Dynamics of a physiologically structured population in a time-varying environment

Physiologically structured population models have become a valuable tool to model the dynamics of populations. In a stationary environment such models can exhibit equilibrium solutions as well as periodic solutions. However, for many organisms the environment is not stationary, but varies more or less regularly. In order to understand the interaction between an external environmental forcing and the internal dynamics in a population, we examine the response of a physiologically structured population model to a periodic variation in the food resource. We explore the addition of forcing in two cases: (A) where the population dynamics is in equilibrium in a stationary environment, and (B) where the population dynamics exhibits a periodic solution in a stationary environment. When forcing is applied in case A, the solutions are mainly periodic. In case B the forcing signal interacts with the oscillations of the unforced system, and both periodic and irregular (quasi-periodic or chaotic) solutions occur. In both cases the periodic solutions include one and multiple period cycles, and each cycle can have several reproduction pulses.

State: Published
Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, National Institute of Aquatic Resources, Centre for Ocean Life, Section for Marine Living Resources
Authors: Heilmann, I. L. T. (Intern), Starke, J. (Intern), Andersen, K. H. (Intern), Thygesen, U. H. (Intern), Sørensen, M. P. (Intern)
Pages: 54-61
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Scopus rating (2016): CiteScore 2.11 SJR 0.799 SNIP 1.039
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.921 SNIP 1.073 CiteScore 2.01
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.876 SNIP 1.5 CiteScore 2.53
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.073 SNIP 1.632 CiteScore 3.29
ISI indexed (2013): ISI indexed yes
Pattern formation in annular systems of repulsive particles

General particle models with symmetric and asymmetric repulsion are studied and investigated for finite-range and exponential interaction in an annulus. In the symmetric case transitions from one- to multi-lane behavior including multistability are observed for varying particle density and for a varying curvature with fixed density. Hence, the system cannot be approximated by a periodic channel. In the asymmetric case, which is important in pedestrian dynamics, we reveal an inhomogeneous new phase, a traveling wave reminiscent of peristaltic motion.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Department of Physics, Bogolyubov Institute for Theoretical Physics
Authors: Marschler, C. (Intern), Starke, J. (Intern), Sørensen, M. P. (Intern), Gaididei, Y. B. (Ekstern), Christiansen, P. L. (Intern)
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Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.713 SNIP 1.159 CiteScore 1.74
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Scopus rating (2014): SJR 0.699 SNIP 1.024 CiteScore 1.71
Web of Science (2014): Indexed yes
Experimental bifurcation analysis—Continuation for noise-contaminated zero problems
Noise contaminated zero problems involve functions that cannot be evaluated directly, but only indirectly via observations. In addition, such observations are affected by a non-deterministic observation error (noise). We investigate the application of numerical bifurcation analysis for studying the solution set of such noise contaminated zero problems, which is highly relevant in the context of equation-free analysis (coarse grained analysis) and bifurcation analysis in experiments, and develop specialized algorithms to address challenges that arise due to the presence of noise. As a working example, we demonstrate and test our algorithms on a mechanical nonlinear oscillator experiment using control based continuation, which we used as a main application and test case for development of the Coco compatible Matlab toolbox Continex that implements our algorithms.
An Iterative Method for the Approximation of Fibers in Slow-Fast Systems

In this paper we extend a method for iteratively improving slow manifolds so that it also can be used to approximate the fiber directions. The extended method is applied to general finite-dimensional real analytic systems where we obtain exponential estimates of the tangent spaces to the fibers. The method is demonstrated on the Michaelis–Menten–Henri model and the Lindemann mechanism. The latter example also serves to demonstrate the method on a slow-fast system in nonstandard slow-fast form. Finally, we extend the method further so that it also approximates the curvature of the fibers.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Mathematics, Dynamical Systems
Authors: Kristiansen, K. U. (Intern), Brøns, M. (Intern), Starke, J. (Intern)
Pages: 861–900
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Main Research Area: Technical/natural sciences

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Journal: SIAM Journal on Applied Dynamical Systems
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.88 SJR 1.256 SNIP 1.297
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.358 SNIP 1.389 CiteScore 1.89
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.167 SNIP 1.217 CiteScore 1.67
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.306 SNIP 1.34 CiteScore 1.85
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.221 SNIP 1.486 CiteScore 1.77
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.494 SNIP 1.41 CiteScore 1.91
Bifurcation analysis of a smoothed model of a forced impacting beam and comparison with an experiment

A piecewise-linear model with a single degree of freedom is derived from first principles for a driven vertical cantilever beam with a localized mass and symmetric stops. The aim is to show that this model constitutes a considerable step toward developing a vibro-impact model that is able to make qualitative and quantitative predictions of the observed dynamics. The resulting piecewise-linear dynamical system is smoothed by a switching function (nonlinear homotopy). For the chosen smoothing function, it is shown that the smoothing can induce bifurcations in certain parameter regimes. These induced bifurcations disappear when the transition of the switching is sufficiently and increasingly localized as the impact becomes harder. The bifurcation structure of the impact oscillator response is investigated via the one- and two-parameter continuation of periodic orbits in the driving frequency and/or forcing amplitude. The results are in good agreement with experimental measurements.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Mathematics, Department of Mechanical Engineering, Solid Mechanics, Dynamical Systems, University of Auckland
Authors: Elmegård, M. (Intern), Krauskopf, B. (Ekstern), Osinga, H. (Ekstern), Starke, J. (Intern), Thomsen, J. J. (Intern)
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Scopus rating (2014): SJR 1.235 SNIP 1.73 CiteScore 3.07
Web of Science (2014): Indexed yes
Bifurcation of learning and structure formation in neuronal maps

Most learning processes in neuronal networks happen on a much longer time scale than that of the underlying neuronal dynamics. It is therefore useful to analyze slowly varying macroscopic order parameters to explore a network's learning ability. We study the synaptic learning process giving rise to map formation in the laminar nucleus of the barn owl's auditory system. Using equation-free methods, we perform a bifurcation analysis of spatio-temporal structure formation in the associated synaptic-weight matrix. This enables us to analyze learning as a bifurcation process and follow the unstable states as well. A simple time translation of the learning window function shifts the bifurcation point of structure formation and goes along with traveling waves in the map, without changing the animal's sound localization performance.
Coarse Analysis of Microscopic Models using Equation-Free Methods

Mathematical models of real-world problems from physics, biology and chemistry have become very complex over the last three decades. Although increasing computational power allows to solve even larger systems of differential equations, the number of differential equations is still a main limiting factor for the complexity of models, e.g., in real-time applications. With the increasing amount of data generated by computer simulations a challenge is to extract valuable information from the models in order to help scientists and managers in a decision-making process. Although the dynamics of these models might be high-dimensional, the properties of interest are usually macroscopic and low-dimensional in nature. Examples are numerous and not necessarily restricted to computer models. For instance, the power output, energy consumption and temperature of engines are interesting quantities for engineers, although the models they base their design on are described for the gas mixture (a system with many degrees-of-freedom) inside a combustion engine. Since good models are often not available on the macroscopic scale the necessary information has to be extracted from the microscopic, high-dimensional models.

The goal of this thesis is to investigate such high-dimensional multiscale models and extract relevant low-dimensional information from them. Recently developed mathematical tools allow to reach this goal: a combination of so-called equation-free methods with numerical bifurcation analysis is used and further developed to gain insight into high-dimensional systems on a macroscopic level of interest. Based on a switching-procedure between a detailed microscopic and a coarse macroscopic level during simulations it is possible to obtain a closure-on-demand for the macroscopic dynamics by only using short simulation bursts of computationally-expensive complex models. Those information is subsequently used to construct bifurcation diagrams that show the parameter dependence of solutions of the system.

The methods developed for this thesis have been applied to a wide range of relevant problems. Applications include the learning behavior in the barn owl's auditory system, traffic jam formation in an optimal velocity model for circular car traffic and oscillating behavior of pedestrian groups in a counter-flow through a corridor with narrow door. The methods do not only quantify interesting properties in these models (learning outcome, traffic jam density, oscillation period), but also allow to investigate unstable solutions, which are important information to determine basins of attraction of stable solutions and thereby reveal information on the long-term behavior of an initial state.

Coarse-grained particle model for pedestrian flow using diffusion maps

Interacting particle systems constitute the dynamic model of choice in a variety of application areas. A prominent example is pedestrian dynamics, where good design of escape routes for large buildings and public areas can improve evacuation in emergency situations, avoiding exit blocking and the ensuing panic. Here we employ diffusion maps to study the coarse-grained dynamics of two pedestrian crowds trying to pass through a door from opposite sides. These macroscopic variables and the associated smooth embeddings lead to a better description and a clearer understanding of the nature of the transition to oscillatory dynamics. We also compare the results to those obtained through intuitively chosen macroscopic variables.
CONTINEX: A Toolbox for Continuation in Experiments
CONTINEX is a MATLAB toolbox for bifurcation analysis based on the development platform COCO (computational continuation core). CONTINEX is specifically designed for coupling to experimental test specimen via DSPACE, but provides also interfaces to SIMULINK-, ODE-, and so-called equation-free models. The current version of the interface for experimental set-ups implements an algorithm for tuning control parameters, a robust noise-tolerant covering algorithm, and functions for monitoring (in)stability. In this talk we will report on experiments with an impact oscillator with magnetic actuators and algorithmic challenges we were facing during toolbox development.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Department of Mechanical Engineering, Solid Mechanics
Authors: Schilder, F. (Intern), Bureau, E. (Intern), Santos, I. (Intern), Thomsen, J. J. (Intern), Starke, J. (Intern)
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Equation-Free Analysis of Macroscopic Behavior in Traffic and Pedestrian Flow
Equation-free methods make possible an analysis of the evolution of a few coarse-grained or macroscopic quantities for a detailed and realistic model with a large number of fine-grained or microscopic variables, even though no equations are explicitly given on the macroscopic level. This will facilitate a study of how the model behavior depends on parameter values including an understanding of transitions between different types of qualitative behavior. These methods are introduced and explained for traffic jam formation and emergence of oscillatory pedestrian counter flow in a corridor with a narrow door.

General information
State: Published
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Main Research Area: Technical/natural sciences
Experimental bifurcation analysis of an impact oscillator – Determining stability

We propose and investigate three different methods for assessing stability of dynamical equilibrium states during experimental bifurcation analysis, using a control-based continuation method. The idea is to modify or turn off the control at an equilibrium state and study the resulting behavior. As a proof of concept the three methods are successfully implemented and tested for a harmonically forced impact oscillator with a hardening spring nonlinearity, and controlled by electromagnetic actuators. We show that under certain conditions it is possible to quantify the instability in terms of finite-time Lyapunov exponents. As a special case we study an isolated branch in the bifurcation diagram brought into existence by a 1:3 subharmonic resonance. On this isola it is only possible to determine stability using one of the three methods, which is due to the fact that only this method guarantees that the equilibrium state can be restored after measuring stability.

General information
State: Published
Organisations: Department of Mechanical Engineering, Department of Applied Mathematics and Computer Science, Dynamical Systems, Mathematics, Solid Mechanics
Authors: Bureau, E. (Intern), Schilder, F. (Intern), Elmegård, M. (Intern), Santos, I. (Intern), Thomsen, J. J. (Intern), Starke, J. (Intern)
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Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.391 SNIP 2.64 CiteScore 2.61
ISI indexed (2013): ISI indexed yes
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BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.495 SNIP 2.992 CiteScore 2.3
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.441 SNIP 2.698 CiteScore 2.05
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
Experimental Bifurcation Analysis Using Control-Based Continuation

The focus of this thesis is developing and implementing techniques for performing experimental bifurcation analysis on nonlinear mechanical systems. The research centers around the newly developed control-based continuation method, which allows to systematically track branches of stable and unstable equilibria under variation of parameters. As a test case we demonstrate that it is possible to track the complete frequency response, including the unstable branches, for a harmonically forced impact oscillator with hardening spring nonlinearity, controlled by electromagnetic actuators. The method requires the constitution of a non-invasive and locally stabilizing control scheme, which must be tuned without a-priori study of a model. We propose a sequence of experiments that allows to choose optimal control-gains, filter parameters and settings for a continuation method. This experimental tuning procedure is applied to our test rig, resulting in a reliable non-invasive, locally stabilizing control. The use of stabilizing control makes it difficult to determine the stability of the underlying uncontrolled equilibrium. Based on the idea of momentarily modifying or disabling the control and study the resulting behavior, we propose and test three different methods for assessing stability of equilibrium states during experimental continuation. We show that it is possible to determine the stability without allowing unbounded divergence, and that it is under certain circumstances possible to quantify instability in terms of finite-time Lyapunov exponents. A software toolbox for the Matlab continuation platform COCO has been developed and will be made freely available. This toolbox implements functions necessary for interfacing a numerical continuation code with a real experiment, as well as provide means for simulating control-based continuation experiments. Finally, the feasibility of implementing the method for rotating machinery is discussed.

General information
State: Published
Organisations: Department of Mechanical Engineering, Solid Mechanics, Department of Applied Mathematics and Computer Science, Dynamical Systems
Authors: Bureau, E. (Intern), Santos, I. (Intern), Thomsen, J. J. (Intern), Starke, J. (Intern)
Number of pages: 145
Publication date: 2014
Experiments in nonlinear dynamics using control-based continuation: Tracking stable and unstable response curves

We show how to implement control-based continuation in a nonlinear experiment using existing and freely available software. We demonstrate that it is possible to track the complete frequency response, including the unstable branches, for a harmonically forced impact oscillator.

Implicit methods for equation-free analysis: convergence results and analysis of emergent waves in microscopic traffic models

We introduce a general formulation for an implicit equation-free method in the setting of slow-fast systems. First, we give a rigorous convergence result for equation-free analysis showing that the implicitly defined coarse-level time stepper converges to the true dynamics on the slow manifold within an error that is exponentially small with respect to the small parameter measuring time scale separation. Second, we apply this result to the idealized traffic modeling problem of phantom jams generated by cars with uniform behavior on a circular road. The traffic jams are waves that travel slowly against the direction of traffic. Equation-free analysis enables us to investigate the behavior of the microscopic traffic model on a macroscopic level. The standard deviation of cars' headways is chosen as the macroscopic measure of the underlying dynamics such that traveling wave solutions correspond to equilibria on the macroscopic level in the equation-free setup. The collapse of the traffic jam to the free flow then corresponds to a saddle-node bifurcation of this macroscopic equilibrium. We continue this bifurcation in two parameters using equation-free analysis.
Mathematical Modeling and Dimension Reduction in Dynamical Systems

Processes that change in time are in mathematics typically described by differential equations. These may be applied to model everything from weather forecasting, brain patterns, reaction kinetics, water waves, finance, social dynamics, structural dynamics and electrodynamics to name only a few. These systems are generically nonlinear and the studies of them often become enormously complex. The framework in which such systems are best understood is via the theory of dynamical systems, where the critical behavior is systematically analyzed by performing bifurcation theory. In that context the current thesis is attacking two problems.

The first is concerned with the mathematical modelling and analysis of an experiment of a vibro-impacting beam. This type of dynamical system has received much attention in the recent years and they occur frequently in mechanical applications, where they induce noise and wear which decrease the life time of machines. From the modelling point of view these systems are often particularly rich in nonlinear dynamics. In the present study a mathematical model is derived. Amongst other outcomes the model was successfully applied to predict a nonlinear phenomenon, namely the existence of isolas of subharmonic orbits. These were then verified in the practical experiment in the lab. The second problem that is addressed in the current thesis is a problem that has developed as a consequence of the increasing power of computers which has created the demand for analysis of ever more advanced and complex systems. These complex systems are computationally very demanding and proper analysis of the qualitative behavior of the systems becomes difficult. In general it is not possible to construct bifurcation diagrams for these so-called high-dimensional models efficiently. In order
to overcome this obstacle much research is going into the direction of development of robust methods to perform
dimension and model reduction such as to pave the way for a qualitative analysis of the high dimensional problems by
analyzing the low-dimensional models.

In this thesis we demonstrate how to reduce the dimension of a certain class of dynamical systems by construction of k-
dimensional submanifolds using the so-called graph transform. The method is suitable for a specific class of problems with
spectral gaps, these are often observed. In particular the method is applied to a mechanical system. Furthermore the
method has some unique and promising properties compared to other methods.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Scientific Computing
Authors: Elmegård, M. (Intern), Starke, J. (Intern), Evgrafov, A. (Intern), Thomsen, J. J. (Intern)
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Multijam Solutions in Traffic Models with Velocity-Dependent Driver Strategies
The optimal-velocity follow-the-leader model is augmented with an equation that allows each driver to adjust their target
headway according to the velocity difference between the driver and the car in front. In this more detailed model, which is
investigated on a ring, stable and unstable multipulse or multijam solutions emerge. Analytical investigations using
truncated Fourier analysis are confirmed and complemented by a detailed numerical bifurcation analysis. In addition to
standard rotating waves, time-modulated waves are found.

General information
State: Published
Organisations: Department of Physics, Department of Applied Mathematics and Computer Science, Dynamical Systems,
Brown University, University of the Basque Country, Bogolyubov Institute for Theoretical Physics
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): SJR 1.046 SNIP 1.311 CiteScore 1.76
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.945 SNIP 1.222 CiteScore 1.63
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.09 SNIP 1.271 CiteScore 1.58
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Nonlinear Effects in Examples of Crowd Evacuation Scenarios

Severe accidents with many fatalities have occurred when too many pedestrians had to maneuver in too tight surroundings, as during evacuations of mass events. This demonstrates the importance of a better general understanding of pedestrians and emergent complex behavior in crowds. To this end, we develop both a new microscopic agent-based pedestrian model and also study simplified evacuation scenarios which permit the isolation of relevant nonlinear effects and their systematic investigation. We concentrate on two effects: First, the influence of the position and size of an obstacle in front of an emergency exit on the flux through the exit, and second, the influence of other pedestrians on the route choice of an individual. The first investigation demonstrates the possibility of improving substantially the flow through an exit by placing an obstacle in a suitable way in front of it. The latter shows clearly bistable states and hysteresis effects, indicating the existence of unstable pedestrian flow states in addition to the stable states. Furthermore, this set-up is an example of a radical change of the pedestrian flux by only a small change in the geometry of the evacuation scenario. The results motivate further investigation and eventually engineering use by optimizing the design of large buildings, stations, airports and stadiums for mass events.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Department of Civil Engineering, Section for Building Design, Technical University of Denmark
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Publisher: IEEE
Controlling traffic jams by time modulating the safety distance

The possibility of controlling traffic dynamics by applying high-frequency time modulation of traffic flow parameters is studied. It is shown that the region of the car density where the uniform (free) flow is unstable changes in the presence of time modulation compared with the unmodulated case. This region shrinks when the speed-up of cars does not exceed some critical value and expands in the opposite case. The flux of the time-modulated flow is an increasing function of the amplitude of the modulation for traffic flows whose density is larger than 1/h where h is the safety distance in the nonmodulated case, while it is a decreasing function in the opposite case. In other words, the safety distance time modulation facilitates car propagation in the case when the mean distance between cars in the congestive traffic is less than h and hinders it when the neighboring cars in the flow are well separated. A link between a microscopic description and the macroscopic fundamental diagram is established.
Several dynamical system approaches to combinatorial optimization problems are described and compared. These include dynamical systems derived from penalty methods; the approach of Hopfield and Tank; self-organizing maps, that is, Kohonen networks; coupled selection equations; and hybrid methods. Many of them are investigated analytically, and the costs of the solutions are compared numerically with those of solutions obtained by simulated annealing and the costs of a global optimal solution.

Using dynamical systems, a solution to the combinatorial optimization problem emerges in the limit of large times as an asymptotically stable point of the dynamics. The obtained solutions are often not globally optimal but good approximations of it. Dynamical system and neural network approaches are appropriate methods for distributed and parallel processing. Because of the parallelization, these techniques are able to compute a given task much faster than algorithms which are using a traditional sequentially working digital computer.

This chapter focuses on dynamical system approaches to the linear two-index assignment problem and the NP-hard three-index assignment problem. These and extensions thereof
can be used as models for many industrial problems like manufacturing planning and optimization of flexible manufacturing systems. This is illustrated for an example in distributed robotic systems.

Experimental bifurcation analysis of an impact oscillator - Tuning a non-invasive control scheme

We investigate a non-invasive, locally stabilizing control scheme necessary for an experimental bifurcation analysis. Our test-rig comprises a harmonically forced impact oscillator with hardening spring nonlinearity controlled by electromagnetic actuators, and serves as a prototype for electromagnetic bearings and other machinery with build-in actuators. We propose a sequence of experiments that allows one to choose optimal control-gains, filter parameters and settings for a continuation method without a priori study of a model. Depending on the algorithm for estimating the Jacobian required by Newton's method we find two almost disjoint sets of suitable control parameters. Control-based continuation succeeds reliably in producing the full bifurcation diagram including both stable and unstable equilibrium states for an appropriately tuned controller.
Stochastic control of traffic patterns

A stochastic modulation of the safety distance can reduce traffic jams. It is found that the effect of random modulation on congestive flow formation depends on the spatial correlation of the noise. Jam creation is suppressed for highly correlated noise. The results demonstrate the advantage of heterogeneous performance of the drivers in time as well as individually. This opens the possibility for the construction of technical tools to control traffic jam formation.

General information

State: Published
Organisations: Department of Applied Mathematics and Computer Science, Department of Physics, Dynamical Systems, Bogolyubov Institute for Theoretical Physics, University of the Basque Country, AKAD University of Applied Sciences, Toyota Central R&D Labs
Authors: Gaididei, Y. B. (Ekstern), Gorria, C. (Ekstern), Berkemer, R. (Ekstern), Christiansen, P. L. (Intern), Kawamoto, A. (Ekstern), Sørensen, M. P. (Intern), Starke, J. (Intern)
Equation-free detection and continuation of a Hopf bifurcation point in a particle model of pedestrian flow

Using an equation-free analysis approach we identify a Hopf bifurcation point and perform a two-parameter continuation of the Hopf point for the macroscopic dynamical behavior of an interacting particle model. Due to the nature of systems with a moderate number of particles and noise, the quality of the available numerical information requires the use of very robust numerical algorithms for each of the building blocks of the equation-free methodology. As an example, we consider a particle model of a crowd of pedestrians where particles interact through pairwise social forces. The pedestrians move along a corridor where they are constrained by the walls of the corridor, and two crowds are aiming, from opposite directions, to pass through a narrowing doorway perpendicular to the corridor. We focus our investigation on the collective behavior of the model. As the width of the doorway is increased, we observe an onset of oscillations of the net pedestrian flux through the doorway, described by a Hopf bifurcation. An equation-free continuation of the Hopf point in the two parameters, door width and ratio of the pedestrian velocities of the two crowds, is performed. © 2012 Society for Industrial and Applied Mathematics.
Experimental Bifurcation Analysis By Control-based Continuation - Determining Stability

The newly developed control-based continuation technique has made it possible to perform experimental bifurcation analysis, e.g. to track stable as well as unstable branches of frequency responses directly in experiments. The method bypasses mathematical models, and systematically explores how vibration characteristics of dynamical systems change under variation of parameters. The method employs a control scheme to modify the response stability. While this facilitates exploration of the unstable branches of a bifurcation diagram, it unfortunately makes it impossible to distinguish previously stable and unstable equilibrium states. We present the ongoing work of developing and applying the control-based continuation method to an experimental mechanical test-rig, consisting of a harmonically forced nonlinear impact oscillator controlled by electromagnetic actuators. Furthermore we propose and test ideas on how to determine the stability of equilibria states during continuation.

General information
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Organisations: Department of Mechanical Engineering, Solid Mechanics, Department of Mathematics, Dynamical systems
Authors: Bureau, E. (Intern), Santos, I. (Intern), Thomsen, J. J. (Intern), Schilder, F. (Intern), Starke, J. (Intern)
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Source: dtu
Source-ID: u::4360
Publication: Research - peer-review › Article in proceedings – Annual report year: 2012

Complex spatiotemporal behavior in a chain of one-way nonlinearly coupled elements

The dynamics of asymmetrically coupled nonlinear elements is considered. It is shown that there are two distinctive regimes of oscillatory behavior of one-way nonlinearly coupled elements depending on the relaxation time and the strength of the coupling. In the subcritical regime when the relaxation time is shorter than a critical one a spatially uniform stationary state is stable. In the supercritical regime due to a Hopf bifurcation traveling waves spontaneously create and propagate along the system. Our analytical approach is in good agreement with numerical simulations of the fully nonlinear model.

General information
State: Published
Organisations: Department of Mathematics, Department of Physics
Authors: Gaididei, Y. B. (Intern), Berkemer, R. (Intern), Gorria, C. (Ekstern), Christiansen, P. L. (Intern), Kawamoto, A. (Ekstern), Shiga, T. (Ekstern), Sørensen, M. P. (Intern), Starke, J. (Intern)
Pages: 1167-1179
Publication date: 2011
Main Research Area: Technical/natural sciences

Publication information
Journal: Discrete and Continuous Dynamical Systems. Series S
Volume: 4
Issue number: 5
ISSN (Print): 1937-1632
Ratings:
Web of Science (2017): Indexed Yes
Scopus rating (2016): SJR 0.67 SNIP 0.617 CiteScore 0.62
Scopus rating (2015): SJR 0.674 SNIP 0.628 CiteScore 0.55
Scopus rating (2014): SJR 0.511 SNIP 0.546 CiteScore 0.52
Scopus rating (2013): SJR 0.615 SNIP 0.923 CiteScore 0.62
ISI indexed (2013): ISI indexed no
Scopus rating (2012): SJR 1.092 SNIP 0.757 CiteScore 0.79
ISI indexed (2012): ISI indexed no
Experimental bifurcation analysis for a driven nonlinear flexible pendulum using control-based continuation

We present a software toolbox that allows to apply continuation methods directly to a controlled lab experiment. This toolbox enables us to systematically explore how stable and unstable steady state periodic vibrations depend on parameters. The toolbox is implemented partly in MATLAB and partly on a dSPACE realtime controller board. Its functionality is tested on a driven mechanical oscillator with a strong impact nonlinearity, controlled with electromagnetic actuators. We show how to tune a controller so that the steady state dynamics of the controlled experiment matches that of the corresponding un-controlled experiment.

Experimental bifurcation by using control-based continuation

Guiding Simulations and Experiments using Continuation

When applying continuation of periodic solutions to high-dimensional finite element models one might face a dilemma. The mesh resolution and thus the dimension N of the model are typically chosen such that a given computer system can store the information necessary to perform one integration step for dimension N, but not for larger dimensions. In other words, a model is usually implemented as a carefully derived implicit integration scheme tailored for numerically stable simulations with the highest spacial resolution admitted by the computational power available. On the other hand, stable numerical methods for periodic solutions, for example, multiple shooting or collocation, typically require the simultaneous storage and manipulation of information for K>1 states, which would imply that periodic solutions cannot be computed without a significant reduction of the model's resolution. The recently developed method of control based continuation allows the
continuation of periodic solutions without a reduction of the model resolution, and even directly in physical experiments. Moreover, both a simulation as well as an experiment can run asynchronously from the actual continuation method, which communicates with the simulation or experiment by setting a control target and by taking measurements. The key ideas of this approach are (1) to introduce a control scheme that locally stabilizes periodic solutions without perturbing them, and (2) to use continuation to guide the simulation or experiment around folds and through bifurcation points. In this talk we will present a Matlab toolbox for control based continuation and illustrate its application with a lab experiment of an impact oscillator that exhibits a large hysteresis loop. We will indicate current challenges with this method and how we intend to tackle them.

**General information**

State: Published
Organisations: Solid Mechanics, Department of Mechanical Engineering, Dynamical systems, Department of Mathematics, IPVS Stuttgart
Authors: Bureau, E. (Intern), Schilder, F. (Intern), Avrutin, V. (Ekstern), Starke, J. (Intern), Santos, I. (Intern), Thomsen, J. J. (Intern)
Publication date: 2011

**Publication information**

Original language: English
Main Research Area: Technical/natural sciences
Electronic versions: prod1132491346398.talk[1].pdf
Source: orbit
Source-ID: 316744
Publication: Research › Sound/Visual production (digital) – Annual report year: 2011

**Low-dimensional approximations for Finite Element Models of mechanical systems**

The present study is dedicated to the dimension reduction of high-dimensional FE models of mechanical systems in which low-dimensional behaviour is observable. A low-dimensional model of the such a FE model is constructed and the bifurcation diagram of the low-dimensional system is compared with that of the FE model in order to investigate the range of validity of the low-dimensional model.

**General information**

State: Published
Organisations: Dynamical systems, Department of Mathematics, Solid Mechanics, Department of Mechanical Engineering, Technical University of Denmark
Authors: Elmegaard, M. (Ekstern), Starke, J. (Intern), Schilder, F. (Intern), Thomsen, J. J. (Intern)
Publication date: 2011

**Host publication information**

Title of host publication: 7th European Nonlinear Dynamics Conference
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 314408
Publication: Research - peer-review › Article in proceedings – Annual report year: 2011

**Self-organized control in cooperative robots using a pattern formation principle**

Self-organized modular approaches proved in nature to be robust and optimal and are a promising strategy to control future concepts of flexible and modular manufacturing processes. We show how this can be applied to a model of flexible manufacturing based on time-dependent robot-target assignment problems where robot teams have to serve manufacturing targets such that an objective function is optimized. Feasibility of the self-organized solutions can be guaranteed even for unpredictable situations like sudden changes in the demands or breakdowns of robots. As example an uncrowed space mission is visualized in a simulation where robots build a space station.

**General information**

State: Published
Organisations: Dynamical systems, Department of Mathematics, Nagoya University, University of Heidelberg
Authors: Starke, J. (Intern), Elsässer, C. (Ekstern), Fukuda, T. (Ekstern)
Pages: 2094-2098
Publication date: 2011
Main Research Area: Technical/natural sciences
Continuation Guided Experiments

General information
State: Published
Organisations: Dynamical systems, Department of Mathematics, Solid Mechanics, Department of Mechanical Engineering, University of Illinois at Urbana-Champaign, University of Portsmouth
Authors: Schilder, F. (Intern), Bureau, E. (Intern), Starke, J. (Intern), Dankowicz, H. (Ekstern), Sieber, J. (Ekstern)
Publication date: 2010

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 271381
Publication: Research › Sound/Visual production (digital) – Annual report year: 2010

Coupling Analysis of Dynamics and Oil Film Lubrication on a Rotor - Floating Bush Bearing System

General information
State: Published
Organisations: Department of Mathematics, Toyota CRDL, University of Heidelberg
Authors: Inagaki, M. (Ekstern), Kawamoto, A. (Ekstern), Abebura, T. (Ekstern), Suzuki, A. (Ekstern), Ruebel, J. (Ekstern), Starke, J. (Intern)
Publication date: 2010

Host publication information
Title of host publication: ACMD 2010
Place of publication: Kyoto, Japan
Main Research Area: Technical/natural sciences
Conference: Asian Conference on Multibody Dynamics, 01/01/2010
Source: orbit
Source-ID: 272698
Publication: Research - peer-review › Article in proceedings – Annual report year: 2010

Deterministic and stochastic modelling of catalytic surface processes

General information
State: Published
Organisations: Department of Mathematics
Authors: Starke, J. (Intern)
Publication date: 2010
Event: Abstract from Ertl Symposium, Gwangju, South Korea
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 272708
Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2010

INTERACTING MANY-PARTICLE SYSTEMS OF DIFFERENT PARTICLE TYPES CONVERGE TO A SORTED STATE

We consider a model class of interacting many-particle systems consisting of different types of particles defined by a gradient flow. The corresponding potential expresses attractive and repulsive interactions between particles of the same type and different types, respectively. The introduced system converges by self-organized pattern formation to a sorted state where particles of the same type share a common position and those of different types are separated from each other. This is proved in the sense that we show that the property of being sorted is asymptotically stable and all other states are unstable. The models are motivated from physics, chemistry, and biology, and the principal investigations can be useful for many systems with interacting particles or agents. The models match particularly well a system in
neuroscience, namely the axonal pathfinding and sorting in the olfactory system of vertebrates.

**General information**
State: Published
Organisations: Department of Mathematics, Dynamical systems
Authors: Kokkendorff, S. L. (Intern), Starke, J. (Intern), Hummel, N. (Ekstern)
Pages: 2534-2555
Publication date: 2010
Main Research Area: Technical/natural sciences

**Publication information**
Journal: S I A M Journal on Applied Mathematics
Volume: 70
Issue number: 7
ISSN (Print): 0036-1399
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): SJR 1.046 SNIP 1.311 CiteScore 1.76
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.945 SNIP 1.222 CiteScore 1.63
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.09 SNIP 1.271 CiteScore 1.58
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 0.972 SNIP 1.151 CiteScore 1.61
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.028 SNIP 1.251 CiteScore 1.69
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 0.798 SNIP 1.193 CiteScore 1.49
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 0.8 SNIP 1.078
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.191 SNIP 1.539
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.101 SNIP 1.215
Scopus rating (2007): SJR 0.975 SNIP 1.262
Scopus rating (2006): SJR 0.908 SNIP 1.41
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.911 SNIP 1.386
Scopus rating (2004): SJR 0.909 SNIP 1.525
Scopus rating (2003): SJR 1.214 SNIP 1.604
Scopus rating (2002): SJR 1.156 SNIP 1.337
Scopus rating (2001): SJR 1.317 SNIP 1.533
Scopus rating (2000): SJR 1.364 SNIP 1.43
Scopus rating (1999): SJR 0.622 SNIP 1.401
Original language: English
neuroscience, self-organization, gradient flows, stability, pattern formation, many-particle systems, olfactory system

**DOIs:**
10.1137/070700693

**Source:** orbit
Analytical solutions of jam pattern formation on a ring for a class of optimal velocity traffic models

A follow-the-leader model of traffic flow on a closed loop is considered in the framework of the extended optimal velocity (OV) model where the driver reacts to both the following and the preceding car. Periodic wave train solutions that describe the formation of traffic congestion patterns are found analytically. Their velocity and amplitude are determined from a perturbation approach based on collective coordinates with the discrete modified Korteweg-de Vries equation as the zero order equation. This contains the standard OV model as a special case. The analytical results are in excellent agreement with numerical solutions.

General information
State: Published
Organisations: Department of Mathematics, Dynamical systems
Authors: Gaididei, Y. B. (Intern), Berkemer, R. (Intern), Caputo, J. G. (Intern), Christiansen, P. L. (Ekstern), Kawamoto, A. (Intern), Shiga, T. (Ekstern), Sørensen, M. P. (Intern), Starke, J. (Intern)
Pages: 073012
Publication date: 2009
Main Research Area: Technical/natural sciences

Publication information
Journal: New Journal of Physics
Volume: 11
ISSN (Print): 1367-2630
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.97 SJR 1.788 SNIP 1.031
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.938 SNIP 1.047 CiteScore 2.8
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.806 SNIP 1.307 CiteScore 2.89
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.871 SNIP 1.372 CiteScore 2.77
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 3.352 SNIP 1.533 CiteScore 3.4
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 3.47 SNIP 1.634 CiteScore 3.99
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 3.395 SNIP 1.421
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 3.215 SNIP 1.503
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 2.913 SNIP 1.396
Equation-free continuation of maximal vibration amplitudes in a nonlinear rotor-bearing model of a turbocharger

General information
State: Published
Organisations: Department of Mathematics, Dynamical systems
Authors: Elmegård, M. (Intern), Ruebel, J. (Ekstern), Inagaki, M. (Ekstern), Kawamoto, A. (Ekstern), Starke, J. (Intern)
Number of pages: 10
Publication date: 2009

Efficient computation of quasiperiodic oscillations in nonlinear systems with fast rotating parts

We present a numerical method for the investigation of quasiperiodic oscillations in applications modeled by systems of ordinary differential equations. We focus on systems with parts that have a significant rotational speed. An important element of our approach is that it allows us to verify whether one can neglect gravitational forces after a change of coordinates into a co-rotating frame. Specifically, we show that this leads to a dramatic reduction of computational effort.

As a practical example we study a turbocharger model for which we give a thorough comparison of results for a model with and without the inclusion of gravitational forces.

General information
State: Published
Organisations: Dynamical systems, Department of Mathematics, University of Bristol, University of Heidelberg, Toyota Central Research and Development Laboratories, Inc., Nagakute Aichi
Authors: Schilder, F. (Ekstern), Rübel, J. (Ekstern), Starke, J. (Intern), Osinga, H. (Ekstern), Krauskopf, B. (Ekstern), Inagaki, M. (Ekstern)
Processing of Sensory Information in the Olfactory System: Minisymposium

The olfactory system is an attractive model system due to the easy control of sensory input and the experimental accessibility in animal studies. The odorant signals are processed from receptor neurons to a neural network of mitral and granular cells while various types of nonlinear behaviour can be observed. These are oscillations and fast adaptation, axonal pathfinding and sorting, as well as spatiotemporal pattern formation including contrast enhancement and travelling waves. A combination of different mathematical approaches like qualitative methods, bifurcation analysis, data analysis and equation-free techniques allow for a better reproduction and understanding of recent experimental findings. Talks:

Olfaction as a Model System for Sensory-Processing Neural Networks (Jens Midtgaard, University of Copenhagen, Denmark) Nonlinear Effects of Signal Transduction in Olfactory Sensory Neurons (Peter Borowski, University of British Columbia, Canada; Juergen Reidl, University of Heidelberg, Germany; Jens Starke, Technical University of Denmark, Denmark; Martin Zapotocky, Max Planck Institute for Physics of Complex Systems, Germany; Markus Eiswirth, Fritz-Haber Institut, Germany; Anke Sensse, Bayer Technology Services) Axonal Pathfinding and Sorting in the Olfactory System (Noemi Hummel, ETH Zuerich, Switzerland; Simon Kokkendorff and Jens Starke, Technical University of Denmark, Denmark) Analysis of Macroscopic Network Activities (Jens Starke, Technical University of Denmark, Denmark; Carmen Ellsaeesser, University of Heidelberg, Germany)

General information
State: Published
Organisations: Dynamical systems, Department of Mathematics, University of Copenhagen
Authors: Starke, J. (Intern), Midtgaard, J. (Ekstern)
Publication date: 2008

Emergence of robust solutions to 0-1 optimization problems in multi-agent systems

Nature shows us in our daily life how robust, flexible and optimal self-organized modular constructions work in complex physical, chemical and biological systems, which successfully adapt to new and unexpected situations. A promising strategy is therefore to use such self-organization and pattern formation principles in engineering by designing multi-agent systems with appropriate interactions. By extracting selection processes as one of the main principles of pattern formation, we bridge the gap between detailed knowledge of self-organization in complex systems in natural science and its constructive application in engineering. The approach is demonstrated by giving two examples: First, time-dependent robot-target assignment problems with several autonomous robots and several targets are considered as model of flexible manufacturing systems. Each manufacturing target has to be served in a given time interval by one and only one robot and the total working costs have to be minimized (or total profits maximized). A specifically constructed dynamical system approach (coupled selection equations) is used which is based on pattern formation principles and results in fault resistant and robust behaviour. An important feature is that this type of control also guarantees feasibility of the assignment solutions. In previous work on adapting pattern formation principles to these problems either no feasibility is guaranteed or only unrealistic toy problems like one-step problems, i.e. no sequences of tasks, are treated. These limitations are overcome in the present work where sequential manufacturing tasks in logical order are fully considered with guaranteed feasibility of the assignment solutions. The performance of the suggested control is demonstrated and visualized with a computer simulation of autonomous space robots building a space station by a distributed transportation of several parts from a space shuttle to defined positions at the space station. Second, the suggested approach is used for the design and selection of traffic networks. The topology of the network is optimized with respect to an additive quantity like the length of route segments and an upper bound for the number of route segments. For this, the dynamics of the selection processes of the previous example is extended such that for each vertex several choices for the edges can be made simultaneously up to an individually given upper bound. The final network topology emerges in a robust way as asymptotically stable state of the coupled selection equations. This behaviour can be guaranteed due to the specific omega limit set of the constructed dynamics and the corresponding basins of attraction. This is in parts joint work with R. Berkemer, C. Ellsaeesser, T. Fukuda, H. Haken, P. Molnar, M. Schanz.

General information
State: Published
Organisations: Department of Mathematics
Authors: Starke, J. (Intern)
Publication date: 2007

Original language: English
Independent component analysis of high-resolution imaging data identifies distinct functional domains

In the vertebrate brain external stimuli are often represented in distinct functional domains distributed across the cortical surface. Fast imaging techniques used to measure patterns of population activity record movies with many pixels and many frames, i.e. data sets with high dimensionality. Here we demonstrate that principal component analysis (PCA) followed by spatial independent component analysis (sICA), can be exploited to reduce the dimensionality of data sets recorded in the olfactory bulb and the somatosensory cortex of mice as well as the visual cortex of monkeys, without loosing the stimulus specific responses. Different neuronal populations are separated based on their stimulus specific time courses of activation. Both, spatial and temporal response characteristics can be objectively obtained, simultaneously. In the olfactory bulb, groups of glomeruli with different response latencies can be identified. This is shown for recordings of olfactory receptor neuron input measured with a calcium sensitive axon tracer and for network dynamics measured with the voltage sensitive dye RH 1838. In the somatosensory cortex, barrels responding to the stimulation of single whiskers can be automatically detected. In the visual cortex orientation columns can be extracted. In all cases artifacts due to movement, heartbeat or respiration were separated from the functional signal by sICA and could be removed from the data set. sICA is therefore a powerful technique for data compression, unbiased analysis and dissection of imaging data of population activity, collected with high spatial and temporal resolution.

General Information
State: Published
Organisations: Dynamical systems, Department of Mathematics, University of Heidelberg, Weizmann Institute of Science, Max Planck Institute
Authors: Reidl, J. (Ekstern), Starke, J. (Intern), Omer, D. (Ekstern), Grinvald, A. (Ekstern), Spors, H. (Ekstern)
Pages: 94-108
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information
Journal: NeuroImage
Volume: 34
Issue number: 1
ISSN (Print): 1053-8119
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 6.31 SJR 3.823 SNIP 1.752
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 4.48 SNIP 1.84 CiteScore 6.71
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 4.201 SNIP 2.029 CiteScore 6.9
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 4.376 SNIP 2.026 CiteScore 7.06
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 3.922 SNIP 1.937 CiteScore 6.86
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 3.626 SNIP 1.81 CiteScore 6.31
ISI indexed (2011): ISI indexed yes
Investigation of macroscopic behavior in traffic networks

General information
State: Published
Organisations: Dynamical systems, Department of Mathematics, Toyota Central R&D Labs
Authors: Berkemer, R. (Intern), Starke, J. (Intern), Kawamoto, A. (Intern), Shiga, T. (Ekstern)
Publication date: 2007
Event: Poster session presented at European Conference on Complex Systems, Dresden, .
Main Research Area: Technical/natural sciences
coarse analysis, equation free approach, traffic models
Source: orbit
Source-ID: 193677
Publication: Research - peer-review › Journal article – Annual report year: 2007

Prospects and limitations of mathematical methods for decision making in nonlinear complex systems: Synopsis of the Workshop "Decision making and uncertainty in nonlinear complex systems" at Conference Hotel Marienlyst, Helsingør, Denmark, 21.-22.11.2006, funded by Toyota CRDL
This report discusses the art of scientific modeling in general. Different modeling approaches and their investigation are outlined. The final issue is to elaborate on the preconditions for utilizing mathematical models for decision making. We are very much indebted to the participants of the workshop Decision making and uncertainty in nonlinear complex systems for their valuable input on topics like uncertainty, nonlinearity, and complex systems in general. Scientists with different research backgrounds from various fields discussed several aspects of mathematical methods for decision making and strategic planning.

General information
Reduction of vibration level in rotordynamics by design optimization

General information
State: Published
Organisations: Dynamical systems, Department of Mathematics
Authors: Strauss, F. (Ekstern), Inagaki, M. (Ekstern), Starke, J. (Intern)
Pages: 139-149
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information
Journal: Structural and Multidisciplinary Optimization
Volume: 34
ISSN (Print): 1615-147X
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.14
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 2.42
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 2.77
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 2.86
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 2.08
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 1.85
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Web of Science (2009): Indexed yes
Stochastic Modeling and Deterministic Limit of Catalytic Surface Processes

Three levels of modeling, microscopic, mesoscopic and macroscopic are discussed for the CO oxidation on low-index platinum single crystal surfaces. The introduced models on the microscopic and mesoscopic level are stochastic while the model on the macroscopic level is deterministic. It can be derived rigorously for low-pressure conditions from the microscopic model, which is characterized as a moderately interacting many-particle system, in the limit as the particle number tends to infinity. Also the mesoscopic model is given by a many-particle system. However, the particles move on a lattice, such that in contrast to the microscopic model the spatial resolution is reduced. The derivation of deterministic limit equations is in correspondence with the successful description of experiments under low-pressure conditions by deterministic reaction-diffusion equations while for intermediate pressures phenomena of stochastic origin can be observed in experiments. The models include a new approach to the platinum phase transition, which allows for a unification of existing models for Pt(100) and Pt(110). The rich nonlinear dynamical behavior of the macroscopic reaction kinetics is investigated and shows good agreement with low pressure experiments. Furthermore, for intermediate pressures, noise-induced pattern formation, which has not been captured by earlier models, can be reproduced in stochastic simulations with the mesoscopic model.

Vom Molekül zum Verhalten: Verarbeitung und Lernen von Sinnesreizen im Geruchssystem

General information
State: Published
Organisations: Department of Mathematics, Dynamical systems
Authors: Spors, H. (Ekstern), Starke, J. (Intern)
Pages: 244-249
Publication date: 2007

Host publication information
Title of host publication: Jahrbuch der Heidelberger Akademie der Wissenschaften fuer 2006
Place of publication: Heidelberg
Publisher: Heidelberger Akademie der Wissenschaften
Fluctuation-Induced Pattern Formation in a Surface Reaction

Spontaneous nucleation, pulse formation, and propagation failure have been observed experimentally in CO oxidation on Pt(110) at intermediate pressures ($\approx 10^{-2}$mbar). This phenomenon can be reproduced with a stochastic model which includes temperature effects. Nucleation occurs randomly due to fluctuations in the reaction processes, whereas the subsequent damping out essentially follows the deterministic path. Conditions for the occurrence of stochastic effects in the pattern formation during CO oxidation on Pt are discussed.

General information
State: Published
Organisations: Dynamical systems, Department of Mathematics, University of Heidelberg, Fritz-Haber-Institut der Max-Planck-Gesellschaft
Authors: Starke, J. (Intern), Reichert, C. (Ekstern), Eiswirth, M. (Ekstern), Rotermund, H. H. (Ekstern), Ertl, G. (Ekstern)
Pages: 820-825
Publication date: 2006

Publication information
Journal: Europhysics Letters
Volume: 73
Issue number: 6
ISSN (Print): 0295-5075
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.18 SJR 0.523 SNIP 0.597
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.584 SNIP 0.628 CiteScore 1.12
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.547 SNIP 0.593 CiteScore 1.04
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 0.537 SNIP 0.54 CiteScore 1
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 0.809 SNIP 0.606 CiteScore 1.28
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.386 SNIP 0.767 CiteScore 1.86
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.782 SNIP 0.769
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.024 SNIP 0.973
BFI (2008): BFI-level 2
Model of Calcium Oscillations Due to Negative Feedback in Olfactory Cilia

We present a mathematical model for Ca oscillations in the cilia of olfactory sensory neurons. The underlying mechanism is based on direct negative regulation of cyclic nucleotide-gated channels by calcium/calmodulin and does not require any autocatalysis such as calcium-induced calcium release. The model is in quantitative agreement with available experimental data, both with respect to oscillations and to fast adaptation. We give predictions for the ranges of parameters in which oscillations should be observable. Relevance of the model to calcium oscillations in other systems is discussed.

General information

State: Published
Organisations: Dynamical systems, Department of Mathematics, University of Heidelberg, Max Planck Institute, Fritz-Haber Institute of the Max-Planck-Society
Authors: Reidl, J. (Ekstern), Borowski, P. (Ekstern), Sensse, A. (Ekstern), Starke, J. (Intern), Zapotocky, M. (Ekstern), Eiswirth, M. (Ekstern)
Pages: 1147-1155
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information

Journal: Biophysical Journal
Volume: 90
Issue number: 4
ISSN (Print): 0006-3495
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.06 SJR 1.946 SNIP 1.018
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.145 SNIP 1.173 CiteScore 3.3
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 2.203 SNIP 1.166 CiteScore 3.33
Self-organization principles result in robust control of flexible manufacturing systems

Nature shows us in our daily life how robust, flexible and optimal self-organized modular constructions work in complex physical, chemical and biological systems, which successfully adapt to new and unexpected situations. A promising strategy is therefore to use such self-organization and pattern formation principles in engineering. By extracting selection processes as one of the main principles of pattern formation, we bridge the gap between detailed knowledge of self-organization in complex systems in natural science and its application in engineering. Time-dependent robot-target assignment problems with several autonomous robots and several targets are considered as model of flexible manufacturing systems. Each manufacturing target has to be served in a given time interval by one and only one robot and the total working costs have to be minimized (or total winnings maximized). A specifically constructed dynamical system approach (coupled selection equations) is used which is based on pattern formation principles and results in fault resistant and robust behaviour. An important feature is that this type of control also guarantees feasiblitiy of the
assignment solutions. In previous work on adapting pattern formation principles to these problems either no feasibility is
guaranteed or only unrealistic toy problems like one-step problems, i.e. no sequences of tasks, are treated. These
limitations are overcome in the present work where sequential manufacturing tasks in logical order are fully considered
with guaranteed feasibility of the assignment solutions. The performance of the suggested control is demonstrated and
visualized with a computer simulation of autonomous space robots building a space station by distributed transporting
several parts from a space shuttle to defined positions at the space station. This is in parts joint work with C. Elsaesser, T.

General information
State: Published
Organisations: Department of Mathematics
Authors: Starke, J. (Intern)
Publication date: 2006

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 193676
Publication: Research › Sound/Visual production (digital) – Annual report year: 2006

Vom Molekuel zum Verhalten: Verarbeitung und Lernen von Sinnesreizen im Geruchssystem

General information
State: Published
Organisations: Dynamical systems, Department of Mathematics, Max Planck Institute
Authors: Kuner, T. (Ekstern), Schaefer, A. (Ekstern), Spors, H. (Ekstern), Starke, J. (Intern)
Pages: 238-247
Publication date: 2006

Host publication information
Title of host publication: Jahrbuch der Heidelberger Akademie der Wissenschaften fuer 2005
Publisher: Heidelberger Akademie der Wissenschaften,
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 193978
Publication: Research › Book chapter – Annual report year: 2006

Projects:

Design and Optimization of Active Feedback Control for Flexible Rotor-Blade Systems
Department of Mechanical Engineering
Period: 15/07/2014 → 30/03/2018
Number of participants: 5
Phd Student: de Souza Reboucas, Geraldo Francisco (Intern)
Supervisor: Schilder, Frank (Intern)
Starke, Jens (Intern)
Thomsen, Jon Juel (Intern)
Main Supervisor: Santos, Ilmar (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Science Without Borders, Brasi
Project: PhD

CITS - Copenhagen ITS
Vision:A Green and Smart City
Objective:Demonstrate urban wifi-localization potentials
Problems:
Traffic congestion and safety
Traffic information flow to user entities and humans
Environmental challenges caused by transportation
Lack of cooperative connection and information systems between: people, vehicles, goods, assets, infrastructure, businesses, and public sector entities
Lack of integrated smart city traffic and transport management systems, including information flows and user-platforms

Potentials:
Ubiquitous data collection in Smart City platform architecture based on a background technological infrastructure
Real-time ITS services and approaches for providing seamless connectivity, interoperability, and secure flow of information across all stakeholders
General Crowd Management - Methods, Technology (Management and flow description of humans, cars, trucks, goods, assets, etc., through smart-id tagging)
Digital infrastructure of a localization system consisting of transmitters and sensors in streetlight platforms
Performance of experimental demonstrations of techniques and systems, consisting of advanced crowd-management systems and next-generation localization technology in Smart City applications
Large-scale demonstrations connected to the street lamp project of Copenhagen and through visualization of use scenarios

National Space Institute
Geodesy
Office for Innovation & Sector Services
Department of Applied Mathematics and Computer Science
Dynamical Systems
Department of Transport
Transport policy and behaviour
Period: 01/10/2013 → 31/05/2014
Number of participants: 5
Acronym: CITS
Project participant:
Starke, Jens (Intern)
Bacher, Peder (Intern)
Nielsen, Thomas Alexander Sick (Intern)
Project Manager, organisational:
Overton Chabre Holm, David (Intern)
Project Manager, academic:
Høeg, Per (Intern)

Analysis of trait-based models in marine ecosystems
Department of Applied Mathematics and Computer Science
Period: 01/10/2012 → 22/09/2017
Number of participants: 8
Phd Student:
Heilmann, Irene Louise Torpe (Intern)
Supervisor:
Andersen, Ken Haste (Intern)
Starke, Jens (Intern)
Thygesen, Uffe Høgsbro (Intern)
Main Supervisor:
Serensen, Mads Peter (Intern)
Examiner:
Karamemadovc, Mirza (Intern)
Andreasen, Viggo (Ekstern)
Wyller, John Andreas (Ekstern)

Financing sources
Analysis of Pattern Formation on Networks
Department of Applied Mathematics and Computer Science
Period: 01/08/2011 → 21/11/2014
Number of participants: 5
Phd Student: Marschler, Christian (Intern)
Main Supervisor: Starke, Jens (Intern)
Examiner: Christiansen, Lasse Engbo (Intern)
Barkley, Dwight (Ekstern)
Sugiyama, Yuki (Ekstern)

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

Dimension reduction methods applied to mechanical systems
Department of Informatics and Mathematical Modeling
Period: 15/12/2009 → 20/03/2014
Number of participants: 7
Phd Student: Elmegård, Michael (Intern)
Supervisor: Evgrafov, Anton (Intern)
Thomsen, Jon Juel (Intern)
Main Supervisor: Starke, Jens (Intern)
Examiner: Hjorth, Poul G. (Intern)
Kerschen, Gaëtan (Ekstern)
Sieber, Jan (Ekstern)

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

Equation-Free Analysis of Mechanical Vibrations
Mechanical vibrations are the cause of substantial operational and safety related problems with many mechanical systems of major importance, in particular in transportation, energy production, and industry. This project aims towards the development of new mathematical techniques to systematically investigate the dependence of vibrations on model parameters (e.g. bearing or material coefficients). To achieve this, equation-free techniques (also called coarse analysis) will be used which allow to obtain an understanding of the dynamic behaviour on a macroscopic scale by disregarding large amounts of unimportant information on the microscopic scale. The method fills the gap between time simulations of complex numerical models, such as nonlinear finite element models (FEM), and stability and bifurcation analyses with much simpler analytical models. The reason is that it enables such informative analyses directly on the complex microscopic models without the (often approximative) derivation of equations of motion on a macroscopic level. Due to the high-dimensional variable and parameter spaces and resulting computational costs, it is not possible to obtain similar information by direct simulations. The scientific goal is to clarify the potential of this approach within an important area of mechanics, rotating machinery (e.g. a turbocharger), where the detailed understanding of time dependent complex models
Mathematical methods in complex systems: International Toyota CRDL Workshop

The workshop is organized by the Technical University of Denmark (DTU) with organizers Jens Starke (DTU), Viktor Jirsa (CNRS) and Thomas Brenner (University of Marburg) in cooperation with Toyota Central R&D Labs. (TCRDL). This is the third workshop in a series. The first Toyota workshop was organized in 2006 in Denmark, the second in 2007 in Austria. The workshop concentrates on mathematics itself, neuro-science and economics. The invited talks should address these topics either directly or should discuss methods with potential applications. The workshop intends to bring together experts from theory and experiments/practice to provide in a close circle a platform for fruitful discussions and also possible cooperations. Program: Takahiro Shiga (Toyota CRDL, Japan): "Math for better Mobility", Gemma Calvert (Warwick, UK): "The application of cognitive neuroscience techniques to industry", Jonathan Rubin (Pittsburgh, USA): "Some insights into central pattern generator activity patterns", Giulio Bottazzi (Scuola Superiore Sant'Anna, Pisa, Italy): "Market Equilibria under Procedural Rationality", Hans Georg Bock (University of Heidelberg, Germany): "Efficient Methods for Parameter Estimation and Optimum Experimental Design for Dynamic Processes", James Lu (Austrian Academy of Sciences, Linz, Austria): "Inverse bifurcation analysis with sparsity-promoting regularization", Olivier Oullier (Marseille, France): "Non-equivalence between levels of description in social neuroeconomics", Yuri Gaididei (Kiev, Ukraine): "Complex spatiotemporal behavior in driven asymmetrically coupled nonlinear elements", Ioannis Kevrekidis (Princeton, USA): "Modelling firms clusters learning mechanism and transaction costs", Reinoud Bootsma (Marseille, France): "Information and dynamics in goal-directed action", Mads P. Sørensen (Technical University of Denmark): "Stochastic and coherent dynamics of single and coupled beta cells", Gustavo Deco (Barcelona, Spain): "Stochastic dynamics as a principle of perception", Edriss S. Titi (University of California, Irvine and Weizmann, USA): "Turbulence - a Paradigm of Complex System".

Mathematical modelling and analysis of marine ecological systems with stage structures and size spectrums

Department of Mathematics

Mathematical modelling and analysis of marine ecological systems with stage structures and size spectrums

Department of Mathematics

Mathematical modelling and analysis of marine ecological systems with stage structures and size spectrums
Matematicum: The mathematical inspiratorium at DTU
This project is concerned with the theme of unfolding mathematical concepts and results for students and other mathematically curious visitors to Matematicum via hands-on experiments and stories. Each story and activity is ideally centered around a well-defined mathematical crux, which is then to be uncovered, unfolded, and applied to properly understand a given, otherwise non-obvious – or maybe even mysterious – phenomenon. For example: How can two circular rotations combine to give the linear motion of a pump? What are the rotors actually doing in the Enigma encryption machine? Why and how does a (good) boomerang return? How do we make a swarm of intercommunicating robots collaborate to solve a given task? How do the ants find or construct their shortest pathways? Which roofs pick up the most solar energy throughout the year? Concerning content and development of concept (as of December 2007): The Matematicum at the Department of Mathematics is a room which has now been arranged to receive up to 15 visitors at a time. A boomerang ‘story’ and a robot swarming ‘story’ have been implemented and tested. A 3D printer and 3D scanner have been installed. The printer is in full operation and supplies concrete models of geometric shape and function such as minimal surfaces and ingenious pumps. A fume cupboard is being installed for proper and safe post-processing of the 3D-printed objects. An original three-rotor German military Enigma machine has been purchased. We expect it to become the essential central ‘object’ for great ‘stories’ and activities in the Matematicum concerning the history and development of modern cryptology. Matematicum was officially opened at a reception at DTU Mathematics on March 6th 2008.

Geometry
Department of Mathematics
Period: 01/07/2007 → 01/12/2009
Number of participants: 5
Mathematical Inspiratorium
Project ID: 10109
Project participant:
Henriksen, Christian (Intern)
Schmidt, Karsten (Intern)
Knudsen, Lars Ramkilde (Intern)
Starke, Jens (Intern)
Project Manager, organisational:
Markvorsen, Steen (Intern)

Financing sources
Source: Forskningsrådene - SNF
Name of research programme: Forskningsrådene - STVF
Amount: 282,000.00 Danish Kroner
Source: Forsk. Private danske - Fonde
Name of research programme: Forsk. Private danske - Fonde
Amount: 100,000.00 Danish Kroner
Source: Udenfor rammen
Name of research programme: Ukendt
Amount: 500,000.00 Danish Kroner
Source: Uddannelse. Statslige. Andre statslige
Name of research programme: Uddannelse. Statslige. Andre statslige
Amount: 48,000.00 Danish Kroner

High Precision Characterization of Active Oil Film Forces
Department of Mechanical Engineering
Decision Making and Uncertainty in Nonlinear Complex Systems: International Workshop in Helsingør, Denmark

The workshop intends to promote the development and application of new methods for decision making and strategic planning in particular with respect to Uncertainty and Nonlinear Effects in Complex Systems through the discussion of a limited number of invited scientists with different research background from various fields. The invited talks address these topics either directly or discuss methods with potential applications thereby. Program: M. Makowski (IIASA): Certain decision-making for uncertain problems T. Brenner (MPI Jena): A stochastic model of industry location - The case of the automobile industry in Germany R. E. Wilson (Bristol): Road Traffic Modelling: Nonlinear Dynamics, Data, and Future Multiscale Directions J. Casti (Santa Fe/IIASA): Would-be worlds: Toward a theory of complex systems K. Sneppen (NBI): Communication and topology in networks M. Eiswirth (FHI Berlin): Stoichiometric network analysis M. Labbe (Universite Libre de Bruxelles): Reliable communication network design: models and solution methods F. Schweitzer (ETH Zürich): The role of local effects in collective decision processes C. Siettos (National Technical University of Athens): Coarse-grained computations for agent-based market models: An equation-free approach to nonlinear analysis and control of complex systems G. Silverberg (UNU-MERIT/University of Maastricht): What a Difference a Dimension Makes: Collective Search and "Rationality" in Complex Technology Spaces

Department of Mathematics

Toyota CRDL

Analysis and Optimization of Dynamical Processes on Networks

Dynamical processes on networks are relevant in many application areas like transportation networks, communication networks, economic networks and production networks in flexible manufacturing systems. It is a common aim in all these cases to better understand and finally optimize the corresponding dynamical processes and networks. In this regard, one major interest is the investigation of macroscopic pattern formation on the network structures. Examples for such patterns are technological propagation (traveling front) in economic networks or waves of traffic jams (traveling pulses) in transportation networks.

Department of Mathematics

Toyota CRDL
Period: 01/09/2006 → 31/08/2009
Number of participants: 2
Project ID: 10088
Project participant:
Berkemer, Rainer (Intern)
Project Manager, organisational:
Starke, Jens (Intern)

Financing sources
Source: Forsk. Andre offentlige og private - Udenlandske
Name of research programme: Forsk. Andre offentlige og private - Udenlandske
Amount: 2,162,400.00 Danish Kroner
Project