind power fluctuations with Markov-switching autoregressive models

Wind power production data at temporal resolutions of a few minutes exhibit successive periods with fluctuations of various dynamic nature and magnitude, which cannot be explained (so far) by the evolution of some explanatory variable. Our proposal is to capture this regime-switching behaviour with an approach relying on Markov-switching autoregressive (MSAR) models. An appropriate parameterization of the model coefficients is introduced, along with an adaptive estimation method allowing accommodation of long-term variations in the process characteristics. The objective criterion to be recursively optimized is based on penalized maximum likelihood, with exponential forgetting of past observations. MSAR models are then employed for one-step-ahead point forecasting of 10 min resolution time series of wind power at two large offshore wind farms. They are favourably compared against persistence and autoregressive models. It is finally shown that the main interest of MSAR models lies in their ability to generate interval/density forecasts of significantly higher skill.
A formal statistical approach to representing uncertainty in rainfall-runoff modelling with focus on residual analysis and probabilistic output evaluation - Distinguishing simulation and prediction

While there seems to be consensus that hydrological model outputs should be accompanied with an uncertainty estimate the appropriate method for uncertainty estimation is not agreed upon and a debate is ongoing between advocates of formal statistical methods who consider errors as stochastic and GLUE advocates who consider errors as epistemic, arguing that the basis of formal statistical approaches that requires the residuals to be stationary and conform to a statistical distribution is unrealistic. In this paper we take a formal frequentist approach to parameter estimation and uncertainty evaluation of the modelled output, and we attach particular importance to inspecting the residuals of the model outputs and improving the model uncertainty description. We also introduce the probabilistic performance measures sharpness, reliability and interval skill score for model comparison and for checking the reliability of the confidence bounds. Using point rainfall and evaporation data as input and flow measurements from a sewer system for model conditioning, a state space model is formulated that accounts for three different flow contributions: wastewater from households, and fast rainfall-runoff from paved areas and slow rainfall-dependent infiltration-inflow from unknown sources.

We consider two different approaches to evaluate the model output uncertainty, the output error method that lumps all uncertainty into the observation noise term, and a method based on Stochastic Differential Equations (SDEs) that separates input and model structure uncertainty from observation uncertainty and allows updating of model states in real-time. The results show that the optimal simulation (off-line) model is based on the output error method whereas the optimal prediction (on-line) model is based on the SDE method and the skill scoring criterion proved that significant predictive improvements of the output can be gained from updating the states continuously. In an effort to attain residual stationarity for both the output error method and the SDE method transformation of the observations were necessary but the statistical assumptions were nevertheless not 100% justified. The residual analysis showed that significant autocorrelation was present for all simulation models. We believe users of formal approaches to uncertainty evaluation within hydrology and within environmental modelling in general can benefit significantly from adopting the evaluation measures applied here, so the probabilistic performance of their models can be assessed properly. (C) 2012 Elsevier B.V. All rights reserved.

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A General Probabilistic Forecasting Framework for Offshore Wind Power Fluctuations

Accurate wind power forecasts highly contribute to the integration of wind power into power systems. The focus of the present study is on large-scale offshore wind farms and the complexity of generating accurate probabilistic forecasts of wind power fluctuations at time-scales of a few minutes. Such complexity is addressed from three perspectives: (i) the modeling of a nonlinear and non-stationary stochastic process; (ii) the practical implementation of the model we proposed; (iii) the gap between working on synthetic data and real world observations. At time-scales of a few minutes, offshore fluctuations are characterized by highly volatile dynamics which are difficult to capture and predict. Due to the lack of adequate on-site meteorological observations to relate these dynamics to meteorological phenomena, we propose a general model formulation based on a statistical approach and historical wind power measurements only. We introduce an advanced Markov Chain Monte Carlo (MCMC) estimation method to account for the different features observed in an empirical time series of wind power: autocorrelation, heteroscedasticity and regime-switching. The model we propose is an extension of Markov-Switching Autoregressive (MSAR) models with Generalized AutoRegressive Conditional Heteroscedastic (GARCH) errors in each regime to cope with the heteroscedasticity. Then, we analyze the predictive power of our model on a one-step ahead exercise of time series sampled over 10 min intervals. Its performances are compared to state-of-the-art models and highlight the interest of including a GARCH specification for density forecasts.

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Scopus rating (2014): SJR 0.87 SNIP 1.601 CiteScore 2.66
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.632 SNIP 1.345 CiteScore 2.29
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.874 SNIP 1.54 CiteScore 2.46
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.659 SNIP 1.439 CiteScore 2.24
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.303 SNIP 0.76
Original language: English
A new ensemble model for short term wind power prediction

As the objective of this study, a non-linear ensemble system is used to develop a new model for predicting wind speed in short-term time scale. Short-term wind power prediction becomes an extremely important field of research for the energy sector. Regardless of the recent advancements in the re-search of prediction models, it was observed that different models have different capabilities and also no single model is suitable under all situations. The idea behind EPS (ensemble prediction systems) is to take advantage of the unique features of each subsystem to detain diverse patterns that exist in the dataset. The conferred results show that the prediction errors can be decreased, while the computation time is reduced.
A Transmission-Cost-Based Model to Estimate the Amount of Market-Integrable Wind Resources

In the pursuit of the large-scale integration of wind power production, it is imperative to evaluate plausible frictions among the stochastic nature of wind generation, electricity markets, and the investments in transmission required to accommodate larger amounts of wind. If wind producers are made to share the expenses in transmission derived from their integration, they may see the doors of electricity markets closed for not being competitive enough. This paper presents a model to decide the amount of wind resources that are economically exploitable at a given location from a transmission-cost perspective. This model accounts for the uncertain character of wind by using a modeling framework based on stochastic optimization, simulates market barriers by means of a bi-level structure, and considers the financial risk of investments in transmission through the conditional value-at-risk. The major features of the proposed model, which is efficiently solved using Benders decomposition, are discussed through an illustrative example.

**General information**

State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Morales González, J. M. (Intern), Pinson, P. (Intern), Madsen, H. (Intern)
Pages: 1060-1069
Publication date: 2012
Main Research Area: Technical/natural sciences

**Publication information**

Journal: IEEE Transactions on Power Systems
Volume: 27
Issue number: 2
ISSN (Print): 0885-8950
Ratings:
- BFI (2018): BFI-level 2
- BFI (2017): BFI-level 2
- Web of Science (2017): Indexed yes
Control of Blood Glucose for People with Type 1 Diabetes: an In Vivo Study

Since continuous glucose monitoring (CGM) technology and insulin pumps have improved recent years, a strong interest in a closed-loop artificial pancreas for people with type 1 diabetes has arisen. Presently, a fully automated controller of blood glucose must face many challenges, such as daily variations of patient's physiology and lack of accuracy of glucose sensors. In this paper we design and discuss an algorithm for overnight closed-loop control of blood glucose in people with type 1 diabetes. The algorithm is based on Model Predictive Control (MPC). We use an offset-free autoregressive model with exogenous input and moving average (ARMAX) to model the patient. Observer design and a time-varying glucose
reference signal improve robustness of the algorithm. We test the algorithm in two clinical studies conducted at Hvidovre Hospital. The rst study took place overnight, and the second one took place during daytime. These trials demonstrate the importance of observer design in ARMAX models and show the possibility of stabilizing blood glucose during the night.

General information
State: Published
Organisations: Center for Energy Resources Engineering, Scientific Computing, Department of Informatics and Mathematical Modeling, Mathematical Statistics, Copenhagen University Hospital
Pages: 133-140
Publication date: 2012

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Place of publication: Kogens Lyngby
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Editors: Jørgensen, J. B., Huusom, J. K., Sin, G.
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Main Research Area: Technical/natural sciences
Conference: 17th Nordic Process Control Workshop, Kongens Lyngby, Denmark, 25/01/2012 - 25/01/2012
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http://npcw17.imm.dtu.dk/default.html
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Publication: Research - peer-review › Article in proceedings – Annual report year: 2012

Control of Blood Glucose for People with Type 1 Diabetes: an in Vivo Study

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http://npcw17.imm.dtu.dk/
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Source-ID: 318545
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Descriptive and predictive evaluation of high resolution Markov chain precipitation models
A time series of tipping bucket recordings of very high temporal and volumetric resolution precipitation is modelled using Markov chain models. Both first and second-order Markov models as well as seasonal and diurnal models are investigated and evaluated using likelihood based techniques. The first-order Markov model seems to capture most of the properties of precipitation, but inclusion of seasonal and diurnal variation improves the model. Including a second-order Markov Chain component does improve the descriptive capabilities of the model, but is very expensive in its parameter use. Continuous modelling of the Markov process proved attractive because of a marked decrease in the number of parameters. Inclusion of seasonality into the continuous Markov chain model proved difficult. Monte Carlo simulations with the models show that it is very difficult for all the model formulations to reproduce the time series on event level. Extreme events with short (10 min), medium (60 min) and long (12 h) durations were investigated because of their importance in urban hydrology. Both the descriptive likelihood based statistics and the predictive Monte Carlo simulation based statistics are valuable and necessary tools when evaluating model fit and performance. Copyright © 2012 John Wiley & Sons, Ltd.
Box–Cox transformation, Monte Carlo simulation, Seasonal variation, Tipping bucket rain gauges, Waiting times
Designing a reliable protocol for web services based robots interconnection

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Madsen, H. (Intern), Albu, R. (Ekstern), Popentiu, F. (Intern), Țarcă, R. C. (Ekstern), Grigore, A. (Intern)
Pages: 435-436
Publication date: 2012

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Title of host publication: Advances in Safety, Reliability and Risk Management : Proceedings Of The European Safety And Reliability Conference, Esrel 2011, Troyes, France, 18–22 September 2011
Place of publication: London
Publisher: Taylor & Francis
Editors: Bérenguer, C., Grall, A., Guedes Soares, C.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 318955
Publication: Research - peer-review › Article in proceedings – Annual report year: 2012

Development of a restricted state space stochastic differential equation model for bacterial growth in rich media

In the present study, bacterial growth in a rich media is analysed in a Stochastic Differential Equation (SDE) framework. It is demonstrated that the SDE formulation and smoothened state estimates provide a systematic framework for data driven model improvements, using random walk hidden states. Bacterial growth is limited by the available substrate and the inclusion of diffusion must obey this natural restriction. By inclusion of a modified logistic diffusion term it is possible to introduce a diffusion term flexible enough to capture both the growth phase and the stationary phase, while concentration is restricted to the natural state space (substrate and bacteria non-negative). The case considered is the growth of Salmonella and Enterococcus in a rich media. It is found that a hidden state is necessary to capture the lag phase of growth, and that a flexible logistic diffusion term is needed to capture the random behaviour of the growth model. Further, it is concluded that the Monod effect is not needed to capture the dynamics of bacterial growth in the data presented.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Møller, J. K. (Intern), Philipsen, K. R. (Intern), Christiansen, L. E. (Intern), Madsen, H. (Intern)
Pages: 78-87
Publication date: 2012
Main Research Area: Technical/natural sciences

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Journal: Journal of Theoretical Biology
Volume: 305
ISSN (Print): 0022-5193
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.918 SNIP 0.932 CiteScore 2.16
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.084 SNIP 1.017 CiteScore 2.21
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.07 SNIP 1.048 CiteScore 2.25
Economic Model Predictive Control for Building Climate Control in a Smart Grid

Model Predictive Control (MPC) can be used to control a system of energy producers and consumers in a Smart Grid. In this paper, we use heat pumps for heating residential buildings with a floor heating system. We use the thermal capacity of the building to shift the electricity consumptions to periods with low energy prices. In this way the heating system of the house becomes a flexible power consumer in the Smart Grid. This scenario is relevant for systems with a significant share of stochastic energy producers, e.g. wind turbines, where the ability to shift power consumption according to production is crucial. We present a model for a house with a heat pump used for supplying thermal energy to a floor heating system. The model is a linear state space model and the resulting controller is an Economic MPC formulated as a linear program. The model includes forecasts of both weather and electricity price. Simulation studies demonstrate the capabilities of the proposed model and algorithm. Compared to traditional operation of heat pumps with constant electricity prices, the optimized operating strategy saves 25-33% of the electricity cost.

General information
State: Published
Organisations: Center for Energy Resources Engineering, Department of Informatics and Mathematical Modeling, Scientific Computing, Mathematical Statistics
Efficient Iterated Filtering

Parameter estimation in general state space models is not trivial as the likelihood is unknown. We propose a recursive estimator for general state space models, and show that the estimates converge to the true parameters with probability one. The estimates are also asymptotically Cramer-Rao efficient. The proposed estimator is easy to implement as it only relies on non-linear filtering. This makes the framework flexible as it is easy to tune the implementation to achieve computational efficiency. This is done by using the approximation of the score function derived from the theory on Iterative Filtering as a building block within the recursive maximum likelihood estimator.

Electric vehicle charge planning using Economic Model Predictive Control

Economic Model Predictive Control (MPC) is very well suited for controlling smart energy systems since electricity price and demand forecasts are easily integrated in the controller. Electric vehicles (EVs) are expected to play a large role in the future Smart Grid. They are expected to provide grid services, both for peak reduction and for ancillary services, by absorbing short term variations in the electricity production. In this paper the Economic MPC minimizes the cost of electricity consumption for a single EV. Simulations show savings of 50–60% of the electricity costs compared to uncontrolled charging from load shifting based on driving pattern predictions. The future energy system in Denmark will most likely be based on renewable energy sources e.g. wind and solar power. These green energy sources introduce stochastic fluctuations in the electricity production. Therefore, energy should be consumed as soon as it is produced to avoid the need for energy storage as this is expensive, limited and introduces efficiency losses. The Economic MPC for EVs described in this paper may contribute to facilitating transition to a fossil free energy system.
ESO2 Optimization of Supermarket Refrigeration Systems: Mixed Integer MPC and System Performance

Supermarket refrigeration systems consist of a number of display cases, cooling cabinets and cold rooms connected to a central compressor pack. This configuration saves energy compared to placing a compressor at each cooling site. The classical control setup of a supermarket refrigeration system is highly distributed. The cooling sites are equipped with an individual hysteresis controller that keeps the air temperature in the cooling site within a defined band by manipulating the opening degree of an inlet valve. The compressor bank maintains a desired suction pressure by adjusting the capacity to the given load from the cooling sites. An illustration of the principle is shown in figure 1. This design is flexible and simple, but its major drawback is however that it introduces self-inflicted disturbances and the dynamic coupling of the display cases makes them synchronize. Synchronization results in low efficiency and high wear of the compressor, because the compressor has to work much harder for short periods of time. The problem increases when the load is small compared to the available compressor capacity, which it is in the winter time, at night and when only a few cooling sites are present in the supermarket. The first approach to solve this problem is to design an overall control system which coordinates the compressor capacity and the current refrigeration load. The drawback of this approach is the complexity of the single controller. The solution is investigated in the first part of the report. A second solution is investigated where only the compressor control is considered. This controller try to feed-forward the measured disturbances, i.e. opening and closing of the cooling site AKV’s. Last a performance analysis of the refrigeration system is performed.

Evaluation of Energy Storage System to Support Danish Island of Bornholm Power Grid

This paper presents a real-time evaluation and simulation approach of energy storage system (ESS) based on large renewable-based electricity generation, which can be used for grid support. The ESS is designed to maintain power quality as a primary regulation, while the conventional generation units handle the secondary frequency regulation to mitigate ramping issues. The real time models of Bornholm distribution grid, which is the combination of an aggregated wind power generation and the energy storage system (ESS) has been used to test the system and control approach in a real time grid simulator to identify the improvement of the grid support capability. The interactive simulation platform with
real-time energy forecasting data running online with a link to the Bornholm power system data are being used to measure and validate the system performance with and without energy storage after a disturbance.

**General information**
State: Published
Authors: Cha, S. (Intern), Zhao, H. (Intern), Wu, Q. (Intern), Østergaard, J. (Intern), Nielsen, T. S. (Ekstern), Madsen, H. (Intern)
Number of pages: 6
Publication date: 2012

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Publisher: IEEE
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Main Research Area: Technical/natural sciences
Conference: The 10th International Power and Energy Conference (IPEC 2012), Ho Chi Minh City, Viet Nam, 12/12/2012 - 12/12/2012
Energy storage system (ESS), Grid support capability, Primary/secondary regulation, Ramping issues, Real time digital simulator (RTDS), Renewable-based electricity generation, Wind forecasting system
Electronic versions:
P0198.pdf
Source: dtu
Source-ID: u::4433
Publication: Research - peer-review › Article in proceedings – Annual report year: 2012

**Evaluation of probabilistic flow predictions in sewer systems using grey box models and a skill score criterion**
In this paper we show how the grey box methodology can be applied to find models that can describe the flow prediction uncertainty in a sewer system where rain data are used as input, and flow measurements are used for calibration and updating model states. Grey box models are composed of a drift term and a diffusion term, respectively accounting for the deterministic and stochastic part of the models. Furthermore, a distinction is made between the process noise and the observation noise. We compare five different model candidates' predictive performances that solely differ with respect to the diffusion term description up to a 4 h prediction horizon by adopting the prediction performance measures; reliability, sharpness and skill score to pinpoint the preferred model. The prediction performance of a model is reliable if the observed coverage of the prediction intervals corresponds to the nominal coverage of the prediction intervals, i.e. the bias between these coverages should ideally be zero. The sharpness is a measure of the distance between the lower and upper prediction limits, and skill score criterion makes it possible to pinpoint the preferred model by taking into account both reliability and sharpness. In this paper, we illustrate the power of the introduced grey box methodology and the probabilistic performance measures in an urban drainage context.

**General information**
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Urban Water Engineering, Department of Environmental Engineering, Krüger A/S
Authors: Thordarson, F. Ø. (Intern), Breinholt, A. (Intern), Møller, J. K. (Intern), Mikkelsen, P. S. (Intern), Grum, M. (Ekstern), Madsen, H. (Intern)
Pages: 1151-1162
Publication date: 2012
Main Research Area: Technical/natural sciences

**Publication information**
Journal: Stochastic Environmental Research and Risk Assessment
Volume: 26
Issue number: 8
ISSN (Print): 1436-3240
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 1.149 SNIP 1.381 CiteScore 2.54
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Forecast generation for real-time control of urban drainage systems using greybox modelling and radar rainfall

We present stochastic flow forecasts to be used in a real-time control setup for urban drainage systems. The forecasts are generated using greybox models with rain gauge and radar rainfall observations as input. Predictions are evaluated as intervals rather than just mean values. We obtain satisfactory predictions for the smaller catchment but rather large uncertainties for the bigger catchment where the applied storage cascade seems too simple. Radar rainfall introduces more uncertainty into the flow forecast model estimation. However, the radar rainfall forecasts also result in a slightly improved point prediction of flows which we aim to exploit with a modified estimation approach in the future.
Integrated Wind Power Planning Tool

This poster presents the Public Service Obligation (PSO) funded project PSO 10464 "Integrated Wind Power Planning Tool". The project goal is to integrate a Numerical Weather Prediction (NWP) model with statistical tools in order to assess wind power fluctuations, with focus on short term forecasting for existing wind farms, as well as long term power system planning for future wind farms.

General information
State: Published
Authors: Rosgaard, M. H. (Ekstern), Hahmann, A. N. (Intern), Nielsen, T. S. (Ekstern), Madsen, H. (Intern), Giebel, G. (Intern), Sørensen, P. E. (Intern)
Number of pages: 1
Publication date: 2012
Event: Poster session presented at EWEA 2012 - European Wind Energy Conference & Exhibition, Copenhagen, Denmark.
Main Research Area: Technical/natural sciences
EWEA 2012
Electronic versions:
Integrated_Wind_Power_Planning_Tool.pdf
Publication: Research - peer-review › Poster – Annual report year: 2012

Integrated Wind Power Planning Tool

This poster describes the status as of April 2012 of the Public Service Obligation (PSO) funded project PSO 10464 "Integrated Wind Power Planning Tool". The project goal is to integrate a meso scale numerical weather prediction (NWP) model with statistical tools in order to better predict short term power variation from offshore wind farms, as well as to conduct forecast error assessment studies in preparation for later implementation of such a feature in an existing simulation model. The addition of a forecast error estimation feature will further increase the value of this tool, as its output can be fed into any type of system model or decision-making problem that wish to account for forecast errors in the planning process, rather than assume perfect forecasts.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology, Department of Applied Mathematics and Computer Science, Dynamical Systems, Wind Energy Systems, ENFOR A/S
Authors: Rosgaard, M. H. (Ekstern), Hahmann, A. N. (Intern), Nielsen, T. S. (Ekstern), Madsen, H. (Intern), Giebel, G. (Intern), Sørensen, P. E. (Intern)
Number of pages: 1
Publication date: 2012
Event: Poster session presented at European Geosciences Union General Assembly 2012, Vienna, Austria.
Main Research Area: Technical/natural sciences
Electronic versions:
prod21359755681462.EGU2012_13636_presentation.pdf
Publication: Research - peer-review › Poster – Annual report year: 2013

Integrated Wind Power Planning Tool

This poster presents the current state of the public service obligation (PSO) funded project PSO 10464, with the working title "Integrated Wind Power Planning Tool". The project commenced October 1, 2011, and the goal is to integrate a numerical weather prediction (NWP) model with purely statistical tools in order to assess wind power fluctuations, with focus on long term power system planning for future wind farms as well as short term forecasting for existing wind farms. Currently, wind power fluctuation models are either purely statistical or integrated with NWP models of limited resolution. With regard to the latter, one such simulation tool has been developed at the Wind Energy Division, Risø DTU, intended for long term power system planning. As part of the PSO project the inferior NWP model used at present will be replaced by the state-of-the-art Weather Research & Forecasting (WRF) model. Furthermore, the integrated simulation tool will be
improved so it can handle simultaneously 10-50 times more turbines than the present 300, as well as additional atmospheric parameters will be included in the model. The WRF data will also be input for a statistical short term prediction model to be developed in collaboration with ENFOR A/S; a Danish company that specialises in forecasting and optimisation for the energy sector. This integrated prediction model will allow for the description of the expected variability in wind power production in the coming hours to days, accounting for its spatio-temporal dependencies, and depending on the prevailing weather conditions deduced by the WRF output. The output from the integrated prediction tool constitute scenario forecasts for the coming period, which can then be fed into any type of system model or decision making problem to be solved. The high resolution of the WRF results loaded into the integrated prediction model will ensure a high accuracy data basis is available for use in the decision making process of the Danish transmission system operator, and the need for high accuracy predictions will only increase over the next decade as Denmark approaches the goal of 50% wind power based electricity in 2020, from the current 20%.

**General information**

State: Published
Organisations: Department of Wind Energy, Wind Energy Systems, Meteorology, Department of Applied Mathematics and Computer Science, Dynamical Systems, ENFOR A/S
Authors: Rosgaard, M. H. (Ekstern), Giebel, G. (Intern), Nielsen, T. S. (Ekstern), Hahmann, A. N. (Intern), Sørensen, P. E. (Intern), Madsen, H. (Intern)
Number of pages: 1
Pages: EGU2012-13636
Publication date: 2012
Conference: European Geosciences Union General Assembly 2012, Vienna, Austria, 22/04/2012 - 22/04/2012
Main Research Area: Technical/natural sciences

**Load Forecasting for Households**

**General information**

State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics, Department of Civil Engineering, Section for Building Physics and Services, ENFOR A/S
Authors: Bacher, P. (ed.) (Intern), Madsen, H. (ed.) (Intern), Perers, B. (ed.) (Intern)
Publication date: 2012

**Publication information**

Publisher: iPower Consortium
Original language: English
Main Research Area: Technical/natural sciences
Publication: Research - peer-review › Conference abstract in journal – Annual report year: 2013

**Model Based Analysis of Ethnic Differences in Type 2 Diabetes**

The present thesis deals with different aspects of population pharmacokinetic/pharmacodynamic (PK/PD) modelling of the glucose homeostatic system. The thesis consist of a summary report and four scientific research papers. A description of the main topics covered in the thesis is given in the summary report. This includes a short introduction to
the mathematical methods applied in the thesis, followed by an outline of the physiological and pathological aspects of the glucose homeostatic system and how to obtain diagnostic indices for characterising the condition of the system. Finally an overview of ethnic differences in type 2 diabetes (T2D) is given, which relates to the subject of the last 2 papers included in the thesis.

One of the main objectives of the thesis was to investigate possible ethnic differences between development of T2D in Caucasian and Japanese and investigate the applicability of stochastic differential equations (SDEs) and non-linear mixed effects (NLME) models for such an assessment. One way to perform such an investigation is to characterise the pathophysiology of the two groups at different stages of disease progression. For T2D this involves a characterisation of the glucose homeostatic system, which is a complex feedback system mainly involving mainly organs such as the liver and the pancreas, the hormones insulin and glucagon, and the carbohydrate glucose.

As for any other dynamical system, a proper characterisation at non-steady state, requires a proper input to the system. This input must reflect the circumstances in which one wants to draw conclusions. In this thesis the intake of oral glucose, which closely resembles the intake of food under daily living has been applied.

Mathematical modelling of such complex physiological phenomena as the glucose homeostatic system will usually be based on both insight into the system and experimental data. Through estimation techniques, free parameters in the models are estimated and can be related directly to behaviour of the system. These semi-physical (grey box) models are well suited for understanding the system, although in many cases they are not able to fully describe the systematic behaviour observed in the applied data sets. This issue can be addressed through an inspection of the autocorrelation function (ACF) of residuals and the description can be improved by switching to the use of stochastic differential equations (SDEs) or another improved description of residuals.

For characterising disease progression in Caucasian and Japanese, established models that include parameters for insulin sensitivity and beta-cell function were implemented in a non-linear mixed-effects setting with ODEs. Based on the ACF of residuals it was clear that the two models provide a good, although not perfect, description of the systematic variation in the analysed data sets. Based on this the models were extended to SDE models for improved description of residuals. Using the SDE models it was not possible to obtain convergence with the full covariate models so the results presented in the thesis mainly originate from the ODE models. This also caused a more fair comparison with the well-established single-subject models implemented using ODEs.

Previous research have stated the importance of the gut hormone glucagon like peptide-1 (GLP-1) as determinant for normal beta-cell function. Based on this a population PK/PD model for secretion of (GLP-1) following an oral glucose tolerance test (OGTT) was developed. This model can be used as a tool to analyse potential differences in the secretion capabilities of GLP-1 between subjects. ACF of residuals did not show any signs of strong serial correlation, and the model was thus not implemented using SDEs.

Assessment of simple and model-based measures for insulin sensitivity and beta-cell function in Japanese and Caucasian subjects stratified according to normal glucose tolerance (NGT), impaired glucose tolerance (IGT), and T2D showed that Japanese in general have higher insulin sensitivity and lower beta-cell function compared to Caucasians. In spite of this, the pattern going from NGT to T2D appeared similar in the two cohorts and the majority of the difference in insulin sensitivity and beta-cell function, measured by simple insulin based measures, could be explained by difference in body size (BMI). This was supported by Forest plots of covariate effects obtained from population models, in general indicating that race had no clinical relevant effect on either the insulin sensitivity or the beta-cell function when measures for obesity (android fat mass or BMI) was taken into account.

**General information**

State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Møller, J. B. (Intern), Madsen, H. (Intern)
Number of pages: 82
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Original language: English

Series: IMM-PHD-2012
Number: 268
ISSN: 0909-3192
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Pharmacokinetic/pharmacodynamic (PK/PD), Type 2 diabetes (T2D), Autocorrelation function (ACF), Stochastic differential equations (SDEs), Oral glucose tolerance test (OGTT), Glucagon-like-peptide 1 (GLP-1), Disease progression, Ethnic differences

Electronic versions:
phd268_Jonas_Bech_Moller.pdf
Source: orbit
Source-ID: 318951
Publication: Research › Ph.D. thesis – Annual report year: 2012
Modeling Demand Response in Electricity Retail Markets as a Stackelberg Game
We model the retail market with dynamic pricing as a Stackelberg game where both retailers (leaders) and flexible consumers (followers) solve an economic cost-minimization problem. The electricity retailer optimizes an economic objective over a daily horizon by setting an hourly price-sequence, which is then communicated to the end-consumers. In turn, on the basis of such price sequence, consumers optimize a utility function that accounts both for energy procurement costs and for the benefit loss resulting from deferring consumption. The game is formulated as a Mathematical Problem with Equilibrium Constraints (MPEC) and cast as a Mixed Integer Linear Program (MILP), which can be solved using off-the-shelf optimization software. In an illustrative example, we consider a retailer associated with both flexible demand and wind power production. Such an example shows the efficiency of dynamic pricing as a way to control the load for minimizing the imbalances due to wind power, assesses the overall economic results for the retailer and the consumers as well as the dynamic properties of consumer flexibility.

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Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Zugno, M. (Intern), Morales González, J. M. (Intern), Pinson, P. (Intern), Madsen, H. (Intern)
Number of pages: 11
Publication date: 2012
Main Research Area: Technical/natural sciences
Demand response, Bilevel programming, Stackelberg games, Wind power, Electricity markets
Electronic versions:
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Source: dtu
Source-ID: u::5684
Publication: Research - peer-review › Paper – Annual report year: 2012

Modeling Smart Energy Systems for Model Predictive Control
Integrating large amounts of renewable energy sources like wind and solar power introduces large fluctuations in the power production. Either this energy must be stored or consumed right away. Storage solutions are very expensive and not applicable everywhere. So utilizing all of this green energy as it is produced requires a very exible and controllable power consumption. Examples of controllable electric loads are heat pumps in buildings and Electric Vehicles (EVs) that are expected to play a large role in the future Danish energy system. These units in a smart energy system can potentially be scheduled depending on the cost, e.g. weather forecasts and usage patterns, are used depending on the unit. The generic state space will be a discrete time state space model with hard input constraints and soft output constraints. For the considered energy systems there is usually a strict limit on the maximum available power, but the output, e.g. a temperature or an EV battery state of charge, can often be relaxed. The output constraints thus define a band of operation, that can be time varying, and the controller must keep the output within these limits in the cheapest possible way. In this paper the price forecast available by all units is assumed to be known and equal to the day-ahead elspot price from the Nordic electricity exchange market NordPool. The resulting electricity cost savings compared to an MPC with no price considerations are around 30-50% for the chosen units. In future work the price could be replaced by an intrahour price that is related to the deviation between the planned and the actual consumption. In this way all units are motivated to stick to the predicted consumption plan.

General information
State: Published
Organisations: Center for Energy Resources Engineering, Department of Informatics and Mathematical Modeling, Scientific Computing, Mathematical Statistics
This paper deals with grey-box modelling of the energy transfer of a double skin Building Integrated Photovoltaic (BIPV) system. Grey-box models are based on a combination of prior physical knowledge and statistics, which enable identification of the unknown parameters in the system and accurate prediction of the most influential variables. The experimental data originates from tests carried out with an air-based BIPV system installed in a Test Reference Environment. BIPV systems represent an interesting application for achieving the requirements of the EU EPBD Directive. Indeed, these systems could reduce the ventilation thermal losses of the building by pre-heating the fresh air. Furthermore, by decreasing PV module temperature, the ventilation air heat extraction can simultaneously increase electrical and thermal energy production of the building. A correct prediction of the PV module temperature and heat transfer coefficients is fundamental in order to improve the thermo-electrical production. The considered grey-box models are composed of a set of continuous time stochastic differential equations, holding the physical description of the system, combined with a set of discrete time measurement equations, which represent the data driven part. In the present work, both one-state and two-state non-linear grey-box models are considered. In order to validate the results, the residuals are analysed for white-noise properties.
Model Predictive Control Algorithms for Pen and Pump Insulin Administration

Despite recent developments within diabetes management such as rapidacting insulin, continuous glucose monitors (CGM) and insulin pumps, tight blood glucose control still remains a challenge. A fully automated closed-loop controller, also known as an artificial pancreas (AP), has the potential to ease the life and reduce the risk of acute and chronic diabetic complications. However, the noise associated to CGMs, the long insulin action time for continuous subcutaneous infusion of insulin (CSII) pumps, and the high intra- and inter-patient variability significantly limits the performance of current closed-loop controllers.

In this thesis, we present different control strategies based on Model Predictive Control (MPC) for an artificial pancreas. We use Nonlinear Model Predictive Control (NMPC) in order to determine the optimal insulin and blood glucose profiles. The optimal control problem (OCP) is solved using a multiple-shooting based algorithm. We use an explicit Runge-Kutta method (DOPRI45) with an adaptive stepsize for numerical integration and sensitivity computation. The OCP is solved...
using a Quasi-Newton sequential quadratic programming (SQP) with a linesearch and a BFGS update for the Hessian of the Lagrangian. In addition, we apply a Continuous-Discrete Extended Kalman Filter (CDEKF) in order to simulate cases where the meal size is uncertain, or even unannounced.

We also propose a novel control strategy based on linear MPC for overnight stabilization of blood glucose. The model parameters are personalized using a priori available patient information. We consider an autoregressive integrated moving average with exogenous input (ARIMAX) model. We summarize and the results of the overnight clinical studies conducted at Hvidovre Hospital. Based on these results, we propose improvements for the stochastic part of our controller model. We state and compare three different stochastic model structures. The first one is the ARIMAX structure that has been used for the clinical studies. The second one is an autoregressive moving average with exogenous input (ARMAX) model. The third one is an adaptive ARMAX model in which we estimate the parameters of the stochastic part using a Recursive Least Square (RLS) method. We test the controller in a virtual clinic of 100 patients. This virtual clinic is based on the Hovorka model. We consider the case where only half of the bolus is administrated at mealtime, and the case where the insulin sensitivity increases during the night.

This thesis consists of a summary report, glucose and insulin profiles of the clinical studies and research papers submitted, peer-reviewed and/or published in the period September 2009 - September 2012.

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Organisations: Department of Applied Mathematics and Computer Science, Center for Energy Resources Engineering, Scientific Computing, Dynamical Systems
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Model predictive control for a smart solar tank based on weather and consumption forecasts
In this work the heat dynamics of a storage tank were modelled on the basis of data and maximum likelihood methods. The resulting grey-box model was used for Economic Model Predictive Control (MPC) of the energy in the tank. The control objective was to balance the energy from a solar collector and the heat consumption in a residential house. The storage tank provides heat in periods where there is low solar radiation and stores heat when there is surplus solar heat. The forecasts of consumption patterns were based on data obtained from meters in a group of single-family houses in Denmark. The tank can also be heated by electric heating elements if necessary, but the electricity costs of operating these heating elements should be minimized. Consequently, the heating elements should be used in periods with cheap electricity. It is proposed to integrate a price-sensitive control to enable the storage tank to serve a smart energy system in which flexible consumers are expected to help balance fluctuating renewable energy sources like wind and solar. Through simulations, the impact of applying Economic MPC shows annual electricity cost savings up to 25-30%.

General information
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Organisations: Center for Energy Resources Engineering, Department of Informatics and Mathematical Modeling, Scientific Computing, Mathematical Statistics, Department of Civil Engineering, Section for Building Physics and Services
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Main Research Area: Technical/natural sciences

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Models for efficient integration of solar energy

Efficient operation of energy systems with substantial amount of renewable energy production is becoming increasingly important. Renewables are dependent on the weather conditions and are therefore by nature volatile and uncontrollable, opposed to traditional energy production based on combustion. The “smart grid” is a broad term for the technology for addressing the challenge of operating the grid with a large share of renewables. The “smart” part is formed by technologies, which models the properties of the systems and efficiently adapt the load to the volatile energy production, by using the available flexiblity in the system.

In the present thesis methods related to operation of solar energy systems and for optimal energy use in buildings are presented. Two approaches for forecasting of solar power based on numerical weather predictions (NWPs) are presented, they are applied to forecast the power output from PV and solar thermal collector systems. The first approach is based on a developed statistical clear-sky model, which is used for estimating the clear-sky output solely based on observations of the output. This enables local effects such as shading from trees to be taken into account. The second approach to solar power forecasting is based on conditional parametric modelling. It is well suited for forecasting of solar thermal power, since it can be make non-linear in the inputs. The approach is also extended to a probabilistic solar power forecasting model.

The statistical clear-sky model is furthermore used as basis for a method for correction of global radiation observations. This method can used for correction of typical errors, for example from shading trees or buildings. Two methods for ecient energy use in buildings are presented in the last part of the thesis. First a method for forecasting of the heat load in single-family houses based on weather forecasts is presented. A model is identied, which works well when applied to forecast the heat load for sixteen single-family houses. The model adapts to the individual houses and needs only no specic information about the buildings. Finally a procedure for identication of a suitable model for the heat dynamics of a building is presented. The applied models are greybox model based on stochastic di erential equations and the identication is carried out with likelihood ratio tests. The models can be used for providing detailed information of the thermal characteristics of buildings and as basis for optimal control for exible heating of buildings.

General information

State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Department of Electrical Engineering
Authors: Bacher, P. (Intern), Madsen, H. (Intern), Nielsen, H. A. (Intern)
Optimal reliability allocation for large software projects through soft computing techniques

Software architecture is considered as a critical design methodology for the development of complex software. As an important step in software quality assurance, the optimal reliability allocation for software projects can be obtained by minimizing the total cost of achieving the target reliability or maximizing the system reliability subject to budget constraints. These kinds of optimization problems were considered both in deterministic and stochastic frameworks in literature. Recently, the intuitionistic-fuzzy optimization approach was considered as a soft computing successful modelling approach. Firstly, a review on existing soft computing approaches to optimization is given. The main section extends the results considering self-organizing migrating algorithms for solving intuitionistic-fuzzy optimization problems attached to complex fault-tolerant software architectures which proved to be convergent with better or similar results (in speed) as genetic or controlled Monte-Carlo approaches.

Overnight Control of Blood Glucose in People with Type 1 Diabetes

In this paper, we develop and test a Model Predictive Controller (MPC) for overnight stabilization of blood glucose in people with type 1 diabetes. The controller uses glucose measurements from a continuous glucose monitor (CGM) and its decisions are implemented by a continuous subcutaneous insulin infusion (CSII) pump. Based on a priori patient information, we propose a systematic method for computation of the model parameters in the MPC. Safety layers improve the controller robustness and reduce the risk of hypoglycemia. The controller is evaluated in silico on a cohort of 100 randomly generated patients with a representative intersubject variability. This cohort is simulated overnight with realistic variations in the insulin sensitivities and needs. Finally, we provide results for the first tests of this controller in a real clinic.
State-space adjustment of radar rainfall and stochastic flow forecasting for use in real-time control of urban drainage systems

Merging of radar rainfall data with rain gauge measurements is a common approach to overcome problems in deriving rain intensities from radar measurements. We extend an existing approach for adjustment of C-band radar data using state-space models and use the resulting rainfall intensities as input for forecasting outflow from two catchments in the Copenhagen area. Stochastic greybox models are applied to create the runoff forecasts, providing us with not only a point forecast but also a quantification of the forecast uncertainty. Evaluating the results, we can show that using the adjusted radar data improves runoff forecasts compared to using the original radar data and that rain gauge measurements as forecast input are also outperformed. Combining the data merging approach with short term rainfall forecasting algorithms may result in further improved runoff forecasts that can be used in real time control.


In view of the increasing penetration of wind power in a number of power systems and markets worldwide, we discuss some of the impacts that wind energy may have on market quantities and cross-border power flows. These impacts are uncovered through statistical analyses of actual market and flow data in Europe. Due to the dimensionality and nonlinearity of these effects, the necessary concepts of dimension reduction using Principal Component Analysis (PCA), as well as nonlinear regression are described. Example application results are given for European cross-border flows, as well as for the impact of load and wind power forecasts on Danish and German electricity markets.
Stochastic Model Predictive Control with Applications in Smart Energy Systems

In response to growing concerns related to environmental issues, limited resources and security of supply, the energy industry is changing. One of the most significant developments has been the penetration of renewable energy sources. In Denmark, the share of wind power generation is expected to cover more than 50% of the total consumption by 2050. Energy systems based on significant amounts of renewable energy sources are subject to uncertainties. To accommodate the need for model predictive control (MPC) of such systems, the effect of the stochastic effects on the constraints must be accounted for. In conventional MPC, the stochastic effects on the constraints is handled by constraint back-off and the MPC problem can still be solved by solution of either a linear program or a quadratic program. Treating the constraints as probabilistic constraints provides a more systematic approach to handle the stochastic effects on constraints. In this formulation, the MPC may be represented by a chance constrained mathematical program. The chance constraints allow a direct tradeoff between a certain (low) frequency of violating the constraints and a performance function (e.g. an economic loss function). This is convenient for energy systems, since some constraints are very important to satisfy with a high probability, whereas violation of others are less prone to have a large economic penalty. In MPC applications the control action is obtained by solving an optimization problem at each sampling instant. To make the controller applicable in real-time efficient and reliable algorithms are required. If the uncertainty is assumed to be Gaussian, the optimization problems associated with chance constrained (linear) MPC can be expressed as second order cone programming (SOCP) problems. In this paper, we show that tailored interior point algorithms are well suited to handle this type of problems. Namely, by utilizing structure-exploiting methods, we implement a special-purpose solver for control of smart energy systems. The solver is compared against general-purpose implementations. As a case study, we consider a system consisting of fuel-fired thermal power plants, wind farms and electric vehicles.

General information
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Studies of Heat Dynamics in an Arctic Low-energy House

A low energy house situated in Sisimiut, Greenland is used as study object for analysis of dynamic thermal properties of energy efficient buildings. The building is instrumented with a number of energy meters and thermal sensors, and these thermal data are logged with fine time intervals. Statistical methods are being developed in a PhD project to derive the properties to be used in a dynamic thermal model of the whole building. Characteristic of the building is its exposure to the extreme Arctic climate, which is both very cold and where the sun in some periods may shine constantly, or not at all. The house is equipped with a weather station measuring temperature, solar radiation, wind speed and direction. The building is highly energy efficient and its performance has been followed since its inception in 2005. The energy efficiency of the building is due to good thermal insulation, large energy-efficient windows, and heat recovery. The house is divided into two symmetric apartments, of which one is inhabited by a family, and the other is used for experiments and demonstration. The situation provides unique options for measuring and analysis with large signal to noise ratios facilitating observation of thermal response to external temperatures, solar radiation, wind, user behaviour, and heating.

Tuning of Controller for Type 1 Diabetes Treatment with Stochastic Differential Equations

People with type 1 diabetes need several insulin injections every day to keep their blood glucose level in the normal range and thereby avoiding the acute and long term complications of diabetes. One of the recent treatments consists of a pump injecting insulin into the subcutaneous layer combined with a continuous glucose monitor (CGM) frequently observing the glucose level. Automatic control of the insulin pump based on CGM observations would ease the burden of constant diabetes treatment and management. We have developed a controller designed to keep the blood glucose level in the normal range by adjusting the size of insulin infusions from the pump based on model predictive control (MPC). A clinical pilot study to test the performance of the MPC controller overnight was performed. The conclusion was that the controller relied too much on the local trend of the blood glucose level which is a problem due to the noise corrupted observations from the CGM. In this paper we present a method to estimate the optimal Kalman gain in the controller based on stochastic differential equation modeling. With this model type we could estimate the process noise and observation noise separately based on data from the rst clinical pilot study. In doing so we obtained a more robust control algorithm which is
less sensitive to fluctuations in the CGM observations and rely more on the global physiological trend of the blood glucose level. Finally, we present the promising results from the second pilot study testing the improved controller.

**General information**

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**Uncertainty in prediction and simulation of flow in sewer systems**

Models are commonly applied for design of urban drainage systems. Typically, they are of deterministic nature although it is well accepted that they only reflect reality approximately. When measurements are available they can be used for calibration of models. However, deviations between model outputs and observations will often remain and should hence be quantified, especially when used for model predictive control. The objective with this thesis has been to quantify and qualify the modelled output uncertainty. For this purpose a catchment in Ballerup (1,320 hectares) was selected and data included flow from downstream the catchment, rain measured at two rain gauges and monthly evaporation. The data period covered subperiods of 2007-2010. The catchment area consists of both combined and separated drainage systems and significant infiltration inflow enters the system through permeable surface areas. The simple serial linear reservoir flow routing principle was applied for modelling both the fast rainfall runoff from paved areas and the slow infiltration inflow from permeable areas. The wastewater flow variation was modelled by a harmonic function. Models of different complexity in terms of describing features such as flow constraints, basins and pumps were tested for their ability to describe the output with a time resolution of 15 minutes.

Two approaches to uncertainty quantification were distinguished and adopted, the stochastic and the epistemic method. Stochastic uncertainty refers to the randomness observed in nature, which is normally irreducible due to the inherent variation of physical systems. Epistemic uncertainty on the contrary arises from incomplete knowledge about a physical system. For quantifying stochastic uncertainties a frequentist approach was applied whereas the generalised likelihood uncertainty estimation method (GLUE) was adopted for the epistemic approach. Two different uncertainty estimates were furthermore distinguished: prediction and simulation uncertainty. To quantify the prediction uncertainty the model should accommodate an updating step thereby benefitting from observations that arrive in continuation of the predictions made. The simulation uncertainty on the other hand is calculated from data of a limited measuring campaign and the model does not accommodate a model correction step. The stochastic approach was applied for uncertainty quantification in both prediction and simulation whereas the epistemic uncertainty was assessed only in simulation. A maximum likelihood method was applied for parameter estimation in the stochastic approach, i.e. one optimal parameter set was derived that minimises the errors between model outputs and observations. Conversely in GLUE, parameters are viewed as stochastic variables and many acceptable parameter sets were therefore identified.

The predictive stochastic models were built on stochastic differential equations that include a drift term containing the physical description of the model and a diffusion term describing the uncertainty in the state variables. Additionally the observation noise is accounted for by a separate observation noise term. This approach is also referred to as stochastic grey-box modelling. A state dependent diffusion term was developed using a Lamperti transformation of the states, and implemented to compensate for heteroscedastic state uncertainty and to avoid predicting negative states. A flow proportional observation noise term introduced by a log transform was furthermore used to avoid predicting negative flows. In the simplest stochastic prediction models all parameters were estimated easily; however increasing the deterministic model complexity involved that some of the parameters had to be fixed. The statistical assumptions that require the residuals to correspond to a white noise process were fulfilled for the one-step prediction but beyond the one-step prediction auto-correlated residuals were obtained. The Akaike’s (AIC) and the Bayesian (BIC) information criteria were
used to identify preferred models for the one-step prediction whereas a skill scoring criterion addressing both the reliability and the sharpness of the confidence bounds was used when assessing the forecasting performance beyond the one-step. The reliability was satisfied for the one-step prediction but were increasingly biased as the prediction horizon was expanded, particularly in rainy periods.

GLUE was applied for estimating uncertainty in such a way that the selection of behavioral parameter sets continued until a required coverage of observations was obtained (targeting 90%). A likelihood measure were used for ranking the parameter sets and two different ways of drawing parameter sets were tested, a Latin Hypercube Monte Carlo method and a modified Monte Carlo Markov Chain method. When using the stochastic models for simulation, it was found that the simulation uncertainty was best described when estimating parameters by the output error minimisation method. In order to remove the heteroschedastic residuals structure it were necessary to apply a transformation of the observations. However autocorrelation remained in the simulation case. A skill scoring comparison of a simulation and a prediction model showed that a major improvement is gained by updating the model states continuously, i.e. updating of model states results in much lower forecasting uncertainty at shorter prediction steps. In the GLUE methodology there are no requirements to the residuals. Nevertheless the aim is the same as for the stochastic simulation models, namely to cover a proportion of observations consistent with the considered quantile with maximum sharpness, i.e. to minimise the skill score. In one calibration case, even though very broad prior parameter ranges were specified, it was difficult to acquire a 90% coverage of observations and the reliability in rainy periods was much lower than in dry weather. However the GLUE method proved quite consistent in the sense that similar coverage rates were obtained in both calibration and validation periods with the same set of retained parameter sets. A comparison of the stochastic and epistemic approaches to uncertainty evaluation was conducted by comparing the sharpness, the reliability and the skill score on the same set of data. Very similar performance was obtained with the stochastic method as the preferred. The thesis has demonstrated that the statistical requirements to the formal stochastic approach are very hard to fulfill in practice when prediction steps beyond the one-step is considered. Thus the underlying assumption of the GLUE methodology, that uncertainty in modeling and simulation is not only of stochastic nature, seems fairly consistent with the results of this thesis. A major drawback of the GLUE methodology as applied here is the lumping of total uncertainty into the parameters, which entails a loss of physicality of the model parameters. Conversely the parameter estimates of the stochastic approach are physically meaningful. This thesis has contributed to developing simplified rainfall-runoff models that are suitable for model predictive control of urban drainage systems that takes uncertainty into account.

General information
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Weather radars - A new pair of eyes for offshore wind farms?

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Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics, Department of Wind Energy, Meteorology, DHI Denmark, Danish Meteorological Institute , DONG Energy A/S, Vattenfall A/S
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Web server's reliability improvements using recurrent neural networks
In this paper we describe an interesting approach to error prediction illustrated by experimental results. The application consists of monitoring the activity for the web servers in order to collect the specific data. Predicting an error with severe consequences for the performance of a server (the result of which is that its functionality becomes totally inaccessible or hard to access for clients) requires measuring the capacity of a server at any given time. This measurement is highly complex, if not impossible. There are several variables which we can measure on a running system, such as: CPU usage, network usage and memory usage. We collect different data sets from monitoring the web server’s activity and for each one we predict the server's reliability with the proposed recurrent neural network. © 2012 Taylor & Francis Group

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Analysis and treatment of the Søndersø time series: Grey Box Well Field Modelling
This report deals with grey box modelling applied to the Well Field Optimisation project. The subject is the real case study of Søndersø, located north-west of Copenhagen, DK. This report contains a comprehensive description on how the dataset of measurements taken at Søndersø have been treated and analysed. The purpose of such analysis is twofold. Firstly is to identify a suitable architecture for the grey-box model. Secondly to design a procedure to select values from the dataset that will be used for the calibration of the parameters of the grey-box model. Section 1 describes the Søndersø well field, and provides an overview of the dataset. Section 2 describes the numeric treatments that have been applied to the dataset; the result is summarized in Section 3. Section 4 illustrates the analysis performed on the treated dataset. In this section, the fundamental mechanisms of the well field system are detected and decomposed (subsections 4.1 - 4.3). Based on the results of such analysis, a simple modelling exercise is performed showing that linear models can be effectively employed to simulate a well field (subsection 4.4). Section 5 describes a sampling approach, designed to calibrate the parameters of the grey-box model with a representative database which is also reasonably reduced in size. Summary and conclusions are in Section 6.

General information
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Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Department of Hydrodynamics and Water Resources
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Can Weather Radars Help Monitoring and Forecasting Wind Power Fluctuations at Large Offshore Wind Farms?

The substantial impact of wind power fluctuations at large offshore wind farms calls for the development of dedicated monitoring and prediction approaches. Based on recent findings, a Local Area Weather Radar (LAWR) was installed at Horns Rev with the aim of improving predictability, controllability and potentially maintenance planning. Additional images are available from a Doppler radar covering the same area. The parallel analysis of rain events detection and of regime sequences in wind (and power) fluctuations demonstrates the interest of employing weather radars for a better operation and management of offshore wind farms.

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Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, DHI Denmark, Vattenfall A/S, DONG Energy A/S
Authors: Trombe, P. (Intern), Pinson, P. (Intern), Madsen, H. (Intern), Jensen, N. E. (Ekstern), Pedersen, L. B. (Ekstern), Sommer, A. (Ekstern), Le, N. F. (Ekstern)
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Closed-Loop and Semi Closed-Loop Strategies for Control of Blood Glucose in People with Type 1 Diabetes

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Estimating animal behaviour and residency from movement data

We present a process-based approach to estimate residency and behavior from uncertain and temporally correlated movement data collected with electronic tags. The estimation problem is formulated as a hidden Markov model (HMM) on a spatial grid in continuous time, which allows straightforward implementation of barriers to movement. Using the grid to explicitly resolve space, location estimation can be supplemented by or based entirely on environmental data (e.g. temperature, daylight). The HMM method can therefore analyze any type of electronic tag data. The HMM computes the joint posterior probability distribution of location and behavior at each point in time. With this, the behavioral state of the animal can be associated to regions in space, thus revealing migration corridors and residence areas. We demonstrate the inferential potential of the method by analyzing satellite-linked archival tag data from a southern bluefin tuna Thunnus maccoyii where longitudinal coordinates inferred from daylight are supplemented by latitudinal information in recorded sea surface temperatures.

General information
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Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Section for Population Ecology and Genetics, National Institute of Aquatic Resources, Commonwealth Scientific and Industrial Research Organisation
Estimation methods for nonlinear state-space models in ecology

The use of nonlinear state-space models for analyzing ecological systems is increasing. A wide range of estimation methods for such models are available to ecologists, however it is not always clear, which is the appropriate method to choose. To this end, three approaches to estimation in the theta logistic model for population dynamics were
benched by Wang (2007). Similarly, we examine and compare the estimation performance of three alternative methods using simulated data. The first approach is to partition the state-space into a finite number of states and formulate the problem as a hidden Markov model (HMM). The second method uses the mixed effects modeling and fast numerical integration framework of the AD Model Builder (ADMB) open-source software. The third alternative is to use the popular Bayesian framework of BUGS. The study showed that state and parameter estimation performance for all three methods was largely identical, however with BUGS providing overall wider credible intervals for parameters than HMM and ADMB confidence intervals.

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BFI (2008): BFI-level 1
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Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.335 SNIP 1.363
Web of Science (2007): Indexed yes
Generating flow forecasts with uncertainty limits from rain gauge inputs in sewer systems require simple models with identifiable parameters that can adequately describe the stochastic phenomena of the system. In this paper, a simple grey-box model is proposed that is attractive for both forecasting and control purposes. The grey-box model is based on stochastic differential equations and a key feature is the separation of the total noise into process and measurement noise. The grey-box approach is properly introduced and hypothesis regarding the noise terms are formulated. Three different hypotheses for the diffusion term are investigated and compared: one that assumes additive diffusion; one that assumes state proportional diffusion; and one that assumes state exponentiated diffusion. To implement the state dependent diffusion terms Itô's formula and the Lamperti transform are applied. It is shown that an additive diffusion noise term description leads to a violation of the physical constraints of the system, whereas a state dependent diffusion noise avoids this problem and should be favoured. It is also shown that a logarithmic transformation of the flow measurements secures positive lower flow prediction limits, because the observation noise is proportionally scaled with the modelled output. Finally it is concluded that a state proportional diffusion term best and adequately describes the one-step flow prediction uncertainty, and a proper description of the system noise is important for ascertaining the physical parameters in question.

**General information**

State: Published  
Organisations: Urban Water Engineering, Department of Informatics and Mathematical Modeling, Mathematical Statistics, Department of Environmental Engineering  
Authors: Breinholt, A. (Intern), Thordarson, F. Ö. (Intern), Møller, J. K. (Intern), Grum, M. (Intern), Mikkelsen, P. S. (Intern), Madsen, H. (Intern)  
Pages: 946-961  
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Main Research Area: Technical/natural sciences

**Publication information**

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Volume: 22  
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ISSN (Print): 1180-4009  
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BFI (2018): BFI-level 1  
BFI (2017): BFI-level 1  
Web of Science (2017): Indexed Yes  
BFI (2016): BFI-level 1  
Scopus rating (2016): SJR 0.944 SNIP 1.045 CiteScore 1.59  
BFI (2015): BFI-level 1  
Scopus rating (2015): SJR 1.014 SNIP 0.892 CiteScore 1.48  
BFI (2014): BFI-level 1  
Scopus rating (2014): SJR 1.061 SNIP 1.178 CiteScore 1.64  
Web of Science (2014): Indexed yes  
BFI (2013): BFI-level 1  
Scopus rating (2013): SJR 1.073 SNIP 1.228 CiteScore 1.65
Grey Box Modelling of Hydrological Systems: With Focus on Uncertainties

The main topic of the thesis is grey box modelling of hydrologic systems, as well as formulation and assessment of their embedded uncertainties. Grey box model is a combination of a white box model, a physically-based model that is traditionally formulated using deterministic ordinary differential equations, and a black box model, which relates to models that are obtained statistically from input-output relations. Grey box model consists of a system description, defined by a finite set of stochastic differential equations, and an observation equation. Together, system and observation equations represent a stochastic state space model. In the grey box model the total noise is divided into a measurement noise and a process noise. The process noise is due to model approximations, undiscovered input and uncertainties in the input series. Estimates of the process noise can be used to highlight the lack of fit in state space formulation, and further support decisions for a model expansion. By using stochastic differential equations to formulate the dynamics of the hydrological system, either the complexity of the model can be increased by including the necessary hydrological processes in the model, or formulation of process noise can be considered so that it meets the physical limits of the hydrological system and give an adequate description of the embedded uncertainty in model structure. The thesis consists of two parts: a summary report and a part which contains six scientific papers. The summary report is divided into three distinct parts that introduce the main concepts and methods used in the following papers. The first part contains the basic concepts in hydrology and related hydrological models. The second part explains the grey box model by presenting stochastic differential equations and show how the equations can be linked to the available measurements. Moreover, impulse response function models are introduced as an alternative to stochastic differential equation based models, but by exploiting known hydrological models as the impulse response function in this model makes this model framework partly physically-based. For estimating the parameters in the grey box models maximum likelihood method is used. The third important part of the summary report is predictions, and with focus on uncertainty of prediction intervals the corresponding performance measures have to include the intervals. The thesis illustrates three performance measures for this performance evaluations: reliability, sharpness and resolution. For decision making, a performance criterion is preferred that quantifies all of these measures in a single number, and for that the quantile skill score criterion is discussed in this
thesis. The second part of the thesis, which contains the papers, is divided into two different subjects. First are four papers, which consider the grey box model approach to a well field with several operating pumps. The model foundation is the governing equation for groundwater flow, which can be simplified and represented a state space form that resembles the methods used in numerical methods for well field modelling. The objective in the first two papers is to demonstrate how a simple grey box model is formulated and, subsequently, extended in terms of parameter estimation using statistical methods. The simple models in these papers consider only part of the well field, but data analysis reveals that the wells in the well field are highly correlated. In the third paper, all wells pumping from the same aquifer are included in the state space formulation of the model, but instead, but instead of extending the physical description of the system, the uncertainty is formulated to handle the spatio-temporal variation in the output. The uncertainty in the model are then evaluated by using the quantile skill score criterion. In the fourth paper, the well field is formulated by considering the impulse response function models to describe water level variation in the wells, as a function of available pumping rates in the well field. The paper illustrates, through a case study, how the model can be used to define and solve the well field management problem. The second half of part II consists of two papers where the stochastic differential equation based model is used for sewer runoff from a drainage system. A simple model is used to describe a complex rainfall-runoff process in a catchment, but the stochastic part of the system is formulated to include the increasing uncertainty when rainwater flows through the system, as well as describe the lower limit of the uncertainty when the flow approaches zero. The first paper demonstrates in detail the grey box model and all related transformations required to obtain a feasible model for the sewer runoff. In the last paper this model is used to predict the runoff, and the performances of the prediction intervals are evaluated by the quantile skill score criterion.
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.088 SNIP 2.174 CiteScore 4.07
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.123 SNIP 2.936 CiteScore 4.21
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.897 SNIP 2.433 CiteScore 3.79
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.816 SNIP 2.737 CiteScore 3.36
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.506 SNIP 2.536 CiteScore 3.23
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.631 SNIP 2.081
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.564 SNIP 1.79
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.624 SNIP 2.028
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.033 SNIP 1.718
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.411 SNIP 1.788
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.293 SNIP 1.277
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.81 SNIP 1.628
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.567 SNIP 1.4
Scopus rating (2002): SJR 1.172 SNIP 1.631
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.942 SNIP 1.095
Scopus rating (2000): SJR 0.505 SNIP 1.226
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 0.25 SNIP 0.589

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DOIs:
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Links:
http://dx.doi.org/10.1016/j.enbuild.2011.02.005
Source: orbit
Source-ID: 270792
Publication: Research - peer-review › Journal article – Annual report year: 2011
Improved experimental setup for observation of non-linear heat dynamics

Modeling of heat dynamics of houses have been reported successful using linear dynamical models. The room they leave for improvement is because of physical relations believed to be partly caused by non-linear relations. As model complexity increases, detailed measurements and highly modular experiments are gaining importance in estimation of model parameters. This paper describes test facilities and new measurement equipment in a low-energy house in arctic area. Furthermore, some of the models that will be applied are described.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Section for Building Physics and Services, Department of Civil Engineering, ENFOR A/S
Authors: Andersen, P. H. D. (Intern), Madsen, H. (Intern), Bacher, P. (Intern), Rode, C. (Intern), Nielsen, H. A. (Ekstern)
Publication date: 2011

Host publication information
Title of host publication: Proceedings of the DYNASTEE international workshop
Main Research Area: Technical/natural sciences
Workshop: DYNASTEE International Workshop on Whole Building Testing, Evaluation and Modelling for Energy Assessment, Lyngby, Denmark, 18/05/2011 - 18/05/2011
Electronic versions:
pd_paper_dynastee_2011.pdf
Source: orbit
Source-ID: 316149
Publication: Research - peer-review › Article in proceedings – Annual report year: 2011

Individual based population inference using tagging data

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Section for Population Ecology and Genetics, National Institute of Aquatic Resources, Section for Freshwater Fisheries Ecology
Publication date: 2011
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 279243
Publication: Research › Conference abstract for conference – Annual report year: 2011

Influence of local wind speed and direction on wind power dynamics – Application to offshore very short-term forecasting

Wind power time series usually show complex dynamics mainly due to non-linearities related to the wind physics and the power transformation process in wind farms. This article provides an approach to the incorporation of observed local variables (wind speed and direction) to model some of these effects by means of statistical models. To this end, a benchmarking between two different families of varying-coefficient models (regime-switching and conditional parametric models) is carried out. The case of the offshore wind farm of Horns Rev in Denmark has been considered. The analysis is focused on one-step ahead forecasting and a time series resolution of 10 min. It has been found that the local wind direction contributes to model some features of the prevailing winds, such as the impact of the wind direction on the wind variability, whereas the non-linearities related to the power transformation process can be introduced by considering the local wind speed. In both cases, conditional parametric models showed a better performance than the one achieved by the regime-switching strategy. The results attained reinforce the idea that each explanatory variable allows the modelling of different underlying effects in the dynamics of wind power time series.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas, Universidad Politécnica de Madrid
Authors: Gallego, C. (Ekstern), Pinson, P. (Intern), Madsen, H. (Intern), Costa, A. (Ekstern), Cuerva, A. (Ekstern)
Pages: 4087-4096
Publication date: 2011
Main Research Area: Technical/natural sciences

Publication information
Journal: Applied Energy
Volume: 88
Issue number: 11
Insulin Administration for People with Type 1 diabetes

In this paper, we apply model predictive control (MPC) for control of blood glucose in people with type 1 diabetes. The two first control strategies are based on nonlinear model predictive control (NMPC). The first control strategy is based on meal announcement in advance, while the second one considers meal announcement at mealtimes only. They give a quantitative upper bound on the achievable control performance. The third control strategy is a feedforward-feedback control strategy. This strategy uses a time-varying setpoint to reduce the risk of hypoglycemia. The feedback controller computes the optimal basal insulin infusion rate. The feedforward controller consists of a bolus calculator. It computes the optimal bolus, along with the time-varying glucose setpoint. We test these three strategies on a virtual patient with type 1 diabetes. The numerical results demonstrate the robustness of the last control strategy with respect to changes in the model parameters and incorrect meal announcement.

Introduction to general and generalized linear models

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Madsen, H. (Intern), Thyregod, P. (Intern)
Number of pages: 302
Publication date: 2011
Markov chain modeling of precipitation time series: Modeling waiting times between tipping bucket rain gauge tips

A very fine temporal and volumetric resolution precipitation time series is modeled using Markov models. Both 1st and 2nd order Markov models as well as seasonal and diurnal models are investigated and evaluated using likelihood based techniques. The 2nd order Markov model is found to be insignificant. The 1st order Markov model seems to be the most important, followed by the seasonal and diurnal ones. The final model is a continuous state-space 1st order Markov process with seasonal variation. Inclusion of seasonality in the continuous Markov chain model proved difficult, and with respect to likelihood it actually makes the model fit decrease.

Mechanism-based population modelling for assessment of L-cell function based on total GLP-1 response following an oral glucose tolerance test

GLP-1 is an insulinotropic hormone that synergistically with glucose gives rise to an increased insulin response. Its secretion is increased following a meal and it is thus of interest to describe the secretion of this hormone following an oral glucose tolerance test (OGTT). The aim of this study was to build a mechanism-based population model that describes the time course of total GLP-1 and provides indices for capability of secretion in each subject. The goal was thus to model the secretion of GLP-1, and not its effect on insulin production. Single 75 g doses of glucose were administered orally to a mixed group of subjects ranging from healthy volunteers to patients with type 2 diabetes (T2D). Glucose, insulin, and total GLP-1 concentrations were measured. Prior population data analysis on measurements of glucose and insulin were performed in order to estimate the glucose absorption rate. The individual estimates of absorption rate constants were used in the model for GLP-1 secretion. Estimation of parameters was performed using the FOCE method with interaction implemented in NONMEM VI. The final transit/indirect-response model obtained for GLP-1 production following an OGTT included two stimulation components (fast, slow) for the zero-order production rate. The fast stimulation was estimated to be faster than the glucose absorption rate, supporting the presence of a proximal–distal loop for fast secretion from L-cells. The fast component (st 3 = 8.64·10−5 [mg−1]) was estimated to peak around 25 min after glucose ingestion, whereas the slower component (st 4 = 26.2·10−5 [mg−1]) was estimated to peak around 100 min. Elimination of total GLP-1 was characterised by a first-order loss. The individual values of the early phase GLP-1 secretion parameter (st 3 ) were correlated (r = 0.52) with the AUC(0–60 min.) for GLP-1. A mechanistic population model was successfully developed to describe total GLP-1 concentrations over time observed after an OGTT. The model provides indices related to different mechanisms of subject abilities to secrete GLP-1. The model provides a good basis to study influence of different demographic factors on these components, presented mainly by indices of the fast- and slow phases of GLP-1 response.
Meso-scale Wind Variability. Final Report

General information
State: Published
Authors: Larsen, S. E. (Intern), Larsen, X. G. (Intern), Vincent, C. L. (Intern), Sørensen, P. E. (Intern), Pinson, P. (Intern), Trombe, P. (Intern), Madsen, H. (Intern), Cutululis, N. A. (Intern)
Number of pages: 114
Publication date: 2011

Original language: English
DOIs:
10.1007/s10928-011-9216-2
Source: orbit
Source-ID: 312496
Publication: Research - peer-review › Journal article – Annual report year: 2011
**Models of the heat dynamics of solar collectors for performance testing**

The need for fast and accurate performance testing of solar collectors is increasing. This paper describes a new technique for performance testing which is based on non-linear continuous time models of the heat dynamics of the collector. It is shown that all important performance parameters can be accurately estimated with measurements from a single day. The estimated parameters are compared with results from standardized test methods (Fischer et al., 2004). Modelling the dynamics of the collector is carried out using stochastic differential equations, which is a well proven efficient method to obtain accurate estimates of parameters in physical models. The applied method is described by Kristensen et al. (2004) and implemented in the software CTSM1. Examples of successful applications of the method includes modelling the of the heat dynamics of integrated photo-voltaic modules (Friling et al., 2009) and modelling of the heat dynamics of buildings (Madsen and Holst, 1995). Measurements obtained at a test site in Denmark during the spring 2010 are used for the modelling. The tested collector is a single glazed large area flat plate collector with selective absorber and Teflon anti convection layer. The test rig is described in Fan et al. (2009). The modelling technique provides uncertainty estimates such as confidence intervals for the parameters, and furthermore enables statistical validation of the results. Such tests can also facilitate procedures for selecting the best model to use, which is a very non-trivial task.

**General Information**

State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Section for Building Physics and Services, Department of Civil Engineering
Authors: Bacher, P. (Intern), Madsen, H. (Intern), Perers, B. (Intern)
Publication date: 2011

**Host publication information**

Title of host publication: Proceedings of ISES Solar World Conference 2011
Main Research Area: Technical/natural sciences
Electronic versions: Bacher2011b.pdf
Source: orbit
Source-ID: 312983
Publication: Research - peer-review › Article in proceedings – Annual report year: 2011

**Nonlinear tracking in a diffusion process with a Bayesian filter and the finite element method**

A new approach to nonlinear state estimation and object tracking from indirect observations of a continuous time process is examined. Stochastic differential equations (SDEs) are employed to model the dynamics of the unobservable state. Tracking problems in the plane subject to boundaries on the state-space do not in general provide analytical solutions. A widely used numerical approach is the sequential Monte Carlo (SMC) method which relies on stochastic simulations to approximate state densities. For offline analysis, however, accurate smoothed state density and parameter estimation can become complicated using SMC because Monte Carlo randomness is introduced. The finite element (FE) method solves the Kolmogorov equations of the SDE numerically on a triangular unstructured mesh for which boundary conditions to the state-space are simple to incorporate. The FE approach to nonlinear state estimation is suited for off-line data analysis because the computed smoothed state densities, maximum a posteriori parameter estimates and state sequence are deterministic conditional on the finite element mesh and the observations. The proposed method is conceptually similar to existing point-mass filtering methods, but is computationally more advanced and generally applicable. The performance of the FE estimators in relation to SMC and to the resolution of the spatial discretization is examined empirically through simulation. A real-data case study involving fish tracking is also analysed.
Online Short-term Solar Power Forecasting

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Bacher, P. (Intern), Madsen, H. (Intern), Nielsen, H. A. (Intern)
Publication date: 2011

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Title of host publication: Proceedings from 1'th International Workshop on Integration of Solar Power into Power Systems
Main Research Area: Technical/natural sciences
Electronic versions:
Poster_SIW11_046_Bacher.pdf
Links:
http://www.solarintegrationworkshop.org/
Source: orbit
Source-ID: 312976
Publication: Research - peer-review › Article in proceedings – Annual report year: 2011

Parameter estimation in a simple stochastic differential equation for phytoplankton modelling

The use of stochastic differential equations (SDEs) for simulation of aquatic ecosystems has attracted increasing attention in recent years. The SDE setting also provides the opportunity for statistical estimation of ecosystem parameters. We present an estimation procedure, based on Kalman filtering and likelihood estimation, which has proven useful in other fields of application. The estimation procedure is presented and the development from ordinary differential equations (ODEs) to SDEs is discussed with emphasis on autocorrelated residuals, commonly encountered with ODEs. The estimation procedure is applied to a simple nitrogen-phytoplankton model, with data from a Danish estuary (1988-2006). The resulting SDE is simple enough to have a well-known stationary distribution and this distribution is presented.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, National Environmental Research Institute
Authors: Møller, J. K. (Intern), Madsen, H. (Intern), Carstensen, J. (Ekstern)
Pages: 1793-1799
Publication date: 2011
Main Research Area: Technical/natural sciences

Publication information
Journal: Ecological Modelling
Extended Kalman Filter, Phytoplankton modelling, Parameter estimation, Maximum likelihood estimation, Stochastic differential equations

DOIs:
10.1016/j.ecolmodel.2011.03.025
Radar@Sea - Towards improving short-term wind power forecasts

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Trombe, P. (Intern), Pinson, P. (Intern), Thomsen, S. C. (Intern), Madsen, H. (Intern)
Publication date: 2011
Event: Poster session presented at European Geosciences Union General Assembly 2011, Vienna, Austria.
Main Research Area: Technical/natural sciences
Electronic versions:
posterEGU_online_final_pjt.pdf
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Publication: Research › Poster – Annual report year: 2011

Scenario generation: A review

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Otterson, S. (Intern), Madsen, H. (Intern), Pinson, P. (Intern), Jónsson, T. (Intern)
Publication date: 2011

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Place of publication: Kgs. Lyngby, Denmark
Publisher: DTU Informatics, Building 305
Original language: English
Series: IMM-Technical Report-2011-08
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 276987
Publication: Research › Report – Annual report year: 2011

Short-Term Solar Collector Power Forecasting

This paper describes a new approach to online forecasting of power output from solar thermal collectors. The method is suited for online forecasting in many applications and in this paper it is applied to predict hourly values of power from a standard single glazed large area flat plate collector. The method is applied for horizons of up to 42 hours. Solar heating systems naturally come with a hot water tank, which can be utilized for energy storage also for other energy sources. Thereby such systems can become an important part of energy systems with a large share of uncontrollable energy sources, such as wind power. In such a scenario online forecasting is a vital tool for optimal control and utilization of solar heating systems. The method is a two-step scheme, where first a non-linear model is applied to transform the solar power into a stationary process, which then is forecasted with robust time-adaptive linear models. The approach is similar to the one by Bacher et al. (2009), but contains additional effects due to differences between solar thermal collectors and photovoltaics. Numerical weather predictions provided by Danish Meteorological Institute are used as input. The applied models adapt over time enabling tracking of changes in the system and in the surrounding conditions, such as decreasing performance due to wear and dirt, and seasonal changes such as leaves on trees. This furthermore facilitates remote monitoring and check of the system.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Section for Building Physics and Services, Department of Civil Engineering
Authors: Bacher, P. (Intern), Madsen, H. (Intern), Perers, B. (Intern)
Publication date: 2011

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Title of host publication: Proceedings of ISES Solar World Conference 2011
Main Research Area: Technical/natural sciences
Spatio‐temporal analysis and modeling of short‐term wind power forecast errors

Forecasts of wind power production are increasingly being used in various management tasks. So far, such forecasts and related uncertainty information have usually been generated individually for a given site of interest (either a wind farm or a group of wind farms), without properly accounting for the spatio‐temporal dependencies observed in the wind generation field. However, it is intuitively expected that, owing to the inertia of meteorological forecasting systems, a forecast error made at a given point in space and time will be related to forecast errors at other points in space in the following period. The existence of such underlying correlation patterns is demonstrated and analyzed in this paper, considering the case‐study of western Denmark. The effects of prevailing wind speed and direction on autocorrelation and cross‐correlation patterns are thoroughly described. For a flat terrain region of small size like western Denmark, significant correlation between the various zones is observed for time delays up to 5 h. Wind direction is shown to play a crucial role, while the effect of wind speed is more complex. Nonlinear models permitting capture of the interdependence structure of wind power forecast errors are proposed, and their ability to mimic this structure is discussed. The best performing model is shown to explain 54% of the variations of the forecast errors observed for the individual forecasts used today. Even though focus is on 1‐h‐ahead forecast errors and on western Denmark only, the methodology proposed may be similarly tested on the cases of further look‐ahead times, larger areas, or more complex topographies. Such generalization may not be straightforward. While the results presented here comprise a first step only, the revealed error propagation principles may be seen as a basis for future related work.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Tastu, J. (Intern), Pinson, P. (Intern), Kotwa, E. (Intern), Madsen, H. (Intern), Nielsen, H. A. (Intern)
Pages: 43-60
Publication date: 2011
Main Research Area: Technical/natural sciences

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Journal: Wind Energy
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BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.37 SJR 1.104 SNIP 2.306
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.196 SNIP 2.086 CiteScore 3.06
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.272 SNIP 3.75 CiteScore 3.42
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.275 SNIP 2.464 CiteScore 2.75
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.126 SNIP 2.39 CiteScore 2.36
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
Spatio-temporal correction of DONG forecast errors

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Thomsen, S. C. (Intern), Otterson, S. (Intern), Tastu, J. (Intern), Madsen, H. (Intern)
Publication date: 2011

Publication Information
Place of publication: Kgs. Lyngby, Denmark
Publisher: DTU Informatics, Building 305
Original language: English
Series: IMM-Technical Report-2011-09
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 276988
Publication: Research › Report – Annual report year: 2011

Spatio-temporal correction targeting Nysted Offshore. Probabilistic forecasts
This report concerns probabilistic forecasts for Nysted Offshore. Different approaches for issuing predictive densities are studied, discussed in details and compared. The results show that the spatial correction of the first order moments of the predictive densities improves the quality of the corresponding forecasts. The spatial correction of the higher order
moments is shown to be unnecessary as does not bring any additional amelioration. The best performing of the studied models is based on the adaptive quantile regression using the spatially corrected point predictions as input. This model is shown to outperform the benchmark approach in terms of the CRPS score (accuracy measure) by 1.5%-8.29% depending on the considered prediction horizon.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Tastu, J. (Intern), Pinson, P. (Intern), Trombe, P. (Intern), Madsen, H. (Intern)
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Publication date: 2011

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Place of publication: Kgs. Lyngby
Publisher: Technical University of Denmark (DTU)
Original language: English

Series: DTU Compute-Technical Report-2013
Number: 16
ISSN: 1601-2321
Main Research Area: Technical/natural sciences
Electronic versions:
tr13_16_Tastu_Pinson_Trombe_Madsen.pdf
Publication: Research › Report – Annual report year: 2011

General Modeling of Long Historical Rain Series

General information
State: Published
Organisations: Department of Environmental Engineering, Mathematical Statistics, Department of Informatics and Mathematical Modeling, Urban Water Engineering
Authors: Sørup, H. J. D. (Intern), Madsen, H. (Intern), Arnbjerg-Nielsen, K. (Intern)
Number of pages: 38
Pages: 22-23
Publication date: 2011

Host publication information
Title of host publication: Abstracts proceedings of the 5th Annual Meeting of The Danish Water Research Platform
Main Research Area: Technical/natural sciences
Electronic versions:
Abstract_HJDS_HM_KARN.pdf
Links:
http://www.forskningsplatformen-vand.dk/Documents/Annual%20meeting%202011/index.html
Source: orbit
Source-ID: 274854
Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2011

Stochastic State Space Modelling of Nonlinear systems - With application to Marine Ecosystems

This thesis deals with stochastic dynamical systems in discrete and continuous time. Traditionally dynamical systems in continuous time are modelled using Ordinary Differential Equations (ODEs). Even the most complex system of ODEs will not be able to capture every detail of a complex system like a natural ecosystem, and hence residual variation between the model and observations will always remain. In stochastic state-space models the residual variation is separated into observation and system noise and a main theme of the thesis is a proper description of the system noise. Additive Gaussian noise is the standard approach to introduce system noise, but this may lead to undesirable consequences for the state variables. In biological models, where the statespace generally contains positive real numbers only, modelling in the log-domain ensures positive state variables, however, this transformation is likely to conflict with the concept of mass balances. One of the central conclusions of the thesis is that the stochastic formulations should be an integral part of the model formulation. As discrete-time stochastic processes are simpler to handle numerically than continuous-time stochastic processes, I start by considering discrete-time processes. An novel approach combining multiplicative and additive log-normal noise has been developed in discrete time, and used to demonstrate the effect of stochastic forcing in simple discrete-time regime shift models. An approximate maximum likelihood estimation procedure based on the second order moment representation of the multiplicative and additive log-normal noise model was developed and tested in simulation studies. The transition to continuous-time stochastic models (here Stochastic Differential Equations (SDEs))
offers the opportunity of embedding parts of the ODE processes into the stochastic part of the model (the diffusion term). The estimation method we use here (maximum likelihood and the Extended Kalman Filter (EKF)) rely on state-independent diffusion, but for a wide class of SDEs there exist an alternative description (given by the Lamperti transform) of the input-output relation, where the diffusion term is independent of the state. This alternative description is used to develop better parametric descriptions of the diffusion term, while maintaining the opportunity of estimation by standard software. Additionally, the state-space formulation facilitates estimation of unobserved states. Based on estimation of random walk hidden states and examination of simulated distributions and stationarity characteristics, a methodological framework for structural identification based on information embedded in the observations of the system has been developed. The applicability of the methodology is demonstrated using phytoplankton and nitrogen data from a Danish estuary as well as bacterial growth data from a controlled experiment. In summary, the novelty of the work presented here is the introduction of more appropriate stochastic descriptions in non-linear state-space models, which can include combinations of additive and multiplicative noise components under various distributional assumptions. A model identification and estimation framework for working with such models has been developed and tested using data from biological and ecological systems typically characterised by non-linear and non-Gaussian responses.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Department of Environmental Science and Engineering
Authors: Møller, J. K. (Intern), Carstensen, N. J. (Intern), Madsen, H. (Intern)
Publication date: 2011

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Publisher: Technical University of Denmark (DTU)
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Main Research Area: Technical/natural sciences
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phd246-jkm.pdf
Source: orbit
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Strategies for glucose control in people with type 1 diabetes
In this paper we apply a robust feedforward-feedback control strategy to people with type 1 diabetes. The feedforward controller consists of a bolus calculator which compensates the disturbance coming from meals. The feedback controller is based on a linearized description of the model describing the patient. We minimize the risk of hypoglycemia by introducing a time-varying glucose setpoint based on the announced meal size and the physiological model of the patient. The simulation results are based on a virtual patient simulated by the Hovorka model. They include the cases where the insulin sensitivity changes, and mismatches in meal estimation. They demonstrate that the designed controller is able to achieve offset-free control when the insulin sensitivity change, and that having a time-varying reference signal enables more robust control of blood glucose in the cases where the meal size is known, but also when the ingested meal does not match the announced one.

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State: Published
Organisations: Center for Energy Resources Engineering, Department of Informatics and Mathematical Modeling, Scientific Computing, Mathematical Statistics
Publication date: 2011

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Title of host publication: Proceedings of the 18th World Congress of the International Federation of Automatic Control (IFAC)
Main Research Area: Technical/natural sciences
Electronic versions:
IFAC2011.pdf
DOIs:
10.3182/20110828-6-IT-1002.03714
The Universal Primer - An open source solution for archiving, organizing and streaming live lectures

Many disparate projects providing open access to educational videos are currently available or under development. These projects lack a unifying interface for accessing content, employ differing content licenses, and provide little or no infrastructure for user-contribution or live teaching. The goal of the Universal Primer is to address these problems, and allow anyone, anywhere, to teach or learn anything that can be reasonably taught or learned through a computer. The Universal Primer is 1: A fully open source solution for streaming live lectures. And 2: A Wikipedia-like website for uploading and organizing open-licensed community contributed educational material.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Technical University of Denmark
Authors: Christoffersen, M. J. (Ekstern), Panton, H. C. H. (Ekstern), Krajowski-Kukiel, M. (Ekstern), Fotel, D. C. A. (Ekstern), Madsen, H. (Intern), Lassen, J. K. (Intern), Haarlev Olsen, P. O. (Intern), Christiansen, L. E. (Intern)
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Links:
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Nonlinear Stochastic Modelling of Antimicrobial resistance in Bacterial Populations

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Philipsen, K. R. (Intern), Christiansen, L. E. (Intern), Madsen, H. (Intern)
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Main Research Area: Technical/natural sciences
Electronic versions:
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Source: orbit
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Publication: Research › Ph.D. thesis – Annual report year: 2010

Markov and mixed models with applications
This thesis deals with mathematical and statistical models with focus on applications in pharmacokinetic and pharmacodynamic (PK/PD) modelling. These models are today an important aspect of the drug development in the pharmaceutical industry and continued research in statistical methodology within these areas are thus important. PK models are concerned with describing the concentration profile of a drug in both humans and animals after drug intake whereas PD models are used to describe the effect of a drug in relation to the drug concentration. PK models for an
individual are usually described as a deterministic mean value using ordinary differential equations to which a random error is added. This thesis explores methods based on stochastic differential equations (SDEs) to extend the models to more adequately describe both true random biological variations and also variations due to unknown or uncontrollable factors in an individual. Modelling using SDEs also provides new tools for estimation of unknown inputs to a system and is illustrated with an application to estimation of insulin secretion rates in diabetic patients. Models for the effect of a drug is a broader area since drugs may affect the individual in almost any thinkable way. This project focuses on measuring the effects on sleep in both humans and animals. The sleep process is usually analyzed by categorizing small time segments into a number of sleep states and this can be modelled using a Markov process. For this purpose new methods for non-parametric estimation of Markov processes are proposed to give a detailed description of the sleep process during the night. Statistically the Markov models considered for sleep states are closely related to the PK models based on SDEs as both models share the Markov property. When the models are applied to clinical data there will often be a large variation between individuals and this can be included in both types of models using the mixed modelling approach. Estimation in these models is discussed with emphasis on data with a more complex grouping structure.
stoves which consumers share, the estimates can be corrected so that adequate values are obtained even for houses
where a wood burning stove is being used. The article includes a short outline of how the methods could be integrated in
an inter-active service such as “My E-Home” minbolig.elsparefonden.dk.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, ENFOR A/S
Authors: Nielsen, H. A. (Ekstern), Mortensen, S. B. (Ekstern), Bacher, P. (Intern), Madsen, H. (Intern)
Publication date: 2010

Host publication information
Title of host publication: Dynamic Methods for Building Energy Assessment
Main Research Area: Technical/natural sciences
Workshop: DYNASTEE International Workshop on Dynamic Methods for Building Energy Assessment, Brussels, Belgium,
11/10/2010 - 11/10/2010
Buildings, thermal characterization, energy labelling, heat consumption, energy performance, smart meters
Links:
http://www.dynastee.info/home.php
Source: orbit
Source-ID: 270965
Publication: Research › Article in proceedings – Annual report year: 2010

ARX MPC for people with type 1 diabetes
Type 1 diabetes is a chronic disease characterized by a lack of production of pancreatic insulin, consequently leading to
high blood glucose concentrations (hyperglycemia). Hyperglycemia has negative health effects in the long term such as
eye, nerve, and kidney disease. Exogenous insulin must be injected to keep the blood glucose in the normoglycemic
range (approximately 60 – 140 mg/dL, or 3.3 – 8 mmol/L). However, the dosing of exogenous insulin must be done
carefully, because low blood glucose concentrations (hypoglycemia) can have immediate and severe consequences like
insulin shock, coma, or even death. Currently, insulin administration is performed by the subject with type 1 diabetes
based on infrequent glucose measurements (in the form of finger-sticks), often resulting in an unsatisfactory blood glucose
control. An artificial pancreas is a medical device that injects exogenous insulin automatically in order to regulate the
glucose concentration. Blood glucose measurements are obtained from a continuous glucose monitor (CGM). Insulin is
administered either continuously through an insulin pump, or at discrete times using an insulin pen. A control algorithm
uses previous glucose measurements and insulin injection information to compute the optimal insulin administration for the
current conditions. We use model predictive control (MPC) to compute the optimal insulin administration for 20 virtual type
1 diabetes subjects. The system (i.e., subject) has one manipulated input (insulin infusion rate), one disturbance input
(carbohydrate meals), and one measured output (blood glucose concentration). The subject is represented by a system of
nonlinear differential equations describing the dynamic effects of insulin and meals on blood glucose. Twenty parameter
sets are used in the study, each representing a different virtual subject. The model used in the MPC is a low order
autoregressive exogenous-input (ARX) model. Due to both the linearity and relative parsimony of the ARX model, there is
a significant amount of subject/model mismatch in the model predictions, reflecting real-world conditions. In general, a
simple ARX MPC cannot reject a step disturbance without a resulting offset; thus, the state vector is reformulated using an
extended ΔARX description (E-ΔARX). The reference signal is time-varying, and is based on the optimal open-loop
glucose profile. Insulin-on-board constraints are implemented to avoid overdosing insulin. State estimation is based on a
Kalman filter using the noise model to simulate a realistic CGM. We present the MPC results for simulations of the 20
virtual subjects with type 1 diabetes. In particular, we investigate the effects of the prediction horizon length on the control
quality of blood glucose and the robustness of the solution.

General information
State: Published
Organisations: Scientific Computing, Department of Informatics and Mathematical Modeling, Mathematical Statistics,
Center for Energy Resources Engineering
Publication date: 2010
Main Research Area: Technical/natural sciences
Type 1 diabetes, ARX model, Model predictive control, Kalman filtering
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Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2010
Calibration of Local Area Weather Radar - Identifying significant factors affecting the calibration

A Local Area Weather Radar (LAWR) is an X-band weather radar developed to meet the needs of high resolution rainfall data for hydrological applications. The LAWR system and data processing methods are reviewed in the first part of this paper, while the second part of the paper focuses on calibration. The data processing for handling the partial beam filling issue was found to be essential to the calibration. LAWR uses a different calibration process compared to conventional weather radars, which use a power-law relationship between reflectivity and rainfall rate. Instead, LAWR uses a linear relationship of reflectivity and rainfall rate as result of the log transformation carried out by the logarithmic receiver as opposed to the linear receiver of conventional weather radars. Based on rain gauge data for a five month period from a dense network of nine gauges within a 500 x 500 m area and data from a nearby LAWR, the existing calibration method was tested and two new methods were developed. The three calibration methods were verified with three external gauges placed in different locations. It can be concluded that the LAWR calibration uncertainties can be reduced by 50% in two out of three cases when the calibration is based on a factorized 3 parameter linear model instead of a single parameter linear model.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Pedersen, L. (Intern), Jensen, N. E. (Ekstern), Madsen, H. (Intern)
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  Scopus rating (2016): SJR 1.568 SNIP 1.657 CiteScore 3.93
  BFI (2015): BFI-level 1
  Scopus rating (2015): SJR 1.65 SNIP 1.678 CiteScore 3.36
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  Scopus rating (2009): SJR 0.991 SNIP 1.212
  Web of Science (2009): Indexed yes
  BFI (2008): BFI-level 1
  Scopus rating (2008): SJR 0.779 SNIP 0.973
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  Scopus rating (2006): SJR 0.822 SNIP 0.813
  Scopus rating (2005): SJR 0.943 SNIP 1.003
Characterization and optimized control by means of multiparameter controllers

General information
State: Published
Organisations: Danish Technological Institute, DHI Denmark, Technical University of Denmark, Businessminds
Authors: Ostergaard Jensen, S. (Ekstern), Nielsen, C. (Ekstern), Heerup, C. (Ekstern), Madsen, H. (Intern), Olsen, L. (Ekstern), Toftum, J. (Ekstern), Andersen, P. H. D. (Intern), Trombe, P. (Intern), Laursen, S. (Ekstern)
Publication date: 2010

Publication information
Publisher: Centre for Refrigeration and Heat Pump Technology, Technological Institute
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Original language: English
Main Research Area: Technical/natural sciences
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Source: orbit
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Publication: Research › Report – Annual report year: 2010

Conditional Weighted Combination of Wind Power Forecasts

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Thordarson, F. Ø. (Intern), Madsen, H. (Intern), Nielsen, H. A. (Intern), Pinson, P. (Intern)
Pages: 751-763
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Main Research Area: Technical/natural sciences

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Web of Science (2017): Indexed yes
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Scopus rating (2016): CiteScore 3.37 SJR 1.104 SNIP 2.306
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Data for Energy Performance Analysis: Financed by The Danish Electricity Saving Trust

General information
State: Published
Organisations: Intelligent Energy Systems Programme, Risø National Laboratory for Sustainable Energy, Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Thavlov, A. (Intern), Bacher, P. (Intern), Madsen, H. (Intern)
Publication date: 2010

Publication information
Place of publication: Kgs. Lyngby
Publisher: Technical University of Denmark, DTU Informatics, Building 321
Dynamic testing, analysis and modelling

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Bloem, J. (Ekstern), Baker, P. (Ekstern), Strachen, P. (Ekstern), Madsen, H. (Intern), Vandaele, L. (Ekstern)
Pages: 473-500
Publication date: 2010

Host publication information
Title of host publication: Stimulating increased energy efficiency and better building ventilation: Leading actions coordinated by INIVE EEIG and sources of other relevant information on EU level and IEA ECBCS projects
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Main Research Area: Technical/natural sciences
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Experiments and Data for Building Energy Performance Analysis: Financed by The Danish Electricity Saving Trust

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Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Bacher, P. (Intern), Madsen, H. (Intern)
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Publisher: Technical University of Denmark, DTU Informatics, Building 321
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Electronic versions:
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Publication: Research › Report – Annual report year: 2010

Feedback, competition and stochasticity in a day ahead electricity market

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Giabardo, P. (Ekstern), Zugno, M. (Intern), Pinson, P. (Intern), Madsen, H. (Intern)
Pages: 292-301
Publication date: 2010
Main Research Area: Technical/natural sciences

Publication information
From State Dependent Diffusion to Constant Diffusion in Stochastic Differential Equations by the Lamperti Transform

This report describes methods to eliminate state dependent diffusion terms in Stochastic Differential Equations (SDEs). Transformations that leave the diffusion term of SDEs constant is important for simulation, and estimation. It is important for simulation because the Euler approximation convergence rate is faster, and for estimation because the Extended Kalman Filter equations are easier to implement than higher order filters needed in the case of state dependent diffusion terms. The general class of transformations which leaves the diffusion term independent of the state is called the Lamperti transform. This note gives an example driven introduction to the Lamperti transform. The general applicability of the
Lamperti transform is limited to univariate diffusion processes, but for a restricted class of multivariate diffusion processes Lamperti type transformations are available and the Lamperti transformation is discussed for both univariate and multivariate diffusion processes. Further some special attention is needed for time-inhomogeneous diffusion processes and these are discussed separately.

**General information**
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Møller, J. K. (Intern), Madsen, H. (Intern)
Number of pages: 25
Publication date: 2010

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Place of publication: Kgs. Lyngby, Denmark
Publisher: Technical University of Denmark, DTU Informatics, Building 321
Original language: English

**Hidden Markov modelling of movement data from fish**
Movement data from marine animals tagged with electronic tags are becoming increasingly diverse and plentiful. This trend entails a need for statistical methods that are able to filter the observations to extract the ecologically relevant content. This dissertation focuses on the development and application of hidden Markov models (HMMs) for analysis of movement data from fish. The main contributions are represented by six scientific publications. Estimation of animal location from uncertain and possibly indirect observations is the starting point of most movement data analyses. In this work a discrete state HMM is employed to deal with this task. Specifically, the continuous horizontal plane is discretised into grid cells, which enables a state-space model for the geographical location to be estimated on this grid. The estimation model for location is extended with an additional state representing the behaviour of the animal. With the extended model can migratory and resident movement behaviour be related to geographical regions. For population inference multiple individual state-space analyses can be interconnected using mixed effects modelling. This framework provides parameter estimates at the population level and allows ecologists to identify individuals that deviate from the rest of the tagged population. The thesis also deals with geolocation on state-spaces with complicated geometries. Using an unstructured discretisation and the finite element method tortuous shore line geometries are closely approximated. This furthermore enables accurate probability densities of location to be computed. Finally, the performance of the HMM approach in analysing nonlinear state space models is compared with two alternatives: the AD Model Builder framework and BUGS, which relies on Markov chain Monte Carlo estimation.

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Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Section for Population Ecology and Genetics, National Institute of Aquatic Resources
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Original language: English

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**Main Research Area:** Technical/natural sciences

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Source: orbit
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Publication: Research › Ph.D. thesis – Annual report year: 2010
Identification of ecosystem parameters by SDE-modelling

Stochastic differential equations (SDEs) for ecosystem modelling have attracted increasing attention during recent years. The modelling has mostly been through simulation experiments in order to analyse how system noise propagates through the ordinary differential equation formulation of ecosystem models. Estimation of parameters in SDEs is, however, possible by combining Kalman filter techniques and likelihood estimation. By modelling parameters as random walks it is possible to identify linear as well as non-linear interactions between ecosystem components. By formulating a simple linear SDE describing interactions between phytoplankton and water-column nitrogen with light as forcing, using data from a Danish estuary covering a 16 years period (1988-2003), and modelling primary production as a random walk, it is demonstrated how non-linear relationships between states can be identified by plotting the (random) production parameter as a function of the states in the system and global radiation. The resulting SDE model (that does not contain random walks), is analysed by simulation studies, to determine the properties of the seasonal distribution of phytoplankton.

**General information**

State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics, National Environmental Research Institute
Authors: Møller, J. K. (Intern), Madsen, H. (Intern), Carstensen, J. (Ekstern)
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**Publication information**

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Marine Ecosystems, Stochastic Differential Equations, Parameter Estimation, Parameter Identification, Nitrogen Phytoplankton models
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Implications and Limitations of Ideal Insulin Administration for People with Type 1 Diabetes

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Organisations: Center for Energy Resources Engineering, Department of Informatics and Mathematical Modeling, Scientific Computing, Mathematical Statistics
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Main Research Area: Technical/natural sciences
Conference: UKACC International Conference on CONTROL, Coventry, United Kingdom, 01/01/2010
Electronic versions: UKACC2010.pdf
Source: orbit
Source-ID: 266921
Publication: Research - peer-review › Article in proceedings – Annual report year: 2010

Individual based population inference using tagging data

A hierarchical framework for simultaneous analysis of multiple related individual datasets is presented. The approach is very similar to mixed effects modelling as known from statistical theory. The model used at the individual level is, in principle, irrelevant as long as a maximum likelihood estimate and its uncertainty (Hessian) can be computed. The individual model used in this text is a hidden Markov model. A simulation study concerning a two-dimensional biased random walk is examined to verify the consistency of the hierarchical estimation framework. In addition, a study based on acoustic telemetry data from pike illustrates how the framework can identify individuals that deviate from the remaining population.

**General information**

State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, National Institute of Aquatic Resources, Section for Population Ecology and Genetics, Section for Freshwater Fisheries Ecology
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**Publication information**

Place of publication: Kgs. Lyngby
Mathematical and Statistical Models and Methods for Describing the Thermal Characteristics of Buildings

This paper describes a number of statistical methods and models for describing the thermal characteristics of buildings using frequent readings of heat consumption, ambient air temperature, and other available climate variables. For some of the methods frequent readings of the indoor air temperature are needed or beneficial. The suite of models described consists of nonlinear stochastic models, linear stochastic models, transfer function models, frequency response function models, impulse response models and regression models. The final choice of model depends on the purpose of the modelling, existence of prior physical knowledge, the data and the available statistical software tools. The importance of statistical model validation is discussed, and some simple tools for that purpose are demonstrated. This paper also briefly describes some of the most frequently used software tools for modelling the thermal characteristics of buildings. Many of the stochastic models are developed and tested using data from outdoor testing during a number of EU projects (PASSYS, PASLINK, DAME-BC, ...). These projects have provided the background for new methods for using frequent readings of the energy consumption to an assessment of the energy performance of buildings. Smart meters are now used more and more often. A smart meter facilitates frequent reading of the energy consumption, and together with some local meteorological measurements, which almost always are available, the scene is now set for using the developed methods for time series modelling or system identification. Applying these methods the following can be achieved: characterization of the energy performance of buildings (including energy labelling), identification of how to improve the thermal performance of the building, and improved control of the energy supply.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Madsen, H. (Intern), Bacher, P. (Intern), Andersen, P. H. D. (Intern)
Publication date: 2010

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Main Research Area: Technical/natural sciences
Continuous time modelling, stochastic differential equations, heat consumption, smart meters, Grey-box models, heat dynamics, thermal dynamics, buildings, energy labelling
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http://www.dynastee.info/home.php
Source: orbit
Source-ID: 270963
Publication: Research › Article in proceedings – Annual report year: 2010
Modelling conjugation with stochastic differential equations

Conjugation is an important mechanism involved in the transfer of resistance between bacteria. In this article a stochastic differential equation based model consisting of a continuous time state equation and a discrete time measurement equation is introduced to model growth and conjugation of two Enterococcus faecium strains in a rich exhaustible media. The model contains a new expression for a substrate dependent conjugation rate. A maximum likelihood based method is used to estimate the model parameters. Different models including different noise structure for the system and observations are compared using a likelihood-ratio test and Akaike's information criterion. Experiments indicating conjugation on the agar plates selecting for transconjugants motivates the introduction of an extended model, for which conjugation on the agar plate is described in the measurement equation. This model is compared to the model without plate conjugation. The modelling approach described in this article can be applied generally when modelling dynamical systems.
Models for Energy Performance Analysis: Financed by The Danish Electricity Saving Trust

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Intelligent Energy Systems Programme, Risø National Laboratory for Sustainable Energy
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Publication: Research › Report – Annual report year: 2010

Multivariate conditional parametric models for a spatio-temporal analysis of short-term wind power forecast errors

General information
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Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Tastu, J. (Intern), Pinson, P. (Intern), Madsen, H. (Intern)
Publication date: 2010

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Main Research Area: Technical/natural sciences
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Nonlinear Model Predictive Control for an Artificial Beta-Cell

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Pages: 299-308
Publication date: 2010

Host publication information
Title of host publication: Recent Advances in Optimization and its Applications in Engineering
Publisher: Springer
Main Research Area: Technical/natural sciences
Source: orbit
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Publication: Research - peer-review › Book chapter – Annual report year: 2010

Non-linear phenomena in greybox-modeling of heat dynamics in buildings

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Department of Civil Engineering, Section for Building Physics and Services, ENFOR A/S
Authors: Andersen, P. H. D. (Intern), Madsen, H. (Intern), Bacher, P. (Intern), Rode, C. (Intern), Nielsen, H. A. (Ekstern)
Publication date: 2010

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Title of host publication: Dynamic Methods for Building Energy Assessment
Main Research Area: Technical/natural sciences
Conference: Dynamic Methods for Building Energy Assessment, Brussels, 01/01/2010
Grey-box modeling, heat dynamics
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On the market impact of wind energy forecasts

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Jónsson, T. (Intern), Pinson, P. (Intern), Madsen, H. (Intern)
Pages: 313-320
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Main Research Area: Technical/natural sciences

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BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.89 SJR 2.387 SNIP 1.951
On the Market Impact of Wind Power (Forecasts) - An Overview of the Effects of Large-scale Integration of Wind Power on the Electricity Market

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Jónsson, T. (Intern), Zugno, M. (Intern), Madsen, H. (Intern), Pinson, P. (Intern)
Publication date: 2010

Host publication information
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Main Research Area: Technical/natural sciences
Conference: IAEE’S Rio 2010 International Conference, Rio de Janeiro, Brazil, 06/06/2010 - 06/06/2010
Source: orbit
Source-ID: 270949
Publication: Research - peer-review › Article in proceedings – Annual report year: 2010
Predictive performance for population models using stochastic differential equations applied on data from an oral glucose tolerance test

Several articles have investigated stochastic differential equations (SDEs) in PK/PD models, but few have quantitatively investigated the benefits to predictive performance of models based on real data. Estimation of first phase insulin secretion which reflects beta-cell function using models of the OGTT is a difficult problem in need of further investigation. The present work aimed at investigating the power of SDEs to predict the first phase insulin secretion (AIR(0-8)) in the IVGTT based on parameters obtained from the minimal model of the OGTT, published by Breda et al. (Diabetes 50(1): 150-158, 2001). In total 174 subjects underwent both an OGTT and a tolbutamide modified IVGTT. Estimation of parameters in the oral minimal model (OMM) was performed using the FOCE-method in NONMEM VI on insulin and C-peptide measurements. The suggested SDE models were based on a continuous AR(1) process, i.e. the Ornstein-Uhlenbeck process, and the extended Kalman filter was implemented in order to estimate the parameters of the models. Inclusion of the Ornstein-Uhlenbeck (OU) process caused improved description of the variation in the data as measured by the auto-correlation function (ACF) of one-step prediction errors. A main result was that application of SDE models improved the correlation between the individual first phase indexes obtained from OGTT and AIR(0-8) (r = 0.36 to r = 0.49 and r = 0.32 to r = 0.47 with C-peptide and insulin measurements, respectively). In addition to the increased correlation also the properties of the indexes obtained using the SDE models more correctly assessed the properties of the first phase indexes obtained from the IVGTT. In general it is concluded that the presented SDE approach not only caused autocorrelation of errors to decrease but also improved estimation of clinical measures obtained from the glucose tolerance tests. Since, the estimation time of extended models was not heavily increased compared to basic models, the applied method is concluded to have high relevance not only in theory but also in practice.
Procedure for identifying models for the heat dynamics of buildings: Financed by The Danish Electricity Saving Trust and Vind i Øresund - Interreg 4A

This report describes a new method for obtaining detailed information about the heat dynamics of a building using frequent reading of the heat consumption. Such a procedure is considered to be of uttermost importance as a key procedure for using readings from smart meters, which is expected to be installed in almost all buildings in the coming years.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Bacher, P. (Intern), Madsen, H. (Intern)
Publication date: 2010

Publication information
Place of publication: Kgs. Lyngby
Publisher: Technical University of Denmark, DTU Informatics, Building 321
Original language: English

Series: IMM-Technical report-2010-04
Quantification of the spatial variability of rainfall based on a dense network of rain gauges
The spatial variability of rainfall within a single Local Area Weather Radar (LAWR) pixel of 500 x 500 m is quantified based on data from two locations. The work was motivated by the need to quantify the variability on this scale in order to provide an estimate of the uncertainty of using a single rain gauge for calibrating the LAWR. A total of nine rain gauges were used, each representing one-ninth of the 500 x 500 m area. The analysis was carried out based on a dataset obtained using tipping bucket gauges during the summer and fall of 2007 and 2008, and the results were compared with results from an earlier campaign in 2003. The fact that the 2007-2008 dataset was almost four times larger than the original dataset from 2003 motivated this extended study. Two methods were used to describe the variability: the coefficient of variation and the spatial correlation structure of the rainfall field. Despite the small area of 0.25 km², accumulated rainfall was found to vary significantly within individual events with durations ranging from 5 min to 13 h. The coefficient of variation was found to range from 1-26% in the 2007-2008 dataset and in some special cases even higher. The 95% prediction interval for a given rainfall depth is estimated and can be used to address the uncertainty of using a single rain gauge to represent the rainfall within a 500 x 500 m area. (C) 2009 Elsevier B.V. All rights reserved.
Reliability diagrams for non-parametric density forecasts of continuous variables: Accounting for serial correlation

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, University of Oxford
Authors: Pinson, P. (Intern), McSharry, P. (Ekstern), Madsen, H. (Intern)
Pages: 77-90
Publication date: 2010
Main Research Area: Technical/natural sciences

Publication information
Journal: Quarterly Journal of the Royal Meteorological Society
Volume: 136
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BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.33 SJR 2.449 SNIP 1.429
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.538 SNIP 1.402 CiteScore 3.1
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 5.04 SNIP 2.339 CiteScore 5
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 4.35 SNIP 2.035 CiteScore 4.17
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 3.564 SNIP 1.566 CiteScore 2.99
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
Resolving Nonstationary Spectral Information in Wind Speed Time Series Using the Hilbert-Huang Transform

This work is motivated by the observation that large-amplitude wind fluctuations on temporal scales of 1–10 h present challenges for the power management of large offshore wind farms. Wind fluctuations on these scales are analyzed at a meteorological measurement mast in the Danish North Sea using a 4-yr time series of 10-min wind speed observations. An adaptive spectral analysis method called the Hilbert–Huang transform is chosen for the analysis, because the nonstationarity of time series of wind speed observations means that they are not well described by a global spectral analysis method such as the Fourier transform. The Hilbert–Huang transform is a local method based on a nonparametric and empirical decomposition of the data followed by calculation of instantaneous amplitudes and frequencies using the Hilbert transform. The Hilbert–Huang transformed 4-yr time series is averaged and summarized to show climatological patterns in the relationship between wind variability and time of day. First, by integrating the Hilbert spectrum along the frequency axis, a scalar time series representing the total variability within a given frequency range is calculated. Second, by calculating average spectra conditional to time of day, the time axis of the Hilbert spectrum is “remapped” to show climatological patterns. Third, the daily patterns in wind variability and wind speed are compared for the four seasons of the year. It is found that the most intense wind variability occurs in autumn even though the strongest observed wind speeds occur in winter.

General information
State: Published
Organisations: Wind Energy Educational Programme, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Meteorology, Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Vincent, C. L. (Intern), Giebel, G. (Intern), Pinson, P. (Intern), Madsen, H. (Intern)
Pages: 253-267
Publication date: 2010
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Applied Meteorology and Climatology
Volume: 49
Issue number: 2
Robust model identification applied to type 1 diabetes

In many realistic applications, process noise is known to be neither white nor normally distributed. When identifying models in these cases, it may be more effective to minimize a different penalty function than the standard sum of squared errors (as in a least-squares identification method). This paper investigates model identification based on two different penalty functions: the 1-norm of the prediction errors and a Huber-type penalty function. For data characteristic of some
realistic applications, model identification based on these latter two penalty functions is shown to result in more accurate estimates of parameters than the standard least-squares solution, and more accurate model predictions for test data. The identification techniques are demonstrated on a simple toy problem as well as a physiological model of type 1 diabetes.

General information
State: Published
Organisations: Scientific Computing, Department of Informatics and Mathematical Modeling, Mathematical Statistics, Center for Energy Resources Engineering
Authors: Finan, D. A. (Intern), Jørgensen, J. B. (Intern), Poulsen, N. K. (Intern), Madsen, H. (Intern)
Pages: 2021-2021
Publication date: 2010

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Title of host publication: Proceedings of the American Control Conference
Publisher: IEEE
ISBN (Print): 978-1-4244-7426-4
Main Research Area: Technical/natural sciences
Conference: American Control Conference (ACC 2010), Baltimore, MD, United States, 03/06/2010 - 03/06/2010
Source: orbit
Source-ID: 257659
Publication: Research - peer-review › Article in proceedings – Annual report year: 2010

Service-oriented Reliability Analysis for Collaborative Mechatronic Laboratories Involved in Virtual Training

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Madsen, H. (Intern), Albeanu, G. (Ekstern), Tarca, R. (Ekstern), Popentiu-Vladicescu, F. (Ekstern)
Publication date: 2010

Host publication information
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Main Research Area: Technical/natural sciences
Conference: Proceedings of ESREL 2010, Annual Conference, 5-9 September 2010, Rhodes, Greece, 01/01/2010
Source: orbit
Source-ID: 273781
Publication: Research - peer-review › Article in proceedings – Annual report year: 2010

Statistical models describing the energy signature of buildings

Approximately one third of the primary energy production in Denmark is used for heating in buildings. Therefore efforts to accurately describe and improve energy performance of the building mass are very important. For this purpose statistical models describing the energy signature of a building, i.e. the heat dynamics of the building, have been developed. The models can be used to obtain rather detailed knowledge of the energy performance of the building and to optimize the control of the energy consumption for heating, which will be vital in conditions with increasing fluctuation of the energy supply or varying energy prices. The paper will give an overview of statistical methods and applied models based on experiments carried out in FlexHouse, which is an experimental building in SYSLAB, Risø DTU. The models are of different complexity and can provide estimates of physical quantities such as UA-values, time constants of the building, and other parameters related to the heat dynamics. A method for selecting the most appropriate model for a given building is outlined and finally a perspective of the applications is given. Acknowledgements to the Danish Energy Saving Trust and the Interreg IV “Vind i Øresund” project.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Intelligent Energy Systems Programme, Risø National Laboratory for Sustainable Energy
Authors: Bacher, P. (Intern), Madsen, H. (Intern), Thavlov, A. (Intern)
Publication date: 2010

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Title of host publication: Dynamic Methods for Building Energy Assessment
Main Research Area: Technical/natural sciences
Intelligent energy systems, Continuous time modelling, heat consumption, smart meters, Grey-box models, heat dynamics, thermal dynamics, buildings, model selection
Predictive tools for designing new insulins and treatment regimens

The thesis deals with the development of "Predictive tools for designing new insulins and treatments regimens" and consists of two parts: A model based approach for bridging properties of new insulin analogues from glucose clamp experiments to meal tolerance tests (MTT) and a second part that describes an implemented software program able to handle stochastic differential equations (SDEs) with mixed effects. The thesis is supplemented with scientific papers published during the PhD. Developing an insulin analogue from candidate molecule to a clinical drug consists of a development programme including different phases targeting safety and efficacy. The focus of this thesis is the shift from Phase I, targeting safety, to Phase II, targeting efficacy. An insulin analogue is typically tested for safety in glucose clamp experiments in Phase I clinical trials and progresses into Phase II where dose and efficacy are investigated. Numerous methods are used to quantify dose and efficacy in Phase II - especially of interest is the 24-hour meal tolerance test as it tries to portray near normal living conditions. Part I describes an integrated model for insulin and glucose which is aimed at simulating 24-hour glucose profiles from a MTT with treatments based on the new insulin analogue that previously only has been tested in clamps. The bridge between insulin analogue properties determined in clamp experiments to meal tolerance test outcomes in Phase II trials is not simple and is complicated by shifts in experimental setup, time horizon and treatment regimen. A bridging strategy was introduced where an integrated model simulating MTTs was extended with models developed on clamp data that described PK and PD for the new insulin analogue. The bridging strategy was tested by building an integrated model based on human insulin trials which was then evaluated using insulin Aspart (IAsp). The integrated model was estimated in two separate sub models due to computational complexity. Insulin model challenges were faced at the estimation step regarding separability of insulin input pathways (exogenous/secretion) which resulted in several fixed parameters but also an insulin delivery model as opposed to a prehepatic insulin secretation model coupled with hepatic extraction. The glucose model was an extended version of the oral glucose minimal model [Man et al., 2002] which had a meal function incorporated. The two sub models were combined into an integrated model which was evaluated in different scenarios: An iso-glucocaemic glucose clamp, an insulin tolerance test and comparing derived measures of glucose effectiveness. The model evaluation pinpointed insulin sensitivity issues which were accommodated with a change in model building towards a more insulin sensitive model type. Conclusively, the integrated model fitted estimation data well both for insulin and glucose. Furthermore, the evaluation scenarios showed overall correspondence with literature with only minor discrepancies. The evaluation on insulin Aspart required a PK model for IAsp and a model describing IAsp action in MTTs. The IAsp PK model was available from a different Novo Nordisk project and the action transfer function was estimated on cross-over clamp data with human insulin and insulin Aspart. The two components were then embedded into the integrated model. The extended integrated model was used to simulate 24-hour profiles of insulin and glucose from meal tolerance tests including treatments with biphasic insulin Aspart. The evaluation showed that the extended integrated model was able to predict insulin levels reasonably both mean profile and variation whereas glucose profiles were not predicted accurately. Post modelling analysis targeting both insulin and glucose components showed that preconditions for the bridging strategy which implied the use of a mean IAsp PK model, could be the cause for the mis-predictions. Future research should look into ways for individualising the insulin treatment when no information on individual level is present. The model building process could have benefitted from the use of SDEs. Unfortunately, availability of a software program able to handle mixed effects and SDEs resulted in a modelling approach based on ordinary differential equations. The absence of such a program motivated the development of new a tool with PK/PD features, SDEs and mixed effects. Part II presents a software package which was developed in order to be able to handle SDEs with mixed effects. The package was implemented in R which allowed for a single environment for data preparation, model building and results handling but also provided accessibility for users and ease of installation. The R-package implements the (Extended) Kalman Filter for handling SDEs and uses the FOCE approximation to calculate the marginal likelihood for parameters used in maximum likelihood estimation. A number of applications of PSM are presented in which deconvolution is the topic for most. Deconvolution based on SDEs was used to determine pre-hepatic insulin secretion rates; hepatic insulin extraction rates using both insulin and C-peptide measurements, and glucose appearance rates constrained to be in the positive range in a simulated minimal model setting. More applications included an insulin secretion model based on an intervention model type and an analysis of in fluence from input error propagation as estimated with ODEs and SDEs.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Department of Chemical and Biochemical Engineering
Authors: Klim, S. (Intern), Madsen, H. (Intern), Kristensen, N. R. (Intern)
Publication date: Dec 2009

Publication information
Place of publication: Kgs. Lyngby
Publisher: Technical University of Denmark, DTU Informatics, Building 321
Data Assimilation in Marine Models

This thesis consists of six research papers published or submitted for publication in the period 2006-2009 together with a summary report. The main topics of this thesis are nonlinear data assimilation techniques and estimation in dynamical models. The focus has been on the nonlinear filtering techniques for large scale geophysical numerical models and making them feasible to work with in the data assimilation framework. The filtering techniques investigated are all Monte Carlo simulation based. Some very nice features that can be exploited in the Monte Carlo based data assimilation framework from a computational point of view, e.g. low storage cost, no linearizations of the numerical models, etc. However, this also gives rise to many unforeseen difficulties, e.g. the curse of dimensionality, huge computational costs, etc. The challenge faced in this thesis was finding filters that could handle the nonlinearities encountered in data assimilation and at the same time are robust and reliable enough given the constraints and difficulties that can arise.

These problems were addressed in the papers A, E and D. The other topic of this thesis is estimation in dynamical geophysical numerical models. The challenge of estimating model parameters for well establish geophysical dynamical systems is that these models are not formulated in a way that incorporates the necessary stochastic assumptions that make estimation possible in a maximum likelihood sense. The maximum likelihood approach is selected due to its unique performance in data rich situations. The estimations are often based on output from the model and the raw observations which lead to suboptimal estimates. The challenge is to give a meaningful description of the model errors through diffusion processes that can be identified and incorporated into the existing maximum likelihood framework. These issues are discussed in paper B. The third part of the thesis falls a bit out of the above context is work published in papers C, F. In the first paper, a simple data assimilation scheme was investigated to examine the potential benefits of incorporating a data assimilation concept into an atmospheric chemical transport model. This paper deals with the results and conclusions obtained through some of the first experiments with the Optimal Interpolation filter in a geophysical model. The second paper F, deals with the construction of a finite element solver for the Fokker-Planck equation on a 2 dimensional flexible mesh system. The report details the construction of the finite element solver and investigates the potential benefits of a parallel FORTRAN implementation through a series of experiments.
A LAWR is normally calibrated against a single rain gauge, which is the normal procedure used to calibrate weather radars. Based on a large set of rain gauge data collected during this project, the uncertainties related to assuming a single gauge representative for a whole LAWR pixel are quantified using statistical methods. Furthermore, the present calibration method is reviewed and a new extended calibration method has been developed and tested resulting in improved rainfall estimates. As part of the calibration analysis a number of elements affecting the LAWR performance were identified and possible improvements suggested. The LAWR is designed to provide rainfall data, especially for urban drainage applications, and as part of the thesis the integration of LAWR data into the DHI software application MIKE URBAN has been analyzed. The work has resulted in identification of scaling issues in connection with boundary assignment besides general improved understanding of the benefits and pitfalls in using distributed rainfall data as input to models. In connection with the use of LAWR data in urban drainage context, the potential for using LAWR data for extreme rainfall statistics has been studied revealing interesting new spatial characteristics of extreme rainfall events not earlier observed.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Department of Environmental Engineering
Authors: Pedersen, L. (Intern), Madsen, H. (Intern), Jensen, N. E. (Ekstern)
Publication date: Aug 2009

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Place of publication: Kgs. Lyngby, Denmark
Publisher: Technical University of Denmark (DTU)
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Series: The PhD is an Industrial PhD and the work has been conducted in a cooperation between DHI Weather Radar Systems, (Chief Engineer, Niels Einar Jensen), and DTU Informatics, the Technical University of Denmark.
Main Research Area: Technical/natural sciences
Electronic versions:
phd215_lip.pdf
Source: orbit
Source-ID: 239427
Publication: Research › Ph.D. thesis – Annual report year: 2009

Adaptive modelling and forecasting of offshore wind power fluctuations with Markov-switching autoregressive models

Wind power production data at temporal resolutions of a few minutes exhibits successive periods with fluctuations of various dynamic nature and magnitude, which cannot be explained (so far) by the evolution of some explanatory variable. Our proposal is to capture this regime-switching behaviour with an approach relying on Markov-Switching AutoRegressive (MSAR) models. An appropriate parameterization of the model coefficients is introduced, along with an adaptive estimation method allowing to accommodate long-term variations in the process characteristics. The objective criterion to be recursively optimized is based on penalized maximum-likelihood, with exponential forgetting of past observations. MSAR models are then employed for 1-step-ahead point forecasting of 10-minute resolution time-series of wind power at two large offshore wind farms. They are favourably compared against persistence and AutoRegressive (AR) models. It is finally shown that the main interest of MSAR models lies in their ability to generate interval/density forecasts of significantly higher skill.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Pinson, P. (Intern), Madsen, H. (Intern)
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Original language: English

Main Research Area: Technical/natural sciences
Source: orbit
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Publication: Research › Report – Annual report year: 2009

Communication of wind power forecast uncertainty: towards a standard
Dynamic two state stochastic models for ecological regime shifts
A simple non-linear stochastic two state, discrete-time model is presented. The interaction between benthic and pelagic vegetation in aquatic ecosystems subject to changing external nutrient loading is described by the nonlinear functions. The dynamical behavior of the deterministic part of the model illustrates that hysteresis effect and regime shifts can be obtained for a limited range of parameter values only. The effect of multiplicative noise components entering at different levels of the model is presented and discussed. Including noise leads to very different results on the stability of regimes, depending on how the noise propagates through the system. The dynamical properties of a system should therefore be described through propagation of the state distributions rather than the state means and consequently, stochastic models should be compared in a probabilistic framework.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Department of Environmental Science and Engineering, University of Oslo
Authors: Møller, J. K. (Intern), Carstensen, N. J. (Intern), Madsen, H. (Intern), Andersen, T. (Ekstern)
Pages: 912-927
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Main Research Area: Technical/natural sciences

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Volume: 20
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BFI (2017); BFI-level 1
Web of Science (2017): Indexed Yes
Ensemble-based forecasting at Horns Rev: Ensemble conversion and kernel dressing

For management and trading purposes, information on short-term wind generation (from few hours to few days ahead) is even more crucial at large offshore wind farms, since they concentrate a large capacity at a single location. The most complete information that can be provided today consists of probabilistic forecasts, the resolution of which may be maximized by using meteorological ensemble predictions as input. The paper concentrates on the test case of the Horns Rev wind farm over a period of approximately one year, in order to describe, apply and discuss a complete ensemble-based forecasting methodology. In a first stage, ensemble forecasts of meteorological variables are converted to power through a suitable power curve model. The relevance and benefits of employing a newly developed orthogonal fitting method for the power curve model over the traditional least-squares one are discussed. The obtained ensemble forecasts of wind power are then converted into predictive distributions with an original adaptive kernel dressing method. The shape of the kernels is driven by a mean-variance model, the parameters of which are recursively estimated in order to maximize the overall skill of obtained predictive distributions. Such a methodology has the benefit of yielding predictive distributions...
that are of increased reliability (in a probabilistic sense) in comparison with the raw ensemble forecasts, while taking advantage of their high resolution.

**General information**
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Pinson, P. (Intern), Madsen, H. (Intern)
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Place of publication: Lyngby
Publisher: Technical University of Denmark, DTU Informatics, Building 321
Original language: English

**Ensemble-based Probabilistic Forecasting at Horns Rev**
For management and trading purposes, information on short-term wind generation (from a few hours to a few days ahead) is crucial at large offshore wind farms, since they concentrate a large capacity at a single location. The most complete information that can be provided today consists of probabilistic forecasts, the resolution of which may be maximized by using meteorological ensemble predictions as input. The paper concentrates on the test case of the Horns Rev wind farm over a period of approximately 1 year, in order to describe, apply and discuss a complete ensemble-based probabilistic forecasting methodology. In a first stage, ensemble forecasts of meteorological variables are converted to power through a suitable power curve model. This model employs local polynomial regression, and is adaptively estimated with an orthogonal fitting method. The obtained ensemble forecasts of wind power are then converted into predictive distributions with an original adaptive kernel dressing method. The shape of the kernels is driven by a mean-variance model, the parameters of which are recursively estimated in order to maximize the overall skill of obtained predictive distributions. Such a methodology has the benefit of yielding predictive distributions that are of increased reliability (in a probabilistic sense) in comparison with the raw ensemble forecasts, at the same time taking advantage of their high resolution.

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Forecasting day-ahead electricity prices and regulation costs in markets with significant wind power penetration

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Jónsson, T. (Intern), Pinson, P. (Intern), Madsen, H. (Intern), Nielsen, H. A. O. T. 3. (Intern)
Publication date: 2009

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Main Research Area: Technical/natural sciences
Conference: 2009 European Wind Energy Conference and Exhibition, Marseille, France, 16/03/2009 - 16/03/2009
Source: orbit
Source-ID: 257343
Publication: Research › Article in proceedings – Annual report year: 2009
From probabilistic forecasts to statistical scenarios of short-term wind power production

Short-term (up to 2-3 days ahead) probabilistic forecasts of wind power provide forecast users with highly valuable information on the uncertainty of expected wind generation. Whatever the type of these probabilistic forecasts, they are produced on a per horizon basis, and hence do not inform on the development of the forecast uncertainty through forecast series. However, this additional information may be paramount for a large class of time-dependent and multistage decision-making problems, e.g. optimal operation of combined wind-storage systems or multiple-market trading with different gate closures. This issue is addressed here by describing a method that permits the generation of statistical scenarios of short-term wind generation that accounts for both the interdependence structure of prediction errors and the predictive distributions of wind power production. The method is based on the conversion of series of prediction errors to a multivariate Gaussian random variable, the interdependence structure of which can then be summarized by a unique covariance matrix. Such matrix is recursively estimated in order to accommodate long-term variations in the prediction error characteristics. The quality and interest of the methodology are demonstrated with an application to the test case of a multi-MW wind farm over a period of more than 2 years.

General information
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Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Pinson, P. (Intern), Papaefthymiou, G. (Ekstern), Klockl, B. (Ekstern), Nielsen, H. A. (Intern), Madsen, H. (Intern)
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Publication date: 2009
Main Research Area: Technical/natural sciences

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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.37 SJR 1.104 SNIP 2.306
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.196 SNIP 2.086 CiteScore 3.06
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.272 SNIP 3.75 CiteScore 3.42
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.275 SNIP 2.464 CiteScore 2.75
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.126 SNIP 2.39 CiteScore 2.36
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.024 SNIP 2.718 CiteScore 2.49
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.487 SNIP 2.013
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.124 SNIP 1.448
Geolocating fish using Hidden Markov Models and Data Storage Tags

Geolocation of fish based on data from archival tags typically requires a statistical analysis to reduce the effect of measurement errors. In this paper we present a novel technique for this analysis, one based on Hidden Markov Models (HMM's). We assume that the actual path of the fish is generated by a biased random walk. The HMM methodology produces, for each time step, the probability that the fish resides in each grid cell. Because there is no Monte Carlo step in our technique, we are able to estimate parameters within the likelihood framework. The method does not require the distribution to be Gaussian or belong to any other of the usual families of distributions and can thus address constraints from shorelines and other nonlinear effects; the method can and does produce bimodal distributions. We discuss merits and limitations of the method, and perspectives for the more general problem of inference in state-space models of animals. The technique can be applied to geolocation based on light, on tidal patterns, or measurement of other variables that vary with space. We illustrate the method through application to a simulated data set where geolocation relies on depth data exclusively.

General information
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Organisations: Section for Population- and Ecosystem Dynamics, National Institute of Aquatic Resources, Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Thygesen, U. H. (Intern), Pedersen, M. W. (Intern), Madsen, H. (Intern)
Number of pages: 452
Pages: 277-293
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Volume: Part 2: Geolocation Methods
Publisher: Springer
Editor: Nielsen, J.
ISBN (Print): 14-02-09639-9

Series: Reviews: Methods and Technologies in Fish Biology and Fisheries
Number: 9
ISSN: 1571-3075
Series: Reviews: Methods and Technologies in Fish Biology and Fisheries
Volume: 9
**Glucose modeling and prediction using physical activity variables**

**General information**
State: Published
Organisations: Scientific Computing, Department of Informatics and Mathematical Modeling, Mathematical Statistics
Publication date: 2009
Event: Poster session presented at Diabetes Technology Meeting.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 250427
Publication: Research › Book chapter – Annual report year: 2009

**Improvements to least-squares model identification: an application to diabetes modeling**

**General information**
State: Published
Organisations: Scientific Computing, Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Finan, D. A. (Intern), Jørgensen, J. B. (Intern), Poulsen, N. K. (Intern), Madsen, H. (Intern)
Publication date: 2009

**Publication information**
Original language: English
Main Research Area: Technical/natural sciences
Links:
http://www.aiche.org/Conferences/AnnualMeeting/index.aspx
Source: orbit
Source-ID: 257646
Publication: Research › Sound/Visual production (digital) – Annual report year: 2009

**Modelling bacterial growth in rich media with a non-parametric extension to an SDE based Model**

**General information**
State: Submitted
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Philipsen, K. R. (Intern), Christiansen, L. E. (Intern), Madsen, H. (Intern)
Publication date: 2009
Main Research Area: Technical/natural sciences

**Publication information**
Journal: Biometrics
ISSN (Print): 0006-341X
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): SJR 1.632 SNIP 1.115 CiteScore 1.35
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.005 SNIP 1.393 CiteScore 1.66
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.241 SNIP 1.398 CiteScore 1.57
Modelling the heat dynamics of building integrated and ventilated photovoltaic modules

This paper deals with mathematical modelling of the heat transfer of building integrated photovoltaic (BIPV) modules. The efficiency of the photovoltaic (PV) module and its temperature are negatively correlated. It is therefore of interest to lower the temperature of the PV module by increasing the heat transfer from the PV module. The experiment and data originate from a test reference module the EC-JRC Ispra. The set-up provides the opportunity of changing physical parameters, the ventilation speed and the type of air flow, and this makes it possible to determine the preferable set-up. To identify best set-up, grey-box models consisting of stochastic differential equations are applied. The models are first order stochastic state space models. Maximum likelihood estimation and the extended Kalman filter are applied in the parameter estimation phase. To validate the estimated models, plots of the residuals and autocorrelation functions of the residuals are analyzed. The analysis has revealed that it is necessary to use non-linear state space models in order to obtain a satisfactory description of the PV module temperature, and in order to be able to distinguish the variations in the set-up. The heat transfer is increased when the forced ventilation velocity is increased, while the change in type of air flow does not have as striking influence. The residual analysis show that the best description of the PV module temperature is obtained when fins, disturbing the laminar flow and making it turbulent, are applied in the set-up combined with high level of air flow. The improved description by the model is mainly seen in periods with high solar radiation.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Technical University of Denmark
Authors: Friling, N. (Ekstern), Jimenez, M. (Ekstern), Bloem, H. (Ekstern), Madsen, H. (Intern)
Pages: 1051-1057
Publication date: 2009
Main Research Area: Technical/natural sciences
Online short-term solar power forecasting

This paper describes a new approach to online forecasting of power production from PV systems. The method is suited to online forecasting in many applications and in this paper it is used to predict hourly values of solar power for horizons of up to 36 hours. The data used is fifteen-minute observations of solar power from 21 PV systems located on rooftops in a small village in Denmark. The suggested method is a two-stage method where first a statistical normalization of the solar power is obtained using a clear sky model. The clear sky model is found using statistical smoothing techniques. Then forecasts of the normalized solar power are calculated using adaptive linear time series models. Both autoregressive (AR) and AR with exogenous input (ARX) models are evaluated, where the latter takes numerical weather predictions (NWPs) as input. The results indicate that for forecasts up to two hours ahead the most important input is the available observations of solar power, while for longer horizons NWPs are the most important input. A root mean square error improvement of around 35% is achieved by the ARX model compared to a proposed reference model.
Scopus rating (2010): SJR 1.419 SNIP 2.161
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.301 SNIP 2.158
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.693 SNIP 2.007
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.708 SNIP 2.101
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.645 SNIP 2.278
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.27 SNIP 1.577
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.535 SNIP 1.675
Scopus rating (2003): SJR 1.184 SNIP 1.421
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.506 SNIP 1.593
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.303 SNIP 1.291
Scopus rating (2000): SJR 1.018 SNIP 1.053
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 0.677 SNIP 1.275
Original language: English
photovoltaic, time series, quantile regression, forecasting, Solar power, prediction, clear sky model, recursive least squares, numerical weather predictions
Electronic versions:
Manuscript.pdf
DOIs:
10.1016/j.solener.2009.05.016
Source: orbit
Source-ID: 227966
Publication: Research - peer-review › Journal article – Annual report year: 2009

On the reliability assessment of density forecasts of continuous variables with reliability diagrams

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, University of Oxford
Authors: Pinson, P. (Intern), McSharry, P. (Ekstern), Madsen, H. (Intern)
Publication date: 2009

Host publication information
Title of host publication: Proc. of the International Symposium on Forecasting 2009
Main Research Area: Technical/natural sciences
Conference: International Symposium on Forecasting 2009, 01/01/2009
Source: orbit
Source-ID: 239540
Publication: Research › Article in proceedings – Annual report year: 2009

Parameter Estimation in State Space Models with Multiplicative Noise - Examples

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Department of Environmental Science and Engineering
Authors: Møller, J. K. (Intern), Carstensen, N. J. (Intern), Madsen, H. (Intern)
Publication date: 2009
Population stochastic modelling (PSM)-An R package for mixed-effects models based on stochastic differential equations

The extension from ordinary to stochastic differential equations (SDEs) in pharmacokinetic and pharmacodynamic (PK/PD) modelling is an emerging field and has been motivated in a number of articles [N.R. Kristensen, H. Madsen, S.H. Ingwersen, Using stochastic differential equations for PK/PD model development, J. Pharmacokinet. Pharmacodyn. 32 (February(l)) (2005) 109-141; C.W. Tomoe, R.V.Overgaard, H. Agerso, H.A. Nielsen, H. Madsen, E.N. Jonsson, Stochastic differential equations in NONMEM: implementation, application, and comparison with ordinary differential equations, Pharm. Res. 22 (August(8)) (2005) 1247-1258; R.V. Overgaard, N. Jonsson, C.W. Tomoe, H. Madsen, Non-linear mixed-effects models with stochastic differential equations: implementation of an estimation algorithm, J. Pharmacokin. Pharmacodyn. 32 (February(1)) (2005) 85-107; U. Picchini, S. Ditlevsen, A. De Gaetano, Maximum likelihood estimation of a time-inhomogeneous stochastic differential model of glucose dynamics, Math. Med. Biol. 25 (June(2)) (2008) 141-155]. PK/PD models are traditionally based ordinary differential equations (ODEs) with an observation link that incorporates noise. This state-space formulation only allows for observation noise and not for system noise. Extending to SDEs allows for a Wiener noise component in the system equations. This additional noise component enables handling of autocorrelated residuals originating from natural variation or systematic model error. Autocorrelated residuals are often partly ignored in PK/PD modelling although violating the hypothesis for many standard statistical tests. This article presents a package for the statistical program R that is able to handle SDEs in a mixed-effects setting. The estimation method implemented is the FOCE1 approximation to the population likelihood which is generated from the individual likelihoods that are approximated using the Extended Kalman Filter’s one-step predictions.
Power fluctuations from large wind farms - Final report

Experience from power system operation with the first large offshore wind farm in Denmark: Horns Rev shows that the power from the wind farm is fluctuating significantly at certain times, and that this fluctuation is seen directly on the power exchange between Denmark and Germany. This report describes different models for simulation and prediction of wind power fluctuations from large wind farms, and data acquired at the two large offshore wind farms in Denmark are applied to validate the models. Finally, the simulation model is further developed to enable simulations of power fluctuations from several wind farms simultaneously in a larger geographical area, corresponding to a power system control area.

General information
State: Published
Authors: Sørensen, P. E. (Intern), Pinson, P. (Intern), Cutululis, N. A. (Intern), Madsen, H. (Intern), Jensen, L. E. (Ekstern), Hjerrild, J. (Ekstern), Heyman Donovan, M. (Ekstern), Runge Kristoffersen, J. (Ekstern), Vigueras-Rodríguez, A. (Ekstern)
Number of pages: 49
Publication date: 2009

Publication information
Place of publication: Roskilde
Publisher: Danmarks Tekniske Universitet, Risø Nationallaboratoriet for Bæredygtig Energi
ISBN (Print): 978-87-550-3782-3
Original language: English
Skill forecasting from ensemble predictions of wind power

Optimal management and trading of wind generation calls for the providing of uncertainty estimates along with the commonly provided short-term wind power point predictions. Alternative approaches for the use of probabilistic forecasting are introduced. More precisely, focus is given to prediction risk indices aiming to give a comprehensive signal on the expected level of forecast uncertainty. Ensemble predictions of wind generation are used as input. A proposal for the definition of prediction risk indices is given. Such skill forecasts are based on the spread of ensemble forecasts (i.e., a set of alternative scenarios for the coming period) for a single prediction horizon or over a look-ahead period. It is shown on the test case of a Danish offshore wind farm how these prediction risk indices may be related to several levels of forecast uncertainty (and potential energy imbalances). Wind power ensemble predictions are derived from the conversion of ECMWF and NCEP ensemble forecasts of meteorological variables to wind power ensemble forecasts, as well as by a lagged average approach alternative. The ability of prediction risk indices calculated from the various types of ensembles forecasts to resolve among situations with different levels of uncertainty is discussed.

General information

State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Pinson, P. (Intern), Nielsen, H. A. (Intern), Madsen, H. (Intern), Kariniotakis, G. (Ekstern)
Pages: 1326-1334
Publication date: 2009
Main Research Area: Technical/natural sciences

Publication information
Journal: Applied Energy
Volume: 86
Issue number: 7-8
ISSN (Print): 0306-2619
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 7.78 SJR 3.058 SNIP 2.573
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.912 SNIP 2.61 CiteScore 6.4
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 3.254 SNIP 3.28 CiteScore 6.93
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 3.164 SNIP 3.377 CiteScore 6.59
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 2.854 SNIP 3.108 CiteScore 5.69
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 2.473 SNIP 2.84 CiteScore 5.5
Temperature prediction at critical points in district heating systems

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Pinson, P. (Intern), Nielsen, T. S. (Intern), Nielsen, H. A. (Intern), Poulsen, N. K. (Intern), Madsen, H. (Intern)
Pages: 163-176
Publication date: 2009
Main Research Area: Technical/natural sciences

Publication information
Journal: European Journal of Operational Research
Volume: 194
Issue number: 1
ISSN (Print): 0377-2217
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.83 SJR 2.505 SNIP 2.339
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1

Isi indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.516 SNIP 2.25
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.003 SNIP 1.781
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 0.974 SNIP 1.215
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.179 SNIP 1.709
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.979 SNIP 1.293
Scopus rating (2005): SJR 1.043 SNIP 0.996
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.643 SNIP 0.839
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.778 SNIP 0.797
Scopus rating (2002): SJR 0.577 SNIP 0.775
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.376 SNIP 0.578
Scopus rating (2000): SJR 0.352 SNIP 0.515
Scopus rating (1999): SJR 0.182 SNIP 0.45

Original language: English
Uncertainty, Wind power, Ensemble forecasting, Prediction risk indices, Forecasting, Skill forecasting
Electronic versions:
pinsonetal_skillfore_rev.pdf
DOIs:
10.1016/j.apenergy.2008.10.009
Source: orbit
Source-ID: 243723
Publication: Research - peer-review › Journal article – Annual report year: 2009
Scopus rating (2015): SJR 2.334 SNIP 2.412 CiteScore 3.59
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 2.186 SNIP 2.485 CiteScore 3.21
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 2.346 SNIP 2.735 CiteScore 3.25
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 2.418 SNIP 2.588 CiteScore 3.01
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 2.401 SNIP 2.441 CiteScore 3.02
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 2.477 SNIP 2.435
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 2.326 SNIP 2.577
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.739 SNIP 1.984
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.679 SNIP 2.041
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.299 SNIP 2.023
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.194 SNIP 1.913
Scopus rating (2004): SJR 1.24 SNIP 1.882
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.991 SNIP 1.507
Scopus rating (2002): SJR 0.97 SNIP 1.279
Scopus rating (2001): SJR 1.078 SNIP 1.183
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 1.046 SNIP 1.135
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 1.104 SNIP 1.059
Original language: English
Electronic versions:
pinsonetal_temppred_rev2.pdf
DOIs:
10.1016/j.ejor.2007.11.065
Source: orbit
Source-ID: 209974
Publication: Research - peer-review › Journal article – Annual report year: 2009

Optimal Experimental Design for Grey Box Models

General information
State: Published
Organisations: Department of Chemical and Biochemical Engineering, Mathematical Statistics, Department of Informatics and Mathematical Modeling, Computer Aided Process Engineering Center
Application of CUSUM charts to detect lameness in a milking robot

In the year 2006 about 4000 farms worldwide used over 6000 milking robots. With increased automation the time that the cattle keeper uses for monitoring animals has decreased. This has created a need for automatic health monitoring systems. Lameness is a crucial welfare and economic issue in modern dairy husbandry. It causes problems especially in loose housing of cattle. This could be greatly reduced by early identification and treatment. A four-balance system for automatically measuring the load on each leg of a cow during milking in a milking robot has been developed. It has been previously shown that the weight distribution between limbs changes when cow get lame. In this paper we suggest CUSUM charts to automatically detect lameness based on the measurements. CUSUM charts are statistical based control charts and are well suited for checking a measuring system in operation for any departure from some target or specified values. The target values for detecting lameness were calculated from the cow’s own historical data so that each animal had an individual chart. The method enables objective monitoring of the changes in leg health, which is valuable information in veterinary research because it provides means for assessing the severity and impact of different causes of lameness and also evaluating the effect of treatment and medication. So far no objective method for calculating these measures has been available and the methodology presented in this paper seems very promising for the task.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Pastell, M. (Ekstern), Madsen, H. (Intern)
Pages: 2032-2040
Publication date: 2008
Main Research Area: Technical/natural sciences

Publication information
Journal: Expert Systems with Applications
Volume: 35
Issue number: 4
ISSN (Print): 0957-4174
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.7 SJR 1.433 SNIP 2.492
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.561 SNIP 2.625 CiteScore 4.11
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.578 SNIP 2.632 CiteScore 3.63
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.364 SNIP 2.408 CiteScore 3.31
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.198 SNIP 2.475 CiteScore 3.38
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.153 SNIP 2.574 CiteScore 3.76
ISI indexed (2011): ISI indexed yes
A review on the young history of the wind power short-term prediction

This paper makes a brief review on 30 years of history of the wind power short-term prediction, since the first ideas and sketches on the theme to the actual state of the art oil models and tools, giving emphasis to the most significant proposals and developments. The two principal lines of thought on short-term prediction (mathematical and physical) are indistinctly treated here and comparisons between models and tools are avoided, mainly because, on the one hand, a standard for a measure of performance is still not adopted and, on the other hand, it is very important that the data are exactly the same in order to compare two models (this fact makes it almost impossible to carry out a quantitative comparison between a huge number of models and methods). In place of a quantitative description, a qualitative approach is preferred for this review, remarking the contribution (and innovative aspect) of each model. On the basis of the review, some topics for future research are pointed out.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Costa, A. (Ekstern), Crespo, A. (Ekstern), Navarro, J. (Ekstern), Lizcano, G. (Ekstern), Madsen, H. (Intern), Feitosa, E. (Ekstern)
Pages: 1725-1744
Publication date: 2008
Main Research Area: Technical/natural sciences

Publication information
Journal: Renewable & Sustainable Energy Reviews
Volume: 12
Issue number: 6
ISSN (Print): 1364-0321
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 9.52 SJR 3.051 SNIP 3.454
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Combined Forecast and Quantile Regression for Wind Power Prediction

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Møller, J. K. (Intern), Madsen, H. (Intern), Nielsen, H. A. O. T. 3. (Intern)
Publication date: 2008

Publication information
Place of publication: Lyngby
Publisher: Technical University of Denmark, DTU Informatics, Building 321
Original language: English

Number: 2007-19
Ecogrid.dk Phase 1 WP4 report: New measures for integration of large scale renewable energy

General information
State: Published
Publication date: 2008

Publication information
Publisher: Danmarks Tekniske Universitet, Risø Nationallaboratorium for Bæredygtig Energi
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions: EcoGrid.dk - WP4 Report Measures.pdf
Source: orbit
Source-ID: 224237
Publication: Research › Report – Annual report year: 2008

Estimating the parameters of a stochastic differential equation model of bacterial growth

General information
State: Submitted
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Christiansen, L. E. (Intern), Andersen, J. S. (Intern), Wegener, H. C. (Ekstern), Madsen, H. (Intern)
Publication date: 2008
Main Research Area: Technical/natural sciences

Publication information
Journal: Biometrics
ISSN (Print): 0006-341X
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): SJR 1.632 SNIP 1.115 CiteScore 1.35
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.005 SNIP 1.393 CiteScore 1.66
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.241 SNIP 1.398 CiteScore 1.57
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.07 SNIP 1.285 CiteScore 1.57
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.719 SNIP 1.39 CiteScore 1.69
Estimation of non-linear continuous time models for the heat exchange dynamics of building integrated photovoltaic
modules

This paper focuses on a method for linear or non-linear continuous time modelling of physical systems using discrete time
data. This approach facilitates a more appropriate modelling of more realistic non-linear systems. Particularly concerning
advanced building components, convective and radiative heat interchanges are non-linear effects and represent
significant contributions in a variety of components such as photovoltaic integrated facades or roofs and those using these
effects as passive cooling strategies, etc. Since models are approximations of the physical system and data is
encumbered with measurement errors it is also argued that it is important to consider stochastic models. More specifically
this paper advocates for using continuous-discrete stochastic state space models in the form of non-linear partially
observed stochastic differential equations (SDE's)-with measurement noise for modelling dynamic systems in continuous
time using discrete time data. First of all the proposed method provides a method for modelling non-linear systems with
partially observed states. The approach allows parameters to be estimated from experimental data in a prediction error
(PE) setting, which gives less biased and more reproducible results in the presence of significant process noise than the
more commonly used output error (OE) setting. To facilitate the use of continuous-discrete stochastic state space models,
a PE estimation scheme that features maximum likelihood (ML) and maximum a posteriori (MAP) estimation is presented
along with a software implementation. As a case study, the modelling of the thermal characteristics of a building integrated
PV component is considered. The EC-JRC Ispra has made experimental data available. Both linear and non-linear models
are identified. It is shown that a description of the non-linear heat transfer is essential. The resulting model is a non-linear
first order stochastic differential equation for the heat transfer of the PV component.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Scientific Computing
Authors: Jimenez, M. (Ekstern), Madsen, H. (Intern), Bloem, J. (Ekstern), Dammann, B. (Intern)
Pages: 157-167
Publication date: 2008
Main Research Area: Technical/natural sciences

Publication information
Journal: Energy and Buildings
thermal analysis, parameter estimation, PV element, extended kalman filters, prediction error methods, software tools, parallel computation, non-linear systems, maximum likelihood estimators, stochastic modelling, continuous time systems
From meteorological ensembles to reliable probabilistic forecasts of wind generation

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Pinson, P. (Intern), Madsen, H. (Intern)
Publication date: 2008

Host publication information
Title of host publication: Proceedings of the 28th Annual International Symposium on Forecasting
Main Research Area: Technical/natural sciences
Conference: 28th Annual International Symposium on Forecasting, 01/01/2008
Source: orbit
Source-ID: 223287
Publication: Research › Article in proceedings – Annual report year: 2008

Geolocation of North Sea cod (Gadus morhua) using Hidden Markov Models and behavioural switching
When geolocating fish based on archival tag data, a realistic assessment of uncertainty is essential. Here, we describe an application of a novel Fokker–Planck-based method to geolocate Atlantic cod (Gadus morhua) in the North Sea area. In this study, the geolocation relies mainly on matching tidal patterns in depth measurements when a fish spends a prolonged period of time at the seabed with a tidal database. Each day, the method provides a nonparametric probability distribution of the position of a tagged fish and therefore avoids enforcing a particular distribution, such as a Gaussian distribution. In addition to the tidal component of the geolocation, the model incorporates two behavioural states, either high or low activity, estimated directly from the depth data, that affect the diffusivity parameter of the model and improves the precision and realism of the geolocation significantly. The new method provides access to the probability distribution of the position of the fish that in turn provides a range of useful descriptive statistics, such as the path of the most probable movement. We compare the method with existing alternatives and discuss its potential in making population inference from archival tag data.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Section for Population- and Ecosystem Dynamics, National Institute of Aquatic Resources
Pages: 2367-2377
Publication date: 2008
Main Research Area: Technical/natural sciences

Publication information
Journal: Canadian Journal of Fisheries and Aquatic Sciences
Volume: 65
Issue number: 11
ISSN (Print): 0706-652X
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.56 SJR 1.322 SNIP 1.163
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.256 SNIP 1.051 CiteScore 2.22
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.443 SNIP 1.379 CiteScore 2.6
HRensembleHR project progress in applying short-range ensemble forecasts for offshore wind power

General information
State: Published
Authors: Moehrlen, C. (Ekstern), Jørgensen, J. (Ekstern), Pinson, P. (Intern), Madsen, H. (Intern), Lange, B. (Ekstern), Cali, U. (Ekstern), Giebel, G. (Intern), Tøfting, J. (Ekstern), Kristoffersen, J. R. (Ekstern)
Publication date: 2008
Identification of the main thermal characteristics of building components using MATLAB

This paper presents the application of the IDENT Graphical User Interface of MATLAB to estimate the thermal properties of building components from outdoor dynamic testing, imposing appropriate physical constraints and assuming linear and time invariant parametric models. The theory is briefly described to provide the background for a first understanding of the models used. The relationship between commonly used RC-network models and the parametric models proposed is presented. The analysis is generalised for different possibilities in the assignment of inputs and outputs and even multiple output. Step by step guidance illustrated by an example is included. Results obtained using the different possibilities in selecting inputs and outputs are reported.
Introduction to PK/PD modelling - with focus on PK and stochastic differential equations

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Mortensen, S. B. (Intern), Jónsdóttir, A. H. (Intern), Klim, S. (Intern), Madsen, H. (Intern)
Publication date: 2008

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Local linear regression with adaptive orthogonal fitting for the wind power application

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Pinson, P. (Intern), Nielsen, H. A. (Intern), Madsen, H. (Intern), Nielsen, T. S. (Intern)
Pages: 59-71
Publication date: 2008
Main Research Area: Technical/natural sciences
Mathematical model for the growth of P. aeruginosa and four mutator strains in sub-MIC concentration of Ciprofloxacin

P. aeruginosa causes very critical and complicated infections, for which treatment is strongly dependent on successful antibiotic treatment. Therefore the evolution of antibiotic resistant P. aeruginosa does have serious consequences. Cystic fibrosis (CF) is characterized by the chronic P. aeruginosa lung infection. Intensive antibiotic treatment has improved the survival and clinical condition of CF patients, but development of resistance to antibiotics makes these infections difficult to treat efficiently. Ciprofloxacin is commonly used in the early and aggressive treatment. A hypothesis is that the presence of antibiotic results in selection of mutators in the lungs of CF patients, as these bacteria has a higher fitness under the
The presence of antibiotics. The goal of this study is to model the growth of P. aeruginosa and four different mutator strains (PAO1 mutT, mutY, mutM and mutM-mutY mutants) when growing under sub-MIC Ciprofloxacin concentration (0.1 μg/ml), in order to describe the growth pattern under the presence of antibiotic. Data available for the modelling process is bioscreen measurements of the bacterial content as a function of time for each bacteria strain growing in LB media with and without the presence of Ciprofloxacin. The growth of the bacteria strains is modelled with a continuous-discrete time stochastic state space model consisting of a continuous time state equation expressed as a system of stochastic differential equations and a discrete time measurement equation. The model parameters are estimated from data using a Maximum Likelihood approach. We introduce a new expression for multiple substrate dependent growth in LB media, which is identified by a method first introducing the growth as a random walk in the model. From the bioscreen measurement we found a change in the growth pattern under the presence of Ciprofloxacin. In most cases the presence of Ciprofloxacin resulted in a longer lag phase, a period of growth followed by a transition phase and then a second period of growth. We have developed a new mathematical model using a multi substrate approach, which will be able to describe this change in growth as a function of the Ciprofloxacin concentration. Following the determination of the growth pattern we wish to continue this study by modelling a competition experiment between PA01 and each of the four mutator strains. The goal is to determine whether the mutator strain has an advantage in an environment with sub-MIC concentrate of Ciprofloxacin.

**General information**

State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, University of Copenhagen
Authors: Philipsen, K. R. (Intern), Christiansen, L. E. (Intern), Madsen, H. (Intern), Mandsberg, L. F. (Ekstern)
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Main Research Area: Technical/natural sciences
Bacterial growth, Pseudomonas aeruginosa, Mutator, Mathematical modelling

**Links:**
http://www.asm.org/Meetings/index.asp?bid=59071
Source: orbit
Source-ID: 228082
Publication: Research - peer-review › Poster – Annual report year: 2008

**Maximum Likelihood based comparison of the specific growth rates for P. aeruginosa and four mutator strains**

The specific growth rate for P. aeruginosa and four mutator strains mutT, mutY, mutM and mutY–mutM is estimated by a suggested Maximum Likelihood, ML, method which takes the autocorrelation of the observation into account. For each bacteria strain, six wells of optical density, OD, measurements are used for parameter estimation. The data is log-transformed such that a linear model can be applied. The transformation changes the variance structure, and hence an OD-dependent variance is implemented in the model. The autocorrelation in the data is demonstrated, and a correlation model with an exponentially decaying function of the time between observations is suggested. A model with a full covariance structure containing OD-dependent variance and an autocorrelation structure is compared to a model with variance only and with no variance or correlation implemented. It is shown that the model that best describes data is a model taking into account the full covariance structure. An inference study is made in order to determine whether the growth rate of the five bacteria strains is the same. After applying a likelihood-ratio test to models with a full covariance structure, it is concluded that the specific growth rate is the same for all bacteria strains. This study highlights the importance of carrying out an explorative examination of residuals in order to make a correct parametrization of a model including the covariance structure. The ML method is shown to be a strong tool as it enables estimation of covariance parameters along with the other model parameters and it makes way for strong statistical tools for inference studies.

**General information**

State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, University of Copenhagen
Authors: Philipsen, K. R. (Intern), Christiansen, L. E. (Intern), Mandsberg, L. F. (Ekstern), Ciufo, O. (Ekstern), Madsen, H. (Intern)
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Maximum Likelihood, Parameter estimation, Specific growth rate, Bacterial growth, Likelihood-ratio test

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http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6T30-4TCHKFG-4&_user=10&_method=export&_format=&_orig=search&_sort=d&view=c&version=1&_urlVersion=0&userid=10&md5=f4c86d0ef73d78cde028e29a668ccc31#FCANote
Modelling of power fluctuations from large offshore wind farms

This paper deals with modelling of power fluctuations from large wind farms. The modelling is supported and validated using wind speed and power measurements from the two large offshore wind farms in Denmark. The time scale in focus is from 1 min to a couple of hours, where significant power fluctuations have been observed from these wind farms. Power and wind speed are measured with 1 s sampling time in all individual wind turbines in almost 1 year, which provides a substantial database for the analyses. The paper deals with diversified models representing each wind turbine individually and with aggregation of a wind farm to be represented by a single large wind turbine model. Copyright (C) 2007 John Wiley & Sons, Ltd.

General information

State: Published
Authors: Sørensen, P. E. (Intern), Cutululis, N. A. (Intern), Vigueras-Rodriguez, A. (Intern), Madsen, H. (Intern), Pinson, P. (Intern), Jensen, L. (Ekstern), Hjerrild, J. (Ekstern), Donovan, M. (Ekstern)
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Main Research Area: Technical/natural sciences

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Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.272 SNIP 3.75 CiteScore 3.42
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BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.275 SNIP 2.464 CiteScore 2.75
ISI indexed (2013): ISI indexed yes
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BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.126 SNIP 2.39 CiteScore 2.36
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.024 SNIP 2.718 CiteScore 2.49
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.487 SNIP 2.013
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.124 SNIP 1.448
Models for describing the thermal characteristics of building components

Outdoor testing of buildings and building components under real weather conditions provides useful information about their dynamic performance. Such knowledge is needed to properly characterize the heat transfer dynamics and provides useful information for implementing energy saving strategies, for example. For the analysis of these tests, dynamic analysis models and methods are required. However, a wide variety of models and methods exists, and the problem of choosing the most appropriate approach for each particular case is a non-trivial and interdisciplinary task. Knowledge of a large family of these approaches may therefore be very useful for selecting a suitable approach for each particular case. This paper presents an overview of models that can be applied for modelling the thermal characteristics of buildings and building components using data from outdoor testing. The choice of approach depends on the purpose of the modelling, existence of prior physical knowledge, the data and the available statistical tools. In this paper, a variety of models are outlined and compared, and a strong relationship among a large number of widely used linear and stationary stochastic models is mathematically demonstrated. The characteristics of each type of model are highlighted. Some available software tools for each of the methods described will be mentioned. A case study also demonstrating the difference between linear and nonlinear models is considered.
Probabilistic forecasting of wind power at the minute time-scale with Markov-switching autoregressive models

Better modelling and forecasting of very short-term power fluctuations at large offshore wind farms may significantly enhance control and management strategies of their power output. The paper introduces a new methodology for modelling and forecasting such very short-term fluctuations. The proposed methodology is based on a Markov-switching autoregressive model with time-varying coefficients. An advantage of the method is that one can easily derive full predictive densities. The quality of this methodology is demonstrated from the test case of 2 large offshore wind farms in Denmark. The exercise consists in 1-step ahead forecasting exercise on time-series of wind generation with a time resolution of 10 minute. The quality of the introduced forecasting methodology and its interest for better understanding power fluctuations are finally discussed.

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State: Published
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Authors: Pinson, P. (Intern), Madsen, H. (Intern)
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Source: orbit
Source-ID: 223285
Publication: Research - peer-review › Article in proceedings – Annual report year: 2008

Regime-switching modelling of the fluctuations of offshore wind generation

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Wind Energy Systems, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Department of Buildings and Energy
Authors: Pinson, P. (Intern), Christensen, L. (Ekstern), Madsen, H. (Intern), Sørensen, P. E. (Intern), Donovan, M. H. (Intern), Jensen, L. E. (Ekstern)
Pages: 2327-2347
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Main Research Area: Technical/natural sciences

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Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.61 SJR 1.002 SNIP 1.92
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.011 SNIP 1.966 CiteScore 2.51
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.929 SNIP 2.328 CiteScore 2.13
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.807 SNIP 2.636 CiteScore 2.43
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.667 SNIP 2.396 CiteScore 1.81
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.952 SNIP 3.274 CiteScore 2.3
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.924 SNIP 2.255
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.723 SNIP 1.396
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.729 SNIP 2.173
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.8 SNIP 2.306
Scopus rating (2006): SJR 0.652 SNIP 1.528
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.737 SNIP 1.343
Scopus rating (2004): SJR 0.527 SNIP 1.103
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.34 SNIP 1.031
Scopus rating (2002): SJR 0.487 SNIP 1.34
Scopus rating (2001): SJR 0.43 SNIP 0.892
Web of Science (2001): Indexed yes
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Web of Science (2000): Indexed yes
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Relations
Projects:
Regime-switching modelling of the fluctuations of offshore wind generation
Simulation Study for Transfer of Antibiotic Resistance via Mutator Subpopulation

Evolution of antibiotic resistance in bacterial populations is an increasing problem having fatal consequences for treatment of diseases. Therefore it is very important to understand this evolution. Traditionally evolution is considered to happen by single point mutations, where each mutant must have a growth advantage over the parent strain and grow to a sufficient number before a second mutation can occur. However, when multiple mutations are necessary for development of resistance, single mutations occurring with a normal mutation rate can not always explain the observed resistance. We introduce an alternative hypothesis by which a subpopulation of mutators drives the evolution process. Resistance is acquired by a subpopulation of mutators, for which the mutation rate is much higher than the wild-type. If the resistance is located on a transferable plasmid it can subsequently be transferred to the wild-type population by conjugation. To examine whether this pathway will in fact speed up evolution, we perform a simulation study, where bacteria are simulated to grow in a chemostat environment, such as the intestine of a human. Since mutation events are stochastic processes, we model the system by a discrete Markov process with the possibility of changes in each state given by a Poisson distribution. Parameters for growth, mutation and conjugation rates used in the simulation study resemble those of E.coli with a mutator obtained with the XL1-red mutator strain having a 5000 times higher mutation rate than the wild-type. We simulate the process for 24 hours and perform 1000 repetitions, which correspond to considering 1000 people with the same initial bacterial population in the intestine. In none of the repetitions a double mutation occurs in the wild-type population, but in almost 300 cases a double mutated strain has been conjugated to the wild-type bacterial population. To confirm these results future work should include an experimental study of the hypothesis.
Time-adaptive quantile regression

An algorithm for time-adaptive quantile regression is presented. The algorithm is based on the simplex algorithm, and the linear optimization formulation of the quantile regression problem is given. The observations have been split to allow a direct use of the simplex algorithm. The simplex method and an updating procedure are combined into a new algorithm for time-adaptive quantile regression, which generates new solutions on the basis of the old solution, leading to savings in computation time. The suggested algorithm is tested against a static quantile regression model on a data set with wind power production, where the models combine splines and quantile regression. The comparison indicates superior performance for the time-adaptive quantile regression in all the performance parameters considered.

General information

State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Møller, J. K. (Intern), Nielsen, H. A. (Intern), Madsen, H. (Intern)
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Main Research Area: Technical/natural sciences

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BFI (2016): BFI-level 1
Scopus rating (2016): SJR 1.47 SNIP 1.685 CiteScore 1.64
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.201 SNIP 1.262 CiteScore 1.3
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.462 SNIP 1.508 CiteScore 1.47
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.375 SNIP 1.502 CiteScore 1.41
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.301 SNIP 1.393 CiteScore 1.4
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.26 SNIP 1.267 CiteScore 1.36
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.342 SNIP 1.357
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.286 SNIP 1.33
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Scopus rating (2008): SJR 1.135 SNIP 1.206
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.856 SNIP 1.235
Scopus rating (2006): SJR 0.849 SNIP 1.487
Scopus rating (2005): SJR 0.868 SNIP 1.151
Scopus rating (2004): SJR 1.082 SNIP 1.385
Scopus rating (2003): SJR 0.904 SNIP 0.845
Using random walk in models specified by stochastic differential equations to determine the best expression for the bacterial growth rate

In this presentation we consider a new method first introduced by Kristensen et al. [1] to improve the model for bacterial growth. Traditionally the substrate dependent growth rate $\mu(S)$ is modeled using the Monod expression, however it fails to describe the growth of bacteria in rich media. For $P$. aeruginosa we observe a growth pattern far from Monod growth. Therefore a reformulation of the growth expression is necessary. Without any pre-knowledge about the functional dependence between the growth rate and the substrate content and with only limited experimental resources necessary, the proposed method allows us to develop a new expression for the growth rate. The method is based on the stochastic continuous-discrete time state-space model, with a continuous-time state equation (a stochastic differential equation, SDE) combined with a discrete-time measurement equation. In our study the SDE contains two state variables, the bacterial and substrate densities. To improve the growth model we initially allow the growth rate $\mu(S)$ to vary as a random walk, i.e. we reformulate the SDE model to include $\mu(S)$ as an extra state variable which change is described by the Wiener process. We use data from Optical Density bioscreen measurements of $P$. aeruginosa to perform a Maximum Likelihood estimation of the model parameters and subsequently obtain a smoothing estimate for the model state variables by means of a nonlinear smoothing algorithm based on the extended Kalman filter, using an implementation described by Kristensen et al [2]. The resulting time series allows us graphically to inspect the functional dependence of the growth rate on the substrate content. From the method described above we find three new plausible expressions for $\mu(S)$. Therefore we apply the likelihood-ratio test to compare the expressions which are nested. Additional inferens concerning the best expression is performed by considering the incremental variance $\sigma^2$ of the Wiener process. The best expression is found to be $S(\alpha/(1 + b(1 − S)^2) + c)$ with $\alpha^2 = 3.46 \cdot 10^{-4}$, which is one order of magnitude lower than the incremental variance for the Monod expression. Thus, the method was applied to successfully determine a significant better expression for the substrate dependent growth expression, and we find the method generally applicable for model development. References [1] Kristensen NR, Madsen H, Jørgensen, SB (2004) A method for systematic improvement of stochastic grey-box models. Computers and Chemical Engineering 28:1431-1449. [2] Kristensen NR, Madsen H, Jørgensen, SB (2004) Parameter estimation in stochastic greybox models. Automatica 40:225-237.

Stochastic Modelling of Hydrologic Systems

In this PhD project several stochastic modelling methods are studied and applied on various subjects in hydrology. The research was prepared at Informatics and Mathematical Modelling at the Technical University of Denmark. The thesis is divided into two parts. The first part contains an introduction and an overview of the papers published. Then an introduction to basic concepts in hydrology along with a description of hydrological data is given. Finally an introduction to stochastic modelling is given. The second part contains the research papers. In the research papers the stochastic methods are described, as at the time of publication these methods represent new contribution to hydrology. The second part also contains additional description of software used and a brief introduction to stiff systems. The system in one of the papers is stiff.

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Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Philipsen, K. R. (Intern), Christiansen, L. E. (Intern), Madsen, H. (Intern)
Publication date: 2008

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Original language: English
Main Research Area: Technical/natural sciences
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Source: orbit
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Publication: Research › Sound/Visual production (digital) – Annual report year: 2008
Application of Parameter Estimation for Diffusions and Mixture Models

The first part of this thesis proposes a method to determine the preferred number of structures, their proportions and the corresponding geometrical shapes of an m-membered ring molecule. This is obtained by formulating a statistical model for the data and constructing an algorithm which samples from a posterior distribution. The sampling algorithm is constructed from a Markov chain which allows the dimension of each sample to vary, this is obtained by utilizing the Reversible jumps methodology proposed by Peter Green. Each sample is constructed such that the corresponding structures are physically realizable; this is obtained by utilizing the geometry of the structures. Determining the shapes, number of structures and proportions for an m-membered ring molecule is of interest, since these quantities determine the chemical properties. The second part of this thesis deals with parameter estimation for diffusions. The first idea is in an optimal way to incorporate prior information in the estimation equation \( G(X_{t1}, \ldots, X_{tn}) = 0 \), used to nd an estimator of the unknown parameter \( \theta \). The general idea is to introduce a new optimality criterion which optimizes the correlation with the posterior score function. From an application point of view this methodology is easy to apply, since the optimal estimating function \( G(X_{t1}, \ldots, X_{tn}) \) is equal to the classical optimal estimating function, plus a correction term which takes into account the prior information. The methodology is particularly useful in situations where prior information is available and only few observations are present. The resulting estimators in some sense have better properties than the classical estimators. The second idea is to formulate Michael Sørensens method "prediction based estimating function" for measurement error models. This is obtained by constructing an estimating function through projections of some chosen function of \( Y_{t+1} \) onto functions of previous observations \( Y_{t1}, \ldots, Y_{t0} \). The process of interest \( X_{t+1} \) is partially observed through a measurement equation \( Y_{t+1} = h(X_{t+1}) + \text{noise} \), where \( h(\cdot) \) is restricted to be a polynomial. Through a simulation study we compare for the CIR process the obtained estimator with an estimator derived from utilizing the extended Kalman filter. The simulation study shows that the two estimation methods perform equally well.

A Computational Efficient and Robust Implementation of the Continuous-Discrete Extended Kalman Filter

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics, Center for Phase Equilibria and Separation Processes, Department of Chemical and Biochemical Engineering, Center for Energy Resources Engineering
Authors: H. (Intern), Madsen, H. (Intern), Palsson, O. P. (Intern)
Publication date: Feb 2007

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Source: orbit
Source-ID: 200806
Publication: Research › Ph.D. thesis – Annual report year: 2007

Application of Parameter Estimation for Diffusions and Mixture Models

The first part of this thesis proposes a method to determine the preferred number of structures, their proportions and the corresponding geometrical shapes of an m-membered ring molecule. This is obtained by formulating a statistical model for the data and constructing an algorithm which samples from a posterior distribution. The sampling algorithm is constructed from a Markov chain which allows the dimension of each sample to vary, this is obtained by utilizing the Reversible jumps methodology proposed by Peter Green. Each sample is constructed such that the corresponding structures are physically realizable; this is obtained by utilizing the geometry of the structures. Determining the shapes, number of structures and proportions for an m-membered ring molecule is of interest, since these quantities determine the chemical properties. The second part of this thesis deals with parameter estimation for diffusions. The first idea is in an optimal way to incorporate prior information in the estimation equation \( G(X_{t1}, \ldots, X_{tn}) = 0 \), used to nd an estimator of the unknown parameter \( \theta \). The general idea is to introduce a new optimality criterion which optimizes the correlation with the posterior score function. From an application point of view this methodology is easy to apply, since the optimal estimating function \( G(X_{t1}, \ldots, X_{tn}) \) is equal to the classical optimal estimating function, plus a correction term which takes into account the prior information. The methodology is particularly useful in situations where prior information is available and only few observations are present. The resulting estimators in some sense have better properties than the classical estimators. The second idea is to formulate Michael Sørensens method "prediction based estimating function" for measurement error models. This is obtained by constructing an estimating function through projections of some chosen function of \( Y_{t+1} \) onto functions of previous observations \( Y_{t1}, \ldots, Y_{t0} \). The process of interest \( X_{t+1} \) is partially observed through a measurement equation \( Y_{t+1} = h(X_{t+1}) + \text{noise} \), where \( h(\cdot) \) is restricted to be a polynomial. Through a simulation study we compare for the CIR process the obtained estimator with an estimator derived from utilizing the extended Kalman filter. The simulation study shows that the two estimation methods perform equally well.

A Computational Efficient and Robust Implementation of the Continuous-Discrete Extended Kalman Filter

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: K. (Intern), Madsen, H. (Intern)
Publication date: Jan 2007

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Place of publication: Kgs. Lyngby, Denmark
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Publication: Research › Ph.D. thesis – Annual report year: 2007
A Computationally Efficient and Robust Implementation of the Continuous-Discrete Extended Kalman Filter

We present a novel numerically robust and computationally efficient extended Kalman filter for state estimation in nonlinear continuous-discrete stochastic systems. The resulting differential equations for the mean-covariance evolution of the nonlinear stochastic continuous-discrete time systems are solved efficiently using an ESDIRK integrator with sensitivity analysis capabilities. This ESDIRK integrator for the mean-covariance evolution is implemented as part of an extended Kalman filter and tested on a PDE system. For moderate to large sized systems, the ESDIRK based extended Kalman filter for nonlinear stochastic continuous-discrete time systems is more than two orders of magnitude faster than a conventional implementation. This is of significance in nonlinear model predictive control applications, statistical process monitoring as well as grey-box modelling of systems described by stochastic differential equations.

Adaptive Markov-switching modelling for offshore wind power fluctuations

We present a novel adaptive Markov-switching model for offshore wind power fluctuations. The model is designed to capture the intermittent nature of wind power and to provide accurate predictions for statistical process monitoring and grey-box model identification. The model is validated on real-world data from an offshore wind farm.
A matlab framework for estimation of NLME models using stochastic differential equations

General information
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Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Scientific Computing, Department of Chemical and Biochemical Engineering
Authors: Mortensen, S. B. (Intern), Klim, S. (Intern), Dammann, B. (Intern), Kristensen, N. R. (Intern), Madsen, H. (Intern), Overgaard, R. V. (Intern)
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Main Research Area: Technical/natural sciences

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BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.709 SNIP 0.953 CiteScore 1.77
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.696 SNIP 0.851 CiteScore 1.82
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.561 SNIP 0.802 CiteScore 1.7
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.974 SNIP 1.179 CiteScore 2.07
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.955 SNIP 1.109 CiteScore 2.2
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.884 SNIP 0.79
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.072 SNIP 1.226
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.024 SNIP 0.993
Scopus rating (2007): SJR 0.579 SNIP 0.938
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.452 SNIP 0.758
Scopus rating (2005): SJR 0.577 SNIP 1.109
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.558 SNIP 0.99
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.67 SNIP 1.107
Scopus rating (2002): SJR 0.538 SNIP 1.08
Scopus rating (2001): SJR 0.452 SNIP 0.732
A Numerically Robust ESDIRK-Based Implementation of the Continuous-Discrete Extended Kalman Filter

**General information**
State: Published
Organisations: Scientific Computing, Department of Informatics and Mathematical Modeling, Department of Chemical and Biochemical Engineering, Mathematical Statistics
Authors: Jørgensen, J. B. (Intern), Kristensen, M. R. (Intern), Thomsen, P. G. (Intern), Madsen, H. (Intern)
Publication date: 2007

**Host publication information**
Title of host publication: European Control Conference 2007
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 224356
Publication: Research - peer-review › Article in proceedings – Annual report year: 2007

Automatic selection of tuning parameters in wind power prediction

**General information**
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Christiansen, L. E. (Intern), Nielsen, H. A. (Intern), Nielsen, T. S. (Intern), Madsen, H. (Intern)
Publication date: 2007

**Publication information**
Publisher: Informatics and Mathematical Modelling, Technical University of Denmark, DTU
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions: tr07_12.pdf
Links: http://www2.imm.dtu.dk/pubdb/views/publication_details.php?id=5316
Source: orbit
Source-ID: 201423
Publication: Research › Report – Annual report year: 2007

Comparative uncertainty analysis of copper loads in stormwater systems using GLUE and grey-box modelling

In this paper two attempts to assess the uncertainty involved with model predictions of copper loads from stormwater systems are made. In the first attempt, the GLUE methodology is applied to derive model parameter sets that result in model outputs encompassing a significant number of the measurements. In the second attempt the conceptual model is reformulated to a grey-box model followed by parameter estimation. Given data from an extensive measurement campaign, the two methods suggest that the output of the stormwater pollution model is associated with significant uncertainty. With the proposed model and input data, the GLUE analysis show that the total sampled copper mass can be predicted within a range of +/- 50% of the median value (385 g), whereas the grey-box analysis showed a prediction uncertainty of less than +/- 30%. Future work will clarify the pros and cons of the two methods and furthermore explore to what extent the estimation can be improved by modifying the underlying accumulation-washout model.

**General information**
State: Published
Organisations: Department of Environmental Engineering, Department of Informatics and Mathematical Modeling, Mathematical Statistics
Conditional parametric models for storm sewer runoff

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Jonsdottir, H. (Intern), Nielsen, H. A. (Intern), Madsen, H. (Intern), Eliasson, J. (Ekstern), Palsson, O. P. (Intern), Nielsen, M. (Ekstern)
Pages: W05443
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information
Journal: Water Resources Research
Volume: 43
Issue number: 5
ISSN (Print): 0043-1397
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 4.1 SJR 2.383 SNIP 1.553
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.58 SNIP 1.617 CiteScore 4.06
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.44 SNIP 1.643 CiteScore 3.75
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.205 SNIP 1.748 CiteScore 3.65
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.123 SNIP 1.567 CiteScore 3.12
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.946 SNIP 1.481 CiteScore 2.92
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.051 SNIP 1.433
Web of Science (2010): Indexed yes
Evaluation of Nonparametric Probabilistic Forecasts of Wind Power

Predictions of wind power production for horizons up to 48-72 hour ahead comprise a highly valuable input to the methods for the daily management or trading of wind generation. Today, users of wind power predictions are not only provided with point predictions, which are estimates of the most likely outcome for each look-ahead time, but also with uncertainty estimates given by probabilistic forecasts. In order to avoid assumptions on the shape of predictive distributions, these probabilistic predictions are produced from nonparametric methods, and then take the form of a single or a set of quantile forecasts. The required and desirable properties of such probabilistic forecasts are defined and a framework for their evaluation is proposed. This framework is applied for evaluating the quality of two statistical methods producing full
predictive distributions from point predictions of wind power. These distributions are defined by 18 quantile forecasts with nominal proportions spanning the unit interval. The relevance and interest of the introduced evaluation framework are consequently discussed.

**General information**
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Pinson, P. (Intern), Møller, J. K. (Intern), Nielsen, H. A. O. 3. (Intern), Madsen, H. (Intern), Kariniotakis, G. N. (Ekstern)
Publication date: 2007

**Publication information**
Publisher: Informatics and Mathematical Modelling, Technical University of Denmark, DTU
Original language: English
Main Research Area: Technical/natural sciences
sharpness, quality evaluation, skill, probabilistic forecasting, reliability, resolution, quantile forecasts, uncertainty, wind power
Electronic versions: imm5024.pdf
Source: orbit
Source-ID: 201019
Publication: Research - peer-review › Report – Annual report year: 2007

**Fluctuations of offshore wind generation: Statistical modelling**
The magnitude of power fluctuations at large offshore wind farms has a significant impact on the control and management strategies of their power output. If focusing on the minute scale, one observes successive periods with smaller and larger power fluctuations. It seems that different regimes yield different behaviours of the wind power output. This paper concentrates on the statistical modelling of offshore power fluctuations, with particular emphasis on regime-switching models. More precisely, Self-Exciting Threshold AutoRegressive (SETAR), Smooth Transition AutoRegressive (STAR) and Markov-Switching AutoRegressive (MSAR) models are considered. The particularities of these models are presented, as well as methods for the estimation of their parameters. Simulation results are given for the case of the Horns Rev and Nysted offshore wind farms in Denmark, for time-series of power production averaged at a 1, 5, and 10-minute rate. The exercise consists in one-step ahead forecasting of these time-series with the various regime-switching models. It is shown that the MSAR model, for which the succession of regimes is represented by a hidden Markov chain, significantly outperforms the other models, for which the rules for the regime-switching are explicitly formulated.

**General information**
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Wind Energy Systems, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Department of Buildings and Energy
Authors: Pinson, P. (Intern), Christensen, L. E. (Ekstern), Madsen, H. (Intern), Sørensen, P. E. (Intern), Donovan, M. H. (Intern), Jensen, L. E. (Ekstern)
Publication date: 2007

**Host publication information**
Title of host publication: EWEC 2007, 'European Wind Energy Conference', Scientific Track, Milan, Italy
Main Research Area: Technical/natural sciences

**Relations**
Projects:
Fluctuations of offshore wind generation: Statistical modelling
Source: orbit
Source-ID: 200321
Publication: Research - peer-review › Article in proceedings – Annual report year: 2007

**HRensembleHR - High Resolution Ensemble for Horns Rev**

**General information**
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Weprog A/S, skill forecasting, Vattenfall A/S
Authors: Moehrlen, C. (Ekstern), Jørgensen, J. (Ekstern), Pinson, P. (Intern), Madsen, H. (Intern), Kristoffersen, J. R. (Ekstern)
Publication date: 2007
Improvement and automation of tools for short term wind power forecasting

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. (Intern), Pinson, P. (Intern), Christiansen, L. E. (Intern), Nielsen, T. S. (Intern), Madsen, H. (Intern), Badger, J. (Ekstern), Giebel, G. (Ekstern), Ravn, H. F. (Ekstern)
Publication date: 2007

Intelligent wind power prediction systems: Final report

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Authors: Nielsen, H. A. (Intern), Pinson, P. (Intern), Nielsen, T. S. (Intern), Christiansen, L. E. (Intern), Madsen, H. (Intern), Giebel, G. (Intern), Badger, J. (Intern), Larsen, X. G. (Intern), Ravn, H. V. (Intern), Tøfting, J. (Ekstern), Voulund, L. (Ekstern)
Publication date: 2007

Methods for the estimation of the uncertainty of wind power forecasts

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Pinson, P. (Intern), Nielsen, H. A. O. 3. (Intern), Madsen, H. (Intern), Lange, M. (Ekstern), Kariniotakis, G. (Ekstern)
Publication date: 2007
Network architecture for small X-band weather radars: Test bed for automatic inter-calibration and nowcasting

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Pedersen, L. (Intern), Jensen, N. (Ekstern), Madsen, H. (Intern)
Publication date: 2007

Host publication information
Title of host publication: The 33rd Conference on Radar Meteorology, Cairns, Australia, 6-10 August
Volume: 12B.2
Main Research Area: Technical/natural sciences
Conference: The 33rd Conference on Radar Meteorology : 6-10 August, Cairns, Australia, 01/01/2007
Source: orbit
Source-ID: 210018
Publication: Research › Article in proceedings – Annual report year: 2007

New Extended Kalman Filter Algorithms for Stochastic Differential Algebraic Equations

General information
State: Published
Organisations: Scientific Computing, Department of Informatics and Mathematical Modeling, Department of Chemical and Biochemical Engineering, Mathematical Statistics
Authors: Jørgensen, J. B. (Intern), Kristensen, M. R. (Intern), Thomsen, P. G. (Intern), Madsen, H. (Intern)
Pages: 359-366
Publication date: 2007

Host publication information
Title of host publication: Assessment and Future Direction of Nonlinear Model Predictive Control : NMPC'05
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 224377
Publication: Research - peer-review › Book chapter – Annual report year: 2007

Non-parametric probabilistic forecasts of wind power: required properties and evaluation
Predictions of wind power production for horizons up to 48-72 hour ahead comprise a highly valuable input to the methods for the daily management or trading of wind generation. Today, users of wind power predictions are not only provided with point predictions, which are estimates of the conditional expectation of future generation for each look-ahead time, but also with uncertainty estimates given by probabilistic forecasts. In order to avoid assumptions on the shape of predictive distributions, these probabilistic predictions are produced from nonparametric methods, and then take the form of a single or a set of quantile forecasts. The required and desirable properties of such probabilistic forecasts are defined and a framework for their evaluation is proposed. This framework is applied for evaluating the quality of two statistical methods producing full predictive distributions from point predictions of wind power. These distributions are defined by a number of quantile forecasts with nominal proportions spanning the unit interval. The relevance and interest of the introduced evaluation framework are discussed.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Pinson, P. (Intern), Nielsen, H. A. (Intern), Møller, J. K. (Intern), Madsen, H. (Intern), Kariniotakis, G. (Ekstern)
Pages: 497-587
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information
Journal: Wind Energy
Volume: 10
Issue number: 6
ISSN (Print): 1095-4244
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Optimal combination of wind power forecasts
Optimal combined wind power forecasts using exogenous variables: PSO2004/FU5766 Improved wind power prediction

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Thordarson, F. Ø. (Intern), Madsen, H. (Intern), Nielsen, H. A. (Intern)
Publication date: 2007

Publication information
Place of publication: Lyngby
Publisher: Informatics and Mathematical Modelling, Technical University of Denmark, DTU
Original language: English
ISSN: 1601-2321
Main Research Area: Technical/natural sciences
Electronic versions:
tr07_17.pdf
Links:
http://www2.imm.dtu.dk/pubdb/views/publication_details.php?id=5539
Source: orbit
Source-ID: 205529
Publication: Research › Report – Annual report year: 2007

PKPD model of interleukin-21 effects on thermoregulation in monkeys - Application and evaluation of stochastic differential equations

Purpose
To describe the pharmacodynamic effects of recombinant human interleukin-21 (IL-21) on core body temperature in cynomolgus monkeys using basic mechanisms of heat regulation. A major effort was devoted to compare the use of ordinary differential equations (ODEs) with stochastic differential equations (SDEs) in pharmacokinetic pharmacodynamic (PKPD) modelling. Methods
A temperature model was formulated including circadian rhythm, metabolism, heat loss, and a thermoregulatory set-point. This model was formulated as a mixed-effects model based on SDEs using NONMEM. Results
The effects of IL-21 were on the set-point and the circadian rhythm of metabolism. The model was able to describe a complex set of IL-21 induced phenomena, including 1) disappearance of the circadian rhythm, 2) no effect after first dose, and 3) high variability after second dose. SDEs provided a more realistic description with improved simulation properties, and further changed the model into one that could not be falsified by the autocorrelation function. Conclusions
The IL-21 induced effects on thermoregulation in cynomolgus monkeys are explained by a biologically plausible model. The quality of the model was improved by the use of SDEs.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Overgaard, R. V. (Intern), Holford, N. (Ekstern), Rytved, K. A. (Ekstern), Madsen, H. (Intern)
Pages: 298-309
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information
Journal: Pharmaceutical Research
Volume: 24
Issue number: 2
ISSN (Print): 0724-8741
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Population pharmacokinetic/pharmacodynamic (PK/PD) modelling of the hypothalamic-pituitary-gonadal axis following treatment with GnRH analogues

Aims To develop a population pharmacokinetic/pharmacodynamic (PK/PD) model of the hypothalamic-pituitary-gonadal (HPG) axis describing the changes in luteinizing hormone (LH) and testosterone concentrations following treatment with the gonadotropin-releasing hormone (GnRH) agonist triptorelin and the GnRH receptor blocker degarelix. Methods Fifty-eight healthy subjects received single subcutaneous or intramuscular injections of 3.75 mg of triptorelin and 170 prostate cancer patients received multiple subcutaneous doses of degarelix of between 120 and 320 mg. All subjects were pooled for the population PK/PD data analysis. A systematic population PK/PD model-building framework using stochastic differential equations was applied to the data to identify nonlinear dynamic dependencies and to deconvolve the functional feedback interactions of the HPG axis. Results In our final PK/PD model of the HPG axis, the half-life of LH was estimated to be 1.3 h and that of testosterone 7.69 h, which corresponds well with literature values. The estimated potency of LH
with respect to testosterone secretion was 5.18 IU l⁻¹, with a maximal stimulation of 77.5 times basal testosterone production. The estimated maximal triptorelin stimulation of the basal LH pool release was 1330 times above basal concentrations, with a potency of 0.047 ng ml⁻¹. The LH pool release was decreased by a maximum of 94.2% by degarelix with an estimated potency of 1.49 ng ml⁻¹. Conclusions Our model of the HPG axis was able to account for the different dynamic responses observed after administration of both GnRH agonists and GnRH receptor blockers, suggesting that the model adequately characterizes the underlying physiology of the endocrine system.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Tornøe, C. W. (Intern), Ågerse, H. (Ekstern), Senderovitz, T. (Ekstern), Nielsen, H. A. (Intern), Madsen, H. (Intern), Karlsson, M. O. (Ekstern), Jonsson, E. N. (Ekstern)
Pages: 648-664
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information
Journal: British Journal of Clinical Pharmacology
Volume: 63
Issue number: 6
ISSN (Print): 0306-5251
Ratings:
  BFI (2018): BFI-level 2
  BFI (2017): BFI-level 2
  Web of Science (2017): Indexed Yes
  BFI (2016): BFI-level 2
  Scopus rating (2016): SJR 1.46 SNIP 1.295 CiteScore 3.42
  BFI (2015): BFI-level 2
  Scopus rating (2015): SJR 1.461 SNIP 1.467 CiteScore 3.24
  Web of Science (2015): Indexed yes
  BFI (2014): BFI-level 2
  Scopus rating (2014): SJR 1.461 SNIP 1.463 CiteScore 3.3
  BFI (2013): BFI-level 2
  Scopus rating (2013): SJR 1.251 SNIP 1.523 CiteScore 3.03
  ISI indexed (2013): ISI indexed yes
  BFI (2012): BFI-level 2
  Scopus rating (2012): SJR 1.358 SNIP 1.584 CiteScore 3.35
  ISI indexed (2012): ISI indexed yes
  BFI (2011): BFI-level 2
  Scopus rating (2011): SJR 1.184 SNIP 1.408 CiteScore 2.97
  ISI indexed (2011): ISI indexed yes
  BFI (2010): BFI-level 2
  Scopus rating (2010): SJR 1.158 SNIP 1.236
  BFI (2009): BFI-level 2
  Scopus rating (2009): SJR 1.176 SNIP 1.391
  BFI (2008): BFI-level 2
  Scopus rating (2008): SJR 1.055 SNIP 1.167
  Scopus rating (2007): SJR 0.293 SNIP 0.358
  Web of Science (2007): Indexed yes
  Scopus rating (2006): SJR 1.308 SNIP 1.442
  Web of Science (2006): Indexed yes
  Scopus rating (2005): SJR 0.695 SNIP 1.275
  Scopus rating (2004): SJR 0.681 SNIP 1.335
  Scopus rating (2003): SJR 0.768 SNIP 2.426
  Scopus rating (2002): SJR 0.377 SNIP 0.275
  Scopus rating (2001): SJR 0.236 SNIP 0.159
  Scopus rating (2000): SJR 0.432 SNIP 0.607
Power Fluctuations From Large Wind Farms

General information
State: Published
Authors: Sørensen, P. E. (Intern), Cutululis, N. A. (Intern), Vigueras-Rodriguez, A. (Ekstern), Jensen, L. E. (Ekstern), Hjerrild, J. (Ekstern), Donovan, M. H. (Ekstern), Madsen, H. (Intern)
Pages: 958-965
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information
Journal: IEEE Transactions on Power Systems
Volume: 22
Issue number: 3
ISSN (Print): 0885-8950
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 8.17 SJR 3.757 SNIP 3.624
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 3.602 SNIP 3.486 CiteScore 6.6
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.831 SNIP 3.577 CiteScore 5.31
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.939 SNIP 4.35 CiteScore 6.33
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.177 SNIP 3.516 CiteScore 5.84
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.725 SNIP 3.254 CiteScore 5.34
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.949 SNIP 2.826
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.94 SNIP 2.723
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.537 SNIP 2.448
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.242 SNIP 2.521
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.233 SNIP 2.316
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.582 SNIP 2.547
Scopus rating (2004): SJR 1.036 SNIP 2.843
Scopus rating (2003): SJR 2.669 SNIP 2.652
Scopus rating (2002): SJR 2.271 SNIP 2.337
Scopus rating (2001): SJR 1.708 SNIP 1.837
Scopus rating (2000): SJR 1.169 SNIP 3.37
Scopus rating (1999): SJR 0.418 SNIP 1.408

Original language: English

DOIs:
10.1109/TPWRS.2007.901615

Links:
http://www2.imm.dtu.dk/pubdb/p.php?5075

Relations
Projects:
Power Fluctuations From Large Wind Farms

Real-time optimisation of groundwater management

General information
State: Published
Organisations: Department of Environmental Engineering, Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Madsen, H. (Ekstern), Falk, J. (Ekstern), Rosbjerg, D. (Intern), Madsen, H. (Intern), Schrøder, N. (Ekstern), Mortensen, J. (Ekstern), Mortensen, B. (Ekstern), Kristensen, J. (Ekstern), Brandt, G. (Ekstern)
Pages: 206-210
Publication date: 2007

Host publication information
Title of host publication: ModelCARE 2007 : 5th International Conference on Calibration and Reliability in Groundwater Modelling Credibility of Modelling, Copenhagen September 9-13, 2007
Volume: Pre-published Proceedings, volume 1
Place of publication: Copenhagen
Publisher: COWIfonden
Main Research Area: Technical/natural sciences
Conference: 5th International Conference on Calibration and Reliability in Groundwater Modelling Credibility of Modelling, Copenhagen, Denmark, 09/09/2007 - 09/09/2007
Source: orbit
Source-ID: 209253
Publication: Research › Article in proceedings – Annual report year: 2007

Robust estimation of time-varying coefficient functions - Application to the modeling of wind power production

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Pinson, P. (Intern), Nielsen, H. A. (Intern), Madsen, H. (Intern)
Publication date: 2007

Publication information
Skill forecasting from different wind power ensemble prediction methods

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Pinson, P. (Intern), Nielsen, H. A. (Intern), Madsen, H. (Intern), Kariniotakis, G. (Ekstern)
Publication date: 2007

Host publication information
Title of host publication: The 2nd Conference on 'The Science of Making Torque from Wind', Lyngby, Denmark
Main Research Area: Technical/natural sciences
Links:
http://www2.imm.dtu.dk/pubdb/views/publication_details.php?id=5074
Source: orbit
Source-ID: 195638
Publication: Research - peer-review › Article in proceedings – Annual report year: 2007

Spatial scan statistics using elliptic windows
The spatial scan statistic is widely used to search for clusters in epidemiologic data. This paper shows that the usually applied elimination of secondary clusters as implemented in SatScan is sensitive to smooth changes in the shape of the clusters. We present an algorithm for generation of set of confocal elliptic windows and propose a new way to present the information when a spatial point process is considered. This method gives smooth changes for smooth expansions of the set of clusters. A simulation study is used to show how the elliptic windows outperforms the usual circular windows. The proposed method for graphical representation of the information in a set of clusters contain more information than just presenting non-overlapping clusters. The authors suggest that more than one graphical representation of a set of clusters should be used to easily extract more information and to avoid pitfalls of the selected method.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, National Food Institute
Authors: Christiansen, L. E. (Intern), Andersen, J. S. (Intern), Wegener, H. C. (Intern), Madsen, H. (Intern)
Publication date: 2007
Event: Abstract from 1st Nordic-Baltic Biometric Conference 2007, Foulum, Denmark.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 220650
Publication: Research › Conference abstract for conference – Annual report year: 2007

Spatio-temporal modelling of short-term wind power prediction errors: 02004/FU5766 - Improved wind power prediction

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Vlasova, J. (Intern), Kotwa, E. (Intern), Nielsen, H. A. (Intern), Madsen, H. (Intern)
Publication date: 2007

Publication information
Publisher: Informatics and Mathematical Modelling, Technical University of Denmark, DTU
Original language: English
Number: 18
ISSN: 1601-2321
Main Research Area: Technical/natural sciences
Electronic versions:
Systematic qualitative experimental design based upon identifiability analysis

General information
State: Published
Organisations: Computer Aided Process Engineering Center, Department of Chemical and Biochemical Engineering, Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Davidescu, F. P. (Intern), Madsen, H. (Intern), Jørgensen, S. B. (Intern)
Publication date: 2007

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 208056
Publication: Research › Sound/Visual production (digital) – Annual report year: 2007

Temperature prediction in district heating systems with cFIR models

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Pinson, P. (Intern), Nielsen, T. S. (Intern), Nielsen, H. A. O. 3. (Intern), Poulsen, N. K. (Intern), Madsen, H. (Intern)
Publication date: 2007

Publication information
Publisher: Informatics and Mathematical Modelling, Technical University of Denmark, DTU
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 201016
Publication: Research - peer-review › Report – Annual report year: 2007

The Effect of Wind Power on Electricity Prices in Denmark

This report is the result of a special course taken by the author at IMM DTU under the guidance of professor Henrik Madsen. The aim of the project is to analyze the influence wind energy has on the electricity spot price in Western Denmark and investigate how information about wind power production can be used to model the electricity spot price.
Various model types were tried, giving very different performance. Here, only the models that performed best are discussed in order to keep focus on the projects goal.

**General information**
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Jonsson, T. (Ekstern), Madsen, H. (Intern)
Publication date: 2007

**Publication information**
Place of publication: Lyngby
Publisher: Informatics and Mathematical Modelling, Technical University of Denmark, DTU
Original language: English
Number: 22
ISSN: 1601-2321
Main Research Area: Technical/natural sciences
Electronic versions: tr07_22.pdf
Source: orbit
Source-ID: 207060
Publication: Research › Report – Annual report year: 2007

**Time series analysis**

**General information**
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Madsen, H. (Intern)
Number of pages: 400
Publication date: 2007

**Publication information**
Publisher: Chapman & Hall
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 209854
Publication: Research - peer-review › Book – Annual report year: 2007

**Pharmacokinetic/Pharmacodynamic modelling with a stochastic perspective. Insulin secretion and Interleukin-21 development as case studies**

**General information**
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Overgaard, R. V. (Intern), Madsen, H. (Intern)
Publication date: Oct 2006

**Publication information**
Original language: English
Series: IMM-PHD-2006-169
Main Research Area: Technical/natural sciences
Electronic versions: imm4677.pdf
Source: orbit
Source-ID: 191710
Publication: Research › Ph.D. thesis – Annual report year: 2006

**A Continuous-Discrete Extended Kalman Filter Algorithm for Prediction-Error-Modelling**
Advanced statistical modeling and uncertainty assessment for wind power forecasting

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Publication date: 2006

Host publication information
Title of host publication: Proceedings of the European Wind Energy Conference & Exhibition 2006
Main Research Area: Technical/natural sciences
Conference: European Wind Energy Conference & Exhibition 2006, 01/01/2006
Source: orbit
Source-ID: 224435
Publication: Research › Article in proceedings – Annual report year: 2006

Algorithms for Adaptive Quantile Regression - and a Matlab Implementation

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Møller, J. K. (Intern), Nielsen, H. A. O. 3. (Intern), Madsen, H. (Intern)
Publication date: 2006

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
imm4727.ps
imm4727.pdf
Source: orbit
Source-ID: 191725
Publication: Research - peer-review › Report – Annual report year: 2006

An Introduction to Generalized Linear Models.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Thyregod, P. (Intern), Madsen, H. (Intern)
Number of pages: 239
Publication date: 2006

Publication information
Place of publication: DTU
Publisher: Informatics and Mathematical Modelling, Technical University of Denmark, DTU
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 224568
Application of Local Area Weather Radar (LAWR) in relation to hydrological modelling – Identification of the pitfalls in using high resolution radar rainfall data

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Pedersen, L. (Intern), Jensen, N. E. (Ekstern), Madsen, H. (Intern)
Publication date: 2006

Host publication information
Title of host publication: Fourth European Conference on Radar in Meteorology and Hydrology (ERAD06), 18-22 September
Main Research Area: Technical/natural sciences
Conference: Fourth European Conference on Radar in Meteorology and Hydrology (ERAD06), 18-22 September, 01/01/2006
Source: orbit
Source-ID: 210021
Publication: Research - peer-review › Article in proceedings – Annual report year: 2006

Data assimilation on atmospheric dispersion of radioactive materials

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Drews, M. (Intern), Madsen, H. (Intern)
Publication date: 2006

Publication information
Original language: English
Series: IMM-PHD-2008-136
Main Research Area: Technical/natural sciences
Links:
http://www2.imm.dtu.dk/pubdb/p.php?3236
Source: orbit
Source-ID: 185920
Publication: Research › Ph.D. thesis – Annual report year: 2005

From wind ensembles to probabilistic information about future wind power production - results from an actual application
Meteorological ensemble forecasts aim at quantifying the uncertainty of the future development of the weather by supplying several possible scenarios of this development. Here we address the use of such scenarios in probabilistic forecasting of wind power production. Specifically, for each forecast horizon we aim at supplying quantiles of the wind power production conditional on the information available at the time at which the forecast is generated. This involves: (i) transformation of meteorological ensemble forecasts into wind power ensemble forecasts and (ii) calculation of quantiles based on the wind power ensemble forecasts. Given measurements of power production, representing a region or a single wind farm, we have developed methods applicable for these two steps. While (ii) should in principle be a simple task we found that the probabilistic information contained in the wind power ensembles from (i) cannot be used directly and therefore both (i) and (ii) requires statistical modelling. Based on these findings an demo-application, supplying quantile forecasts for operational horizons of up to approximately 6 days, was developed for two utilities participating in a common project. The application use ECMWF-ensembles. One setup corresponds to an offshore wind farm (Nysted, Denmark) and one corresponds to regional forecasting (Western Denmark). In the paper we analyze the results obtained from 8 months of actual operation of this system. It is concluded that the demo-application produce reliable forecasts. The average difference between the 75% and 25% quantile forecasts exceeds 50% of the installed capacity for horizons longer than approximately 4 days for the wind farm setup. For the regional forecasts the corresponding horizon is not reached within 7 days, which is the maximum horizon available. The ability of the demo-application to differentiate between situations with low and high uncertainty is analysed. Also, the relation between the forecasted uncertainty and the actual skill of a point forecast is analysed. A satisfactory agreement is observed

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. (Intern), Nielsen, T. S. (Intern), Madsen, H. (Intern), Giebel, G. (Ekstern), Badger, J. (Ekstern), Landberg, L. (Ekstern), Sattler, K. (Ekstern), Voulund, L. (Ekstern), Tafting, J. (Ekstern)
Grey-box stochastic modelling of industrial fed-batch cultivation

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Computer Aided Process Engineering Center, Department of Chemical and Biochemical Engineering
Authors: Rasmussen, J. (Ekstern), Madsen, H. (Intern), Jørgensen, S. B. (Intern)
Pages: 421-426
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Computer - Aided Chemical Engineering
Volume: 21
ISSN (Print): 1570-7946
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.48 SJR 0.198 SNIP 0.215
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.245 SNIP 0.249 CiteScore 0.39
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.239 SNIP 0.217 CiteScore 0.4
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.216 SNIP 0.175 CiteScore 0.28
ISI indexed (2013): ISI indexed no
Scopus rating (2012): SJR 0.196 SNIP 0.267 CiteScore 0.33
ISI indexed (2012): ISI indexed no
Scopus rating (2011): SJR 0.194 SNIP 0.199 CiteScore 0.3
ISI indexed (2011): ISI indexed no
Scopus rating (2010): SJR 0.181 SNIP 0.135
Scopus rating (2009): SJR 0.16 SNIP 0.163
Scopus rating (2008): SJR 0.167 SNIP 0.124
Scopus rating (2007): SJR 0.182 SNIP 0.094
Introduction to Wind Technology

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Giebel, G. (Ekstern), Landberg, L. (Ekstern), Madsen, H. (Intern), Nielsen, T. S. (Intern), Nielsen, H. A. (Intern)
Publication date: 2006

Host publication information
Title of host publication: Lecture Series 2006-02
ISBN (Print): 2-930389-64-8
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 195751
Publication: Research - peer-review › Book chapter – Annual report year: 2006

Mathematical Beta Cell Model for Insulin Secretion following IVGTT and OGTT
Evaluation of beta cell function is conducted by a variety of glucose tolerance tests and evaluated by a number of different models with less than perfect consistency among results obtained from different tests. We formulated a new approximation of the distributed threshold model for insulin secretion in order to approach a model for quantifying beta cell function, not only for one, but for several different experiments. Data was obtained from 40 subjects that had both an oral glucose tolerance test (OGTT) and an intravenous tolerance test (IVGTT) performed. Parameter estimates from the two experimental protocols demonstrate similarity, reproducibility, and indications of prognostic relevance. Useful first phase indexes comprise the steady state amount of ready releasable insulin A and the rate of redistribution k, where both yield a considerable correlation (both r=0.67) between IVGTT and OGTT estimates. For the IVGTT, A correlates well (r=0.96) with the 10 min area under the curve of insulin above baseline, whereas k represents a new and possibly more fundamental first phase index. For the useful second phase index, a correlation of 0.75 was found between IVGTT and OGTT estimates.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Madsen, H. (Intern), Henriksen, J. E. (Ekstern), Karlsson, M. (Ekstern), Jelic, K. (Ekstern), Overgaard, R. V. (Intern)
Pages: 1343-1354
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Annals of Biomedical Engineering
Volume: 34
Issue number: 8
ISSN (Print): 0090-6964
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
Modelling the Heat Consumption in District Heating Systems using a Grey-box approach

The heat consumption in a large geographical area is considered together with climate measurements on a single location in the area. The purpose is to identify a model linking the heat consumption to climate and calendar information.

The process of building a model is split into a theoretical based identification of an overall model structure followed by data-based modelling, whereby the details of the model are identified. This approach is sometimes called grey-box modelling, but the specific approach used here does not require states to be specified. Overall, the paper demonstrates the power of the grey-box approach. (c) 2005 Elsevier B.V. All rights reserved.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. (Intern), Madsen, H. (Intern)
Pages: 63-71
Publication date: 2006
Main Research Area: Technical/natural sciences
On using soft computing techniques in software reliability engineering

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Madsen, H. (Intern), Thyregod, P. (Intern), Burtschy, B. (Ekstern), Popenteu, F. (Ekstern), Albeneau, G. (Ekstern)
Pages: 61-72
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: International Journal of Reliability, Quality and Safety Engineering
Volume: 13
Issue number: 1
ISSN (Print): 0218-5393
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.267 SNIP 0.494 CiteScore 0.45
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.29 SNIP 0.761 CiteScore 0.66
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.36 SNIP 0.522 CiteScore 0.54
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.379 SNIP 0.583 CiteScore 0.67
ISI indexed (2013): ISI indexed no
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.308 SNIP 0.482 CiteScore 0.45
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.265 SNIP 0.552 CiteScore 0.45
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.223 SNIP 0.508
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.254 SNIP 0.558
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.213 SNIP 0.357
Scopus rating (2007): SJR 0.332 SNIP 0.54
Scopus rating (2006): SJR 0.323 SNIP 0.608
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.197 SNIP 0.377
Scopus rating (2004): SJR 0.208 SNIP 0.255
Scopus rating (2003): SJR 0.185 SNIP 0.364
Scopus rating (2002): SJR 0.377 SNIP 0.393
Scopus rating (2001): SJR 0.174 SNIP 0.631
Parameter estimation in stochastic rainfall-runoff models

A parameter estimation method for stochastic rainfall-runoff models is presented. The model considered in the paper is a conceptual stochastic model, formulated in continuous-discrete state space form. The model is small and a fully automatic optimization is, therefore, possible for estimating all the parameters, including the noise terms. The parameter estimation method is a maximum likelihood method (ML) where the likelihood function is evaluated using a Kalman filter technique. The ML method estimates the parameters in a prediction error settings, i.e. the sum of squared prediction error is minimized. For a comparison the parameters are also estimated by an output error method, where the sum of squared simulation error is minimized. The former methodology is optimal for short-term prediction whereas the latter is optimal for simulations. Hence, depending on the purpose it is possible to select whether the parameter values are optimal for simulation or prediction. The data originates from Iceland and the model is designed for Icelandic conditions, including a snow routine for mountainous areas. The model demands only two input data series, precipitation and temperature and one output data series, the discharge. In spite of being based on relatively limited input information, the model performs well and the parameter estimation method is promising for future model development.
Parameter sensitivity of three Kalman Filter Schemes for the assimilation of tide guage data in coastal and self sea models

In applications of data assimilation algorithms, a number of poorly known assimilation parameters usually need to be specified. Hence, the documented success of data assimilation methodologies must rely on a moderate sensitivity to these parameters. This contribution presents a parameter sensitivity study of three well known Kalman filter approaches for the assimilation of water levels in a three dimensional hydrodynamic modelling system. The filters considered are the ensemble Kalman filter (EnKF), the reduced rank square root Kalman filter (RRSQRT) and the steady Kalman filter. A sensitivity analysis of key parameters in the schemes is undertaken for a setup in an idealised bay. The sensitivity of the resulting root mean square error (RMSE) is shown to be low to moderate. Hence the schemes are robust within an acceptable range and their application even with misspecified parameters is to be encouraged in this perspective.

However, the predicted uncertainty of the assimilation results are sensitive to the parameters and hence must be applied with care. The sensitivity study further demonstrates the effectiveness of the steady Kalman filter in the given system as well as the great impact of assimilating even very few measurements.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Sørensen, J. V. T. (Intern), Madsen, H. (Intern), Madsen, H. (Ekstern)
Pages: 441-463
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Ocean Modelling
Volume: 11
Issue number: 3-4
ISSN (Print): 1463-5003
Ratings:
BFI (2018): BFI-level 1
Population PK/PD modelling of the hypothalamic-pituitary-gonadal axis following treatment with GnRH analogues

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Tornøe, C. W. (Ekstern), Agersø, H. (Ekstern), Madsen, H. (Intern), Jonsson, E. N. (Ekstern), Karlsson, M. (Ekstern)
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: British Journal of Clinical Pharmacology
ISSN (Print): 0306-5251
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): SJR 1.46 SNIP 1.295 CiteScore 3.42
BFI (2015): BFI-level 2
Properties of Quantile and Interval Forecasts of Wind Generation and their Evaluation

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Pinson, P. (Intern), Kariniotakis, G. (Ekstern), Nielsen, H. A. (Intern), Nielsen, T. S. (Intern), Madsen, H. (Intern)
Publication date: 2006

Host publication information
Title of host publication: Proceedings of the European Wind Energy Conference & Exhibition
Main Research Area: Technical/natural sciences
Conference: Proceedings of the European Wind Energy Conference & Exhibition, 01/01/2006
Links:
http://www2.imm.dtu.dk/pubdb/p.php?4250
Source: orbit
Source-ID: 191563
Publication: Research - peer-review › Article in proceedings – Annual report year: 2006

Regime Shift Models for Simulation of the Interaction between Benthic and Pelagic Production

Links:
http://www2.imm.dtu.dk/pubdb/p.php?5143
Source: orbit
Source-ID: 199820
Publication: Research - peer-review › Journal article – Annual report year: 2006
Spatial scan statistics using elliptic windows

The spatial scan statistic is widely used to search for clusters. This article shows that the usually applied elimination of secondary clusters as implemented in SatScan is sensitive to smooth changes in the shape of the clusters. We present an algorithm for generation of a set of confocal elliptic windows and propose a new way to present the information when a spatial point process is considered. This method gives smooth changes for smooth expansions of the set of clusters. A simulation study is used to show how the elliptic windows outperforms the usual circular windows. The proposed method for graphical representation of the information in a set of clusters contain more information than just presenting nonoverlapping clusters. We suggest that more than one graphical representation of a set of clusters should be used to easily extract more information and to avoid pitfalls of the selected method.
Stochastic Grey Box Modelling of the Enzymatic Biochemical Reaction Network E-coli Mutants

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Computer Aided Process Engineering Center, Department of Chemical and Biochemical Engineering
Authors: Florin-Paul, D. (Ekstern), Madsen, H. (Intern), Schumperli, M. (Ekstern), Heinemann, M. (Ekstern), Panke, S. (Ekstern), Jørgensen, S. B. (Intern)
Pages: 161-166
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Computer - Aided Chemical Engineering
Volume: 21
ISSN (Print): 1570-7946
Stochastic modeling of kHz quasi-periodic oscillation light curves

Kluzniak & Abramowicz explain the high frequency, double peak, "3:2" QPOs observed in neutron star and black hole sources in terms of a non-linear parametric resonance between radial and vertical epicyclic oscillations of an almost Keplerian accretion disk. The 3:2 ratio of epicyclic frequencies occurs only in strong gravity. Recently, a simple model incorporating their suggestion was studied analytically: the result is that a small forcing may indeed excite the parametric 3:2 resonance. However, no explanation has been provided on the nature of the forcing which is given an "ad hoc" deterministic form. In the present paper the same model is considered. The equation are numerically integrated, dropping the ad hoc forcing and adding instead a stochastic term to mimic the action of the very complex processes that occur in accretion disks as, for example, MRI turbulence. We demonstrate that the presence of the stochastic term is able to trigger the resonance in epicyclic oscillations of nearly Keplerian disks, and it influences their pattern.
Using Quantile Regression to Extend an Existing Wind Power Forecasting System with Probabilistic Forecasts

For operational planning it is important to provide information about the situation-dependent uncertainty of a wind power forecast. Factors which influence the uncertainty of a wind power forecast include the predictability of the actual meteorological situation, the level of the predicted wind speed (due to the non-linearity of the power curve) and the forecast horizon. With respect to the predictability of the actual meteorological situation a number of explanatory variables are considered, some inspired by the literature. The article contains an overview of related work within the field. An existing wind power forecasting system (Zephyr/WPPT) is considered and it is shown how analysis of the forecast error can be used to build a model of the quantiles of the forecast error. Only explanatory variables or indices which are predictable are considered, whereby the model obtained can be used for providing situation-dependent information regarding the uncertainty. Finally, the article contains directions enabling the reader to replicate the methods and thereby extend other forecast systems with situation-dependent information on uncertainty. Copyright © 2005 John Wiley & Sons, Ltd.
Population pharmacokinetic/pharmacodynamic modelling of the hypothalamic-pituitary-gonadal axis

The present thesis deals with different aspects of population pharmacokinetic/pharmacodynamic (PK/PD) modelling of the male hypothalamic-pituitary-gonadal (HPG) axis. The thesis consists of a summary report and five scientific research papers. An overview of the main topics covered in the thesis is provided in the summary report including PK/PD modelling in drug development, the pathological, physiological, and pharmacological aspects of the male HPG axis, and a detailed description of the methodology behind non-linear mixed-effects modelling based on stochastic differential equations (SDEs). The main objective of the work underlying this thesis was to develop mechanism-based population PK/PD models of the HPG axis. The HPG axis is a multivariate closed-loop control system consisting of regulatory hormonal feedback mechanisms. The number and complexity of the physiological mechanisms involved in such models makes them difficult to develop and are often too complex to be conveniently described by empirical models. Hence, the use of SDEs in population PK/PD modelling was used as a tool to systematically develop a mechanism-based model of the HPG axis following treatment with gonadotropin-releasing hormone (GnRH) agonist triptorelin and GnRH antagonist degarelix in a combined model. The use of SDEs in non-linear mixed-effects modelling was investigated by implementing the Extended Kalman Filter in the NONMEM software. Non-linear mixed-effects models based on SDEs extend the first-stage model of the hierarchical structure by decomposing the intra-individual variability into two types of noise, i.e. a system noise term representing unknown or incorrectly specified dynamics and a measurement noise term accounting for uncorrelated errors such as assay error. This setup makes identification of structural model mis-specification feasible by quantifying the model uncertainty, which subsequently provides the basis for systematic population PK/PD model development. To support the model building process, the SDE approach was applied to clinical PK/PD data and used as a tool for tracking unexplained variations in parameters, identifying complicated non-linear dynamic dependencies, and deconvolving the functional feedback relationships of the HPG axis. The developed mechanism-based model of the HPG axis consisted of four compartments where the secretion of readily releasable LH from a pool compartment was stimulated and inhibited by the plasma triptorelin and degarelix concentrations, respectively. Circulating LH stimulated the testosterone secretion while the delayed testosterone feedback on the non-basal LH synthesis and release was modelled through a receptor compartment where testosterone stimulates the production of receptors. The derived mechanism-based model of the HPG axis was able to account for the observed LH and testosterone concentration-time profiles following treatment with both GnRH agonist triptorelin and GnRH antagonist degarelix thereby indicating that the model is sufficient at mimicking the underlying physiology of the endocrine system.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Tornøe, C. W. (Intern), Madsen, H. (Intern), Nielsen, H. A. (Intern)
Publication date: Oct 2005

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions: imm3926.pdf
Links:
http://www2.imm.dtu.dk/pubdb/p.php?3926
Source: orbit
Source-ID: 185937
Publication: Research › Ph.D. thesis – Annual report year: 2005

Analysis of a Kalman filter based method for on-line estimation of atmospheric dispersion parameters using radiation monitoring data
A Kalman filter method is discussed for on-line estimation of radioactive release and atmospheric dispersion from a time series of off-site radiation monitoring data. The method is based on a state space approach, where a stochastic system equation describes the dynamics of the plume model parameters, and the observables are linked to the state variables through a static measurement equation. The method is analysed for three simple state space models using experimental data obtained at a nuclear research reactor. Compared to direct measurements of the atmospheric dispersion, the Kalman filter estimates are found to agree well with the measured parameters, provided that the radiation measurements are spread out in the cross-wind direction. For less optimal detector placement it proves difficult to distinguish variations in the source term and plume height; yet the Kalman filter yields consistent parameter estimates with large associated uncertainties. Improved source term assessment results, when independent estimates of the plume height can be used. Perspectives for using the method in the context of nuclear emergency management are discussed, and possible extensions to the present modelling scheme are outlined, to account for realistic accident scenarios.
Analysis of the Results of an On-line Wind Power Quantile Forecasting System

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. (Intern), Yates, D. (Ekstern), Madsen, H. (Intern), Nielsen, T. S. (Intern), Badger, J. (Ekstern), Giebel, G. (Ekstern), Landberg, L. (Ekstern), Sattler, K. (Ekstern), Feddersen, H. (Ekstern)
Publication date: 2005

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 185952
Publication: Research - peer-review › Report – Annual report year: 2005

A Probabilistic-Fuzzy Approach for TQSEM

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Albeanu, G. (Ekstern), Popentiu-Vladicescu, F. (Ekstern), Thyregod, P. (Intern), Madsen, H. (Intern)
Publication date: 2005

Host publication information
Title of host publication: Fifth Annual Meeting of ENBIS
Main Research Area: Technical/natural sciences
Links: http://www.enbis.org/newcastleconference/abstracts.html#97
Source: orbit
Source-ID: 185660
Publication: Research - peer-review › Article in proceedings – Annual report year: 2005

Assessment of serious water shortage in the Icelandic water resource system

Water resources are economically important and environmentally extremely vulnerable. The electrical power system in Iceland is hydropower based and due to the country's isolation, power import is not an option as elsewhere in Europe. In the hydropower system, a water shortage is met by flow augmentation from reservoirs. The management of these reservoirs are a human intervention in a natural flow and therefore necessarily limited by environmental regulations. During a heavy drought, the available water storage in the reservoir may not be sufficient to cater for the demand and
consequently there will be a shortage of electrical power. This is politically acceptable as long as it only touches heavy industries but not power deliveries to the common market. Empty or near empty reservoirs cause power shortage that will be felt by homeowners and businesses, until spring thaw sets in and inflow to the reservoirs begins. If such a power shortage event occurs, it will cause heavy social problems and a political decision making will follow. It is commonly agreed, that management methods leading to such a disastrous event as a general power shortage in the whole country, are not acceptable. It is therefore very important to have mathematical tools to estimate the risk of water shortage in the system when searching for the best management method. In view of the fact that the subject is to estimate the risk of events that have to be very rare, i.e. with large recurrence time, stochastic simulation is used to produce synthetically run-off records with adequate length, in order to estimate very rare droughts. The method chosen is to make the run-off series stationary in the mean and the variance and simulating the resulting stationary process. When this method is chosen, future trends in the run-off from climate change and glacier reduction can easily be incorporated in the model. The probabilities of extreme droughts are calculated and their frequencies are compared to theoretical distributions. (c) 2005 Elsevier Ltd. All rights reserved.
A tool for predicting the wind power production of off-shore wind plants

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Madsen, H. (Intern), Nielsen, H. A. (Intern), Nielsen, T. S. (Intern)
Publication date: 2005

Host publication information
Title of host publication: Proceedings of the Copenhagen Offshore Wind Conference & Exhibition
Main Research Area: Technical/natural sciences
Links:
Publication: Research - peer-review › Journal article – Annual report year: 2005

Bayesian conformational analysis of ring molecules through reversible jump MCMC

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Nolsøe, K. (Intern), Kessler, M. (Ekstern), Pérez, J. (Ekstern), Madsen, H. (Intern)
Pages: 412-426
Publication date: 2005
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Chemometrics
Volume: 19
Issue number: 8
ISSN (Print): 0886-9383
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): SJR 0.5 SNIP 0.873 CiteScore 1.71
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.553 SNIP 0.984 CiteScore 1.82
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.536 SNIP 1.235 CiteScore 1.72
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 0.749 SNIP 1.316 CiteScore 2.2
Candidate Prediction Models and Methods

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. (Intern), Nielsen, T. S. (Intern), Madsen, H. (Intern), Giebel, G. (Ekstern)
Publication date: 2005

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Links:
http://www2.imm.dtu.dk/pubdb/p.php?4200
Source: orbit
Source-ID: 185621
Publication: Research - peer-review › Journal article – Annual report year: 2005
Computer Aided Statistical Modelling fights Pollution

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Madsen, H. (Intern), Thyregod, P. (Intern), Popentiu, F. (Intern), Grigore, A. (Intern)
Publication date: 2005

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Links:
http://www.scientific-computing.com
Source: orbit
Source-ID: 185974
Publication: Research - peer-review › Report – Annual report year: 2005

Considerations Concerning a Fuzzy-Genetic Algorithm with Application to CEM I Type Cements Quality Optimization

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Pages: 350-353
Publication date: 2005

Host publication information
Title of host publication: Proceedings of the 9th World Multi-Conference on Systemics, Cybernetics and Informatics, Orlando
Main Research Area: Technical/natural sciences
Conference: 9th World Multi-Conference on Systemics, Cybernetics and Informatics, Orlando, 01/01/2005
Source: orbit
Source-ID: 185712
Publication: Research - peer-review › Article in proceedings – Annual report year: 2005

Efficient Filtering and Prediction in Stochastic Differential Equations

General information
State: Published
Organisations: Scientific Computing, Department of Informatics and Mathematical Modeling, Department of Chemical and Biochemical Engineering, Mathematical Statistics
Authors: Jørgensen, J. B. (Intern), Kristensen, M. R. (Intern), Thomsen, P. G. (Intern), Madsen, H. (Intern)
Publication date: 2005

Host publication information
Title of host publication: International Workshop on Assessment and Future Directions of NMPC : NMPC'05
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 224376
Publication: Research - peer-review › Article in proceedings – Annual report year: 2005

Insights to the minimal model of insulin secretion through a mean-field beta cell model

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Overgaard, R. V. (Intern), Henriksen, J. E. (Ekstern), Madsen, H. (Intern)
Pages: 382-389
Publication date: 2005
Main Research Area: Technical/natural sciences
On Using Soft Computing Techniques in Software Reliability Engineering

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Madsen, H. (Intern), Thyregod, P. (Intern), Burtschy, B. (Ekstern), Popentiu, F. (Intern), Albeanu, G. (Ekstern)
Pages: 1317-1323
Publication date: 2005

Host publication information
Title of host publication: Advances in Safety and Reliability, ESREL 2005
Publisher: Taylor and Francis Group
Main Research Area: Technical/natural sciences
Conference: European Safety and Reliability Conference, Tri City, Poland, 27/06/2005 - 27/06/2005
Source: orbit
Source-ID: 185714
Publication: Research - peer-review › Article in proceedings – Annual report year: 2005

Standardizing the performance evaluation of short-term wind prediction models

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Madsen, H. (Intern), Pinson, P. (Intern), Kariniotakis, G. (Ekstern), Nielsen, H. A. (Intern), Nielsen, T. S. (Intern)
Pages: 475-489
Publication date: 2005
Main Research Area: Technical/natural sciences

Publication Information
Journal: Wind Engineering
Volume: 29
Issue number: 6
ISSN (Print): 0309-524X
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.267 SNIP 0.515 CiteScore 0.58
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.369 SNIP 0.632 CiteScore 0.63
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.412 SNIP 1 CiteScore 0.78
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.382 SNIP 1.105 CiteScore 0.62
ISI indexed (2013): ISI indexed no
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.325 SNIP 1.095 CiteScore 0.56
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Stochastic differential equations in NONMEM: implementation, application, and comparison with ordinary differential equations

Purpose. The objective of the present analysis was to explore the use of stochastic differential equations (SDEs) in population pharmacokinetic/pharmacodynamic (PK/PD) modeling.

Methods. The intra-individual variability in nonlinear mixed-effects models based on SDEs is decomposed into two types of noise: a measurement and a system noise term. The measurement noise represents uncorrelated error due to, for example, assay error while the system noise accounts for structural misspecifications, approximations of the dynamical model, and true random physiological fluctuations. Since the system noise accounts for model misspecifications, the SDEs provide a diagnostic tool for model appropriateness. The focus of the article is on the implementation of the Extended Kalman Filter (EKF) in NONMEM(R) for parameter estimation in SDE models.

Results. Various applications of SDEs in population PK/PD modeling are illustrated through a systematic model development example using clinical PK data of the gonadotropin releasing hormone (GnRH) antagonist degarelix. The dynamic noise estimates were used to track variations in model parameters and systematically build an absorption model for subcutaneously administered degarelix.

Conclusions. The EKF-based algorithm was successfully implemented in NONMEM for parameter estimation in population PK/PD models described by systems of SDEs. The example indicated that it was possible to pinpoint structural model deficiencies, and that valuable information may be obtained by tracking unexplained variations in parameters.
In this paper we consider the problem of the limits concerning the physical information that can be extracted from the analysis of one or more time series (light curves) typical of astrophysical objects. On the basis of theoretical considerations and numerical simulations, we show that with no a priori physical model there are not many possibilities to obtain interpretable results. For this reason, the practice to develop more and more sophisticated statistical methods of time series analysis is not productive. Only techniques of data analysis developed in a specific physical context can be expected to provide useful results. The field of stochastic dynamics appears to be an interesting framework for such an
approach. In particular, it is shown that modelling the experimental time series by means of the stochastic differential equations (SDE) represents a valuable tool of analysis. For example, besides a more direct connection between data analysis and theoretical models, in principle the use of SDE permits the analysis of a continuous signal independent of the characteristics (e.g., frequency, regularity,...) of the sampling with which the experimental time series were obtained. In this respect, an efficient approach based on the extended Kalman filter technique is presented. Its performances and limits are discussed and tested through numerical experiments. Freely downloadable software is made available.

**General information**

State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Vio, R. (Ekstern), Kristensen, N. (Ekstern), Madsen, H. (Intern), Wamsteker, W. (Ekstern)
Pages: 773-780
Publication date: 2005
Main Research Area: Technical/natural sciences

**Publication information**

Journal: Astronomy & Astrophysics
Volume: 435
Issue number: 2
ISSN (Print): 0004-6361
Ratings:
- BFI (2018): BFI-level 2
- BFI (2017): BFI-level 2
- Web of Science (2017): Indexed yes
- BFI (2016): BFI-level 2
- Scopus rating (2016): CiteScore 3.68 SJR 2.246 SNIP 1.16
- Web of Science (2016): Indexed yes
- BFI (2015): BFI-level 2
- Scopus rating (2015): SJR 2.543 SNIP 1.189 CiteScore 3.5
- Web of Science (2015): Indexed yes
- BFI (2014): BFI-level 2
- Scopus rating (2014): SJR 2.823 SNIP 1.219 CiteScore 2.82
- Web of Science (2014): Indexed yes
- BFI (2013): BFI-level 2
- Scopus rating (2013): SJR 2.544 SNIP 1.058 CiteScore 2.01
- ISI indexed (2013): ISI indexed yes
- Web of Science (2013): Indexed yes
- BFI (2012): BFI-level 2
- Scopus rating (2012): SJR 2.585 SNIP 1.295 CiteScore 3.14
- ISI indexed (2012): ISI indexed yes
- Web of Science (2012): Indexed yes
- BFI (2011): BFI-level 2
- Scopus rating (2011): SJR 2.373 SNIP 1.231 CiteScore 3.42
- ISI indexed (2011): ISI indexed yes
- Web of Science (2011): Indexed yes
- BFI (2010): BFI-level 2
- Scopus rating (2010): SJR 2.74 SNIP 1.444
- Web of Science (2010): Indexed yes
- BFI (2009): BFI-level 2
- Scopus rating (2009): SJR 2.879 SNIP 1.404
- Web of Science (2009): Indexed yes
- BFI (2008): BFI-level 2
- Scopus rating (2008): SJR 2.923 SNIP 1.297
- Web of Science (2008): Indexed yes
- Scopus rating (2007): SJR 2.816 SNIP 1.34
- Web of Science (2007): Indexed yes
- Scopus rating (2006): SJR 3.224 SNIP 1.349
Using Stochastic Differential Equations for PK/PD Model Development

General information
State: Published
Organisations: Department of Chemical and Biochemical Engineering, Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Kristensen, N. R. (Intern), Madsen, H. (Intern), Ingwersen, S. H. (Ekstern)
Pages: 109-141
Publication date: 2005
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Pharmacokinetics and Pharmacodynamics
Volume: 32
Issue number: 1
ISSN (Print): 1567-567X
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.8 SJR 0.696 SNIP 0.801
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.709 SNIP 0.953 CiteScore 1.77
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.696 SNIP 0.851 CiteScore 1.82
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.561 SNIP 0.802 CiteScore 1.7
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.974 SNIP 1.179 CiteScore 2.07
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.955 SNIP 1.109 CiteScore 2.2
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Wind farm controllers with grid support

General information
State: Published
Authors: Sørensen, P. E. (Intern), Hansen, A. D. (Intern), Thomsen, K. (Intern), Madsen, H. (Intern), Nielsen, H. A. (Intern), Poulsen, N. K. (Intern), Lov, F. (Ekstern), Bkaabjerg, F. (Ekstern), Donovan, M. H. (Ekstern)
Pages: 157-166
Publication date: 2005

Host publication information
Title of host publication: Proceedings of the 5th International Workshop on Large-Scale Integration of Wind Power and Transmission Networks for Offshore Wind Farms
Place of publication: Stockholm
Publisher: Royal Institute of Technology
Editors: Ackermann, T., Matevosyan, J.
Main Research Area: Technical/natural sciences
Workshop: 5th International Workshop on Large-Scale Integration of Wind Power and Transmission Networks for Offshore Wind Farms, Glasgow, United Kingdom, 07/04/2005 - 07/04/2005
Links:
http://www2.imm.dtu.dk/pubdb/p.php?3643
Source: orbit
Source-ID: 185751
Publication: Research - peer-review » Journal article – Annual report year: 2005

Wind Power Ensemble Forecasting Using Wind Speed and Direction Ensembles from ECMWF or NCEP

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. (Intern), Madsen, H. (Intern), Nielsen, T. S. (Intern), Badger, J. (Ekstern), Giebel, G. (Ekstern), Landberg, L. (Ekstern), Sattler, K. (Ekstern), Feddersen, H. (Ekstern)
Publication date: 2005
Wind Power Prediction using Ensembles

The Ensemble project investigated the use of meteorological ensemble forecasts for the prognosis of uncertainty of the forecasts, and found a good method to make use of ensemble forecasts. This method was then tried based on ensembles from ECMWF in form of a demo application for both the Nysted offshore wind farm and the whole Jutland/Funen area. The utilities used these forecasts for maintenance planning, fuel consumption estimates and over-the-weekend trading on the Leipzig power exchange. Other notable scientific results include the better accuracy of forecasts made up from a simple superposition of two NWP provider (in our case, DMI and DWD), an investigation of the merits of a parameterisation of the turbulent kinetic energy within the delivered wind speed forecasts, and the finding that a "naive" downscaling of each of the coarse ECMWF ensemble members with higher resolution HIRLAM did not improve the error scores or the result space enough to warrant the computational effort.

Data assimilation in hydrodynamic modelling: on the treatment of non-linearity and bias

The state estimation problem in hydrodynamic modelling is formulated. The three-dimensional hydrodynamic model MIKE 3 is extended to provide a stochastic state space description of the system and observations are related to the state through the measurement equation. Two state estimators, the maximum a posteriori (MAP) estimator and the best linear unbiased estimator (BLUE), are derived and their differences discussed. Combined with various schemes for state and error covariance propagation different sequential estimators, based on the Kalman filter, are formulated. In this paper, the ensemble Kalman filter with either an ensemble or central mean state propagation and the reduced rank square root Kalman filter are implemented for assimilation of tidal gauge data. The efficient data assimilation algorithms are based on a number of assumptions to enable practical use in regional and coastal oceanic models. Three measures of non-linearity and one bias measure have been implemented to assess the validity of these assumptions for a given model set-up. Two of these measures further express the non-Gaussianity and thus guide the proper statistical interpretation of the results. The applicability of the measures is demonstrated in two twin case experiments in an idealised set-up.
Main Research Area: Technical/natural sciences

Publication information
Journal: Stochastic Environmental Research and Risk Assessment
Volume: 18
Issue number: 4
ISSN (Print): 1436-3240
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 1.149 SNIP 1.381 CiteScore 2.54
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.999 SNIP 1.015 CiteScore 1.74
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.008 SNIP 1.429 CiteScore 2.3
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.145 SNIP 1.607 CiteScore 2.49
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.343 SNIP 1.452 CiteScore 2.08
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.906 SNIP 1.135 CiteScore 1.56
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.776 SNIP 1.019
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.438 SNIP 0.777
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.586 SNIP 0.801
Scopus rating (2007): SJR 0.516 SNIP 0.908
Scopus rating (2006): SJR 0.56 SNIP 0.617
Scopus rating (2005): SJR 0.513 SNIP 0.674
Scopus rating (2004): SJR 0.559 SNIP 0.966
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.481 SNIP 0.625
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.594 SNIP 0.948
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.537 SNIP 0.741
Scopus rating (2000): SJR 0.517 SNIP 0.66
Scopus rating (1999): SJR 0.528 SNIP 0.662
Original language: English
data assimilation, Kalman filter, non-linearity measure, bias, hydrodynamic modelling
DOIs:
10.1007/s00477-004-0181-9
Links:
Source: orbit
Source-ID: 154571
Data Assimilation in Hydrodynamic Models of Continental Shelf Seas
This thesis consists of seven research papers published or submitted for publication in the period 2002-2004 together with a summary report. The thesis mainly deals with data assimilation of tide gauge data in two- and three-dimensional hydrodynamic models of the continental shelf seas. Assimilation of sea surface temperature and parameter estimation in hydrodynamic models are also considered. The main focus has been on the development of robust and efficient techniques applicable in real operational settings. The applied assimilation techniques all use a Kalman filter approach. They consist of a stochastic state propagation step using a numerical hydrodynamic model and an update step based on a best linear unbiased estimator when new measurements are available. The main challenge is to construct a stochastic model of the high dimensional ocean state that provides sufficient skill for a proper update to be calculated. Such a stochastic model requires model and measurement errors to be described, which is a di cult task independent of the computational resources at hand. Further, the need for efficient solutions necessitates further assumptions to be imposed that maintain a skillful and robust state estimate. The assimilation schemes used in this work are primarily based on two ensemble based schemes, the Ensemble Kalman Filter and the Reduced Rank Square Root Kalman Filter. In order to investigate the applicability of these and derived schemes, the sensitivity to filter parameters, nonlinearity and bias is examined in artificial tests. Approximate schemes, which are theoretically presented as using regularised Kalman gains, are introduced and successfully applied in artificial as well real case scenarios. Particularly, distant dependent and slowly time varying or constant Kalman gains are shown to possess good hindcast and forecast skill in the Inner Danish Waters. The framework for combining data assimilation and off-line error correction techniques is discussed and presented. Early results show a potential for such an approach, but a more elaborate investigation is needed to further develop the idea. Finally, work has been initiated on parameter estimation in two-dimensional hydrodynamic models with an approach that avoids the development of an adjoint code by using an algorithmic structure that favours application of oce- grids as they are envisaged to look in the near future. The main contribution is the development of a number of regularisation techniques for tide gauge assimilation. Further, the techniques used to assess the validity of underlying assumptions (weak non-linearity, unbiasedness or error model skill) provide a valuable tool-box for investigating a dynamical system prior to potentially selecting an assimilation approach. The combined data assimilation error correction framework may be an important contribution to future improvements of forecast skill for a number of systems. The work done on parameter estimation is expected to mature into a future standard procedure for model calibration for models with rapidly evolving complex codes.

A Decision Support System for Pollution Control in Cement Plants,

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Madsen, H. (Intern), Thyregod, P. (Intern), Popentiu, F. (Intern), Albeanu, G. (Ekstern), Serbanescu, L. (Ekstern)
Pages: 1784-1789
Publication date: 2004

Host publication information
Title of host publication: Probabilistic Safety Assessment and Management, PSAM 07 - ESREL'04
Publisher: Springer
Main Research Area: Technical/natural sciences
Conference: PSAM 07, 01/01/2004
Source: orbit
A Method for Systematic Improvement of Stochastic Grey-Box Models

A systematic framework for improving the quality of continuous time models of dynamic systems based on experimental data is presented. The framework is based on an interplay between stochastic differential equation modelling, statistical tests and nonparametric modelling and provides features that allow model deficiencies to be pinpointed and their structural origin to be uncovered. More specifically, the proposed framework can be used to obtain estimates of unknown functional relations, in turn allowing unknown or inappropriately modelled phenomena to be uncovered. In this manner the framework permits systematic iterative model improvement. The performance of the proposed framework is illustrated through a case study involving a dynamic model of a fed-batch bioreactor, where it is shown how an inappropriately modelled biomass growth rate can be uncovered and a proper functional relation inferred. A key point illustrated through this case study is that functional relations involving unmeasured variables can also be uncovered.

General information
State: Published
Organisations: Computer Aided Process Engineering Center, Department of Chemical and Biochemical Engineering, Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Kristensen, N. R. (Intern), Madsen, H. (Intern), Jørgensen, S. B. (Intern)
Pages: 1431-1449
Publication date: 2004
Main Research Area: Technical/natural sciences

Publication information
Journal: Computers & Chemical Engineering
Volume: 28
Issue number: 8
ISSN (Print): 0098-1354
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.39 SJR 1.008 SNIP 1.607
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.122 SNIP 1.724 CiteScore 3.04
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.184 SNIP 1.738 CiteScore 3.22
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.223 SNIP 1.776 CiteScore 3.06
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.161 SNIP 1.92 CiteScore 3.05
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.185 SNIP 1.736 CiteScore 2.8
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.176 SNIP 1.796
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.154 SNIP 2.166
A protocol for standardizing the performance evaluation of short-term wind power prediction models

**General information**
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Madsen, H. (Intern), Kariniotakis, G. (Ekstern), Nielsen, H. A. (Intern), Nielsen, T. S. (Intern), Pinson, P. (Intern)
Publication date: 2004

**Host publication information**
Title of host publication: Proceedings of the 2004 Global Windpower Conference and Exhibition
Main Research Area: Technical/natural sciences
Conference: 2004 Global Windpower Conference and Exhibition, Chicago, IL, United States, 28/03/2004 - 28/03/2004
Links: http://www.awea.org
Source: orbit
Source-ID: 154636
Publication: Research - peer-review › Article in proceedings – Annual report year: 2004

Comparison of ensemble forecasts with the measurements from the meteorological mast at Risø National Laboratory

**General information**
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. (Intern), Madsen, H. (Intern), Nielsen, T. S. (Intern), Badger, J. (Ekstern), Giebel, G. (Ekstern), Landberg, L. (Ekstern), Sattler, K. (Ekstern), Feddersen, H. (Ekstern)
Publication date: 2004

**Publication information**
Original language: English
Main Research Area: Technical/natural sciences
Links:
Computer Aided Modeling and Pollution Control in Cement Plants

Effects of Climate on Incidence of Campylobacter spp. in Humans and Prevalence in Broiler Flocks in Denmark

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Effects of Climate on Incidence of Campylobacter spp. in Humans and Prevalence in Broiler Flocks in Denmark

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Effects of Climate on Incidence of Campylobacter spp. in Humans and Prevalence in Broiler Flocks in Denmark

Effects of Climate on Incidence of Campylobacter spp. in Humans and Preva...
Efficient Kalman filter techniques for the assimilation of tide gauge data in three-dimensional modeling of the North Sea and Baltic Sea system

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Sørensen, J. V. T. (Intern), Madsen, H. (Intern), Madsen, H. (Intern)
Forecasting wind speeds on the minute time-scale using up-stream information

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. (Intern), Madsen, H. (Intern)
Publication date: 2004

Grey-Box Modelling of Pharmacokinetic /Pharmacodynamic Systems

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Tornøe, C. W. (Intern), Jacobsen, J. L. (Intern), Pedersen, O. (Ekstern), Hansen, T. (Ekstern), Madsen, H. (Intern)
Pages: 401-417
Publication date: 2004
Main Research Area: Technical/natural sciences
Grey-box pharmacokinetic/pharmacodynamic modelling of a euglycaemic clamp study

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Tornøe, C. W. (Intern), Jacobsen, J. L. (Intern), Madsen, H. (Intern)
Pages: 591-604
Publication date: 2004
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Mathematical Biology
Volume: 48
Issue number: 6
ISSN (Print): 0303-6812
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): SJR 0.838 SNIP 1.171 CiteScore 1.58
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.993 SNIP 1.329 CiteScore 1.58
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.971 SNIP 1.319 CiteScore 1.81
Web of Science (2014): Indexed yes
Modelling the Heat Consumption in District Heating Systems using a Grey-box approach

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. (Intern), Madsen, H. (Intern)
Publication date: 2004

Host publication information
Title of host publication: Proceedings of the International Workshop on Dynamic Analysis Methods Applied to Energy Performance Assessment of Buildings
Main Research Area: Technical/natural sciences

Non-linear mixed-effects pharmacokinetic/pharmacodynamic modelling in NLME using differential equations
The standard software for non-linear mixed-effect analysis of pharmacokinetic/pharmacodynamic (PK/PD) data is NONMEM while the non-linear mixed-effects package NLME is an alternative as long as the models are fairly simple. We
present the nlmeODE package which combines the ordinary differential equation (ODE) solver package odesolve and the
non-linear mixed effects package NLME thereby enabling the analysis of complicated systems of ODEs by non-linear
mixed-effects modelling. The pharmacokinetics of the anti-asthmatic drug theophylline is used to illustrate the applicability
of the nlmeODE package for population PK/PD analysis using the available data analysis tools in R for model inspection
and validation. The nlmeODE package is numerically stable and provides accurate parameter estimates which are
consistent with NONMEM estimates. (C) 2004 Elsevier Ireland Ltd. ALL rights reserved.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Tornøe, C. W. (Intern), Agersø, H. (Ekstern), Madsen, H. (Intern), Jonsson, E. N. (Ekstern), Nielsen, H. A.
(Intern)
Pages: 31-40
Publication date: 2004
Main Research Area: Technical/natural sciences

Publication information
Journal: Computer Methods and Programs in Biomedicine
Volume: 76
Issue number: 1
ISSN (Print): 0169-2607
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.639 SNIP 1.492 CiteScore 2.67
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.867 SNIP 1.636 CiteScore 2.65
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.775 SNIP 1.604 CiteScore 2.65
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.642 SNIP 1.5 CiteScore 2.28
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.487 SNIP 1.574 CiteScore 2.08
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.564 SNIP 1.629 CiteScore 2.25
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.53 SNIP 1.394
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.445 SNIP 1.299
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.484 SNIP 1.108
Scopus rating (2007): SJR 0.467 SNIP 0.892
Scopus rating (2006): SJR 0.371 SNIP 0.793
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.426 SNIP 1.224
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.363 SNIP 1.007
Nonlinear time series analysis of zoonoses

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Christiansen, L. E. (Intern), Madsen, H. (Intern)
Publication date: 2004

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
imm3361.ps
Links:
Source: orbit
Source-ID: 154838
Publication: Research › Ph.D. thesis – Annual report year: 2004

Parameter estimation in a hydrodynamic model of the North Sea and Baltic Sea

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Sørensen, J. V. T. (Intern), Madsen, H. (Intern), Madsen, H. (Intern)
Publication date: 2004

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 154866
Publication: Research › Report – Annual report year: 2004

Parameter Estimation in Stochastic Grey-Box Models
An efficient and flexible parameter estimation scheme for grey-box models in the sense of discretely, partially observed Itô stochastic differential equations with measurement noise is presented along with a corresponding software implementation. The estimation scheme is based on the extended Kalman filter and features maximum likelihood as well as maximum a posteriori estimation on multiple independent data sets, including irregularly sampled data sets and data sets with occasional outliers and missing observations. The software implementation is compared to an existing software tool and proves to have better performance both in terms of quality of estimates for nonlinear systems with significant diffusion and in terms of reproducibility. In particular, the new tool provides more accurate and more consistent estimates of the parameters of the diffusion term.
Pharmacokinetic/Pharmacodynamic Modelling of GnRH Antagonist Degarelix: A Comparison of the Non-linear Mixed-Effects Programs NONMEM and NLME

In this paper, the two non-linear mixed-effects programs NONMEM and NLME were compared for their use in population pharmacokinetic/pharmacodynamic (PK/PD) modelling. We have described the first-order conditional estimation (FOCE) method as implemented in NONMEM and the alternating algorithm in NLME proposed by Lindstrom and Bates. The two programs were tested using clinical PK/PD data of a new gonadotropin-releasing hormone (GnRH) antagonist degarelix currently being developed for prostate cancer treatment. The pharmacokinetics of intravenous administered degarelix was analysed using a three compartment model while the pharmacodynamics was analysed using a turnover model with a pool compartment. The results indicated that the two algorithms produce consistent parameter estimates. The bias and precision of the two algorithms were further investigated using a parametric bootstrap procedure which showed that NONMEM produced more accurate results than NLME together with the nlmeODE package for this specific study.
Population Pharmacokinetic Modeling of a Subcutaneous Depot for GnRH Antagonist Degarelix

Purpose. The objective of this study is to develop a population pharmacokinetic (PK) model that describes the subcutaneous (SC) depot formation of gonadotropin-releasing hormone (GnRH) antagonist degarelix, which is being developed for treatment of prostate cancer, exhibiting dose-volume and dose-concentration dependent absorption.

Methods. The PK analysis is made in NONMEM through joint analysis of data from two phase I clinical studies; an intravenous infusion study and a single SC dose escalation study. The SC absorption is modeled using an approximation to Ficks' second law of diffusion out of a spherical depot. The dose-volume effect on the SC release is estimated using a B-spline basis whereas the bioavailability is modeled as a function of the dose-concentration.

Results. The SC depot model is approximated by using two concentric spherical compartments for the SC absorption combined with a two-compartment disposition model. The results indicate that the volume effect is most apparent at low injection volumes whereas the effect is diminishing at higher injection volumes. The dose-concentration effect on the bioavailability is estimated to decrease at increasing dose-concentrations.

Conclusions. The presented SC depot model describes the PK profile of GnRH antagonist degarelix. This modeling approach might also be applicable for other depot-formulated drugs exhibiting complex PK profiles.
Degarelix, NONMEM, Population pharmacokinetic modeling, Prostate cancer, Subcutaneous depot

DOIs:
10.1023/B:PHAM.0000022403.60314.51

Links:
Source: orbit
Source-ID: 154575
Publication: Research - peer-review › Journal article – Annual report year: 2004

Population PK/PD modelling framework for systematic model improvement

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Tønøe, C. W. (Intern), Agersø, H. (Ekstern), Nielsen, H. A. (Intern), Madsen, H. (Intern), Jonsson, E. N. (Ekstern)
Publication date: 2004

Host publication information
Title of host publication: Rosenön meeting, Stockholm
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 154711
Simulation and optimization of wind farm controller

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Sørensen, P. (Ekstern), Hansen, A. D. (Ekstern), Thomsen, K. (Ekstern), Madsen, H. (Intern), Nielsen, H. A. (Intern), Poulsen, N. K. (Intern), Iov, F. (Ekstern), Blaabjerg, F. (Ekstern), Okkels, B. (Ekstern)
Publication date: 2004

Host publication information
Title of host publication: European Wind Energy Conference and Exhibition, London
Publisher: I
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 154672
Publication: Research - peer-review › Article in proceedings – Annual report year: 2004

Statistics in Finance

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Lund University
Authors: Madsen, H. (Intern), Nielsen, J. N. (Intern), Lindström, E. (Ekstern), Baadsgaard, M. (Intern), Holst, J. (Intern)
Number of pages: 300
Publication date: 2004

Publication information
Place of publication: Lund University
Publisher: Centre for Mathematical Sciences
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 224566
Publication: Education › Book – Annual report year: 2004

Stochastic Differential Equation in NONMEM

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Tornøe, C. W. (Intern), Agersø, H. (Ekstern), Overgaard, R. V. (Intern), Nielsen, H. A. (Intern), Madsen, H. (Intern), Jonsson, E. N. (Ekstern)
Publication date: 2004

Host publication information
Title of host publication: PAGE meeting, Uppsala
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 154710
Publication: Research - peer-review › Article in proceedings – Annual report year: 2004

Stochastic Differential Equation in NONMEM: A diagnostic tool for pinpointing model deficiencies

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Tornøe, C. W. (Intern), Agersø, H. (Ekstern), Overgaard, R. V. (Intern), Nielsen, H. A. (Intern), Madsen, H. (Intern), Jonsson, E. N. (Ekstern)
Ultra-short term wind speed forecasting

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. (Intern), Madsen, H. (Intern), Sørensen, P. (Ekstern)
Publication date: 2004

Host publication information
Title of host publication: Proceedings of the European Wind Energy Conference & Exhibition
Main Research Area: Technical/natural sciences
Links:
http://www.ewea.org
Source: orbit
Source-ID: 154643
Publication: Research - peer-review › Article in proceedings – Annual report year: 2004

Using quantile regression to extend an existing wind power forecasting system with probabilistic forecasts

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. (Intern), Madsen, H. (Intern), Nielsen, T. S. (Intern)
Publication date: 2004

Host publication information
Title of host publication: Scientific Proceedings of the European Wind Energy Conference & Exhibition
Main Research Area: Technical/natural sciences
Links:
http://www.ewea.org
Source: orbit
Source-ID: 154642
Publication: Research - peer-review › Article in proceedings – Annual report year: 2004

Wind Power Ensemble Forecasting

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. (Intern), Madsen, H. (Intern), Nielsen, T. S. (Intern), Badger, J. (Ekstern), Giebel, G. (Ekstern), Landberg, L. (Ekstern), Sattler, K. (Ekstern), Feddersen, H. (Ekstern)
Publication date: 2004

Host publication information
Title of host publication: Proceedings of the 2004 Global Windpower Conference and Exhibition
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 154647
Publication: Research - peer-review › Article in proceedings – Annual report year: 2004
Wind Power Forecasting Using Ensembles

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Giebel, G. (Ekstern), Badger, J. (Ekstern), Landberg, L. (Ekstern), Nielsen, H. A. O. 3. (Intern), Madsen, H. (Intern), Sattler, K. (Ekstern), Feddersen, H. (Ekstern)
Publication date: 2004

Host publication information
Title of host publication: Proceedings of the 2004 Global Windpower Conference and Exhibition
Main Research Area: Technical/natural sciences
Conference: PSO-finansieret Forskning og Udvikling, 01/01/2004
Source: orbit
Source-ID: 200092
Publication: Research › peer-review › Article in proceedings – Annual report year: 2004

Short-term wind power prediction
The present thesis consists of 10 research papers published during the period 1997-2002 together with a summary report. The objective of the work described in the thesis is to develop models and methods for calculation of high accuracy predictions of wind power generated electricity, and to implement these models and methods in an on-line software application. The economical value of having predictions available is also briefly considered. The summary report outlines the background and motivation for developing wind power prediction models. The meteorological theory which is relevant for the thesis is outlined and the background for the models and methods which are proposed in the various papers is described. The software system, Zephyr, which has been developed is also described in the summary report. The main part of the papers have been written in conjunction with two research projects where the Department of Informatics and Mathematical Modelling and the Department of Wind Energy and Atmospheric Physics have been two major participants. The first project entitled Implementing Short-term Prediction at Utilities, founded by the European Commission under the JOULE programme. The second project is founded by the Danish Ministry of Energy under the Energy Research Programme, and is entitled (in Danish) Vindmølleparks Produktions Prediktor. Both projects have now finished.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics, Risø National Laboratory for Sustainable Energy
Authors: Joensen, A. K. (Intern), Madsen, H. (Intern), Landberg, L. (Intern)
Publication date: Apr 2003

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
imm2448.pdf
Links:
Source: orbit
Source-ID: 58682
Publication: Research › Ph.D. thesis – Annual report year: 2003

Adaptiv kalibrering af COD-sensor baseret på fluorescens-spektre

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. (Intern), Madsen, H. (Intern)
Publication date: 2003

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Links:
An investigation of some tools for process model identification for prediction

General information
State: Published
Organisations: Department of Chemical and Biochemical Engineering, Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Kristensen, N. R. (Intern), Madsen, H. (Intern), Jørgensen, S. B. (Intern)
Pages: 41-62
Publication date: 2003

Host publication information
Title of host publication: Dynamic Model Development: Methods, Theory and Applications
Publisher: Elsevier
ISBN (Print): 0444514651
Main Research Area: Technical/natural sciences
Links:
Source: orbit

A unified framework for systematic model improvement

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Computer Aided Process Engineering Center, Department of Chemical and Biochemical Engineering
Authors: Kristensen, N. (Ekstern), Madsen, H. (Intern), Jørgensen, S. B. (Intern)
Pages: 1292-1297
Publication date: 2003
Main Research Area: Technical/natural sciences

Publication information
Journal: Process Systems Engineering
Volume: 15
ISSN (Print): 1874-5970
Ratings:
Scopus rating (2009): SNIP 0 SJR 0.101
Scopus rating (2008): SNIP 0 SJR 0.101
Scopus rating (2007): SNIP 0 SJR 0.101
Scopus rating (2006): SNIP 0 SJR 0.101
Scopus rating (2005): SNIP 0 SJR 0.101
Scopus rating (2004): SNIP 0 SJR 0.101
Scopus rating (2003): SNIP 0 SJR 0.1
Web of Science (2003): Indexed yes
Scopus rating (2002): SNIP 0 SJR 0.1
Scopus rating (2001): SNIP 0 SJR 0.1
Scopus rating (2000): SNIP 0 SJR 0.1
Original language: English
Source: orbit
Source-ID: 224588
Publication: Research - peer-review › Journal article – Annual report year: 2003

Climate as a predictor of prevalence of campylobacter spp. in humans and broilers in Denmark

General information
State: Published
Data assimilation in an operational forecast system of the North Sea-Baltic Sea system

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Sørensen, J. V. (Ekstern), Madsen, H. (Intern)
Publication date: 2003

Host publication information
Title of host publication: Building the European Capacity in Operational Oceanography: Proceedings of the Third International Conference of EuroGOOS
Publisher: Elsevier Science & Technology Books
Main Research Area: Technical/natural sciences
Conference: Building the European Capacity in Operational Oceanography: Proceedings of the Third International Conference of EuroGOOS, 01/01/2003
Source: orbit
Source-ID: 200394
Publication: Research - peer-review › Article in proceedings – Annual report year: 2003

Estimating Functions with Prior Knowledge, (EFPK) for diffusions

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Nolsøe, K. (Intern), Kessler, M. (Ekstern), Madsen, H. (Intern)
Publication date: 2003

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
imm3035.pdf
Links:
Source: orbit
Source-ID: 58714
Publication: Research - peer-review › Report – Annual report year: 2003

Flavor release measurement by atmospheric pressure chemical ionization ion trap mass spectrometry, construction of interface and mathematical modeling of release profiles

An instrumental on-line retronasal flavor analysis was developed to obtain information about the release of flavor compounds in expired air from humans during eating. The volatile flavor compounds were measured by ion trap mass spectrometry with an atmospheric pressure chemical ionization source (APCI). An interface was designed to sample the breath directly from the nose. The repeat-ability in vitro for seven different flavor compounds came out with relative standard derivation less than 10% in most cases, which is acceptable. In vitro quantification was carried out by a determination of the concentration in the gas phase over a flavor solution by GC/MS, followed by measurements of intensities by the APCI ion trap. Ion suppression by acetone in the breath was negligible at concentration levels relevant in these experiments. The instrumental limits of detection for menthone and menthol coincide with that of the flavor detection
threshold. An application study on the release of menthone and menthol from chewing gum by a group of six test persons was performed. Flavored chewing gum was used as a model matrix because of the long chewing periods and the simplicity of the system. It is concluded that the interface and the method can be used to measure breath from the nose. A mathematical model of the data was developed to give a quantitative method for description and characterization of the release of flavor compounds. The release profiles consisted of two sequences, one for a chewing period, and one for a phasing out process. The proposed method for modeling provided a reasonable description of the release process. In addition to flavor compounds, this new interface and mathematical application could provide information on chemicals in the human breath which could be interesting, for example, within medical diagnosis.

General information
State: Published
Organisations: Department of Systems Biology, Enzyme and Protein Chemistry, National Institute of Aquatic Resources, Department of Informatics and Mathematical Modeling, Center for Microbial Biotechnology, Food Biotechnology and Engineering Group
Authors: Haahr, A. (Intern), Madsen, H. (Intern), Smedsgaard, J. (Intern), Bredie, W. (Ekstern), Stahnke, L. H. (Intern), Refsgaard, H. (Intern)
Pages: 655-662
Publication date: 2003
Main Research Area: Technical/natural sciences

Publication information
Journal: Analytical Chemistry
Volume: 75
Issue number: 3
ISSN (Print): 0003-2700
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 6.08
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 6
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.79
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 6.01
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.8
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 5.86
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Web of Science (2008): Indexed yes
Web of Science (2007): Indexed yes
Web of Science (2006): Indexed yes
Web of Science (2005): Indexed yes
Fluorescens-spektre målt vha. BioView i indløbet på rensningsanlæg

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. (Intern), Madsen, H. (Intern)
Publication date: 2003

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 58710
Publication: Research - peer-review › Report – Annual report year: 2003

How to get physical parameters using MATLAB

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Madsen, H. (Intern), Jimenez, M. J. (Ekstern), Andersen, K. K. (Intern)
Publication date: 2003

Host publication information
Title of host publication: Conference on Dynamic Analysis and Modelling, DAME-BC, Ispra, November
Main Research Area: Technical/natural sciences
Conference: Conference on Dynamic Analysis and Modelling, DAME-BC, Ispra, 01/01/2003
Source: orbit
Source-ID: 58543
Publication: Research - peer-review › Article in proceedings – Annual report year: 2003

Identification of Continuous Time Models Using Discrete Time Data

General information
State: Published
Organisations: Department of Chemical and Biochemical Engineering, Mathematical Statistics, Department of Informatics and Mathematical Modeling, Computer Aided Process Engineering Center
Authors: Kristensen, N. R. (Intern), Madsen, H. (Intern), Jørgensen, S. B. (Intern)
Publication date: 2003

Host publication information
Title of host publication: SYSID2003, Rotterdam, Holland - Aug. 2003
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 199919
Kalibrering af COD-sensor (BioView) placeret i indløb til renseanlæg

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. (Intern), Madsen, H. (Intern)
Publication date: 2003

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 58712
Publication: Research - peer-review › Report – Annual report year: 2003

Model Validation in Non-Linear Continuous-Discrete Grey-Box Models

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Holst, J. (Intern), Lindström, E. (Ekstern), Madsen, H. (Intern), Nielsen, H. A. (Intern)
Publication date: 2003

Host publication information
Title of host publication: Proceedings of the 13th IFAC Symposium on System Identification, SYSID 2003, Rotterdam, The Netherlands, August
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 58531
Publication: Research - peer-review › Article in proceedings – Annual report year: 2003

Non-Linear Mixed-Effects Models in NLME with Differential Equations

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Tornøe, C. W. (Intern), Agersø, H. (Ekstern), Nielsen, H. A. (Intern), Madsen, H. (Intern), Jonsson, E. N. (Ekstern)
Publication date: 2003
Event: Abstract from PAGE Meeting 2003, Verona, Italy.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 200558
Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2003

Population pharmacokinetic modeling of a subcutaneous depot for GnRH antagonist degarelix

Purpose. The objective of this study is to develop a population pharmacokinetic (PK) model that describes the subcutaneous (SC) depot formation of gonadotropin-releasing hormone (GnRH) antagonist degarelix, which is being developed for treatment of prostate cancer, exhibiting dose-volume and dose-concentration dependent absorption.

Methods. The PK analysis is made in NONMEM through joint analysis of data from two phase I clinical studies; an intravenous infusion study and a single SC dose escalation study. The SC absorption is modeled using an approximation to Fick's second law of diffusion out of a spherical depot. The dose-volume effect on the SC release is estimated using a B-spline basis whereas the bioavailability is modeled as a function of the dose-concentration. Results. The SC depot model is approximated by using two concentric spherical compartments for the SC absorption combined with a two-compartment disposition model. The results indicate that the volume effect is most apparent at low injection volumes whereas the effect is diminishing at higher injection volumes. The dose-concentration effect on the bioavailability is estimated to decrease at increasing dose-concentrations. Conclusions. The presented SC depot model describes the PK profile of GnRH antagonist degarelix. This modeling approach might also be applicable for other depot-formulated drugs.
exhibiting complex PK profiles.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Tornøe, C. W. (Intern), Agersø, H. (Ekstern), Nielsen, H. A. (Intern), Madsen, H. (Intern), Jonsson, E. N. (Ekstern)
Publication date: 2003
Event: Abstract from PAGE Meeting 2003, Verona, Italy.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 200559
Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2003

Population pharmacokinetic modelling of a subculaneous depot for GnRH antagonist degarelix

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Tornøe, C. W. (Intern), Agersø, H. (Ekstern), Nielsen, H. A. (Intern), Madsen, H. (Intern), Jonsson, E. N. (Ekstern)
Publication date: 2003

Host publication information
Title of host publication: PAGE meeting, Verona, June
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 58577
Publication: Research › Article in proceedings – Annual report year: 2003

Short-term Prediction - An Overview
This article gives an overview of the different methods used today for predicting the power output from wind farms on the 1-2 day time horizon. It describes the general set-up of such prediction systems and also gives examples of their performance. Copyright (C) 2003 John Wiley Sons, Ltd.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Landberg, L. (Ekstern), Giebel, G. (Ekstern), Nielsen, H. A. (Intern), Nielsen, T. S. (Intern), Madsen, H. (Intern)
Pages: 273-280
Publication date: 2003
Main Research Area: Technical/natural sciences

Publication information
Journal: Wind Energy
Volume: 6
Issue number: 3
ISSN (Print): 1095-4244
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.37 SJR 1.104 SNIP 2.306
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.196 SNIP 2.086 CiteScore 3.06
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.272 SNIP 3.75 CiteScore 3.42
Stochastic Grey-Box Modelling as a Tool for Improving the Quality of First Engineering Principles Models

General information
State: Published
Organisations: Department of Chemical and Biochemical Engineering, Mathematical Statistics, Department of Informatics and Mathematical Modeling, Computer Aided Process Engineering Center
Authors: Kristensen, N. R. (Intern), Madsen, H. (Intern), Jørgensen, S. B. (Intern)
Publication date: 2003

Host publication information
Title of host publication: Proceedings of the International Symposium on Advanced Control of Chemical Processes
Main Research Area: Technical/natural sciences
Teksturdata til beregning af friktionsværdier - anvendelse på vejoverflader?

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. (Intern), Madsen, H. (Intern)
Publication date: 2003

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Links:
http://www.vd.dk/wimpdoc.asp?page=document&objno=71776
Source: orbit
Source-ID: 199920

Analyse og simulering af prædiktionsfejl for vindenergiproduktion ved indmelding til NordPool

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. (Intern), Madsen, H. (Intern)
Publication date: 2002

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 58709

Anvendelse af teksturdata til beregning af friktionsværdier for vejbelægninger

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. (Intern), Madsen, H. (Intern)
Publication date: 2002

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 58389

Calibration with empirically weighted mean subset
In this article a new calibration method called empirically weighted mean subset (EMS) is presented. The method is illustrated using spectral data. Using several near-infrared (NIR) benchmark data sets, EMS is compared to partial least-squares regression (PLS) and interval partial least-squares regression (iPLS). It is found that EMS improves on the prediction performance over PLS in terms of the mean squared errors and is more robust than iPLS. Furthermore, by investigating the estimated coefficient vector of EMS, knowledge about the important spectral regions can be gained. The EMS solution is obtained by calculating the weighted mean of all coefficient vectors for subsets of the same size. The weighting is proportional to SSgamma-omega, where SSgamma is the residual sum of squares from a linear regression with subset gamma and omega is a weighting parameter estimated using cross-validation. This construction of the
weighting implies that even if some coefficients will become numerically small, none will become exactly zero. An efficient algorithm has been implemented in MATLAB to calculate the EMS solution and the source code has been made available on the Internet.

**General information**

State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Øjelund, H. (Intern), Madsen, H. (Intern), Thyregod, P. (Intern)
Pages: 887-896
Publication date: 2002
Main Research Area: Technical/natural sciences

**Publication information**

Journal: Applied Spectroscopy
Volume: 56
Issue number: 7
ISSN (Print): 0003-7028
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.48 SNIP 0.967 CiteScore 1.76
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.649 SNIP 1.09 CiteScore 1.96
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.619 SNIP 1.077 CiteScore 1.96
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.627 SNIP 1.162 CiteScore 2.08
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.581 SNIP 1.103 CiteScore 1.81
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.6 SNIP 1.031 CiteScore 1.62
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.687 SNIP 0.989
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.634 SNIP 0.907
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.85 SNIP 1.09
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.772 SNIP 0.992
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.795 SNIP 1.004
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.883 SNIP 1.135
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.879 SNIP 1.021
Web of Science (2004): Indexed yes
Control of Supply Temperature in District Heating Systems

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Nielsen, T. S. (Intern), Madsen, H. (Intern)
Publication date: 2002

Host publication information
Title of host publication: Proceedings of the 8th International Symposium on District heating and Cooling
Main Research Area: Technical/natural sciences
Electronic versions:
imm1734.pdf

Grey-box modelling of aeration tank settling

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Bechmann, H. (Intern), Nielsen, M. K. (Ekstern), Poulsen, N. K. (Intern), Madsen, H. (Intern)
Pages: 1887-1895
Publication date: 2002
Main Research Area: Technical/natural sciences

Publication information
Journal: Water research
Volume: 36
Issue number: 7
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 7.49 SJR 2.629 SNIP 2.558
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.689 SNIP 2.507 CiteScore 6.63
Grey-box modelling of insulin clamp study

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Tornøe, C. W. (Intern), Jacobsen, J. L. (Intern), Madsen, H. (Intern)
Improving Prediction Models in Complex Terrain

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Marti, I. (Ekstern), Nielsen, T. S. (Intern), Madsen, H. (Intern), Roldan, A. (Ekstern), Perez, S. (Ekstern)
Publication date: 2002

Host publication information
Title of host publication: Proceedings of the 2002 Global Windpower Conference, Paris (FR), 2-5 Apr
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 58192
Publication: Research - peer-review › Article in proceedings – Annual report year: 2002

Modeling of a thermostatic valve with hysteresis effects

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Andersen, K. K. (Intern), Madsen, H. (Intern), Knop, O. (Ekstern)
Publication date: 2002

Host publication information
Title of host publication: 15. World Congress on Automatic Control, Barcelona, July 21-26
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 58146
Publication: Research - peer-review › Article in proceedings – Annual report year: 2002

On On-line Systems for Short-term Forecasting for Energy Systems

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. (Intern), Nielsen, T. S. (Intern), Madsen, H. (Intern)
Pages: 265-271
Publication date: 2002

Host publication information
Title of host publication: Proceedings of the OR 2002 conference
Publisher: Springer
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 58201
Publication: Research - peer-review › Article in proceedings – Annual report year: 2002

Optimal control of micro CHP

General information
Prediction based on mean subset

Shrinkage methods have traditionally been applied in prediction problems. In this article we develop a shrinkage method (mean subset) that forms an average of regression coefficients from individual subsets of the explanatory variables. A Bayesian approach is taken to derive an expression of how the coefficient vectors from each subset should be weighted. It is not computationally feasible to calculate the mean subset coefficient vector for larger problems, and thus we suggest an algorithm to find an approximation to the mean subset coefficient vector. In a comprehensive Monte Carlo simulation study, it is found that the proposed mean subset method has superior prediction performance than prediction based on the best subset method, and in some settings also better than the ridge regression and lasso methods. The conclusions drawn from the Monte Carlo study is corroborated in an example in which prediction is made using spectroscopic data.
Scopus rating (2009): SJR 2.684 SNIP 1.972
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.272 SNIP 1.724
Scopus rating (2007): SJR 1.27 SNIP 1.73
Scopus rating (2006): SJR 1.277 SNIP 2.08
Scopus rating (2005): SJR 1.39 SNIP 1.683
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.155 SNIP 1.886
Scopus rating (2003): SJR 1.551 SNIP 1.522
Scopus rating (2002): SJR 1.021 SNIP 1.893
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.455 SNIP 1.943
Scopus rating (2000): SJR 1.614 SNIP 2.411
Scopus rating (1999): SJR 2.118 SNIP 2.216
Original language: English
DOIs: 10.1198/004017002188618563
Links:
Source: orbit
Source-ID: 58117
Publication: Research - peer-review › Journal article – Annual report year: 2002

Prediction of Regional Wind Power

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Nielsen, T. S. (Intern), Madsen, H. (Intern), Nielsen, H. A. (Intern), Giebel, G. (Ekstern), Landberg, L. (Ekstern)
Publication date: 2002

Host publication information
Title of host publication: Proceedings of the 2002 Global Windpower Conference, Paris, France
Main Research Area: Technical/natural sciences
Electronic versions:
imm1733.pdf
Links:
Source: orbit
Source-ID: 58202
Publication: Research - peer-review › Article in proceedings – Annual report year: 2002

Prediction of Wind Power Using Time-varying Coefficient-functions

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Nielsen, T. S. (Intern), Madsen, H. (Intern), Nielsen, H. A. (Intern)
Publication date: 2002

Host publication information
Title of host publication: Proceedings of the 15th IFAC World Congress on Automatic Control
Place of publication: Barcelona, Spain
Main Research Area: Technical/natural sciences
Conference: 15th IFAC World Congress on Automatic Control, 01/01/2002
Source: orbit
Source-ID: 58204
Publication: Research - peer-review › Article in proceedings – Annual report year: 2002
Predictive control of supply temperature in district heating systems

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Nielsen, T. S. (Intern), Madsen, H. (Intern), Holst, J. (Intern), Søgaard, H. T. (Ekstern)
Publication date: 2002

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions: imm1727.ps
Links:
Source: orbit
Source-ID: 58388
Publication: Research - peer-review › Report – Annual report year: 2002

Towards an operational data assimilation system for a three-dimensional hydrodynamic model

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Sørensen, J. V. (Ekstern), Madsen, H. (Intern)
Publication date: 2002

Host publication information
Title of host publication: Hydroinformatics 2000, Cardiff 1-5 July 20
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 58142
Publication: Research › Article in proceedings – Annual report year: 2002

Using continuous time stochastic modelling and nonparametric statistics to improve the quality of first principles models

General information
State: Published
Organisations: Department of Chemical and Biochemical Engineering, Mathematical Statistics, Department of Informatics and Mathematical Modeling, Computer Aided Process Engineering Center
Authors: Kristensen, N. R. (Intern), Madsen, H. (Intern), Jørgensen, S. B. (Intern)
Pages: 901-906
Publication date: 2002
Main Research Area: Technical/natural sciences

Publication information
Journal: Computer - Aided Chemical Engineering
Volume: 10
ISSN (Print): 1570-7946
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.48 SJR 0.198 SNIP 0.215
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.245 SNIP 0.249 CiteScore 0.39
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.239 SNIP 0.217 CiteScore 0.4
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Using meteorological forecasts for short term wind power forecasting

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. (Intern), Nielsen, T. S. (Intern), Madsen, H. (Intern)
Pages: 49-58
Publication date: 2002

Host publication information
Title of host publication: Proceedings of the IEA R&D Wind Annex XI Joint Action Symposium on Wind Forecasting Techniques
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 58248
Publication: Research › Article in proceedings – Annual report year: 2002

Zephyr - The Next Generation Prediction System

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Giebel, G. (Ekstern), Landberg, L. (Ekstern), Nielsen, T. S. (Intern), Madsen, H. (Intern)
Publication date: 2002

Host publication information
Title of host publication: Proceedings of the 2002 Global Windpower Conference
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 58237
Publication: Research › Article in proceedings – Annual report year: 2002
**Calibration with Absolute Shrinkage**

In this paper, penalized regression using the L-1 norm on the estimated parameters is proposed for chemometric calibration. The algorithm is of the lasso type, introduced by Tibshirani in 1996 as a linear regression method with bound on the absolute length of the parameters, but a modification is suggested to cope with the singular design matrix most often seen in chemometric calibration. Furthermore, the proposed algorithm may be generalized to all convex norms like Sigma/beta (j)(gamma) where gamma greater than or equal to 1, i.e. a method that continuously varies from ridge regression to the lasso. The lasso is applied both directly as a calibration method and as a method to select important variables/wave lengths. It is demonstrated that the lasso algorithm, in general, leads to parameter estimates of which some are zero while others are quite large (compared to e.g. the traditional PLS or RR estimates). By using several benchmark data sets, it is shown that both the direct lasso method and the regression where the lasso acts as a wavelength selection method most often outperform the PLS and RR methods. Copyright (C) 2001 John Wiley & Sons, Ltd.

**General information**

State: Published  
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics  
Authors: Øjelund, H. (Intern), Madsen, H. (Intern), Thyregod, P. (Intern)  
Pages: 497-510  
Publication date: Jul 2001  
Main Research Area: Technical/natural sciences

**Publication information**

Journal: Journal of Chemometrics  
Volume: 15  
Issue number: 6  
ISSN (Print): 0886-9383

Ratings:  
BFI (2018): BFI-level 1  
BFI (2017): BFI-level 2  
Web of Science (2017): Indexed Yes  
BFI (2016): BFI-level 2  
Scopus rating (2016): SJR 0.5 SNIP 0.873 CiteScore 1.71  
BFI (2015): BFI-level 2  
Scopus rating (2015): SJR 0.553 SNIP 0.984 CiteScore 1.82  
Web of Science (2015): Indexed yes  
BFI (2014): BFI-level 2  
Scopus rating (2014): SJR 0.536 SNIP 1.235 CiteScore 1.72  
BFI (2013): BFI-level 2  
Scopus rating (2013): SJR 0.749 SNIP 1.316 CiteScore 2.2  
ISI indexed (2013): ISI indexed yes  
Web of Science (2013): Indexed yes  
BFI (2012): BFI-level 2  
Scopus rating (2012): SJR 0.66 SNIP 1.342 CiteScore 2.03  
ISI indexed (2012): ISI indexed yes  
BFI (2011): BFI-level 2  
Scopus rating (2011): SJR 0.742 SNIP 1.037 CiteScore 1.66  
ISI indexed (2011): ISI indexed yes  
BFI (2010): BFI-level 2  
Scopus rating (2010): SJR 0.591 SNIP 0.75  
BFI (2009): BFI-level 2  
Scopus rating (2009): SJR 0.931 SNIP 1.008  
Web of Science (2009): Indexed yes  
BFI (2008): BFI-level 1  
Scopus rating (2008): SJR 0.868 SNIP 0.903  
Web of Science (2008): Indexed yes  
Scopus rating (2007): SJR 0.829 SNIP 1.097  
Scopus rating (2006): SJR 1.073 SNIP 1.509
Modelling and monitoring in injection molding

This thesis is concerned with the application of statistical methods in quality improvement of injection molded parts. The methods described are illustrated with data from the manufacturing of parts for a medical device. The emphasis has been on the variation between cavities in multi-cavity molds. From analysis of quality measurements from a longer period of manufacturing, it was found that differences in cavities was that source of variation with greatest influence on the length of the molded parts. The other large contribution to the length variation was the different machine settings. Samples taken within the same machine set-point did not cause great variation compared to the two preceding sources of variation. A simple graphical approach is suggested for finding patterns in the cavity differences. Applying this method to data from a 16 cavity mold, a clear connection was found between a part's length and the producing cavity's position in the mold. In a designed experiment it was possible to isolate the machine parameters contributing to the variation between cavities. Thus, with a proper choice of levels for the machine variables, it was possible to reduce the variation between cavities substantially. Also an alternative model for the shrinkage of parts from a multi-cavity mold is suggested. From applying the model to data from a shrinkage study, it seemed that the observed part differences were not only due to differences in cavity dimensions. A model for the in-control variation for a multi-cavity molding process was suggested. Based on this model, control charting procedures have been suggested for monitoring the quality of the molded parts. Moreover, a capability index for multi-cavity molds has been suggested. Furthermore an alternative method for in-line quality charting is suggested. The method is for continuous control by attributes, and it is an alternative to the batch-oriented approach mostly used. The procedure is especially efficient for quality requirements of very low proportion non-conformities. For the proposed charts the ARL function is derived. It is shown that in the case where a non-conforming unit is only expected very rarely during sampling, a moving sum chart and a CUSUM chart are equivalent. Finally, the correlation structure of 21 process variables has been studied prior to monitoring the process. It is illustrated how the process can be analysed with multivariate techniques. It was found that two principal components reflected changes in machine set-points. Thus, there seems to be great potential in monitoring the process variables using a multivariate approach.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Thyregod, P. (Intern), Spliid, H. (Intern), Melgaard, H. (Intern), Madsen, H. (Intern)
Publication date: Apr 2001

Publication Information
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions: imm788.pdf
Links:
Source: orbit
Source-ID: 58005
A Generalization of Some Classical Time Series Tools

In classical time series analysis the sample autocorrelation function (SACF) and the sample partial autocorrelation function (SPACF) has gained wide application for structural identification of linear time series models. We suggest generalizations, founded on smoothing techniques, applicable for structural identification of non-linear time series models. A similar generalization of the sample cross correlation function is discussed. Furthermore, a measure of the departure from linearity is suggested. It is shown how bootstrapping can be applied to construct confidence intervals under independence or linearity. The generalizations do not prescribe a particular smoothing technique. In fact, when the smoother is replaced by a linear regression the generalizations reduce to close approximations of SACF and SPACF. For this reason a smooth transition from the linear to the non-linear case can be obtained by varying the bandwidth of a local linear smoother. By adjusting the flexibility of the smoother the power of the tests for independence and linearity against specific alternatives can be adjusted. The generalizations allow for graphical presentations, very similar to those used for SACF and SPACF. In this paper the generalizations are applied to some simulated data sets and to the Canadian lynx data. The generalizations seem to perform well and the measure of the departure from linearity proves to be an important additional tool.
A grey box model describing the hydraulics in a creek

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Jonsdottir, H. (Intern), Jacobsen, J. L. (Intern), Madsen, H. (Intern)
Pages: 347-356
Publication date: 2001
Main Research Area: Technical/natural sciences

Publication information
Journal: Environmetrics
Volume: 12
Issue number: 4
ISSN (Print): 1180-4009
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.944 SNIP 1.045 CiteScore 1.59
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.014 SNIP 0.892 CiteScore 1.48
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.061 SNIP 1.178 CiteScore 1.64
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.073 SNIP 1.228 CiteScore 1.65
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.563 SNIP 0.897 CiteScore 1.12
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.537 SNIP 1.015 CiteScore 1.3
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.684 SNIP 0.811
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.467 SNIP 0.912
Applying the EKF to stochastic differential equations with level effects

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Nielsen, J. N. (Intern), Madsen, H. (Intern)
Pages: 107-112
Publication date: 2001
Main Research Area: Technical/natural sciences

Publication Information
Journal: Automatica
Volume: 37
Issue number: 1
ISSN (Print): 0005-1098
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 6.96 SJR 4.172 SNIP 3.332
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 4.079 SNIP 3.068 CiteScore 5.61
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 3.59 SNIP 3.109 CiteScore 5.37
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 3.623 SNIP 3.292 CiteScore 5.57
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 3.738 SNIP 3.728 CiteScore 6.08
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 3.774 SNIP 3.661 CiteScore 4.87
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Calibration with near-continuous spectral measurements

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. (Intern), Rasmussen, M. (Ekstern), Madsen, H. (Intern), Jensen et al., N. (ed.) (Ekstern)
Pages: 255-264
Publication date: 2001

Host publication information
Title of host publication: 23. Symposium i Anvendt Statistik, Økonomisk Institut, Københavns Universitet / Danmarks Statistik
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 57813
Publication: Research - peer-review › Journal article – Annual report year: 2001

Computer Aided Continuous Time Stochastic Process Modelling
A grey-box approach to process modelling that combines deterministic and stochastic modelling is advocated for identification of models for model-based control of batch and semi-batch processes. A computer-aided tool designed for supporting decision-making within the corresponding modelling cycle is presented.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Department of Chemical and Biochemical Engineering
Authors: Kristensen, N. (Ekstern), Madsen, H. (Intern), Jørgensen, S. B. (Intern)
Pages: 189-194
Publication date: 2001

Host publication information
ISBN (Print): 978-0-444-50709-9
Series: Computer - Aided Chemical Engineering
Data Assimilation of tidal gauge data in a three-dimensional coastal model

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Sørensen, J. V. T. (Intern), Madsen, H. (Intern)
Publication date: 2001

Host publication information
Title of host publication: DHI Software Conference, 6-8 June, Scanticon Conference Centre, Helsingør, Denmark
Main Research Area: Technical/natural sciences

Intelligent Control

General Information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Madsen, H. (Intern), Rasmussen, M. (Ekstern), Nielsen, H. A. (Intern)
Pages: 14-16
Publication date: 2001
Main Research Area: Technical/natural sciences

Publication Information
Journal: Danish Board of District Heating -- News from DBDH
Issue number: 3
Original language: English

Måling af COD i indløbet på rensningsanlæg på basis af fluorescens-spektre fra BioView

General Information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. (Intern), Madsen, H. (Intern)
Publication date: 2001

Publication Information
Original language: English
Main Research Area: Technical/natural sciences
Links:
Modellering og analyse af kvælstof i Randers Fjord

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Le, T. T. (Ekstern), Madsen, H. (Intern), Rasmussen, B. (Ekstern), Sømod, B. (Ekstern)
Publication date: 2001

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 58023
Publication: Research › Report – Annual report year: 2001

Prediction models in complex terrain.
The objective of the work is to investigate the performance of HIRLAM in complex terrain when used as input to energy production forecasting models, and to develop a statistical model to adapt HIRLAM prediction to the wind farm. The features of the terrain, specially the topography, influence the performance of HIRLAM in particular with respect to wind predictions. To estimate the performance of the model two spatial resolutions (0.5 Deg. and 0.2 Deg.) and different sets of HIRLAM variables were used to predict wind speed and energy production. The predictions of energy production for the wind farms are calculated using on-line measurements of power production as well as HIRLAM predictions as input thus taking advantage of the auto-correlation, which is present in the power production for shorter prediction horizons. Statistical models are used to describe the relationship between observed energy production and HIRLAM predictions. The statistical models belong to the class of conditional parametric models. The models are estimated using local polynomial regression, but the estimation method is here extended to be adaptive in order to allow for slow changes in the system e.g. caused by the annual variations of the climate. The results show that HIRLAM wind speed predictions can be improved by considering other HIRLAM variables that wind speed e.g. pressure gradients, and increasing the spatial resolution of the HIRLAM model.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Marti, I. (Ekstern), Nielsen, T. S. (Intern), Madsen, H. (Intern), Navarro, J. (Ekstern), Barquero, C. (Ekstern)
Number of pages: 1,248
Publication date: 2001

Host publication information
Title of host publication: European Wind Energy Conference, Copenhagen
Publisher: WIP-Renewable Energies/ETA
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 57904
Publication: Research › Article in proceedings – Annual report year: 2001

Spectral transformation and range-selection in multivariate calibration

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. (Intern), Rasmussen, M. (Ekstern), Madsen, H. (Intern)
Publication date: 2001
Event: Poster session presented at 7th Scandinavian Symposium on Chemometrics / Book of Abstracts
Main Research Area: Technical/natural sciences

Bibliographical note
pp. A69
Source: orbit
Stochastic Modelling of Energy Systems

In this thesis dynamic models of typical components in Danish heating systems are considered. Emphasis is made on describing and evaluating mathematical methods for identification of such models, and on presentation of component models for practical applications. The thesis consists of seven research papers (case studies) together with a summary report. Each case study takes it's starting point in typical heating system components and both, the applied mathematical modelling methods and the application aspects, are considered. The summary report gives an introduction to the scope of application and the applied modelling method and summarizes the research papers. The foundation of the identification process is the grey box modelling method. The grey box modelling method is characterized by using information from measurements in conjunction with physical knowledge. The combination of statistical methods and physical interpretation is exploited in the modelling procedure, from the design of experiments to parameter estimation and model validation. The presented models are mainly formulated as state space models in continuous time with discrete time observation equations. The state equations are expressed in terms of stochastic differential equations. From a theoretical viewpoint the techniques for experimental design, parameter estimation and model validation are considered. From the practical viewpoint emphasis is put on how this methods can be used to construct models adequate for heating system simulations. Significant parts of the research work have been done in cooperation with leading companies from the Danish heating industry. The presented models have been developed for the purpose of analyzing typical heating system installations. The focal point of the developed models is that the model structure has to be adequate for practical applications, such as system simulation, fault detection and diagnosis, and design of control strategies. This also reflects on the methods used for identification of the component models. The main result from this research is the identification of component models, such as e.g. heat exchanger and valve models, adequate for system simulations. Furthermore, the thesis demonstrates and discusses the advantages and disadvantages of using statistical methods in conjunction with physical knowledge in establishing adequate component models of heating systems.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Andersen, K. K. (Intern), Madsen, H. (Intern)
Number of pages: 198
Publication date: 2001

Publication information
Original language: English
Series: IMM-PHD-2001-79
Main Research Area: Technical/natural sciences
Electronic versions:
imm314.pdf
Links:
Source: orbit
Source-ID: 57994
Publication: Research › Ph.D. thesis – Annual report year: 2001

Zephyr - the next generation prediction.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Giebel, G. (Ekstern), Landberg, L. (Ekstern), Nielsen, T. S. (Intern), Madsen, H. (Intern)
Number of pages: 1,248
Publication date: 2001

Host publication information
Title of host publication: the European Wind Energy Conference, Copenhagen
Publisher: WIP-Munich and ETA-Florence
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 57900
Publication: Research › Article in proceedings – Annual report year: 2001
**Estimating Multivariate Exponential-Affine Term Structure Models from Coupon Bound Prices using Nonlinear Filtering**

An econometric analysis of continuous-time models of the term structure of interest rates is presented. A panel of coupon bond prices with different maturities is used to estimate the embedded parameters of a continuous-discrete state space model of unobserved state variables: the spot interest rate, the central tendency and stochastic volatility. Emphasis is placed on the particular class of exponential-affine term structure models that permits solving the bond pricing PDE in terms of a system of ODEs. It is assumed that coupon bond prices are contaminated by additive white noise, where the stochastic noise term should account for model errors. A nonlinear filtering method is used to compute estimates of the state variables, and the model parameters are estimated by a quasi-maximum likelihood method provided that some assumptions are imposed on the model residuals. Both Monte Carlo simulation results and empirical results based on the Danish bond market are presented.

**Estimation in continuous-time stochastic volatility models using nonlinear filters**

Experimental design and setup for heat exchanger modelling

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Andersen, K. K. (Intern), Madsen, H. (Intern), Palsson, O. P. (Intern), Knudsen, L. (Ekstern)
Publication date: 2000
Main Research Area: Technical/natural sciences

Publication information
Journal: International Journal of Heat Exchangers
Volume: 1
Issue number: 2
Original language: English
Source: orbit
Source-ID: 176375
Publication: Research - peer-review › Journal article – Annual report year: 2000
Load scheduling for decentralized CHP plants
This report considers load scheduling for decentralized combined heat and power plants where the revenue from selling power to the transmission company and the fuel cost may be time-varying. These plants produce both heat and power with a fixed ratio between these outputs. A heat storage facility is used to be able to deviate from this restriction. The load scheduling must be performed with only approximate knowledge about the future. At present in Denmark this uncertainty is only associated with the heat demand, but in the future revenues of produced energy and the fuel costs might also be uncertain and dependent on time. It is suggested to use a combination of background knowledge of the operator and computer tools to solve the scheduling problem. More specifically, it is suggested that the plant is equipped with (i) an automatic on-line system for forecasting the heat demand, (ii) an interactive decision support tool by which optimal schedules can be found given the forecasts or user-defined modifications of the forecasts, and (iii) an automatic on-line system for monitoring when conditions have changed so that rescheduling is appropriate. In this report the focus is on methods applicable for items (ii) and (iii). For item (i), the approach taken in this report is explicitly to describe how the total revenue from running the plant depends on the schedule for the heat and power producing units of the plant. Hereafter optimization theory, in this case dynamic programming, is applied to find the optimal schedule. To take the uncertainties into account it might be considered to use stochastic dynamic programming. However, it is argued that this is unpractical because the forecasting system will need to be integrated into the optimization system, whereby a modular design of the software cannot be obtained. Furthermore, we believe that all relevant forecasting methods are far too complicated to allow for this integration; both uncertainties originating from the dependence of heat load on climate and from meteorological forecasts need to be taken into account. Instead we suggest that the decision support system allows the operator to investigate the sensitivity of the optimal schedule to variations in the input. Furthermore, we suggest that the system is equipped with the possibility to simulate realistic realizations of the heat demand based on the actual forecast and previous forecast errors. By letting the system find optimal schedules for each of these realizations, the operator can gain some insight into the importance of the uncertainties. It is shown that with modern personal computers (e.g. 1 GHz Pentium III), operating systems (e.g. RedHat Linux 6.0), and compilers (e.g. GNU C 2.91) the calculations can be performed quickly enough to allow use to be applicable in practice. One optimal schedule covering one week can easily be found within 5 to 10 seconds. When considering many possible realizations of the future heat demand, some techniques are needed to reduce the amount of CPU time required. The results indicate that it is possible to find optimal schedules for 100 realizations of heat demand using less than 3 minutes of CPU time. Furthermore, the methods allow for massive use of parallel processing.

Modelling the heat dynamics of a building using stochastic differential equations
This paper describes the continuous time modelling of the heat dynamics of a building. The considered building is a residential like test house divided into two test rooms with a water based central heating. Each test room is divided into thermal zones in order to describe both short and long term variations. Besides modelling the heat transfer between thermal zones, attention is put on modelling the heat input from radiators and solar radiation. The applied modelling procedure is based on collected building performance data and statistical methods. The statistical methods are used in parameter estimation and model validation, while physical knowledge is used in forming the model structure. The suggested lumped parameter model is thus based on thermodynamics and formulated as a system of stochastic differential equations. Due to the continuous time formulation the parameters of the model are directly physical interpretable. Finally, the prediction and simulation performance of the model is illustrated. (C) 2000 Elsevier Science S.A. All rights reserved.
Modelling the heat dynamics of buildings using stochastic differential equations

This paper describes the continuous time modelling of the heat dynamics of a building. The considered building is a residential like test house divided into two test rooms with a water based central heating. Each test room is divided into thermal zones in order to describe both short and long term variations. Besides modelling the heat transfer between thermal zones, attention is put on modelling the heat input from radiators and solar radiation. The applied modelling procedure is based on collected building performance data and statistical methods. The statistical methods are used in parameter estimation and model validation, while physical knowledge is used in forming the model structure. The suggested lumped parameter model is thus based on thermodynamics and formulated as a system of stochastic differential equations. Due to the continuous time formulation the parameters of the model are directly physical interpretable. Finally, the prediction and simulation performance of the model is illustrated.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Andersen, K. K. (Intern), Madsen, H. (Intern)
Pages: 13-24
Publication date: 2000
Main Research Area: Technical/natural sciences

Publication information
Journal: Energy and Buildings
Volume: 31
Issue number: 1
ISSN (Print): 0378-7788
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 4.64 SJR 2.093 SNIP 1.965
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.088 SNIP 2.174 CiteScore 4.07
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.123 SNIP 2.936 CiteScore 4.21
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.897 SNIP 2.433 CiteScore 3.79
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.816 SNIP 2.737 CiteScore 3.36
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.506 SNIP 2.536 CiteScore 3.23
Parameter Estimation in Stochastic Differential Equations; An Overview

This paper presents an overview of the progress of research on parameter estimation methods for stochastic differential equations (mostly in the sense of Ito calculus) over the period 1981-1999. These are considered both without measurement noise and with measurement noise, where the discretely observed stochastic differential equations are embedded in a continuous-discrete time state space model. Every attempt has been made to include results from other scientific disciplines. Maximum likelihood estimation of parameters in nonlinear stochastic differential equations is in general not possible due to the unavailability of closed form expressions for the transition and stationary probability density functions of the states. However, major developments are classified according to their approximation to the “true” maximum likelihood solution as opposed to a historical order of presentation.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Nielsen, J. N. (Intern), Madsen, H. (Intern), Young, P. C. (Ekstern)
Pages: 83-94
Publication date: 2000
Main Research Area: Technical/natural sciences

Publication information
Journal: Annual Reviews in Control
Volume: 24
ISSN (Print): 1367-5788
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Predicting the Heat Consumption in District Heating Systems using Meteorological Forecasts

Methods for on-line prediction of heat consumption in district heating systems hour by hour for horizons up to 72 hours are considered in this report. Data from the district heating system Vestegns Kraftvarmeselskab I/S is used in the investigation. During the development it has been assumed that meteorological forecasts are available on-line. Such a service has recently been introduced by the Danish Meteorological Institute. However, actual meteorological forecasts have not been available for the work described here. Assuming the climate to be known the mean absolute relative prediction error for 72 hour predictions is 3.8% for data in November, 1995 (17% when no climate information is used). However, at some occasions large deviations occur and in January 1996 a value of 5.5% is obtained. The relative prediction error tends to increase with decreasing heat consumption. Approaches to implementation are suggested in a separate chapter of the report. The methods of prediction applied are based on adaptive estimation, whereby the methods adapt to slow changes in the system. This approach is also used to track the transition from e.g. warm to cold periods. Due to different preferences of the households to which the heat is supplied this transition is smooth. By simulation, combined with theory known from the literature, it is shown that it is crucial to use the actual meteorological forecasts and not the observations of climate when estimating the parameters of the model. To our knowledge, this is somewhat contrary to practice. The work presented is a demonstration of the value of the so called gray box approach where theoretical knowledge about the system under consideration is combined with information from measurements performed on the system in order to obtain a mathematical description of the system. Furthermore it is also demonstrated that it is important to select the estimation method depending on the particular application. Maximum likelihood estimates are often considered optimal, but here they prove to be inferior to output error estimates for long-term prediction. This is because the optimality of the maximum
likelihood estimates are related to the properties of the estimates, whereas for prediction purposes the properties of the prediction errors should be in focus.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. O. 3. (Intern), Madsen, H. (Intern)
Publication date: 2000

Publication information
Publisher: Informatics and Mathematical Modelling, Technical University of Denmark, DTU
Original language: English
Main Research Area: Technical/natural sciences
greybox modelling, forecasting
Source: orbit
Source-ID: 200981
Publication: Research - peer-review › Report – Annual report year: 2000

Short-term prediction towards the 21st century
A new chapter in the continued and exiting story of short-term prediction has begun! The paper will describe a new project funded by the Danish Ministry of Energy where all the Danish utilities (Elkraft, ELsam, Eltra, and SEAS) will participate. The goal of the project is to develop and implement on-line a model combining the RISO and IMM models. This will ensure that the best forecasts are given on all prediction horizons form the very short range (0-9 hours) to the very long range (36-48 hours).

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Risø National Laboratory for Sustainable Energy
Authors: Nielsen, T. S. (Intern), Joensen, A. K. (Intern), Madsen, H. (Intern), Landberg, L. (Intern), Giebel, G. (Intern)
Pages: 371-376
Publication date: 2000

Host publication information
Title of host publication: Wind energy 1999: Wind power comes of age
Place of publication: Bury St Edmunds
Publisher: Institution of Mechanical Engineers
Editor: Hinson, P.
ISBN (Print): 1-86058-206-0
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 172496
Publication: Research - peer-review › Article in proceedings – Annual report year: 2000

The Zephyr-Project - The Next Generation Prediction System

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Giebel, G. (Ekstern), Landberg, L. (Ekstern), Joensen, A. K. (Intern), Nielsen, T. S. (Intern), Madsen, H. (Intern)
Publication date: 2000

Host publication information
Title of host publication: Proceedings of Wind Power for the 21st Century, Kassel, Germany, 25-27 September
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 200093
Publication: Research - peer-review › Article in proceedings – Annual report year: 2000

Tracking time-varying coefficient-functions
A method for adaptive and recursive estimation in a class of non-linear autoregressive models with external input is proposed. The model class considered is conditionally parametric ARX-models (CPARX-models), which is conventional ARX-models in which the parameters are replaced by smooth, but otherwise unknown, functions of a low-dimensional input process. These coefficient functions are estimated adaptively and recursively without specifying a global parametric,
form, i.e. the method allows for online tracking of the coefficient functions. Essentially, in its most simple form, the method is a combination of recursive least squares with exponential forgetting and local polynomial regression. It is argued, that it is appropriate to let the forgetting factor vary with the value of the external signal which is the argument of the coefficient functions. Some of the key properties of the modified method are studied by simulation.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. (Intern), Nielsen, T. S. (Intern), Joensen, A. K. (Intern), Madsen, H. (Intern), Holst, J. (Ekstern)
Pages: 813-828
Publication date: 2000
Main Research Area: Technical/natural sciences

Publication information
Volume: 14
Issue number: 8
ISSN (Print): 0890-6327
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.04 SJR 0.886 SNIP 1.102
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.012 SNIP 1.084 CiteScore 1.69
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.245 SNIP 1.357 CiteScore 1.98
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.945 SNIP 1.256 CiteScore 2.07
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.843 SNIP 1.286 CiteScore 1.84
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.889 SNIP 0.988 CiteScore 1.45
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.871 SNIP 1.217
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.39 SNIP 1.578
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.374 SNIP 1.89
Scopus rating (2007): SJR 1.049 SNIP 1.59
Scopus rating (2006): SJR 0.716 SNIP 1.047
Scopus rating (2005): SJR 0.657 SNIP 1.217
Scopus rating (2004): SJR 0.744 SNIP 1.105
Scopus rating (2003): SJR 1.275 SNIP 1.448
Scopus rating (2002): SJR 1.339 SNIP 0.988
Scopus rating (2001): SJR 0.34 SNIP 0.476
Scopus rating (2000): SJR 0.654 SNIP 0.997
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 0.634 SNIP 0.991
Original language: English
DOIs: 10.1002/1099-1115(200012)14:8<813::AID-ACS622>3.0.CO;2-6
Tracking time-varying parameters with local regression

This paper shows that the recursive least-squares (RLS) algorithm with forgetting factor is a special case of a varying-coefficient model, and a model which can easily be estimated via simple local regression. This observation allows us to formulate a new method which retains the RLS algorithm, but extends the algorithm by including polynomial approximations. Simulation results are provided, which indicates that this new method is superior to the classical RLS method, if the parameter variations are smooth.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Joensen, A. K. (Ekstern), Nielsen, H. A. (Intern), Nielsen, T. S. (Intern), Madsen, H. (Intern)
Pages: 1199-1204
Publication date: 2000
Main Research Area: Technical/natural sciences

Publication Information
Journal: Automatica
Volume: 36
Issue number: 8
ISSN (Print): 0005-1098
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 6.96 SJR 4.172 SNIP 3.332
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 4.079 SNIP 3.068 CiteScore 5.61
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 3.59 SNIP 3.109 CiteScore 5.37
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 3.623 SNIP 3.292 CiteScore 5.57
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 3.738 SNIP 3.728 CiteScore 6.08
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 3.774 SNIP 3.661 CiteScore 4.87
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.734 SNIP 2.921
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 3.663 SNIP 3.595
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 3.834 SNIP 4.041
Scopus rating (2007): SJR 3.401 SNIP 2.957
Scopus rating (2006): SJR 3 SNIP 2.794
Scopus rating (2005): SJR 1.847 SNIP 2.505
Scopus rating (2004): SJR 2.54 SNIP 2.612
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 2.753 SNIP 2.445
Scopus rating (2002): SJR 4.199 SNIP 2.479
WPPT - A Tool for Wind Power Prediction

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Nielsen, T. S. (Intern), Madsen, H. (Intern)
Publication date: 2000

Host publication information
Place of publication: Kassel, Germany
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 176507
Publication: Research - peer-review › Article in proceedings – Annual report year: 2000

Zephyr and short-term wind power prediction models

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Madsen, H. (Intern), Landberg, L. (Ekstern), Geibel, G. (Ekstern), Nielsen, H. A. O. 3. (Intern)
Publication date: 2000

Host publication information
Title of host publication: In Wind power for the 21st century
Place of publication: Kassel
Main Research Area: Technical/natural sciences
Conference: In Wind power for the 21st century, Kassel, 01/01/2000
Source: orbit
Source-ID: 176501
Publication: Research - peer-review › Article in proceedings – Annual report year: 2000

A Semi-parametric Approach for Decomposition of Absorption Spectra in the Presence of Unknown Components

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Sadegh, P. (Intern), Nielsen, H. A. O. 3. (Intern), Madsen, H. (Intern)
Publication date: 1999

Publication information
Publisher: Department of Mathematical Modelling, Technical University of Denmark
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 201035
Publication: Research - peer-review › Report – Annual report year: 1999
Goodness of fit of stochastic differential equations

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Bak, J. (Ekstern), Nielsen, H. A. (Intern), Madsen, H. (Intern), Linde, P. (ed.) (Ekstern), Holm, A. (ed.) (Ekstern)
Publication date: 1999

Host publication information
Title of host publication: 21. Symposium i anvendt statistik
Main Research Area: Technical/natural sciences
Conference: Denmark, 01/01/1999
Source: orbit
Source-ID: 224585

Publication: Research - peer-review › Journal article – Annual report year: 1999
Grey-box Modelling of Pollutant Loads From a Sewer System

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Kryger
Authors: Bechmann, H. (Intern), Nielsen, M. K. (Ekstern), Madsen, H. (Intern), Poulsen, N. K. (Intern)
Pages: 71-78
Publication date: 1999
Main Research Area: Technical/natural sciences

Publication information
Journal: Urban Water
Volume: 1
Ratings:
Scopus rating (2005): SJR 1.111 SNIP 3.025
Scopus rating (2004): SJR 0.518 SNIP 1.426
Scopus rating (2003): SJR 0.592 SNIP 1.787
Scopus rating (2002): SJR 0.505 SNIP 0.792
Scopus rating (2001): SJR 0.257 SNIP 0.461
Scopus rating (2000): SJR 0.178 SNIP 0.11
Original language: English
Source: orbit
Source-ID: 173062
Publication: Research - peer-review › Journal article – Annual report year: 1999

Identification of continuous time smooth threshold models of physical systems

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Andersen, K. K. (Intern), Lundby, M. (Intern), Madsen, H. (Intern)
Publication date: 1999

Host publication information
Title of host publication: Joint Statistical Meetings
Main Research Area: Technical/natural sciences
Conference: Joint Statistical Meetings, 01/01/1999
Source: orbit
Source-ID: 199938
Publication: Research - peer-review › Article in proceedings – Annual report year: 1999

Implementation of Short-term Prediction

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Risø National Laboratory for Sustainable Energy, Rutherford Appleton Laboratory, Danish Meteorological Institute, National Observatory of Athens, Elsam A/S, Elkraft A.m.b.A., WECTEC Inc., OEM Development Corp.
Pages: 57-62
Publication date: 1999

Host publication information
Title of host publication: Wind energy for the next millennium. Proceedings
Place of publication: London
Publisher: James and James Science Publishers
Editors: Petersen, E., Hjuler Jensen, P., Rave, K., Helm, P., Ehmann, H.
ISBN (Print): 1-902916-00-X
Implementing short-term prediction at utilities

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, RISØ, Rutherford Appleton Laboratory, Danish Meteorological Institute, National Observatory of Athens, Elsam A/S, Elkraft A.m.b.A., WECTEC Inc., OEM Development Corp.
Number of pages: 350
Publication date: 1999

Publication Information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 172865
Publication: Research - peer-review › Report – Annual report year: 1999

Integer Valued Autoregressive Models for Tipping Bucket Rainfall Measurements

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Department of Environmental Science and Engineering
Authors: Thyregod, P. (Intern), Carstensen, N. J. (Intern), Madsen, H. (Intern), Arnbjerg-Nielsen, K. (Intern)
Pages: 395-411
Publication date: 1999
Main Research Area: Technical/natural sciences

Publication Information
Journal: Environmetrics
Volume: 10
Original language: English
Source: orbit
Source-ID: 172579
Publication: Research - peer-review › Journal article – Annual report year: 1999

Model output statistics applied to wind power prediction

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Risø National Laboratory for Sustainable Energy, Mathematical Statistics
Authors: Joensen, A. K. (Intern), Giebel, G. (Intern), Landberg, L. (Intern), Madsen, H. (Intern), Nielsen, H. A. O. 3. (Intern)
Pages: 1177-1180
Publication date: 1999

Host publication information
Title of host publication: Proceedings of Wind energy for the next millennium
Place of publication: London
Publisher: James and James Science Publishers
Editors: Petersen, E., Hjuler Jensen, P., Rave, K., Helm, P., Ehmann, H.
ISBN (Print): 1-902916-00-X
Main Research Area: Technical/natural sciences
Conference: 1999 European Wind Energy Conference and Exhibition, Nice, France, 01/03/1999 - 01/03/1999
Source: orbit
Parameter Estimation in Nonlinear Stochastic Differential Equations: An Overview

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Lancaster University
Authors: Nielsen, J. N. (Intern), Madsen, H. (Intern), Young, P. (Ekstern)
Pages: 289-294
Publication date: 1999

Host publication information
Title of host publication: Proceedings of 14th IFAC World Congress - Vol J.
Publisher: Elsevier Science
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 170967
Publication: Research - peer-review » Article in proceedings – Annual report year: 1999

Subset Selection by Local Convex Approximation

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Øjelund, H. (Intern), Sadegh, P. (Intern), Madsen, H. (Intern), Thyregod, P. (Intern)
Pages: 220-230
Publication date: 1999

Host publication information
Title of host publication: Symposium i Anvendt Statistik
Place of publication: Copenhagen
Publisher: AKF - SI F Suvey
Main Research Area: Technical/natural sciences
Conference: Symposium in Applied Statistics, Copenhagen, 01/01/1999
Source: orbit
Source-ID: 172603
Publication: Research - peer-review » Article in proceedings – Annual report year: 1999

Tracking Time-Varying Coefficient-Functions

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Lund Institute of Technology
Authors: Nielsen, H. A. (Intern), Nielsen, T. S. (Intern), Joensen, A. K. (Intern), Madsen, H. (Intern), Holst, J. (Ekstern)
Number of pages: 28
Publication date: 1999

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 172571
Publication: Research - peer-review » Report – Annual report year: 1999

Using meteorological forecasts in on-line predictions of wind power

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Elsam A/S, ELTRA I/S
Authors: Nielsen, T. S. (Intern), Nielsen, H. A. (Intern), Madsen, H. (Intern), Tofting, J. (Ekstern), Parbo, H. (Ekstern), Grud, A. (Ekstern), Sorensen, A. G. (Ekstern)
Number of pages: 300
A Grey Box Model for the Hydraulics in a Creek

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Jonsdottir, H. (Intern), Jacobsen, J. L. (Intern), Madsen, H. (Intern)
Publication date: 1998

Host publication information
Title of host publication: Biometry at work towards environment 2000
Place of publication: Victoria Falls
Publisher: Environmetrics
Main Research Area: Technical/natural sciences
Conference: Biometry at Work Towards Environment 2000, Victoria Falls, 01/01/1998
Source: orbit
Source-ID: 170388
Publication: Research - peer-review › Article in proceedings – Annual report year: 1998


General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Madsen, H. (Intern), Nielsen, J. N. (Intern), Nielsen, T. S. (Intern)
Number of pages: 20
Publication date: 1998

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 170412
Publication: Research - peer-review › Report – Annual report year: 1998

A New Reference for Wind Power Forecasting
In recent years some research towards developing forecasting models for wind power or energy has been carried out. In order to evaluate the prediction ability of these models, the forecasts are usually compared with those of the persistence forecast model. As shown in this article, however, it is not reasonable to use the persistence model when the forecast length is more than a few hours. Instead, a new statistical reference for predicting wind power, which basically is a weighting between the persistence and the mean of the power, is proposed. This reference forecast model is adequate for all forecast lengths and, like the persistence model, requires only measured time series as input. Copyright © 1998 John Wiley & Sons, Ltd.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, RISØ
Authors: Nielsen, T. S. (Intern), Joensen, A. K. (Intern), Madsen, H. (Intern), Landberg, L. (Ekstern), Giebel, G. (Ekstern)
Pages: 29-34
Publication date: 1998
Main Research Area: Technical/natural sciences

Publication information
Journal: Wind Energy
Volume: 1
Control of Sewer systems and Wastewater treatment plants using pollutant concentration profiles

On-line measurements of pollutants in the wastewater combined with grey-box modelling are used to estimate the amount of deposits in the sewer system. The pollutant mass flow at the wastewater treatment plant is found to consist of a diurnal profile minus the deposited amount of pollutants. The diurnal profile is found to be a second order harmonic function and the pollutants deposited in the sewer are identified using first order ordinary differential equations.
Design Values for the CUSUM-MS Chart

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Novo Nordisk A/S
Authors: Madsen, H. (Intern), Iversen, J. (Ekstern), Nielsen, J. N. (Intern), Nielsen, T. S. (Intern)
Number of pages: 8
Publication date: 1998

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 170387
Publication: Research - peer-review › Journal article – Annual report year: 1998

Empirisk bestemt model for elforbruget i Østdanmark

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. O. 3. (Intern), Andersen, K. K. (Intern), Madsen, H. (Intern)
Publication date: 1998
Estimation in Continuous-time Stochastic Volatility Models using Nonlinear Filters

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Nielsen, J. N. (Intern), Vestergaard, M. (Ekstern), Madsen, H. (Intern)
Pages: 1-29
Publication date: 1998
Main Research Area: Technical/natural sciences

Publication information
Journal: Int. Journal of Theoretical and Applied Finance
Original language: English
Source: orbit
Source-ID: 171103
Publication: Research - peer-review › Journal article – Annual report year: 1998


General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Novo Nordisk A/S
Authors: Nielsen, J. N. (Intern), Madsen, H. (Intern), Melgaard, H. (Ekstern), Baadsgaard, M. (Intern)
Number of pages: 23
Publication date: 1998

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 172611
Publication: Research - peer-review › Report – Annual report year: 1998


General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Nielsen, J. N. (Intern), Madsen, H. (Intern)
Number of pages: 29
Publication date: 1998

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 172610
Publication: Research - peer-review › Report – Annual report year: 1998

Formulating and testing a rain series generator based on tipping bucket gauges

General information
State: Published
Grey-Box Modelling of pollutant Loads from the Sewer System for Control of Equalisation Basins

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Bechmann, H. (Intern), Nielsen, M. (Ekstern), Madsen, H. (Intern), Poulsen, N. K. (Intern)
Pages: 773-780
Publication date: 1998

Host publication information
Title of host publication: the Fourth International Conference on Developments in Urban Drainage Modelling (UDM'98), London, UK
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 199966
Publication: Research - peer-review › Article in proceedings – Annual report year: 1998

Identification of a Linear CONTinuous Time Stochastic Model of the Heat Dynamics of a Greenhouse

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Danish Institute of Agricultural Sciences
Authors: Nielsen, B. (Ekstern), Madsen, H. (Intern)
Pages: 249-256
Publication date: 1998

Publication information
Volume: 71
Original language: English
Source: orbit
Source-ID: 170414
Publication: Research - peer-review › Journal article – Annual report year: 1998

Input design for linear dynamic systems using maxmin criteria

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Grundfos A/S, Lund University
Authors: Sadegh, P. (Intern), Hansen, L. H. (Ekstern), Madsen, H. (Intern), Holst, J. (Ekstern)
Pages: 223-240
Publication date: 1998

Publication information
Journal: Journal of Information & Optimization Sciences
Volume: 19
Modelling the dynamical effect of solar radiation on the oxygen content of a small creek

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Department of Environmental Science and Engineering
Authors: Jacobsen, J. L. (Intern), Madsen, H. (Intern), Harremoës, P. (Intern)
Pages: 3-14
Publication date: 1998
Main Research Area: Technical/natural sciences

Publication information
Journal: Environmetrics
Volume: 9
ISSN (Print): 1180-4009
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.944 SNIP 1.045 CiteScore 1.59
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.014 SNIP 0.892 CiteScore 1.48
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.061 SNIP 1.178 CiteScore 1.64
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.073 SNIP 1.228 CiteScore 1.65
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.563 SNIP 0.897 CiteScore 1.12
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.537 SNIP 1.015 CiteScore 1.3
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Modelling the embedded rainfall process using tipping bucket data

A new method for modelling the dynamics of rain measurement processes is suggested. The method takes the discrete nature and autocorrelation of measurements from the tipping bucket rain gauge into consideration. The considered model is a state space model with a Poisson marginal distribution. In the model there is only one parameter, a thinning parameter. The model is tested on 39 rain events. The estimated value for the various rain events is reflecting a subjective classification of rain events into frontal and convective rain. Finally, it is demonstrated how the model can be used for simulation and prediction.

General information

State: Published
Organisations: Department of Informatics and Mathematical Modeling, Department of Environmental Science and Engineering
Authors: Thyregod, P. (Intern), Arnbjerg-Nielsen, K. (Intern), Madsen, H. (Intern), Carstensen, N. J. (Intern)
Pages: 57-64
Publication date: 1998
Main Research Area: Technical/natural sciences

Publication information

Journal: Water Science and Technology
Volume: 37
Issue number: 11
ISSN (Print): 0273-1223
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.3 SJR 0.394 SNIP 0.621
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.466 SNIP 0.599 CiteScore 1.19
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.587 SNIP 0.685 CiteScore 1.14
Web of Science (2014): Indexed yes
Nonlinear Filtering of Univariate Stochastic Volatility Models

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Nielsen, J. N. (Intern), Vestergaard, M. (Ekstern), Madsen, H. (Intern)
Pages: 123-128
Publication date: 1998

Host publication information
Title of host publication: Proceedings of the 14th IFAC World Congress - Vol. M
Online data validation: Outlier detection and accommodation

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Nielsen, J. N. (Intern), Madsen, H. (Intern)
Number of pages: 27
Publication date: 1998

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 170966
Publication: Research - peer-review › Article in proceedings – Annual report year: 1998

On the Mathematics behind the CUSUM Control Charts

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Madsen, H. (Intern)
Number of pages: 23
Publication date: 1998

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 170405
Publication: Research - peer-review › Report – Annual report year: 1998

SAS-makroer til estimation og prædiktion i elforbrugsmodel

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. (Intern), Madsen, H. (Intern)
Number of pages: 33
Publication date: 1998

Publication information
Publisher: Institut for Matematisk Modellering, |Danmarks Tekniske Universitet, Lyngby
Original language: Danish
Series: Technical Reports
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 200986
Publication: Research - peer-review › Report – Annual report year: 1998

Some Tools for Identification of Nonlinear Time Series

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. (Intern), Madsen, H. (Intern)
Statistics in Finance

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Madsen, H. (Intern), Nielsen, J. N. (Intern), Baadsgaard, M. (Intern)
Number of pages: 336
Publication date: 1998

WPPT, A Tool for On-Line Wind Power Prediction

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Elsam A/S
Authors: Nielsen, T. S. (Intern), Madsen, H. (Intern), Tøfting, J. (Ekstern)
Number of pages: 23
Publication date: 1998

A Method for Automatic Calibration of Parameters of an Integrated Model

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Department of Environmental Science and Engineering
Authors: Jacobsen, J. L. (Intern), Madsen, H. (Intern), Rauch, W. (Intern), Harremoes, P. (Intern)
Publication date: 1997

ARX-models with parameter variations estimated by local fitting
A Stochastic model for two-station hydraulics exhibiting transient impact

The objective of the paper is to interpret data on water level variation in a river affected by overflow from a sewer system during rain. The simplest possible, hydraulic description is combined with stochastic methods for data analysis and model parameter estimation. This combination of deterministic and stochastic interpretation is called grey box modelling.

As a deterministic description the linear reservoir approximation is used. A series of linear reservoirs in sufficient number will approximate a plug how reactor. The choice of number is an empirical expression of the longitudinal dispersion in the river. This approximation is expected to be a sufficiently good approximation as a tool for the ultimate aim: the description of pollutant transport in the river.

The grey box modelling involves a statistical tool for estimation of the parameters in the deterministic model. The advantage is that the parameters have physical meaning, as opposed to many other statistically estimated, empirical parameters. The identifiability of each parameter, the uncertainty of the parameter estimation and the overall uncertainty of the simulation are determined. (C) 1997 IAWQ. Published by Elsevier Science Ltd.
Conditionally Parametric ARX-models for Modelling time delays in district heating systems

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. (Intern), Madsen, H. (Intern), Nielsen, T. S. (Intern), Pálsson, Ö. P. (ed.) (Ekstern)
Publication date: 1997

Host publication information
Title of host publication: International Symposium on District Heating and Simulation
Main Research Area: Technical/natural sciences
Conference: 7th International Symposium on District Heating and Simulation, Reykjavik, Iceland, 01/01/1997
Source: orbit
Source-ID: 200255
Publication: Research - peer-review › Article in proceedings – Annual report year: 1997
Control of Supply Temperature in District Heating Systems - An Application.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Nielsen, T. S. (Intern), Madsen, H. (Intern)
Publication date: 1997

Host publication information
Title of host publication: 7. International Symposium on District Heating and Simulation
Main Research Area: Technical/natural sciences
Conference: 7th International Symposium on District Heating and Simulation, Reykjavik, Iceland, 01/01/1997
Source: orbit
Source-ID: 168669
Publication: Research - peer-review › Article in proceedings – Annual report year: 1997

Design of CUSUM Control Charts for Emission Data: CEN/TC 264/WG9, No. 41

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Novo Nordisk A/S
Authors: Madsen, H. (Intern), Iwersen, J. (Ekstern)
Publication date: 1997

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 168625
Publication: Research - peer-review › Report – Annual report year: 1997


General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. O. 3. (Intern), Madsen, H. (Intern)
Publication date: 1997

Publication information
Publisher: Department of Mathematical Modelling, Technical University of Denmark, DK-2800 Lyngby, Denmark in collaboration with NESA A/S,
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 200991
Publication: Research - peer-review › Report – Annual report year: 1997


General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. O. 3. (Intern), Madsen, H. (Intern)
Publication date: 1997

Publication information
Publisher: Department of Mathematical Modelling, Technical University of Denmark, DK-2800 Lyngby, Denmark in collaboration with NESA A/S,
Original language: English
Estimation in Stochastic Differential Equations with a State Dependent Diffusion Term: 11th IFAC Symposium on System Identification, Vol. 3

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Baadsgaard, M. T. (Intern), Nielsen, J. N. (Intern), Spliid, H. (Intern), Madsen, H. (Intern)
Pages: 1425-1430
Publication date: 1997

Host publication information
Title of host publication: 11th IFAC Symposium on System Identification, Vol. 3
Place of publication: Kitakyushu, Fukuoka
Main Research Area: Technical/natural sciences
Conference: 11th IFAC Symposium on System Identification (SYSID'97), Fukuoka, Japan, 07/07/1997 - 07/07/1997
Source: orbit
Source-ID: 168644
Publication: Research - peer-review › Article in proceedings – Annual report year: 1997

Estimation of a low pass filter for solar radiation data

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Department of Environmental Science and Engineering
Authors: Jacobsen, J. L. (Intern), Madsen, H. (Intern), Harremoes, P. (Intern)
Pages: 35-42
Publication date: 1997

Host publication information
Title of host publication: Progress in Industrial Mathematics at ECMI 96
Place of publication: Stuttgart
Publisher: B.G. Teubner Stuttgart Leipzig
Editors: Brøns, M., Bendsoe, P., Sørensen, M. P.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 169783
Publication: Research - peer-review › Article in proceedings – Annual report year: 1997

Identification of Physical Parameters for A Hydraulic Robot

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Department of Control and Engineering Design
Authors: Madsen, H. (Intern), Zhou, J. (Intern), Hansen, L. H. (Intern)
Publication date: 1997

Host publication information
Title of host publication: Identification of Physical Parameters for A Hydraulic Robot
Main Research Area: Technical/natural sciences
Conference: The 4th International Conference on Fluid Power (Transmission and Control Hangzhou, China 1997), Hangzhou, China, 01/01/1997
Source: orbit
Source-ID: 170221
Publication: Research › Article in proceedings – Annual report year: 1997

Implementation of mini CHP
General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Espensen, A. (Ekstern), Bergstrøm, W. (Ekstern), Nielsen, H. A. O. 3. (Intern), Madsen, H. (Intern)
Publication date: 1997

Host publication information
Title of host publication: 7th International Symposium on district Heating and Simulation
Main Research Area: Technical/natural sciences
Conference: 7th International Symposium on District Heating and Simulation, Reykjavik, Iceland, 01/01/1997
Source: orbit
Source-ID: 168649
Publication: Research - peer-review › Article in proceedings – Annual report year: 1997

Integer valued autoregressive models for rainfall measurement processes

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Department of Environmental Science and Engineering
Authors: Thyregod, P. (Ekstern), Madsen, H. (Intern), Carstensen, N. J. (Intern), Arnbjerg-Nielsen, K. (Intern)
Pages: 121-126
Publication date: 1997

Host publication information
Title of host publication: Operational Water Management. (eds. Refsgaard,J.C., Karalis,E.A.)
Place of publication: Rotteerdam, NL
Publisher: Balkema Publishers, A.A. / Taylor & Francis The Netherlands
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 169784
Publication: Research - peer-review › Article in proceedings – Annual report year: 1997

Lecture notes for Advanced Time Series Analysis

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Lund University
Authors: Madsen, H. (Intern), Holst, J. (Ekstern)
Publication date: 1997

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 168643
Publication: Research - peer-review › Book – Annual report year: 1997

Local fitting of autoregressive models with external input

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Pages: 175-188
Publication date: 1997

Host publication information
Title of host publication: Symposium i anvendt statistik
Main Research Area: Technical/natural sciences
Conference: Lyngby, Denmark, 01/01/1997
Source: orbit
Source-ID: 200495
Maxmin Input Design for Linear Dynamic Systems

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Lund University
Authors: Sadegh, P. (Intern), Hansen, L. H. (Intern), Madsen, H. (Intern), Holst, J. (Ekstern)
Pages: 1431-1436
Publication date: 1997

Host publication information
Title of host publication: 11th IFAC Symposium on System Identification, Vol. 3
Main Research Area: Technical/natural sciences
Conference: 11th IFAC Symposium on System Identification (SYSID’97), Fukuoka, Japan, 07/07/1997 - 07/07/1997
Source: orbit
Source-ID: 168651
Publication: Research - peer-review › Article in proceedings – Annual report year: 1997

Modelling of Hydraulic Robot

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Department of Control and Engineering Design
Authors: Madsen, H. (Intern), Zhou, J. (Intern), Hansen, L. H. (Intern)
Number of pages: 30
Publication date: 1997

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 169398
Publication: Research - peer-review › Report – Annual report year: 1997

Modelling the Embedded Rainfall Process using Tipping Bucket Data

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Department of Environmental Science and Engineering
Authors: Thyregod, P. (Intern), Arnbjerg-Nielsen, K. (Intern), Carstensen, J. (Ekstern), Madsen, H. (Intern)
Pages: 197-204
Publication date: 1997

Host publication information
Title of host publication: Third International Workshop on Rainfall in Urban Areas
Main Research Area: Technical/natural sciences
Conference: Third International Workshop on Rainfall in Urban Areas, Pontresina, Switzerland, 04/12/1997 - 04/12/1997
Source: orbit
Source-ID: 168667
Publication: Research - peer-review › Article in proceedings – Annual report year: 1997

On Optical Flow Estimation in Radar Images for Precipitation Forecasting

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Tamstorf, R. P. (Intern), Madsen, H. (Intern), Carstensen, J. M. (Intern)
Pages: 65-72
Publication date: 1997

Host publication information
Using meteorological forecasts in on-line predictions of wind power.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Nielsen, T. S. (Intern), Madsen, H. (Intern)
Number of pages: 77
Publication date: 1997

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 168638
Publication: Research - peer-review › Report – Annual report year: 1997


General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Madsen, H. (Intern), Thyregod, P. (Intern)
Publication date: 1996

Host publication information
Title of host publication: Quality Assurance in Testing, Analysis and Modelling, JRC European Commission, Special Publication No. 1.96.71.
Publisher: Bloem, J.J. (ed.)
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 165145
Publication: Research - peer-review › Article in proceedings – Annual report year: 1996

Application of a Thermal Network Model on Case 3. System Identification Competition

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Novo Nordisk A/S, Lund University
Authors: Madsen, H. (Intern), Melgaard, H. (Ekstern), Holst, J. (Ekstern)
Publication date: 1996

Host publication information
Title of host publication: Application of a Thermal Network Model on Case 3. System Identification Competition
Publisher: Bloem, J.J. (ed.)
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 165144
Publication: Research - peer-review › Article in proceedings – Annual report year: 1996


General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Host publication information
Title of host publication: Conditional Maximul Likelihood Estimation in Coupon-bond Pricing.
Place of publication: Odense
Main Research Area: Technical/natural sciences
Conference: Odense, Denmark, 01/01/1996
Source: orbit
Source-ID: 165159
Publication: Research › Article in proceedings – Annual report year: 1996

Control of Supply Temperature: EFP 1323/93-07

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Madsen, H. (Intern), Nielsen, H. A. (Intern), Nielsen, T. S. (Intern), Søgaard, H. T. (Ekstern)
Number of pages: 195
Publication date: 1996

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 165140
Publication: Research - peer-review › Report – Annual report year: 1996

En Statistisk Bearbejdning af Slaggeanalyser og Forslag til Godkendelse af Slagger

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Madsen, H. (Intern)
Publication date: 1996

Publication information
Original language: Danish
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 165143
Publication: Research - peer-review › Report – Annual report year: 1996

Grey Box Modelling of Oxygen Levels in a Small Stream

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Madsen, H. (Intern), Jacobsen, J. L. (Intern)
Pages: pp. 109-121
Publication date: 1996
Main Research Area: Technical/natural sciences

Publication information
Journal: Environmetrics
Volume: 7
Original language: English
Source: orbit
Source-ID: 165160
Publication: Research - peer-review › Journal article – Annual report year: 1996

Interpretation of a pumping station as an on-line flow measurement
Modelling heat dynamics using thermal networks: Chapter 13 in System Identification Competition

Modelling of Heat Dynamics using Thermal Networks: System Identification Competition

Modelling the transient impact of rain events on the oxygen content of a small creek
Models and Methods for Predicting Wind Power

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. (Intern), Madsen, H. (Intern)
Publication date: 1996

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 169785
Publication: Research - peer-review › Journal article – Annual report year: 1996


General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Madsen, H. (Intern)
Publication date: 1996

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 165676
Publication: Research - peer-review › Report – Annual report year: 1996

Predictive Control of Air Temperature in Greenhouses: 13th World Congress of IFAC, San Francisco, California, July 1996

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Madsen, H. (Intern), Nielsen, B. (Ekstern)
Publication date: 1996

Host publication information
Title of host publication: Predictive Control of Air Temperature in Greenhouses
Place of publication: San Francisco
Publisher: International Federation of Automatic Control
Main Research Area: Technical/natural sciences
Conference: 13th IFAC World Congress 1996, San Francisco, United States, 30/06/1996 - 30/06/1996
Source: orbit
Source-ID: 165141
Publication: Research - peer-review › Report – Annual report year: 1996

Sampling Techniques in stochastic differential equations: Conference on Mathematical Finance

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Baadsgaard, M. T. (Intern), Nielsen, J. N. (Intern), Madsen, H. (Intern), Preisel, M. (Ekstern)
Publication date: 1996

Host publication information
Wind Power Prediction using ARX Models and Neural Networks: Proceedings of the Fifteenth IASTED International Conference on Modelling, Identification and Control

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. (Intern), Madsen, H. (Intern)
Publication date: 1996

Host publication information
Title of host publication: Proceedings of the 15th IASTED International Conf. on Modelling, Identification adn Control
Main Research Area: Technical/natural sciences
Conference: 15th IASTED International Conference on Modelling, Identification and Control, 01/01/1996
Source: orbit
Source-ID: 165675
Publication: Research - peer-review › Article in proceedings – Annual report year: 1996

Estimation of Continuous-Time Models for the Heat Dynamics of a Building

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Madsen, H. (Intern), Holst, J. (Intern)
Pages: 67-79
Publication date: 1995
Main Research Area: Technical/natural sciences

Publication information
Journal: Energy and Buildings
Volume: 22
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 4.64 SJR 2.093 SNIP 1.965
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.088 SNIP 2.174 CiteScore 4.07
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.123 SNIP 2.936 CiteScore 4.21
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.897 SNIP 2.433 CiteScore 3.79
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.816 SNIP 2.737 CiteScore 3.36
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Experiment Design for Grey Box Identification

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Sadegh, P. (Intern), Holst, J. (Intern), Madsen, H. (Intern), Melgaard, H. (Intern)
Pages: 491-507
Publication date: 1995
Main Research Area: Technical/natural sciences

Publication information
Volume: 9
ISSN (Print): 0890-6327
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.04 SJR 0.886 SNIP 1.102
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.012 SNIP 1.084 CiteScore 1.69
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.245 SNIP 1.357 CiteScore 1.98
Identification of Transfer Functions for Control of Greenhouse Air Temperature

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, B. (Ekstern), Madsen, H. (Intern)
Pages: 25-34
Publication date: 1995
Main Research Area: Technical/natural sciences

Publication information
Volume: 60
Original language: English
Source: orbit
Source-ID: 224584
Publication: Research - peer-review › Journal article – Annual report year: 1995

Methodologies for the Analysis of Data from Sewers and Wastewater Treatment Plants

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Department of Environmental Science and Engineering, Krüger A/S
Authors: Nielsen, M. K. (Ekstern), Carstensen, J. (Ekstern), Madsen, H. (Intern), Poulsen, N. K. (Intern), Harremoës, P. (Intern)
Publication date: 1995
Methodologies for the Analysis of Data From Sewersm and Wastewater Treatment Plants

General information
State: Published
Organisations: Department of Environmental Science and Engineering, Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, M. K. (Ekstern), Carstensen, N. J. (Intern), Madsen, H. (Intern), Poulsen, N. K. (Intern), Harremo, P. (Ekstern)
Publication date: 1995

Host publication information
Title of host publication: Nordic Seminar on Nitrogen removal from Municipal Wastewater Finland
Main Research Area: Technical/natural sciences
Conference: Nordic Seminar on Nitrogen removal from Municipal Wastewater Finland, 01/01/1995
Source: orbit
Source-ID: 200496
Publication: Research › Article in proceedings – Annual report year: 1995

Model for brændselsforbrug og elproduktion på Korsør kraftvarmeværk

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. O. 3. (Intern), Madsen, H. (Intern)
Publication date: 1995

Publication information
Publisher: Institut for Matematisk Modellering, Danmarks Tekniske Universitet
Original language: Danish
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 200999
Publication: Research - peer-review › Report – Annual report year: 1995


General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Nielsen, H. A. (Intern), Madsen, H. (Intern)
Publication date: 1995

Publication information
Publisher: Institut for Matematisk Modellering, Danmarks Tekniske Universitet
Original language: English
Main Research Area: Technical/natural sciences
Links:

Bibliographical note
14 pages
Source: orbit
Source-ID: 201262
Publication: Research - peer-review › Book – Annual report year: 1995
Optimal input design for fault detection and diagnosis
In the paper, the design of optimal input signals for detection and diagnosis in a stochastic dynamical system is investigated. The design is based on maximization of Kullback measure between the model under fault and the model under normal operation conditions. It is established that the optimal input design for change detection when the magnitude of change is small is equivalent to optimal input design for parameter estimation.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Lund University
Authors: Sadegh, P. (Intern), Madsen, H. (Intern), Holst, J. (Ekstern)
Pages: 1147-1148
Publication date: 1995

Bibliographical note
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Statistical Identification of Monod-Kinetic Parameters from On-line Measurements
General information
State: Published
Organisations: Department of Environmental Science and Engineering, Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Carstensen, N. J. (Intern), Harremoës, P. (Intern), Madsen, H. (Intern)
Pages: 125-133
Publication date: 1995
Main Research Area: Technical/natural sciences

Publication information
Journal: Water Science and Technology
Volume: 31
Issue number: 2
ISSN (Print): 0273-1223
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.3 SJR 0.394 SNIP 0.621
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.466 SNIP 0.599 CiteScore 1.19
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.587 SNIP 0.685 CiteScore 1.14
Web of Science (2014): Indexed yes
Identification of wastewater processes

The introduction of on-line sensors for monitoring of nutrient salts concentrations on wastewater treatment plants with nutrient removal, opens a new area of modelling wastewater processes. The subject of this thesis is the formulation of operational dynamic models based on time series of ammonia, nitrate, and phosphate concentrations, which are measured in the aeration tanks of the biological nutrient removal system. The alternate operation modes of the BIO-DENITRO and BIO-DENIPHOS processes are of particular interest. Time series models of the hydraulic and biological processes are very useful for gaining insight in real time operation of wastewater treatment systems with variable influent flows and pollution loads, and for the design of plant operation control. In the present context non-linear structural time series models are proposed, which are identified by combining the well-known theory of the processes with the significant effects found in data. These models are called grey box models, and they contain rate expressions for the processes of influent load of nutrients, transport of nutrients between the aeration tanks, hydrolysis and growth of biomass, nitrification, denitrification, biological phosphate uptake in biomass, and stripping of phosphate. Several of the rate expressions for the biological processes are formulated on the assumption of Monod-kinetics. The formulation of models for time-varying parameters in a new time domain divides the variations of the processes into fast dynamics and slower dynamics. In
addition, this modelling in two time domains increases the interpretability of the parameters. The models are put into state space form and the parameters are estimated by the maximum likelihood method, where a Kalman filter is used in calculating the likelihood function. The grey box models are estimated on data sets from the Lundtofte pilot scale plant and the Aalborg West wastewater treatment plant. Estimation of Monod-kinetic expressions is made possible through the application of large data sets. Parameter estimates from the two plants show a reasonable consistency with suggested kinetic parameter values of the literature. A large amount of information about the two plants and their performances is obtained from the models, of which the variations of the influent ammonia load, and the autotrophic and heterotrophic biomass activity have particular interest. The models are appropriate for control, because the present states of the plants are reflected in the parameter estimates. The grey box models may be applied to control of wastewater treatment plants in many ways. In this thesis off-line simulations of control strategies and on-line model-based predictive control are discussed. Both methods include the evaluation of a cost function incorporating the cost of operation and discharge of nutrients to the recipient. The concept of prediction based control is demonstrated in a simulation study.

General information
State: Published
Organisations: Department of Environmental Science and Engineering, Department of Informatics and Mathematical Modeling
Authors: Carstensen, N. J. (Intern), Madsen, H. (Intern)
Publication date: Nov 1994

Emission of Dioxins from Danish Wood-Stoves
The main purpose of the investigation was to estimate the annual dioxin emission from Danish wood-stoves. 4 stoves of different designs and 3 types of fuel were tested in 2 operating conditions. Sampling was carried out in a dilution tunnel, making reproducible sampling possible. The dioxin emission was found to depend significantly on the type of stove, the type of fuel and the operating conditions. The average emission was 0.18 ng TEQ/Nm(3) (Nordic) in fluegas, or 1.9 ng TEQ/kg fuel. The annual emission in Denmark was estimated to 0.40 g TEQ/year, roughly 100 times lower than the emission from incinerators previously reported.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Vikelsæ, J. (Ekstern), Madsen, H. (Intern), Hansen, K. (Ekstern)
Pages: 2019-2027
Publication date: 1994
Main Research Area: Technical/natural sciences

Publication Information
Journal: Chemosphere
Volume: 29
Issue number: 9-11
ISSN (Print): 0045-6535
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 4.39 SJR 1.417 SNIP 1.606
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Generalized Predictive Control for Non-Stationary Systems

This paper shows how the generalized predictive control (GPC) can be extended to non-stationary (time-varying) systems. If the time-variation is slow, then the classical GPC can be used in context with an adaptive estimation procedure of a time-invariant ARIMAX model. However, in this paper prior knowledge concerning the nature of the parameter variations is assumed available. The GPC is based on the assumption that the prediction of the system output can be expressed as a linear combination of present and future controls. Since the Diophantine equation cannot be used due to the time-variation
of the parameters, the optimal prediction is found as the general conditional expectation of the system output. The underlying model is of an ARMAX-type instead of an ARIMAX-type as in the original version of the GPC (Clarke, D. W., C. Mohtadi and P. S. Tuffs (1987). Automatica, 23, 137-148) and almost all later references. This implies some further modifications of the classical GPC.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics, Department of Electrical Engineering
Authors: Palsson, O. P. (Intern), Madsen, H. (Intern), Søgaard, H. T. (Intern)
Pages: 1991-1997
Publication date: 1994
Main Research Area: Technical/natural sciences

Publication information
Journal: Automatica
Volume: 30
Issue number: 12
ISSN (Print): 0005-1098
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 6.96 SJR 4.172 SNIP 3.332
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 4.079 SNIP 3.068 CiteScore 5.61
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 3.59 SNIP 3.109 CiteScore 5.37
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 3.623 SNIP 3.292 CiteScore 5.57
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 3.738 SNIP 3.728 CiteScore 6.08
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 3.774 SNIP 3.661 CiteScore 4.87
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.734 SNIP 2.921
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 3.663 SNIP 3.595
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 3.834 SNIP 4.041
Scopus rating (2007): SJR 3.401 SNIP 2.957
Scopus rating (2006): SJR 3 SNIP 2.794
Scopus rating (2005): SJR 1.847 SNIP 2.505
Scopus rating (2004): SJR 2.54 SNIP 2.612
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 2.753 SNIP 2.445
Scopus rating (2002): SJR 4.199 SNIP 2.479
Scopus rating (2001): SJR 3.545 SNIP 2.833
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 3.323 SNIP 2.457
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 1.319 SNIP 1.695
Identification and Control of Nutrient Removing Processes in Wastewater Treatment Plants

Today the use of on-line control for wastewater treatment plants is very low. A main reason is the lack of quality of the data, and the fact that more sophisticated control strategies must be based on a model of the dynamics of the biological processes. This paper discusses the historical reasons for the limited use of modern control strategies for wastewater treatment plants. Today, however, on-line nutrient sensors are more reliable. In the present context the use of on-line monitored values of ammonia, nitrate and phosphate from a full scale plant are used as the background for discussing the possibility of using statistical methods for identifying dynamical models for the biological processes. These models can then be used for simulating various control strategies and the parameters of the controllers can be found by off-line optimization. Simulation studies have shown that considerable savings are possible by using modified on-line control strategies.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Department of Environmental Science and Engineering, Krüger A/S
Authors: Nielsen, M. K. (Ekstern), Madsen, H. (Intern), Carstensen, N. J. (Intern)
Pages: 1005-1010
Publication date: 1994
Conference: The 3th IEEE Conference on Control Applications, Glasgow, UK, 01/01/1994
Main Research Area: Technical/natural sciences

Publication information
Journal: Proceedings of the IEEE Conference on Control Applications
Volume: 2
ISSN (Print): 1085-1992
Ratings:
BFI (2016): BFI-level 1
BFI (2015): BFI-level 1
BFI (2014): BFI-level 1
BFI (2013): BFI-level 1
ISI indexed (2013): ISI indexed no
BFI (2012): BFI-level 1
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
BFI (2009): BFI-level 1
BFI (2008): BFI-level 1
Scopus rating (2006): SJR 0.179 SNIP 0.584
Scopus rating (2005): SJR 0.155 SNIP 0.378
Scopus rating (2004): SJR 0.206 SNIP 0.433
Scopus rating (2003): SJR 0.249 SNIP 0.411
Scopus rating (2002): SJR 0.36 SNIP 0.299
Scopus rating (2001): SJR 0.313 SNIP 0.664
Scopus rating (2000): SJR 0.231
Scopus rating (1999): SJR 0.134
Original language: English
Source: orbit
Source-ID: 317623
Publication: Research - peer-review › Conference article – Annual report year: 1994
Identification of wastewater treatment processes for nutrient removal on a full-scale WWTP by statistical methods

The introduction of on-line sensors of nutrient salt concentrations on wastewater treatment plants opens a wide new area of modelling wastewater processes. Time series models of these processes are very useful for gaining insight in real time operation of wastewater treatment systems which deal with variable influent flows and pollution loads. In this paper nonlinear time series models describing the variations of the ammonia and nitrate concentrations in the aeration tanks of a biological nutrient removal WWTP are established. The models proposed herein are identified by combining well-known theory of the processes, i.e. including prior knowledge, with the significant effects found in data by using statistical identification methods. Rates of the biochemical and hydraulic processes are identified by statistical methods and the related constants for the biochemical processes are estimated assuming Monod kinetics. The models only include those hydraulic and kinetic parameters, which have shown to be significant in a statistical sense, and hence they can be quantified. The application potential of these models is on-line control, because the present state of the plant is given by the variables of the models which are continuously updated as new information from the on-line sensors becomes available.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Carstensen, J. (Ekstern), Madsen, H. (Intern), Poulsen, N. K. (Intern), Nielsen, M. K. (Ekstern)
Pages: 2055-2066
Publication date: 1994
Main Research Area: Technical/natural sciences

Publication Information
Journal: Water Research
Volume: 28
Issue number: 10
ISSN (Print): 0043-1354
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 7.49 SJR 2.629 SNIP 2.558
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.689 SNIP 2.507 CiteScore 6.63
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.957 SNIP 2.727 CiteScore 6.13
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.956 SNIP 2.693 CiteScore 6.02
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.966 SNIP 2.456 CiteScore 5.15
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 2.867 SNIP 2.374 CiteScore 5.43
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.582 SNIP 2.196
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.319 SNIP 2.225
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Methods for Robust Estimation of AR-parameters

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics, Lund University
Authors: Sejling, K. (Intern), Madsen, H. (Intern), Holst, J. (Intern), Holst, U. (Ekstern), Englund, J. (Ekstern)
Pages: 509-536
Publication date: 1994
Main Research Area: Technical/natural sciences

Publication information
Journal: Computational Statistics and Data Analysis
Volume: 17
Original language: English
Source-ID: 199537
Publication: Research - peer-review › Journal article – Annual report year: 1994

On Flow and Supply Temperature Control in District Heating Systems

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Madsen, H. (Intern)
Pages: 613-620
Publication date: 1994
Main Research Area: Technical/natural sciences

Publication information
Journal: Heat Recovery Systems and CHP
Volume: 14
Issue number: 6
Original language: English
Source: orbit
Optimal experiment design for identification of grey-box models

Optimal experiment design is investigated for stochastic dynamic systems where the prior partial information about the system is given as a probability distribution function in the system parameters. The concept of information is related to entropy reduction in the system through Lindley’s measure of average information, and the relationship between the choice of information related criteria and some estimators (MAP and MLE) is established. A continuous time physical model of the heat dynamics of a building is considered and the results show that performing an optimal experiment corresponding to a MAP estimation results in a considerable reduction of the experimental length. Besides, it is established that the physical knowledge of the system enables us to design experiments, with the goal of maximizing information about the physical parameters of interest.

Application of Predictive Control in District Heating Systems

In district heating systems, and in particular if the heat production cakes place at a combined heat and power (CHP) plant, a reasonable control strategy is to keep the supply temperature from the district heating plant as low as possible. However, the control is subject to some restrictions, for example, that the total heat requirement for all consumers is supplied at any time and each individual consumer is guaranteed some minimum supply temperature at any time. A lower supply temperature implies lower heat loss from the transport and the distribution network, and lower production costs. A district heating system is an example of a non-stationary system, and the model parameters have to be time varying. Hence, the classical predictive control theory has to be modified. Simulation experiments are performed in order to study the performance of modified predictive controllers. The systems are, however, described by transfer function models identified from real data.
Grey box modelling in two time domains of a wastewater pilot scale plant

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Carstensen, J. (Ekstern), Madsen, H. (Intern), Poulsen, N. K. (Intern), Nielsen, M. K. (Ekstern)
Pages: 187-208
Publication date: 1993
Main Research Area: Technical/natural sciences

Publication information
Journal: Environmetrics
Volume: 4
ISSN (Print): 1180-4009
Ratings:
BFI (2018): BFI-level 1
Identification of wastewater processes using nonlinear grey box models

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Carstensen, J. (Ekstern), Madsen, H. (Intern), Poulsen, N. K. (Intern)
Publication date: 1992

Publication information
Publisher: Institute of Mathematical Statistics and Operations Research (IMSOR), The Technical University of Denmark
Methods for quantification of the estimator uncertainty in recursive estimation of restricted

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Sejling, K. (Intern), Madsen, H. (Intern), Henningsen, A. (Ekstern), Poulsen, N. K. (Intern)
Publication date: 1992

Publication information
Publisher: Institute of Mathematical Statistics and Operations Research (IMSOR), The Technical University of Denmark
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 200894
Publication: Research - peer-review › Report – Annual report year: 1992

Models and Methods for Optimization of District Heating Systems.: Part II: Models and Control Methods

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Department of Electrical Engineering
Authors: Madsen, H. (Intern), Søgaard, H. T. (Intern), Sejling, K. (Intern), Palsson, O. P. (Intern)
Number of pages: 206
Publication date: 1992

Publication information
Place of publication: Technical University of Denmark
Publisher: Institut for Matematisk Statistik og Operationsanalyse
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 224564
Publication: Research - peer-review › Book – Annual report year: 1992

On an Adaptive Acceptance Control Chart for Autocorrelated Processes

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Mathematical Statistics
Authors: Thyregod, P. (Intern), Madsen, H. (Intern)
Pages: 138-154
Publication date: 1992
Main Research Area: Technical/natural sciences

Publication information
Journal: Frontiers in Statistical Quality Control
Volume: 4
Original language: English
Source: orbit
Source-ID: 224572
Publication: Research - peer-review › Journal article – Annual report year: 1992

Validation of Grey Box Models

General information
State: Published
The Use of Phase Type Distributions for Modelling Packet-Switched Traffic

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Madsen, H. (Intern), Nielsen, B. F. (Intern), Jensen, A. (ed.) (Ekstern), Iversen, V. (ed.) (Ekstern)
Pages: 593-599
Publication date: 1991

Host publication information
Title of host publication: Teletraffic and Datatraffic in a Period of Change
Publisher: Elsevier Science Publishers
Main Research Area: Technical/natural sciences
Conference: Teletraffic and Datatraffic in a Period of Change, 01/01/1991
Source: orbit
Source-ID: 200224
Publication: Research - peer-review › Article in proceedings – Annual report year: 1991

Continuous Identification of a Four-Stroke SI Engine

Compact engine models often consist of a set of nonlinear differential equations which predict the time development of the mean value of the engine state variables (and perhaps some internal variables): such models are sometimes called mean value engine models. Currently a great deal of attention is focused on constructing such continuous time models and on finding their parameters. This paper shows, that it is possible to identify an engine model from a linearized version of a mean value model for a CFI four-cycle spark ignition (SI) engine. Such an approach is useful because it preserves a physical understanding of the engine throughout the identification stage. Afterwards the identification results are available for general dynamic engine studies. The identification techniques discussed in this paper include classical methods (step response) as well as modern statistical methods (Kalman filtering and Maximum Likelihood estimation). These techniques have been applied to a four cylinder SI engine. The results include an identification of the most important parameters and time constants of the engine. These are of interest for the construction of engine simulation models, for control studies and condition monitoring applications.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Automation and Control, Department of Electrical Engineering, Mathematical Statistics
Authors: Melgaard, H. (Intern), Hendricks, E. (Intern), Madsen, H. (Intern)
Pages: 1876-1881
Publication date: 1990

Host publication information
Title of host publication: American Control Conference
Publisher: IEEE
Main Research Area: Technical/natural sciences
Electronic versions:
Melgaard.pdf

Bibliographical note
Copyright: 1990 IEEE. Personal use of this material is permitted. However, permission to reprint/republish this material for advertising or promotional purposes or for creating new collective works for resale or redistribution to servers or lists, or to
Models and Methods for Optimization of District Heating Systems.: Part I: Models and Identification Methods

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Department of Electrical Engineering
Authors: Madsen, H. (Intern), Søgaard, H. T. (Intern), Sejling, K. (Intern), Palsson, O. P. (Intern)
Number of pages: 218
Publication date: 1990

Publication information
Place of publication: Technical University of Denmark
Publisher: Institut for Matematisk Statistik og Operationsanalyse
Original language: English
Main Research Area: Technical/natural sciences

The Danish Incinerator Dioxin Study .1.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Manscher, O. (Ekstern), Heidam, N. (Ekstern), Vikelsøe, J. (Ekstern), Nielsen, P. (Ekstern), Blinksbjerg, P. (Ekstern), Madsen, H. (Intern), Pallesen, L. (Intern), Tierman, T. (Ekstern)
Pages: 1779-1784
Publication date: 1990
Main Research Area: Technical/natural sciences

Publication information
Journal: Chemosphere
Volume: 20
Issue number: 10-12
ISSN (Print): 0045-6535
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 4.39 SJR 1.417 SNIP 1.606
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.51 SNIP 1.57 CiteScore 4.04
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.593 SNIP 1.651 CiteScore 3.76
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.724 SNIP 1.767 CiteScore 3.92
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.818 SNIP 1.623 CiteScore 3.5
ISI indexed (2012): ISI indexed yes
Estimation of traffic models for a packet-switched network

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Madsen, H. (Intern), Nielsen, B. F. (Intern)
Publication date: 1989

Host publication information
Title of host publication: NTS-8
Main Research Area: Technical/natural sciences
Conference: NTS-8, 01/01/1989
Source: orbi
Source-ID: 200229
Publication: Research - peer-review › Article in proceedings – Annual report year: 1989

Tidsrækkeanalyse: Time series analysis

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Modelling the Time Correlation in Hourly Observations of Direct Radiation in Clear Skies

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Madsen, H. (Intern), Thyregod, P. (Intern)
Pages: 201-211
Publication date: 1988
Main Research Area: Technical/natural sciences

Publication information
Journal: Energy and Buildings
Volume: 11
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 4.64 SJR 2.093 SNIP 1.965
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.088 SNIP 2.174 CiteScore 4.07
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.123 SNIP 2.936 CiteScore 4.21
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.897 SNIP 2.433 CiteScore 3.79
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.816 SNIP 2.737 CiteScore 3.36
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.506 SNIP 2.536 CiteScore 3.23
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.631 SNIP 2.081
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.564 SNIP 1.79
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.624 SNIP 2.028
Markov models in discrete and continuous time for hourly observations of cloud cover

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling
Authors: Madsen, H. (Intern), Spliid, H. (Intern), Thyregod, P. (Intern)
Publication date: 1985
Main Research Area: Technical/natural sciences

Publication information
Journal: J. of climate and applied climatology
Original language: English
Links:
http://www2.imm.dtu.dk/pubdb/p.php?4381
Source: orbit
Source-ID: 199714
Publication: Research - peer-review › Journal article – Annual report year: 1988

Projects:
Smart Cities Accellerator
European Interreg Project with 6 municipality implementing the research findings of the CITIES project in cooperation with other universities in the area Copenhagen, Southern Sweden.

Centre for IT-Intelligent Energy Systems in Cities
Department of Civil Engineering
Department of Applied Mathematics and Computer Science
Department of Management Engineering
Period: 20/04/2018 → 20/07/2018
Number of participants: 3
Acronym: SCA
Project participant:
Heller, Alfred (Intern)
Nielsen, Per Sieverts (Intern)
Project Manager, academic:
Madsen, Henrik (Intern)
Stochastic Predictive Control of Wastewater Treatment Processes

Department of Applied Mathematics and Computer Science
Period: 15/09/2017 → 14/09/2020
Number of participants: 6
Phd Student:
Stentoft, Peter Alexander (Intern)
Supervisor:
Madsen, Henrik (Intern)
Mikkelsen, Peter Steen (Intern)
Munk-Nielsen, Thomas (Ekstern)
Vezzaro, Luca (Intern)
Main Supervisor:
Møller, Jan Kloppenborg (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Industrial PhD
Project: PhD

Stochastic Dynamic Optimization and Control Theory

Department of Applied Mathematics and Computer Science
Period: 01/09/2017 → 31/08/2020
Number of participants: 4
Phd Student:
Brok, Niclas Laursen (Intern)
Supervisor:
Jørgensen, John Bagterp (Intern)
Poulsen, Niels Kjølstad (Intern)
Main Supervisor:
Madsen, Henrik (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

Tools for Reliable Energy Performance Characterisation of Buildings

Department of Applied Mathematics and Computer Science
Period: 01/01/2017 → 31/12/2019
Number of participants: 3
Phd Student:
Rasmussen, Christoffer (Intern)
Supervisor:
Rode, Carsten (Intern)
Main Supervisor:
Madsen, Henrik (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

Models for real time warning and control strategies in urban drainage and wastewater systems

Department of Environmental Engineering
Statistics and Data Analytics on Smart Zero

Department of Applied Mathematics and Computer Science
Period: 01/10/2016 → 30/09/2019
Number of participants: 4
Phd Student:
Pedersen, Jonas Wied (Intern)
Supervisor:
Madsen, Henrik (Intern)
Vezzaro, Luca (Intern)
Main Supervisor:
Mikkelsen, Peter Steen (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

Statistics and Data Analytics on Smart Zero

Department of Applied Mathematics and Computer Science
Period: 15/09/2016 → 14/09/2019
Number of participants: 2
Phd Student:
Wolf, Sebastian (Ekstern)
Main Supervisor:
Madsen, Henrik (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

Statistics and Data Analytics on Smart Zero

Department of Applied Mathematics and Computer Science
Period: 15/09/2016 → 14/09/2019
Number of participants: 3
Phd Student:
Wolf, Sebastian (Intern)
Supervisor:
Krogstie, John (Ekstern)
Main Supervisor:
Madsen, Henrik (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

SDE-modelling in CITIES

Department of Applied Mathematics and Computer Science
Centre for IT-Intelligent Energy Systems in Cities
Period: 15/07/2016 → 13/11/2019
Number of participants: 4
Phd Student:
Junker, Rune Grønborg (Intern)
Supervisor:
Jørgensen, John Bagterp (Intern)
Thygesen, Uffe Høgsbro (Intern)
Main Supervisor:
Madsen, Henrik (Intern)
Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

SDE-modelling in CITIES
Department of Applied Mathematics and Computer Science
Period: 15/07/2016 → 13/11/2019
Number of participants: 4
Phd Student:
Junker, Rune Grønborg (Intern)
Supervisor:
Jørgensen, John Bagterp (Intern)
Thygesen, Uffe Høgsbro (Intern)
Main Supervisor:
Madsen, Henrik (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

Datadriven models for energy advising leading to behavioural changes in SMEs and residences
Department of Applied Mathematics and Computer Science
Period: 15/05/2016 → 14/05/2019
Number of participants: 4
Phd Student:
Liisberg, Jon Anders Reichert (Intern)
Supervisor:
Bacher, Peder (Intern)
Madsen, Henrik (Intern)
Main Supervisor:
Møller, Jan Kloppenborg (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Industrial PhD
Project: PhD

Classification and aggregation of energy components
Department of Electrical Engineering
Period: 01/04/2016 → 31/03/2019
Number of participants: 4
Phd Student:
Richert, Thibaut Pierre (Intern)
Supervisor:
Gehrke, Oliver (Intern)
Madsen, Henrik (Intern)
Main Supervisor:
Bindner, Henrik W. (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering

Relations
Activities:
CITIES consortium 2016
Market Mechanisms for the integration of Distributed Energy Resources

Department of Applied Mathematics and Computer Science
Period: 01/04/2016 → 31/03/2019
Number of participants: 3
Phd Student: De Zotti, Giulia (Intern)
Supervisor: Madsen, Henrik (Intern)
Main Supervisor: Morales González, Juan Miguel (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

Sensor Based Process Monitoring of Large Scale Vacuum Casting Process

Department of Applied Mathematics and Computer Science
Period: 01/01/2016 → 31/12/2018
Number of participants: 4
Phd Student: Nauheimer, Michael (Intern)
Supervisor: Kirkeby, Klaus (Ekstern)
Olesen, Bendt (Ekstern)
Main Supervisor: Madsen, Henrik (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Industrial PhD
Project: PhD

Decision-making for the Management and Planning of Integrated Energy Systems

Department of Applied Mathematics and Computer Science
Period: 01/11/2015 → 31/10/2018
Number of participants: 4
Phd Student: Blanco, Ignacio (Intern)
Supervisor: Morales González, Juan Miguel (Intern)
Kitzing, Lena (Intern)
Main Supervisor: Madsen, Henrik (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

Analysis of high frequency (*smart meter*) energy consumption data

Department of Management Engineering
Period: 01/08/2015 → 31/07/2018
Number of participants: 3
Phd Student:

Department of Applied Mathematics and Computer Science
Period: 15/11/2014 → 14/11/2017
Number of participants: 8
Phd Student: Nystrup, Peter (Intern)
Supervisor: Hansen, Bo William (Ekstern)
Larsen, Henrik Olejasz (Ekstern)
Lindstrøm, Karl Joakim Erik Ludvig (Ekstern)
Main Supervisor: Madsen, Henrik (Intern)
Examiner: Pinson, Pierre (Intern)
Dahlquist, Magnus (Ekstern)
Pedersen, Lasse Heje (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Industrial PhD

Relations
Publications:
Dynamic Asset Allocation - Identifying Regime Shifts in Financial Time Series to Build Robust Portfolios
Project: PhD

Model Predictive Control based on Stochastic Differential Equations - An Artificial Pancreas with Fast Insulin, Glucagon and Multiple Sensors

Department of Applied Mathematics and Computer Science
Period: 01/09/2014 → 28/02/2018
Number of participants: 5
Phd Student: Hagdrup, Morten (Intern)
Supervisor: Madsen, Henrik (Intern)
Poulsen, Bjarne (Intern)
Poulsen, Niels Kjølstad (Intern)
Main Supervisor: Jørgensen, John Bagterp (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

Innovationsnetwork Smart Energy (CLEAN)
Innovation network under CLEAN for smart energy innovation activities.
IEA EBC Annex 67 - Energy Flexible Buildings

Energy flexibility in buildings will play an important role in facilitating energy systems based entirely on renewable energy sources. Flexibility is necessary to control the energy consumption to match the actual energy generation from various energy sources such as solar and wind power. However, there is lack of comprehensive knowledge about how much energy flexibility different building types and their usage may be able to offer to the future energy systems.

The aim of this project is to demonstrate how energy flexibility in buildings can provide generating capacity for energy grids, and to identify critical aspects and possible solutions to manage such flexibility. This knowledge is important in order to incorporate energy flexibility of buildings into future smart energy systems and to better accommodate renewable sources in energy systems. It is also important when developing the business case for using building energy flexibility within future systems to potentially reduce costly upgrades of energy distribution grids.

The project objectives are:

– development of common terminology, a definition of ‘energy flexibility in buildings’ and a classification method,
– investigation of user comfort, motivation and acceptance associated with the introduction of energy flexibility in buildings,
– investigation of the energy flexibility potential in different buildings and contexts, and development of design guidelines, control strategies and algorithms
– investigation of the aggregated energy flexibility of buildings and the potential effect on energy grids, and
– demonstration of energy flexibility through experimental and field studies.

Participants: Austria, Belgium, Denmark, France, Italy, the Netherlands, Norway, Portugal, Spain, Switzerland, United Kingdom

Waste-2-Energy Smart Grid Upgrade

Department of Applied Mathematics and Computer Science

Krüger A/S

Højteknologifonden

Period: 02/04/2014 → 02/04/2016

Number of participants: 2

WWTP, Smart Grid, MPC
Modeling of Pharmacokinetics and Pharmacodynamics of Novel Glucagon Analogues for Closed-Loop Dual Hormone Blood Glucose Control

Department of Applied Mathematics and Computer Science
Period: 15/03/2014 → 16/08/2017
Number of participants: 7
Phd Student:
Wendt, Sabrina Lyngbye (Intern)

Supervisor:
Knudsen, Carsten Boye (Ekstern)
Madsen, Henrik (Intern)

Main Supervisor:
Jørgensen, John Bagterp (Intern)

Examiner:
Thygesen, Uffe Høgsbro (Intern)
Dalla-Man, Chiara (Ekstern)
Hovorka, Roman (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Industrial PhD

Relations
Publications:
Modeling Pharmacokinetics and Pharmacodynamics of Glucagon for Simulation of the Glucoregulatory System in Patients with Type 1 Diabetes.
Project: PhD

Center for IT-Intelligent Energy Systems for Cities
A wide range of research activities have arisen to support the Danish target of a 100% renewable energy system by 2050. Projects focused on individual aspects of the energy system, such as zero emissions buildings or intelligent power systems provide valuable insight, that facilitates flexibility throughout the energy system. CITIES will address this deficiency by establishing an integrated research centre covering all aspects of the energy system, including gas, power, district heating/cooling and biomass, and most importantly methods to forecast, control and optimize their interactions through the use of advanced ICT solutions.

The high densities of population, energy consumption, and energy and communications networks in cities offer the greatest potential for flexibility at the last cost, and the fact that cities account for 80% of global energy consumption and emissions [1] make the urban environment an ideal setting for energy systems integration research. CITIES will pioneer research into fully integrated city energy systems, building short-term operational models that feed longer term planning models, considering the spatiotemporal variations, interactions, dynamics and stochastics in the energy system. Low level models of system components will inform higher-level aggregate models employed in market and control framework design. The leading position of European academia and industry and the rapidly growing market for smart energy solutions indicates substantial scope for increased competitiveness and job creation within this field. CITIES will, in collaboration with its industrial and academic partners, conduct research with a view to developing tools for the implementation of integrated energy system solutions.

Center granted by Strategic Research Council.

To be a sustainable organisation.

Department of Applied Mathematics and Computer Science
Department of Civil Engineering
Department of Management Engineering
Department of Energy Conversion and Storage
Department of Informatics and Mathematical Modeling
Centre for IT-Intelligent Energy Systems in Cities
Aalborg University

Period: 01/01/2014 → 31/12/2019
Number of participants: 8

Strategic
Acronym: CITIES
Number of related Ph.D. students: 12
Project participants:
Madsen, Henrik (Intern)
Heller, Alfred (Intern)
Nielsen, Per Sieverts (Intern)
Pedersen, Allan Schroder (Intern)
Rode, Carsten (Intern)
Pinson, Pierre (Intern)
Jorgensen, John Bagterp (Intern)
Project Manager, organisational:
Herrmann, Ivan Tengbjerg (Intern)

Financing sources
Source: Forskningsradene - Andre
Name of research programme: Energy Programme
Amount: 44.00 Danish Kroner
Year of approval: 2013

Relations
Activities:
12th International SDEWES Conference
Energy Supply Modelling in Cities: Illustrated Using Data from the Danish Municipality of Sønderborg
Energy Supply Modelling in Cities: Illustrated Using Data from the Case of Sønderborg
Big Data som værktøj til at styre byens energi
Blockchain Summer School 2017
Climate-KIC PhD Summer School Urban Transition Amsterdam-Bologna 2017
Executive Development Programme with Technical University of Denmark
The 40th International IAEE Conference
Big Data as a tool for controlling the cities energy: Data aspects and data management
30th International Conference on Efficiency, Cost, Optimization, Simulation and Environmental Impact of Energy Systems
3rd International Workshop on Design in Civil and Environmental Engineering
Status and Results of Energy Supply Modelling in CITIES: Illustrated using Data from the Case of Sønderborg
CITIES Annual Conference
Publications:
Model Identification for Control of Display Units in Supermarket Refrigeration Systems

Stochastic Dynamics of Demand Response and the impact on Power Systems Service Provision
Department of Applied Mathematics and Computer Science
Period: 01/01/2013 → 20/04/2016
Number of participants: 7
PhD Student:
O'Connell, Niamh (Intern)
Supervisor:
O'Malley, Mark J. (Ekstern)
Pinson, Pierre (Intern)
Main Supervisor:
Madsen, Henrik (Intern)
Examiner:
Stochastic energy systems
Department of Applied Mathematics and Computer Science
Period: 15/12/2012 → 12/12/2016
Number of participants: 6
Phd Student:
Saez Gallego, Javier (Intern)
Supervisor:
Morales González, Juan Miguel (Intern)
Main Supervisor:
Madsen, Henrik (Intern)
Examiner:
Hjorth, Poul G. (Intern)
Fleten, Stein-Erik (Ekstern)
Lindström, Erik (Ekstern)
Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)

Relations
Publications:
Inverse Optimization and Forecasting Techniques Applied to Decision-making in Electricity Markets
Project: PhD

Adaptive Load Forecasting
Department of Applied Mathematics and Computer Science
Period: 15/09/2012 → 31/07/2016
Number of participants: 5
Phd Student:
Parvizi, Jacopo (Intern)
Main Supervisor:
Madsen, Henrik (Intern)
Examiner:
Sørensen, Mads Peter (Intern)
Petersen, Steffen (Intern)
Sartori, Igor (Ekstern)
Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.

Relations
Publications:
Modeling and Control for Price Responsive Electricity Loads
Project: PhD
Methodologies for the economic and societal valuation of wind, energy storage and demand-side management in the electricity supply

Department of Applied Mathematics and Computer Science
Period: 01/05/2012 → 30/04/2015
Number of participants: 3
PhD Student:
Simonsen Nielsen, Michael Pascal (Intern)
Supervisor:
Madsen, Henrik (Intern)
Main Supervisor:
Pinson, Pierre (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD

Stochastic Differential Equations in PK/PD Modelling

Department of Applied Mathematics and Computer Science
Period: 15/01/2012 → 16/07/2015
Number of participants: 3
PhD Student:
Juhl, Rune (Intern)
Supervisor:
Jørgensen, John Bagterp (Intern)
Main Supervisor:
Madsen, Henrik (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

Integrated Wind Power Planning Tool

Department of Wind Energy
Period: 01/10/2011 → 24/08/2015
Number of participants: 6
PhD Student:
Rosgaard, Martin Haubjerg (Intern)
Supervisor: 
Madsen, Henrik (Intern)
Main Supervisor: 
Hahmann, Andrea N. (Intern)
Examiner:
Pinson, Pierre (Intern)
Nissen, Jesper Nielsen (Intern)
Wilson, Clive George (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Ansat eksternt
Project: PhD

Multivariate Probabilistic Forecasting for Energy Systems
Department of Applied Mathematics and Computer Science
Period: 01/10/2011 → 21/09/2015
Number of participants: 7
Phd Student: 
Iversen, Jan Emil Banning (Intern)
Supervisor:
Morales González, Juan Miguel (Intern)
Møller, Jan Kloppenborg (Intern)
Main Supervisor: 
Madsen, Henrik (Intern)
Examiner: 
Pinson, Pierre (Intern)
Dent, Chris (Ekstern)
Lindström, Erik (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD

Adaptive Load Forecasting
Department of Applied Mathematics and Computer Science
Period: 15/09/2011 → 30/06/2012
Number of participants: 2
Phd Student:
de Saint-Aubain, Philip Anton (Intern)
Main Supervisor: 
Madsen, Henrik (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD

Scenario modeling for optimized integrated real-time control of sewer - wastewater treatment plant systems
Department of Applied Mathematics and Computer Science
Period: 01/01/2011 → 25/09/2014
Number of participants: 6
Phd Student: 
Löwe, Roland (Intern)
Supervisor: 
Mikkelsen, Peter Steen (Intern)
Main Supervisor:
Madsen, Henrik (Intern)
Examiner:
Bauer-Gottwein, Peter (Intern)
Heemink, Arnold Willem (Ekstern)
Muschalla, Dirk (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD

Model Predictive Control for Smart Energy Systems
Department of Applied Mathematics and Computer Science
Period: 01/11/2010 → 25/04/2014
Number of participants: 7
Phd Student:
Halvgaard, Rasmus Fogtmann (Intern)
Supervisor:
Madsen, Henrik (Intern)
Poulsen, Niels Kjølstad (Intern)
Main Supervisor:
Jørgensen, John Bagterp (Intern)
Examiner:
Bindner, Henrik W. (Intern)
Chmielewski, Donald J. (Ekstern)
Jones, Colin N. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

Models for the energy performance of low-energy houses
Department of Informatics and Mathematical Modeling
Period: 01/05/2010 → 24/01/2014
Number of participants: 6
Phd Student:
Andersen, Philip Hvidthøft Delff (Intern)
Supervisor:
Rode, Carsten (Intern)
Main Supervisor:
Madsen, Henrik (Intern)
Examiner:
Hattel, Jesper Henri (Intern)
Heiselberg, Per (Ekstern)
Roels, Staf (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

Impact of Stochastic Generation on Electricity Market Dynamics
Department of Informatics and Mathematical Modeling
Period: 01/01/2010 → 30/08/2013
Number of participants: 7
Phd Student:
Zugno, Marco (Intern)
Supervisor:
Morales González, Juan Miguel (Intern)
Madsen, Henrik (Intern)
Main Supervisor:
Pinson, Pierre (Intern)
Examiner:
Rasmussen, Kourosh Marjani (Intern)
Boomsma (fhv. Kristoffersen), Trine Krogh (Intern)
Hobbs, Benjamin F. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

Statistisk modellering af marine økosystemer
Department of Informatics and Mathematical Modeling
Period: 01/11/2009 → 30/08/2013
Number of participants: 7
Phd Student:
Berg, Casper Willestofte (Intern)
Supervisor:
Nielsen, Anders (Intern)
Thygesen, Uffe Høgsbro (Intern)
Main Supervisor:
Madsen, Henrik (Intern)
Examiner:
Andersen, Ken Haste (Intern)
Cadigan, Noel G. (Ekstern)
Nielsen, Søren F. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD

Model Predictive Control algorithms for pen and pump insulin administration
Department of Informatics and Mathematical Modeling
Period: 01/09/2009 → 22/11/2012
Number of participants: 7
Phd Student:
Boiroux, Dimitri (Intern)
Supervisor:
Madsen, Henrik (Intern)
Poulsen, Niels Kjølstad (Intern)
Main Supervisor:
Jørgensen, John Bagterp (Intern)
Examiner:
Sørensen, Mads Peter (Intern)
Knudsen, Jørgen K. H. (Ekstern)
del Re, Luigi (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering
Project: PhD
Stokastisk dynamisk modellering til kort-tidsregulering af glukose/insulin-metabolismen
Department of Informatics and Mathematical Modeling
Period: 01/06/2009 → 12/12/2013
Number of participants: 6
Phd Student: Duun-Henriksen, Anne Katrine (Intern)
Supervisor: Jensen, Peter Ruhdal (Intern)
Main Supervisor: Madsen, Henrik (Intern)
Examiner: Christiansen, Lasse Engbo (Intern)
Andreassen, Steen (Ekstern)
Gabrielsson, Johan (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering
Project: PhD

NonLinear modelling for energy systems
Department of Informatics and Mathematical Modeling
Period: 01/01/2009 → 22/03/2013
Number of participants: 6
Phd Student: Trombe, Pierre-Julien (Intern)
Supervisor: Pinson, Pierre (Intern)
Main Supervisor: Madsen, Henrik (Intern)
Examiner: Larsen, Rasmus Werner (Intern)
Greiner, Martin O. W. (Ekstern)
Thorarinsdottir, Thordis L. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD

Model based analysis of ethnic differences in Type 2 diabetes
Department of Informatics and Mathematical Modeling
Period: 01/10/2008 → 24/08/2012
Number of participants: 7
Phd Student: Møller, Jonas Bech (Intern)
Supervisor: Ingwersen, Steen Hvass (Ekstern)
Overgaard, Rune Viig (Intern)
Main Supervisor: Madsen, Henrik (Intern)
Examiner: Brockhoff, Per B. (Intern)
Jacqmin, Philippe (Ekstern)
Madsbad, Sten (Ekstern)
Financing sources
Source: Internal funding (public)
Name of research programme: ErhvervsPhD-ordningen VTU
Project: PhD

Models for efficient integration of solar energy
Department of Informatics and Mathematical Modeling
Period: 01/10/2008 → 24/08/2012
Number of participants: 6
Phd Student:
Bacher, Peder (Intern)
Supervisor:
Nielsen, Henrik Aalborg (Intern)
Main Supervisor:
Madsen, Henrik (Intern)
Examiner:
Christiansen, Lasse Engbo (Intern)
Palsson, Olafur Petur (Intern)
Taboada, Maria Jose Jimenez (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD

Grey box Modelling of Hydraulic Systems
Department of Informatics and Mathematical Modeling
Period: 01/10/2007 → 23/02/2012
Number of participants: 6
Phd Student:
Thordarson, Fannar Órn (Ekstern)
Supervisor:
Madsen, Henrik (Intern)
Main Supervisor:
Madsen, Henrik (Intern)
Examiner:
Poulsen, Niels Kjølstad (Intern)
Rasmussen, Michael Robdrup (Ekstern)
Willems, Patrick (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering
Project: PhD

Framework for Real Time Control of Integrated Urban Wastewater Systems
Department of Environmental Engineering
Period: 01/09/2007 → 27/06/2012
Number of participants: 7
Phd Student:
Breinholt, Anders (Intern)
Supervisor:
Grum, Morten (Intern)
Main Supervisor:
Mikkelsen, Peter Steen (Intern)
Examiner:
Bauer-Gottwein, Peter (Intern)
Madsen, Henrik (Ekstern)
Vanrolleghem, Peter (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: 1/3 DTU-stip, 2/3 FUR/andet
Project: PhD

Estimation of Conditional densities for predictions in nonlinear stochastic processes - with applications to wind power systems

Department of Informatics and Mathematical Modeling
Period: 01/08/2007 → 12/12/2013
Number of participants: 6
Phd Student:
Tastu, Julija (Intern)
Supervisor:
Pinson, Pierre (Intern)
Main Supervisor:
Madsen, Henrik (Intern)
Examiner:
Poulsen, Niels Kjølstad (Intern)
Kariniotakis, George (Ekstern)
Lindström, Erik (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU-lønnet stipendie
Project: PhD

Statistical modelling of tagging data from marine animals

Department of Informatics and Mathematical Modeling
Period: 01/07/2007 → 02/02/2011
Number of participants: 6
Phd Student:
Pedersen, Martin Wæver (Intern)
Supervisor:
Thygesen, Uffe Høgsbro (Intern)
Main Supervisor:
Madsen, Henrik (Intern)
Examiner:
Poulsen, Niels Kjølstad (Intern)
Huse, Geir (Ekstern)
Zucchini, Walter (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU-lønnet stipendie
Project: PhD

Nonlinear Stochastic Modelling of Antimicrobial resistance in Bacterial Populations

Department of Informatics and Mathematical Modeling
Period: 01/10/2006 → 30/06/2010
Number of participants: 6
Phd Student:
Philipsen, Kirsten Riber (Intern)
Supervisor:
Christiansen, Lasse Engbo (Intern)
Identification of Ecological Thresholds of Sustaniability in Marine Ecosystems

Department of Informatics and Mathematical Modeling
Period: 01/08/2006 → 25/05/2011
Number of participants: 6
Phd Student: Møller, Jan Kloppenborg (Intern)
Supervisor: Carstensen, Niels Jacob (Intern)
Main Supervisor: Madsen, Henrik (Intern)
Examiner: Nielsen, Bo Friis (Intern)
Diekmann, Odo (Ekstern)
Ersbøll, Annette Kjær (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering
Project: PhD

Improved Statistical Analysis of Sleep EEG Data in Relation to Pharmacokinetics

Department of Informatics and Mathematical Modeling
Period: 01/07/2006 → 10/02/2010
Number of participants: 6
Phd Student: Mortensen, Stig Bousgaard (Intern)
Supervisor: Hougaard, Philip (Ekstern)
Main Supervisor: Madsen, Henrik (Intern)
Examiner: Rootzén, Helle (Intern)
Ditlevsen, Susanne (Ekstern)
Guttrop, Peter (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: 1/3 DTU-stip, 2/3 FUR/andet
Project: PhD

Predictive Tools for Designing new Insulins and Treatment Regimes

Department of Informatics and Mathematical Modeling
Period: 01/07/2006 → 16/12/2009
Number of participants: 7
Phd Student: Klim, Søren (Intern)
Methods for Investigation of QT Prolongations

Department of Informatics and Mathematical Modeling
Period: 01/04/2006 → 31/05/2010
Number of participants: 2
Phd Student:
Jónsdóttir, Anna Helga (Intern)
Main Supervisor:
Madsen, Henrik (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: ErhvervsPhD-ordningen VTU
Project: PhD

Data Assimilation in Marine Modelling

Department of Informatics and Mathematical Modeling
Period: 01/03/2006 → 25/11/2009
Number of participants: 6
Phd Student:
Frydendall, Jan (Intern)
Supervisor:
Sørensen, Jacob Viborg Tornfeldt (Intern)
Main Supervisor:
Madsen, Henrik (Intern)
Examiner:
Poulsen, Niels Kjølstad (Intern)
Carstensen, Niels Jacob (Intern)
Heemink, Arnold Willem (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: 1/3 DTU-stip, 2/3 FUR/andet
Project: PhD

Automatisk kalibrering og attenuation korrektion i netværk af små vejrradar

Department of Informatics and Mathematical Modeling
Period: 01/02/2006 → 26/08/2009
Number of participants: 6
Phd Student:
Pedersen, Lisbeth (Intern)
Supervisor:
Jensen, Niels Einar (Ekstern)
Self-Organising Distributed Control of a Distributed Energy System with a High Penetration of Renewable Energy

Department of Informatics and Mathematical Modeling
Period: 01/04/2005 → 17/02/2010
Number of participants: 8
PhD Student:
Gehrke, Oliver (Intern)
Supervisor:
Bindner, Henrik W. (Intern)
Madsen, Henrik (Intern)
Nielsen, Arne Hejde (Intern)
Main Supervisor:
Poulsen, Niels Kjølstad (Intern)
Examiner:
Lind, Morten (Intern)
Degner, Thomas (Ekstern)
McArthur, Stephen (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: ErhvervsPhD-ordningen VTU
Project: PhD

Power Fluctuations from Large Offshore Wind Farms

The project has developed and verified simulation and prediction models for power fluctuations in large wind farms. The verification is based on extensive measurements in the two large offshore wind farms in Denmark: Horns Rev and Nysted. The models can also be applied to simulation of wind power fluctuations from wind turbines distributed over a larger area than a wind farm. The advantage of the prediction models is that they can be applied in the operation, but these models require a training period before they work in a new system. On the other hand, the simulation model can simulate power fluctuations with possible future wind power developments, based on information about size and location of the individual wind turbines. Thus, the simulation model is a planning tool.

Department of Wind Energy
Wind Energy Systems
Risø National Laboratory for Sustainable Energy
Department of Applied Mathematics and Computer Science
DONG Energy A/S
Vattenfall A/S
Period: 01/10/2004 → 31/03/2007
Number of participants: 4
Project participant:
Cutululis, Nicolaos Antonio (Intern)
Madsen, Henrik (Intern)
Pinson, Pierre (Intern)
Project Manager, academic:
Sørensen, Poul Ejnar (Intern)
Relations
Publications:
Fluctuations of offshore wind generation: Statistical modelling
Regime-switching modelling of the fluctuations of offshore wind generation
Analysis of the experimental spectral coherence in the Nysted Wind Farm
Models for assessing power fluctuations from large wind farms
Power Fluctuations From Large Wind Farms
Power fluctuations from large offshore wind farms
Modelling of power fluctuations from large offshore wind farms

Project

Conflict-based Method for Economical, Subsustainable, Safe and Environmentally Clean Process (Retrofit)Design and Operation
Department of Chemical and Biochemical Engineering
Period: 01/02/2004 → 25/09/2008
Number of participants: 6
Phd Student:
Davidescu, Florin Paul (Intern)
Supervisor:
Madsen, Henrik (Intern)
Main Supervisor:
Jørgensen, Sten Bay (Intern)
Examiner:
Gernaey, Krist V. (Intern)
Kristensen, Niels Rode (Intern)
Marquardt, Wolfgang (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Offentlig finansiering
Project: PhD

Modelling for Monitoring, Control and Optimization of Fed-Batch
Department of Chemical and Biochemical Engineering
Period: 01/09/2003 → 02/06/2008
Number of participants: 7
Phd Student:
Rasmussen, Jan Kamyno (Intern)
Supervisor:
Jørgensen, Henrik Steen (Ekstern)
Madsen, Henrik (Intern)
Main Supervisor:
Jørgensen, Sten Bay (Intern)
Examiner:
Gernaey, Krist V. (Intern)
Lei, Frede (Intern)
Lübbert, Andreas (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU, Samfinansiering
Project: PhD

Computer Supported Drug Development
Department of Informatics and Mathematical Modeling
Period: 01/10/2002 → 20/10/2005
Number of participants: 8
Phd Student:
Tornøe, Christoffer Wenzel (Intern)
Supervisor:
Agerø, Henrik (Ekstern)
Jonsson, E. Niclas (Ekstern)
Nielsen, Henrik Aalborg (Intern)
Main Supervisor:
Madsen, Henrik (Intern)
Examiner:
Rootzén, Helle (Intern)
Gabrielsson, Johan (Ekstern)
Vølund, Aage (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Ansat eksternt
Project: PhD

Estimationsteori for stokastiske differentialisninger
Department of Informatics and Mathematical Modeling
Period: 01/10/2002 → 15/01/2007
Number of participants: 6
Phd Student:
Nolsøe, Kim (Intern)
Supervisor:
Kessler, Mathieu (Ekstern)
Main Supervisor:
Madsen, Henrik (Intern)
Examiner:
Nielsen, Bo Friis (Intern)
Jørgensen, Bent (Intern)
Rydén, Tobias (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU-lønnet stipendie
Project: PhD

Stokastisk dynamik i kompkese systemer
Department of Informatics and Mathematical Modeling
Period: 01/07/2002 → 25/10/2006
Number of participants: 7
Phd Student:
Overgaard, Rune Viig (Intern)
Supervisor:
Carlsson, Mats (Ekstern)
Knudsen, Carsten (Intern)
Main Supervisor:
Madsen, Henrik (Intern)
Examiner:
Nielsen, Henrik Aalborg (Intern)
Gabrielsson, Johan (Ekstern)
Vicini, Paolo (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU-lønnet stipendie
Project: PhD
Minimizing antibiotic resistance development MINIRESIST

The overall objective is to minimize resistance development in the intestinal flora of pigs following antibiotic treatment. The project has the following specific objectives: - To investigate the influence of antibiotic treatment regimes on the efficacy of treatment, the development and spread of resistant bacteria and on the load of resistant bacteria in the intestine at the point of slaughter. - To investigate the underlying kinetics of selection of resistant bacteria and the spread of resistance genes between bacteria in the intestine. - To investigate the association between the load of resistant bacteria in the intestine at the time of slaughter and the load on the carcasses after slaughter. - To develop and validate a comprehensive mathematical model for resistance development associated with the use of antibiotics in pig production. - To formulate improved treatment regimes using the mathematical model.
Schwarz, Stefan (Ekstern)
Project Manager, organisational:
Olsen, John Elmerdahl (Ekstern)

Financing sources
Source: Forskningsprojekter - Andre ministerier og styrelser
Name of research programme: Forskningsprojekter - Andre ministerier og styrelser
Amount: 3,726,720.00 Danish Kroner
Project

Data assimilation in atmosphere dispersion of radioactive material

Department of Informatics and Mathematical Modeling
Period: 01/10/2000 → 18/03/2005
Number of participants: 6
Phd Student:
Drews, Martin (Intern)
Supervisor:
Lauritzen, Bent (Intern)
Main Supervisor:
Madsen, Henrik (Intern)
Examiner:
Poulsen, Niels Kjølstad (Intern)
Finck, Robert R. (Ekstern)
Holst, Jan (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Risø (Løn)
Project: PhD

Data assimilering og autokalibrering i 2D/3D hydrodynamisk numerisk modellering af det marine miljø

Department of Informatics and Mathematical Modeling
Period: 01/04/2000 → …
Number of participants: 6
Phd Student:
Sørensen, Jacob Viborg Tornfeldt (Intern)
Supervisor:
Madsen, Henrik (Intern)
Main Supervisor:
Madsen, Henrik (Intern)
Examiner:
Poulsen, Niels Kjølstad (Intern)
Cañizares, Rafael (Ekstern)
Heemink, Arnold Willem (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Erhvervsforskerordningen
Project: PhD

Nonlinear identification and optimal control of fed-batch processes

Department of Chemical and Biochemical Engineering
Period: 01/08/1999 → 24/03/2003
Number of participants: 6
Phd Student:
Kristensen, Niels Rode (Intern)
Supervisor:
Madsen, Henrik (Intern)
Main Supervisor:
Jørgensen, Sten Bay (Intern)

Examiner:
Wiebe, Lars (Ekstern)
Holst, Jan (Ekstern)
Poulsen, Niels Kjølstad (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU-lønnet stipendie
Project: PhD

Vindmøllepark-produktionsprediktor
Prediction of the windpower production in Denmark. A prediction model covering wind turbines in question will be installed at 4 major utilities in Denmark. ELSAM, ELKRAFT, SEAS, and ELTRA. The prediction model is based on a combination of online observations and meteorological forecasts. The forecasts will be delivered from DMI using their numerical weather forecasting model, HIRLAM.

Department of Informatics and Mathematical Modeling
Risø National Laboratory
Elkraft A.m.b.A.
SEAS-NVE
Elsam A/S
ELTRA I/S
Danish Meteorological Institute
Period: 01/04/1999 → 31/03/2002
Number of participants: 3
Project participant:
Joensen, Alfred K. (Intern)
Nielsen, Torben Skov (Intern)
Project Manager, organisational:
Madsen, Henrik (Intern)

Financing sources
Source: Unknown
Name of research programme: Ukendt
Amount: 1,200,000.00 Danish Kroner
Project

Non- and semiparametric methods with applications in engineering
The purpose of the project is to collect various research activities within area of non- and semi-parametric methods and application of these. Relevant topics includes applications and developments within the areas of: (i) non- and semi-parametric methods of regression in general, (ii) combination of parametric and non-parametric methods, (iii) adaptive estimation, (iv) structural identification of on-linear time series, (v) non- and semi-parametric methods for dynamic systems

Department of Informatics and Mathematical Modeling
Period: 01/01/1999 → …
Number of participants: 6
Project participant:
Joensen, Alfred K. (Intern)
Nielsen, Henrik Aalborg (Intern)
Nielsen, Torben Skov (Intern)
Sadegh, Payman (Intern)
Øjelund, Henrik (Intern)
Project Manager, organisational:
Madsen, Henrik (Intern)
Project
**PRESS installation hos Sonderborg Fjernvarme**
Implementering af PRESS prognosesystem hos Sonderborg Fjernvarme. Samarbejdsaftale.

Department of Informatics and Mathematical Modeling

Sønderborg Fjernvarme A.m.b.a.
Period: 01/01/1999 → 31/12/2000
Number of participants: 2
Project participant:
Nielsen, Torben Skov (Intern)
Project Manager, organisational:
Madsen, Henrik (Intern)

**Financing sources**
Source: Unknown
Name of research programme: Ukendt
Amount: 64,000.00 Danish Kroner

**IT based optimization of District Heating Networks**
The projects superior objective is to work as a catalyzer for distribution and practical use of a number of optimization methods and tools for the district heating sector. By collecting these functions in one modern IT-tool and by introducing new working methods the project will work as a lever and make these optimizations practically operational and attractive for the district heating companies. It is the aim of the IT-tool to be able to integrate a number of functions, such as: * Network tools for dimensioning and analysis. * Optimization of storage tanks and other supply sources. * Strategies for optimum pump operation and control. * Advanced forecasts and temperature controllers. * On-line measurements and status from SCADA systems. * Geographic map information from pipe registration / GIS systems. * Information from customer databases. * An uncomplicated and clear presentation of deviations from the optimum operation condition. The main contributions from DTU/IMM are: * Installation of the DTU/IMM on-line system PRESS (Prognose- og EnergiStyrings System) at Frederiksberg Varmeværk. * Research regarding heat load forecasting using on-line meteorological forecasts. * Research regarding optimal load scheduling of storage tanks.

Department of Informatics and Mathematical Modeling

ABB Energi & Industri A/S
Period: 01/02/1998 → 31/12/2002
Number of participants: 3
Project participant:
Madsen, Henrik (Intern)
Laursen, Peter (Ekstern)
Project Manager, organisational:
Nielsen, Henrik Aalborg (Intern)

**IT-baseret driftoptimering af fjernvarmedistribution**
Projektets formål er at udvikle og afprove modeller og metoder til langtidsforudsigelser (op til 5-7 døgn) af varmebehovet i fjernvarmesystemer. Samtidig skal der udvikle og afproves metoder til optimering af driften af akkumulatortanke. Disse metoder vil udnytte saavel forudsigelser af varmebehov som tidligere udviklede metoder til bestemmelse af optimal fremlobstemperatur.

Department of Informatics and Mathematical Modeling

VESTKRAFT

VEKS

ABB Energi & Industri A/S
Rambøll Danmark A/S
Frederiksberg Varmeværk
Period: 01/02/1998 → 30/10/2000
Number of participants: 3
Project participant:
Nielsen, Henrik Aalborg (Intern)
Nielsen, Torben Skov (Intern)
Project Manager, organisational:
Madsen, Henrik (Intern)

**Financing sources**
Source: Unknown
Name of research programme: Ukendt
Amount: 767,000.00 Danish Kroner

**Dynamic modelling of Energy Systems**
Department of Informatics and Mathematical Modeling
Period: 01/01/1998 → 03/12/2001
Number of participants: 5
Phd Student:
Andersen, Klaus Kaae (Intern)
Main Supervisor:
Madsen, Henrik (Intern)
Examiner:
Spliid, Henrik (Intern)
Bidstrup, Niels (Intern)
Lebrun, Jean (Ekstern)

**Financing sources**
Source: Internal funding (public)
Name of research programme: DTU-lønnet stipendie

**Multivariat kalibrering af kemiske sensorer**
Department of Informatics and Mathematical Modeling
Period: 01/01/1998 → …
Number of participants: 7
Phd Student:
Øjelund, Henrik (Intern)
Supervisor:
Steen-Pedersen, Jørgen (Ekstern)
Thyregod, Poul (Intern)
Main Supervisor:
Madsen, Henrik (Intern)
Examiner:
Hansen, Lars Kai (Intern)
Olsen, Eli Vibeke (Ekstern)
Sundberg, Rolf (Ekstern)

**Financing sources**
Source: Internal funding (public)
Name of research programme: Erhvervsforskerordningen

**Elforbrugsmodeller for ELKRAFT-området**

Department of Informatics and Mathematical Modeling
Elkraft A.m.b.A.
Grey-box identification
In the modelling of dynamic systems several approaches exist. For the so-called black box approach the modelling is based solely on measurements obtained for the actual system, and any prior information about the system is not used. The opposite approach is used in the white box or physical approach where the model is formulated solely on prior knowledge. In the project methods for combining the two approaches are developed, and such methods are called grey-box methods. The methods are based on Bayesian statistics. Typically the structure of the models are formulated as stochastic differential equations and the parameters are estimated using available data. The modelling approach has been tested with great success on many physical and technical systems.

Department of Informatics and Mathematical Modeling

Center for IT-tools in the Energy Sector
In this center models for the energy sector is constructed and tested. The purpose is simulation and to be able to develop intelligent components for heating systems. Under this center some other projects are established.

Department of Informatics and Mathematical Modeling

APV
Period: 01/09/1997 → 31/08/2001
Number of participants: 2
Project participant:
Andersen, Klaus Kaae (Intern)
Project Manager, organisational:
Madsen, Henrik (Intern)

Financing sources
Source: Unknown
Name of research programme: Ukendt
Amount: 77,880.00 Danish Kroner
Project
Modellering og styring af sprøjtestøbeproces

Project no.: 1247 Ph.D. project: ATV Ph.D. student: Peter Thyregod


Department of Informatics and Mathematical Modeling
Novo Nordisk A/S
Period: 01/08/1997 → 31/07/2000
Number of participants: 3

Phd Student:
Spliid, Henrik (Intern)
Thyregod, Peter (Intern)

Project Manager, organisational:
Madsen, Henrik (Intern)

Financing sources
Source: Unknown
Name of research programme: Ukendt
Amount: 30,645.00 Danish Kroner

Modellering og styring af sprøjtestøbeproces

Department of Informatics and Mathematical Modeling

Project: PhD
Combined physical and statistical on-line prediction of wind power from wind farms.
The purpose is to develop methods for embedding physical and statistical information in prediction models for long term forecasting of wind power in wind mill farms.

Department of Informatics and Mathematical Modeling
Risø National Laboratory for Sustainable Energy
Period: 01/04/1997 → 31/03/2000
Number of participants: 7

Phd Student:
Thyregod, Peter (Intern)

Supervisor:
Melgaard, Henrik (Intern)
Spliid, Henrik (Intern)

Main Supervisor:
Madsen, Henrik (Intern)
Examiner:
Rootzén, Helle (Intern)
Bisgaard, Søren (Ekstern)
Olsen, Klaus Juel (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Erhvervsforskerordningen
Project: PhD
**Kombineret fysik og statistisk on-line forudsigelse af produktion fra vindmølleparker**

Department of Informatics and Mathematical Modeling  
Period: 01/04/1997 → 20/05/2003  
Number of participants: 6  
Phd Student:  
Joensen, Alfred K. (Intern)  
Supervisor:  
Landberg, Lars (Intern)  
Main Supervisor:  
Madsen, Henrik (Intern)  
Examiner:  
Spliid, Henrik (Intern)  
Knudsen, Torben (Ekstern)  
Larsen, Søren Ejling (Intern)

**Financing sources**  
Source: Internal funding (public)  
Name of research programme: Risø (Løn)  
Project: PhD

**Multivariate Calibration in Optical Sensors**  
The purpose is to develop statistical methods for robust, and efficient calibration of optical sensors used in waste water treatment plants. Several regulatization methods and non-parametric methods will be considered. Also robust techniques are investigated.

Department of Informatics and Mathematical Modeling  
Danfoss A/S  
Period: 01/04/1997 → 31/05/2001  
Number of participants: 3  
Project participant:  
Thyregod, Poul (Intern)  
Øjelund, Henrik (Intern)  
Project Manager, organisational:  
Madsen, Henrik (Intern)

**Financing sources**  
Source: Unknown  
Name of research programme: Ukendt  
Amount: 18,017.00 Danish Kroner  
Project

**Stochastic Dynamic modelling of Oxigen**  
Department of Informatics and Mathematical Modeling  
Period: 01/04/1997 → 08/02/2007  
Number of participants: 7  
Phd Student:  
Jonsdottir, Harpa (Intern)  
Supervisor:  
Eliasson, Jonas (Ekstern)  
Palsson, Olafur Petur (Intern)  
Main Supervisor:  
Madsen, Henrik (Intern)  
Examiner:  
Poulsen, Niels Kjældstad (Intern)
Financing sources
Source: Internal funding (public)
Name of research programme: DTU-Su Stipendium, Eksperiment
Project: PhD

Estimation in Stochastic Differential Equations
The purpose is to investigate and eventually develop methods for estimating embedded parameters in stochastic differential equations using discrete time data. We focus on models for describing the dynamics of interest rates.

Department of Informatics and Mathematical Modeling

Unibank
Period: 01/09/1996 → 31/08/1999
Number of participants: 2
Project participant:

Baadsgaard, Mikkel (Intern)
Project Manager, organisational:
Madsen, Henrik (Intern)

Financing sources
Source: Unknown
Name of research programme: Ukendt
Amount: 81,075.00 Danish Kroner
Project

Estimation Techniques in Stochastic
Department of Informatics and Mathematical Modeling

Period: 01/09/1996 → 01/09/1999
Number of participants: 2
Phd Student:

Baadsgaard, Mikkel (Intern)
Main Supervisor:
Madsen, Henrik (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU-Su Stipendium, Eksperiment
Project: PhD

Identifikation og regulering af rensningsanlæg

Department of Informatics and Mathematical Modeling

Krüger A/S
Period: 01/05/1996 → 30/04/1999
Number of participants: 4
Project participant:

Poulsen, Niels Kjølstad (Intern)
Bechmann, Henrik (Intern)
Nielsen, Marinus (Ekstern)
Project Manager, organisational:
Madsen, Henrik (Intern)
Financing sources
Source: Unknown
Name of research programme: Ukendt
Amount: 36,175.00 Danish Kroner
Project

Modellering og Prædiktiv Styring af Spildevandssystemer
Department of Informatics and Mathematical Modeling
Period: 01/05/1996 → 28/04/2000
Number of participants: 3
Phd Student:
Bechmann, Henrik (Intern)
Supervisor:
Poulsen, Niels Kjølstad (Intern)
Main Supervisor:
Madsen, Henrik (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Erhvervsforskerordningen
Project: PhD

Stochastic modelling of nonlinear systems
Department of Informatics and Mathematical Modeling
Period: 01/03/1996 → 29/03/2001
Number of participants: 4
Phd Student:
Nielsen, Jan Nygaard (Intern)
Main Supervisor:
Madsen, Henrik (Intern)
Examiner:
Poulsen, Niels Kjølstad (Intern)
Ljung, Lennert (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU-Su Stipendium, Eksperiment
Project: PhD

Prædiktorer i kompkekse stokastiske systemer
Department of Informatics and Mathematical Modeling
Period: 01/02/1996 → 25/09/2000
Number of participants: 3
Phd Student:
Nielsen, Henrik Aalborg (Intern)
Supervisor:
Holst, Jens Juul (Ekstern)
Main Supervisor:
Madsen, Henrik (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Kandidatstipendium ansat på DT
Project: PhD

Stokastisk Prædiktiv Kontrol i Komplekse Systemer
Department of Informatics and Mathematical Modeling
Dynamisk kvalitetskontrol

Department of Informatics and Mathematical Modeling
Period: 01/01/1996 → ...
Number of participants: 3
Project participant:
Thyregod, Poul (Intern)
Iwersen, Jørgen (Ekstern)

Project Manager, organisational:
Madsen, Henrik (Intern)

Prediction models for wind energy production
During the resent years the number of wind mills in Denmark has increased dramatically. The amount of electricity produced by wind mills is now considerable compared to what is produced by other sources, and it is necessary to take this amount into consideration in the production planning. This is in particular the case for the areas Funen and Jutland where ELSAM is responsible for the production and delivery of electricity. Due to rather large startup periods for some production units it is advantageous to estimate the amount of wind energy up to about 36 hours ahead. In this project statistical methods for predicting the wind energy for the ELSAM area 36 hours ahead are developed. The methods are based on actual measurements from 7 wind mill parks distributed across the area. Methods for taking meteorological forecasts into the model are developed. Also models for on-line detection and correction of errors in the data are formulated. All the models are implemented with a graphical user interface, and the results will be used in the daily production planning at ELSAM. An off-line version of the program is developed for a distribution company called SEP in Holland.

Department of Informatics and Mathematical Modeling
Elsam A/S
SEP
Period: 01/01/1996 → 31/12/1998
Number of participants: 4
Project participant:
Nielsen, Torben Skov (Intern)
Sejling, Ken (Ekstern)
**Center for informationsteknologi i miljøsektoren**

CINTEM: I projektet udvikles såvel målemetoder som modelleringsmetoder i forbindelse med spildevandssystemer. Der udvikles eksempelvis nye optiske målesystemer i samarbejde med Danfoss, og i samarbejde med Kruger Systems udvikles modeller til forbedret styring af renseanlæg.

**Department of Informatics and Mathematical Modeling**

**Department of Environmental Science and Engineering**

Danfoss A/S

VKI Water Quality Institute

Krüger A/S

KTH - Royal Institute of Technology

Period: 01/06/1995 → 01/04/1999

Number of participants: 3

Project participant:

Øjelund, Henrik (Intern)

Sadegh, Payman (Intern)

**Project Manager, organisational:**

Madsen, Henrik (Intern)

**Financing sources**

Source: Unknown

Name of research programme: Ukendt

Amount: 301,500.00 Danish Kroner

**Development of methods for evaluation of electricity saving and load levelling measures**

The purpose of the project is to (i) develop and test methods for analysis of the dependence of the electricity power consumption on factors (possibly) affecting the consumption, (ii) develop and test methods for the planning and execution of relatively small trials concerning power conservation campaigns, and (iii) develop methods for estimation of the effect of power conservation campaigns, based on trial data. The results of the project have been published as two reports, both listed under the title of this project.

**Department of Informatics and Mathematical Modeling**

NESA A/S

Elkraft A.m.b.a.

Period: 01/03/1995 → 31/12/1997

Number of participants: 3

Project participant:

Nielsen, Henrik Aalborg (Intern)

Bergstrøm, Willy (Ekstern)

**Project Manager, organisational:**

Madsen, Henrik (Intern)

**Financing sources**

Source: Unknown

Name of research programme: Ukendt

Amount: 250,273.00 Danish Kroner

**Project**
Implementing Short Term Predictions at Utilities

The purpose of the project is to investigate possible prediction models for wind power in a larger area using on-line measurements from selected wind farms and meteorological forecasts of weather variables. The resulting models are implemented in a software tool for on-line wind power predictions - WPPT - and tested at utilities (ELSAM and ELTRA).

Department of Informatics and Mathematical Modeling

Rise National Laboratory

Danish Meteorological Institute

Elsam A/S

OEM Development Corp.

National Observatory of Athens

University of Athens

Elkraft A.m.b.A.

Rutherford Appleton Laboratory

Period: 01/01/1995 → 31/12/1998

Number of participants: 3

Project participant:

Nielsen, Torben Skov (Intern)

Nielsen, Henrik Aalborg (Intern)

Project Manager, organisational:

Madsen, Henrik (Intern)

Financing sources

Source: Unknown

Name of research programme: Ukendt

Amount: 1,500,000.00 Danish Kroner

Prognosemodeller for gasforbrug

Der udvikles statistiske modeller til prognoser af gasforbrug. Modellerne implementeres i samarbejde med LICconsult i en større tysk by.

Department of Informatics and Mathematical Modeling

LICconsult

Period: 17/06/1994 → 30/06/1996

Number of participants: 2

Project participant:

Nielsen, Torben Skov (Intern)

Project Manager, organisational:

Madsen, Henrik (Intern)

Financing sources

Source: Unknown

Name of research programme: Ukendt

Amount: 200,000.00 Danish Kroner

Identification af modeller for kedel og varmeanlæg


Department of Informatics and Mathematical Modeling

Lund Institute of Technology

Grundfos A/S
Period: 01/06/1994 → 31/05/1997
Number of participants: 5
Project participant:
Hansen, Lars Henrik (Intern)
Holst, Jan (Ekstern)
Bidstrup, Niels (Ekstern)
Vadstrup, Pierre (Ekstern)
Project Manager, organisational:
Madsen, Henrik (Intern)

Financing sources
Source: Unknown
Name of research programme: Ukendt
Amount: 30,645.00 Danish Kroner

Identifikation af modeller for kedel- og varmeanlæg
Department of Informatics and Mathematical Modeling
Period: 01/06/1994 → …
Number of participants: 4
Phd Student:
Hansen, Lars Henrik (Intern)
Main Supervisor:
Madsen, Henrik (Intern)
Examiner:
Hansen, Poul Erik (Ekstern)
Poulsen, Niels Kjølstad (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Erhvervsforskerordningen
Project: PhD

Tidsrækkeanalyse og Danamisk Modellering af Regnvands påvirkede Recipienter
Department of Informatics and Mathematical Modeling
Period: 01/04/1994 → …
Number of participants: 2
Phd Student:
Jacobsen, Judith L. (Intern)
Main Supervisor:
Madsen, Henrik (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Erhvervsforskerordningen
Project: PhD

Time series analysis and dynamic modelling of processes in rivers affected by precipitation runoff
Physical, chemical and biological processes involved in the oxygen dynamics in receiving waters are assessed through identification and estimation of stochastic dynamical models. The dynamics are expressed as a function of solar radiation, precipitation, surface runoff and runoff from urban sewer systems. The goal is a formulation in continuous time, which facilitates a direct physical interpretation and involves known physical laws and parameters in the model. The models will be used to assess the water quality of the receiving waters, with respect to the planning and management of water quality as well as the sensitivity to external influences. This will in turn increase the understanding of the complicated processes involved. The methods used, are the so-called “grey/box” techniques, which combine and exploit the strongest parts of the hitherto most used methodology. Here, known physical differential equations, as well as the data, are used to estimate parameters and possibly unknown processes. This means that non-linear processes can easily be included in the model, as opposed to traditional black-box models. Furthermore, stochastic effects, that any natural system will contain, can be accommodated.
Identification af Grey-Modeller

Forsøgsplanlægning for identifikation af delvis kendte systemer (grey-box modeller)

Forsøgsplanlægning er et fundamentalt område inden for system-identifikation. Optimalt planlagte eksperimenter fører til en mere effektiv model som f.eks. kan bruges til estimation af ukendte parametre, regulering, fejl-detektering, mv. Apriori viden (delvis viden) kan i denne sammenhæng formuleres og benyttes i design.

Statistisk finansieringsteori

Liberaliseringen af de internationale finansmarkeder har gjort det nødvendigt for banker og investeringselskaber mm. at anvende avancerede matematiske og statistiske metoder til risikostyring og -elimination (hedging). Der benyttes ikke-lineære filteringsmetoder til parameter- og tilstandsestimation i diskret observerede stokastiske differentialligninger. Der anvendes ikke-parametriske metoder til identifikation af stokastiske differentialligninger og heteroskedastiske modeller i diskret tid. Metoderne anvendes til modellering af multivariate rentestrukturnmodeller og stokastiske volatilitetsmodeller.

Identification af Grey-Modeller
Optimering af fjernvarmesystemer


Department of Informatics and Mathematical Modeling

Rambøll Danmark A/S

HTF

Period: 01/07/1993 → 30/06/1996

Number of participants: 3

Project participant:

Nielsen, Torben Skov (Intern)

Nielsen, Henrik Aalborg (Intern)

Project Manager, organisational:

Madsen, Henrik (Intern)

Financing sources

Source: Unknown

Name of research programme: Ukendt

Amount: 200,000.00 Danish Kroner

Project

Udvikling, afprøvning og implementering af GPC-regulatorer i fjernvarmesystemer

Formålet med projektet er at udvikle praktisk anvendelige GPC (General Predictive Control) reguleringsalgoritmer til driftsoptimering af kraftvarme- og fjernvarmesystemer. Arbejdet er en videreførelse af et tidligere EFP projekt - "Optimeret drift af fjernvarmesystemer". GPC-regulatoren er baseret på tidligere fundne modeller for tidsforsinkelse og temperatur forløb i distributionssystemet samt på prognosemodeller for forventet varmeforbrug. Den styrede variabel er fremløbstemperaturen der optimeres mht. brændselsforbrug, forsyningssikkerhed, siltage på distributionssystemet mm.. De udviklede algoritmer afprøves online hos Høje Taastrup Fjernvarme. Arbejdet er delvist finansieret af Energi ministeriets Forskningsprogram gennem EFP93 - "Regulering af fremløbstemperatur".

Department of Informatics and Mathematical Modeling

Høje Tåstrup Fjernvarme

Rambøll, Hannemann og Højlund

Period: 01/07/1993 → 30/06/1996

Number of participants: 2

Project participant:

Nielsen, Torben Skov (Intern)

Project Manager, organisational:

Madsen, Henrik (Intern)
Financing sources
Source: Unknown
Name of research programme: Ukendt
Amount: 300,000.00 Danish Kroner
Project:

Identifikation og styring af spildevandsprocesser
Department of Informatics and Mathematical Modeling
Period: 01/01/1991 → …
Number of participants: 3
Phd Student:
Carstensen, Niels Jacob (Intern)
Main Supervisor:
Madsen, Henrik (Intern)
Examiner:
Harremoës, Poul (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: ATV- Gammel ordning
Project: PhD

Undersøgelser af kontrolstrategier for regulering af fjernvarmesystemer
Department of Informatics and Mathematical Modeling
Period: 01/07/1990 → 16/06/1994
Number of participants: 3
Phd Student:
Palsson, Olafur Petur (Intern)
Supervisor:
Ravn, Hans V. (Intern)
Main Supervisor:
Madsen, Henrik (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Nordisk finansiering
Project: PhD

Identifikation af dynamiske systemer i kontinuert tid
Department of Informatics and Mathematical Modeling
Period: 01/03/1990 → 17/03/1995
Number of participants: 4
Phd Student:
Melgaard, Henrik (Intern)
Supervisor:
Hendricks, Elbert (Intern)
Holst, Jan (Intern)
Main Supervisor:
Madsen, Henrik (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Gammel ordning u/skema-SU
Project: PhD

Identifikation af varmedynamikken for bygningskomponenter
EF-projektet PASSYS har til formål at styrke grundlaget for udnyttelse af passiv solvarme i bygninger. Vha. en udendørs testcelle med udskiftelig endeveg ønskes de varmedynamiske egenskaber for en sådan væg bestemt. Det er meningen, at projektet skal munde ud i en fælles europæisk testmetode. Den danske metode til estimering i kontinuert tid (stokastiske differentialligninger) er blevet valgt som den ene af de to metoder, der arbejdes med. En del statistiske
problemstillinger indgår i projektet, fx. bestemmelse af et optimaal testsignal, som giver den bedst mulige bestemmelse af testcellens dynamik. Gruppen har deltager i CEN standardisering omkring måling på bygningselementer.

Department of Informatics and Mathematical Modeling

JRC
Lund Institute of Technology
Period: 01/01/1990 → …
Number of participants: 2
Project participant:
Melgaard, Henrik (Ekstern)
Project Manager, organisational:
Madsen, Henrik (Intern)

Financing sources
Source: Unknown
Name of research programme: Ukendt
Amount: 400,000.00 Danish Kroner
Project

Identifikation og estimation af underliggende parametervariationer i stokastiske modeller
Department of Informatics and Mathematical Modeling
Period: 15/02/1989 → 30/05/1994
Number of participants: 3
Phd Student:
Søgaard, Henning Tangen (Intern)
Supervisor:
Holst, Jan (Intern)
Main Supervisor:
Madsen, Henrik (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Gammel ordning u/skema-SU
Project: PhD

Modelling and prediction of load in district heating systems
Department of Informatics and Mathematical Modeling
Period: 01/02/1989 → 01/02/1994
Number of participants: 2
Phd Student:
Sejling, Ken (Intern)
Main Supervisor:
Madsen, Henrik (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Gammel ordning u/skema-SU
Project: PhD

System til optimal regulering af fjernvarme produktion
drift af fjernvarmesystemer*

Department of Informatics and Mathematical Modeling
Rambøll Danmark A/S

HTF
Period: 01/01/1988 → …
Number of participants: 3
Project participant:
Nielsen, Torben Skov (Intern)
Nielsen, Henrik Aalborg (Intern)
Project Manager, organisational:
Madsen, Henrik (Intern)

Financing sources
Source: Unknown
Name of research programme: Ukendt
Amount: 1,780,000.00 Danish Kroner

Activities:

A Stochastic Method to Manage Delay and Missing Values for In-Situ Sensors in an Alternating Activated Sludge Process
Period: 13 Jun 2017
Peter Alexander Stentoft (Speaker)
Jan Kloppenborg Møller (Other)
Henrik Madsen (Other)
Peter Steen Mikkelsen (Other)
Thomas Munk-Nielsen (Other)
Department of Applied Mathematics and Computer Science
Dynamical Systems
Department of Environmental Engineering
Urban Water Systems

Description
Oral Presentation
Degree of recognition: International

Related event
12th IWA Specialized Conference on Instrumentation, Control and Automation
11/06/2017 → 14/06/2017
Quebec, Canada
Activity: Talks and presentations › Conference presentations

Cities research for District Heating Innovation
Period: 6 Mar 2017
Alfred Heller (Speaker)
Henrik Madsen (Speaker)

Centre for IT-Intelligent Energy Systems in Cities
Department of Civil Engineering
Department of Applied Mathematics and Computer Science

Description
Workshop on further development of district heatings after 4DH.
Henrik presented mathematical tools for district heating, and Alfred presented the Science Cloud for District Heating Innovation.
5-års seminar om Lavenerghuset i Sisimiut
Period: 2 Jun 2010
Henrik Madsen (Speaker)

Department of Informatics and Mathematical Modeling
Mathematical Statistics
Arctic Technology Centre

Links:

Related event
5-års seminar om Lavenerghuset i Sisimiut
02/06/2010 → 02/06/2010
DTU Mødecenter
Activity: Other