Performance Comparison of Controllers with Fault-Dependent Control Allocation for UAVs

This paper combines fault-dependent control allocation with three different control schemes to obtain fault tolerance in the longitudinal control of unmanned aerial vehicles. The paper shows that fault-dependent control allocation is able to accommodate actuator faults that would otherwise be critical and it makes a performance assessment for the different control algorithms: an L1 adaptive backstepping controller; a robust sliding mode controller; and a standard PID controller.

The actuator faults considered are the partial to total loss of the elevator, which is a critical component for the safe operation of unmanned aerial vehicles. During nominal operation, only the main actuator, namely the elevator, is active for pitch control. In the event of a partial or total loss of the elevator, fault-dependent control allocation is used to redistribute control to available healthy actuators. Using simulations of a Cessna 182 aircraft model, controller performance and robustness are evaluated by metrics that assess control accuracy and energy use. System uncertainties are investigated over an envelope of pertinent variation, showing that sliding mode and L1 adaptive backstepping provide robustness, where PID control falls short. Additionally, a key finding is that the fault-dependent control allocation is instrumental when handling actuator faults.
Adaptive feedforward control of exhaust recirculation in large diesel engines

Environmental concern has led the International Maritime Organization to restrict NOₓ emissions from marine diesel engines. Exhaust gas recirculation (EGR) systems have been introduced in order to comply to the new standards. Traditional fixed-gain feedback methods are not able to control the EGR system adequately in engine loading transients so alternative methods are needed. This paper presents the design, convergence proofs and experimental validation of an adaptive feedforward controller that significantly improves the performance in loading transients. First the control concept is generalized to a class of first order Hammerstein systems with sensor delay and exponentially converging bounds of the control error are proven analytically. It is then shown how to apply the method to the EGR system of a two-stroke crosshead diesel engine. The controller is validated by closed loop simulation with a mean-value engine model, on an engine test bed and on a vessel operating at sea. A significant reduction of smoke formation during loading transients is observed both visually and with an opacity sensor.
Adaptive Observer for Nonlinearly Parameterised Hammerstein System with Sensor Delay – Applied to Ship Emissions Reduction

Taking offspring in a problem of ship emission reduction by exhaust gas recirculation control for large diesel engines, an underlying generic estimation challenge is formulated as a problem of joint state and parameter estimation for a class of multiple-input single-output Hammerstein systems with first order dynamics, sensor delay and a bounded time-varying parameter in the nonlinear part. The paper suggests a novel scheme for this estimation problem that guarantees exponential convergence to an interval that depends on the sensitivity of the system. The system is allowed to be nonlinear parameterized and time dependent, which are characteristics of the industrial problem we study. The approach requires the input nonlinearity to be a sector nonlinearity in the time-varying parameter. Salient features of the approach include simplicity of design and implementation. The efficacy of the adaptive observer is shown on simulated cases, on tests with a large diesel engine on test bed and on tests with a container vessel.

General information
State: E-pub ahead of print
Organisations: Department of Electrical Engineering, Automation and Control, MAN Diesel & Turbo, Linköping University
Authors: Nielsen, K. V. (Ekstern), Blanke, M. (Intern), Eriksson, L. (Ekstern)
Number of pages: 8
Publication date: 2017
Main Research Area: Technical/natural sciences
Nonlinear control systems, Joint state and parameter observer, Sensor delay
Model-based plant-wide optimization of large-scale lignocellulosic bioethanol plants.
Second generation biorefineries transform lignocellulosic biomass into chemicals with higher added value following a conversion mechanism that consists of: pretreatment, enzymatic hydrolysis, fermentation and purification. The objective of this study is to identify the optimal operational point with respect to maximum economic profit of a large scale biorefinery plant using a systematic model-based plantwide optimization methodology. The following key process parameters are identified as decision variables: pretreatment temperature, enzyme dosage in enzymatic hydrolysis, and yeast loading per batch in fermentation. The plant is treated in an integrated manner taking into account the interactions and trade-offs between the conversion steps. A sensitivity and uncertainty analysis follows at the optimal solution considering both model and feed parameters. It is found that the optimal point is more sensitive to feedstock composition than to model parameters, and that the optimization supervisory layer as part of a plantwide automation system has the following benefits: (1) increases the economical profit, (2) flattens the objective function allowing a wider range of operation without negative impact on profit, and (3) reduces considerably the uncertainty on profit.

General information
State: Published
Organisations: Department of Electrical Engineering, Automation and Control, Department of Chemical and Biochemical Engineering, CAPEC-PROCESS
Authors: Prunescu, R. M. (Intern), Blanke, M. (Intern), Jakobsen, J. G. (Ekstern), Sin, G. (Intern)
Number of pages: 13
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Main Research Area: Technical/natural sciences

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Journal: Biochemical Engineering Journal
Volume: 124
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Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.16
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 2.75
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 2.72
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 3.03
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 3.15
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 2.95
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Stability Boundaries for Offshore Wind Park Distributed Voltage Control

In order to identify mechanisms causing slow reactive power oscillations observed in an existing offshore wind power plant, and be able to avoid similar events in the future, voltage control is studied in this paper for a plant with a static synchronous compensator, type-4 wind turbines and a park pilot control. Using data from the actual wind power plant, all stabilizing subsystem voltage proportional-integral controller parameters are first characterized based on their Hurwitz signature. Inner loop current control is then designed using Internal Mode Control principles, and guidelines for feed forward filter design are given to obtain required disturbance rejection properties. The paper contributes by providing analytical relations between power plant control, droop, sampling time, electrical parameters and voltage control characteristics, and by assessing frequencies and damping of reactive power modes over a realistic envelope of electrical impedances and control parameters.

General information
State: Published
Organisations: Department of Electrical Engineering, Center for Electric Power and Energy, Electric power systems, Automation and Control, DONG Energy A/S
Authors: Gryning, M. P. (Ekstern), Wu, Q. (Intern), Kocewiak, L. (Ekstern), Niemann, H. H. (Intern), Andersen, K. P. (Ekstern), Blanke, M. (Intern)
Pages: 1496 - 1504
Publication date: 2017
Main Research Area: Technical/natural sciences

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Journal: IEEE Transactions on Control Systems Technology
Volume: 25
Issue number: 4
ISSN (Print): 1063-6536
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BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): SJR 2.017 SNIP 2.755 CiteScore 5.17
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.85 SNIP 2.757 CiteScore 4.72
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.958 SNIP 3.042 CiteScore 4.34
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.825 SNIP 3.498 CiteScore 4.41
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
Adaptive FTC based on Control Allocation and Fault Accommodation for Satellite Reaction Wheels

This paper proposes an active fault tolerant control scheme to cope with faults or failures affecting the flywheel spin rate sensors or satellite reaction wheel motors. The active fault tolerant control system consists of a fault detection and diagnosis module along with a control allocation and fault accommodation module directly exploiting the on-line fault estimates. The use of the nonlinear geometric approach and radial basis function neural networks allows to obtain a precise fault isolation, independently from the knowledge of aerodynamic disturbance parameters, and to design generalised estimation filters, which do not need a priori information about the internal model of the signal to be estimated. The adaptive control allocation and sensor fault accommodation can handle both temporal faults and failures. Simulation results illustrate the convincing fault correction and attitude control performances of the proposed system.
Combined Geometric and Neural Network Approach to Generic Fault Diagnosis in Satellite Actuators and Sensors

This paper presents a novel scheme for diagnosis of faults affecting the sensors measuring the satellite attitude, body angular velocity and flywheel spin rates as well as defects related to the control torques provided by satellite reaction wheels. A nonlinear geometric design is used to avoid that aerodynamic disturbance torques have unwanted influence on the residuals exploited for fault detection and isolation. Radial basis function neural networks are used to obtain fault estimation filters that do not need a priori information about the fault internal models. Simulation results are based on a detailed nonlinear satellite model with embedded disturbance description. The results document the efficacy of the proposed diagnosis scheme.

General information

State: Published
Organisations: Department of Electrical Engineering, Automation and Control, University of Ferrara
Authors: Baldi, P. (Ekstern), Blanke, M. (Intern), Castaldi, P. (Ekstern), Mimmo, N. (Ekstern), Simani, S. (Ekstern)
Pages: 432–437
Publication date: 2016
Conference: 20th IFAC Symposium on Automatic Control in Aerospace, Sherbrooke, Quebec, Canada, 21/08/2016 - 21/08/2016
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Ratings:
Scopus rating (2016): SJR 0.263 SNIP 0.334 CiteScore 0.45
Scopus rating (2015): SJR 0.256 SNIP 0.324
Scopus rating (2014): SJR 0.285 SNIP 0.342
Scopus rating (2013): SJR 0.305 SNIP 0.364
Scopus rating (2012): SJR 0.247 SNIP 0.278
Scopus rating (2011): SJR 0.257 SNIP 0.312
Scopus rating (2010): SJR 0.196 SNIP 0.26
Scopus rating (2009): SJR 0.215 SNIP 0.296
Scopus rating (2008): SJR 0.125 SNIP 0.105
Scopus rating (2007): SJR 0.126 SNIP 0.065
Scopus rating (2006): SJR 0.101 SNIP 0.005
Scopus rating (2005): SJR 0.21 SNIP 0.467
Scopus rating (2004): SJR 0.268 SNIP 0.432
Scopus rating (2003): SJR 0.276 SNIP 0.41
Original language: English
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DOIs:
10.1016/j.ifacol.2016.09.074
Source: PublicationPreSubmission
Source-ID: 125022478
Publication: Research - peer-review › Journal article – Annual report year: 2016
Control-Oriented Model of Molar Scavenge Oxygen Fraction for Exhaust Recirculation in Large Diesel Engines

Exhaust gas recirculation (EGR) systems have been introduced to large marine engines in order to reduce NOx formation. Adequate modelling for control design is one of the bottlenecks to design EGR control that also meets emission requirements during transient loading conditions. This paper therefore focus on deriving and validating a mean-value model of a large two-stroke crosshead diesel engines with EGR. The model introduces a number of amendments and extensions to previous, complex models and shows in theory and practice that a simplified nonlinear model captures all essential dynamics that is needed for EGR control. Our approach is to isolate and reduce the gas composition part of the more complex models using nonlinear model reduction techniques. The result is a control-oriented model (COM) of the oxygen fraction in the scavenge manifold with three molar flows being inputs to the COM, and it is shown how these flows are estimated from signals that are commonly available. The COM is validated by first comparing the output to a simulation of the full model, then by comparing with measurement series from two engines. The control oriented nonlinear model is shown to be able to replicate the behavior of the scavenge oxygen fraction well over the entire envelope of load and blower speed range that are relevant for EGR. The simplicity of the new model makes it suitable for observer and control design, which are essential steps to meet the emission requirements for marine diesel engines that take effect from 2016.

General information
State: Published
Organisations: Department of Electrical Engineering, Automation and Control, Linköping University, MAN B&W Diesel A/S
Authors: Nielsen, K. V. (Intern), Blanke, M. (Intern), Eriksson, L. (Ekstern), Vejlgaard-Laursen, M. (Ekstern)
Number of pages: 10
Publication date: 2016
Main Research Area: Technical/natural sciences

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Journal: Journal of Dynamic Systems, Measurement and Control
Volume: 139
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Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.52 SNIP 0.792 CiteScore 1.29
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.626 SNIP 0.89 CiteScore 1.36
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.673 SNIP 1.23 CiteScore 1.38
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.723 SNIP 1.234 CiteScore 1.4
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.579 SNIP 1.043 CiteScore 1.09
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.564 SNIP 0.995 CiteScore 0.96
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.844 SNIP 1.639
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.812 SNIP 1.476
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.711 SNIP 1.364
Scopus rating (2007): SJR 0.551 SNIP 1.368
Scopus rating (2006): SJR 0.657 SNIP 1.53
Scopus rating (2005): SJR 0.512 SNIP 1.169
Scopus rating (2004): SJR 0.724 SNIP 1.351
Scopus rating (2003): SJR 0.923 SNIP 1.474
Scopus rating (2002): SJR 1.187 SNIP 1.365
Diagnosis for Control and Decision Support for Autonomous Vehicles

Diagnosis and, when possible, prognosis of faults are essential for safe and reliable operation. The area of fault diagnosis has emerged over three decades. The majority of studies are related to linear systems but real-life systems are complex and nonlinear. The development of methodologies coping with complex and nonlinear systems have matured and even though there are many unsolved problems, methodology and associated tools have become available in the form of theory and software for design. Genuine industrial cases have also become available. Analysis of system topology, referred to as structural analysis, has proven to be unique and simple in use and a recent extension to active structural techniques have made fault isolation possible in a wide range of systems.

Following residual generation using these topology-based methods, deterministic and statistical change detection has proven very useful for online prognosis and diagnosis. For complex systems, results from nonGaussian detection theory have been employed with convincing results. The chapter presents the theoretical foundation for design methodologies that now appear as enabling technology for a new area of design of systems that are reliable in practise. Yet they are also affordable due to the use of fault-tolerant philosophies and tools that make engineering efforts minimal for their implementation. The chapter includes examples for an autonomous aircraft and a baling system for agriculture to illustrate the generic design procedures and real life results.

General information
State: Published
Organisations: Department of Electrical Engineering, Automation and Control, CLAAS Agrosystems
Authors: Blanke, M. (Intern), Hansen, S. (Intern), Rufus Blas, M. (Ekstern)
Pages: 3-37
Publication date: 2016

Efficient Modelling Methodology for Reconfigurable Underwater Robots

This paper considers the challenge of applying reconfigurable robots in an underwater environment. The main result presented is the development of a model for a system comprised of N, possibly heterogeneous, robots dynamically connected to each other and moving with 6 Degrees of Freedom (DOF). This paper presents an application of the Udwadia-Kalaba Equation for modelling the Reconfigurable Underwater Robots. The constraints developed to enforce the rigid connection between robots in the system is derived through restrictions on relative distances and orientations. To avoid singularities in the orientation and, thereby, allow the robots to undertake any relative configuration the attitude is represented in Euler parameters.

General information
State: Published
Organisations: Department of Electrical Engineering, Automation and Control, Norwegian University of Science and Technology
Exhaust Recirculation Control for Reduction of NOx from Large Two-Stroke Diesel Engines

Increased awareness of the detrimental effects on climate, ecosystems and human health have led to numerous restrictions of the emissions from internal combustion engines. Recently the International Maritime Organization has introduced the Tier III standard, which includes a significantly stricter restriction on NOx emissions from large two-stroke diesel engines on vessels operating in certain NOx Emission Control Areas. Exhaust Gas Recirculation (EGR) is one of the three technologies on the market that are able to reduce the NOx emission adequately for Tier III operation. EGR is well known from the automotive industry, but have only recently been introduced commercially to large two-stroke diesel engines. Recirculation of exhaust gas to the cylinders lowers the oxygen availability and increases the heat capacity during combustion, which in turn leads to less formation of NOx. Experience shows, that while large two-stroke engines with EGR perform well in steady state, fast engine load transients cause smoke formation due to the decreased oxygen availability. The aim of this thesis is to design a control system that enables the large two-stroke engines with EGR to meet the emission limits of the Tier III standard, while still maintaining maneuverability performance without smoke formation. The design methods acknowledge that engine specific parameter tuning is a scarce resource in the industry and controller complexity is kept to a minimum. An existing dynamic model of the engine and EGR system is adapted and used for high-fidelity simulation. By isolating the gas composition part of the model and removing non-essential dynamics, a novel nonlinear reduced model of scavenge oxygen fraction is developed. Based on the reduced model, a novel nonlinear joint state and parameter observer for the scavenge oxygen fraction is designed. This observer compensates for a significant delay in the oxygen sensor, and observer errors are proven to converge exponentially. By inverting part of the reduced model and using the parameter observer, a novel scavenge oxygen controller based on nonlinear adaptive feed forward is developed. The controller error is proven to converge exponentially. This controller requires only one tuning parameter in addition to a number of physical parameters of the engine system. It exploits the availability of fuel and EGR flow estimates and the turbocharger speed to provide fast adjustment of EGR flow. In addition to the scavenge oxygen controller, a novel fuel index limiter based on oxygen/fuel-ratio is introduced and investigated. The limiter ensures that the maximal fuel flow set by the engine speed governor does not exceed the amount that can be completely burned, by
considering the oxygen contents of the scavenge gas. The reduced model, observer, controller and limiter designs are validated by simulation of the high-fidelity engine model, and by closed loop experiments on an engine at test bed and on a vessel operating at sea. Significant performance improvements promised by the simulations are verified in the experiments. Scavenge oxygen control during transients is improved, when compared to the reference controller. Formation of visible smoke is completely avoided, while acceleration performance is maintained. The contributions of this project enable the EGR technology on large two-stroke diesel engines to reduce NOx emissions by a factor of four without compromising vessel maneuverability. Project partner MAN Diesel & Turbo has applied for a patent covering the EGR controller design in Japan, China and South Korea. The controllers developed in this project are planned to be included as standard in commercially available EGR controller software by 2017. The thesis consists of a summary of the methods developed and validations performed during the project. The results are disseminated in a number of papers submitted to research journals and a conference.

General information
State: Published
Organisations: Department of Electrical Engineering, Automation and Control
Authors: Nielsen, K. V. (Intern), Blanke, M. (Intern), Vejlgaard-Laursen, M. (Ekstern), Eriksson, L. (Ekstern)
Number of pages: 142
Publication date: 2016

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Original language: English
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Projects:
Exhaust Recirculation Control for Reduction of NOx from Large Two-Stroke Diesel Engines
Source: PublicationPreSubmission
Source-ID: 131478224
Publication: Research › Ph.D. thesis – Annual report year: 2017

Fault Tolerant Emergency Control to Preserve Power System Stability
This paper introduces a method for fault-masking and system reconfiguration in power transmission systems. The paper demonstrates how faults are handled by reconfiguring remaining controls through utilisation of wide-area measurement in real time. It is shown how reconfiguration can be obtained using a virtual actuator concept, which covers Lure-type systems. The paper shows the steps needed to calculate a virtual actuator, which relies on the solution of a linear matrix inequality. The solution is shown to work with existing controls by adding a compensation signal. Simulation results of a benchmark system show ability of the reconfiguration to maintain stability.

General information
State: Published
Organisations: Department of Electrical Engineering, Automation and Control, Center for Electric Power and Energy, Electric power systems
Authors: Pedersen, A. S. (Intern), Richter, J. H. (Ekstern), Tabatabaeipour, M. (Intern), Jóhannsson, H. (Intern), Blanke, M. (Intern)
Pages: 151–159
Publication date: 2016
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 3.42 SJR 1.287 SNIP 2.156
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
On-Line Generation and Arming of System Protection Schemes

This paper presents a new method to automatically generate system protection schemes in real-time, where contingencies are filtered using a method providing N–1 system snapshots. With future power systems consisting largely of renewable distributed generation with time-varying production, highly fluctuating conditions throughout the day will be the result. This makes off-line design of extensive defense plans for power systems infeasible, forming the motivation for the presented method. It relies on the real-time identification of which disturbances that threatens a power systems integrity. The method is based on a recently proposed method of calculating post-contingency Thevenin equivalents, which are used to assess the security of the post-contingency condition. The contingencies that violate the emergency limits are contained by pre-determining event-based remedial actions. The instability mechanisms threatening the system are individually treated, such that appropriate controls are allocated. The procedure is illustrated through a case study using the Nordic32 benchmark system.

General information
State: Published
Organisations: Department of Electrical Engineering, Automation and Control, Center for Electric Power and Energy, Electric power systems
Response Analysis and Comparison of a Spar-Type Floating Offshore Wind Turbine and an Onshore Wind Turbine under Blade Pitch Controller Faults

This paper analyses the effects of three pitch controller faults on the responses of an onshore wind turbine and a spar-type offshore floating wind turbine. These faults include: a stuck blade pitch actuator, a fixed value fault and a bias fault of the blade pitch sensor. The faults are modeled in the controller dynamic link library and a short-term extreme response analysis is performed using the HAWC2 simulation tool. The main objectives of this paper are to investigate how different faults affect the performance of wind turbines for condition monitoring purposes and which differences exist in the structural responses between onshore and offshore floating wind turbines. Statistical analysis of the selected response parameters are conducted using the six 1-hour stochastic samples for each load case. For condition monitoring purposes, the effects of faults on the responses at different wind speeds and fault amplitudes are investigated by comparing the same response under normal operation. The severities of the individual faults are categorized by the extreme values of structural loads and the structural components are sorted based on the magnitude of the fault effects on the extreme values. The pitch sensor fixed value fault is determined as the most severe fault case and the shaft appears as the structural component that experiences the highest risk. The effects of fault conditions on the offshore floating and the onshore wind turbines are compared to investigate the potential differences. The results show that faults cause more damage to the tower and the yaw bearing for the onshore wind turbine and more damage to the shaft for the offshore floating wind turbine.

General information
State: Published
Organisations: Department of Electrical Engineering, Automation and Control, Norwegian University of Science and Technology
Authors: Etemaddar, M. (Ekstern), Blanke, M. (Intern), Gao, Z. (Ekstern), Moan, T. (Ekstern)
Number of pages: 15
Pages: 35–50
Publication date: 2016
Main Research Area: Technical/natural sciences

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- Web of Science (2017): Indexed Yes
- BFI (2016): BFI-level 2
- Scopus rating (2016): SJR 1.104 SNIP 2.306 CiteScore 3.37
- 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
Statistical fault diagnosis of wind turbine drivetrain applied to a 5MW floating wind turbine

Deployment of large scale wind turbine parks, in particular offshore, requires well organized operation and maintenance strategies to make it as competitive as the classical electric power stations. It is important to ensure systems are safe, profitable, and cost-effective. In this regards, the ability to detect, isolate, estimate, and prognose faults plays an important role. One of the critical wind turbine components is the gearbox. Failures in the gearbox are costly both due to the cost of the gearbox itself and also due to high repair downtime. In order to detect faults as fast as possible to prevent them to develop into failure, statistical change detection is used in this paper. The Cumulative Sum Method (CUSUM) is employed to detect possible defects in the downwind main bearing. A high fidelity gearbox model on a 5-MW spar-type wind turbine is used to generate data for fault-free and faulty conditions of the bearing at the rated wind speed and the associated wave condition. Acceleration measurements are utilized to find residuals used to indirectly detect damages in the bearing. Residuals are found to be non-Gaussian, following a t-distribution with multivariable characteristic parameters. The results in this paper show how the diagnostic scheme can detect change with desired false alarm and detection probabilities.
Validation of multi-body modelling methodology for reconfigurable underwater robots

This paper investigates the problem of employing reconfigurable robots in an underwater setting. The main results presented is the experimental validation of a modelling methodology for a system consisting of N dynamically connected robots with heterogeneous dynamics. Two distinct types of experiments are performed, a series of hydrostatic free-decay tests and a series of open-loop trajectory tests. The results are compared to a simulation based on the modelling methodology. The modelling methodology shows promising results for usage with systems composed of reconfigurable underwater modules. The purpose of the model is to enable design of control strategies for cooperative reconfigurable underwater systems.

Centralised versus Decentralised Control Reconfiguration for Collaborating Underwater Robots.

The present paper introduces an approach to fault-tolerant reconfiguration for collaborating underwater robots. Fault-tolerant reconfiguration is obtained using the virtual actuator approach, Steen (2005). The paper investigates properties of a centralised versus a decentralised implementation and assesses the capabilities under communication constraints between the individual robots. In the centralised case, each robot sends information related to its own status to a unique virtual actuator that computes the necessary reconfiguration. In the decentralised case, each robot is equipped with its own virtual actuator that is able to accommodate both local faults and faults within a collaborating unit. The paper discusses how this is done through exploiting structural information (e.g. thruster configuration) for each participant in the cooperation. A test scenario is presented as a case in which an underwater drill needs to be transported and positioned by three collaborating robots as part of an underwater autonomous operation.
Collective Modular Underwater Robotic System for Long-Term Autonomous Operation
This paper provides a brief overview of an underwater robotic system for autonomous inspection in confined offshore underwater structures. The system, which is currently in development, consists of heterogeneous modular robots able to physically dock and communicate with other robots, transport tools and robots, and recharge their batteries while underwater. These properties will provide the system, when fully developed, with unique capabilities such as ability to adapt robotic morphology and function to the current task and tolerate failures leading to long-term autonomous operations.

General information
State: Published
Organisations: Department of Electrical Engineering, Automation and Control, Centre for Playware
Authors: Christensen, D. J. (Intern), Andersen, J. C. (Intern), Blanke, M. (Intern), Furno, L. (Intern), Galeazzi, R. (Intern), Hansen, P. N. (Intern), Nielsen, M. C. (Intern)
Publication date: 2015
Main Research Area: Technical/natural sciences
Electronic versions:

Combined Geometric and Neural Network Approach to Generic Fault Diagnosis in Satellite Reaction Wheels
This paper suggests a novel diagnosis scheme for detection, isolation and estimation of faults affecting satellite reaction wheels. Both spin rate measurements and actuation torque defects are dealt with. The proposed system consists of a fault detection and isolation module composed by a bank of residual filters organized in a generalized scheme, followed by a fault estimation module consisting of a bank of adaptive estimation filters. The residuals are decoupled from aerodynamic disturbances thanks to the Nonlinear Geometric Approach. The use of Radial Basis Function Neural Networks is shown to allow design of generalized fault estimation filters, which do not need a priori information about the faults internal model. Simulation results with a detailed nonlinear spacecraft model, which includes disturbances, show that the proposed diagnosis scheme can deal with faults affecting both reaction wheel torques and flywheel spin rate measurements, and obtain precise fault isolation as well as accurate fault estimates.

General information
State: Published
Organisations: Department of Electrical Engineering, Automation and Control, University of Bologna, University of Ferrara
Authors: Baldi, P. (Ekstern), Blanke, M. (Intern), Castaldi, P. (Ekstern), Mimmo, N. (Ekstern), Simani, S. (Ekstern)
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Publication date: 2015
Main Research Area: Technical/natural sciences

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BFI (2016): BFI-level 1
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.228 SNIP 0.217 CiteScore 0.27
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.252 SNIP 0.242 CiteScore 0.26
Convex Relaxation of Power Dispatch for Voltage Stability Improvement

A method for enhancing the voltage stability of a power system is presented in this paper. The method is based on a stability-constrained optimal power flow approach, where dispatch is done such that a maximum L-index is minimized for all load busses in a transmission grid. It is shown that optimal dispatch is obtainable with enhanced margins for voltage stability using a semidefinite relaxation of the optimal power flow problem, and that this problem can be formulated as a semidefinite program with a quasi-convex objective. Numerical tests are performed on the IEEE-30 bus and BPA systems. The feasibility of the method is demonstrated through demonstrating that improved voltage stability margins are obtained for both systems.
Convex Relaxation of Power Dispatch for Voltage Stability Improvement
Source: PublicationPreSubmission
Source-ID: 116686023
Publication: Research - peer-review › Article in proceedings – Annual report year: 2015

Diagnosis and Fault-tolerant Control, 3rd Edition
The book presents effective model-based analysis and design methods for fault diagnosis and fault-tolerant control. Architectural and structural models are used to analyse the propagation of the fault through the process, to test the fault detectability and to find the redundancies in the process that can be used to ensure fault tolerance. It also introduces design methods suitable for diagnostic systems and fault-tolerant controllers for continuous processes that are described by analytical models of discrete-event systems represented by automata.

General information
State: Published
Organisations: Department of Electrical Engineering, Automation and Control, Universite Libre de Bruxelles
Authors: Blanke, M. (Intern), Kinnaert, M. (Ekstern), Lunze, J. (Ekstern), Staroswiecki, M. (Ekstern)
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10.1007/978-3-662-47943-8
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Source-ID: 116747803
Publication: Research - peer-review › Book – Annual report year: 2015

Diagnosis of CO Pollution in HTPEM Fuel Cell using Statistical Change Detection
The fuel cell technologies are advancing and maturing for commercial markets. However proper diagnostic tools needs to be developed in order to insure reliability and durability of fuel cell systems. This paper presents a design of a data driven method to detect CO content in the anode gas of a high temperature fuel cell. In this work the fuel cell characterization is based on an experimental equivalent electrical circuit, where model parameters are mapped as a function of the load current. The designed general likelihood ratio test detection scheme detects whether a equivalent electrical circuit parameter differ from the non-faulty operation. It is proven that the general likelihood ratio test detection scheme, with a very low probability of false alarm, can detect CO content in the anode gas of the fuel cell.

General information
State: Published
Organisations: Department of Electrical Engineering, Automation and Control, Aalborg University
Authors: Jeppesen, C. (Forskerdatabase), Blanke, M. (Intern), Zhou, F. (Forskerdatabase), Andreasen, S. J. (Forskerdatabase)
Pages: 547-553
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Main Research Area: Technical/natural sciences

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Journal: IFAC-PapersOnLine
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Scopus rating (2015): SJR 0.256 SNIP 0.324
Scopus rating (2014): SJR 0.285 SNIP 0.342
Scopus rating (2013): SJR 0.305 SNIP 0.364
Scopus rating (2012): SJR 0.247 SNIP 0.278
Diagnosis of Wing Icing Through Lift and Drag Coefficient Change Detection for Small Unmanned Aircraft

This paper addresses the issue of structural change, caused by ice accretion, on UAVs by utilizing a Neyman Pearson (NP) based statistical change detection approach, for the identification of structural changes of fixed wing UAV airfoils. A structural analysis is performed on the nonlinear aircraft system and residuals are generated, where a generalised likelihood ratio test is applied to detect faults. Numerical simulations demonstrate a robust detection with adequate balance between false alarm rate and sensitivity.

General information
State: Published
Organisations: Department of Electrical Engineering, Automation and Control
Authors: Sørensen, K. L. (Ekstern), Blanke, M. (Intern), Johansen, T. A. (Ekstern)
Pages: 541-546
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Conference: IFAC Safeprocess'15, Paris, France, 02/09/2015 - 02/09/2015
Main Research Area: Technical/natural sciences

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Volume: 48
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Scopus rating (2014): SJR 0.285 SNIP 0.342
Scopus rating (2013): SJR 0.305 SNIP 0.364
Scopus rating (2012): SJR 0.247 SNIP 0.278
Scopus rating (2011): SJR 0.257 SNIP 0.312
Scopus rating (2010): SJR 0.196 SNIP 0.26
Scopus rating (2009): SJR 0.215 SNIP 0.296
Scopus rating (2008): SJR 0.125 SNIP 0.105
Scopus rating (2007): SJR 0.126 SNIP 0.065
Scopus rating (2006): SJR 0.101 SNIP 0.005
Scopus rating (2005): SJR 0.21 SNIP 0.467
Scopus rating (2004): SJR 0.268 SNIP 0.432
Drillstring Washout Diagnosis Using Friction Estimation and Statistical Change Detection

In oil and gas drilling, corrosion or tensile stress can give small holes in the drillstring, which can cause leakage and prevent sufficient flow of drilling fluid. If such washout remains undetected and develops, the consequence can be a complete twist-off of the drillstring. Aiming at early washout diagnosis, this paper employs an adaptive observer to estimate friction parameters in the nonlinear process. Non-Gaussian noise is a nuisance in the parameter estimates, and dedicated generalized likelihood tests are developed to make efficient washout detection with the multivariate t-distribution encountered in data. Change detection methods are developed using logged sensor data from a horizontal 1400 m managed pressure drilling test rig. Detection scheme design is conducted using probabilities for false alarm and detection to determine thresholds in hypothesis tests. A multivariate approach is demonstrated to have superior diagnostic properties and is able to diagnose a washout at very low levels. The paper demonstrates the feasibility of fault diagnosis technology in oil and gas drilling.
Hydrothermal pretreatment of lignocellulosic biomass is a cost effective technology for second generation biorefineries. The process occurs in large horizontal and pressurized thermal reactors where the biomatrix is opened under the action of steam pressure and temperature to expose cellulose for the enzymatic hydrolysis process. Several by-products are also formed, which disturb and act as inhibitors downstream. The objective of this study is to formulate and validate a large scale hydrothermal pretreatment dynamic model based on mass and energy balances, together with a complex conversion mechanism and kinetics. The study includes a comprehensive sensitivity and uncertainty analysis, with parameter estimation from real-data in the 178-185° range. To highlight the application utility of the model, a state estimator for biomass composition is developed. The predictions capture well the dynamic trends of the process, outlining the value of the model for simulation, control design, and optimization for full-scale applications.
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Original language: English

Electronic versions:

Prunescu_et_al._2015_Dynamic_Modeling_and_Validation_of_a_Biomass_Hydrothermal_Pretreatment_Process_A_Demo
nstration_Scale_Study.pdf

DOIs:

10.1002/aic.14954
Second generation biorefineries transform agricultural wastes into biochemicals with higher added value, e.g. bioethanol, which is thought to become a primary component in liquid fuels [1]. Extensive endeavors have been conducted to make the production process feasible on a large scale, and recently several commercial size biorefineries became operational: Beta Renewables (Italy, 2014), Abengoa Bioenergy (USA, 2014), POET-DSM (USA, 2014), GranBio (Brazil, 2014) [2], while others are under construction, e.g. the Måbjerg Energy Consortium in Denmark. This thesis presents the findings of a 3 years PhD project that was run by Technical University of Denmark (DTU) in collaboration with the largest Danish energy company DONG Energy A/S between 2012 and 2015. The company owns a demonstration scale second generation biorefinery in Kalundborg, Denmark, also known as the Inbicon demonstration plant [3]. The goal of the project is to utilize realtime data extracted from the large scale facility to formulate and validate first principle dynamic models of the plant. These models are then further exploited to derive model-based tools for process optimization, advanced control and real-time monitoring. The Inbicon biorefinery converts wheat straw into bioethanol utilizing steam, enzymes, and genetically modified yeast. The biomass is first pretreated in a steam pressurized and continuous thermal reactor where lignin is relocated, and hemicellulose partially hydrolyzed such that cellulose becomes more accessible to enzymes. The biorefinery is integrated with a nearby power plant following the Integrated Biomass Utilization System (IBUS) principle for reducing steam costs [4]. During the pretreatment, by-products are also created such as organic acids, furfural, and pseudo-lignin, which act as inhibitors in downstream processes. The pretreated fibers consist of cellulose and xylan, which are then liquefied in the enzymatic hydrolysis process with the help of enzymes. High glucose and xylose yields are thus obtained for co-fermentation. Ethanol is recovered in distillation columns followed by molecular sieves for achieving a high concentration ethanol. Lignin is separated in the first column and recovered as bio-pellets in an evaporation unit. The bio-pellets are then burnt in the nearby power plant for steam generation. The first part of this research presents a large scale dynamic model of the plant, separated in modules for pretreatment, enzymatic hydrolysis, and fermentation. The pretreatment and enzymatic hydrolysis models have been validated and analyzed in this study together with a comprehensive sensitivity and uncertainty analysis [5, 6]. The models embed mass and energy balances with a complex conversion route. Computational fluid dynamics is used to model transport phenomena in large reactors capturing tank profiles, and delays due to plug flows. This work publishes for the first time demonstration scale real data for validation showing that the model library is suitable for optimization, control and monitoring purposes. As an application, the pretreatment dynamic model is used to construct a realtime observer that acts both as a measurement filter, and soft sensor for biomass components that are not measured, e.g. pretreatment inhibitors [5]. The next part of this study deals with building a plantwide model-based optimization layer, which searches for optimal values regarding the pretreatment temperature, enzyme dosage in liquefaction, and yeast seed in fermentation such that profit is maximized [7]. When biomass is pretreated, by-products are also created that affect the downstream processes acting as inhibitors in enzymatic hydrolysis and fermentation. Therefore, the biorefinery is treated in an integrated manner capturing the trade-offs between the conversion steps. Sensitivity and uncertainty analysis is also performed in order to identify the modeling bottlenecks and which feedstock components need to be determined for an accurate prediction. This analysis is achieved with Monte Carlo simulations and Latin Hypercube Sampling (LHS) on feedstock composition and kinetic parameters following the methodology from [5, 6, 8, 9]. In the last part of this work, two applications of the L1 adaptive output feedback controller [10] are developed: one for biomass pretreatment temperature [11] and another one for pH in enzymatic hydrolysis [12]. Biomass conversion is highly sensitive to these process parameters, which exhibit nonlinear behavior and can change nominal values. The adaptive controllers are found to perform better across multiple operational points without the need of retuning.

**General information**

- **State:** Published
- **Organisations:** Department of Electrical Engineering, Automation and Control, Department of Chemical and Biochemical Engineering, CAPEC-PROCESS, DONG Energy A/S
- **Authors:** Prunescu, R. M. (Intern), Blanke, M. (Intern), Sin, G. (Intern), Jensen, J. M. (Ekstern), Jakobsen, J. G. (Ekstern)
- **Number of pages:** 244
- **Publication date:** 2015

**Publication information**

- **Publisher:** Technical University of Denmark, Department of Electrical Engineering
- **Original language:** English
- **Main Research Area:** Technical/natural sciences
- **Electronic versions:** Remus_phdthesis.pdf
Early Detection and Localization of Downhole Incidents in Managed Pressure Drilling

Downhole incidents such as kick, lost circulation, pack-off, and hole cleaning issues are important contributors to downtime in drilling. In managed pressure drilling (MPD), operations margins are typically narrower, implying more frequent incidents and more severe consequences. Detection and handling of symptoms of downhole contingencies at an early stage are therefore crucial for the reliability and safety of MPD operations. In this paper we describe a method for early detection and localization of such incidents, based on a fit for purpose model of the downhole pressure hydraulics, distributed pressure measurements from wired pipe, and statistical change detection methods. Using statistical change detection methods, it is possible to detect the incidents and their location at a very early stage when small changes in operating parameters are covered in measurement noise. The method has successfully been tested on experimental data from a medium-scale horizontal flow loop in Stavanger, Norway. The flow loop represents a 700 m borehole with emulation of the following downhole contingencies: drillstring washout, drill bit nozzle plugging, gas influx and fluid loss. In the tests, these incidents have been successfully detected at an early stage, when detection by a human operator observing the measured data is almost impossible. The developed detection and localization method can be included as a diagnosis tool in a drilling system with MPD or conventional drilling.

Early pack-off diagnosis in drilling using an adaptive observer and statistical change detection

Pack-off is a partially or complete blocking of the circulation flow in oil and gas drilling, which can lead to costly delays. Early detection and localization of a pack-off is crucial in order to take necessary actions avoiding downtime. This incident will affect physical friction parameters in the well. A model-based adaptive observer is used to estimate these friction parameters as well as flow rates. Detecting changes to these estimates can then be used for pack-off diagnosis, which due to measurement noise is done using statistical change detection. Isolation of incident type and location is done using a multivariate generalized likelihood ratio test, determining the change direction of the estimated mean values. The method is tested on simulated data from the commercial high-fidelity multi-phase simulator OLGA, where three different pack-offs at different locations and with different magnitudes are successfully detected at an early stage and with low false alarms.
Fault diagnosis of downhole drilling incidents using adaptive observers and statistical change detection

Downhole abnormal incidents during oil and gas drilling causes costly delays, and may also potentially lead to dangerous scenarios. Different incidents will cause changes to different parts of the physics of the process. Estimating the changes in physical parameters, and correlating these with changes expected from various defects, can be used to diagnose faults while in development. This paper shows how estimated friction parameters and flow rates can detect and isolate the type of incident, as well as isolating the position of a defect. Estimates are shown to be subjected to non-Gaussian, t-distributed noise, and a dedicated multivariate statistical change detection approach is used to detect and isolate faults by detecting simultaneous changes in estimated parameters and flow rates. The properties of the multivariate diagnosis method are analyzed, and it is shown how detection and false alarm probabilities are assessed and optimized using data-based learning to obtain thresholds for hypothesis testing. Data from a 1400 m horizontal flow loop is used to test the method, and successful diagnosis of the incidents drillstring washout (pipe leakage), lost circulation, gas in flow, and drill bit plugging are demonstrated.

General information
State: Published
Organisations: Department of Electrical Engineering, Automation and Control, Norwegian University of Science and Technology
Authors: Willersrud, A. (Ekstern), Blanke, M. (Intern), Imsland, L. (Ekstern), Pavlov, A. K. (Ekstern)
Pages: 90-103
Publication date: 2015
Main Research Area: Technical/natural sciences

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Journal: Journal of Process Control
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ISSN (Print): 0959-1524
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BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 1.21 SNIP 2.241 CiteScore 3.41
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Fault Tolerance for Industrial Actuators in Absence of Accurate Models and Hardware Redundancy
This paper investigates Fault-Tolerant Control for closed-loop systems where only coarse models are available and there is lack of actuator and sensor redundancies. The problem is approached in the form of a typical servomotor in closed-loop. A linear model is extracted from input/output data to describe the system over a frequency range. Two methods based on the Kalman Filter and Statistical Change Detection techniques are proposed for detecting degradation faults and component failures, respectively. Finally, a reference correction setup is used to compensate for degradation faults.
Incident detection and isolation in drilling using analytical redundancy relations

Early diagnosis of incidents that could delay or endanger a drilling operation for oil or gas is essential to limit field development costs. Warnings about downhole incidents should come early enough to allow intervention before it develops to a threat, but this is difficult, since false alarms must be avoided. This paper employs model-based diagnosis using analytical redundancy relations to obtain residuals which are affected differently by the different incidents. Residuals are found to be non-Gaussian - they follow a multivariate t-distribution - hence, a dedicated generalized likelihood ratio test is applied for change detection. Data from a 1400 meter horizontal flow loop test facility is used to assess the diagnosis method. Diagnosis properties of the method are investigated assuming either with available downhole pressure sensors through wired drill pipe or with only topside measurements available. In the latter case, isolation capability is shown to be reduced to group-wise isolation, but the method would still detect all serious events with the prescribed false alarm probability.
Modelling and Identification for Control of Gas Bearings

Gas bearings are popular for their high speed capabilities, low friction and clean operation, but suffer from poor damping, which poses challenges for safe operation in presence of disturbances. Enhanced damping can be achieved through active lubrication techniques using feedback control laws. Such control design requires models with low complexity, able to describe the dominant dynamics from actuator input to sensor output over the relevant range of operation. The mathematical models based on first principles are not easy to obtain, and in many cases, they cannot be directly used for control design due to their complexity and parameter uncertainties. As an alternative, this paper presents an experimental technique for “in situ” identification of low complexity models of the entire rotor-bearingactuator system. Using grey-box identification techniques, the approach is shown to be easily applied to industrial rotating machinery with gas bearings and to allow for subsequent control design. The paper shows how piezoelectric actuators in a gas bearing are efficiently used to perturb the gas film for identification over relevant ranges of rotational speed and gas injection pressure. Parameter-varying linear models are found to capture the dominant dynamics of the system over the range of operation. Based on the identified models, decentralised proportional control is designed and is shown to obtain the required damping in theory as well as in a laboratory test rig.

General information
State: Published
Organisations: Department of Electrical Engineering, Automation and Control, Department of Mechanical Engineering, Solid Mechanics
Authors: Theisen, L. R. S. (Intern), Niemann, H. H. (Intern), Santos, I. (Intern), Galeazzi, R. (Intern), Blanke, M. (Intern)
Number of pages: 26
Pages: 1150-1170
Publication date: 2015
Main Research Area: Technical/natural sciences

Publication information
Journal: Mechanical Systems and Signal Processing
Volume: 70-71
ISSN (Print): 0888-3270
Ratings:
Mooring System Diagnosis and Structural Reliability Control for Position Moored Vessels

Early diagnosis and fault-tolerant control are essential for safe operation of floating platforms where mooring systems maintain vessel position and must withstand environmental loads. This paper considers two critical faults, line breakage and loss of a buoyancy element and employs vector statistical change detection for timely diagnosis of faults. Diagnosis design is scrutinized and a procedure is proposed based on specified false alarm probability and estimation of the distribution of the test statistics on which change detection is based. A structural reliability index is applied for monitoring the safety level of each mooring line and, a set-point chasing algorithm accommodates the effects of line failure, as an integral part of the reliability-based set-point chasing control algorithm. The feasibility of the diagnosis and of the fault-tolerant control strategy is verified in model basin tests.
Nonlinear Adaptive Control of Exhaust Gas Recirculation for Large Diesel Engines
A nonlinear adaptive controller is proposed for the exhaust gas recirculation system on large two-stroke diesel engines. The control design is based on a control oriented model of the nonlinear dynamics at hand that incorporates load and engine speed changes as known disturbances to the exhaust gas recirculation. The paper provides proof of exponential stability for closed loop control of the model given. Difficulties in the system include that certain disturbance levels will make a desired setpoint in O2 unreachable, for reasons of the physics of the system, and it is proven that the proposed control will make the system converge exponentially to the best achievable state. Simulation examples confirm convergence and good disturbance rejection over relevant operational ranges of the engine.

General information
State: Published
Organisations: Department of Electrical Engineering, Automation and Control, MAN B&W Diesel A/S
Authors: Nielsen, K. V. (Intern), Blanke, M. (Intern), Vejlgaard-Laursen, M. (Ekstern)
Pages: 254-260
Publication date: 2015
Conference: 10th IFAC Conference on Manoeuvring and Control of Marine Craft, Lyngby, Denmark, 24/08/2015 - 24/08/2015
Main Research Area: Technical/natural sciences

Publication information
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Volume: 48
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BFI (2016): BFI-level 1
BFI (2015): BFI-level 1
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Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.252 SNIP 0.242 CiteScore 0.26
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.249 SNIP 0.22 CiteScore 0.27
ISI indexed (2013): ISI indexed no
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.204 SNIP 0.165 CiteScore 0.17
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.142 SNIP 0.078 CiteScore 0.05
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.121 SNIP 0.054
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.111 SNIP 0.032
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.109 SNIP 0.033
Scopus rating (2007): SJR 0.107 SNIP 0.021
Scopus rating (2006): SJR 0.101 SNIP 0.004
Scopus rating (2005): SJR 0.103 SNIP 0.014
Scopus rating (2004): SJR 0.106 SNIP 0.017
Offshore Wind Park Control Assessment Methodologies to Assure Robustness

The transition from fossil fuels to renewable energy is an expensive but necessary process to ensure a habitable world for future generations. Renewable energy sources such as hydro-, solar- and wind energy continues to increase their share of the total power production. With national goals set by the Renewable Energy Directive of the European Commission to decrease carbon dioxide emission, the demand for renewable energy is increasing. Wind energy has been harnessed since 1887 [1] and has seen a large growth since the first multi-megawatt turbine in 1978. Gradually the wind energy technology has matured to a point where turbines are reaching a production capability exceeding 6 megawatt and the turbines have moved offshore due to stronger wind, and to avoid proximity to populated areas. The placement of wind power plants (WPP) with a typical size of 60 large turbines in remote locations with a weak grid interconnection point, is a challenge with respect to power system stability. This dissertation considers the interaction between the offshore grid and the control of power electronic devices (PED), its effect on system stability and challenges with respect to unwanted interaction between controllers in the rather complex control hierarchy on an offshore WPP. The output waveform of modern turbines utilizing PEDs is distorted at high frequencies, and the stability of the control system is affected by resonances and harmonics present in the weak offshore grid. These phenomena pose a risk to drive the system to instability, as they exist within the bandwidth of the turbine controllers. The resonances and the number of turbines in operation are characteristics of the grid, which are partly unknown at the controller design stage. The uncertainty and the unwanted interaction in the grid are difficult challenges for control designers. This project deals with these challenges and provides insight in root causes to phenomena that have been issues during wind power plant commissioning in the past. This is done through development of design and validation methods for controllers, by analyzing turbine interaction with the grid and suggestion of design guidelines to ensure proper operation of stacked controllers. Two specific faults serve as basis for the analysis and development, a rotor blade deformation and an unwanted oscillation in the reactive power, both of which experienced at a WPP. The low frequency reactive power oscillations observed were suspected to be i caused by the voltage control at the point of common coupling. The fault was thought to involve the interaction between the static synchronous compensator (STATCOM), the wind turbine voltage control and the power plant control (PPC). By establishing bounds on the sets of possible parameters of all involved controllers, the thesis replicates the phenomena by simulation and a method is proposed that analytically finds the set of controller parameters, which ensure stable operation. The method enables DONG Energy to calculate bounds on controller parameters based on network parameters and the thesis contributes by ensuring proper operation before energization. The analysis of the voltage control philosophy related to the reactive power oscillations showed the need for proper handling of the resonances introduced by the offshore grid in the turbine control structure. The dissertation contributes to this area with the development of a robust H∞ converter controller employing notch filters in the performance specification to suppress harmonics of the grid frequency. This method combines attenuation of selected resonance frequencies with system stability and performance within the defined envelope of uncertainty of the grid. The controller is tested in a model of the WPP, and is shown to improve performance, control effort and output disturbance rejection compared to standard PI control. The second fault was that a turbine rotor blade was observed to deform in a WPP. This severe fault was suspected to have contributory causes from both mechanical and electrical systems. A preceding investigation was conducted which ruled out physical generator phenomena such as cogging torque, as well as network voltage disturbances and delays in the converter control system. The investigation indicated that the problem was an insufficient implementation of the rotor speed controller. The thesis addresses the problem by the development of control methods to limit the shaft stress, and thereby the rotor blade vibration. The contributions include a feedback linerization controller and an observer based backstepping controller for a wind turbine. The thesis consists of an introduction part that briefly describes the field, the investigations conducted in the study, the models developed and the controller designs suggested to deal with the challenges described above. The main results of the research are highlighted in the introduction and the detailed results are described in four papers, which are enclosed in the last part of the thesis.

General information
State: Published
Organisations: Department of Electrical Engineering, Automation and Control, Center for Electric Power and Energy, Electric power systems, DONG Energy A/S
Authors: Gryning, M. P. S. (Intern), Blanke, M. (Intern), Andersen, K. H. (Ekstern), Wu, Q. (Intern), Niemann, H. H. (Intern)
Number of pages: 200
Publication date: 2015
Parametric roll resonance monitoring using signal-based detection

Extreme roll motion of ships can be caused by several phenomena, one of which is parametric roll resonance. Several incidents occurred unexpectedly around the millennium and caused vast fiscal losses on large container vessels. The phenomenon is now well understood and some consider parametric roll a curiosity, others have concerns. This study employs novel signal-based detection algorithms to analyse logged motion data from a container vessel (2800 TEU) and a large car and truck carrier (LCTC) during one year at sea. The scope of the study is to assess the performance and robustness of the detection algorithms in real conditions, and to evaluate the frequency of parametric roll events on the selected vessels. Detection performance is scrutinised through the validation of the detected events using owners’ standard methods, and supported by available wave radar data. Further, a bivariate statistical analysis of the outcome of the signal-based detectors is performed to assess the real life false alarm probability. It is shown that detection robustness and very low false warning rates are obtained. The study concludes that small parametric roll events are occurring, and that the proposed signal-based monitoring system is a simple and effective mean to provide timely warning of resonance conditions.
This paper investigates a minimalistic laser-based range sensor, used for underwater inspection by Autonomous Underwater Vehicles (AUV). This range detection system system comprise two lasers projecting vertical lines, parallel to a camera’s viewing axis, into the environment. Using both lasers for distance estimation, the sensor offers three dimensional interpretation of the environment. This is obtained by triangulation of points extracted from the image using the Hough Transform. We evaluate the system in simulation and by physical proof-of-concept experiments on an OpenROV platform.

Short-Range Sensor for Underwater Robot Navigation using Line-lasers and Vision

This paper investigates a minimalistic laser-based range sensor, used for underwater inspection by Autonomous Underwater Vehicles (AUV). This range detection system system comprise two lasers projecting vertical lines, parallel to a camera’s viewing axis, into the environment. Using both lasers for distance estimation, the sensor offers three dimensional interpretation of the environment. This is obtained by triangulation of points extracted from the image using the Hough Transform. We evaluate the system in simulation and by physical proof-of-concept experiments on an OpenROV platform.

General information
State: Published
Organisations: Department of Electrical Engineering, Automation and Control, Centre for Playware
Authors: Hansen, P. N. (Intern), Nielsen, M. C. (Intern), Christensen, D. J. (Intern), Blanke, M. (Intern)
Pages: 113–120
Publication date: 2015
Conference: 10th IFAC Conference on Manoeuvring and Control of Marine Craft, Lyngby, Denmark, 24/08/2015 - 24/08/2015
Main Research Area: Technical/natural sciences

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Journal: IFAC-PapersOnLine
Volume: 48
Issue number: 16
ISSN (Print): 2405-8963
Ratings:
Scopus rating (2016): SJR 0.263 SNIP 0.334 CiteScore 0.45
Smart Sensor Based Obstacle Detection for High-Speed Unmanned Surface Vehicle

This paper describes an obstacle detection system for a high-speed and agile unmanned surface vehicle (USV), running at speeds up to 30 m/s. The aim is a real-time and high performance obstacle detection system using both radar and vision technologies to detect obstacles within a range of 175 m. A computer vision horizon detector enables a highly accurate attitude estimation despite large and sudden vehicle accelerations. This further facilitates the reduction of sea clutter by utilising a attitude based statistical measure. Full scale sea trials show a significant increase in obstacle tracking performance using sensor fusion of radar and computer vision.

General information
State: Published
Organisations: Department of Electrical Engineering, Automation and Control
Authors: Hermann, D. (Intern), Galeazzi, R. (Intern), Andersen, J. C. (Intern), Blanke, M. (Intern)
Pages: 190–197
Publication date: 2015
Conference: 10th IFAC Conference on Manoeuvring and Control of Marine Craft, Lyngby, Denmark, 24/08/2015 - 24/08/2015
Main Research Area: Technical/natural sciences

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Ratings:
BFI (2017): BFI-level 1
BFI (2016): BFI-level 1
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.228 SNIP 0.217 CiteScore 0.27
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.252 SNIP 0.242 CiteScore 0.26
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.249 SNIP 0.22 CiteScore 0.27
ISI indexed (2013): ISI indexed no
BFI (2012): BFI-level 1
Wide-Area Emergency Control In Power Transmission

This thesis concerns the development of new emergency control algorithms for electric power transmission systems. Diminishing global resources and climate concerns force operators to change production away from fossil fuels and towards distributed renewable energy sources. Along with the change on production side measures must be taken on the demand side to maintain power balance. Due to these changes, the operating point of the power system will be less predictable. Traditionally, emergency controls are designed off-line by extensive simulations. The future power system is expected to fluctuate more, thus making the behaviour less predictable, suggesting the need for new intelligent wide-area emergency control algorithms. The fluctuating nature of the future power system calls for new methods of calculating remedial actions that are able to adapt to changing conditions. As part of this thesis convex relaxations are used to compute remedial actions when an emergency condition is detected, and the method is assessed using a set of benchmark systems. An optimal power flow approach is suggested to reconfigure a power system, and methods are introduced to be able to recover from an emergency condition and reach a secure stable equilibrium. In order to contain fast instability mechanisms, event-based emergency controls can be necessary, and this thesis also presents a contribution to real-time generation of event-based emergency control. By the use of contingency screening with post-contingency stability-margin information, system protection schemes are automatically generated and armed, and it is shown that, by examination of the physical phenomena behind the security threat, emergency controls can be properly allocated. Power systems can exhibit low-frequency oscillations due to the inertia of synchronous machines affecting each-other through electric power transfers. Today, dedicated controllers are applied to cope with such oscillations. However, faults can affect the behaviour of these controllers, or even separate them. The thesis presents a novel method that – without particular knowledge on existing controllers – reconfigures the close-loop system to guarantee stability in the case of faults. This is achieved through a stability-preserving reconfiguration design using absolute stability results for Lure type nonlinear power systems. It is implemented using a wide-area virtual actuator approach, and relies on the solution of a linear matrix inequality. The developed methods enables emergency control for real-time stabilization that adapts to changing conditions in the future power system. The results contribute to the development of a self-healing power system, where the power system automatically responds to system disturbances.

General information
State: Published
Organisations: Department of Electrical Engineering, Automation and Control, Center for Electric Power and Energy, Electric power systems
Authors: Pedersen, A. S. (Intern), Blanke, M. (Intern), Tabatabaei Pour, M. (Intern), Jóhannsson, H. (Intern)
Number of pages: 188
Publication date: 2015
Wind turbine inverter robust loop-shaping control subject to grid interaction effects

An H∞ robust control of wind turbine inverters employing an LCL filter is proposed in this paper. The controller dynamics are designed for selective harmonic filtering in an offshore transmission network subject to parameter perturbations. Parameter uncertainty in the network originates from the grid and the number of wind turbines connected. Power converter based turbines inject harmonic currents, which are attenuated by passive filters. A robust high order active filter controller is proposed to complement the passive filtering. The H∞ design of the control loop enables desired tracking with integral effect while bounding the induced change. The design was tested in an aggregated model of the London Array offshore wind power plant and compared with traditional PI controller designs. Robust stability and performance and a reduction of control effort by 25% are obtained over the full envelope of operation.
A Framework for Diagnosis of Critical Faults in Unmanned Aerial Vehicles

Unmanned Aerial Vehicles (UAVs) need a large degree of tolerance towards faults. If not diagnosed and handled in time, many types of faults can have catastrophic consequences if they occur during flight. Prognosis of faults is also valuable and so is the ability to distinguish the severity of the different faults in terms of both consequences and the frequency with which they appear. In this paper flight data from a fleet of UAVs is analysed with respect to certain faults and their frequency of appearance. Data is taken from a group of UAVs of the same type but with small differences in weight and handling due to different types of payloads and engines used. Categories of critical faults, that could and have caused UAV crashes are analysed and requirements to diagnosis are formulated. Faults in air system sensors and in control surfaces are given special attention. In a stochastic framework, and based on a large number of data logged during flights, diagnostic methods are employed to diagnose faults and the performance of these fault detectors are evaluated against light data. The paper demonstrates a significant potential for reducing the risk of unplanned loss of remotely piloted vehicles used by the Danish Navy for target practice.

Calculation of critical fault recovery time for nonlinear systems based on region of attraction analysis

In safety critical systems, the control system is composed of a core control system with a fault detection and isolation scheme together with a repair or a recovery strategy. The time that it takes to detect, isolate, and recover from the fault (fault recovery time) is a critical factor in safety of a system. It must be guaranteed that the trajectory of a system subject to fault remains in the region of attraction (ROA) of the post-fault system during this time. This paper proposes a new algorithm to compute the critical fault recovery time for nonlinear systems with polynomial vector fields using sum of squares programming. The proposed algorithm is based on computation of ROA of the recovered system and time-stability of the faulty system.
Compositional Finite-Time Stability analysis of nonlinear systems

This paper investigates finite-time stability and finite-time boundedness for nonlinear systems with polynomial vector fields. Finite-time stability requires the states of the system to remain a given bounded set in a finite-time interval and finite-time boundedness considers the same problem for the system but with bounded disturbance. Sufficient conditions for finite-time stability and finite-time boundedness of nonlinear systems as well as a computational method based on sum of squares programming to check the conditions are given. The problem of finite-time stability for a system that consists of an interconnection of subsystems is also considered and we show how to decompose the problem into subproblems for each subsystem with coupling constraints. A solution to the problem using sum of squares programming and dual decomposition is presented. The method is demonstrated through some examples.

General information
State: Published
Organisations: Department of Electrical Engineering, Automation and Control
Authors: Tabatabaei, M. (Intern), Blanke, M. (Intern)
Pages: 1851-1857
Publication date: 2014

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Title of host publication: Proceedings of 2014 American Control Conference
Publisher: IEEE
ISBN (Print): 978-1-4799-3271-9
Main Research Area: Technical/natural sciences
Conference: 2014 American Control Conference, Portland, OR, United States, 04/06/2014 - 04/06/2014
DOIs:
10.1109/ACC.2014.6859034
Source: PublicationPreSubmission
Source-ID: 93043937
Publication: Research - peer-review › Article in proceedings – Annual report year: 2014

Diagnosis of airspeed measurement faults for unmanned aerial vehicles

Airspeed sensor faults are common causes for incidents with unmanned aerial vehicles with pitot tube clogging or icing being the most common causes. Timely diagnosis of such faults or other artifacts in signals from airspeed sensing systems could potentially prevent crashes. This paper employs parameter adaptive estimators to provide analytical redundancies and a dedicated diagnosis scheme is designed. Robustness is investigated on sets of flight data to estimate distributions of test statistics. The result is robust diagnosis with adequate balance between false alarm rate and fault detectability.

General information
State: Published
Organisations: Department of Electrical Engineering, Automation and Control
Authors: Hansen, S. (Intern), Blanke, M. (Intern)
Pages: 224-239
Publication date: 2014
Main Research Area: Technical/natural sciences

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Journal: IEEE Transactions on Aerospace and Electronic Systems
Volume: 50
Issue number: 1
ISSN (Print): 0018-9251
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Experimental Grey Box Model Identification of an Active Gas Bearing

Gas bearings have inherent dynamics that gives rise to low damping and potential instability at certain rotational speeds. Required damping and stabilization properties can be achieved by active ow control if bearing parameters are known. This paper deals with identifacation of parameters in a dynamic model of an active gas bearing and subsequent control loop design. A grey box model is determined based on experiments where piezo actuated valves are used to perturb the journal and hence excite the rotor-bearing system. Such modelling from actuator to output is shown to effciently support controller design, in contrast to impact models that focus on resonance dynamics. The identified model is able to accurately reproduce the lateral dynamics of the rotor-bearing system in a desired operating range, in this case around the frst two natural frequencies. The identified models are validated and used to design a model-based controller capable of improving the damping of the gas bearing. Experimental impact responses show an increase in damping by a factor nine for the investigated conditions.

General information
State: Published
Organisations: Department of Electrical Engineering, Automation and Control, Department of Mechanical Engineering, Solid Mechanics
Authors: Theisen, L. R. S. (Intern), Pierart Vásquez, F. G. (Intern), Niemann, H. H. (Intern), Santos, I. (Intern), Blanke, M. (Intern)
Fault Diagnosis for Electrical Distribution Systems using Structural Analysis

Fault-tolerance in electrical distribution relies on the ability to diagnose possible faults and determine which components or units cause a problem or are close to doing so. Faults include defects in instrumentation, power generation, transformation and transmission. The focus of this paper is the design of efficient diagnostic algorithms, which is a prerequisite for fault-tolerant control of power distribution. Diagnosis in a grid depend on available analytic redundancies, and hence on network topology. When topology changes, due to earlier fault(s) or caused by maintenance, analytic redundancy relations (ARR) are likely to change. The algorithms used for diagnosis may need to change accordingly, and finding efficient methods to ARR generation is essential to employ fault-tolerant methods in the grid. Structural analysis (SA) is based on graph-theoretical results, that offer to find analytic redundancies in large sets of equations only from the structure (topology) of the equations. A salient feature is automated generation of redundancy relations. The method is indeed feasible in electrical networks where circuit theory and network topology together formulate the constraints that define a structure graph. This paper shows how three-phase networks are modelled and analysed using structural methods, and it extends earlier results by showing how physical faults can be identified such that adequate remedial actions can be taken. The paper illustrates a feasible modelling technique for structural analysis of power systems, it demonstrates detection and isolation of failures in a network, and shows how typical faults are diagnosed. Nonlinear fault simulations illustrate the results.

General information
State: Published
Organisations: Department of Electrical Engineering, Automation and Control, Center for Electric Power and Energy
Authors: Knüppel, T. (Intern), Blanke, M. (Intern), Østergaard, J. (Intern)
Pages: 1446–1465
Publication date: 2014
Main Research Area: Technical/natural sciences

Publication information
Journal: International Journal of Robust and Nonlinear Control
Volume: 24
Issue number: 8-9
ISSN (Print): 1049-8923
Ratings:
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): SJR 2.206 SNIP 1.681 CiteScore 3.57
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.944 SNIP 1.648 CiteScore 3.12
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.258 SNIP 1.947 CiteScore 3.51
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
This paper presents the design of an L1 adaptive controller for maximum power point tracking (MPPT) of a small variable speed Wind Energy Conversion System (WECS). The proposed controller generates the optimal torque command for the vector controlled generator side converter (GSC) based on the wind speed estimation. The proposed MPPT control algorithm has a generic structure and can be used for different generator types. In order to verify the efficacy of the proposed L1 adaptive controller for the MPPT of the WECS, a full converter wind turbine with a squirrel cage induction generator (SCIG) is used to carry out case studies using Matlab/Simulink. The case study results show that the designed L1 adaptive controller has good tracking performance even with unmodeled dynamics and in the presence of parameter uncertainties and unknown disturbances.
Navigation System Fault Diagnosis for Underwater Vehicle

This paper demonstrates fault diagnosis on unmanned underwater vehicles (UUV) based on analysis of structure of the nonlinear dynamics. Residuals are generated using different approaches in structural analysis followed by statistical change detection. Hypothesis testing thresholds are made signal based to cope with non-ideal properties seen in real data. Detection of both sensor and thruster failures are demonstrated. Isolation is performed using the residual signature of detected faults and the change detection algorithm is used to assess severity of faults by estimating their magnitude. Numerical simulations and sea trial data show results with very favourable balance between detection and false alarm.
A particle filter based robust navigation with fault diagnosis is designed for an underwater robot, where 10 failure modes of sensors and thrusters are considered. The nominal underwater robot and its anomaly are described by a switching mode hidden Markov model. By extensively running a particle filter on the model, the fault diagnosis and robust navigation are achieved. Closed-loop full-scale experimental results show that the proposed method is robust, can diagnose faults effectively, and can provide good state estimation even in cases where multiple faults occur. Comparing with other methods, the proposed method can diagnose all faults within a single structure, it can diagnose simultaneous faults, and it is easily implemented.
Stabiliser Fault Emergency Control using Reconfiguration to Preserve Power System Stability

Stabiliser faults in multi-machine power systems are examined in this paper where fault-masking and system reconguration of the nonlinear system is obtained using a virtual actuator approach. Phasor Measurement Units, which can be integrated in wide-area transmission grids to improve the performance of power system stabilisers, are utilised when reconguring remaining stabilisers after one has been inoperable by a local failure. A stabilitypreserving reconguration is designed using absolute stability results for Lure type systems: The calculation of the virtual actuator that relies on a solution of a linear matrix inequality (LMI) is detailed in the paper. Simulation results of a benchmark transmission system show the ability of the fault-tolerant reconguration strategy to maintain wide-area stability of a power system despite failure in a stabiliser.

General information
State: Published
Organisations: Department of Electrical Engineering, Automation and Control, Center for Electric Power and Energy, Siemens
Authors: Pedersen, A. S. (Intern), Richter, J. H. (Ekstern), Tabatabaeipour, M. (Intern), Jóhannsson, H. (Intern), Blanke, M. (Intern)
Number of pages: 7
Publication date: 2014

Host publication information
Title of host publication: Proceedings of the 19th IFAC World Congress
Call for Papers: ‘Adaptive methods and signal processing for marine systems’

General information
State: Published
Organisations: Department of Electrical Engineering, Automation and Control, University of Plymouth
Authors: Blanke, M. (Intern), Sutton, R. (Ekstern)
Pages: 200
Publication date: 2013
Main Research Area: Technical/natural sciences

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Issue number: 2
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BFI (2017): BFI-level 1
Scopus rating (2016): SJR 0.886 SNIP 1.102 CiteScore 2.04
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
Control Surface Fault Diagnosis with Specified Detection Probability - Real Event Experiences

Diagnosis of actuator faults is crucial for aircraft since loss of actuation can have catastrophic consequences. For autonomous aircraft the steps necessary to achieve fault tolerance is limited when only basic and non-redundant sensor and actuator suites are present. Through diagnosis that exploits analytical redundancies it is, nevertheless, possible to cheaply enhance the level of safety. This paper presents a method for diagnosing control surface faults by using basic sensors and hardware available on an autonomous aircraft. The capability of fault diagnosis is demonstrated obtaining desired levels of false alarms and detection probabilities. Self-tuning residual generators are employed for diagnosis and are combined with statistical change detection to form a setup for robust fault diagnosis. On-line estimation of test statistics is used to obtain a detection threshold and a desired false alarm probability. A data based method is used to determine the validity of the methods proposed. Verification is achieved using real data and shows that the presented diagnosis method is efficient and could have avoided incidents where faults led to loss of aircraft.

Early Detection of Parametric Roll Resonance on Container Ships

Parametric roll resonance on ships is a nonlinear phenomenon where waves encountered at twice the natural roll frequency can bring the vessel dynamics into a bifurcation mode and lead to extreme values of roll. Recent years have seen several incidents with dramatic damage to container vessels. The roll oscillation, which is subharmonic with respect to the wave excitation, may be completely unexpected and a system for detection of the onset of such resonance could warn the navigators before roll angles reach serious levels. Timely warning could make remedial actions possible, such as change the ship's speed and course, to escape from the bifurcation condition. This paper proposes nonparametric methods to detect the onset of roll resonance and demonstrates their performance. Theoretical conditions for parametric resonance are revisited and are used to develop efficient methods to detect its onset. Spectral and temporal correlations
of the square of roll with pitch (or heave) are demonstrated to be of particular interest as indicators. Properties of the indicators are scrutinized, and a change detector is designed for the Weibull-type of distributions that were observed from a time-domain indicator for phase correlation. Hypothesis testing for resonance is developed using a combination of detectors to obtain robustness. Conditions of forced roll and disturbances in real weather conditions are analyzed and robust detection techniques are suggested. The efficacy of the methodology is shown on experimental data from model tests and on data from a container ship crossing the Atlantic during a storm.

**General information**

State: Published

Organisations: Automation and Control, Department of Electrical Engineering, Department of Informatics and Mathematical Modeling, Mathematical Statistics

Authors: Galeazzi, R. (Intern), Blanke, M. (Intern), Poulsen, N. K. (Intern)

Pages: 489-503

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Main Research Area: Technical/natural sciences

**Publication information**

Journal: IEEE Transactions on Control Systems Technology

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Web of Science (2017): Indexed Yes

BFI (2016): BFI-level 2

Scopus rating (2016): SJR 2.017 SNIP 2.755 CiteScore 5.17

Web of Science (2016): Indexed yes

BFI (2015): BFI-level 2

Scopus rating (2015): SJR 2.85 SNIP 2.757 CiteScore 4.72

Web of Science (2015): Indexed yes

BFI (2014): BFI-level 2

Scopus rating (2014): SJR 1.958 SNIP 3.042 CiteScore 4.34

Web of Science (2014): Indexed yes

BFI (2013): BFI-level 2

Scopus rating (2013): SJR 1.825 SNIP 3.498 CiteScore 4.41

ISI indexed (2013): ISI indexed yes

Web of Science (2013): Indexed yes

BFI (2012): BFI-level 2

Scopus rating (2012): SJR 1.62 SNIP 3.037 CiteScore 3.7

ISI indexed (2012): ISI indexed yes

BFI (2011): BFI-level 2

Scopus rating (2011): SJR 1.698 SNIP 3.013 CiteScore 3.26

ISI indexed (2011): ISI indexed yes

Web of Science (2011): Indexed yes

BFI (2010): BFI-level 2

Scopus rating (2010): SJR 1.171 SNIP 2.483

BFI (2009): BFI-level 2

Scopus rating (2009): SJR 1.737 SNIP 2.84

BFI (2008): BFI-level 2

Scopus rating (2008): SJR 1.503 SNIP 2.787

Scopus rating (2007): SJR 1.147 SNIP 2.26

Scopus rating (2006): SJR 1.066 SNIP 2.409

Scopus rating (2005): SJR 1.12 SNIP 2.694

Scopus rating (2004): SJR 1.349 SNIP 2.247

Scopus rating (2003): SJR 1.722 SNIP 2.408

Scopus rating (2002): SJR 2.532 SNIP 2.721

Scopus rating (2001): SJR 2.182 SNIP 2.124
Exhaust Gas Recirculation Control for Large Diesel Engines - Achievable Performance with SISO Design

This paper investigates control possibilities for Exhaust Gas Recirculation (EGR) on large diesel engines. The goal is to reduce the amount of NOx in the exhaust gas by reducing the oxygen concentration available for combustion. Control limitations imposed by the system are assessed using linear analysis of the highly non-linear dynamics. Control architectures are investigated and performance in terms of disturbance rejection and reference tracking are investigated under model uncertainty. Classical feed-forward and feedback controller designs are investigated using classical and Quantitative Feedback Theory (QFT) designs. Validation of the controller is made on the model with focus on disturbance reduction ability.

HVDC Connected Offshore Wind Power Plants: Review and Outlook of Current Research

This paper presents a state-of-the-art review on grid integration of large offshore wind power plants (OWPPs) using high voltage direct voltage (HVDC) for grid connection. The paper describes in detail selected challenges hereto and presents how DONG Energy Wind Power (DEWP) is addressing these challenges through three coordinated PhD projects in close collaboration with leading academia within the field. The overall goal of these projects is to acquire in-depth knowledge of relevant operating phenomena in the offshore OWPP grid, rich with power electronics devices (PEDs) such as the HVDC and the PED widely used in the wind turbine generators (WTGs). Challenges hereto include PED control system interaction (from a stability point of view), assessment of the quality of vendor supplied control systems and their robustness against e.g. short circuits and load rejection. Furthermore, the outcome of the projects will be developed and validated models of e.g. the HVDC system, methodologies for assessment of control system stability and fault identification in implemented control system.
Modelling and L1 Adaptive Control of pH in Bioethanol Enzymatic Process

The enzymatic process is a key step in second generation bioethanol production. Pretreated biomass fibers are liquefied with the help of enzymes to facilitate fermentation. Enzymes are very sensitive to pH and temperature and the main control challenge in the nonlinear process is to ensure minimum deviations from the optimal pH level. This article develops a mathematical model for the pH, which has not been reported earlier for this particular process. The new model embeds flow dynamics and pH calculations and serves both for simulation and control design. Two control strategies are then formulated for pH level regulation: one is a classical PI controller; the other an L1 adaptive output feedback controller. Model-based feed-forward terms are added to the controllers to enhance their performances. A new tuning method of the L1 adaptive controller is also proposed. Further, a new performance function is formulated and tailored to this type of processes and is used to monitor the performances of the process in closed loop. The L1 design is found to outperform the PI controller in all tests.

General information
State: Published
Organisations: Department of Electrical Engineering, Automation and Control, Department of Chemical and Biochemical Engineering, Computer Aided Process Engineering Center
Authors: Prunescu, R. M. (Intern), Blanke, M. (Intern), Sin, G. (Intern)
Pages: 1888 - 1895
Publication date: 2013
Host publication information
Title of host publication: Proceedings of the 2013 American Control Conference
Publisher: IEEE
ISBN (Print): 978-1-4799-0177-7
Main Research Area: Technical/natural sciences
Conference: 2013 American Control Conference, Washington, DC, United States, 17/06/2013 - 17/06/2013

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Activities:
2013 American Control Conference
Source: dtu
Source-ID: u::7726
Publication: Research - peer-review › Article in proceedings – Annual report year: 2013

Modelling and L1 Adaptive Control of Temperature In Biomass Pretreatment

Biomass steam pretreatment is a key process in converting agricultural wastes to bioethanol. The pretreatment occurs in a large pressurized tank called a thermal reactor. Two key parameters influence the successfulness of the process: the reactor temperature, and the retention time. A particle pump pressurizes untreated biomass from atmospheric to reactor
pressure with recycled steam from the reactor. This paper formulates a steam mathematical model both for the thermal reactor and the particle pump, which is then used to design an L1 adaptive output feedback controller for the reactor temperature. As steam is recycled from the reactor to pressurize the particle pump, pressure drops and the reactor temperature is disturbed. The main control challenge is to reject these disturbances and keep a steady temperature. The nonlinear process model embeds mass and energy balances, valve characteristics, and enthalpy-pressure and pressure-temperature dependencies. Nonlinear feed-forward terms are added in the control strategy. The process model, the control strategy, the application of the L1 adaptive controller and its tuning method based on minimizing a cost function represent novelties of this paper.

General information
State: Published
Organisations: Department of Electrical Engineering, Automation and Control, Department of Chemical and Biochemical Engineering, Computer Aided Process Engineering Center
Authors: Prunescu, R. M. (Intern), Blanke, M. (Intern), Sin, G. (Intern)
Pages: 3152-3159
Publication date: 2013

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Title of host publication: Proceedings of 52nd IEEE Conference on Decision and Control
Publisher: IEEE
ISBN (Print): 9781467357142
BFI conference series: IEEE Conference on Decision and Control (5010888)
Main Research Area: Technical/natural sciences
Conference: 52nd IEEE Conference on Decision and Control (CDC 2013), Florence, Italy, 10/12/2013 - 10/12/2013
Computing and Processing
Electronic versions:
2013-CDC-rmpr-mb-gs.pdf
DOIs:
10.1109/CDC.2013.6760364

Modelling for Control of Exhaust Gas Recirculation on Large Diesel Engines
Exhaust Gas Recirculation (EGR) reduces NOx emissions by reducing O2 concentration for the combustion and is a preferred way to obtain emission regulations that will take effect from 2016. If not properly controlled, reduction of O2 has adverse side effects and proper control requires proper dynamic models. While literature is rich on four-stroke automotive engines, this paper considers two-stroke engines and develops a non-linear dynamic model of the exhaust gas system. Parameters are determined by system identification. The paper uses black-box nonlinear model identification and modelling from first principles followed by parameter identification and compares the results of these approaches. The paper performs a validation against experimental data from a test engine and presents a linearised model for EGR control design.

General information
State: Published
Organisations: Department of Electrical Engineering, Automation and Control, MAN Diesel & Turbo SE, Technical University of Denmark
Authors: Hansen, J. M. (Ekstern), Zander, C. (Ekstern), Pedersen, N. (Ekstern), Blanke, M. (Intern), Vejlgaard-Laursen, M. (Ekstern)
Pages: 380-385
Publication date: 2013

Host publication information
Title of host publication: Proceedings of the 9th IFAC conference on Control Applications in Marine Systems
Publisher: Elsevier Science
Series: IFAC Proceedings Volumes (IFAC-PapersOnline)
ISSN: 1474-6670
Main Research Area: Technical/natural sciences
Conference: 9th IFAC Conference on Control Applications in Marine Systems, Osaka, Japan, 17/09/2013 - 17/09/2013
NOx emission, Exhaust gas recirculation, Diesel engine, Identification, Green Ship
Observer Backstepping Control for Variable Speed Wind Turbine

This paper presents an observer backstepping controller as feasible solution to variable speed control of wind turbines to maximize wind power capture when operating between cut-in and rated wind speeds. The wind turbine is modeled as a two-mass drive-train system controlled by the generator torque. The nonlinear controller aims at regulating the generator torque such that an optimal tip-speed ratio can be obtained. Simply relying on the measured rotor angular velocity the proposed observer backstepping controller guarantees global asymptotic tracking of the desired trajectory while maintaining a globally uniformly ultimately bounded torsional angle. The proposed controller shows convincing performance when simulated in closed loop within a stochastic environment.

Position Mooring Control Based on a Structural Reliability Criterion

To prevent failure of mooring lines in modern position mooring (PM) systems, position moored vessels are kept within a small distance from a desired reference position. A safe position within such region is where stress in all mooring lines are kept well below tensile strength. To prevent several mooring lines simultaneously from exceeding a stress threshold, this paper suggests a new algorithm to determine the reference position and an associated control system.

The safety of each line is assessed through a structural reliability index. A reference position where all mooring lines are safe is achieved using structural reliability indices in a cost function, where both the mean mooring-line tension and dynamic effects are considered. An optimal set-point is automatically produced without need for manual interaction. The parameters of the extreme value distribution are calculated on-line thereby adapting the set-point calculations to the prevailing environment. In contrast to earlier approaches, several mooring line are simultaneously accounted for by the algorithm, not only the most critical one. Detailed simulations illustrate the features of the new method and it is shown that the structural reliability criterion based algorithm ensures the safety of mooring lines in a variety of external environmental conditions and also in situations of failure of a single line.
Power Management for Energy Systems

In this thesis, we consider the control of two different industrial applications that belong at either end of the electricity grid; a power consumer in the form of a commercial refrigeration system, and wind turbines for power production. Our primary studies deal with economic model predictive control of a commercial multi-zone refrigeration system, consisting of several cooling units that share a common compressor, and is used to cool multiple areas or rooms, e.g., in supermarkets. Substantial amounts of energy are consumed in refrigeration systems worldwide and there is a strong motivation for introducing more energy efficient as well as cost reducing control techniques. At the same time, the power grid is evolving from a centralized system with rather controllable production in the conventional power plants to a much more decentralized network of many independent power generators and a large penetration of renewable, fossil-free energy sources such as solar and wind power. To facilitate such intermittent power producers, we must not only control the production of electricity, but also the consumption, in an efficient and exible manner. By enabling the use of thermal energy
storage in supermarkets, we open up for exible power consumption schemes with the possibility of reducing operational costs and we develop and demonstrate prototype control technology that creates completely new business opportunities for selling regulating power to the grid. Moreover, this enables a larger penetration of wind energy in the power production and increases the potential market size for wind power generators and other renewable energy sources. Thus, we aim at promoting the use of environmentally sustainable power production technologies while creating new business opportunities for both power consumers and producers of renewable energy.

The second application, wind turbines, takes us to the production side of the power grid. The key concern here is to improve the quality and integrability of power delivered to the grid from large parks of wind turbines. Our goal is to reduce the fluctuating nature of the power output and to meet tightened demands from the grid by enabling a more intelligent control at both the individual turbine level, at the park controller level, and in cooperation with exible power consumers or other means of energy storage. The possible interaction and synergies of the two applications are obvious reasons to consider both in this thesis, and as we will see, the similarities in our formulations of the dierent control problems allow us to apply almost identical techniques despite the lack of immediate similarity.

For control of the commercial refrigeration application as well as the wind turbine application, we propose an economic optimizing model predictive controller, economic MPC. MPC is a feedback control technique that is characterized by its explicit handling of constrained control problems in which a model is used to predict the future behavior of a system along with forecasts of future disturbances. At each time step the values of the control inputs are computed by solving an open-loop nite time optimal control problem over a dened prediction horizon. Only the rst step in this optimal open-loop sequence is implemented as a control command. Feedback is obtained by solving the open-loop problem repeatedly, in a receding horizon fashion, as new predictions become available.

Our investigations are primarily concerned with: 1) modeling of the applications to suit the chosen control framework; 2) formulating the MPC controller laws to overcome challenges introduced by the industrial applications, and dening economic objectives that reect the real physics of the systems as well as our control objectives; 3) solving the involved, non-trivial optimization problems eiently in real-time; 4) demonstrating the feasibility and potential of the proposed methods by extensive simulation and comparison with existing control methods and evaluation of data from systems in actual operation.

We present contributions on:
- Economic MPC for commercial refrigeration systems, including
  - Linear economic MPC formulations that utilize the exibility in refrigeration systems to counteract uctuations in the balance between power consumption and production.
  - Economic MPC with probabilistic constraints, ensuring a robust performance and constraint satisfaction in spite of inaccurate system models and forecasts.
  - Nonlinear economic MPC, reecting the nonconvexity in the realistic description of temperature dependent efficiencies in the refrigeration cycle.
  - Nonlinear economic MPC with uncertain predictions and the implementation of very simple predictors that use entirely historical data of, e.g., electricity prices and outdoor temperatures.
- Economic MPC for wind turbines, including
  - Optimal steady-state calculation for wind farms.
  - Nonlinear economic MPC for individual turbines.
  - Change of variables and convex formulations of economic MPC for individual turbines.
- Tractable optimization methods for the MPC problems, including
  - Sequential convex programming (SCP) for specic nonconvex problems originating from our studies of commercial refrigeration as well as from our studies concerning wind power.
  - Successful demonstration of the SCP approach on three different problems the commercial refrigeration system with linear dynamics and constraints and a nonconvex objective, the individual wind turbine with nonlinear dynamics and constraints, and the static optimization of the wind farm with a black-box model.

The major contribution is the formulation of these problems and the demonstrations to show that the SCP method can be used for their solution. We demonstrate, i.e., substantial cost savings, on the order of 30 %, compared to a standard thermostat-based supermarket refrigeration system and show how our methods exhibit sophisticated demand response to real-time variations in electricity prices. Violations of the temperature ranges can be kept at a very low frequency of occurence inspite of the presence of uncertainty. For the power output from wind turbines, ramp rates, as low a 3 % of the rated power per minute, can be effectively ensured with the use of energy storage and we show how the active use of rotor inertia as an additional energy storage can reduce the needed storage capacity by up to 30 % without reducing the power output.

General information
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Organisations: Department of Applied Mathematics and Computer Science , Scientific Computing, Center for Energy Resources Engineering, Department of Electrical Engineering, Automation and Control, VESTAS Wind Systems A/S
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Towards self-tuning residual generators for UAV control surface fault diagnosis

Control surface fault diagnosis is essential for timely detection of manoeuvring and stability risks for an unmanned aircraft. Timely detection is crucial since control surface related faults impact stability of flight and safety. Reliable diagnosis require well fitting dynamical models but with the high cost of detailed modelling and wind tunnel testing, it would be highly desirable if good diagnosis could be obtained with very generic models that are adapted to individual conditions of aircraft and of its operation. This paper presents an approach where a basic generic model is Applied and necessary parameters in residual generators are identified on the fly. Initial estimates of parameters are known from off-line analysis of previous flights. The paper analyses how such self-tuning residual generators are combined with change detection to obtain timely fault diagnosis. The paper investigates the parameter convergence and detection properties for the suggested combination of identification and change detection techniques and shows design aspects and trade-offs to be made to make this scheme an effective and robust system for diagnosis or even prognosis. Results are verified using a number of test flights with different members of a population of UAVs that have inherent model uncertainty from one member to another and from one flight to another. Events with actual faults on control surfaces demonstrates the efficacy of the approach.

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Unmanned Water Craft Identification and Adaptive Control in Low-Speed and Reversing Regions
This paper treats L1 adaptive hovering control of an unmanned surface vehicle in a station-keeping mode where a region of zero control authority and under-actuation are main challenges. Low-speed and reversing dynamics are identified from full scale sea trials, and parameter uncertainty is estimated. With significant parameter variation, an L1 adaptive controller is employed for heading control. The L1 family of controllers allows for several topologies and an architecture is suggested that suits heading control of a vessel, the requirements of which differ from that of previous L1 literature. The control design is tackled directly in discrete time to allow a fast embedded implementation in the vehicle. Analysis of robustness, tracking performance and wave disturbance response are detailed in the paper.

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Addressing the security of a future sustainable power system: The Danish SOSPO project

Current power systems have been undergoing in depth changes by the increasing use of renewable generations. At one hand, the grid is progressively more interconnected in order to collect the renewable generation from geographically dispersed places meanwhile reduce the risks of intermittency; on the other, the power is increasingly generated at relative low voltage networks which in turn gives rise to new challenges in the conventional system design. The high governmental objective of greenhouse gas reduction provokes accelerating adoption of the renewables. The effect of this has to be carefully evaluated to secure the operation from both transmission and distribution levels. The Danish SOSPO project is launched from 2012 targeting at the system security assessment in the control room for the future scenarios. Methods will be developed in this project to counteract with the future challenges, and a testing platform will be developed in the laboratory for algorithm testing and demonstration.

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Autonomous Robot Supervision using Fault Diagnosis and Semantic Mapping in an Orchard

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Cascade Controller Including Back-stepping for Hydraulic-Mechanical Systems

Development of a cascade controller structure including adaptive backstepping for a nonlinear hydraulic-mechanical system is considered in this paper where a dynamic friction (LuGre) model is included to obtain the necessary accuracy. The new control architecture is analysed and enhanced tracking performance is demonstrated when including the extended friction model. The complexity of the backstepping procedure is significantly reduced due to the cascade structure. Hence, the proposed control structure is better suited to real-time implementation. © 2012 IFAC.

Contingency Estimation of States for Unmanned Aerial Vehicle using a Spherical Simplex Unscented Filter

Aiming at survival from contingency situations for unmanned aerial vehicles, a square root spherical simplex unscented Kalman filter is applied for state and parameter estimation and a rough model is used for state prediction when essential measurements are lost. Processing real flight data, received by telemetry at quite low sampling rate, the paper shows that filter performance of reasonable quality can be achieved despite the low sampling rate and the result is a low order model that can be useful during contingency operation. It is shown that the filter-estimator approach can cope with the low rate measurements requiring very little system knowledge and very limited tuning efforts. A generic aircraft model is utilised as process model where the non dimensional coefficients are identified online with joint estimation of states. Numerical stability is guaranteed by mathematically efficient square root implementation of the filter algorithm. A case of loss of GPS signal demonstrates the use of the state estimates to obtain return of the UAV to close to its home base where safe recovery is possible.
Detection of Parametric Roll on Ships

Recent years have shown several incidents with dramatic damage on container vessels caused by parametric resonance. When the resonance starts, the roll oscillation at a sub-harmonic frequency of the wave excitation may be completely unexpected. Timely warning about the onset of the resonance phenomenon could make the navigator change ship’s speed and heading, and these remedial actions could make the vessel escape the bifurcation. This chapter proposes non-parametric methods to detect the onset of parametric roll resonance. Theoretical conditions for parametric resonance are re-visited and signal-based methods are developed to detect its onset. Hypothesis testing is derived for the particular distribution of the indicators for resonance. Robustness is investigated by analyzing forced roll and disturbances in real weather conditions. The performance of the novel methods is demonstrated on experimental data from towing tank tests and data from a container ship passing an Atlantic storm.

Fault Diagnosis and Fault Handling for Autonomous Aircraft

Unmanned Aerial vehicles (UAVs) or drones are used increasingly for missions where piloted aircraft are unsuitable. The unmanned aircraft has a number of advantages with respect to size, weight and manoeuvrability that makes it possible for them to solve tasks that an aircraft previously has been unable to solve. The primary cause that UAVs has reached the current level of development is their military potential. Both for surveillance operations and direct strikes, UAVs has many benefits compared to manned aircraft, and the biggest of those are that no pilots are put in direct contact with enemy troops. Gradually UAV’s are also being introduced in civilian applications. In this setting they have reduced the difficulty of tasks such as photo inspections of large buildings and rescue missions at sea. All in all UAVs have shown their great potential within the recent years. The increasing use of UAVs causes them to coexist with manned aircraft and in areas where humans are present on ground. This of course carries demands to the safety and reliability of the aircraft. It is inevitable that components onboard a UAV will fail at some point in time. When this happens it is important that the fault is discovered in time such that appropriate actions can be taken. That could either be the aircraft controlling computer taking the fault into account or a human operator that intervenes. Detection of faults that occur during flight is exactly the subject of this thesis. Safety towards faults for manned aircraft is often achieved by making most of the systems onboard redundant. This is an easy way to obtain safety since no single system fault is catastrophic. The failed subsystem can be disconnected and the redundant systems can take over the tasks of the failed system. For smaller UAVs both price and weight of the aircraft is very important meaning that redundant hardware will not be an applicable safety solution. This is why focus of this thesis have
been on methods where redundancies are obtained by models and knowledge about the aircraft behaviour. Based on telemetry data from a specific UAV, used by the Danish military, it is investigated how a number of critical faults can be detected and handled. One of the challenges using telemetry data for the fault diagnosis is the limited bandwidth in the radio link between the aircraft and the base-station on ground. This combined with noise on the signals makes it difficult to use precise models for the fault diagnosis. This is solved by using statistical distributions to describe the aircraft’s normal behaviour and deviations from this, indicating different faults. To increase the applicability of the models, used for fault diagnosis, these are adaptive to some extent. This makes small discrepancies between aircraft and wind conditions to have less influence on the performance of the fault diagnosis with respect to time to detect and false alarms. It also means that less adjustment is needed if the methods should be applied to another type of aircraft with different parameters. Amongst the main findings of this research project is a method to handle faults on the UAV’s pitot tube, which measures the aircraft speed. A set of software redundancies based on GPS velocity information and engine thrust are used to detect abnormal airspeed signals. Another contribution worth mentioning considers diagnosis of control surface faults. Here a set of low-complexity models between the aircraft’s turn rates and input deflections are used in the fault detection. Both methods has been verified against data from incidents where the respective faults occurs, and show good potential. The thesis consists of a summary of the different methods, investigations and results obtained during the project. Detailed descriptions are found in a number of papers submitted to research conferences and journals during the project. These have been enclosed in the last part of the thesis.

**General information**

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**In-Flight Fault Diagnosis for Autonomous Aircraft Via Low-Rate Telemetry Channel**

An in-flight diagnosis system that is able to detect faults on an unmanned aircraft using real-time telemetry data could provide operator assistance to warn about imminent risks due to faults. However, limited bandwidth of the air-ground radio-link makes diagnosis difficult. Loss of information about rapid dynamic changes and high parameter uncertainty are the main difficulties. This paper explores time-domain relations in received telemetry signals and uses knowledge of aircraft dynamics and the mechanics behind physical faults to obtain a set of greybox models for diagnosis. Relating actuator fin deflections with angular rates of the aircraft, low order models are derived and parameters are estimated using system identification techniques. Change detection methods are applied to the prediction error of angular rate estimates and properties of the test statistics are determined. Techniques to overcome correlations in data and cope with non-Gaussian distributions are employed and threshold selection is obtained for the particular distributions of test statistics. Verification using real data showed that the diagnosis method is efficient and could have avoided incidents where faults led to loss of aircraft.

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L1 Adaptive Maneuvering Control of Unmanned High-speed Water Craft
This work addresses the issue of designing an adaptive robust control system to govern the steering of a high speed unmanned personal watercraft (PWC) maintaining equal performance across the craft's envelope of operation. The maneuvering dynamics of a high speed PWC is presented and a strong variation over the envelope of operational conditions, including speed, is highlighted. The complexity of the nonlinear dynamics is overcome through identification of linear models at different speed regimes. A gray-box identification is conducted from full scale experiments and results in a four degrees-of-freedom surge-sway-yaw-roll model. An L1 adaptive autopilot is then designed, which allows to achieve fast adaptation to system parameters' changes and robustness of the closed loop system.

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Particle Filter Based Fault-tolerant ROV Navigation using Hydro-acoustic Position and Doppler Velocity Measurements
This paper presents a fault tolerant navigation system for a remotely operated vehicle (ROV). The navigation system uses hydro-acoustic position reference (HPR) and Doppler velocity log (DVL) measurements to achieve an integrated navigation. The fault tolerant functionality is based on a modified particle filter. This particle filter is able to run in an asynchronous manner to accommodate the measurement drop out problem, and it overcomes the measurement outliers by switching observation models. Simulations with experimental data show that this fault tolerant navigation system can accurately estimate the ROV kinematic states, even when sensor failures appear frequently.

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Particle filter, Remotely operated vehicle, Fault tolerant navigation
Electronic versions:
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Particle Filter ROV Navigation using Hydrodynamic Position and Speed log Measurements

An integrated navigation system design is presented for an underwater remotely operated vehicle (ROV). The available navigation information is an acoustic position measurement and a Doppler log speed measurement. Both measurements are studied in detail and modeled statistically. A kinematic model is assigned to the ROV with its driving noise from a Gaussian mixture, and a particle filter is suggested to estimate ROV position and velocity. The advantages of using a particle filter in this ROV navigation scheme are: 1) to make full use of all available information to improve the estimation performance, such as the speed measurement that is a nonlinear function of the states; 2) the particle filter makes good use of a Gaussian mixture as the driving noise, which makes the ROV kinematic model more realistic in both high and low frequency ranges; 3) a good estimate of the ROV velocity vector is achieved. The algorithm of the particle filter is presented and verified through a simulation based on real data. This shows that the estimation performance of the particle filter is clearly better than that of a Kalman filter.

Performance Assessment and Active System Monitoring for Refrigeration Systems

The refrigeration system in a supermarket is an important part of the business for the supermarkets, both in terms of the possibility it provides and because of the associated cost of operating the system. It provides the possibility of selling chilled and frozen food but on the other hand the operation of the refrigeration system is associated with a significant cost. Cost efficient operation of the refrigeration system is therefore very important for the supermarkets. To ensure that the systems are operated cost efficient a performance assessment scheme is required. In addition, there exists a need for algorithms that ensures or improves the performance of the system. A supermarket refrigeration system is usually a complex and distributed control system, and it can therefore be difficult to assess the performance without a formal method. The main interest for a supermarket, with respect to the refrigeration system, is to optimise the total cost of ownership, (TCO). However, directly measuring TCO provides some challenges. It can therefore be beneficial to divide TCO into performance criteria, which can be quantified and measured. For supermarket refrigeration systems the performance criteria can be divided into three categories: quality-, energy- and reliability-related criteria. Hence, it is important to operate the refrigeration system such that it ensures good quality of the stored goods as energy efficient as possible without compromising the reliability of the system. A performance function that quantifies and measures the criteria has been developed in this project. The quality is measured by the control errors in the system because there is a connection between the quality of the stored goods and the ability of the refrigeration system to provide the required temperature. A deviation from the controller set-point corresponds to a temperature deviation, which will eventually harm the stored goods. The energy efficiency is measured by the coefficient of performance, COP, which basically is the delivered cooling power divided by the consumed electrical power of the system. The reliability criteria is measure by the switch frequency of the compressors in the refrigeration system. The reason is that excessive compressor switching will wear down the compressors too fast and thereby decrease the reliability of the system due to a higher demand for maintenance. The proposed performance function provides a method for assessing the operational performance at a plant-wide level and is therefore providing a tool for improving the plant-wide performance. The performance function has been used in different setups to improve the performance of the refrigeration system. Static and the dynamic performance of the refrigeration system has been addressed in the project. The proposed methods for improvement relies on a minimum of detailed knowledge about the refrigeration system. In addition, since a refrigeration system often operates in steady state an active system monitoring setup has been proposed, to enable improvement of the dynamic performance.
Ship Roll Damping Control

The technical feasibility of roll motion control devices has been amply demonstrated for over 100 years. Performance, however, can still fall short of expectations because of difficulties associated with control system designs, which have proven to be far from trivial due to fundamental performance limitations and large variations of the spectral characteristics of wave-induced roll motion. This tutorial paper presents an account of the development of various ship roll motion control systems together with the challenges associated with their design. It discusses the assessment of performance and the applicability of different mathematical models, and it surveys the control methods that have been implemented and validated with full scale experiments. The paper also presents an outlook on what are believed to be potential areas of research within this topic.
Statistical Change Detection for Diagnosis of Buoyancy Element Defects on Moored Floating Vessels

Floating platforms with mooring systems are used extensively in off-shore operations. Part of the mooring systems are underwater buoyancy elements that are attached to the mooring lines. Loss or damage of a buoyancy element is invisible but changes the characteristics of the mooring system and alters its ability to provide the necessary responses to withstand loads from weather. Damage of a buoyancy element increases the operation risk and could even cause abortion during an oil-offloading. The objective of this paper is to diagnose the loss of a buoyancy element using diagnostic methods. After residual generation, statistical change detection scheme is derived from mathematical models supported by experimental data. To experimentally verify loss of an underwater buoyancy element, an underwater line breaker is designed to create realistic replication of abrupt faults. The paper analyses the properties of residuals and suggests a dedicated GLRT change detector based on a vector residual. Special attention is paid to threshold selection for non ideal (non-IID) test statistics.

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Temperature Modelling of the Biomass Pretreatment Process

In a second generation biorefinery, the biomass pretreatment stage has an important contribution to the efficiency of the downstream processing units involved in biofuel production. Most of the pretreatment process occurs in a large pressurized thermal reactor that presents an irregular temperature distribution. Therefore, an accurate temperature model is critical for observing the biomass pretreatment. More than that, the biomass is also pushed with a constant horizontal speed along the reactor in order to ensure a continuous throughput. The goal of this paper is to derive a temperature model that captures the environmental temperature differences inside the reactor using distributed parameters. A Kalman filter is then added to account for any missing dynamics and the overall model is embedded into a temperature soft sensor. The operator of the plant will be able to observe the temperature in any point of the thermal reactor. Real data sets were extracted from the Inbicon biorefinery situated in Kalundborg, Denmark, and will be utilized to validate and test the temperature model.

General information
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Control Surface Fault Diagnosis for Small Autonomous Aircraft

Small unmanned aerial vehicles require a large degree of fault-tolerance in order to fulfil their duties in an satisfactory way, both with respect to economy and safety in operation. Small aerial vehicles are commonly constructed without much redundancy in hardware, primarily for reasons of cost but also weight. Single point of failure solutions are therefore commonly used and operation is typically allowed only in closed airspace. In order to enhance dependability, fault prognosis and diagnosis are needed. This paper explores principal redundancies at a very overall level, whether based on hardware or are analytical, and formulates residuals from which faults can be prognosticated or diagnosed. An approach is suggested where detailed modelling is not needed but normal behaviour is learned from short segments of flight data using adaptive methods for learning. Statistical characterisation of distributions and change detection methods are employed to reach decisions about not-normal behaviour and it is shown how control surface faults can be diagnosed for a specific UAV without adding additional hardware to the platform. Only telemetry data from the aircraft is used together with a basic model of relations between signals within the aircraft. Frequency domain methods are shown to be robust in exploring relevant properties of the signals. The detection is shown to work on data from a real incident where an aileron gets stuck during launch of a UAV.

General information
Detection of Oestrus and Lameness in Dairy Cows

This thesis describes studies conducted on the subject of detecting oestrus and lameness in dairy cows. The studies comprise methods of statistical change detection and model-based diagnosis, respectively. In the case of statistical change detection, the development of algorithms for a decision support system is based on identifying behaviour from patterns of normal and deviant behaviour. Signal processing combined with statistical methods, e.g., likelihood ratio tests, are utilized to correlate observed behaviours with normal and detect changes. Diagnosis includes data from the available population of animals in order to isolate patterns of behaviours outside the norm for individuals, while being robust to common disturbance factors. The research is based on methods from change detection and fault diagnosis. Fault diagnosis techniques are employed to reduce the false alarm ratio, and attempts are made to isolate events and artefacts in signals that otherwise can give rise to false alarms. For the model-based diagnosis, the diagnosis is generally done evaluating an estimated probability distribution against hypotheses about causes of change behaviour, e.g., oestrus or lameness. The models used for diagnosis are chosen to represent the behaviours. A quantized system description is used as a diagnostic model. This technique is based on automata theory. The methods are in most cases specified to take into account parameters specific to the differences between production systems. The development of these methods and algorithms is an interdisciplinary activity including methods from fault diagnosis, information technology, and statistics.

Diagnosis for Control and Decision Support in Complex Systems

Diagnosis and, when possible, prognosis of faults are essential for safe and reliable operation. The area of fault diagnosis has emerged over three decades. The majority of studies related to linear systems but real-life systems are complex and nonlinear. The development of methodologies coping with complex and nonlinear systems has matured and even though there are many unsolved problems, methodology and associated tools have become available in the form of theory and software for design. Genuine industrial cases have also become available. Analysis of system topology, referred to as structural analysis, has proven to be unique and simple in use and a recent extension to active structural techniques have made fault isolation possible in a wide range of systems. Following residual generation using these topology-based methods, deterministic and statistical change detection has proven very useful for on-line prognosis and diagnosis. For complex systems, results from non-Gaussian detection theory have been employed with convincing results. The paper presents the theoretical foundation for design methodologies that now appear as enabling technology for a new area of
design of systems that are reliable in practise. Yet they are also affordable due to the use of fault-tolerant philosophies and tools that make engineering efforts minimal for their implementation. The paper includes examples for an autonomous aircraft and a baling system for agriculture.

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**Fault Diagnosis for Nonlinear Hydraulic-Mechanical Drilling Pipe Handling System**
Leakage and increased friction are common faults in hydraulic cylinders that can have serious consequences if they are not detected at early stage. In this paper, the design of a fault detector for a nonlinear hydraulic mechanical system is presented. By considering the system in steady state, two residual signals are generated and analysed with a composite hypothesis test which accommodates for unknown parameters. The resulting detector is able to detect abrupt changes in leakage or friction given the noisy pressure and position measurements. Test rig measurements validate the properties of residuals and high fidelity simulation and experimental results demonstrate the performance and feasibility of the proposed method.

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**Fault Monitoring and Fault Recovery Control for Position Moored Tanker**
This paper addresses fault tolerant control for position mooring of a shuttle tanker operating in the North Sea. A complete framework for fault diagnosis is presented but the loss of a sub-sea mooring line buoyancy element is given particular attention, since this fault could lead to mooring line breakage and a high-risk abortion of an oil-loading operation. With significant drift forces from waves, non-Gaussian elements dominate forces and the residuals designed for fault diagnosis. Hypothesis testing need be designed using dedicated change detection for the type of distribution encountered. In addition to dedicated diagnosis, an optimal position algorithm is proposed to accommodate buoyancy element failure and keep the mooring system in a safe state. Furthermore, even in the case of line breakage, this optimal position strategy could be utilised to avoid breakage of a second mooring line. Properties of detection and fault-tolerant control are demonstrated by high fidelity simulations.

**General information**
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Organisations: Automation and Control, Department of Electrical Engineering, Norwegian University of Science and Technology
Modeling of tethered satellite formations using graph theory

Tethered satellite formations have recently gained increasing attention due to future mission proposals. Several different formations have been investigated for their dynamic properties and control schemes have been suggested. Formulating the equations of motion and investigation which geometries could form stable formations in space are cumbersome when done at a case to case basis, and a common framework providing a basic model of the dynamics of tethered satellite formations can therefore be advantageous. This paper suggests the use of graph theoretical quantities to describe a tethered satellite formation and proposes a method to deduce the equations of motion for the attitude dynamics of the formation in a compact form. The use of graph theory and Lagrange mechanics together allows a broad class of formations to be described using the same framework. A method is stated for finding stationary configurations and an upper limit of their number is determined. The method is shown to be valid for general tethered satellite formations that form a tree structure.

General information
State: Published
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Nonlinear, Adaptive and Fault-tolerant Control for Electro-hydraulic Servo Systems
Fluid power systems have been in use since 1795 with the rst hydraulic press patented by Joseph Bramah and today form the basis of many industries. Electro hydraulic servo systems are uid power systems controlled in closed-loop. They transform reference input signals into a set of movements in hydraulic actuators (cylinders or motors) by the means of hydraulic uid under pressure. With the development of computing power and control techniques during the last few decades, they are used increasingly in many industrial elds which require high actuation forces within limited space. However, despite numerous attractive properties, hydraulic systems are always subject to potential leakages in their components, friction variation in their hydraulic actuators and deciency in their sensors. These violations of normal behaviour reduce the system performances and can lead to system failure if they are not detected early and handled. Moreover, the task of controlling electro hydraulic systems for high performance operations is challenging due to the highly nonlinear behaviour of such systems and the large amount of uncertainties present in their models. This thesis focuses on nonlinear adaptive fault-tolerant control for a representative electro hydraulic servo controlled motion system. The thesis extends existing models of hydraulic systems by considering more detailed dynamics in the servo valve and in the friction inside the hydraulic cylinder. It identies the model parameters using experimental data from a test bed by analysing both the time response to standard input signals and the variation of the outputs with dierent excitation frequencies. The thesis also presents a model that accurately describes the static and dynamic normal behaviour of the system. Further, in this thesis, a fault detector is designed and implemented on the test bed that successfully diagnoses internal or external leakages, friction variations in the actuator or fault related to pressure sensors. The presented algorithm uses the position and pressure measurements to detect and isolate faults, avoiding missed detection and false alarm. The thesis also develops a high performance adaptive nonlinear controller for the hydraulic system which outperforms comparable linear controllers widely used in the industry. Because of the controller adaptivity, uncertainties in the model parameters can be handled. Moreover, a special attention is given to reduce the complexity of the controller in order to demonstrate its real-time implementation. Finally the thesis combines the techniques developed in fault detection and nonlinear control in order to develop an active fault-tolerant controller for electro hydraulic servo systems. In order to maintain overall service and performances as high as possible when a potential fault occurs, the fault-tolerant controlled system prognoses the fault and changes its controller parameters or structure. The consequences of an unexpected fault are avoided, high availability is ensured and the overall safety in electro hydraulic servo systems is increased.

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Authors: Choux, M. (Intern), Blanke, M. (Intern), Hovland, G. (Ekstern)
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Oestrus Detection in Dairy Cows from Activity and Lying Data using on-line Individual Models
Automated monitoring and detection of oestrus in dairy cows is attractive for reasons of economy in dairy farming. While high performance detection has been shown possible using high-priced progesterone measurements, detection results were less reliable when only low-cost sensor data were available. Aiming at improving detection scheme reliability with the use of low-cost sensor data, this study combines information from step count and leg tilt sensors. Introducing a lying balance for the individual animal, a novel change detection scheme is derived from observed distributions of the step count data and the lying balance. Detection and hypothesis testing are based on generalised likelihood ratio optimisation combined with time-wise joint probability windowing based on the duration of oestrus and oestrus intervals. It is shown to be essential that cow-specic parameters and test statistics are derived on-line from data to cope with behaviours of individuals. Performance is validated on 18 sequences of data where deinite proof of prior oestrus was available in form of subsequent pregnancy. These data were extracted from data sequences from 44 dairy cows over an 8 months period. The results show sensitivity 88.9% and error rate 5.9.%, which is very satisfactory when only cheap sensor data are used.

General information
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Passivity-Based Control of a Rigid Electrodynamic Tether

Electrodynamic tethers provide actuation for performing orbit correction of spacecrafts. When an electrodynamic tether system is orbiting the Earth in an inclined orbit, periodic changes in the magnetic field result in a family of unstable periodic solutions in the attitude motion. This paper shows how these periodic solutions can be stabilized by controlling only the current through the tether. A port-controlled Hamiltonian formulation is employed to describe the tethered satellite system and a passive input-output connection is utilized in the control design. The control law consists of two parts, a feedback connection, which stabilizes the open-loop equilibrium, and a bias term, which is able to drive the system trajectory away from this equilibrium, a feature necessary to obtain orbit adjustment capabilities of the electrodynamic tether. It is then shown how the periodic solutions of the closed-loop system can be approximated by power series and a relation is found between control gain and perturbations around the open-loop solution. Stability properties of the system are investigated using Floquet analysis and the region of stability is found in the plane defined by the control parameters.
Prediction of Parametric Roll Resonance by Multilayer Perceptron Neural Network

Parametric roll resonance is a ship stability related phenomenon that generates sudden large amplitude oscillations up to 30-40 degrees of roll. This can cause severe damage, and it can put the crew in serious danger. The need for a parametric rolling real time prediction system has been acknowledged in the last few years. This work proposes a prediction system based on a multilayer perceptron (MP) neural network. The training and testing of the MP network is accomplished by feeding it with simulated data of a three degrees-of-freedom nonlinear model of a fishing vessel. The neural network is shown to be capable of forecasting the ship’s roll motion in realistic scenarios.

Reliability-based dynamic positioning of floating vessels with riser and mooring system

To maintain safety of a floating vessel with associated slender components such as risers and mooring line, the vessel is normally kept within a limited region. To specify a safe position in that region, this paper suggests a new position chasing algorithm with the consideration of both riser angles and mooring line tensions. The riser angles were considered in an object function in [1] and the mooring line tension was considered in an object function in [2]. The contribution of this paper is to combine rolling real time prediction system and mooring line tension together in one unified object function. A combination of scaled riser angles and structural reliability index is utilized to evaluate the “reserve capacity” relative to failure events. With this object function, the riser angles and mooring line tension are considered in a unified formulation, with higher weight added to the riser angles due to their criticality. An optimal position set-point is produced by minimization of the value of the cost function. Numerical simulations show the effectiveness of the proposed algorithm.
Stochastic Automata for Outdoor Semantic Mapping using Optimised Signal Quantisation

Autonomous robots require many types of information to obtain intelligent and safe behaviours. For outdoor operations, semantic mapping is essential and this paper proposes a stochastic automaton to localise the robot within the semantic map. For correct modelling and classification under uncertainty, this paper suggests quantising robotic perceptual features, according to a probabilistic description, and then optimising the quantisation. The proposed method is compared with other state-of-the-art techniques that can assess the confidence of their classification. Data recorded on an autonomous agricultural robot are used for verification and the new method is shown to compare very favourably with existing ones.

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Organisations: Department of Electrical Engineering, Automation and Control
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Vertical Position Control for Top Tensioned Riser with Active Heave Compensator

The top and bottom angles of a marine riser are of crucial importance during e.g. drilling and workover operations. A vertical position control with active heave compensator (AHC) is proposed to maintain the safety of the riser when subjected to environmental excitations. The possibility of reducing the maximum angular response level by adjusting the vertical rod position by means of an active heave compensator is investigated with a positioning algorithm based on adaptive backstepping. Riser top and bottom angles are dealt with by the algorithm in order to minimize both angles.

General information
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from a set of sensors. The overall dependability of a shipboard monitoring and decision support system such as the SeaSense system can be improved using fault-tolerant techniques (Fault Diagnosis and System Re-design) and a Sensor Fusion Quality (SFQ) test. Fault diagnosis means to detect the presence of faults in the system. In case sea state estimation is conducted by a ship-wave buoy analogy the best solution is achieved when a set of three different ship responses are used. Faulty signals should be discarded from the procedure for sea state estimation if it is possible, if not the fault should be estimated. The fault diagnosis can be divided into three steps: Fault detection, fault isolation and fault estimation. Fault detection means to decide whether or not a fault has occurred. This step determines the time at which the system is subjected to the given fault. Fault isolation will find in which component a fault has occurred. This step determines the location of the fault. Fault estimation provides an estimate of magnitude of a fault. A supervisory function determines the severity of the fault once its origin has been isolated and its magnitude estimated. Fault-tolerant Sensor Fusion means that the monitoring and decision support system can accommodate faults so that the overall system continues to satisfy its goal and on the other hand in the absence of a fault, the system should be able to provide the most accurate information using the SFQ test.

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Modeling and Control of Electrodynamic Tethers - an Energy and Topology Approach
A space tether is a cable used to connect spacecrafts in an orbiting structure. If an electrical current is lead through the tether, it can be utilized to provide propulsion for the spacecraft. In this case the cable is referred to as an electrodynamic tether. The system utilizes the magnetic field of the Earth for creating a Lorentz force along the tether which occur when a current carrying wire operates in a magnetic field. The use of electrodynamic tethers are interesting since they operate solely on electrical energy, which can be provided by solar panels of the spacecrafts. In this way the amount of propellant a spacecraft need to bring from Earth can be reduced. In this thesis the modeling and control of electrodynamic tethers are investigated, both when a single tether is used to connect two spacecrafts, and when the tethers are used i more general formations of spacecrafts. One of the main challenges when using electrodynamic tethers is that the force created along the tether is based on an external uncontrollable condition, namely the magnetic field. Even with a known model of the magnetic field, limitations to the creation of the Lorentz force still exists, since the force can only be generated perpendicular to the instantaneous magnetic field. Furthermore, the control problem is complicated by the time variations in the magnetic field. This thesis solves these problems by utilizing an energy-based system description and a passivity-based control design. An advantage of the energy-based approach is that the stability of the system can easily be investigated, based on the energy flow in the system. Systems of several spacecrafts connected by tethers has many applications, for example in connection with space telescopes and space stations. Tethered formations are advantageous, compared to formations of free-flying spacecrafts, since a predetermined geometry of spacecrafts is easily maintained. This thesis investigates the use of electrodynamic tethers for such tethered satellite formations with focus on the modeling and control aspects. One can think of many different structures for solving tasks in space, and separate derivations of the dynamical equations can be cumbersome. It can therefore be advantageous to be able to model a formation independent of its topology, i.e. the way tethers and satellites are interconnected. The thesis treats a class of formations in a generic framework, using graph theory to describe the topology of the formations. The framework can be used both to deduce the equations of motion for the attitude motion of the formation and for control design regarding the same motion. The main part of the thesis consists of five scientific papers which have been submitted for international journals and conferences during the PhD project.
Fault-Tolerant Vision for Vehicle Guidance in Agriculture
The emergence of widely available vision technologies is enabling for a wide range of automation tasks in industry and other areas. Agricultural vehicle guidance systems have benefitted from advances in 3D vision based on stereo camera technology. By automatically guiding vehicles along crops and other field structures the operator’s stress levels can be reduced. High precision steering in sensitive crops can also be maintained for longer periods of time as the driver is less.tired. Safety and availability must be inherent in such systems in order to get widespread market acceptance. To tolerate dropout of 3D vision, faults in classification, or other defects, redundant information should be utilized. Such information can be used to diagnose faulty behavior and to temporarily continue operation with a reduced set of sensors when faults or artifacts occur. Additional sensors include GPS receivers and inertial sensors. To fully utilize the possibilities in 3D vision, the system must also be able to learn and adapt to changing environments. By learning features of the environment new diagnostic relations can be generated by creating redundant feed-forward information about crop location. Also, by mapping the field that is seen by the stereo camera, it is possible to support the guidance system by storing salient information about the environment. By tracking the motion of the vehicle, vision output can be fused over time to create more reliable and robust estimates of crop location. This thesis approaches these challenges by considering systematic design methods using graph-based analysis. It is demonstrated how diagnostic relations can be derived and remedial actions can be done to maintain safety and healthy functioning of vision systems. The combination of redundant information from 3D vision, mapping, and aiding sensors such as GPS provide means to detect and isolate single faults in the system. In addition, learning is employed to adapt the system to variational changes in the natural environment. 3D vision is enhanced by learning texture and color information. Intensity gradients on small neighborhoods of pixels are shown to provide a superior approach to modeling texture information than other methods. Stochastic automata using optimally quantized data is demonstrated as a strong approach for offline learning. It is considered how 3D vision provides labeling of training data that subsequently can be fed into a learning system. Statistical change detection theory is shown to be a suitable approach to detecting artifacts in the learning process so safe operation can be maintained. The system can be used to perform real-time classification using a fast online approach that is superior to state-of-the-art. Advances in tracking vehicle motion using 3D vision is demonstrated to allow unprecedented high accuracy maps to be created of the local environment. Features in the environment are extracted and tracked using novel feature detectors relying on approximating the Laplacian operator with a bi-level octagonal kernel. It is shown how these features display high levels of accuracy and stability while being considerable faster than similar feature detectors. Artifacts in 3D vision range measurements are demonstrated to be detectable by using the generated 3D maps and a probabilistic approach to fusing and comparing range measurements.
Autonomous Supervision and Control of Parametric Roll Resonance

When ships sail in longitudinal waves, and the encounter frequency and wave length satisfy certain conditions, passage of wave crest and wave trough along the hull continuously amplifies the roll motion at half the frequency of encounter. This gives the onset of a resonance condition. The phenomenon can induce a rapid increase in roll motion that can reach 40 degrees or more. Recent incidents have shown that modern container ships and some fishing vessels are particularly prone to this due to their hull shape. Such incidents can result in damages counting to millions of USD. Theoretically, the resonance behaviour is well understood and it can be reproduced by quasi-periodic changes in parameters of nonlinear differential equations that describe ship motion. Practically, the challenge is whether detection and stabilization can be achieved in time to avoid damage. The research in this thesis has therefore two objectives. The first is to develop methods for detection of the inception of parametric roll resonance. The second is to develop control strategies to stabilize the motion after parametric roll has started. Stabilisation of parametric roll resonance points to two possible courses of action. One is a direct stabilisation through an increase of damping in roll, which increases the threshold that triggers the resonant motion. A second is to obtain a change in wave encounter frequency by means of changes in ship forward speed and/or heading. As direct stabilisation, this thesis considers the increase of roll damping by using fin stabilisers, which are controlled using integrator backstepping methods. As indirect stabilisation, a shift in the encounter frequency is considered by varying the ship forward speed. The speed controller is designed using nonlinear Lyapunov methods. The two control strategies are then combined to stabilise parametric roll resonance within few roll cycles. Limitations on the maximum stabilisable roll angle are analysed and linked to the ii slew rate saturation and hydrodynamic stall characteristics of the fin stabilisers. The study on maximum stabilisable roll angle leads to the requirements for early detection. Two novel detectors are proposed, which work within a short time prediction horizon, and issue early warnings of parametric roll inception within few roll cycles from its onset. The main idea behind these detection schemes is that of exploiting the link between the second harmonic of roll angle and the first harmonic of heave or pitch motions. A nonlinear energy flow indicator, which measures the transfer of energy from the first harmonic of heave or pitch into the second harmonic of roll, is at the core of the first detector. The second detector relies on a driving signal that carries information about the phase correlation between either pitch or heave and roll. A generalised likelihood ratio test is designed to detect a change in distribution of the driving signal. The detectors are validated against experimental data of tests of a 1:45 scale model of a container ship. The validation shows excellent performance in terms of time to detect and false-alarm rate for both the proposed detectors. The detectors are the main contribution of this research. The thesis also offers a contribution regarding modeling. A 3 degree-offreedom nonlinear model in heave-pitch-roll of a container ship suitable for parametric roll resonance study is proposed. The model, which has been developed in collaboration with other researchers, provides a benchmark for the study and simulation of parametric roll over a large range of ship speeds and sea states. The results of this research have been published in articles enclosed in this dissertation and in an international patent application.

Active Sensor Configuration Validation for Refrigeration Systems

Major faults in the commissioning phase of refrigeration systems are caused by defects related to sensors. With a number of similar sensors available that do not differ by type but only by spatial location in the plant, interchange of sensors is a common defect. With sensors being used quite differently by the control system, fault-finding is difficult in practice and defects are regularly causing commissioning delays at considerable expense. Validation and handling of faults in the sensor configuration are therefore essential to cut costs during commissioning. With passive fault-diagnosis methods falling short on this problem, this paper suggests an active diagnosis procedure to isolate sensor faults at the commissioning stage, before normal operation has started. Using statistical methods, residuals are evaluated versus multiple hypothesis models in a minimization process to uniquely identify the sensor configuration. The method as such is
generic and is shown in the paper to work convincingly on refrigeration systems with significant nonlinear behaviors.

**Diagnosis of UAV Pitot Tube Defects Using Statistical Change Detection**

Unmanned Aerial Vehicles need a large degree of tolerance to faults. One of the most important steps towards this is the ability to detect and isolate faults in sensors and actuators in real time and make remedial actions to avoid that faults develop to failure. This paper analyses the possibilities of detecting faults in the pitot tube of a small unmanned aerial vehicle, a fault that easily causes a crash if not diagnosed and handled in time. Using as redundant information the velocity measured from an onboard GPS receiver, the air-speed estimated from engine throttle and the pitot tube based airspeed, the paper analyses the properties of residuals. A dedicated change detector is suggested that works on pre-whitened residuals and a generalised likelihood ratio test is derived for a Cauchy probability density, which the residuals are observed to have. A detection scheme is obtained using a threshold that provides desired quantities of false alarm and detection probabilities. Fault detectors are build based on raw residual data and on a whitened edition of these. The two detectors are compared against recorded telemetry data of an actual event where a pitot tube defect occurred.

**Fault Isolation and quality assessment for shipboard monitoring**

In this paper a new approach for increasing the overall reliability of a monitoring and decision support system will be explained. The focus is on systems used for ship operator guidance with respect to, say, speed and heading. The basic idea is to convert the given system into a fault tolerant system and to improve multi-sensor data fusion for the particular system. Fault isolation is an important part of the fault tolerant design for in-service monitoring and decision support systems for ships. In the paper, a virtual example of fault isolation will be presented. Several possible faults will be simulated and isolated using residuals and the generalized likelihood ratio (GLR) algorithm. It will be demonstrated that the approach can be used to increase accuracy of sea state estimations employing sensor fusion quality test.
**Fault Isolation for Shipboard Decision Support**

Fault detection and fault isolation for in-service decision support systems for marine surface vehicles will be presented in this paper. The stochastic wave elevation and the associated ship responses are modeled in the frequency domain. The paper takes as an example fault isolation of a containership on which a decision support system has been installed and it will be demonstrated that all the faults can be isolated. The paper shows how a shipboard decision support system could become highly reliable and comprise built-in supervision of the quality of the sensor signals that are crucial to the quality of decisions given to navigators.

**Optimal Set-point Chasing of Position Moored Vessel**

Dynamic positioning of surface vessels moored to the seabed via a spread mooring system are referred to as position mooring (PM), the main objective of which is to keep the vessel within a small radius from a given position while preventing mooring line breakage. When environmental loads become high, position mooring systems apply thruster forces to protect mooring lines and position accuracy may need be relaxed. This paper suggests an new position chasing algorithm that works entirely online, is optimal according to a criterion and can protect any number of mooring lines simultaneously. Tensions of all mooring lines are included in a cost function where the criticality for each mooring line determine individual weights. With this strategy, external environment effects are included directly by without needing predefined tabular settings of environmental loads as in earlier approaches. There is no limitation to the number of mooring lines that can be close to critical tension. A reliability index is used as weight to include the dynamic influence of mooring line tension. Detailed simulations illustrate the features and advantages of the new method and results are compared with those of a fixed weight algorithm.
Prediction of resonant oscillation

The invention relates to methods for prediction of parametric rolling of vessels. The methods are based on frequency domain and time domain information in order to set up a detector able to trigger an alarm when parametric roll is likely to occur. The methods use measurements of e.g. pitch and roll oscillations and compare the measured oscillations using FFT analysis of signal correlations, variance analysis of signals and other comparisons. As an example, the presence of a growing peak around a frequency that doubles the roll natural frequency indicates the possibility that parametric roll is going to happen.

Satellite Dynamics and Control in a Quaternion Formulation (2nd edition)

This lecture note treats modelling and attitude control design using a quaternion description of attitude for a rigid body in space. Dynamics and kinematics of a satellite is formulated as a non-linear model from Euler’s moment equations and a description of kinematics using the attitude quaternion to represent rotation. A general linearised model is derived such that the user can specify an arbitrary point of operation in angular velocity and wheel angular momentum, specifying the inertia matrix for a rigid satellite. A set of Simulink® models that simulate the satellite’s nonlinear behaviour are described and a Matlab® function is described that has been written to calculate the linear model in an arbitrary point of operation.
Ship Roll Motion Control
The technical feasibility of roll motion control devices has been amply demonstrated for over 100 years. Performance, however, can still fall short of expectations because of deficiencies in control system designs, which have proven to be far from trivial due to fundamental performance limitations. This tutorial paper presents an account of the development of various ship roll motion control systems and the challenges associated with their design. The paper discusses how to assess performance, the applicability of different models, and control methods that have been applied in the past.

Stereo vision with texture learning for fault-tolerant automatic baling
This paper presents advances in using stereovision for automating baling. A robust classification scheme is demonstrated for learning and classifying based on texture and shape. Using a state-of-the-art texton approach a fast classifier is obtained that can handle non-linearities in the data. The addition of shape information makes the method robust to large variations and greatly reduces false alarms by applying tight geometrical constraints. The classifier is tested on data from a stereovision guidance system on a tractor. The system is able to classify cut plant material (called swath) by learning it's appearance. A 3D classifier is used to train and supervise the texture classifier.
Robotic Navigation in Orchard - Diagnosis and Supervision for Enhanced Availability

Autonomous vehicles require a very high degree of availability and safety to become accepted by authorities and the public. Diagnosis and supervision are necessary means to achieve this. This paper investigates ways of using laser-scanner data to do localisation, and as a source of independent supervision, using expectation maximisation of laser-scanner output against uncertain map features. Analysis of system behaviours and their structure shows which redundant information is available to construct a supervisor. Tests on real life orchard data demonstrates the feasibility of the new approach.

General information
State: Published
Organisations: Department of Electrical Engineering, Automation and Control
Authors: Hansen, S. (Intern), Blanke, M. (Intern), Andersen, J. C. (Intern)
Pages: 360-365
Publication date: 2009
Combination of activity and lying/standing data for detection of oestrus in cows

The objective of this study is to develop an algorithm for detecting oestrus in dairy cows from measurements of activity and duration of lying/standing periods. Each cow’s activity is measured by a sensor attached to the neck that returns an activity index for each hour. Duration of lying is measured by a sensor attached to the hind leg of the cow. Activity and lying/standing behaviour are modelled as a discrete event system, constructed using automata theory. In an attempt to estimate a biologically relevant lying balance, a lying balance indicator is constructed and influences transition probabilities in the stochastic automata. The cows’ lying balance indicates how much the cow has been resting during the immediately past period, and the balance expresses to the automata the tendency of the cow to continue resting or not. Automata for describing the two scenarios; normal and oestrus are designed and results of decision algorithms are presented for Oestrus detection. Detection based on the lying balance indicator and the two sets of measured information are demonstrated to increase the detection sensitivity to 100% for a set of 10 cows.

Combining Stochastic Automata and Classification Techniques for Supervision and Safe Orchard Navigation

Cost drivers in commercial orchards are time-consuming tasks as the drive through rows for spraying, cutting grass or collecting fruit. An automated tractor can be an answer to enhance production efficiency. For this to be acceptable by public and authorities, safety and reliability are crucial, hence information redundancy is needed to achieve a fault-tolerant system. This paper addresses ways to extract information from laser scanner data. A Gaussian Mixture model is used to classify laser data into obstacles, while through diagnosis, a stochastic automaton model gives a semantic position estimate relying only on laser perception. Results demonstrate the feasibility of implementation in an autonomous tractor that uses diagnosis and active fault-tolerant control to enhance availability and safety.
Control by damping Injection of Electrodynamic Tether System in an Inclined Orbit
Control of a satellite system with an electrodynamic tether as actuator is a time-periodic and underactuated control problem. This paper considers the tethered satellite in a Hamiltonian framework and determines a port-controlled Hamiltonian formulation that adequately describes the nonlinear dynamical system. Based on this model, a nonlinear controller is designed that will make the system asymptotically stable around its open-loop equilibrium. The control scheme handles the time-varying nature of the system in a suitable manner resulting in a large operational region. The performance of the closed loop system is treated using Floquet theory, investigating the closed loop properties for their dependency of the controller gain and orbit inclination.

Detection of Parametric Roll Resonance on Ships from Indication of Nonlinear Energy Flow
The detection of the onset of parametric roll resonance on ships is of a central importance in order to activate specific control strategies able to counteract the large roll motion. One of the main priorities is to have detectors with a small detection time, such that warnings can be issued when the roll oscillations are about 5°. This paper proposes two different detection approaches: the first one based on sinusoidal detection in white gaussian noise; the second one utilizes an energy flow indicator in order to catch the onset of parametric roll based upon the transfer of energy from heave and pitch to roll. Both detectors have been validated against experimental data of a scale model of a container vessel excited with both regular and irregular waves. The detector based on the energy flow indicator proved to be very robust to different scenarios (regular/irregular waves) since it does not rely on any specific assumption on the signal to be detected.
DIAGNOSIS OF PITCH AND LOAD DEFECTS

The invention relates to a method, system and computer readable code for diagnosis of pitch and/or load defects of e.g. wind turbines as well as wind turbines using said diagnosis method and/or comprising said diagnosis system.

General information
State: Published
Organisations: Automation and Control, Department of Electrical Engineering, VESTAS Wind Systems A/S
Authors: Blanke, M. (Intern), Dalsgaard, S. (Ekstern), Brath, P. (Ekstern)
Publication date: 2009

Publication information
Patent number: WO2009059606
Date: 14/05/2009
Original language: English

Discussion on: "Structural Analysis of the Partial State and Input Observability for Structured Linear Systems. Application to Distributed Systems"

General information
State: Published
Organisations: Automation and Control, Department of Electrical Engineering
Authors: Izadi-Zamanabadi, R. (Ekstern), Blanke, M. (Intern)
Pages: 519-520
Publication date: 2009
Main Research Area: Technical/natural sciences

Publication information
Journal: European Journal of Control
Volume: 15
Issue number: 5
ISSN (Print): 0947-3580
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 1.702 SNIP 1.714 CiteScore 2.4
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.934 SNIP 1.146 CiteScore 1.46
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.901 SNIP 1.326 CiteScore 1.07
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.609 SNIP 0.817 CiteScore 0.84
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Fault Detection for Shipboard Monitoring – Volterra Kernel and Hammerstein Model Approaches

In this paper nonlinear fault detection for in-service monitoring and decision support systems for ships will be presented. The ship is described as a nonlinear system, and the stochastic wave elevation and the associated ship responses are conveniently modelled in frequency domain. The transformation from time domain to frequency domain has been conducted by use of Volterra theory. The paper takes as an example fault detection of a containership on which a decision support system has been installed.

General information

State: Published
Organisations: Coastal, Maritime and Structural Engineering, Department of Mechanical Engineering, Automation and Control, Department of Electrical Engineering
Authors: Lajic, Z. (Intern), Blanke, M. (Intern), Nielsen, U. D. (Intern)
Pages: 24-29
Publication date: 2009

Host publication information

Title of host publication: 7. IFAC Symposium on Fault Detection, Supervision and Safety of Technical Processes
ISBN (Print): 978-3-902661-46-3
Main Research Area: Technical/natural sciences
Conference: 7th IFAC Symposium on Fault Detection, Supervision and Safety of Technical Processes, Barcelona, Spain, 30/06/2009 - 30/06/2009
Sensor and actuator faults, Nonlinear methods, Marine applications
DOIs: 10.3182/20090630-4-ES-2003.00004
Source: orbit
Source-ID: 257007
Publication: Research - peer-review › Journal article – Annual report year: 2009

Fault Monitoring and Fault Recovery Control for Position Moored Tanker

This paper addresses fault tolerant control for position mooring of a shuttle tanker operating in the North Sea. A complete framework for fault diagnosis is presented but the loss of a sub-sea mooring line buoyancy element is given particular attention, since this fault could lead to line breakage and risky abortion of an oil-loading operation. With significant drift forces from waves, non-Gaussian elements dominate in residuals and fault diagnosis need be designed using dedicated
change detection for the type of distribution encountered. In addition to dedicated diagnosis, an optimal position algorithm is proposed to accommodate buoyancy element failure and keep the mooring system in a safe state. Detection properties and fault-tolerant control are demonstrated by high fidelity simulations.

**General information**
State: Published
Organisations: Automation and Control, Department of Electrical Engineering
Authors: Fang, S. (Ekstern), Blanke, M. (Intern)
Publication date: 2009

**Host publication information**
Title of host publication: Proceedings of Workshop on Advanced Control and Diagnosis : ACD'2009
Main Research Area: Technical/natural sciences
Conference: Workshop on Advanced Control and Diagnosis, Zielona Góra, Poland, 01/01/2009
Fault Diagnosis
Electronic versions:
78_ACD_2009.pdf

**Bibliographical note**
Proceedings on CD-rom
Source: orbit
Source-ID: 255010
Publication: Research - peer-review › Article in proceedings – Annual report year: 2009

Fault-tolerant 3D Mapping with Application to an Orchard Robot
In this paper we present a geometric reasoning method for dealing with noise as well as faults present in 3D depth maps. These maps are acquired using stereo-vision sensors, but our framework makes no assumption about the origin of the underlying data. The method is based on observations made on the environment from different camera poses (viewpoints), where the occupied space as well as uncertainties in the range measurement are modelled using dynamic octree structures. This scheme allows us to detect and diagnose faulty range measurements in an efficient manner. We present results on the acquisition of comprehensive 3D maps for an agricultural robot operating in an orchard.

**General information**
State: Published
Organisations: Automation and Control, Department of Electrical Engineering, Technical University of Munich
Authors: Blas, M. R. (Intern), Blanke, M. (Intern), Rusu, R. B. (Ekstern), Beetz, M. (Ekstern)
Pages: 893-898
Publication date: 2009

**Host publication information**
Title of host publication: 7. IFAC Symposium on Fault Detection, Supervision and Safety of Technical Processes
ISBN (Print): 978-3-902661-46-3
Main Research Area: Technical/natural sciences
Conference: 7th IFAC Symposium on Fault Detection, Supervision and Safety of Technical Processes, Barcelona, Spain, 30/06/2009 - 30/06/2009
Other applications, Sensor and actuator faults
DOI: 10.3182/20090630-4-ES-2003.00147
Source: orbit
Source-ID: 246430
Publication: Research - peer-review › Article in proceedings – Annual report year: 2009

Improving Oestrus Detection in Dairy Cows by Combining Statistical Detection with Fuzzy Logic Classification
Ecient automated oestrus detection in cows and heifers deeply influences reproductive performance of the animals, and the livestock farmers' profitability. The main problem for practical application of automated detection is the high number generation of false-positive alerts. False alerts could be triggered by changes in feeding or heard behaviour. The detection to false alarm ratio need be very high to get farmers' confidence in an oestrus detection system. Therefore, a method to enhance detection and reduce false alarm probabilities is necessary. Earlier research investigated statistical change detection and hypothesis testing applied on activity sensor data. This paper enhances earlier method by employing fuzzy logic technique to classify oestrus alerts from a model-based detection method utilising the cyclic nature of oestrus. Based on the distribution of the trait period since last detected oestrus, a set of membership functions is introduced with the objective of decreasing the number of false positive alerts as well as improve missed detection rate. The approach was tested on data from twelve diary cows collected over six months. The results show that the number of true detected cases decreased slightly after classification but false positive alerts were almost eliminated.
This paper concerns localisation of an autonomous tractor in an orchard environment, with the purpose of designing a localisation solution to be compared with GPS. The localisation is based on an estimate found by an extended Kalman filter, which fuses measurements from encoders and gyro with row measurements provided by a laser scanner. Kalmtool is used as a toolbox for developing the localisation algorithm. The result shows that the toolbox can be used successfully for dealing with localisation and sensor fusion.

This paper addresses detection of oestrus in dairy cows using automata-based modelling and diagnosis. Measuring lying/standing behaviour of the cows by a sensor attached to the cows hindleg, lying/standing behaviour is modelled as a stochastic automaton. The paper introduces a cow's lying-balance as a biologically inspired quantity describing how much the cow has been resting for a preceding period. A dynamic lying-balance model is identified from real data and the lying balance is used as input, together with lying/standing sensor measurements. Using different automata models for oestrus and non-oestrus conditions, with state transition probability densities identified from observations, diagnosis theory for stochastic automata is employed to obtain diagnoses of oestrus. The oestrus cases are detected using consistency based diagnosis on real data.
Parametric Roll Resonance Detection using Phase Correlation and Log-likelihood Testing Techniques

Real-time detection of parametric roll is still an open issue that is gathering an increasing attention. A first generation warning systems, based on guidelines and polar diagrams, showed their potential to face issues like long-term prediction and risk assessment. This paper presents a second generation warning system the purpose of which is to provide the master with an onboard system able to trigger an alarm when parametric roll is likely to happen within the immediate future. A detection scheme is introduced, which is able to issue a warning within five roll periods after a resonant motion started. After having determined statistical properties of the signals at hand, a detector based on the generalised log-likelihood ratio test (GLRT) is designed to look for variation in signal power. The ability of the detector to trigger alarms when parametric roll is going to onset is evaluated on two sets of experimental data, covering both regular and irregular seas in a model basin.

Robust Adaptive Backstepping Control Design for a Nonlinear Hydraulic-Mechanical System

The complex dynamics that characterize hydraulic systems make it difficult for the control design to achieve prescribed goals in an efficient manner. In this paper, we present the design and analysis of a robust nonlinear controller for a nonlinear hydraulic-mechanical (NHM) system. The system consists of an electrohydraulic servo valve and two hydraulic cylinders. Specifically, by considering a part of the dynamics of the NHM system as a norm-bounded uncertainty, two adaptive controllers are developed based on the backstepping technique that ensure the tracking error signals asymptotically converge to zero despite the uncertainties in the system according to the Barbalat lemma. The resulting controllers are able to take into account the interval uncertainties in Coulomb friction parameters and in the internal leakage parameters in the cylinders. Two adaptation laws are obtained by using the Lyapunov functional method and inequality techniques. Simulation results demonstrate the performance and feasibility of the proposed method.
Safe and Reliable - Further Development of a Field Robot

General information
State: Published
Organisations: Automation and Control, Department of Electrical Engineering, University of Copenhagen, Hako Werke GmbH, Agrocom Vision
Authors: Griepentrog, H. W. (Ekstern), Andersen, N. A. (Intern), Andersen, J. C. (Intern), Blanke, M. (Intern), Heinemann, O. (Ekstern), Nielsen, J. (Ekstern), Pedersen, S. M. (Ekstern), Madsen, T. E. (Ekstern), Ravn, O. (Intern), Wulfsohn, D. (Ekstern)
Pages: 857-866
Publication date: 2009

Stabilisation of Parametric Roll Resonance by Combined Speed and Fin Stabiliser Control

Parametric roll resonance on a ship is a condition where large roll motion develops rapidly in moderate head or following seas. The phenomenon is caused by bifurcation in the nonlinear equations of motion when a restoring moment is subject to periodic variation. This paper analyzes the stability of the nonlinear system and suggests active control of both ship speed and fin stabilizers to stabilise the roll resonance condition. Lyapunov and backstepping designs are employed to achieve two nonlinear controllers, which are proved to stabilise the nonlinear system. The designed controllers are validated employing a high fidelity simulation model. The combined speed and fin stabiliser control is shown to efficiently drive the vessel out of the bifurcation condition and to quickly damp the residual roll motion.

General information
State: Published
Organisations: Automation and Control, Department of Electrical Engineering, Norwegian University of Science and Technology
Authors: Galeazzi, R. (Intern), Holden, C. (Ekstern), Blanke, M. (Intern), Fossen, T. I. (Ekstern)
Pages: 4895-4900
Publication date: 2009

Stabilization of periodic solutions in a tethered satellite system by damping injection

A spacecraft with electrodynamic tether orbiting the Earth will be subject to a periodic forcing term induced by the variation of the magnetic field along the orbit. The periodic forcing term leads to a family of unstable periodic solutions for a tether
carrying a constant current. This paper presents a control design for stabilizing these periodic solutions. The design consists of a control law for stabilizing the open-loop equilibrium and a bias term which forces the system trajectory away from the equilibrium. The tether needs to be positioned away from open-loop equilibrium for the tether to affect the orbit parameters. An approximation of the periodic solutions of the closed-loop system is found as a series expansion in the parameter plane spanned by the controller gain and the bias term. The stability of the solutions is investigated using linear Floquet analysis of the variational equation and the region of stable periodic solutions in the parameter plane is found.

**General information**
State: Published
Organisations: Department of Electrical Engineering, Automation and Control
Authors: Larsen, M. B. (Intern), Blanke, M. (Intern)
Pages: 2169-2174
Publication date: 2009

**Host publication information**
Title of host publication: Proceedings of the European Control Conference 2009
Publisher: IEEE
ISBN (Print): 9783952417393
Main Research Area: Technical/natural sciences
Control and Systems Engineering, Closed loop systems, Orbits, Space flight, Damping injection, Electro-dynamic tether, Periodic forcing, Periodic solution, Series expansion, System trajectory, Tethered satellite systems, Variational equations, Tetherlines
Source: FindIt
Source-ID: 2288790427
Publication: Research - peer-review › Article in proceedings – Annual report year: 2009

Stabilization of Periodic Solutions in a Tethered Satellite System by Damping Injection
A spacecraft with electrodynamic tether orbiting the Earth will be subject to a periodic forcing term induced by the variation of the magnetic field along the orbit. The periodic forcing term leads to a family of unstable periodic solutions for a tether carrying a constant current. This paper presents a control design for stabilizing these periodic solutions. The design consists of a control law for stabilising the open-loop equilibrium and a bias term which forces the system trajectory away from the equilibrium. The tether needs to be positioned away from open-loop equilibrium for the tether to affect the orbit parameters. An approximation of the periodic solutions of the closed-loop system is found as a series expansion in the parameter plane spanned by the controller gain and the bias term. The stability of the solutions is investigated using linear Floquet analysis of the variational equation and the region of stable periodic solutions in the parameter plane is found.

**General information**
State: Published
Organisations: Automation and Control, Department of Electrical Engineering
Authors: Larsen, M. B. (Intern), Blanke, M. (Intern)
Pages: 2169-2174
Publication date: 2009

**Host publication information**
Title of host publication: Proceedings of European Control Conference 2009 : ECC 2009
ISBN (Print): 978-963-311-369-1
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 248519
Publication: Research - peer-review › Article in proceedings – Annual report year: 2009

Structural Analysis Extended with Active Fault Isolation - Methods and Algorithms
Isolabilility of faults is a key issue in fault diagnosis whether the aim is maintenance or active fault-tolerant control. It is often encountered that while faults are detectable, they are only group-wise isolable from a usual diagnostic point of view. However, active injection of test signals on system inputs can considerably enhance fault isolability. This paper investigates this possibility of active fault isolation from a structural point of view. While such extension of the structural analysis approach was suggested earlier, algorithms and case studies were needed to explore this theory. The paper develops algorithms for investigation of the possibilities of active structural isolation and it offers illustrative examples and a larger case study to explore the properties of active structural isolability ideas.

**General information**
State: Published
Organisations: Department of Electrical Engineering, Automation and Control, Universitat de Girona
Fault Diagnosis Of A Water For Injection System Using Enhanced Structural Isolation

A water for injection system supplies chilled sterile water as solvent to pharmaceutical products. There are ultimate requirements to the quality of the sterile water, and the consequence of a fault in temperature or in flow control within the process may cause loss of one or more batches of the production. Early diagnosis of faults is hence of considerable interest for this process. This study investigates the properties of multiple matchings with respect to isolability and it suggests to explore the topologies of multiple use-modes for the process and to employ active techniques for fault isolation to enhance structural isolability of faults. The suggested methods are validated on a high-fidelity simulation of the process.
Natural Environment Modeling and Fault-Diagnosis for Automated Agricultural Vehicle

This paper presents results for an automatic navigation system for agricultural vehicles. The system uses stereo-vision, inertial sensors and GPS. Special emphasis has been placed on modeling the natural environment in conjunction with a fault-tolerant navigation system. The results are exemplified by an agricultural vehicle following cut grass (swath). It is demonstrated how faults in the system can be detected and diagnosed using state of the art techniques from fault-tolerant literature. Results in performing fault-diagnosis and fault accommodation are presented using real data.

General information
State: Published
Organisations: Automation, Department of Electrical Engineering
Authors: Blas, M. R. (Intern), Blanke, M. (Intern)
Pages: 1590-1595
Publication date: 2008

Host publication information
Title of host publication: Proceedings 17th IFAC World Congress
Publisher: Elsevier
Main Research Area: Technical/natural sciences
Conference: 17th IFAC World Congress, Seoul, Korea, Republic of, 06/07/2008 - 06/07/2008
Autonomous vehicles in agriculture, Image analysis in agriculture

Oestrus Detection in Dairy Cows Using Likelihood Ratio Tests

This paper addresses detection of oestrus in dairy cows using methods from statistical change detection. The activity of the cows was measured by a necklace attached sensor. Statistical properties of the activity measure were investigated. Using data sets from 17 cows, diurnal activity variations were identified for the ensemble and for the individual cows. A diurnal filter was adapted to remove the daily variation of the individual. Change detection algorithms were designed for the actual probability densities, which were Rayleigh distributed with individual parameters for each cow. A generalized likelihood ratio algorithm was derived for the compensated activity signal and detection algorithm was tested on 2323 days of activity, which contained 42 oestruses on 12 cows in total. The application of statistical change detection methods is a new approach for detecting oestrus in dairy cows and the results are shown to outperform earlier approaches in respect to combined statistics of false alarms and missed detections.

General information
State: Published
Organisations: Automation, Department of Electrical Engineering, Mathematical Statistics, Department of Informatics and Mathematical Modeling, Aarhus University
Authors: Jónsson, R. I. (Intern), Björgvinsson, T. (Ekstern), Blanke, M. (Intern), Poulsen, N. K. (Intern), Højsgaard, S. (Ekstern), Munksgaard, L. (Ekstern)
Pages: 658-663
Publication date: 2008
Special section on maneuvering and control of marine craft

General information
State: Published
Organisations: Automation, Department of Electrical Engineering, University of Girona
Authors: Blanke, M. (Intern), Ridao, P. (Ekstern)
Pages: 444-445
Publication date: 2008
Main Research Area: Technical/natural sciences

Publication information
Journal: Control Engineering Practice
Volume: 16
Issue number: 4
ISSN (Print): 0967-0661
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BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.42 SJR 1.287 SNIP 2.156
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.194 SNIP 2.091 CiteScore 3.05
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.323 SNIP 2.626 CiteScore 3.26
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.433 SNIP 3.278 CiteScore 3.5
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.267 SNIP 3.118 CiteScore 3.02
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.544 SNIP 2.911 CiteScore 2.96
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.343 SNIP 2.745
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.487 SNIP 3.019
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.432 SNIP 2.917
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.105 SNIP 2.169
Scopus rating (2006): SJR 0.909 SNIP 1.894
Scopus rating (2005): SJR 0.579 SNIP 1.595
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.476 SNIP 1.304
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.658 SNIP 1.33
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.481 SNIP 1.05
Stability Analysis of the Parametric Roll Resonance under Non-constant Ship Speed

The aim of this work is to analyze the influence of a nonconstant ship speed on the onset and development of the parametric roll resonance. A 2-DOF nonlinear surge-roll model is set up and analyzed. Perturbation methods are also applied to evaluate the influence of dynamic variations of surge velocity on the onset of parametric roll. The theoretical results are illustrated and validated using a 4-DOF hydrodynamic and control theory model.

An Efficiency Optimizing Shaft Speed Control for Ships in Moderate Seas

Ships in moderate sea experience time-varying thrust and torque load on the shaft of their prime mover. The reason is the varying inflow velocity to the propeller during the passage of a wave. This variation has been considered a nuisance to the main engine control where the induced fluctuations in torque, shaft speed and power have been suppressed by some control schemes and ignored in others. This paper shows how the fluctuation in inflow velocity can be utilized to increase the average efficiency of propulsion in waves without reducing the vessel speed. A non-linear controller is proposed that is shown to theoretically enhance the propulsion efficiency. Model tests determine dynamic characteristics of propellers in waves and a simulation is employed to validate the novel control scheme.
Diagnosis and Fault-Tolerant Control for Thruster-Assisted Position Mooring System

Development of fault-tolerant control systems is crucial to maintain safe operation of offshore installations. The objective of this paper is to develop a fault-tolerant control for thruster-assisted position mooring (PM) system with faults occurring in the mooring lines. Faults in line's pretension or line breaks will degrade the performance of the positioning of the vessel. Faults will be detected and isolated through a fault diagnosis procedure. When faults are detected, they can be accommodated through the control action in which only parameter of the controlled plant has to be updated to cope with the faulty condition. Simulations will be carried out to verify the advantages of the fault-tolerant control strategy for the PM system.
Fault Diagnosis in a Water for Injection System Using Enhanced Structural Isolation

General information
State: Published
Organisations: Automation, Department of Electrical Engineering, Florida State University
Authors: Laursen, M. (Intern), Blanke, M. (Intern), Düstegör, D. (Ekstern)
Pages: 295-302
Publication date: 2007

Host publication information
Title of host publication: Fault Diagnosis and Fault Tolerant Control
Publisher: Lubusky Scientific Society
Editors: Korbicz, J., Kowalczuk, Z.
Main Research Area: Technical/natural sciences
Conference: 8th conference on Diagnostics of Processes and Systems, Slubice, Poland, 01/01/2007
Source: orbit
Source-ID: 208185
Publication: Research - peer-review › Article in proceedings – Annual report year: 2007

Nonlinear Container Ship Model for the Study of Parametric Roll Resonance
Parametric roll is a critical phenomenon for ships, whose onset may cause roll oscillations up to 40, leading to very dangerous situations and possibly capsizing. Container ships have been shown to be particularly prone to parametric roll resonance when they are sailing in moderate to heavy head seas. A Matlab/Simulink parametric roll benchmark model for a large container ship has been implemented and validated against a wide set of experimental data. The model is a part of a Matlab/Simulink Toolbox (MSS, 2007). The benchmark implements a 3rd-order nonlinear model where the dynamics of roll is strongly coupled with the heave and pitch dynamics. The implemented model has shown good accuracy in predicting the container ship motions, both in the vertical plane and in the transversal one. Parametric roll has been reproduced for all the data sets in which it happened, and the model provides realistic results which are in good agreement with the model tank experiments.

General information
State: Published
Organisations: Automation, Department of Electrical Engineering, Norwegian University of Science and Technology, Universidade Federal do Rio de Janeiro, University of Newcastle
Authors: Holden, C. (Ekstern), Galeazzi, R. (Intern), Rodriguez, C. (Ekstern), Perez, T. (Ekstern), Fossen, T. I. (Ekstern), Blanke, M. (Intern), Neves, M. D. A. S. (Ekstern)
Pages: 87-103
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information
Journal: Modeling, Identification and Control (Online Edition)
Volume: 28
Issue number: 4
ISSN (Print): 1890-1328
Ratings:
BFI (2017): BFI-level 1
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.319 SNIP 0.89
Scopus rating (2015): SJR 0.253 SNIP 0.757
Web of Science (2015): Indexed yes
Scopus rating (2014): SJR 0.317 SNIP 0.897
Web of Science (2014): Indexed yes
Scopus rating (2013): SJR 0.579 SNIP 1.211
ISI indexed (2013): ISI indexed no
Scopus rating (2012): SJR 0.479 SNIP 1.36
ISI indexed (2012): ISI indexed no
Scopus rating (2011): SJR 0.238 SNIP 0.841
Nonlinear Control of Electrodynamic Tether in Equatorial or Somewhat Inclined Orbits

This paper applies different control design methods to a tethered satellite system (TSS) to investigate essential control properties of this under-actuated and nonlinear system. When the tether position in the orbit plane is controlled by the tether current, out of orbit plane motions occur as an unwanted side effect, due to nonlinear interaction with the Earth's magnetic field. This paper focus on the uncontrollable out-of-plane motions and the robustness against B-field uncertainty associated with each of three popular controller design methodologies for nonlinear systems: linear quadratic feedback designed for the controllable subspace of the system, a feedback linearization design and a sliding mode control. The controllers are evaluated by their ability to suppress variations in the B-field and their robustness with respect to the internal dynamics.

On the Feasibility of Stabilizing Parametric Roll with Active Bifurcation Control

When parametric resonance occurs on a ship, large roll motion develops rapidly and severe damage on cargo is likely. Some vessels have even capsized in moderate seas for reasons believed to be parametric resonance. This paper revisits the analysis of parametric resonance and assess the possibility to dynamically modify the instability region where
parametric roll can occur. It is shown how a control strategy for roll stabilization could be modified to change a bifurcation in roll motion and stabilize the motion, even after parametric resonance has started. The paper addresses issues of achievable performance and demonstrates the approach on a yaw-sway-roll-surge model of a containership.

**General information**
State: Published
Organisations: Automation, Department of Electrical Engineering
Authors: Galeazzi, R. (Intern), Blanke, M. (Intern)
Publication date: 2007

**Host publication information**
Title of host publication: Control Applications in Marine Systems
Volume: 7
ISBN (Print): 978-3-902661-62-3
Main Research Area: Technical/natural sciences
Parametric roll, Ship motion control, Parametric resonance
DOIs:
10.3182/20070919-3-HR-3904.00010
Source: orbit
Source-ID: 208187
Publication: Research - peer-review › Article in proceedings – Annual report year: 2007

**Robust Control Mixer Method for Reconfigurable Control Design Using Model Matching Strategy**
A novel control mixer method for reconfigurable control designs is developed. The proposed method extends the matrix-form of the conventional control mixer concept into a LTI dynamic system-form. The H\textsubscript{\infty} control technique is employed for these dynamic module designs after an augmented control system is constructed through a model-matching strategy. The stability, performance and robustness of the reconfigured system can be guaranteed when some conditions are satisfied. To illustrate the effectiveness of the proposed method, a robot system subjected to failures is used to demonstrate the reconfiguration procedure.

**General information**
State: Published
Organisations: Automation, Department of Electrical Engineering, Aalborg University, Delft University of Technology
Authors: Yang, Z. (Ekstern), Blanke, M. (Intern), Verhagen, M. (Ekstern)
Pages: 349-357
Publication date: 2007
Main Research Area: Technical/natural sciences

**Publication information**
Journal: IET Control Theory and Applications
Volume: 1
Issue number: 1
ISSN (Print): 1751-8644
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 1.247 SNIP 1.199 CiteScore 3.05
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.345 SNIP 1.452 CiteScore 3.05
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.284 SNIP 1.544 CiteScore 3.05
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.362 SNIP 1.849 CiteScore 3.22
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.296 SNIP 1.728 CiteScore 2.75
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
Diagnosis and Fault-tolerant Control, 2nd edition.
Fault-tolerant control aims at a graceful degradation of the behaviour of automated systems in case of faults. It satisfies the industrial demand for enhanced availability and safety, in contrast to traditional reactions to faults that bring about sudden shutdowns and loss of availability. The book presents effective model-based analysis and design methods for fault diagnosis and fault-tolerant control. Architectural and structural models are used to analyse the propagation of the fault through the process, to test the fault detectability and to find the redundancies in the process that can be used to ensure fault tolerance. Design methods for diagnostic systems and fault-tolerant controllers are presented for processes that are described by analytical models, by discrete-event models or that can be dealt with as quantised systems. Five case studies on pilot processes show the applicability of the presented methods. The theoretical results are illustrated by two running examples used throughout the book. The second edition includes new material about reconfigurable control, diagnosis of nonlinear systems, and remote diagnosis. The application examples are extended by a steering-by-wire system and the air path of a diesel engine, both of which include experimental results. The bibliographical notes at the end of all chapters have been up-dated. The chapters end with exercises to be used in lectures.

General information
State: Published
Organisations: Automation, Department of Electrical Engineering
Authors: Blanke, M. (Intern), Kinnaert, M. (Ekstern), Lunze, J. (Ekstern), Starosweicki, M. (Ekstern)
Number of pages: 672
Publication date: 2006

Publication information
Publisher: Springer
Edition: 2
Original language: English
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 190562
Early Control Textbooks in Denmark

General information
State: Published
Organisations: Automation, Department of Electrical Engineering
Authors: Blanke, M. (Intern), Gertler, J. (ed.) (Ekstern)
Pages: 45-52
Publication date: 2006

Host publication information
Title of host publication: Historic Control Textbooks
Place of publication: Linacre House, Jordan Hill, Oxford OX2 8DP, UK
Publisher: Elsevier
ISBN (Print): 0-08-045346-5
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 192400

Efficient Parameterization for Grey-box Model Identification of Complex Physical Systems
Grey-box model identification preserves known physical structures in a model but with limits to the possible excitation, all parameters are rarely identifiable, and different parametrizations give significantly different model quality. Convenient methods to show which parameterizations are the better would be very useful. This paper shows how we can assess the parameter interdependence and model quality. Hessian matrix decomposition is employed to show linear dependencies between variables and to put a quality tag on different parameterizations. The method determines parameter relations that need be constrained to achieve satisfactory convergence. Identification of nonlinear models for a ship illustrate the concept.

General information
State: Published
Organisations: Automation, Department of Electrical Engineering
Authors: Blanke, M. (Intern), Knudsen, M. (Ekstern)
Publication date: 2006

Host publication information
Title of host publication: Proceedings 14. IFAC Symposium on System Identification SYSID'2006
Publisher: International Federation of Automatic Control
Main Research Area: Technical/natural sciences
Conference: 14th IFAC Symposium on System Identification (SYSID 2006), Newcastle, Australia, 01/01/2006
Grey-box identification, Parameter inter-depence, Factor analysis, Marine systems
DOIs:
10.3182/20060329-3-AU-2901.00049
Source: orbit
Source-ID: 189891

Electrical Steering of Vehicles - Fault-tolerant Analysis and Design
The topic of this paper is systems that need be designed such that no single fault can cause failure at the overall level. A methodology is presented for analysis and design of fault-tolerant architectures, where diagnosis and autonomous reconfiguration can replace high cost triple redundancy solutions and still meet strict requirements to functional safety. The paper applies graph-based analysis of functional system structure to find a novel fault-tolerant architecture for an electrical steering where a dedicated AC-motor design and cheap voltage measurements ensure ability to detect all relevant faults. The paper shows how active control reconfiguration can accommodate all critical faults and the fault-tolerant abilities are demonstrated on a warehouse truck hardware.

General information
State: Published
Organisations: Automation, Department of Electrical Engineering, Aalborg University
Authors: Blanke, M. (Intern), Thomsen, J. S. (Ekstern)
Pages: 1421-1432
Fault-tolerant Actuator System for Electrical Steering of Vehicles

Being critical to the safety of vehicles, the steering system is required to maintain the vehicles ability to steer until it is brought to halt, should a fault occur. With electrical steering becoming a cost-effective candidate for electrical powered vehicles, a fault-tolerant architecture is needed that meets this requirement. This paper studies the fault-tolerance properties of an electrical steering system. It presents a fault-tolerant architecture where a dedicated AC motor design...
used in conjunction with cheap voltage measurements can ensure detection of all relevant faults in the steering system. The paper shows how active control reconfiguration can accommodate all critical faults. The fault-tolerant abilities of the steering system are demonstrated on the hardware of a warehouse truck.

**Fault-tolerant Sensor Fusion for Marine Navigation**

Reliability of navigation data are critical for steering and manoeuvring control, and in particular so at high speed or in critical phases of a mission. Should faults occur, faulty instruments need be autonomously isolated and faulty information discarded. This paper designs a navigation solution where essential navigation information is provided even with multiple faults in instrumentation. The paper proposes a provable correct implementation through auto-generated state-event logics in a supervisory part of the algorithms. Test results from naval vessels document the performance and shows events where the fault-tolerant sensor fusion provided uninterrupted navigation data despite temporal instrument defects.

**Marine Vessel Models in Changing Operational Conditions - A Tutorial**

This tutorial paper provides an introduction, from a systems perspective, to the topic of ship motion dynamics of surface ships. It presents a classification of parametric models currently used for monitoring and control of marine vessels. These models are valid for certain vessel operational conditions (VOC). However, since marine systems operate in changing VOCs, there is a need to adapt the models. To date, there is no theory available to describe a general model valid across different VOCs due to the complexity of the hydrodynamic involved. It is believed that system identification could provide a significant contribution towards obtaining such a general model. Therefore, the main aim of the paper is to highlight the essential characteristics of marine system dynamics so as to provide a background for practitioners who would attempt future application of system identification techniques to marine systems.
Pitch Motion Stabilization by Propeller Speed Control Using Statistical Controller Design

This paper describes dynamics analysis of a small training boat and a possibility of ship pitch stabilization by control of propeller speed. After upgrading the navigational system of an actual small training boat, in order to identify the model of the ship, the real data collected by sea trials were used for statistical analysis and system identification. This analysis shows that the pitching motion is indeed influenced by engine speed and it is suggested that there exists a possibility of reducing the pitching motion by properly controlling the engine throttle. Based on this observation, a controller is designed using statistical optimal control. Controller robustness is investigated and recorded data of motion in a seaway are used to show it is feasible to reduce pitch motion in waves.

SaTool - a Software Tool for Structural Analysis of Complex Automation Systems

The paper introduces SaTool, a tool for structural analysis, the use of the Matlab (R)-based implementation is presented and special features are introduced, which were motivated by industrial users. Salient features of tool are presented, including the ability to specify the behavior of a complex system at a high level of functional abstraction, analyze single and multiple fault scenarios and automatically generate parity relations for diagnosis for the system in normal and impaired conditions. User interface and algorithmic details are presented.

General information
State: Published
Organisations: Automation, Department of Electrical Engineering
Authors: Blanke, M. (Intern), Lorentzen, T. (Intern)
Pages: 673-678
Publication date: 2006
Spectral Signatures of Surface Materials in Pig Buildings

Manual cleaning of pig production buildings based on high-pressure water cleaners is unappealing to workers, because it is tedious and health threatening. To replace manual cleaning, a few cleaning robots have been commercialised. With no cleanliness sensor available, the operation of these robots is to follow a cleaning procedure initially defined by the operator. Experience shows that the performance of such robots is poor regarding effectiveness of cleaning and utilisation of water. The development of an intelligent cleanliness sensor for robotic cleaning is thus crucial in order to optimise the cleaning process and to minimise the amount of water and electricity consumed. This research is aimed at utilising a spectral imaging method for cleanliness detection. Consequently, information on the reflectance of building materials and contamination in different spectral ranges is important.

In this study, the optical properties of different types of surfaces to be cleaned and the dirt found in finishing pig units were investigated in the visual and the near infrared (VIS-NIR) optical range. Four types of commonly used materials in pig buildings, i.e. concrete, plastic, wood and steel were applied in the investigation. Reflectance data were sampled under controlled lighting conditions using a spectrometer communicating with a portable computer. The measurements were performed in a laboratory with materials used in a pig house for 4-5 weeks. The spectral data were collected for the surfaces before, during and after high-pressure water cleaning.

The spectral signatures of the surface materials and dirt attached to the surfaces showed that it is possible to make discrimination and hence to classify areas that are visually clean. When spectral bands 450, 600, 700 and 800 nm are chosen, there are at least two spectral bands for each type of the materials, in which the spectral signals can be used for discrimination of dirty and clean condition of the surfaces. (c) 2006 IAgrE. All rights reserved Published by Elsevier Ltd

General information
State: Published
Organisations: Automation, Department of Electrical Engineering
Authors: Zhang, G. (Ekstern), Strøm, J. (Ekstern), Blanke, M. (Intern), Braithwaite, I. D. (Ekstern)
Pages: 495-504
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Biosystems Engineering
Volume: 94
Issue number: 4
ISSN (Print): 1537-5110
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.738 SNIP 1.573 CiteScore 2.64
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.856 SNIP 1.64 CiteScore 2.41
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.894 SNIP 1.753 CiteScore 2.17
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.785 SNIP 1.739 CiteScore 2.1
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.887 SNIP 1.655 CiteScore 1.95
Structural Design of Systems with Safe Behavior under Single and Multiple Faults

Handling of multiple simultaneous faults is a complex issue in fault-tolerant control. The design task is particularly made difficult by the numerous different cases that need to be analyzed. Aiming at safe fault-handling, this paper shows how structural analysis can be applied to find the analytical redundancy relations for all relevant combinations of faults, and can cope with the complexity and size of a real system. Being essential for fault-tolerant control schemes that shall handle particular cases of faults/failures, fault isolation is addressed. The paper introduces an extension to structural analysis to disclose which faults could be isolated from a structural point of view using active fault isolation. Results from application on a marine control system illustrate the concepts.

General information
State: Published
Organisations: Automation, Department of Electrical Engineering, Ecole Normale Superieure de Cachan
Authors: Blanke, M. (Intern), Staroswiecki, M. (Ekstern)
Pages: 511-516
Publication date: 2006

Host publication information
Title of host publication: Fault Detection, Supervision and Safety of Technical Processes : A Proceedings Volume from the 6th IFAC Symposium, SAFEPROCESS 2006
Volume: 6
Publisher: Elsevier Science
ISBN (Print): 978-0-08-044485-7
Main Research Area: Technical/natural sciences
Fault diagnosis, Structural analysis, Fault-tolerant control, Structural analysis, Fault diagnosis, Marine Control Systems
Electronic versions: oersted-dtu2489.pdf
Traversable terrain classification for outdoor autonomous robots using single 2D laser scans
Interpreting laser data to allow autonomous robot navigation on paved as well as dirt roads using a fixed angle 2D laser scanner is a daunting task. This paper introduces an algorithm for terrain classification that fuses seven distinctly different classifiers: raw height, roughness, step size, curvature, slope, width and invalid data. These are then used to extract road borders, traversable terrain and identify obstacles. Experimental results are shown and discussed. The results were obtained using a DTU developed mobile robot, and the autonomous tests were conducted in a national park environment.

General information
State: Published
Organisations: Automation, Department of Electrical Engineering
Authors: Andersen, J. C. (Intern), Blas, M. R. (Ekstern), Andersen, N. A. (Intern), Ravn, O. (Intern), Blanke, M. (Intern)
Pages: 223-232
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Integrated Computer-Aided Engineering
Volume: 13
Issue number: 3
ISSN (Print): 1069-2509
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 1.291 SNIP 1.448 CiteScore 4.02
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.954 SNIP 1.48 CiteScore 4.07
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.949 SNIP 1.322 CiteScore 2.93
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.133 SNIP 1.672 CiteScore 3.73
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.916 SNIP 1.272 CiteScore 2.85
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.66 SNIP 1.469 CiteScore 2.69
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.647 SNIP 0.946
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.55 SNIP 0.933
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.246 SNIP 0.672
Scopus rating (2007): SJR 0.147 SNIP 0.356
Scopus rating (2006): SJR 0.218 SNIP 0.371
Web of Science (2006): Indexed yes
A Note on Variance and Factor Analysis of ISAC Spectral Reflectance Data

General information
State: Published
Organisations: Department of Electrical Engineering
Authors: Blanke, M. (Intern)
Number of pages: 46
Publication date: 2005

Publication information
Place of publication: DK 2800 Kgs. Lyngby
Publisher: Automation at Ørsted-DTU
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 182214
Publication: Research › Report – Annual report year: 2005

A Structure-graph Approach to Diagnosis and Control Reconfiguration Design - exemplified by Station-keeping Control
This paper addresses the design process of diagnosis and fault-tolerant control when a system should operate despite multiple failures in sensors or actuators. Graph-theory based analysis of system's structure is demonstrated to be a unique design methodology that can cope with the diagnosis design for systems of high complexity, and also analyse the cases of cascaded or multiple faults. The paper demonstrates the design method on a ship with three actuators: two shafts with CP propellers and a bow thruster, and navigation instruments: global position sensors (GPS), inertial navigation units and conventional gyros to provide ship motion information. A salient feature of the design method is shown to be the ability to analyse cases where one or more faults have occurred and rapidly determine where in the faulty system reconfigurability, diagnosability and controllability are retained.

General information
State: Published
Organisations: Department of Electrical Engineering
Authors: Blanke, M. (Intern)
Publication date: 2005

Host publication information
Title of host publication: ASNE Symposium on Reconfiguration and Survivability
Publisher: American Society of Naval Engineers
Main Research Area: Technical/natural sciences
Conference: ASNE Symposium on Reconfiguration and Survivability, 01/01/2005
Source: orbit
Source-ID: 181092
Publication: Research - peer-review › Article in proceedings – Annual report year: 2005

Combining a Novel Computer Vision Sensor with a Cleaning Robot to Achieve Autonomous Pig House Cleaning
Cleaning of livestock buildings is the single most health-threatening task in the agricultural industry and a transition to robot-based cleaning would be instrumental to improving working conditions for employees. Present cleaning robots fall short on cleanliness quality, as they cannot perform condition based cleaning. This paper describes how a novel sensor, developed for the purpose, and algorithms for classification and learning are combined with a commercial robot to obtain an autonomous system which meets the necessary quality attributes. These include features to make selective cleaning
where dirty areas are detected, that operator assistance is called only when cleanness hypothesis cannot be made with confidence. The paper describes the design of the system where learning from experience maps and operator instructions are combined to obtain a smart and autonomous cleaning robot.

**General information**

State: Published

Organisations: Automation, Department of Electrical Engineering

Authors: Andersen, N. A. (Intern), Braithwaite, I. D. (Ekstern), Blanke, M. (Intern), Sørensen, T. (Ekstern)

Pages: 8331-8336

Publication date: 2005

**Host publication Information**

Title of host publication: Proceedings of the 44th IEEE Conference on Decision and Control, and European Control Conference

Publisher: IEEE

ISBN (Print): 0-7803-9567-0

Main Research Area: Technical/natural sciences

Conference: 44th IEEE Conference on Decision and Control, and European Control Conference, Seville, Spain, 01/01/2005

Electronic versions: oersted-dtu1651.pdf

DOIs: 10.1109/CDC.2005.1583511

**Bibliographical note**

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Source: orbit

Source-ID: 192425

Publication: Research - peer-review › Article in proceedings – Annual report year: 2005

**Design of a vision-based sensor for autonomous pighouse cleaning**

Current pig house cleaning procedures are hazardous to the health of farm workers, and yet necessary if the spread of disease between batches of animals is to be satisfactorily controlled. Autonomous cleaning using robot technology offers salient benefits. This paper addresses the feasibility of designing a vision-based system to locate dirty areas and subsequently direct a cleaning robot to remove dirt. Novel results include the characterisation of the spectral properties of real surfaces and dirt in a pig house and the design of illumination to obtain discrimination of clean from dirty areas with a low probability of misclassification. A Bayesian discriminator is shown to be efficient in this context and implementation of a prototype tool demonstrates the feasibility of designing a low-cost vision-based sensor for autonomous cleaning.

**General information**

State: Published

Organisations: Department of Electrical Engineering, Automation, Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling

Authors: Braithwaite, I. D. (Intern), Blanke, M. (Intern), Zhang, G. (Ekstern), Carstensen, J. M. (Intern)

Pages: 2005-2018

Publication date: 2005

Main Research Area: Technical/natural sciences

**Publication information**

Journal: EURASIP Journal on Applied Signal Processing

Issue number: 13

ISSN (Print): 1110-8657

Ratings:

BFI (2008): BFI-level 1

Web of Science (2007): Indexed yes

Web of Science (2006): Indexed yes

Web of Science (2005): Indexed yes

Scopus rating (2003): SNIP 0

Scopus rating (2002): SNIP 0.133

Scopus rating (2001): SNIP 0.497

Scopus rating (2000): SNIP 0.143
Diagnosis and Fault-tolerant Control for Ship Station Keeping

This paper addresses the design process of diagnosis and fault-tolerant control when the system should operate despite multiple failures in sensors or actuators. Graph-theory based analysis of systems structure is demonstrated to be a unique design methodology that can cope with the diagnosis design for systems of high complexity, and also analyse the cases of cascaded or multiple faults. The paper takes as example a ship with two CP propellers, rudders and a bow thruster as actuators, and instrumentation with a suite of global position sensors, inertial navigation units and conventional gyro units to provide ship motion information. A salient feature of the design method is the ability to analyse cases where faults have occurred and easily determine where in the faulty system diagnosability and controllability are retained.

Frequently asked questions on filtered noise

This note was made in response to several returning questions on noise and ways to calculate covariance of filtered random signals, where filters could origin from residual generators. Reference is made to stochastic signals treated in appendix 2 of the book Diagnosis and Fault-tolerant Control by Blanke, Kinnaert, Lunze and Staroswiecki, 2003. The note is aimed at graduate students who follow their first course in diagnosis and fault-tolerant control where design of appropriate filters is an important part of the design of fault diagnosis.
Sensor Fault Masking of a Ship Propulsion System

This paper presents the results of a study on fault-tolerant control of a ship propulsion benchmark (Izadi-Zamanabadi and Blanke, 999), which uses estimated or virtual measurements as feedback variables. The estimator operates on a self-adjustable design model so that its outputs can be made immune to the effects of a specific set of component and sensor faults. The adequacy of sensor redundancy is measured using the control reconfigurability (Wu, Zhou, and Salomon, 2000), and the number of sensor based measurements are increased when this level is found inadequate. As a result, sensor faults that are captured in the estimator's design model can be tolerated without the need for any reconfiguration actions. Simulations for the ship propulsion benchmark show that, with additional sensors added as described, satisfactory fault-tolerance is achieved under two additive sensor faults, an incipient fault, and a parametric fault, without having to alter the original controller in the benchmark.

General information
State: Published
Organisations: Automation, Department of Electrical Engineering
Authors: Wu, N. E. (Ekstern), Thavamani, S. (Ekstern), Zhang, Y. (Ekstern), Blanke, M. (Intern)
Pages: 1337-1345
Publication date: 2005
Main Research Area: Technical/natural sciences

Publication information
Journal: Control Engineering Practice
Volume: 14
Issue number: 11
ISSN (Print): 0967-0661
Ratings:
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.42 SJR 1.287 SNIP 2.156
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.194 SNIP 2.091 CiteScore 3.05
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.323 SNIP 2.626 CiteScore 3.26
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.433 SNIP 3.278 CiteScore 3.5
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.267 SNIP 3.118 CiteScore 3.02
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.544 SNIP 2.911 CiteScore 2.96
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.343 SNIP 2.745
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.487 SNIP 3.019
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.432 SNIP 2.917
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.105 SNIP 2.169
Scopus rating (2006): SJR 0.909 SNIP 1.894
Scopus rating (2005): SJR 0.579 SNIP 1.595
Web of Science (2005): Indexed yes
Terrain Classification for Outdoor Autonomous Robots using 2D Laser Scans.: Robot perception for dirt road navigation

General information
State: Published
Organisations: Automation, Department of Electrical Engineering
Authors: Rufus Blas, M. (Ekstern), Riisgaard, S. (Ekstern), Ravn, O. (Intern), Andersen, N. A. (Intern), Blanke, M. (Intern), Andersen, J. C. (Intern)
Pages: 347-351
Publication date: 2005

Host publication information
Title of host publication: 2nd int. Conf. on Informatics in Control, Automation and Robotics, ICINCO-2005
ISBN (Print): 972-8865-30-9
Main Research Area: Technical/natural sciences
Conference: 2nd International Conference on Informatics in Control, Automation and Robotics : 14-17 September, Barcelona, Spain, 01/01/2005
Source: orbit
Source-ID: 182284
Publication: Research - peer-review › Article in proceedings – Annual report year: 2005

Udvikling af sensorsystem for robotbaseret rengøring af svinestalde

General information
State: Published
Organisations: Department of Electrical Engineering, Engineering Design and Product Development, Department of Mechanical Engineering
Authors: Andersen, N. A. (Intern), Braithwaite, I. D. (Intern), Sørensen, T. (Intern), Blanke, M. (Intern)
Pages: 9-13
Publication date: 2005

Publication information
Journal: Dira Nyt
Volume: 23
Issue number: 1
ISSN (Print): 1601-1635
Ratings:
ISI indexed (2013): ISI indexed no
ISI indexed (2012): ISI indexed no
ISI indexed (2011): ISI indexed no
Classification of Clean and Dirty Pighouse Surfaces Based on Spectral Reflectance

General information
State: Published
Organisations: Department of Electrical Engineering
Authors: Blanke, M. (Intern), Braithwaite, I. D. (Intern), Zhang, G. (Ekstern)
Publication date: 2004

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 60973
Publication: Research - peer-review › Report – Annual report year: 2004

Electron Emitter for small-size Electrodynamic Space Tether using MEMS Technology
Adjustment of the orbit of a spacecraft using the forces created by an electro-dynamic space-tether has been shown as a theoretic possibility in recent literature. Practical implementation is being pursued for larger scale missions where a hot filament device controls electron emission and the current flowing in the electrodynamic space tether. Applications to small spacecraft, or space debris in the 1–10 kg range, possess difficulties with electron emission technology, as low power emitting devices are needed. This paper addresses the system concepts of a small spacecraft electrodynamic tether system with focus on electron emitter design and manufacture using micro-electro-mechanical system (MEMS) technology. The paper addresses the system concepts of a small size electrodynamic tether mission and shows a novel electron emitter for the 1-2 mA range where altitude can be effectively affected and other orbit parameters can be controlled for small sized missions, without on-board propulsion.

General information
State: Published
Organisations: Department of Electrical Engineering
Authors: Fleron, R. A. W. (Ekstern), Blanke, M. (Intern)
Pages: 227-232
Publication date: 2004

Host publication information
Title of host publication: Proceedings of the ESA Symposium on Small Spacecraft Systems
Place of publication: La Rochelle
Publisher: European Space Agency, ESA
Main Research Area: Technical/natural sciences
Conference: ESA Symposium on Small Spacecraft Systems, La Rochelle, France, Sept. 20-24, 01/01/2004
Electronic versions:
oersted-dtu852.pdf
Links:
Source: orbit
Source-ID: 60928
Publication: Research - peer-review › Article in proceedings – Annual report year: 2004

Industrial use of structural analysis - a rapid prototyping tool in the public domain

General information
State: Published
Organisations: Department of Electrical Engineering
Authors: Lorentzen, T. (Intern), Blanke, M. (Intern)
Pages: 166-171
Publication date: 2004

Host publication information
Title of host publication: Advanced Control and Diagnosis
Publisher: Deutch-Französisches Institut für Automation und Robotik (IAR)
Satellite Dynamics and Control in a Quaternion Formulation


Users Manual for SaTool - a Tool for Structural Analysis of Automated Systems
An Affordable, Low-Risk Approach to Launching Research Spacecraft as Tertiary Payloads

Rapid and affordable access to space for university researchers and educators has always been a challenge. Despite the availability of lower-cost (e.g., Russian) launch vehicles, launching payloads 20 kg or less typically involves a certain minimum cost that necessitates a cost sharing arrangement among numerous parties and the handling of complex export control issues. In turn, this complicates mission scheduling and increases the risk of missing launch deadlines. The University of Toronto Institute for Aerospace Studies, Space Flight Laboratory (UTIAS/SFL) has taken a leading role in addressing this challenge, and has successfully led a group of international spacecraft developers in manifesting one 1-kg Canadian spacecraft, two 1-kg Danish spacecraft, and one 3-kg American spacecraft on a 2003 Eurockot launch. This paper outlines the approach taken by UTIAS/SFL in negotiating and securing launches for its own spacecraft in collaboration with other spacecraft developers. A summary of how this approach is applied in planning and coordinating the June 2003 Eurockot launch is also presented.

Cheap diagnosis using structural modelling and fuzzy-logic based detection

Practical fault diagnosis can be based on simple, yet efficient, analysis of redundant information about the state of a plant, and diagnostic algorithms can be made without detailed and expensive modelling efforts. This paper shows how it is possible, using structural analysis, to find redundancy relations for linear or non-linear dynamic behaviour, and combine this with fuzzy output observer design to provide an effective diagnostic approach. An adaptive neuro-fuzzy inference method is used. A fuzzy adaptive threshold is employed to cope with practical uncertainty. The methods are demonstrated using measurements on a ship propulsion system subject to simulated faults.
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<th>BFI Rating</th>
<th>Scopus SJR</th>
<th>Scopus SNIP</th>
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**Original language:** English

**fault-detection, benchmarks, structural analysis, fuzzy output observer, Fault-diagnosis**

**DOIs:**

10.1016/S0967-0661(02)00056-4

**Links:**

http://dads.dtv.dk/globalproxy.cvt.dk:2048/cgi-bin/fulltext/elsevier/ohm03930/09670661/v0011i04/02000564/main.pdf

**Source:** orbit

**Source-ID:** 60728

**Publication:** Research - peer-review › Journal article – Annual report year: 2003

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**DCMV a Matlab/Simulink Toolbox for Dynamics and Control of Marine Vehicles**

**General information**

State: Published
Organisations: Department of Electrical Engineering
Authors: Perez, T. (Ekstern), Blanke, M. (Intern)
Publication date: 2003

**Host publication information**

Title of host publication: Proceedings 6th Conference on Manoeuvering and Control of Marine Craft, MCMC
Main Research Area: Technical/natural sciences
Links:


**Source:** orbit

**Source-ID:** 60829
Diagnosis and Fault-tolerant Control
The book presents effective model-based analysis and design methods for fault diagnosis and fault-tolerant control. Architectural and structural models are used to analyse the propagation of the fault through the process, to test the fault detectability and to find the redundancies in the process that can be used to ensure fault tolerance. Design methods for diagnostic systems and fault-tolerant controllers are presented for processes that are described by analytical models, by discrete-event models or that can be dealt with as quantised systems. Four case studies on pilot processes show the applicability of the presented methods. The theoretical results are illustrated by two running examples which are used throughout the book. The book addresses engineering students, engineers in industry and researchers who wish to get a survey over the variety of approaches to process diagnosis and fault-tolerant control.

General information
State: Published
Organisations: Automation, Department of Electrical Engineering, Ruhr-Universität Bochum, Université Lille Nord de France, Université Libre de Bruxelles
Authors: Blanke, M. (Intern), Kinnaert, M. (Ekstern), Lunze, J. (Ekstern), Staroswiecki, M. (Ekstern)
Number of pages: 565
Publication date: 2003

Fault-tolerant and Diagnostic Methods for Navigation
Precise and reliable navigation is crucial, and for reasons of safety, essential navigation instruments are often duplicated. Hardware redundancy is mostly used to manually switch between instruments should faults occur. In contrast, diagnostic methods are available that can use analytic redundancy to diagnose faults and autonomously provide valid navigation data, disregarding any faulty sensor data and use sensor fusion to obtain a best estimate for users. This paper discusses how diagnostic and fault-tolerant methods are applicable in marine systems. An example chosen is sensor fusion for navigation. Diagnosis design is based on parity relations and statistical hypothesis tests. Sensor fusion on healthy signals is made using a Kalman filter with inverse covariance updating to deal with asynchronous or missing data from instruments. The paper is presented at a tutorial level.

General information
State: Published
Organisations: Department of Electrical Engineering
Authors: Blanke, M. (Intern)
Publication date: 2003

Host publication information
Title of host publication: Proc. 9th International Conference on Marine Engineering Systems, ICMES'2003
Publisher: Society of Naval Architects and Marine Engineers SNAME, New York
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 60827
Publication: Research - peer-review › Article in proceedings – Annual report year: 2003

Intelligent Sensor for Autonomous Cleaning in livestock buildings (ISAC) - A challenge in bioenvironmental engineering

General information
State: Published
Organisations: Department of Electrical Engineering
Sensor Fault Masking of a Ship Propulsion System

This paper presents the results of a study on fault-tolerant control of a ship propulsion benchmark (Izadi-Zamanabadi and Blanke, 1999), which uses estimated or virtual measurements as feedback variables. The estimator operates on a self-adjustable design model so that its outputs can be made immune to the effects of a specific set of component and sensor faults. The adequacy of sensor redundancy is measured using the control reconfigurability (Wu, Zhou, and Salomon, 2000), and the number of sensor based measurements are increased when this level is found inadequate. As a result, sensor faults that are captured in the estimator's design model can be tolerated without the need for any reconfiguration actions. Simulations for the ship propulsion benchmark show that, with additional sensors added as described, satisfactory fault-tolerance is achieved under two additive sensor faults, an incipient fault, and a parametric fault, without having to alter the original controller in the benchmark.

Special Section on Maneuvering and Control of Marine Craft

Journal: Control Engineering Practice
Volume: 11
Issue number: 4
ISSN (Print): 0967-0661
Ratings:
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.42 SJR 1.287 SNIP 2.156
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.194 SNIP 2.091 CiteScore 3.05
Structural Analysis - A case study of the Rømer Satellite

Spacecraft systems increase in functionality and complexity. At the same time, requirements increase to autonomy in order to cut expensive ground station support. Complexity and autonomy combine to a problem that is very difficult to analyze by traditional means. Structural analysis is a tool that in theory has the potential to cope with this complexity, but the technique is not yet in widespread use. This paper shows how structural analysis can be used in practice to aid in the design of the autonomy related parts of an entire spacecraft subsystem.

General information
State: Published
Organisations: Department of Electrical Engineering
Authors: Lorentzen, T. (Intern), Blanke, M. (Intern), Niemann, H. H. (Intern)
Number of pages: 6
Publication date: 2003

Host publication information
Title of host publication: Proceedings of IFAC SAFEPROCESS 2003
Main Research Area: Technical/natural sciences
Links:
Drag-Free Motion Control of Satellite for High-Precision Gravity Field Mapping
High precision mapping of the geoid and the Earth's gravity field are of importance to a wide range of ongoing studies in areas like ocean circulation, solid Earth physics and ice sheet dynamics. Using a satellite in orbit around the Earth gives the opportunity to map the Earth's gravity field in 3 dimensions with much better accuracy and spatial resolution than ever accomplished. To reach the desired quality of measurements, the satellite must fly in a low Earth orbit where disturbances from atmospheric drag and the Earth's magnetic field will perturb the satellite's motion. These effects will compromise measurement accuracy, unless they are accurately compensated by on-board thrusters. The paper concerns the design of a control system to performing such delicate drag compensation. A six degrees-of-freedom model for the satellite is developed with the model including dynamics of the satellite, sensors, actuators and environmental disturbances to the required micro-Newton accuracy. A control system is designed to compensate the non-gravitational disturbances on the satellite in three axes using an $H_\infty$-design. Performance is validated against mission requirements. Keywords: Spacecraft Attitude and Orbit Control, Drag Compensation, Drag-free motion.

Fine-pointing control for the Rømer Satellite

Mathematical Ship Modelling for Marine applications
Modelling and Experiments of a Standing Wave Piezomotor

General information
State: Published
Organisations: Department of Electrical Engineering
Authors: Helbo, J. (Ekstern), Andersen, B. (Ekstern), Blanke, M. (Intern)
Publication date: 2002

Host publication information
Title of host publication: Proceedings of the 8th International Conference on New Actuators
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 60665
Publication: Research › peer-review › Article in proceedings – Annual report year: 2002

Rømer Subsystem Analysis for Fault Detection Design

General information
State: Published
Organisations: Department of Electrical Engineering
Authors: Lorentzen, T. (Intern), Blanke, M. (Intern), Niemann, H. H. (Intern)
Publication date: 2002

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 60690
Publication: Research › Report – Annual report year: 2002

Simulation of Ship Motion in Seaway

General information
State: Published
Organisations: Department of Electrical Engineering
Authors: Pérez, T. (Ekstern), Blanke, M. (Intern)
Publication date: 2002

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 60692
Publication: Research › Report – Annual report year: 2002
Structural Analysis for Diagnosis - the Matching Problem Revisited

Aiming at design of algorithms for fault diagnosis, structural analysis of systems offers concise yet easy overall analysis. Graph-based matching, which is the essential technique to obtain redundant information for diagnosis, is re-considered in this paper. Matching is re-formulated as a problem of relating faults to known parameters and measurements of a system. Using explicit fault modelling, minimal over-determined subsystems are shown to provide necessary redundancy relations from the matching. Details of the method are presented and a realistic example used to clearly describe individual steps.

General information
State: Published
Organisations: Department of Electrical Engineering
Authors: Izadi-Zamanabadi, R. (Ekstern), Blanke, M. (Intern)
Publication date: 2002

Host publication information
Title of host publication: Proceedings of the 15. IFAC World Congress
Publisher: Elsevier
Main Research Area: Technical/natural sciences
Conference: Proceedings of the 15. IFAC World Congress, Barcelona, Spain, 01/01/2002
FDI, Fault diagnosis, Structural analysis, Autonomous systems
DOIs: 10.3182/20020721-6-ES-1901.00792
Source: orbit
Source-ID: 60662
Publication: Research - peer-review › Article in proceedings – Annual report year: 2002

Concepts and Methods in Fault-tolerant Control
Faults in automated processes will often cause undesired reactions and shut-down of a controlled plant, and the consequences could be damage to technical parts of the plant, to personnel or the environment. Fault-tolerant control combines diagnosis with control methods to handle faults in an intelligent way. The aim is to prevent that simple faults develop into serious failure and hence increase plant availability and reduce the risk of safety hazards. Fault-tolerant control merges several disciplines into a common framework to achieve these goals. The desired features are obtained through on-line fault diagnosis, automatic condition assessment and calculation of appropriate remedial actions to avoid certain consequences of a fault. The envelope of the possible remedial actions is very wide. Sometimes, simple could be achieved by replacing a measurement from a faulty sensor by an estimate. In yet other situations, complex reconfiguration or on-line controller redesign is required. This paper gives an overview of recent tools to analyze and explore structure and other fundamental properties of an automated system such that any inherent redundancy in the controlled process can be fully utilized to maintain availability, even though faults may occur.

General information
State: Published
Organisations: Department of Electrical Engineering
Authors: Blanke, M. (Intern), Staroswiecly, M. (Ekstern), Wu, N. (Ekstern)
Pages: 2606-2620
Publication date: 2001

Host publication information
Title of host publication: Proc. American Control Conference 2001
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 60461
Publication: Research - peer-review › Article in proceedings – Annual report year: 2001

Enhanced Maritime Safety through Diagnosis and Fault Tolerant Control
Faults in steering, navigation instruments or propulsion machinery are serious on a marine vessel since the consequence could be loss of maneuvering ability, and imply risk of damage to vessel personnel or environment. Early diagnosis and accommodation of faults could enhance safety. Fault-tolerant control is a methodology to help prevent that faults develop into failure. The means include on-line fault diagnosis, automatic condition assessment and calculation of remedial action to avoid hazards. This paper gives an overview of methods to obtain fault-tolerance: fault diagnosis; analysis of properties of a faulty system; means to determine remedial actions. The paper illustrates the techniques by two marine examples, sensor fusion for automatic steering and control of the main engine.
The Robust Control Mixer Method for Reconfigurable Control Design By Using Model Matching Strategy

This paper proposes a robust reconfigurable control synthesis method based on the combination of the control mixer method and robust H1 control techniques through the model-matching strategy. The control mixer modules are extended from the conventional matrix-form into the LTI system form. By regarding the nominal control system as the desired model, an augmented control system is constructed through the model-matching formulation, such that the current robust control techniques can be used to synthesize these dynamical modules. One extension of this method with respect to the performance recovery besides the functionality recovery is also discussed under this framework. Comparing with the conventional control mixer method, the proposed method considers the reconfigured system's stability, performance and robustness simultaneously. Finally, the proposed method is illustrated by a case study of one space robot arm system subjected to failures.
Two Mode Resonator and Contact Model for Standing Wave Piezomotor

The paper presents a model for a standing wave piezoelectric motor with a two bending mode resonator. The resonator is modelled using Hamilton's principle and the Rayleigh-Ritz method. The contact is modelled using the Lagrange Multiplier method under the assumption of slip and it is showed how to solve the set of differential-algebraic equations. Detailed simulations show resonance frequencies as function of the piezoelement's position, tip trajectories and contact forces. The paper demonstrates that contact stiffness and stick should be included in such model to obtain physically realistic results and a method to include stick is suggested.

Adaptive Control Mixer method for Nonlinear Control reconfiguration - A Case Study

General Information
State: Published
Organisations: Department of Automation
Authors: Yang, Z. (Ekstern), Blanke, M. (Intern)
Publication date: 2000

Host publication information
Title of host publication: IFAC Conference on Control System Design 2000
Main Research Area: Technical/natural sciences
Source-ID: 176635
Publication: Research - peer-review › Article in proceedings – Annual report year: 2000

A Unified Approach for Controllability Analysis of Hybrid Control Systems

General Information
State: Published
Organisations: Department of Automation
Authors: Yang, Z. (Ekstern), Blanke, M. (Intern)
Publication date: 2000

Host publication information
Title of host publication: IFAC Conference on Control System Design 2000, 2000
Control of Complex Systems

General information
State: Published
Organisations: Department of Automation
Authors: Albertos, P. (Ekstern), Åström, K. J. (Ekstern), Blanke, M. (Intern), Isidori, A. (Ekstern), Schaufelberger, W. (Ekstern), Santz, R. (. (Ekstern)
Publication date: 2000

Publication information
Publisher: Springer
Original language: English
Main Research Area: Technical/natural sciences
Source-ID: 176612
Publication: Research - peer-review › Book – Annual report year: 2000

Dynamic Model for Thrust Generation of Marine Propellers
Mathematical models of propeller thrust and torque are traditionally based on steady state thrust and torque characteristics obtained in model basin or cavitation tunnel tests. Experimental results showed that these quasi steady state models do not accurately describe the transient phenomena in a thruster. A recently published dynamic model was based on the experimental observations. Describing zero advance speed conditions accurately, this model, however, does not work for a vessel at non-zero relative water speed. This paper derives a large signal dynamic model of propeller that includes the effects of transients in the flow over a wide range of operation. The results are essential for accurate thrust control in dynamic positioning and in underwater robotics.

General information
State: Published
Organisations: Department of Automation, Department of Electrical Engineering, Automation and Control, Norwegian University of Science and Technology
Authors: Blanke, M. (Intern), Lindegaard, K. (Ekstern), Fossen, T. I. (Ekstern)
Pages: 363-368
Publication date: 2000

Host publication information
Title of host publication: Manoeuvring and control of marine craft 2000 (MCMC 2000) : Proceedings volume from the 5th IFAC conference.
Publisher: International Federation of Automatic Control
Editors: Blanke, M., Pourzanjani, M., Vukić, Z.
ISBN (Print): 0080436595
Main Research Area: Technical/natural sciences
Propellers, Thrusters, Dynamic positioning, Underwater robotics, Thrust control
Electronic versions:
blanke_lindegaard_fossen_2000.pdf
Source-ID: 176634
Publication: Research - peer-review › Article in proceedings – Annual report year: 2000

Electrical Steering System

General information
State: Published
Authors: Blanke, M. (Intern), Thomsen, J. S. (Ekstern), Kristensen, J. (Ekstern), Frederiksen, T. (Ekstern)
Publication date: 2000

Publication information
Patent number: US6693405-B2
Fault-tolerant Control of Complex Systems

General information
State: Published
Organisations: Department of Automation
Authors: Blanke, M. (Intern), Frei, C. (Ekstern), Kraus, K. (Ekstern), Patton, R. J. (Ekstern), Staroswiecki, M. (Ekstern)
Publication date: 2000

Host publication information
Title of host publication: Control of Complex Systems
Publisher: Springer-Verlag
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 176641
Publication: Research - peer-review › Article in proceedings – Annual report year: 2000

Nonlinear output feedback control of underwater vehicle propellers using feedback form estimated axial flow velocity

General information
State: Published
Organisations: Department of Automation
Authors: Fossen, T. I. (Ekstern), Blanke, M. (Intern)
Pages: 241-255
Publication date: 2000
Main Research Area: Technical/natural sciences

Publication information
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ISSN (Print): 0364-9059
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.747 SNIP 2.156 CiteScore 3.21
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.888 SNIP 2.386 CiteScore 3.02
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.536 SNIP 1.956 CiteScore 2.19
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.576 SNIP 1.973 CiteScore 2.21
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.514 SNIP 2.07 CiteScore 1.96
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.516 SNIP 1.512 CiteScore 1.64
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.566 SNIP 1.497
BFI (2009): BFI-level 1
On-line Multiple-model Based Adaptive Control Reconfiguration for a Class of Non-linear Control Systems

General information
State: Published
Organisations: Department of Automation
Authors: Yang, Z. (Ekstern), Izadi-Zamanabadi, R. (Ekstern), Blanke, M. (Intern)
Publication date: 2000

Host publication information
Title of host publication: Proc. IFAC Safeprocess'2000
Main Research Area: Technical/natural sciences
Source-ID: 176638
Publication: Research - peer-review › Article in proceedings – Annual report year: 2000

Rudder Roll Damping in Coastal Region Sea Conditions

General information
State: Published
Organisations: Department of Automation
Authors: Blanke, M. (Intern), Adrian, J. (Ekstern), Larsen, K. (Ekstern), Bentsen, J. (Ekstern)
Pages: 30-44
Publication date: 2000

Host publication information
Title of host publication: Proc. 5th IFAC Conference on Manoeuvring and Control of Marine Craft, MCMC'2000
Main Research Area: Technical/natural sciences
Source-ID: 176632
Publication: Research - peer-review › Article in proceedings – Annual report year: 2000

Ship Propulsion Control and Reconfiguration

General information
State: Published
Organisations: Department of Automation
Authors: Izadi-Zamanabadi, R. (Ekstern), Amann, P. (Ekstern), Blanke, M. (Intern), others, A. (Ekstern)
Publication date: 2000

Host publication information
Title of host publication: Control of Complex Systems
Publisher: Springer-Verlag
Main Research Area: Technical/natural sciences
Structural Modeling and Fuzzy-logic Based Diagnosis of a Ship Propulsion Benchmark

General information
State: Published
Organisations: Department of Automation
Authors: Izadi-Zamanabadi, R. (Ekstern), Blanke, M. (Intern), Katebi, S. (Ekstern)
Pages: 375-380
Publication date: 2000

Host publication information
Title of host publication: Proc. 5th IFAC Conference on Manoeuvring and Control of Marine Craft, MCMC'2000
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 176633
Publication: Research - peer-review › Article in proceedings – Annual report year: 2000

The Robust Control Mixer Module Method for Control Reconfiguration

General information
State: Published
Organisations: Department of Automation
Authors: Yang, Z. (Ekstern), Blanke, M. (Intern)
Publication date: 2000

Host publication information
Title of host publication: American Control Conference
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 176637
Publication: Research - peer-review › Article in proceedings – Annual report year: 2000

The Satellite Attitude Control Problem

General information
State: Published
Organisations: Department of Automation
Authors: Wisniewski, R. (Ekstern), Astolfi, A. (Ekstern), Bak, T. (Ekstern), Blanke, M. (Intern), others, A. (Ekstern)
Publication date: 2000

Host publication information
Title of host publication: Control of Complex Systems
Publisher: Springer-Verlag
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 176640
Publication: Research - peer-review › Article in proceedings – Annual report year: 2000

What is Fault Tolerant Control

General information
State: Published
Organisations: Department of Automation
Authors: Blanke, M. (Intern), Frei, C. W. (Ekstern), Kraus, K. (Ekstern), Patton, R. J. (Ekstern), Staroswiecki, M. (Ekstern)
Publication date: 2000

Host publication information
Title of host publication: Proc.IFAC Safeprocess 2000
Main Research Area: Technical/natural sciences
Source: orbit
**Adaptive Observer for Diesel Fault Detection in a Ship Propulsion Benchmark**

Prime movers on ships deliver power for both propelling and breaking a vessel and failure of the propulsion unit means loss of the ability to manoeuvre. Propulsion system malfunction must therefore be rapidly detected. The paper analyses detection and isolation of faults in a diesel engine and the associated shaft speed sensor. The dynamics involved is non-linear and one fault is in the system parameters while the other affects a system sensor as an additive fault. The problem is shown to require combined state and parameter estimation. With known structure it is shown to be an advantage to use continuous-time methods, where known functions and parameters can be easily incorporated and the physical parameters can be directly assessed. Application to the non-linear ship propulsion benchmark illustrates the method in detail.

**General information**

State: Published
Organisations: Aalborg University
Authors: Blanke, M. (Intern), Lootsma, T. F. (Ekstern)
Pages: 199-205
Publication date: 1999

**Host publication information**

Title of host publication: *Proceedings of European Control Conference*
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 232540
Publication: Research - peer-review › Article in proceedings – Annual report year: 1999

**A Robust Roll Damping Controller**

The effectiveness of rudder roll damping is sensitive to ship dynamic parameters. A recent model of a containership in waves include a nonlinear model and wave response operators. The vessel is sensitive in roll and has a low metacentric height, with a long natural roll period of 25 s. It was therefore interesting to investigate whether rudder roll damping was feasible. In this paper an H∞ controller is designed to optimise rudder roll damping. Steering and roll damping are hierarchical loops. Sea-way simulation results show that a successful controller design can be made

**General information**

State: Published
Organisations: Dalian Maritime University, Aalborg University
Authors: Yang, C. (Ekstern), Blanke, M. (Intern)
Pages: 60-64
Publication date: 1999

**Host publication information**

Title of host publication: *4th IFAC Conference on Marine Craft Manoeuvring Control*
Main Research Area: Technical/natural sciences
Conference: 4th IFAC Conference on Manoeuvering and Control of Marine Craft., Croatia, 01/01/1997
Source: orbit
Source-ID: 242618
Publication: Research - peer-review › Article in proceedings – Annual report year: 1997

**A Rudder Roll Damping controller with Wave Observer**

The perturbations in parameters or structure of the ship are important for RRD. H∞ control is useful in the design of RRD controllers when this kind of model uncertainty exists. The design method of a parallel RRD controller is discussed. The course keeping controller with a wave observer and the roll damping controller are designed by mixed sensitivity approach to deal with the perturbations. The seaway simulation results show that the rudder motion is very small when course keeping is in operation only, and the effectiveness of RRD is satisfactory when it is active

**General information**

State: Published
Organisations: Dalian Maritime University, Aalborg University
Authors: Yang, C. (Ekstern), Xinle, J. (Ekstern), Blanke, M. (Intern)
Pages: 563-568
Publication date: 1999
A sensitivity approach to identification of ship dynamics from sea trial data

Non-linear mathematical models of ships comprise one hundred parameters or more, and differences between full-scale trials and model tests are difficult to associate with the individual terms. Direct identification of parameters would be advantageous. The paper employs a sensitivity approach in an attempt to achieve this. Using the method on full-scale data from a container ship, a good fit in roll and yaw is obtained, but the method reveals that this does not imply good determination of individual parameters. The sensitivity method is found to be easily applied for both identification and evaluation of the reliability of parameter estimates.

Development of an automated technique for failure modes and effect analysis

Fault-tolerant Control for Complex Systems, invited semi-plenary lecture
Flight Results and Lessons Learned from the Ørsted Attitude Control System

General information
State: Published
Organisations: Automation, Department of Electrical Engineering
Authors: Bak, T. (Ekstern), Blanke, M. (Intern), Wisniewski, R. (Ekstern)
Publication date: 1999

Host publication information
Title of host publication: 4th ESA International Conference on Spacecraft Guidance, Navigation and Control Systems
Publisher: European Space Agency, ESA
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 188985
Publication: Research - peer-review › Article in proceedings – Annual report year: 1999

Fully Magnetic Attitude Control for Spacecraft Subject to Gravity Gradient

General information
State: Published
Organisations: Aalborg University
Authors: Wisnievski, R. (Ekstern), Blanke, M. (Intern)
Pages: 1201-1214
Publication date: 1999
Main Research Area: Technical/natural sciences

Publication information
Journal: Automatica
Volume: 35
Issue number: 7
ISSN (Print): 0005-1098
Ratings:
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): SJR 4.172 SNIP 3.332 CiteScore 6.96
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
Optimised Experiment Design for Identification of Marine Systems

General information
State: Published
Organisations: Automation, Department of Electrical Engineering
Authors: Blanke, M. (Intern), Knudsen, M. (Ekstern)
Publication date: 1999

Host publication information
Title of host publication: IFAC World Congress
Main Research Area: Technical/natural sciences
Conference: IFAC World Congress, Beijing, PRC, 01/01/1999
Links:
Source: orbit
Source-ID: 188387
Publication: Research - peer-review › Article in proceedings – Annual report year: 1999

Reconfigurability viewed as a system property

General information
State: Published
Organisations: Automation, Department of Electrical Engineering
Authors: Frei, C. (Ekstern), Klaus, F. (Ekstern), Blanke, M. (Intern)
Publication date: 1999

Host publication information
Title of host publication: European Control Conference
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 188385
Publication: Research - peer-review › Article in proceedings – Annual report year: 1999
The atmosphere X-ray observatory (AXO): proposal submitted to the Danish Small Satellite Programme

General information
State: Published
Organisations: Solar System Physics, National Space Institute, Astrophysics, Measurement & Instrumentation, Department of Electrical Engineering, Automation
Publication date: 1999

Control of a Complex satellite System

General information
State: Published
Organisations: Automation, Department of Electrical Engineering
Authors: Blanke, M. (Intern), Begh, S. A. (Ekstern), Wisniewski, R. (Ekstern), Bak, T. (Ekstern)
Publication date: 1998

Fault Monitoring and Re-configurable Control for a Ship Propulsion Plant

Minor faults in ship propulsion and their associated automation systems can cause dramatic reduction on ships’ ability to propel and manoeuvre, and eective means are needed to prevent simple faults from developing into severe failure. The paper analyses the control system for a propulsion plant on a ferry. It is shown how fault detection, isolation and subsequent reconfiguration can cope with many faults that would otherwise have serious consequences. The paper emphasizes analysis of re-conguration possibilities as a necessary tool to obtain fault tolerance, showing how sensor fusion and control system reconfiguration can be systematically approached. Detector design is also treated and parameter adaptation within fault detectors is shown to be needed to locate non-additive propulsion machinery faults. Test trials with a ferry are used to validate the principles.

General information
State: Published
Organisations: Aalborg University, Aalborg Universitet
Authors: Blanke, M. (Intern), Izadi-Zamanabadi, R. (Ekstern), Lootsma, T. F. (Ekstern)
Pages: 671-688
Publication date: 1998
Main Research Area: Technical/natural sciences

Volume: 12
Industrial Cost-Benefit Assessment for Fault-tolerant Control Systems

General information
State: Published
Organisations: Automation, Department of Electrical Engineering
Authors: Thybo, C. (Ekstern), Blanke, M. (Intern)
Publication date: 1998

Host publication information
Title of host publication: IEE Control'98
Main Research Area: Technical/natural sciences
Links:
Non-linear Fault Detection for use in Thruster Control

General information
State: Published
Organisations: Automation, Department of Electrical Engineering
Authors: Blanke, M. (Intern)
Publication date: 1998

Host publication information
Title of host publication: IEEE Workshop on Fault Tolerance in Autonomous Systems
Main Research Area: Technical/natural sciences
Conference: IEEE Workshop on Fault Tolerance in Autonomous Systems, 05/11/1829
Links:
Source: orbit
Source-ID: 188381
Publication: Research - peer-review › Article in proceedings – Annual report year: 1998

Quantitative Analysis and Design of a Rudder Roll Damping Controller

General information
State: Published
Organisations: Automation, Department of Electrical Engineering
Authors: Hearns, G. (Ekstern), Blanke, M. (Intern)
Pages: 115-120
Publication date: 1998

Host publication information
Title of host publication: 4th IFAC Symposium on Control Applications in Marine Systems
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 188380
Publication: Research - peer-review › Article in proceedings – Annual report year: 1998

Residual Generation for the Ship Benchmark Using Structural Approach

General information
State: Published
Organisations: Automation, Department of Electrical Engineering
Authors: Cocquempot, V. (Ekstern), Izadi-Zamanabadi, R. (Ekstern), Staroswiecki, M. (Ekstern), Blanke, M. (Intern)
Publication date: 1998

Host publication information
Title of host publication: IEE Control'98
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 188382
Publication: Research - peer-review › Article in proceedings – Annual report year: 1998

Rudder-Roll Damping Controller Design using Synthesis

General information
State: Published
A Ship Propulsion System as a Benchmark for Fault-tolerant Control

Fault detection and isolation (FDI) methods and algorithms for linear systems is matured during the past decade. However, an extension of these methods/algorithms to the non-linear is necessary, as many industrial processes are of non-linear nature. This paper introduces a propulsion system for (low speed) marine vehicles characterized by its non-linearity and complexity. The aim is to provide a realistic industrial system for comparison of various FDI methods and experience achievement hereby. The paper describes the benchmark system and requirements to fault detection. Furthermore, a simple version of the system is provided for early design purposes. The model makes it possible to test various methods, compare their properties such as robustness, and evaluate their effectiveness in the presence of unknown inputs and disturbances.

Dynamic Properties of Containership with Low Metacentric Height

Fault Detection and Isolation in a Marine Liquid Cargo System
Fault-tolerant control - a case study of the Ørsted Satellite

General information
State: Published
Organisations: Automation, Department of Electrical Engineering
Authors: Bøgh, S. A. (Ekstern), Blanke, M. (Intern)
Pages: 1-13
Publication date: 1997

Host publication information
Title of host publication: IEE colloquium on fault diagnosis in process systems
Publisher: IEE
Main Research Area: Technical/natural sciences
Conference: IEE colloquium on fault diagnosis in process systems, York, UK, 05/11/1929
Links:
Source: orbit
Source-ID: 188361
Publication: Research - peer-review › Article in proceedings – Annual report year: 1997

Fault-tolerant Control - a Holistic View

General information
State: Published
Organisations: Automation, Department of Electrical Engineering
Authors: Blanke, M. (Intern), Izadi-Zamanabadi, R. (Ekstern), Bøgh, S. A. (Ekstern), Lunau, C. P. (Ekstern)
Pages: 693-702
Publication date: 1997
Main Research Area: Technical/natural sciences

Publication information
Journal: Control Engineering Practice
ISSN (Print): 0967-0061
Ratings:
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.42 SJR 1.287 SNIP 2.156
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.194 SNIP 2.091 CiteScore 3.05
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.323 SNIP 2.626 CiteScore 3.26
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.433 SNIP 3.278 CiteScore 3.5
Multivariable Identification of Ship Steering and Roll Motions

General information
State: Published
Organisations: University of Pavia, Aalborg University
Authors: Tiano, A. (Ekstern), Blanke, M. (Intern)
Pages: 62-71
Publication date: 1997
Main Research Area: Technical/natural sciences

Publication information
Journal: Transactions of the Institute of Measurement and Control
Volume: 19
Issue number: 2
ISSN (Print): 0142-3312
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.377 SNIP 0.69 CiteScore 1.21
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.435 SNIP 0.697 CiteScore 1.03
A Component Based Approach for Industrial Fault Detection and Accommodation

Design of fault handling in control systems is discussed and a consistent method for design is presented. It is based on analysis of component fault modes and their effects. Automated analysis provides decision tables for fault handling. Mathematical models for fault detection and isolation are obtained from bond-graph models of components and subsystems. The outcome is a methodology for engineering design which presents the propagation of component faults and shows where fault handling should be applied to stop migration of a fault. The result is a way to obtain significantly improved dependability with simple means.

General information
State: Published
Organisations: Aalborg University
Authors: Blanke, M. (Intern)
Pages: 167-174
Publication date: 1996

Host publication information
Title of host publication: On-Line Fault Detection and Supervision in the Chemical Process Industries 1995
Publisher: Pergamon
ISBN (Print): 0080426077
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 242619
Publication: Research - peer-review › Article in proceedings – Annual report year: 1996
Autonomous Attitude Determination and Control System for the Ørsted Satellite

The Ørsted satellite mission imposes comparatively high requirements on autonomy of the attitude control system. Cost requirements, on the other hand, impose simple hardware and cheap actuators in form of magnetorquer coils. These conflicting requirements are fulfilled through development of novel attitude and control algorithms and wide on-board autonomy. The entire control and attitude determination system has the ability to reconfigure in real time, based on mission phase and contingency operation requirements. Attitude determination embraces three different strategies, dependent on the availability of attitude sensors. Possible sensor faults are detected and a control system supervisor autonomously reconfigures attitude determination. Estimated satellite attitude and angular velocity are used in the attitude controller. Control tasks vary with the mission phase. Initially, after release from the launch vehicle, the angular velocity is controlled. In subsequent mission phases, the satellite is three-axis stabilized. The main contributions are development of novel algorithms for attitude control applying magnetic torquing, attitude determination schemes based on the geomagnetic field measurements, and integration into a supervisory control architecture. The salient feature of this system is fault tolerant autonomous operation with a minimum of hardware redundancy.

General information
State: Published
Organisations: Aalborg University
Authors: Bak, T. (Ekstern), Wisnievski, R. (Ekstern), Blanke, M. (Intern)
Pages: 173-86
Publication date: 1996

Host publication information
Title of host publication: IEEE Aerospace Applications Conference
Volume: 2
Publisher: IEEE
ISBN (Print): 0780331966
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 242615
Publication: Research - peer-review › Article in proceedings – Annual report year: 1996

Consistent design of dependable control systems

General information
State: Published
Organisations: Aalborg University
Authors: Blanke, M. (Intern)
Pages: 1305-1312
Publication date: 1996
Main Research Area: Technical/natural sciences

Publication information
Journal: Control Engineering Practice
Volume: 4
Issue number: 9
ISSN (Print): 0967-0661
Ratings:
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.42 SJR 1.287 SNIP 2.156
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.194 SNIP 2.091 CiteScore 3.05
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.323 SNIP 2.626 CiteScore 3.26
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.433 SNIP 3.278 CiteScore 3.5
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
On the design and realisation of supervisory functions in fault tolerant control

**General information**
State: Published
Organisations: Automation, Department of Electrical Engineering
Authors: Izadi-Zamanabadi, R. (Ekstern), Blanke, M. (Intern), Bøgh, S. A. (Ekstern)
Publication date: 1996

**Host publication information**
Title of host publication: KOREMA
Main Research Area: Technical/natural sciences
Conference: KOREMA, Opatia, Croatia, 05/11/1829
Source: orbit
Source-ID: 188362
Publication: Research - peer-review › Article in proceedings – Annual report year: 1996

Uncertainty Models for Rudder-Roll Damping Control

**General information**
State: Published
Organisations: Automation, Department of Electrical Engineering
Authors: Blanke, M. (Intern)
Pages: 285-290
Publication date: 1996

**Host publication information**
Title of host publication: IFAC World Congress
Fault Detection for A Diesel Engine Actuator - A Benchmark for FDI

General information
State: Published
Organisations: Aalborg University, University of Hull
Authors: Blanke, M. (Intern), Bagh, S. A. (Ekstern), Jørgensen, R. B. (Ekstern), Paton, R. J. (Ekstern)
Pages: 1731-1740
Publication date: 1995
Main Research Area: Technical/natural sciences

Publication information
Journal: Control Engineering Practice
Volume: 3
Issue number: 12
ISSN (Print): 0967-0661
Ratings:
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.42 SJR 1.287 SNIP 2.156
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.194 SNIP 2.091 CiteScore 3.05
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.323 SNIP 2.626 CiteScore 3.26
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.433 SNIP 3.278 CiteScore 3.5
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.267 SNIP 3.118 CiteScore 3.02
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.544 SNIP 2.911 CiteScore 2.96
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.343 SNIP 2.745
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.487 SNIP 3.019
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.432 SNIP 2.917
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.105 SNIP 2.169
Scopus rating (2006): SJR 0.909 SNIP 1.894
Scopus rating (2005): SJR 0.579 SNIP 1.595
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.476 SNIP 1.304
Web of Science (2004): Indexed yes
Identification of a Class of Non-linear State Space Models using RPE Techniques

The RPE (recursive prediction error) method in state-space form is developed in the nonlinear systems and extended to include the exact form of a nonlinearity, thus enabling structure preservation for certain classes of nonlinear systems. Both the discrete and the continuous-discrete versions of the algorithm in an innovations model are investigated, and a nonlinear simulation example shows a quite convincing performance of the filter as combined parameter and state estimator.

General information
State: Published
Organisations: Department of Electrical Engineering, Technical University of Denmark
Authors: Zhou, W. (Ekstern), Blanke, M. (Intern)
Pages: 312-316
Publication date: 1989
Main Research Area: Technical/natural sciences

Publication information
Journal: IEEE Transactions on Automatic Control
Volume: 34
Issue number: 3
ISSN (Print): 0018-9286
Ratings:
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): SJR 4.174 SNIP 3.159 CiteScore 6.06
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 3.926 SNIP 2.884 CiteScore 5.08
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 4.196 SNIP 3.347 CiteScore 5.14
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 4.096 SNIP 3.13 CiteScore 5.24
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 4.143 SNIP 3.292 CiteScore 5.11
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 3.749 SNIP 2.961 CiteScore 4.11
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.939 SNIP 2.917
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 3.945 SNIP 3.449
BFI (2008): BFI-level 2
Identification of a class of nonlinear state-space models using RPE techniques

The recursive prediction error methods in state-space form have been efficiently used as parameter identifiers for linear systems, and especially Ljung's innovations filter using a Newton search direction has proved to be quite ideal. In this paper, the RPE method in state-space form is developed to the nonlinear case and extended to include the exact form of a nonlinearity, thus enabling structure preservation for certain classes of nonlinear systems. Both the discrete and the continuous-discrete versions of the algorithm in an innovations model are investigated, and a nonlinear simulation example shows a quite convincing performance of the filter as combined parameter and state estimator.

General information
State: Published
Organisations: Department of Automation, Technical University of Denmark
Authors: Zhou, W. W. (Ekstern), Blanke, M. (Intern)
Pages: 1637-1642
Publication date: 1986

Host publication information
Title of host publication: 25th IEEE Conference on Decision and Control
Volume: Volume 25
Publisher: IEEE
Main Research Area: Technical/natural sciences
Conference: 25th IEEE Conference on Decision and Control, Athens, Greece, 10/12/1986 - 10/12/1986
Electronic versions:
Blanke.pdf
DOIs:
10.1109/CDC.1986.267185

Bibliographical note
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Source: orbit
Source-ID: 264526
Publication: Research - peer-review › Article in proceedings – Annual report year: 1986
The Impact of Analog and Bang-Bang Steering Gear Control on Ship's Fuel Economy

The latest years have shown considerable efforts towards improving steering generated propulsion losses of ships by the introduction of various sophisticated control algorithms in the autopilots. However, little previous attention has been given to the steering gear control loop, although it is found to be at least equally important regarding steering performance and fuel economy. The paper presents a comprehensive survey of steering gear principles commonly used, including relevant details of three analog steering gear servo principles, which have outperformed conventional designs. Control system performance is evaluated from direct measurements of speed and fuel consumption, and results from several ships are given. The results presented should enhance the ability of ship owners and steering gear manufacturers to choose and design systems, which will minimize steering generated propulsion losses.

General information
State: Published
Organisations: Department of Electrical Engineering, Automation and Control, EMRI APS, University of Illinois
Authors: Nørtoft Thomsen, J. C. (Ekstern), Blanke, M. (Intern), Reid, R. E. (Ekstern), Youhanaie, M. (Ekstern)
Pages: 51-63.
Publication date: 1982

Projects:
Data-driven Condition Monitoring of Switches and Crossings
Department of Electrical Engineering
Period: 01/06/2016 → 31/05/2019
Number of participants: 3
Phd Student:
Barkhordari, Pegah (Intern)
Supervisor:
Blanke, Mogens (Intern)
Main Supervisor:
Galeazzi, Roberto (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering
Project: PhD

Intelligent Quality Assessment of Railway Switches and Crossings
This project aims at significantly improving the safety, reliability and operational lifetime of the 3500 switches and crossings (S&Cs) in the Danish railway network. The project is a close cooperation between the Technical University of Denmark (DTU), the Danish rail infrastructure provider Rail Net Denmark and four affiliated European partners with significant expertise within this field. An inter-disciplinary scientific effort is employed to obtain enhanced rail transport reliability and regularity simultaneously with significant savings in S&Cs maintenance costs. The project results will make maintenance based on intelligent fault prediction tools, instead of the presently used regular planned inspections, and it will provide sophisticated tools to prevent hidden faults from developing to failure in the future. In a novel approach, the project will install state-of-the-art sensor technology in selected S&Cs and correlate dynamic parameters during train passage with static geometry data from conventional measurement vehicles. Monitoring of the dynamic responses will provide diagnosis of patterns that indicate when components or ballast begin to deviate from fully functional conditions. Modelling of dynamics will identify root causes to signs of degradation. Damage assessment of components identified by anomalous readings will be done by metallurgical examinations. Data and results will be processed by a holistic model that can produce Maintenance Performance Indicators (MPI) for the S&C condition. The correlation of sensor data to measuring vehicle data will allow existing data to be used reliably as input for the MPI model. It is expected that this project will enable optimisation of maintenance procedures, by which appropriate maintenance can be predicted in...
advance, thus avoiding unscheduled repairs and delays in the railway traffic.

Department of Electrical Engineering
Automation and Control
Department of Wind Energy
Materials science and characterization
Department of Mechanical Engineering
Solid Mechanics
Department of Applied Mathematics and Computer Science
Statistics and Data Analysis

Banedanmark
Period: 01/03/2015 → 28/02/2019
Number of participants: 9
Acronym: INTELLISWITCH
Project participant:
Galeazzi, Roberto (Intern)
Blanke, Mogens (Intern)
Hansen, Søren (Intern)
Santos, Ilmar (Intern)
Danielsen, Hilmar Kjartansson (Intern)
Tejada, Alejandro de Miguel (Intern)
Ersbøll, Bjarne Kjær (Intern)
Kulahci, Murat (Intern)
Project Manager, academic:
Juul Jensen, Dorte (Intern)

Financing sources
Source: Public research council
Name of research programme: Innovationsfonden
Web address: http://innovationsfonden.dk/da
Amount: 12,700,000.00 Danish Kroner
Year of approval: 2014

Fault-Tolerant Control with Coarse Models in industrial Application

Department of Electrical Engineering
Automation and Control
Period: 15/08/2014 → 15/08/2017
Number of participants: 3
Fault-tolerant control, fault diagnosis, fault estimation, nonlinear control, nonlinear systems, industrial motors
Project participant:
Papageorgiou, Dimitrios (Intern)
Supervisor:
Niemann, Hans Henrik (Intern)
Main Supervisor:
Blanke, Mogens (Intern)

Relations
Activities:
2015 IEEE Multi-Conference on Systems and Control

Fault-tolerance and reconfiguration for collaborating heterogeneous underwater robots

Department of Electrical Engineering
Fault-Tolerant Control with Coarse Models in industrial Application

Department of Electrical Engineering
Period: 15/08/2014 → 14/08/2017
Number of participants: 4
Phd Student:
Papageorgiou, Dimitrios (Intern)
Supervisor:
Niemann, Hans Henrik (Intern)
Richter, Jan H. (Ekstern)
Main Supervisor:
Blanke, Mogens (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Eksternt finansieret virksomhed
Project: PhD

Modular Robotics for Underwater Environments

Department of Electrical Engineering
Period: 15/12/2013 → 14/03/2017
Number of participants: 3
Phd Student:
Furno, Lidia (Intern)
Supervisor:
Christensen, David Johan (Intern)
Main Supervisor:
Blanke, Mogens (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

Multiphysics approach applied to the design of AMB for high speed turbomachinery

Department of Mechanical Engineering
Period: 01/12/2013 → 30/05/2017
Number of participants: 6
Phd Student:
Lauridsen, Jonas Skjødt (Intern)
Supervisor:
Schlee, Mathias (Ekstern)
Main Supervisor:
Santos, Ilmar (Intern)
Examiner:
Blanke, Mogens (Intern)
Keogh, Patrick Sean (Ekstern)
Maslen, Eric Harvey (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansierede - Virksomhed
Project: PhD

Exhaust Recirculation Control for Reduction of NOx from Large Two-stroke Diesel Engines
Department of Electrical Engineering
Period: 01/09/2013 → 12/04/2017
Number of participants: 7
Phd Student:
Nielsen, Kræn Vodder (Intern)
Supervisor:
Hoffmann, Mark (Intern)
Laursen, Morten (Intern)
Main Supervisor:
Blanke, Mogens (Intern)
Examiner:
Galeazzi, Roberto (Intern)
Johansen, Tor Arne (Ekstern)
Theotokatos, Gerasimos (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Industrial PhD

Relations
Publications:
Exhaust Recirculation Control for Reduction of NOx from Large Two-Stroke Diesel Engines
Project: PhD

Emergency Control in Power Transmission
Department of Electrical Engineering
Period: 01/11/2012 → 20/01/2016
Number of participants: 7
Phd Student:
Pedersen, Andreas Søndergaard (Intern)
Supervisor:
Jóhannsson, Hjörtur (Intern)
Tabatabaeipour, Mojtaba (Intern)
Main Supervisor:
Blanke, Mogens (Intern)
Examiner:
Niemann, Hans Henrik (Intern)
Erlich, István (Ekstern)
Stoustrup, Jakob (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD

Offshore Wind Park Control Assessment Methodologies to Assure Robustness and Fault tolerance
Department of Electrical Engineering
Period: 01/09/2012 → 20/01/2016
Number of participants: 9
Phd Student:
Gryning, Mikkel Peter Sidoroff (Intern)

Supervisor:
Andersen, Karsten Hvalkof (Intern)
Niemann, Hans Henrik (Intern)
Sørensen (fratrådt), Troels (Intern)
Wu, Qiuwei (Intern)

Main Supervisor:
Blanke, Mogens (Intern)

Examiner:
Cutululis, Nicolaos Antonio (Intern)
Erlich, István (Ekstern)
Stoustrup, Jakob (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: ErhvervsPhD-ordningen VTU
Project: PhD

Performance Monitoring, Diagnosis and Advanced Control for Bio-Refinery
Department of Electrical Engineering
Period: 01/04/2012 → 17/02/2016
Number of participants: 7
Phd Student:
Prunescu, Remus Mihail (Intern)

Supervisor:
Jakobsen, Jon Geest (Intern)
Sin, Gürkan (Intern)

Main Supervisor:
Blanke, Mogens (Intern)

Examiner:
Huusom, Jakob Kjøbsted (Intern)
Lidén, Gunnar (Ekstern)
Skogestad, Sigurd (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: ErhvervsPhD-ordningen VTU

Relations
Publications:
Dynamic Modeling, Optimization, and Advanced Control for Large Scale Biorefineries
Project: PhD

Secure Operation of Sustainable Power Systems
Funded by the Danish Council for strategic research (DSF)

The project period spans four years, starting in January 2012. The total budget for the project is approximately 30.2 million DKK, which covers among others the funding of 5 PhD and 3 PostDoc positions. The project is managed by prof. Jacob Østergaard, head of Centre for Electric Technology.

The SOSPO project focuses on a critical, difficult and not yet treated problem regarding how secure operation of future sustainable power systems (based on wind and solar energy) can be ensured.

The research in the SOSPO project focuses on methods that enable system stability and security assessment in real-time and on methods for automatically determining control actions that regain system security when an insecure operation has been detected.
Centre for Electric Technology
Department of Electrical Engineering
Electric Energy Systems
Automation and Control
Center for Electric Power and Energy
Electric power systems
Eidgenössische Technische Hochschule
Lund University
Chalmers University of Technology
Energinet.dk
Siemens

Ken M Consulting
Period: 01/01/2012 → 31/12/2015
Number of participants: 13
Stability sustainable power system
Acronym: SOSPO
Number of related Ph.D. students: 5
Project participant:
Nielsen, Arne Hejde (Intern)
Garcia-Valle, Rodrigo (Intern)
Yang, Guangya (Intern)
Lind, Morten (Intern)
Blanke, Mogens (Intern)
Zhang, Xinxin (Intern)
Phd Student:
Weckesser, Johannes Tilman Gabriel (Intern)
Wittrock, Martin Lindholm (Intern)
Møller, Jakob Glarbo (Intern)
Perez, Angel (Intern)
Pedersen, Andreas Søndergaard (Intern)
Project Manager, academic:
Østergaard, Jacob (Intern)
Jóhannsson, Hjörtur (Intern)

Relations
Publications:
Method of determining remedial control actions for a power system in an insecure state
Wide Area Prosumption Control and Sensitivities of Aperiodic Small Signal Stability Indicators
Early Prevention Method for Power Systems Instability
Uncertainty in real-time voltage stability assessment methods based on Thevenin equivalent due to PMU's accuracy
Sensitivity based Assessment of Transient Voltage Sags caused by Rotor Swings
Impact of Model Detail of Synchronous Machines on Real-time Transient Stability Assessment
Evaluation of enhancements to Thevenin equivalent based methods for real-time voltage stability assessment
Suitability of voltage stability study methods for real-time assessment
Evaluation of HVDC interconnection models for considering its impact in real-time voltage stability assessment
Wide-Area Assessment of Aperiodic Small Signal Rotor Angle Stability in Real-Time
Computation of Steady State Nodal Voltages for Fast Security Assessment in Power Systems
Wide-Area Assessment of Aperiodic Small Signal Rotor Angle Stability in Real-Time
Real-Time Thevenin Impedance Computation
Improved method for considering PMU's uncertainty and its effect on real-time stability assessment methods based on Thévenin equivalent

Identification of Critical Transmission Limits in Injection Impedance Plane

System security assessment in real-time using synchrophasor measurements

Fast assessment of the effect of preventive wide area emergency control

Critical machine cluster identification using the equal area criterion

Convex Relaxation of Power Dispatch for Voltage Stability Improvement

Investigation of Suitability of Cascading Outage Assessment Methods for Real-Time Assessment

Early prevention of instability - search for optimal grid nodes for applying countermeasures

Addressing the security of a future sustainable power system: The Danish SOSPO project

Improved method for considering PMU's uncertainty and its effect on real-time stability assessment methods based on Thévenin equivalent

Early Prevention of Instability-Use of Self Propagating Graph for the Fast Search for Optimal Grid Nodes to Apply Countermeasures

Thevenin Equivalent Method for Dynamic Contingency Assessment

Technical Resource Potential of Non-disruptive Residential Demand Response in Denmark

Wind farms generation limits and its impact in real-time voltage stability assessment

Investigation of the Adaptability of Transient Stability Assessment Methods to Real-Time Operation

Early Prediction of Transient Voltage Sags caused by Rotor Swings

An implementation and test platform for wide area stability assessment methods

Assessment of the impact that individual voltage source has on a generator's stability

SW-platform for R&D in Applications of Synchrophasor Measurements for Wide-Area Assessment, Control and Visualization in Real-Time

Influence of current limitation on voltage stability with voltage sourced converter HVDC


Stabiliser Fault Emergency Control using Reconfiguration to Preserve Power System Stability

Derivation and application of sensitivities to assess transient voltage sags caused by rotor swings

Early Prevention Method for Power System Instability

Real-Time Stability Assessment based on Synchrophasors

Documents:

SOSPO Public Fact Sheet 2013

Project
Fejldiagnose og fejlhåndtering til autonome fly
Department of Electrical Engineering
Period: 01/06/2009 → 21/02/2013
Number of participants: 6
Phd Student:
Hansen, Søren (Intern)
Supervisor:
Adrian, Jens (Ekstern)
Main Supervisor:
Blanke, Mogens (Intern)
Examiner:
Niemann, Hans Henrik (Intern)
Gustafsson, Fredrik (Ekstern)
Henry, David (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Ansat eksternt
Project: PhD

Direct vision based molten pool feature extraction in automated arc welding
Department of Management Engineering
Period: 01/07/2008 → 25/01/2012
Number of participants: 8
Phd Student:
Liu, Jinchao (Intern)
Supervisor:
Christensen, Kim Hardam (Intern)
Klæstrup Kristensen, Jens (Intern)
Olsen, Søren Ingvar (Ekstern)
Main Supervisor:
Fan, Zhun (Intern)
Examiner:
Blanke, Mogens (Intern)
Lucas, William (Ekstern)
Sporring, Jon (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: ErhvervsPhD-ordningen VTU
Project: PhD

Robotic Manipulation of Offshore Drilling Equipment
Department of Electrical Engineering
Period: 01/02/2008 → 19/04/2012
Number of participants: 6
Phd Student:
Choux, Martin (Intern)
Supervisor:
Hovland, Geir (Ekstern)
Main Supervisor:
Blanke, Mogens (Intern)
Examiner:
Poulsen, Niels Kjøstad (Intern)
Andersen, Torben Ole (Intern)
Egeland, Olav (Ekstern)
Automated Design of Advanced Mechatronic Systems

Department of Management Engineering
Period: 15/05/2007 → 11/05/2011
Number of participants: 7
Phd Student:
Dupuis, Jean-Francois (Intern)
Supervisor:
Goodman, Erik (Ekstern)
Sigmund, Ole (Intern)
Main Supervisor:
Fan, Zhun (Intern)
Examiner:
Blanke, Mogens (Intern)
Jin, Yaochu (Ekstern)
Zhang, Qingfu (Ekstern)

Nonlinear Methods for Spacecraft Orbit Control using an Electrodynamic Tether

Department of Electrical Engineering
Period: 01/05/2007 → 30/09/2010
Number of participants: 5
Phd Student:
Larsen, Martin Birkelund (Intern)
Main Supervisor:
Blanke, Mogens (Intern)
Examiner:
Santos, Ilmar (Intern)
Ortega, Romeo (Ekstern)
Wisniewski, Rafal (Ekstern)

Fault Diagnosis for Identification of Deviant Behavior

Department of Electrical Engineering
Period: 01/04/2007 → 22/06/2011
Number of participants: 7
Phd Student:
Jónsson, Ragnar Ingi (Intern)
Supervisor:
Højsgaard, Søren (Ekstern)
Poulsen, Niels Kjølstad (Intern)
Main Supervisor:
Blanke, Mogens (Intern)
Examiner:
Madsen, Henrik (Ekstern)
Fault-tolerant Guidance for Precision Farming using 2D/3D Vision and Computer-Based Learning

Department of Electrical Engineering
Period: 01/09/2006 → 30/06/2010
Number of participants: 6
Phd Student:
Blas, Morten Rufus (Intern)
Supervisor:
Madsen, Tommy Ertbølle (Intern)
Main Supervisor:
Blanke, Mogens (Intern)
Examiner:
Lind, Morten (Intern)
Christensen, Henrik Iskov (Ekstern)
Schilling, Klaus (Ekstern)

Autonomous Supervision and Control to Prevent Parametric Resonance

Department of Electrical Engineering
Period: 01/08/2006 → 03/03/2010
Number of participants: 6
Phd Student:
Galeazzi, Roberto (Intern)
Supervisor:
Jensen, Jørgen Juncher (Intern)
Main Supervisor:
Blanke, Mogens (Intern)
Examiner:
Santos, Ilmar (Intern)
Kinnaert, Michel (Ekstern)
Nijmeijer, Henk (Ekstern)

Building a Fast Time Numerical Navigator for Assessing Collision and Grounding Frequencies in a Given Navigational Area

Department of Mechanical Engineering
Period: 01/10/2004 → 31/05/2006
Number of participants: 3
Phd Student:
Søborg, Anders Veldt (Intern)
Supervisor:
Blanke, Mogens (Intern)
Experimental Contribution to the Problem of Model Parameter Identification in Rotating Machines via Active Magnetic Bearings

Department of Mechanical Engineering
Period: 01/02/2004 → 11/04/2008
Number of participants: 5
Phd Student:
Kjølhede, Klaus Kirkebæk (Intern)
Main Supervisor:
Santos, Ilmar (Intern)
Examiner:
Braun, Minel J. (Ekstern)
Blanke, Mogens (Intern)
Dmochowski, Waldemar M. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Anden EU-finansiering
Project: PhD

Menneske-maskine samarbejde i distribuerede automatiseringssystemer

Department of Electrical Engineering
Period: 01/07/2003 → 30/03/2007
Number of participants: 7
Phd Student:
Olsen, Mikkel Holm (Intern)
Supervisor:
Ravn, Ole (Intern)
Rose, Michael (Intern)
Main Supervisor:
Lind, Morten (Intern)
Examiner:
Blank, Mogens (Intern)
Andersen, Peter Bøgh (Intern)
Johnsen, Terje (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU-lønnet stipendie
Project: PhD

Fejltolerant Regulering med Anvendelser indenfor Rumfart

Department of Electrical Engineering
Period: 01/09/2002 → 30/09/2003
Number of participants: 3
Phd Student:
Ziegler, Bent Lindvig (Intern)
Supervisor:
Niemann, Hans Henrik (Intern)
Main Supervisor:
Blank, Mogens (Intern)
Design and Implementation of Automatic Control in High Efficiency Tractors for Agricultural Applications

Department of Mechanical Engineering

Period: 01/09/2001 → 11/02/2005

Number of participants: 6

PhD Student:

Christensen, Rene Hardam (Intern)

Supervisor:

Klit, Peder (Intern)

Main Supervisor:

Santos, Ilmar (Intern)

Examiner:

Blanke, Mogens (Intern)

Keogh, Patrick Sean (Ekstern)

Nordmann, Rainer (Ekstern)

Financing sources

Source: Internal funding (public)

Name of research programme: DTU-lønnet stipendie

Project: PhD

Dynamics and control of thrusters for ships and underwater vehicles

Dynamic effects were reported in the literature in recent literature but mathematical models of the axial flow phenomena only covered near-zero speed conditions. These models could not be used for conditions with current or for ships at voyage speed. A large signal model was developed. A nonlinear controller that provided improved control. The model and the new control concept explained phenomena with overshoot in propeller speed controls observed during many years and proposed a more accurate control system. The results are important for accurate manoeuvring of autonomous underwater vehicles and robots.

Department of Automation

Department of Electrical Engineering

Norwegian University of Science and Technology

Period: 01/01/2000 → 01/01/9999

Number of participants: 3

Project participant:

Fossen, T. I. (Ekstern)

Lindegaard, P. (Ekstern)

Project Manager, organisational:

Blanke, Mogens (Intern)

Project

Fault-tolerant control for complex systems

Concepts that enable systems to autonomously diagnose and react to faults have been under development since the 1990ties. The concept, referred to as fault-tolerant control, utilise diagnosis with change detection to investigate whether faults have occurred in an automated system. If a fault has been detected, and a hypothesis about the nature of the fault has been confirmed, control system supervision can autonomously reconfigure the controller to handle the fault. One motivation for fault-tolerant control is the safety aspects associated with loss of control when faults occur in automated systems. Another is the economic incentive that downtime of industrial processes is a major factor for total process yield. Fault-tolerant control was demonstrated to be able to improve availability and make control systems react sensibly for systems in different areas.

Department of Automation

Department of Electrical Engineering

Lund Institute of Technology
Ultrasound actuator for aerospace applications
Aiming primarily at aerospace applications, principles of designing a spherical ultrasound motor are being investigated. The motivation for ultrasound motors in aerospace applications is the possibility to make a non-magnetic, lightweight and high precision torque device for control applications. The research project aims in particular at investigating the contact modelling effects, which play a major role for developed torque and efficiency of the motor.

Real-Time 'Plant-Wide' Diagnosis
Department of Electrical Engineering
Period: 01/05/1997 → 27/03/2000
Number of participants: 3
PhD Student:
Petersen, Johannes (Intern)
Main Supervisor:
Lind, Morten (Intern)
Examiner:
Blanke, Mogens (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsstip.-SU, Eksp
Project: PhD

Navigation
Department of Electrical Engineering
Period: 01/03/1997 → 04/12/2002
Number of participants: 6
PhD Student:
Larsen, Mikael Bliksted (Intern)
Supervisor:
Lind, Morten (Intern)
Main Supervisor:
Andersen, Nils Axel (Intern)
Examiner:
Blanke, Mogens (Intern)
Holst, Jan (Ekstern)
Pascoal, António M. (Ekstern)

**Financing sources**
Source: Internal funding (public)
Name of research programme: Forskningsrådsstip.-SU, Eksp
Project: PhD

**Analyse af ruteoptimeringssystemer for skibe**
Technical University of Denmark
Period: 01/08/1982 → 04/09/1996
Number of participants: 2
PhD Student:
Andersen, Nils Axel (Intern)
Main Supervisor:
Blanke, Mogens (Intern)

**Financing sources**
Source: Internal funding (public)
Name of research programme: Gammel ordning u/skema-SU
Project: PhD

**Activities:**

**Professorship evaluation (External organisation)**
Mogens Blanke (Member)
Department of Electrical Engineering
Automation and Control

Description
Member of evaluation committee for Professorship at Linköping University (SE)
Evaluation of candidate(s) for Professorship at Linköping University (SE)

Body type: University
Degree of recognition: International

Related external organisation

**Professorship evaluation**
Activity: Membership › Membership in committee, council, board

**10th IFAC Conference on Manoeuvring and Control of Marine Craft**
Period: 24 Aug 2015
Mogens Blanke (Organizer)
Department of Electrical Engineering
Automation and Control

Description
Organiser of 10th IFAC Conference on Marine Craft Manoeuvring and Control (MCMC'2015)

Links:
In committee for PhD thesis evaluation at Linköping University, Sweden (External organisation)
Period: 22 May 2015
Mogens Blanke (Member)
Department of Electrical Engineering
Automation and Control

Description
Thesis by Daniel Jung

Body type: University
Degree of recognition: International

Related external organisation
In committee for PhD thesis evaluation at Linköping University, Sweden (External organisation)
Activity: Membership › Membership in review committee

Professorship Evaluation for NTNU - International Chair (External organisation)
Period: 1 May 2015 → 30 Jun 2015
Mogens Blanke (Member)
Department of Electrical Engineering
Automation and Control

Description
Evaluation of candidate for position as NTNU International Chair

Body type: International Evaluation Committee
Degree of recognition: International

Related external organisation
Professorship Evaluation for NTNU - International Chair
Activity: Membership › Membership in review committee

Evaluation for University of Cambridge (External organisation)
Period: 25 Jan 2015 → 6 Feb 2015
Mogens Blanke (Member)
Department of Electrical Engineering
Automation and Control

Description
Faculty member evaluation

Body type: University
Degree of recognition: International

Related external organisation
Evaluation for University of Cambridge
Activity: Membership › Membership in review committee
IFAC Technical Committee on Marine Systems (External organisation)
Period: 2014 → 2017
Mogens Blanke (Member)
Department of Electrical Engineering
Automation and Control

Description
Member of IFAC TC on Marine Systems 2014 -2017

Body type: Technical Committee
Degree of recognition: International

Related external organisation
IFAC Technical Committee on Marine Systems
Activity: Membership › Membership in committee, council, board

University of Bordeaux (External organisation)
Period: 19 Nov 2014
Mogens Blanke (Member)
Department of Electrical Engineering
Automation and Control

Description
Opponent on PhD thesis by Robert Fonod

Body type: University
Degree of recognition: International

Related external organisation
University of Bordeaux
France
Activity: Membership › Membership in review committee

Aarhus University (External organisation)
Period: 12 Nov 2014
Mogens Blanke (Member)
Department of Electrical Engineering
Automation and Control

Description
Opponent on PhD thesis by Martin Andreas Falk Jensen

Body type: University

Related external organisation
Aarhus University
Denmark
Activity: Membership › Membership in review committee

University of Cambridge (External organisation)
Period: 3 Nov 2014
Mogens Blanke (Member)
Department of Electrical Engineering
Automation and Control

**Description**
External examiner of PhD thesis

**Body type:** University  
**Degree of recognition:** International

**Related external organisation**

**University of Cambridge**  
United Kingdom  
**Activity:** Membership › Membership in review committee

**Linköping University (External organisation)**  
**Period:** 25 Apr 2014  
Mogens Blanke (Member)  
Department of Electrical Engineering  
Automation and Control  

**Description**  
Opponent for the PhD thesis of Christofer Sundström  

**Body type:** University  
**Degree of recognition:** International

**Related external organisation**

**Linköping University**  
Sweden  
**Activity:** Membership › Membership in review committee

**Referee, Professor in Robotics at Queensland University of Technology (External organisation)**  
**Period:** 28 Jan 2014 → 10 Feb 2014  
Mogens Blanke (Member)  
Department of Electrical Engineering  
Automation and Control  

**Description**  
Referee for Employment of Professor in Robotics at Queensland University of Technology  
**Degree of recognition:** International

**Related external organisation**

**Referee, Professor in Robotics at Queensland University of Technology**  
**Activity:** Membership › Membership in review committee

**International Journal of Adaptive Control and Signal Processing (Journal)**  
**Period:** 1 Jan 2014 → 1 May 2015  
Mogens Blanke (Editor)  
Department of Electrical Engineering  
Automation and Control  

**Description**  
Journal of Adaptive Control and Signal Processing  
**Special Issue on Adaptive Control and Signal Processing in Marine Systems**
Designated Editor for Special Issue on Adaptive control and Signal Processing in Marine Systems

**Related journal**

*International Journal of Adaptive Control and Signal Processing*

0890-6327

BFI (2017): BFI-level 1, Scopus rating (2016): CiteScore 2.04 SJR 0.886 SNIP 1.102, ISI indexed (2013): ISI indexed yes,

Web of Science (2017): Indexed Yes

Central database

Activity: Research › Editor of Research journal

**Aalborg University (External organisation)**

Period: 5 Oct 2012 → 18 Dec 2012

Mogens Blanke (Member)

Department of Electrical Engineering

Automation and Control

**Description**

Member of evaluation committee for position as full professor in automation and control

Member of evaluation committee for position as full professor in automation and control

Body type: University

**Related external organisation**

**Aalborg University**

Aalborg, Denmark

Activity: Membership › Membership in review committee

**Linköping University (External organisation)**

Period: 15 Jun 2012

Mogens Blanke (Member)

Department of Electrical Engineering

Automation and Control

**Description**

Official opponent for PhD candidate Carl Svärd’s defense for the degree Dr.Ing

Official opponent for PhD candidate Carl Svärd’s defense for the degree Dr.Ing

Body type: University

Degree of recognition: International

**Related external organisation**

**Linköping University**

Sweden

Activity: Membership › Membership in review committee

**Aalborg University (External organisation)**

Period: 21 Mar 2012

Mogens Blanke (Member)

Department of Electrical Engineering

Automation and Control

**Description**

Opponent for PhD Candidate Tom Nørgaard Jensen’s Thesis

External examiner for PhD Thesis
Member IFAC Technical Committee on Marine Systems (External organisation)
Period: 2011 → 2014
Mogens Blanke (Member)
Department of Electrical Engineering
Automation and Control

Description
Member of IFAC TC on Marine Systems 2011 -2014
Member of IFAC TC on Marine Systems 2014 -2017

Body type: International Organization
Degree of recognition: International

Related external organisation
Member IFAC Technical Committee on Marine Systems
Activity: Membership › Membership in committee, council, board

Linköping University (External organisation)
Period: 28 Dec 2011 → 1 Mar 2012
Mogens Blanke (Member)
Department of Electrical Engineering
Automation and Control

Description
External evaluator for promotion to Docent
Evaluation of promotion to Docent

Body type: Evaluation committee
Degree of recognition: International

Related external organisation
Linköping University
Sweden
Activity: Membership › Membership in review committee

Control Engineering Practice (Journal)
Period: Oct 2008 → …
Mogens Blanke (Reviewer)
Department of Electrical Engineering
Automation and Control

Description
Control Engineering Practice
Associate Editor

Related journal
IEEE Transactions on Aerospace and Electronic Systems (Journal)

Mogens Blanke (Editor)
Department of Electrical Engineering
Automation and Control

Description
Transactions on Aerospace and Electronic Systems

Technical Editor for Fault-tolerant Systems

Technical editor for Fault-tolerant Systems

Related journal

IEEE Transactions on Aerospace and Electronic Systems
0018-9251
BFI (2017): BFI-level 1, Scopus rating (2016): CiteScore 2.89 SJR 0.85 SNIP 1.916, ISI indexed (2013): ISI indexed yes,
Web of Science (2017): Indexed Yes
Central database
Activity: Research › Editor of Research journal