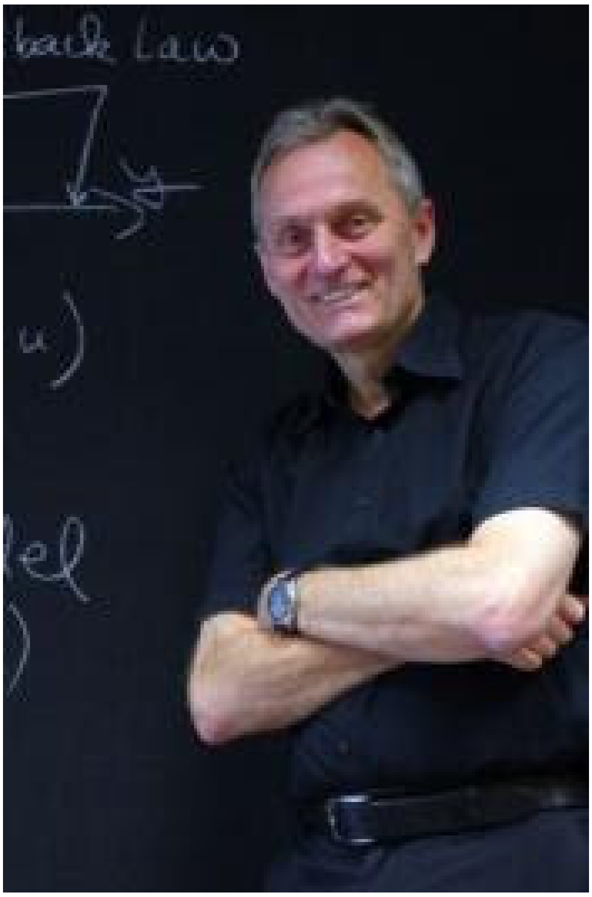
EMOSC 25:
Energy-based modeling, simulation, and control of dynamical systems

Workshop in honor of Volker Mehrmann's 70th birthday

May 26 - 28, 2025

TU Berlin



Book of Abstracts

In honor of Volker Mehrmann's 70th birthday, this workshop will bring together researchers from the theory and numerics of energy-based system models and their applications. The workshop will focus on aspects such as modeling, model reduction, system identification, and system analysis, as well as analytical and numerical methods for structured simulation and control.

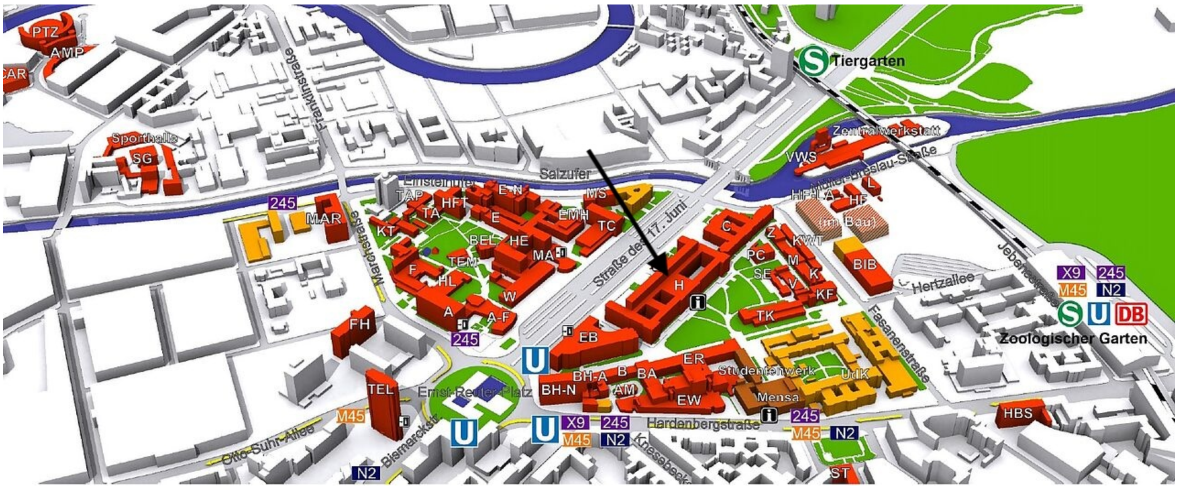
Organizing committee

Peter Benner
Janine Holzmann
Christian Mehl
Alexandra Schulte
Tatjana Stykel
Benjamin Unger
Matthias Voigt

Conference venue

The workshop takes place at the TU Berlin.

Address: Main building, rooms H2035, H2036, and H2037
Straße des 17. Juni 135, 10623 Berlin



Conference dinner

The conference dinner will take place at **Alte Pumpe** on Tuesday, May 27 starting at 7pm.

Address: Lützowstraße 42, 10785 Berlin

Programme

Monday, May 26

12:00 – 13:00	**Welcome/Registration**
13:00 – 13:30	**Opening**
13:30 – 14:00	**Paul Van Dooren** (Université catholique de Louvain) Optimal robustness of passive systems
14:00 – 14:30	**Karim Cherifi** (Bergische Universität Wuppertal) Structure-preserving model reduction of linear time-varying port-Hamiltonian systems
14:30 – 15:00	**Timo Reis** (TU Ilmenau) Port-Hamiltonian formulation of cable harnesses with radiation effects
15:00 – 15:30	**Coffee break**
15:30 – 16:00	**Serkan Gugercin** (Virginia Tech) Model reduction of bilinear port-Hamiltonian systems
16:00 – 16:30	**Valeria Simoncini** (Universita di Bologna) Recent developments in multiterm matrix equations solvers
16:30 – 17:00	**Daniel Kressner** (EPFL) Adaptive randomized DEIM
17:10 – 19:00	**Poster blitz and Poster session**
	Attila Karsai (TU Berlin) Passive feedback control for nonlinear systems
	Dorothea Hinsen (TU Berlin) Energy efficiency in subway systems through port-Hamiltonian formulation
	Shubhaditya Burela (TU Berlin) Optimal control for a class of linear transport-dominated systems via the shifted proper orthogonal decomposition
	Arijit Sarkar (BUT Cottbus) Scalable modeling of electro-thermal microgrids using a reversible irreversible port-Hamiltonian systems approach
	Alessandro Borghi (TU Berlin) H2 model reduction in general domains - optimality conditions and the role of the Schwarz function
	Hanna Blazhko (Jagiellonian University Kraków) Detection of the index and discretization of port-Hamiltonian descriptor systems
	Andrii Dmytryshyn (Chalmers University of Technology) Singular matrix pencils: minimal indices through perturbation behavior
	Paul Schwerdtner (New York University) Structured sparse regression in quadratic manifolds
	Carsten Hartmann (BTU Cottbus-Senftenberg) Realisation of constraints in stochastic Langevin and port-Hamiltonian dynamics
	Jakob Niehues (Potsdam Institute for Climate Impact Research) Power-based modeling of power grids
	Till Peters (TU Braunschweig) Balanced truncation for bilinear-quadratic output systems
	Markus Lohmayer (FAU Erlangen-Nürnberg) A compositional, energy-based software framework for modeling mechanical, electromagnetic and thermodynamic systems
	Jonas Nicodemus (University of Stuttgart) KLAP: KYP lemma based low rank approximation for passivation

Tuesday, May 27

09:00 – 09:30	**Zdeněk Strakoš** (Charles University Prague) Spectral approximation and generalized eigenvalue problem in operator preconditioning
09:30 – 10:00	**Michał Wojtylak** (Jagiellonian University Kraków) Singular and regular operator port Hamiltonian pencils
10:00 – 10:30	**Jörg Liesen** (TU Berlin) M = H + S
10:30 – 11:00	**Coffee break**
11:00 – 11:30	**Michael Overton** (New York University) Multi-fidelity robust controller design with gradient sampling
11:30 – 12:00	**Christopher Beattie** (Virginia Tech) Data driven dynamics in trees
12:00 – 12:30	**Rafikul Alam** (Indian Institute of Technology Guwahati) Zeros, poles and system equivalence of time-delay systems
12:30 – 14:00	**Lunch**
14:00 – 14:30	**Arjan van der Schaft** (University of Groningen) Linear systems with symmetry structures: reciprocal, relaxation, and input-output Hamiltonian systems
14:30 – 15:00	**Emre Mengi** (Kos University) Minimization of the pseudospectral abscissa of a matrix polynomial with applications to damping optimization
15:00 – 15:30	**Punit Sharma** (Indian Institute of Technology Delhi) Finding the nearest bounded-real port-Hamiltonian system
15:30 – 16:00	**Hoang Linh Vu** (Vietnam National University Hanoi) Characterizing and computing the stability region of singular nonlinear dynamical systems
16:00 – 16:30	**Coffee break**
16:30 – 17:00	**Hongguo Xu** (University of Kansas) Invariant subspace perturbations of Hamiltonian matrices with defective imaginary eigenvalues
17:00 – 17:30	**Shreemayee Bora** (Indian Institute of Technology Guwahati) Removing critical eigenvalues of structured matrix pencils and Hamiltonian matrices with optimal perturbations
17:30 – 18:00	**Vasile Sima** (ICI Bucharest) New results on block diagonalization of matrix pencils
19:00	**Conference dinner**

Wednesday, May 28

09:30 – 10:00	**Riccardo Morandin** (OvGU Magdeburg) Discrete gradient methods for semi-explicit port-Hamiltonian DAEs
10:00 – 10:30	**Paul Kotyczka** (TU München) Port-based modeling and discretization of thermo-visco-elasticity from various perspectives
10:30 – 11:00	**Manuel Schaller** (TU Chemnitz) A system node approach to port-Hamiltonian partial differential equations
11:00 – 11:30	**Coffee break**
11:30 – 12:00	**David Watkins** (Washington State University) Bulge chasing is pole swapping
12:00 – 12:30	**Anton Arnold** (TU Wien) Short- and long-time behavior in evolution equations: the role of the hypocoercivity index
12:30 – 13:00	**Froilán Dopico** (Universidad Carlos III de Madrid) Polynomial and rational matrices with the invariant rational functions and the four sequences of minimal indices prescribed
13:00 – 13:10	**Closing**

Talk

Optimal robustness of passive systems

Authors: Paul Van Dooren[1]; Volker Mehrmann[2]

[1] *Université catholique de Louvain*

[2] *TU Berlin*

We construct optimally robust port-Hamiltonian realizations of a given rational transfer function that represents a passive system. We show that the realization with a maximal passivity radius is a normalized port-Hamiltonian one. Its computation is linked to a particular solution of a linear matrix inequality that defines passivity of the transfer function, and we provide an algorithm to construct this optimal solution. We also consider the problem of finding the nearest passive system to a given nonpassive one and provide a simple but suboptimal solution. These problems are formulated for both continuous-time and discrete-time systems and is linked to the problem of finding a realization of a rational transfer function such that its passivity radius is maximized.

Talks

Structure-preserving model reduction of linear time-varying port-Hamiltonian systems

Authors: Karim Cherifi[1] ; Riccardo Morandin[2]

[1] *Wuppertal University*

[2] *Otto von Guericke University Magdeburg*

Port-Hamiltonian (pH) systems are a natural way to model many physical processes. Numerous specialized numerical techniques have been created to take advantage of and maintain the structure of pH systems, such as model order reduction (MOR) and space- and time-discretization. In this work, we focus on the structure-preserving MOR of linear time-varying (LTV) pH systems. LTV systems appear quite naturally in many applications, e.g. in the linearization of nonlinear systems around non-stationary reference solutions, or when some of the system parameters are time dependent. In the literature there are few works on the MOR of general LTV systems, but even fewer on the MOR of LTV-pH systems. In this talk, we introduce a general approach for or the structure-preserving MOR of LTV-pH systems based on (Petrov)-Galerkin projection. We present multiple variants of the usual balanced truncation method to obtain a reduced pH model. Numerical experiments are provided to demonstrate the effectiveness of the proposed methods.

Talks

Port-Hamiltonian formulation of cable harnesses with radiation effects

Authors: Timo Reis[1]; Nathanael Skrepek[2]

[1] *Technische Universität Ilmenau*

[2] *Universiteit Twente*

We consider cables that interact with the electromagnetic field through radiation in a bidirectional way. We show that the port-Hamiltonian framework is well-suited to model this interaction. The cable is described by the telegraph equations, while the electromagnetic field is (unsurprisingly) described by Maxwell's equations. The coupling goes via boundary conditions for the electric and magnetic fields at the lateral surfaces of the cables, and is determined by the voltages and currents along the transmission line. Additionally, we discuss some analytical properties, including the semigroup property of the autonomous dynamics.

Talks

Model reduction of bilinear port-Hamiltonian systems

Authors: Serkan Gugercin[1]; Heike Faßbender[2]; Till Peters[2]

[1] *Virginia Tech*

[2] *TU Braunschweig*

Port-Hamiltonian systems have emerged as a fundamental framework for modeling a wide range of physical phenomena due to their energy-based structure and inherent stability properties. To address the complexity of such models, various structure-preserving model reduction techniques have been developed for both linear and nonlinear port-Hamiltonian dynamics. In this work, we focus on bilinear port-Hamiltonian systems and explore novel model reduction methods that maintain their intrinsic structure. By leveraging techniques designed for bilinear systems with quadratic outputs, we propose both interpolatory and balancing-based reduction approaches. These methods ensure computational efficiency while preserving the key dynamical and physical properties of the original system, making them well-suited for large-scale applications.

Talks

Recent developments in multiterm matrix equations solvers

Author: Valeria Simoncini[1]

[1] *Universita di Bologna*

The efficient solution of large-scale multiterm linear matrix equations is a challenging task in numerical linear algebra, and it is a largely open problem. The topic has attracted great interest within the numerical community in the past decade, thanks to the applicability of linear matrix equations in a growing number of applications. In this talk we will discuss recent developments in different directions, from the use of effective randomized strategies to subspace-rich algorithms that conveniently leverage the problem structure.

This talk is partially based on collaborations with Martina Iannacito, Davide Palitta, Marcel Schweitzer and Yihong Wang.

Talks

Adaptive randomized DEIM

Authors: Daniel Kressner[1]; Alice Cortinovis[2]

[1] *EPFL*

[2] *University of Pisa*

The Discrete Empirical Interpolation Method (DEIM) is an important tool in model reduction, significantly reducing the cost of evaluating a high-dimensional function if the function value is known to be nearly contained in a low-dimensional subspace. On a matrix level, DEIM requires one to select a well-conditioned square submatrix $U(I,:)$ of an orthonormal basis $U \in \mathbb{R}^{n\times k}$. Commonly used approaches to selecting the row index set I proceed in a greedy manner. For example, Q-DEIM by Drmac and Gugercin first selects the row of maximum norm, then removes this selected row by orthogonal projection and updates U before selecting the next row of maximum norm, etc. While such greedy strategies often work well, there are cases for which $\|U(I,:)^{-1}\|_2$ grows exponentially with k. Randomization provides a simple cure: Instead of choosing the row of maximum norm, one selects the row index randomly with probability proportional to the row norm. The selected row is removed by orthogonal projection and, in turn, the probability distribution for selecting the next row is adapted. The index set I resulting from this adaptive randomized selection satisfies $\|U(I,:)^{-1}\|_2 \leq \sqrt{1+k(n-k)}$ in expectation, which matches the bound obtained from solving the NP complete problem of finding the submatrix of maximum volume. The derandomization of our adaptive randomized DEIM strategy results in a deterministic algorithm recently proposed by Osinsky, which is slightly more expensive but satisfies the same bound deterministically. The talk will also consider various applications and extensions, including symplectic model reduction and Lagrangian graph bases.

Poster Blitz & Poster Section

Passive feedback control for nonlinear systems

Authors: Attila Karsai[1]; Tobias Breiten[1]

[1] *TU Berlin*

Dynamical systems can be used to model a broad class of physical processes, and conservation laws give rise to system properties like passivity or port-Hamiltonian structure. An important problem in practical applications is to steer dynamical systems to prescribed target states, and feedback controllers combining a regulator and an observer are a powerful tool to do so. However, controllers designed using classical methods do not necessarily obey energy principles, which makes it difficult to model the controller-plant interaction in a structured manner. In this talk, we show that a particular choice of the observer gain gives rise to passivity properties of the controller that are independent of the plant structure. Furthermore, we state conditions for the controller to have a port-Hamiltonian realization and show that a model order reduction scheme can be deduced using the framework of nonlinear balanced truncation. Two dimensional numerical examples based on physical models will illustrate benefits and current limitations of the method.

Poster Blitz & Poster Section

Energy efficiency in subway systems through port-Hamiltonian formulation

Author: Dorothea Hinsen[1]

[1] *TU Berlin*

Efficient mobility and sustainable transportation are crucial for driving economic growth and preserving the environment in today's globalized society. However, the transportation sector, responsible for a substantial portion of energy consumption and CO2 emissions, presents a significant challenge for achieving sustainable and ecological transformations, especially in countries like Germany. Rail transport, a key mode of transportation, plays a major role in electricity consumption.

Despite Germany's progress in enhancing energy efficiency, there remains untapped potential for further reducing energy consumption and CO2 emissions. The EKSSE research project is focused on improving the energy efficiency of Nuremberg's and Hamburg's subway systems. This presentation outlines the project's objectives and introduces various approaches for modeling the subway system as a port-Hamiltonian system, offering a promising avenue for optimizing energy usage.

Poster Blitz & Poster Section

Optimal control for a class of linear transport-dominated systems via the shifted proper orthogonal decomposition

Author: Shubhaditya Burela[1]

[1] *TU Berlin*

Solving optimal control problems for transport-dominated partial differential equations (PDEs) can become computationally expensive, especially when dealing with high-dimensional systems. To overcome this challenge, we focus on developing and deriving reduced-order models that can replace the full PDE system in solving the optimal control problem. Specifically, we explore the use of the shifted proper orthogonal decomposition (POD) as a reduced-order model, which is particularly effective for capturing high-fidelity, low-dimensional representations of transport-dominated phenomena. Furthermore, we propose two distinct frameworks for addressing these problems: one where the reduced-order model is constructed first, followed by optimization of the reduced system, and another where the original PDE system is optimized first, with the reduced-order model subsequently applied to the optimality system. We consider a 1D linear advection equation problem and compare the computational performance of the shifted POD method against conventional methods like the standard POD when the reduced-order models are used as surrogates within a backtracking line search.

Poster Blitz & Poster Section

Scalable modeling of electro-thermal microgrids using a reversible irreversible port-Hamiltonian systems approach

Authors: Arijit Sarkar[1]; Johannes Schiffer[1]; Juan E. Machado[1]

[1] *Brandenburg University of Technology Cottbus - Senftenberg*

As the demand for energy grows, energy systems are becoming increasingly complex. Current systems heavily rely on fossil fuels, leading to negative environmental impacts. To mitigate this, future systems are expected to feature a significant proportion of renewable sources, though these are often uncertain and intermittent. One solution to better allocate renewable resources involves enabling a stronger operational coupling among the principal energy carriers: electric, heat, and gas grids. This introduces major challenges from a control perspective, as the complexity and scale of integrated energy systems grow substantially.
In this context, port-Hamiltonian systems theory provides a systematic and intrinsically modular framework for the modeling and control of complex multi-energy systems. Although port-Hamiltonian formulations for thermodynamically reversible processes are well established, systematically and modularly representing systems with both reversibilities and irreversibilities remains an active research area.
This work addresses the challenging problem of modularly modeling complex electro-thermal microgrids featuring converter-interfaced electrical sources, heat exchangers, and heat pumps. The latter components enable strong coupling between electric and heat grids but introduce very complex thermodynamic phenomena, such as phase-changing flows and other irreversibilities.

Poster Blitz & Poster Section

H2 model reduction in general domains - optimality conditions and the role of the Schwarz function

Author: Alessandro Borghi[1]

[1] *TU Berlin*

From the approximation of complex-valued functions to the reduction of dynamical systems, Hardy spaces provide a powerful framework for the analysis and construction of optimal rational approximants. One of the most widely used methods in linear model order reduction is the iterative rational Krylov algorithm (IRKA), designed to construct rational interpolants that satisfy the first order optimality conditions introduced by Meier and Luenberger. In this work, we explore possible extensions of the H2 optimal model reduction framework to a broader class of domains in the complex plane. In particular, two different approaches will be discussed: in the first case, the reduced order models are assumed to have a rational structure; in the second case, the assumption is that a rational structure is obtained only after composition with a conformal map which relates to the underlying domain. For both approaches, we examine connections between H2-like optimality conditions and the Schwarz function from both theoretical and numerical perspectives.

Poster Blitz & Poster Section

Detection of the index and discretization of port-Hamiltonian descriptor systems

Authors: Hanna Blazhko[1]; Michał Wojtylak[1]

[1] *Jagiellonian University, Kraków*

We provide a method for detecting Kronecker blocks of size two in port-Hamiltonian pencils of the form $\lambda E - (J - R)Q$, where QE and R are positive definite, and J is skew-Hermitian. The method is based on first-order perturbation theory and randomization. Furthermore, we study the impact of proximity to unstable systems on the numerical solutions (via the midpoint rule) of the corresponding DAE.

Poster Blitz & Poster Section

Singular matrix pencils: minimal indices through perturbation behavior

Author: Andrii Dmytryshyn[1]

[1] *Chalmers University of Technology*

Computing the complete eigenstructure of matrix pencils is a challenging problem. Small perturbations can change both the eigenvalues with their multiplicities, as well as the minimal indices of a given pencil. Recently, however, perturbation theory was used to compute eigenvalues of singular matrix pencils. In this poster, we investigate how the behavior of a general matrix pencil under small perturbations can help determine its minimal indices.

Poster Blitz & Poster Section

Structured sparse regression in quadratic manifolds

Authors: Paul Schwerdtner[1]; Serkan Gugercin[2]; Benjamin Peherstorfer[1]

[1] *New York University*

[2] *Virginia Tech*

Approximating field variables and data vectors from sparse samples is a key challenge for model order reduction of nonlinear dynamical systems. Without utilizing sparse samples – a process often referred to as hyper-reduction – the online costs of the reduced model continue to scale with the dimension of the full model. In this talk, we present a new methodology for empirical sparse regression that computes approximations as nonlinear projections onto precomputed quadratic manifolds. Empirical sparse regression on quadratic manifolds can reduce approximation errors by several orders of magnitude compared to widely used methods such as gappy proper orthogonal decomposition or discrete empirical interpolation, which rely on linear approximation spaces by several orders of magnitude. This advantage is particularly pronounced when the data represents transport-dominated or wave-like dynamics, as commonly observed in energy-conserving dynamical systems. After revisiting our greedy quadratic manifold construction, we detail the sparse regression algorithm and demonstrate its effectiveness through numerical examples, showcasing applications in Vlasov systems and a rotating detonation rocket engine.

Poster Blitz & Poster Section

Realisation of constraints in stochastic Langevin and port-Hamiltonian dynamics

Authors: Carsten Hartmann[1]; Lara Neureither[1]; Upanshu Sharma[2]

[1] *BTU Cottbus-Senftenberg, Institut für Mathematik*

[2] *UNSW Sydney*

The realisation of constraints by strong confining forces is a classical theme in mechanics. Constraining a mechanical system typically leads to a differential algebraic equation of differential index 3. Recently, there has been a growing interest in studying constrained stochastic differential equations, due to their relevance in molecular dynamics, material science, computational statistics, or machine learning.

In this talk, I will discuss the realisation of algebraic constraints on stochastic differential equations with degenerate noise, specifically, Langevin-type systems and closely related port-Hamiltonian systems. The constraints are realised by adding stiff confinement terms that penalise deviations of the stochastic dynamics from the constraint surface. In doing so, we focus on two aspects: (1) the pathwise approximation of the constrained dynamics by an unconstrained one with a strong confining force, (2) the preservation of structural properties, such as stability or invariant measures.

Poster Blitz & Poster Section

Power-based modeling of power grids

Author: Jakob Niehues[1]

[1] *Potsdam Institute for Climate Impact Research*

Renewable energy sources such as wind turbines and solar cells are connected to the power grid via grid-forming inverters (GFIs), which can contribute to grid stability and synchronization. Their rollout presents a significant modeling challenge, as GFIs are a relatively new and complex technology, of which there is a limited practical and theoretical understanding. In fact, physics-based modeling is often not feasible.

The so-called normal form of GFIs is a technology-neutral formulation of power grid dynamics that encompasses the space of all plausible GFIs, including established models for conventional generators. It has proven itself to be suited for grey-box modeling, system identification from data, and stability analysis of heterogeneous mixes of technologies. In the normal form approach, GFIs are voltage sources reacting to a collocated current, with the aim of providing a specified amount of power (voltage times current). Therefore, a connection to energy-based modeling lies at hand.

Energy-based modeling is often associated with a bottom-up approach, starting at the underlying physics, while the normal form is a top-down approach starting at the design goal. This contribution explores whether these two complementary approaches can be brought together.

Poster Blitz & Poster Section

Balanced truncation for bilinear-quadratic output systems

Authors: Till Peters[1] ; Heike Faßbender[1]; Serkan Gugercin[2]

[1] *TU Braunschweig*

[2] *Virginia Tech*

We study so called bilinear-quadratic output (BQO) systems of the form

$$\dot{x}(t) = Ax(t) + \sum_{k=1}^{m} N_k x(t) u_k(t) + Bu(t)$$

with initial condition $x(0) = 0$ and output $y(t) = Cx(t) + \begin{bmatrix} x(t)^T M_1 x(t) & \ldots & x(t)^T M_p x(t) \end{bmatrix}^T$, where $A \in \mathbb{R}^{n\times n}, B \in \mathbb{R}^{n\times m}, C \in \mathbb{R}^{p\times n}, N_k \in \mathbb{R}^{n\times n}$ for $k = 1, \ldots, m$, $M_j \in \mathbb{R}^{n\times n}$ for $j = 1, \ldots, p$, $t \in [0, \infty)$. Here, $x(t) \in \mathbb{R}^n$ describes the state, $u(t) \in \mathbb{R}^m$ the input and $y(t) \in \mathbb{R}^p$ the output of the system. Moreover, we assume M_j to be symmetric due to $x(t)^T M_j x(t) = x(t)^T M_j^T x(t) = \frac{1}{2} x(t)^T (M_j + M_j^T) x(t)$.

We present algebraic Gramians in different variants for these BQO systems, compare them and their relations to Lyapunov equations arising from bilinear ($M_j = 0$) or linear-quadratic output ($N_k = 0$) systems. Next, we propose a balancing algorithm for truncation of certain states with the goal of structure-preserving model order reduction. This algorithm is tested in several numerical experiments.

Poster Blitz & Poster Section

A compositional, energy-based software framework for modeling mechanical, electromagnetic and thermodynamic systems

Authors: Markus Lohmayer[1]; Owen Lynch[2]; Sigrid Leyendecker[1]

[1] *FAU Erlangen-Nürnberg*

[2] *University of Oxford*

This talk introduces a compositional, energy-based modeling language for classical mechanics, electromagnetism, and irreversible thermodynamics. The formal, domain-specific language has a graphical syntax, whose expressions are morphisms in a symmetric monoidal category. This enables the straightforward modular and hierarchical composition of complex systems from simpler subsystems. Primitive subsystems are classified into energy storage, reversible energy exchange, and irreversible processes.

The proposed framework builds on established theories, including port-Hamiltonian systems, bond graph notation, and the metriplectic or GENERIC formalisms. Additionally, some category theory is applied to ensure a well-behaved, compositional structure. Unlike general-purpose modeling languages such as Modelica, which handle unstructured differential-algebraic equations, this framework is specifically designed for physical systems, having a structure that ensures adherence to principles such as the first and second laws of thermodynamics.

After summarizing the theoretical setup, the talk presents a prototype implementation of the modeling language, as a first step toward practical applications. It concludes with reflections on potential directions for future work.

Poster Blitz & Poster Section

KLAP: KYP lemma based low rank approximation for passivation

Authors: Jonas Nicodemus[1]; Benjamin Unger[2]; Matthias Voigt[3]; Serkan Gugercin[4]

[1] *University of Stuttgart*

[2] *Karlsruhe Institute of Technology*

[3] *UniDistance Suisse*

[4] *Virginia Tech*

We present a novel passivation method, called KLAP, for linear time-invariant systems based on the Kalman-Yakubovich-Popov (KYP) lemma in low-rank factorized form. The passivation problem in our framework corresponds to finding a perturbation to a given non-passive system that renders the system passive while minimizing the $\mathcal{H}_2$ distance between the original non-passive and the resulting passive system. We show that this problem can be formulated as an unconstrained optimization problem whose objective function can be differentiated efficiently even in large-scale settings. We show that any global minimizer of the unconstrained problem yields the same passive system. Furthermore, we prove that, in the absence of a feedthrough term, every local minimizer is also a global minimizer. For cases involving a non-trivial feedthrough term, we analyze global minimizers in relation to the extremal solutions of the algebraic Riccati equations, which can serve as tools for identifying local minima. To solve the resulting numerical optimization problem efficiently, we propose an initialization strategy based on modifying the feedthrough term and a restart strategy when it is likely that the optimization has converged to a local minimum. Numerical examples illustrate the effectiveness of the proposed method.

Talks

Spectral approximation and generalized eigenvalue problem in operator preconditioning

Author: Zdeněk Strakoš[1]

[1] *Charles University Prague*

This contribution will address relationship between spectra of preconditioned self-adjoint PDE operators associated with boundary value problems and their approximations using generalized matrix eigenvalue problems arising from discretization. We will recall several results from operator theory literature, compare them with results on the generalised eigenvalue problem in the numerical PDE setting, and discuss the issue of spectral polution. Relationship between spectra of infinite dimensional operators and eigenvalues of the associated finite matrices will be illustrated using second order self-adjoint PDE operators.

Talks

Singular and regular operator port Hamiltonian pencils

Authors: Christian Mehl[1]; Michał Wojtylak[2]; Volker Mehrmann[1]

[1] *TU Berlin*

[2] *Jagiellonian University, Kraków*

We provide a systematic theory of singular pencils $\lambda E - A$, with (possibly unbounded) operator coefficients in a Hilbert space. Apparently, the situation is more complicated than in the finite dimensional case. Several equivalent statements connected to the Kronecker canonical form become essentially different when the dimension is infinite. We show the relation of these concepts to solvability of the corresponding (infinite dimensional) differential-algebraic equations $E\dot{x} = Ax$.

While the general theory is rather complicated, it essentially simplifies for the operator pencils of type $\lambda E - (J - R)$, where E, R are positive semidefinite, J is skew-symmetric. Here the results are analogous to the finite dimensional situation. In particular we give necessary and sufficient conditions for uniqueness of solutions of the corresponding Cauchy problem.

The talk is based on:

C. Mehl, V. Mehrmann, M. Wojtylak, Spectral theory of infinite dimensional dissipative Hamiltonian systems, arXiv preprint arXiv:2405.11634.

Talks

$M = H + S$

Author: Jörg Liesen[1]

[1] *TU Berlin*

Any (real or complex) square matrix M can be split into $M = H + S$, where H is the Hermitian and S is the skew-Hermitian part of M. Interestingly, this splitting occurs *naturally* and with a *physical meaning* in applications that involve energy-based modeling using DAE systems in dissipative Hamiltonian form (dHDAEs). The applicability of this modeling approach has been demonstrated in a variety of application areas including thermodynamics, electromagnetics, and fluid mechanics. The linear algebraic systems that arise from the linearization and/or discretization of such dHDAEs have matrices of the form $M = H + S$, where H is positive definite or positive semidefinite. This class of matrices has intriguing properties. We will discuss several important examples in this context as well as efficient approaches for solving the resulting linear algebraic systems iteratively. The talk will be based on joint work with Candan Güdücü, Volker Mehrmann, Justus Ramme (all TU Berlin), and Daniel Szyld (Temple University).

Talks

Multi-fidelity robust controller design with gradient sampling

Authors: Michael Overton[1]; Steffen Werner[2]; Benjamin Peherstorfer[1]

[1] *New York University*

[2] *Virginia Tech*

Robust controllers that stabilize dynamical systems even under disturbances and noise are often formulated as solutions of nonsmooth, nonconvex optimization problems. While methods such as gradient sampling can handle the nonconvexity and nonsmoothness, the costs of evaluating the objective function may be substantial, making robust control challenging for dynamical systems with high-dimensional state spaces. In this work, we introduce multifidelity variants of gradient sampling that leverage low-cost, low-fidelity models with low-dimensional state spaces for speeding up the optimization process while nonetheless providing convergence guarantees for a high-fidelity model of the system of interest, which is primarily accessed in the last phase of the optimization process. Our first multifidelity method initiates gradient sampling on higher-fidelity models with starting points obtained from cheaper, lower-fidelity models. Our second multifidelity method relies on ensembles of gradients that are computed from low- and high-fidelity models. Numerical experiments with controlling the cooling of a steel rail profile and laminar flow in a cylinder wake demonstrate that our new multifidelity gradient sampling methods achieve up to two orders of magnitude speedup compared to the single-fidelity gradient sampling method that relies on the high-fidelity model alone.

Talks

Data driven dynamics in trees

Author: Christopher Beattie[1]

[1] *Virginia Tech*

This talk concerns the challenge of identifying states of dynamic systems that operate across multiple time scales, ranging from youth to old age, drawing on personal experiences of the speaker in collaboration with V. Mehrmann.

The central state identification challenge arises from the fact that data is only accessible at the finest time scales, and may be rapidly forgotten (e.g., breakfast to dinner), rendering longer trends nearly unobservable, and thus necessitating the introduction of coarser, hidden variables that are able to capture broader temporal dependencies. Our approach extends the usual framework of Kalman filtering to graphical models and has elements in common with methods for modeling multiresolution stochastic processes on dyadic trees, while avoiding some of the limitations of tree-structured models.

Talks

Zeros, poles and system equivalence of time-delay systems

Authors: Rafikul Alam[1]; Jibrail Ali[1]

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Consider the linear time-invariant time-delay system (TDS)

$$\begin{aligned}\frac{\mathrm{d}\mathbf{x}(t)}{\mathrm{d}t} &= A_0\mathbf{x}(t)+\sum_{j=1}^{N_1}A_j\mathbf{x}(t-\tau_j)+\sum_{j=1}^{N_2}B_j\mathbf{u}(t-t_j),\\ \mathbf{y}(t) &= \sum_{j=1}^{N_3}C_j\mathbf{x}(t-s_j)+\sum_{j=1}^{N_4}D_j\mathbf{u}(t-h_j),\end{aligned}$$

where $\mathbf{x}(t)\in\mathbb{C}^r$ and $\mathbf{u}(t)\in\mathbb{C}^n$ are state and control vectors, respectively, at a time t, $(A_i,B_i,C_i,D_i)\in\mathbb{C}^{r\times r}\times\mathbb{C}^{r\times n}\times\mathbb{C}^{m\times r}\times\mathbb{C}^{m\times n}$ and (τ_i,t_i,s_i,h_i) are time-delay parameters. A system matrix $\mathbf{S}(\lambda)$ and the transfer function $\mathbf{M}(\lambda)$ of the TDS are given by

$$\mathbf{S}(\lambda):=\left[\begin{array}{c|c}A(\lambda) & B(\lambda)\\ \hline -C(\lambda) & D(\lambda)\end{array}\right] \text{ and } \mathbf{M}(\lambda):=[D(\lambda)+C(\lambda)A(\lambda)^{-1}B(\lambda)],$$

where $A(\lambda):=\lambda I_r-A_0-\sum_{j=1}^{N_1}A_je^{-\lambda\tau_j}$, $B(\lambda):=\sum_{j=1}^{N_2}B_je^{-\lambda t_j}$, $C(\lambda):=\sum_{j=1}^{N_3}C_je^{-\lambda s_j}$ and $D(\lambda):=\sum_{j=1}^{N_4}D_je^{-\lambda h_j}$ are entire matrix-valued functions.

Our main aim is two-fold. First, to study the canonical forms of $\mathbf{S}(\lambda)$ and $\mathbf{M}(\lambda)$ so as to analyze zeros and poles of the TDS. Second, to investigate system equivalence, that is, if $\mathbf{S}_1(\lambda)$ and $\mathbf{S}_2(\lambda)$ are system matrices of time-delay systems, then investigate Rosenbrock system equivalence (written as $\mathbf{S}_1(\lambda)\sim_{rse}\mathbf{S}_2(\lambda)$) as well as Fuhrmann system equivalence (written as $\mathbf{S}_1(\lambda)\sim_{fse}\mathbf{S}_2(\lambda)$).

We show that $\mathbf{M}(\lambda)$ admits a Smith-McMillan form $\Sigma_{\mathbf{M}}(\lambda)$ given by

$$\Sigma_{\mathbf{M}}(\lambda)=\left[\begin{array}{ccc|c}\phi_1(\lambda)/\psi_1(\lambda) & & & \\ & \ddots & & \\ & & \phi_p(\lambda)/\psi_p(\lambda) & \\ \hline & & & 0_{m-p\times n-p}\end{array}\right], \tag{1}$$

where $\phi_1,\ldots,\phi_p$ and $\psi_1,\ldots,\psi_p$ are entire functions, ϕ_j and ψ_j are relatively prime. Further, ϕ_j divides ϕ_{j+1} and ψ_{j+1} divides ψ_j for $j=1:p-1$. Furthermore, $\phi_1,\cdots,\phi_p$ and $\psi_1,\ldots,\psi_p$ are given by

$$\phi_j(\lambda)=\prod_{\ell=1}^{\infty}(\lambda-\lambda_\ell)^{\partial_j(\lambda_\ell)}u_{j\ell}(\lambda) \text{ and } \psi_j(\lambda)=\prod_{\ell=1}^{\infty}(\lambda-\mu_\ell)^{\delta_j(\mu_\ell)}v_{j\ell}(\lambda),$$

where $u_{j\ell},v_{j\ell}$ are entire functions with no zeros in $\mathbb{C}$, λ_ℓ and μ_ℓ are zeros and poles of $\mathbf{M}(\lambda)$, $\partial_j(\lambda_\ell)$ are $\delta_j(\mu_\ell)$ are appropriate non-negative integers for $j=1:p$ and $\ell\in\mathbb{N}$.

We also show that $\mathbf{M}(\lambda)$ admits a right coprime matrix-fraction description (MFD), that is, there exist entire matrix-valued functions $N(\lambda)$ and $D(\lambda)$ such that $N(\lambda)$ and $D(\lambda)$ are right coprime, $D(\lambda)$ is regular, and

$$\mathbf{M}(\lambda)=N(\lambda)D(\lambda)^{-1}.$$

Further, $\sigma_{\mathbb{C}}(\mathbf{M})=\sigma_{\mathbb{C}}(N)$ and $\wp_{\mathbb{C}}(\mathbf{M})=\sigma_{\mathbb{C}}(D)$, where $\sigma_{\mathbb{C}}(X)$ is the spectrum (set of zeros) and $\wp_{\mathbb{C}}(X)$ is the set of poles of a meromorphic matrix-valued function $X(\lambda)$.

For system matrices, we show that

$$\mathbf{S}_1(\lambda)\sim_{rse}\mathbf{S}_2(\lambda)\Longleftrightarrow\mathbf{S}_1(\lambda)\sim_{fse}\mathbf{S}_2(\lambda).$$

Further, if $\mathbf{S}_1(\lambda)$ and $\mathbf{S}_2(\lambda)$ are *irreducible* then $\mathbf{S}_1(\lambda)\sim_{rse}\mathbf{S}_2(\lambda)\Longleftrightarrow\mathbf{S}_1(\lambda)$ and $\mathbf{S}_2(\lambda)$ have the same transfer function. Finally, if $\mathbf{S}(\lambda)$ is irreducible and $\Sigma_{\mathbf{M}}(\lambda)$ is the Smith-McMillan form of $\mathbf{M}(\lambda)$ as given above, then we show that

$$\begin{aligned}S_A(\lambda) &= I_{r-p}\oplus\mathrm{diag}(\psi_p(\lambda),\psi_{p-1}(\lambda),\psi_1(\lambda))\\ S_{\mathbf{S}}(\lambda) &= I_r\oplus\mathrm{diag}(\phi_1(\lambda),\ldots,\phi_p(\lambda))\oplus 0_{m-p,n-p}\end{aligned}$$

are the Smith forms of $A(\lambda)$ and $\mathbf{S}(\lambda)$, respectively. Hence we show that $\sigma_{\mathbb{C}}(\mathbf{M})=\sigma_{\mathbb{C}}(\mathbf{S})$ and $\wp_{\mathbb{C}}(\mathbf{M})=\sigma_{\mathbb{C}}(A)$.

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Talks

Linear systems with symmetry structures: reciprocal, relaxation, and input-output Hamiltonian systems

Author: Arjan van der Schaft[1]

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A classical topic in analog design is the study of input-output systems with extra structure. Recently, this interest is renewed by motivations stemming from e.g. neuro-computing, dynamical networks, and scalable control. In this talk we will discuss various, often related, symmetry structures for standard linear systems, including gradient systems, relaxation systems and input-output Hamiltonian systems.

Talks

Minimization of the pseudospectral abscissa of a matrix polynomial with applications to damping optimization

Authors: Emre Mengi[1]; Volker Mehrmann[2]

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We consider a matrix polynomial dependent on several parameters. The minimization of its spectral abscissa, the real part of its rightmost eigenvalue, over the parameters is motivated by stability considerations on the associated higher-order linear control system, yet comes with computational challenges especially due to the non-Lipschitz nature of the spectral abscissa. We instead propose approaches to minimize the pseudospectral abscissa, the real part of the rightmost eigenvalue attainable over all perturbations of the matrix polynomial of prescribed norm. The efficiency and applicability of the proposed approaches are illustrated on several large matrix polynomials depending on parameters, especially those arising from damping optimization.

Talks

Finding the nearest bounded-real port-Hamiltonian system

Authors: Karim Cherifi[1]; Nicolas Gillis[2]; Punit Sharma[3]

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We consider linear time-invariant continuous control systems that are bounded real, also known as scattering passive. Our main theoretical contribution is to show the equivalence between such systems and port-Hamiltonian (PH) systems whose factors satisfy certain linear matrix inequalities. Based on this result, we propose a formulation for the problem of finding the nearest bounded real system to a given system and design an algorithm combining alternating optimization and Nesterov's fast gradient method. This formulation also allows us to check whether a given system is bounded real by solving a semidefinite program and provide a PH parametrization for it. We illustrate our proposed algorithms on real and synthetic data sets.

Talks

Characterizing and computing the stability region of singular nonlinear dynamical systems

Author: Hoang Linh Vu[1]

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In this presentation, we explore the challenge of computing the stability region for a class of singular nonlinear continuous- and discrete-time systems. Under specific conditions, we derive topological properties of the stability region. After providing key characterizations of its boundary, we introduce a practical, direct method for computing this region. The proposed method involves solving an associated eigenvalue problem and performing forward and backward integration of the singular system in question. Numerical examples are included to illustrate the approach. This work extends concepts discussed in the monograph Stability Regions of Nonlinear Dynamical Systems: Theory, Estimation, and Applications (Cambridge University Press, 2015) by H.-D. Chiang and L. F. Alberto.

The talk is based on joint work with Pham Hong Quan and Le Huy Hoang.

Talks

Invariant subspace perturbations of Hamiltonian matrices with defective imaginary eigenvalues

Author: Hongguo Xu[1]; Volker Mehrmann[2]

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We show how invariant subspaces will change when a defective matrix is perturbed. We focus on the case when an invariant subspace corresponding to the same size Jordan blocks of a single eigenvalue is perturbed. The perturbations are characterized in terms of fractional orders. As an application, we study a class of Hamiltonian matrices that are related to Riccati inequalities. We show how the purely imaginary eigenvalues and their invariant subspaces are perturbed under certain structured perturbations.

Talks

Removing critical eigenvalues of structured matrix pencils and Hamiltonian matrices with optimal perturbations

Authors: Shreemayee Bora[1]; Kannan R[1]

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It is well known that eigenvalues of a Hermitian matrix pencil $L(\lambda) = \lambda A - B$, occur in pairs $(\lambda, \bar{\lambda})$ with eigenvalues, if any, on the extended real line being the ones where the symmetry breaks down. We refer to such eigenvalues as critical eigenvalues and study the problem of finding optimal Hermitian perturbations of $L(\lambda)$ when it is of even size such that the perturbed Hermitian matrix pencil is regular and if it has any critical eigenvalues, then those can be removed by a further arbitrarily small Hermitian perturbation. Additionally, the optimal perturbations are required to be real if $L(\lambda)$ is real. This leads to upper and lower bounds on the distance to a nearest regular Hermitian matrix pencil without critical eigenvalues. It is observed that when $L(\lambda)$ is randomly generated, the upper bound is sometimes equal to the lower bound and is often within a factor of $\sqrt{2}$ of the lower bound.

The work is also extended to the case of $*$-alternating and $*$-palindromic matrix pencils of even size with respect to their corresponding critical eigenvalues.

Under additional assumptions on the coefficient A of $L(\lambda)$, we also study the same problem while perturbing only B. In such cases, the distance is attained by the lower bound if $L(\lambda)$ is a definite pencil. However, in practice we find many examples where this happens even when $L(\lambda)$ is not a definite pencil. The techniques may also be applied to the Hamiltonian matrices to find upper and lower bounds on the distance to \emph{bounded realness}. In such cases it is proved that if the Hamiltonian matrix has only purely imaginary eigenvalues with the ones of positive type being separated from those of negative type, then the distance is attained by the lower bound. However, as experiments demonstrate, this can also happen when the Hamiltonian matrix does not satisfy this condition.

Talks

New results on block diagonalization of matrix pencils

Author: Vasile Sima[1]

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Block diagonalization algorithms have many applications, including computation of reciprocal condition numbers for eigenvalues and invariant or deflating subspaces of matrices or matrix pencils, respectively, fast computation of matrix functions, or of the response of linear time invariant standard or descriptor systems. For matrix pencils, this algorithm is applied to a matrix pair in a generalized (real) Schur form, obtained using unitary transformations. The off-diagonal blocks are annihilated by solving generalized Sylvester equations, but this involves non-unitary transformations. In order to ensure good accuracy, the numerical condition of these transformations should be bounded. Specifically, if any element of the solution of a Sylvester equation is larger than a specified constant b, the process of solving that equation is stopped, a new pair of diagonal blocks is selected, and another Sylvester equation is attempted to be solved.

There are several strategies to choose a new pair of blocks after each failure. For real matrices, the original strategy chooses a pair of diagonal blocks of order 1 or 2 whose eigenvalue(s) are closest to the mean of eigenvalues of the current pair of diagonal blocks. The chosen pair is moved by unitary equivalence transformations at the bottom of the current pair. Another attempt is made to solve the corresponding generalized Sylvester equation. If the new transformation matrices have all elements with magnitude bounded by b, then the added blocks are accepted and the same procedure is applied to the remaining part. Another strategy selects the pair of diagonal blocks whose eigenvalues are closest to the eigenvalues of the current pair. Two pairs of blocks are supposed to belong to the same cluster if all their eigenvalues satisfy an absolute or relative distance condition.

Such strategies are of the bottom-up type, and they are very efficient for matrix pencils with relatively small order and well separated eigenvalues, in which case the solver often succeeds to obtain diagonal blocks of order at most two. But for large order problems with clustered eigenvalues, the solution time can be high, due to the possibility to have a big number of unsuccessful attempts to split the blocks.

A preliminary analysis of the clustered structure of the spectrum, followed by an appropriate reordering of the eigenvalues, could improve the efficiency. Specifically, starting by the most separated eigenvalues, the solver could quickly decouple them, leaving to the end all possibly big clusters of eigenvalues. Few failed attempts to split such a cluster could signal that there is no reason to continue the computations and, therefore, finish the process with one or more large blocks. These strategies could be considered as being of "top-down" type. This paper investigates such a top-down technique.

Numerical tests have been performed to assess the possible performance improvement using a clustering technique. For random problems of order 100, the mean CPU time has been reduced by a factor of about 2 compared to the results using bottom-up strategies. For a real problem of order 999, with a clustered block of order 734 (for $b = 5000$), the computing time has been reduced from about 62.7 to 4.7 seconds. The symmetric chordal metric is used as a suitable "distance", which seems appropriate for problems that may have infinite eigenvalues. The properties of the chordal metric are also studied, and reliable and efficient algorithms for its computation are proposed.

Talks

Discrete gradient methods for semi-explicit port-Hamiltonian DAEs

Authors: Riccardo Morandin[1]; Philipp L. Kinon[2]; Philipp Schulze[3]

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[3] *TU Berlin*

Port-Hamiltonian systems extend Hamiltonian systems to incorporate network structure and energy exchanges through ports, enabling the modeling of open and interconnected systems from various physical domains. The interconnection of network components often leads to differential-algebraic equations (DAEs), which also include algebraic constraints, for example Kirchhoff's laws. To ensure that these constraints are not violated, additional care is necessary when applying numerical methods to DAEs.

In this talk we discuss the application of discrete gradient methods to nonlinear port-Hamiltonian DAEs, with a focus on the case of semi-explicit DAEs. Discrete gradient methods are particularly suitable for the time discretization of port-Hamiltonian systems, since they are structure-preserving regardless of the form of the Hamiltonian, unlike other common methods whose structure-preserving characteristics are limited to quadratic Hamiltonians, like the implicit midpoint rule or other Gauss-Legendre collocation schemes. We also present numerical results to demonstrate the capabilities of our methods.

Talks

Port-based modeling and discretization of thermo-visco-elasticity from various perspectives

Authors: Paul Kotyczka[1]; Peter Betsch[2]

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[2] *Karlsruhe Institute of Technology*

Different avenues exist for the thermodynamically consistent modeling of open multi-physical systems with reversible-irreversible couplings. Thermodynamically consistent means that both the first (energy conservation) and the second (entropy production) law of thermodynamics are reflected in the model structure and the numerical schemes derived therefrom.

Founded on the port-Hamiltonian paradigm, which emerged from combining and generalizing network theory and Hamiltonian mechanics, and which is closely related to the bond graph language, several formulations have been proposed: quasi-Hamiltonian, port contact systems, reversible-irreversible port-Hamiltonian systems (riPHS), exergetic PHS or port-thermodynamic systems from a Liouville geometry point of view. The dynamcis in these formulations is in principle generated by the total energy or a homogeneous Hamiltonian as the single potential. All approaches directly include ports and interfaces with a (control) environment, whose role has recently been investigated from a geometric perspective.

Differently, in formulations like GENERIC or metriplectic systems, recently proposed in a four-bracket formulation, the dynamics is derived from two generators, the energy and the entropy, as potentials. The port-based perspective is not at the origin of these approaches, yet extensions to the open case have already been sketched. Finally, thermodynamic systems and their interconnections can be modeled via variational principles, similar to the ones for non-holonomic mechanical systems.

To mimic the fundamental physical properties of the models at a discrete level, structure-preserving numerical methods have to be constructed. In particular (but not only) for the GENERIC formulation, energy-momentum-entropy (EME) preserving schemes have been developed and successfully applied for the simulation of coupled phenomena as from thermo-visco-elasticity.

The main purpose of this talk is to present the different energy- and entropy-based formulations of a discrete thermo-visco-elastic model problem and to discuss their properties and relations, in particular in view of the free choice of thermodynamic variables, which is facilitated by a special form of GENERIC proposed by Mielke (2011). We highlight structure preservation under numerical integration on the finite-dimensional case and close with comments on spatial discretization and simulation examples.

Talks

A system node approach to port-Hamiltonian partial differential equations

Author: Manuel Schaller[1]

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Infinite-dimensional state-space systems with boundary control and observation pose significant analytical challenges due to the typically unbounded nature of input and output maps. A common approach to establishing a solution theory, such as via a variation of constants formula, relies on the admissibility of input and output operators—an assumption that is often difficult to verify in practical applications. In this talk, we introduce a system node-based approach for port-Hamiltonian partial differential equations that (i) naturally extends the finite-dimensional input-state-output model proposed by Volker Mehrmann and coauthors in 2018 and (ii) seamlessly integrates boundary control and observation. The versatility of this approach is demonstrated through various examples, including beam equations, heat equations, wave equations, and Oseen equations.

Talks

Bulge chasing is pole swapping

Author: David Watkins[1]

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At the beginning of the era of electronic computing there was a big effort to produce software to make the newly constructed hardware useful. In the area of scientific computing, one need that was recognized early on was for efficient and reliable methods to compute the eigenvalues of a matrix. This need was met around 1960 by the so-called QR algorithm, especially the implicitly-shifted variant due to John Francis. For the generalized eigenvalue problem, Moler and Stewart introduced a variant of Francis's algorithm called the QZ algorithm. These algorithms, with various bells and whistles added over the years, are still the dominant algorithms today. These are \emph{bulge-chasing} algorithms. They create bulges at one end of a (Hessenberg) matrix or pencil and chase them to the other end. A few years ago a new class of algorithms, \emph{pole-swapping} algorithms, was introduced by Camps, Meerbergen, Vandebril, and others. It turns out that pole swapping is a generalization of bulge chasing. It might happen that new pole-swapping codes will supplant the current QR and QZ codes in the major software packages. Whether this turns out to be true or not, the pole-swapping viewpoint is extremely valuable for a detailed understanding of what makes this class of algorithms, both bulge-chasing and pole-swapping, work.

Talks

Short- and long-time behavior in evolution equations: the role of the hypocoercivity index

Authors: Anton Arnold[1] ; Eduard Nigsch[1]; Eric Carlen[2]; Franz Achleitner[1]; Volker Mehrmann[3]

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[3] *TU Berlin*

The "index of hypocoercivity" is defined via a coercivity-type estimate for the self-adjoint/skew-adjoint parts of the generator, and it quantifies 'how degenerate' a hypocoercive evolution equation is, both for ODEs and for evolutions equations in a Hilbert space. We show that this index characterizes the polynomial decay of the propagator norm for short time and illustrate these concepts for the Lorentz kinetic equation on a torus.

Discrete time analogues of the above systems (obtained via the mid-point rule) are contractive, but typically not strictly contractive. For this setting we introduce "hypocontractivity" and an "index of hypocontractivity" and discuss their close connection to the continuous time evolution equations.

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Talks

Polynomial and rational matrices with the invariant rational functions and the 4 sequences of minimal indices prescribed

Author: Froilán Dopico[1]

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The complete eigenstructure, or structural data, of a rational matrix R(s) is comprised by its invariant rational functions, both finite and at infinity, which determine its finite and infinite pole and zero structures, and by the minimal indices of its left and right null spaces. These quantities arise in many applications in control theory and have been thoroughly studied in numerous references. However, R(s) has other two fundamental subspaces which, in contrast, have received much less attention in the literature. They are its column and row spaces, which also have their associated minimal indices. This work solves the problems of finding necessary and sufficient conditions for the existence of rational matrices in two scenarios: (a) when the invariant rational functions and the minimal indices of the column and row spaces are prescribed, and (b) when the complete eigenstructure together with the minimal indices of the column and row spaces are prescribed. The particular, but extremely important, cases of these problems for polynomial matrices are solved first and are the main tool for solving the general problems.

This is a joint work with Itziar Baragaña, Silvia Marcaida and Alicia Roca.