Program DISC-NWO-DFG Summer School on
Modeling and Control of Distributed Parameter Systems

Conferentiehotel Drienerburght, University of Twente, Enschede, The Netherlands
June 17-June 20, 2013

Monday, June 17, 2013

09.30 -	11.00	Registration and opening	
11.00 -	11.45	Birgit Jacob/Hans Zwart	Welcome and Introduction
12.00 -	12.45		
12.45 -	14.15	Lunch	
14.15 -	15.00	Georges Bastin	Stability and boundary control of hyperbolic systems, part 1
15.15 -	16.00		
16.15 -	17.00	Timo Reis	Balanced Truncation for Infinite-Dimensional Systems - Analysis and Numerics
17.15 -	18.00		
19.00		Dinner	

Tuesday, June 18, 2013

08.45 -	09.30	Laurent Lefèvre	Modelling distributed parameters systems using the port-Hamiltonian approach, part 1.
09.45 -	10.30		
11.00 -	11.45	Onno Bokhove	Hamiltonian Finite Element Methods for Hydrodynamic Waves.
12.00 -	12.45		
12.45 -	14.15	Lunch	
14.15 -	15.00	Georges Bastin	Stability and boundary control of hyperbolic systems, part 2
15.15 -	16.00		
16.15 -	17.00	Instruction by G.B.	
17.15 -	18.00		
19.00		Dinner	

Wednesday, June 19, 2013

08.45 -	09.30	Laurent Lefèvre	Modelling distributed parameters systems using the port-Hamiltonian approach, part 2
09.45 -	10.30		
11.00 -	11.45	Alessandro Macchelli	Energy-based control of distributed port-Hamiltonian systems, part 1
12.00 -	12.45		
12.45 -	14.15	Lunch	
14.15 -	15.00	Instruction by L.L.	
15.15 -	16.00		
16.15 -	17.00		Tour in the Control Engineering Lab
17.15 -	18.00		
19.00		Dinner	

Thursday, June 20, 2013

08.45 -	09.30	Alessandro Macchelli	Energy-based control of distributed port-Hamiltonian systems, part 2
09.45 -	10.30		
11.00 -	11.45	Instruction by A.M.	
12.00 -	12.45		
12.45 -	14.15	Lunch	
14.15 -	15.00	Markus Schöberl	Geometric Modelling, Analysis and Control of Infinite-Dimensional Port-Hamiltonian Systems.
15.15 -	16.00	Siep Weiland	Structure preserving discretizations of infinite dimensional port-Hamiltonian systems
16.00 -	16.15	Closing	

1 About the speakers

Georges Bastin

Laurent Lefèvre

Laurent Lefèvre got his BSc from Ecole Polytechnique de Bruxelles (ULB, 1991) and his MSc in applied mathematics from Ecole Poytechnique de Louvain (UCL, 1994), both in Belgium. Then he moved to Lille (North of France) and got his PhD in control from Ecole Centrale de Lille (USTL, 1999). In 2000, he obtained an associated professor position in the Grenoble control lab (now Gipsa Lab) and from 2005 in the Lyon lab for process and control (LAGEP). Since 2011 he got a full professor position with the Laboratoire de Conception et d'Intégration des Systèmes (at Grenoble Institute of Technology). His current domains of interest are numerical methods for control, modelling of distributed parameters systems either using the port-Hamiltonian or cellular automata / Lattice Boltzmann approaches and nonlinear control of PDEs. He is involved in various project related to applications in hydraulic and irrigation, energy management for buildings and plasma physics.

Alessandro Macchelli

Alessandro Macchelli received the M.Sc. degree (cum laude) in computer science engineering in 2000 and the Ph.D. degree in 2003, both from the University of Bologna, Bologna, Italy. In 2001, he was appointed as a Visiting Scholar and, again, in 2003, got a Postdoctorate position with the Department of Applied Mathematics, University of Twente, Enschede, the Netherlands. Since 2005, he has been a Faculty Member with the Department of Electronics, Computer Science, and Systems, University of Bologna, as an Assistant Professor. His research interests include the modelling, simulation, and control aspects of finite- and infinite-dimensional systems within the port-Hamiltonian framework. He is member of the IFAC TC 2.6 on Distributed Parameter Systems.

Timo Reis

CV:

born

1979, Trier Education and academic degrees:

10/98 - 09/02 Studies of Mathematics and Electrical Engineering, Universitt Kaiserslautern

09/02 Diploma in Mathematics ("Dipl.-Math."), Universitt Kaiserslautern

11/02 - 09/05 PhD student, scholarship of the research training group "Mathematik und Praxis", Technische Universitt Kaiserslautern

06/06 Doctoral degree ("Dr. rer. nat.") in Mathematics, Technische Universitt Kaiserslautern, supervised by Eva Zerz Positions:

10/05 - 08/08 Research assistant, Institut fr Mathematik, Technische Universität Berlin

11/06 - 08/11 Member and project head in the DFG research center Matheon, Berlin

09/08 - 05/09 Guest researcher, Department of Computational and Applied Mathematics, Rice University, Houston, Texas

06/09 - 03/10 Research assistant, Institut fr Mathematik, Technische Universitt Berlin

04/10 - 08/11 Interim professor, Institut fr Numerische Simulation, Technische Universität Hamburg-Harburg

since 09/11 Professor, Department of Mathematics, Universität Hamburg

2 Abstracts

- **Stability and boundary control of hyperbolic systems** by Georges Bastin

  Abstract: The operation of many physical networks having an engineering relevance may be represented by hyperbolic systems of balance laws in one space dimension. By using a Lyapunov stability analysis, it can be shown that the exponential stability of the equilibrium is guaranteed if the boundary conditions are dissipative. This essential property is helpful for solving the associated control problem of designing control laws at the network junctions in order to stabilize the system. The theory is illustrated with examples and practical applications to electrical networks, hydraulic networks and navigable rivers.

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- **Modelling distributed parameters systems using the port-Hamiltonian approach** by Laurent Lefèvre

  Abstract In these two lectures, the port Hamiltonian approach for the modelling of distributed parameters systems is introduced. The concerned systems are physical systems of conservation laws which may be described using classical irreversible thermodynamics. These systems range from classical academic examples - such as the transmission line, vibrating string, beam, heat conduction or diffusion equations - to more involved multiphysics examples, such as chemical reactors, plasma dynamics, nonlinear flows, etc. The lecture starts with classical examples of systems of two conservation (balance) equations. State spaces of differential forms are introduced and some basics of exterior calculus recalled. Dirac interconnection structures used in finite dimensional circuit theory are generalized to Stokes-Dirac interconnection structures for infinite-dimensional systems. Boundary port-Hamiltonian systems are then defined and illustrated with examples. Higher order interconnection structures are introduced to represent higher order distributed parameters systems such as the Timoshenko beam equation (4th order). The case of non quadratic and non separable Hamiltonian is examined with the shallow water equation example. Then we consider the case of systems with dissipation, hyperbolic and parabolic, and show how the Stokes-Dirac structures may be modified to represent both cases. Finally, we examine with some details a model for plasma dynamics in tokamaks. Balance equations are written in the electromagnetic domain and for the material domain (mass, momentum, entropy). Closure constitutive equations are obtained from the Boltzmann equation and from the kinetic theory. Finally, symplectic reduction methods to 1D and finite dimensional models are investigated.

- **Energy-based control of distributed port-Hamiltonian systems** by Alessandro Macchelli

  Abstract Once the main results dealing with the energy-based control of finite dimensional port-Hamiltonian systems have been briefly presented, their extension to the distributed parameter case is discussed. More in details, the first part of these two lectures deals with the energy-balacing passivity-based control, and the control by interconnection and energy shaping via Casimir generation of distributed port-Hamiltonian systems, with emphasis on the linear case, and on systems with one dimensional domain. Since these approaches fail when an infinite amount of energy is required at the equilibrium (dissipation obstacle), in the second part it is shown how the Dirac structure properties can be exploited in the development of energy-based control laws also in the distributed parameter scenario. More precisely, the class of stabilising controllers is enlarged if the synthesis relies on the parametrisation of the dynamics provided by the image representation of the Dirac structure, able to show the effects of the (boundary) inputs on state evolution. Some tools for proving the asymptotic stability of the closed-loop systems are also discussed. The general methodologies are illustrated with the help of simple but illustrative examples, namely the transmission line equation and the Timoshenko beam model.

- **Balanced Truncation for Infinite-Dimensional Systems - Analysis and Numerics** by Timo Reis

  Abstract Balanced truncation is one of the most popular model reduction methods for finite-dimensional input-output-systems governed by ordinary differential equations. This technique relies on the solution of the observability and controllability Gramian matrices and error bounds in the H_∞ norm. For this method, a variety of efficient numerical methods have been developed in the past couple of years.

  After giving an overview of these methods, we present theoretical for balanced truncation of infinite-dimensional linear systems such as, for instance, an error bound and the construction of the reduced order model. Thereafter we present a numerical method for balanced truncation of infinite-dimensional linear systems. We will show that, for systems governed by partial differential equations, this leads to a sequence of finite-element problems

3 Constraints in the program