Section for Dynamical Systems (DYNSYS)

Henrik Madsen, Professor, Head of section



Niels Kjølstad Poulsen, Associate professor



Lasse Engbo Christiansen, Associate professor



Jens Oliver Starke, Associate professor



Juan Miguel Morales Gonzales, Associate professor



Mads Peter Sørensen, Professor



Poul Hjorth, Associate professor



Jan Kloppenborg Møller, Assistant Professor



Number of people (31. august):

In total 32 people: 8 Faculty, 3 Adm, 2 Research Ass., 5 Post Doc, 14 PhD Stud.



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	er	- FILL	410	en	bio	- 541	The
math.& stat.modeling	1,2,3, 4,5,8	1,3,4	6–8	1,3,5	1,2,3, 5–8	6,8	2,7,8
det. dyn. system	8		6-8		3, 6,7,8	6,8	3,7,8
stoch. dyn. system	1,2,3, 4,5	1,3,4	6,8	1,3,5	1,2,3, 5,6	1,8	2
optimization	1,2, 4,5	4	6,8		8		2,8
control	1,2		2,8		1,2		2,7,8
numerical methods	1,3,4, 5,8	1,4	6,7,8	1	1,3, 6,8	6,8	2,8
multi-scale & -level	1	1,3	6-8	3	3,6,8	6,8	8

Henrik Madsen, 2) Niels Kjølstad Poulsen 3) Lasse Engbo Christiansen, 4) Juan Miguel Morales,
 Jan Kloppenborg Møller, 6) Mads Peter Sørensen, 7) Poul G. Hjorth, 8) Jens Starke

DynSys Profile – Methodological and Application axis



Henrik Madsen Professor

Methodological profile

- Time Series Analysis
- Modeling using Stochastic Differential Equations
- Non-linear and Non-stationary Dynamics Modeling
- Probabilistic Forecasting

Applications

- Energy (wind, solar, building, ..)
- Smart Cities and Smart Grids
- Pharmaceutics
- Finance
- Environmental Research
- Hydrology and Wastewater Treatment

Activities

- Currently supervisor of 8 PhD projects
- Completed 41 PhD projects
- Involved in 27 projects with external funding (including EU projects) (2008-13).
- Head of new DSF Research Centre CITIES (the largest research funding from DSF this year)
- Papers: Approx. 600 reviewed papers 1994-2013
- > Approx. 200 journal papers 1994-2013.
- Published books since 2008: (2008, 2011, 2013)
- New book contract (Statistics for Finance)
- Involved in H2020, EERA JP, IEA, Climate KIC,
- H-index 37 (GS)

Outlook

- > Methods for energy systems integration
- > Probabilistic forecasting and optimization
- Modeling using SDEs





Mads Peter Sørensen Professor mso

Methodological profile

- Nonlinear PDEs, solitons
- Nonlinear ODEs, bifurcation and chaos
- Industrial Mathematics

Applications

- Biology (blood coagulation + beta cells
- Superconductivity (wind turbines and fundamentals)
- Nonlinear optics
- Physics and nano technology
- Fluid mechanics
- Traffic

Activities

- Nanomechanical sensors and actuators, fundamentals and new directions. Partner in Villum Kann Rasmussen Centre of Excellence.
- NanoPlast, the Danish National Advanced Technology Foundation.
- Consultancy. Currently two companies
- International cooperation: Helmholtz Institute, Munich, Germany; University of Salermo, Italy; Univ. Of Kiev, Ukraine; Univ of Rouen, France; Univ of Arizona, USA; Physical Technical Institute, Tashkent, Uzbekistan; TU Lappeentanta, Finland.

Outlook

- Reaction diffusion advection problems in Bio mathematics
- Bacterial cell aggregation, traffic, electron microscopy, rogue waves
- Nonlinear coherent and stochastic phenomena in smart cities and eco-mathematics
- Nonlinear dynamics in industrial mathematics and physics





Niels Kjølstad Poulsen Associate Professor

Methodological profile

- Modeling of stochastic systems
- Control (including MPC) of systems influenced by stochastic disturbances and uncertainties
- State estimation (filtering, prediction and smoothing). Filter tuning
- Fault diagnosis (detection, isolation and estim.) and fault tolerant control
- Adaptive control
- Dynamic optimization

Applications

- Modeling / control of wind turbines
- Wind parks and energy systems
- Rigid and flexible robots. Mobile robots
- Navigation and guidance.
 Localization and mapping
- Biological systems (Diabetes control)

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Activities

- Journal papers (37), Patents application: 1, Conference papers (131), books and chapters: 6, lecture notes and thesis (10), reports (65)
- Teaching: Ph.D. (co)supervision (26+7 active). M.Sc. (co)supervision (98+3 active). Post doc projects and collaborations: 5.
- Master courses:
 - Stochastic adaptive control (02421), static and dynamics optimization (02711), stochastic simulation (02442).
- Ph.D. courses:
 - System identification, adaptive control, sensor fusion, model based predictive control, fault detection.

Outlook

- Bridging the gap between stochastic control, MPC, robust and nonlinear control
- Develop and extend collaboration within the newly established section – especially within the area of biological production (fish) and robotics





Jens Starke Associate Professor

Methodological profile

- Modeling & analysis of dynamical systems (multiscale, equation-free methods, dim. reduction, bifurcation analysis, unstable states in exper.)
- Industrial & interdisciplinary cooperations

Applications



- Biology & medicine
- Chemistry & physics ⁻⁰
- Robotics & mechanics

Publications: 64 in total (2 patens, 23 journal papers, 2 books, 11 book chapters, 20 refereed proceedings, 6 lecture notes)

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Service: Reviewer for NSF and ERC, Chair of Advisory board "Dynamics Days Europe"; Organizer of 5 international conferences and workshops

> Supervision: Currently 4 PhDs & 1 Post Doc.

Excellence, Knud Højgaards Fond, Danish Research Council; 2.5 Mio EUR funding in total

Current External funding: VKR Centre of

Research Stays: University of Tokyo, Princeton, Fritz Haber Institute of the MPG, UC Berkeley, Nagoya University, Univ. Of Heidelberg,

Outlook

Activities

- Further development in equation-free analysis & bifurcation analysis of experiments (implicit methods, consideration of noise)
- Bifurcations & spatio-temporal pattern formation under influence of noise





Poul G. Hjorth Associate Professor

Methodological profile

- Modeling with ODEs
- Geometry
- Equation-Free Analysis

Applications

- Geometrical Mechanics
- Collective phenomena in granular media, flocks and swarms
- Mathematical Biology

Outlook

- New formats for Mathematics-Industry collaboration
- New modeling, using deterministic and stochastic methods of climate, and of finance

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Activities

- Currently supervisor of 2 MSc projects
- > Completed 5 PhD projects
- Papers: Approx. 50 papers and technical reports, 1979-2013
- > Approx. 25 journal papers, 1979-2013
- Published books (2000, 2002, 2006)
- Industrial Mathematics. Initiator of, and in the last 15 years organiser of, Danish Study Groups with Industry (ESGI)
- Consultant to Industrial Study Groups in Poland, India, Hong Kong
- Editor for the Newsletter of the Danish Mathematical Society



Juan M. Morales **Associate Professor**

Methodological profile

- Uncertainty
- Hierarchical Optimization and Equilibrium Models
- Scenario Generation and **Reduction Methods**
- Uncertainty Modeling

Applications

- Integration of Renewable Energy Sources
- Power Systems Operations and Economics
- Markets, Finance, Trading
- Demand Response

Activities

- Techniques of Optimization Under > Papers: 20 peer-reviewed journal papers
 - > 21 conference contributions
 - Two books in Springer (2010, 2013)
 - Projects: Involved in Ensymora (energy systems modeling), 5s (design of future electricity markets) and iPower (valuation of flexible demand)
 - Co-supervision of 4 PhD projects, completed 1 PhD project and 5 MSc Projects
 - Sponsored by DONG Energy

Outlook

- Decision rules
- Stochastic equilibria
- Pareto efficiency in robust optimization
- Probabilistic forecasting using SDEs



Lasse Engbo Christiansen Associate Professor

Methodological profile

- Time Series Analysis
- Modeling using Stochastic Differential Equations
- Non-linear and Non-stationary Dynamics Modeling

Applications

- Diseases
- Bacteria
- Energy Systems (Buildings, ...)
- Finance
- Wastewater treatment

Activities

- Currently co-supervisor of 3 PhD projects
- > Completed 2 PhD projects
- Currently involved in 3 projects with external funding
- Program coordinator for the MSc Program in Mathematical Modeling and Computing

Outlook

- Transition from stochastic to deterministic process when the population increases
- Flexible demand as a mean to integrate more renewables



Jan Kloppenborg Møller Assistant Professor

Methodological profile

- Time Series Analysis
- Stochastic Differential Equations
- (Adaptive) Quantile Regression

Applications

- Marine ecosystems
- Wind power forecasts
- Bacteria growth
- Sewer systems

Activities

- > Papers: 7 peer review papers
- Projects: Involved in Ensymora (Energy systems) and iPower (Energy systems)
- Co-supervising 2 PhD projects

Outlook

- Spatio-temperal models for wind and solar power forecasting
- Multivariate SDEs for forecasting
- Stochastic partial differential equations







Bibliometric Data

Section name: DYNSYS - Dynamical Systems

			553 Q.1		
Faculty	8				
Post-Docs	not included				
PhDs	not included				
Name	Publications	Citations	h-index	Publications 2008-now	Citations 2008-now
Total	1937	12744		597	8033
Henrik Madsen	1165	6496	37	350	4275
Niels K. Poulsen	336	3194	20	112	1912
Mads Peter Sørensen	161	1114	22	26	339
Jan K. Møller	20	198	4	14	184
Poul G. Hjorth	101	301	9	17	132
Juan M. M. Gonzalez	26	812	11	25	802
Lasse E. Christiansen	63	238	7	36	187
Jens Starke	65	391	11	17	202

Projects (2008-13) with external funding:

DynSys – 45 (EU: 7), Stat – (41), CogSys – 30, ESE – 28, SciComp – 22, Image – 20, Mat – 10, Algolog – 7, Crypto – 9, LBT – 9, SE – 6.



Objectives (CITIES) (National Centre: Largest DSF project this year)

To establish MATHEMATICAL and ITC solutions for design and operation of Integrated Energy Systems at all scales using Complex Dynamical Models



DynSys Misc Results

Some Misc Results:

- Method for predictive control of systems with unknown and timevarying time delays (Savings in CHP systems is min. 50 Mio EUR/year in DK)
- Artificial pancreas Closed loop control of blood glucose (DIACON models).
- Wind Power Prediction Tool (One of the most widely used software worldwide for Wind Power Forecasting)
- New methods for optimal operation of wastewater runoff systems
- Method for estimation of aerodynamics derivatives. (Used eg. for stability analysis of worlds largest bridge)



- Continuous Time Stochastic Modeling (CTSM-R): Software for estimation of discretely observed stochastic differential equations
- CoCo: Library for Computational Continuation Core (Computational solutions to nonlinear mathematical equations)
- Leading expertise in modelling of the thermal dynamics of buildings and building components (IEA Annex 58 og 63)



DynSys Outlook

Methodological outlook

- Combining methods from stochastic systems with methods from numerical bifurcation analysis
- Spatio-temporal modeling
- Nonlinear and Nonstationary Dynamics Modeling
- Multivariate forecasting using SDEs
- Bridging nonlinear dynamics, stochastics and optimization (control)
 Example: Robotics and Mechanics*
- Bridging the gap between MPC, optimization, robust and nonlinear control

(a)

Response Amplitude Norm [c]

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Applications

- Rainfall run-off and flooding modeling
- Finance and Energy markets
- Smart Cities (traffic, light, sensors,.)
- Equation-free methods to obtain a better understanding of vibrations and reliable modes

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*Uncovering and tracking of unstable states in a forced impact and oscillator experiment



DynSys Outlook

Activities

- Harvest the benefit from combined mathematical and stochastic expertises on dynamics
- Synergy by focusing on ESGI and ECMI using our contacts with the industry
- Math. Colloquium, Energy Dynamics Seminar,
- Focus on external collaboration, guests, etc. (US, EU, Japan, Korea, China, Africa, ...)
- Fine-tuning of math and stat courses
- Increased collaboration with industry, etc.
- Focus on H2020, EERA, INNO+, Innovation network, Climate KIC, SPIR, ...
- International workshops at DynSys
- Smart Cities Lab (Compute is coordinating Smart Cities on DTU)





The future is now ...



Thanks for your attention!

