30th IFIP TC7 Conference
System Modeling and Optimization

Conference Materials

July 4–8, 2022, Warsaw

Organizers

Institute of Mathematics Polish Academy of Sciences

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Conference programme

Monday, July 4th

9:00 - 9:30	**Conference opening** (Room A)	
9:30 – 10:30	Plenary talk (Room A) **Hans Georg Bock** (University of Heidelberg) *Inverse Optimal Control Problems and Application to Modeling the Gait of Cerebral Palsy Patients* Chair: Marek Niezgódka	
10:30 – 11:30	Coffee break	
	Session talks (Room A) **Control and Optimization in PDEs**	Session talks (Room B) **Modeling, analysis and optimization in infinite dimensional dynamics [distributed parameter systems] with applications**
11:30 – 12:00	**Vanja Nikolić** (Radboud University) *A phase-field approach to shape and topology optimization of acoustic waves in dissipative media*	**Marcelo Bongarti** (Weierstrass Institute for Applied Analysis and Stochastics) *Nonlinear gas transport on a network of pipelines: analysis and control*
12:00 – 12:30	**Nicolas Vanspranghe** (GIPSA-lab, Université Grenoble Alpes) *Output regulation of nonlinear infinite-dimensional systems*	**Piotr Fulmański** (University of Łódź) *Optimal Control in Machine Learning to Model Approximation of Neural Network*
12:30 – 13:00	**Barbara Kaltenbacher** (University of Klagenfurt) *On the inverse problem of nonlinearity parameter imaging with ultrasound*	**Marcelo Bongarti** (Weierstrass Institute for Applied Analysis and Stochastics) In place of **Irena Lasiecka** (University of Memphis) *Boundary feedback stabilization of a critical nonlinear JMGT equation with Neumann-undissipated part of the boundary*
13:00 – 14:30	Lunch break	
14:30 – 15:30	Plenary talk (Room A) **Martin Kružík** (Institute of Information Theory and Automation Czech Academy of Sciences) *Nonlinear and linearized models in thermoviscoelasticity* Chair: Fredi Troeltzsch	
15:30 – 16:00	Coffee break	

	Session talks (Room A) **Control and Optimization in PDEs**	Session talks (Room B) **Modeling, analysis and optimization in infinite dimensional dynamics [distributed parameter systems] with applications**	Session talks (Room C) **Stochastic dynamic games in continuous time and related topics**
16:00 – 16:30	**Paul Manns** (TU Dortmund University) *Improved Regularity for Sequential Linear Integer Programming for Integer Optimal Control*	**Krzysztof Leśniewski** (Systems Research Institute Polish Academy of Sciences) New regularity conditions for abstract infinite-dimensional optimization problems	**Maike Klein** (Christian-Albrecht University of Kiel) *On a time-inconsistent optimal stopping problem with expectation constraint*
16:30 – 17:00	**Sebastian Hillbrecht** (TU Dortmund University) *L^2 Regularized Control of Kantorovich Problems*	**Marta Lipnicka** (University of Łódź) *Optimal control using to approximate probability distribution of observation set*	**Josef Strini** (Graz University of Technology) *A time-inconsistent variation of the dividend problem*
17:00 – 17:30	**Iryna Ryzhkova** (V.N. Karazin Kharkiv National University) *On an attractor for smooth solutions to the interactive system of the fluid and the full von Karman shell without rotational inertia*	**Radosław Matusik** (University of Łódź) *Fixed-time anti-synchronization for reaction-diffusion neural networks*	**Oskar Hallmann** (Christian-Albrecht University of Kiel) *Crossing concave curves - first hitting times of Brownian motion via Linear Programming*
17:30 – 18:00	**Weiwei Hu** (University of Georgia) *Feedback Control of Flow-Transport Systems* TALK ONLINE		**Kristoffer Lindensjö** (Stockholm University) *Mixed strategies for time-inconsistent stopping*

Tuesday, July 5th

9:00 – 10:00	Plenary talk (Room A) **Anna Marciniak-Czochra** (University of Heidelberg) *Mathematical hematology: Model-based approach to understand cancer heterogeneity and resistance to therapy* Chair: Jan Palczewski		
	Session talks (Room A) **Stochastic analysis and applications** Chair: Miklos Rasonyi	Session talks (Room B) **Inverse Problems for Fractional Diffusion**	Session talks (Room C) **Numerics and analysis of optimal control problems with partial differential equations**
10:00 – 10:30	**Jacek Jakubowski** (University of Warsaw) *Distribution of local time of regular diffusions*	**Jaan Janno** (Tallinn University of Technology) *On some inverse problems that use nonlocality of fractional derivatives*	**Luis Ammann** (University of Duisburg-Essen) *Acoustic Full-Waveform Inversion via Optimal Control*
10:30 – 11:00	**Maciej Wiśniewolski** (University of Warsaw) *On certain integro-differential equations and local time of diffusions*	**Zhi Zhou** (Hong Kong Polytechnic University) Inverse potential problem for subdiffusion: numerical approximation and error analysis TALK ONLINE	**Maurice Hensel** (University of Duisburg-Essen) *Quasilinear Obstacle Problems in Ferromagnetic Shielding: Analysis and Optimal Control*
11:00 – 11:30	Coffee break		
	Session talks (Room A) **Stochastic analysis and applications** Chair: Łukasz Stettner	Session talks (Room B) **Inverse Problems for Fractional Diffusion**	Session talks (Room C) **Control and Optimization in PDEs**
11:30 – 12:00	**Christoph Belak** (Technische Universität Berlin) *Convergence of Deep Solvers for Semilinear PDEs*	**Zhidong Zhang** (Sun Yat-sen University) *Inverse source problem in (fractional) diffusion equation with sparse data* TALK ONLINE	**Genni Fragnelli** (University of Tuscia) *Controllability and stabilization for a degenerate wave equation in non divergence form with drift* TALK ONLINE
12:00 – 12:30	**Mariusz Niewęgłowski** (Warsaw University of Technology) *Multivariate Markovian Hawkes processes*	**Yavar Kian** (Aix Marseille Université) *Inverse problems for diffusion equations using single measurement*	**Sarah Strikwerda** (North Carolina State University) *Optimal Control in Fluid Flows through Deformable Porous Media*

12:30 – 13:00	**Agnieszka Rygiel** (Cracow University of Economics) *On utility based pricing of contingent claims in finite discrete time*	**Masahiro Yamamoto** (The University of Tokyo) *Uniqueness for inverse source problems for time-fractional diffusion-wave equations by data after incident* TALK ONLINE	**Tamara Fastovska** (V.N. Karazin Kharkiv National University) *Long time behavior of solutions to a nonlinear beam transmission problem*
13:00 – 14:30	Lunch break		
14:30 – 15:30	Plenary talk (Room A) **Benedikt Wirth** (University of Münster) *Exact reconstruction and reconstruction from noisy data: Going beyond point sources?* Chair: Barbara Kaltenbacher		
15:30 – 16:00	Coffee break		
	Session talks (Room A) **Stochastic control and games** Chair: Jan Palczewski	Session talks (Room B) **Inverse Problems for Fractional Diffusion** and **Inverse problems, Modeling and Analysis for Fractional PDEs**	
16:00 – 16:30	**Miklos Rasonyi** (Alfred Renyi Institute of Mathematics) *Highly risk-averse investors in mean-reverting market models*	Session **Inverse Problems for Fractional Diffusion** **Tuhin Ghosh** (Bielefeld University) *Nonlocal Calderón problem* TALK ONLINE	
16:30 – 17:00	**Damian Jelito** (Jagiellonian University) *Long-run impulse control in the risk-sensitive framework*	Session **Inverse problems, Modeling and Analysis for Fractional PDEs** **Vanja Nikolić** (Radboud University) *Nonlinear acoustic modeling based on fractional heat flux laws*	
17:00 – 17:30	**Marcin Pitera** (Jagiellonian University) *Long-run risk-sensitive stochastic control: entropic formulation and MPE existence*	Session **Inverse problems, Modeling and Analysis for Fractional PDEs** **William Rundell** (Texas A&M University) *On Recovering the Fractional Damping Operator in a Wave Equation from Time Trace Data* TALK ONLINE	
17:30 – 18:00	**Łukasz Stettner** (Institute of Mathematics Polish Academy of Sciences) *On an approximation of average cost per unit time impulse control of Markov processes*		

Wednesday, July 6th

9:00 – 10:00	Plenary talk (Room A) **Małgorzata Peszyńska** (Oregon State University) *Coupled systems across the scales in the subsurface. Models or data?* Chair: Marek Niezgódka		
	Session talks (Room A) **Stochastic control and games** Chair: Marcin Pitera	Session talks (Room B) **PDES in physics and biology**	Session talks (Room C) **Modeling, analysis and optimization in infinite dimensional dynamics [distributed parameter systems] with applications**
10:00 – 10:30	**Neofytos Rodosthenous** (University College London) *Two-sided Singular Control of an Inventory with Unknown Demand Trend*	**Mikołaj Sierżęga** (University of Warsaw) *On optimal Harnack bounds for a non-local heat equation*	**Andrzej Myśliński** (Systems Research Institute Polish Academy of Sciences) *Topology optimization for static contact in elastoplasticity*
10:30 – 11:00	**Alessandro Milazzo** (Uppsala University) *The de Finetti problem with unknown competition*	**Jacopo Schino** (North Carolina State University) *Orbital stability of ground states to Schrödinger equations with mass constraints*	**Andrzej Nowakowski** (University of Łódź) *Approximate optimality conditions for control of coefficients in parabolic free boundary problem*
11:00 – 11:30	Coffee break		
	Session talks (Room A) **Stochastic control and games** Chair: Neofytos Rodosthenous	Session talks (Room B) **PDES in physics and biology**	Session talks (Room C) **Modeling, analysis and optimization in infinite dimensional dynamics [distributed parameter systems] with applications**
11:30 – 12:00	**Kristofer Lindensjö** (Stockholm University) *How to detect a salami slicer: a stochastic controller-and-stopper game with unknown competition*	**Jarosław Mederski** (Institute of Mathematics Polish Academy of Sciences) *Normalized ground states of the nonlinear Schrödinger equation with at least mass critical growth*	**Krzysztof Rutkowski** (Cardinal Stefan Wyszyński University in Warsaw) *Dynamical system related to a class of primal-dual algorithms for convex optimization*
12:00 – 12:30	**Jan Palczewski** (University of Leeds) *Non-zero sum game of exit from a stochastic market*	**Mario Fuest** (Leibniz University Hannover) *Finite-time blow-up in chemotaxis systems with a logistic source*	**Katarzyna Szulc** (Systems Research Institute Polish Academy of Sciences) *Numerical approximation of a stationary case of hinged-free plate under non-conservative forces*
12:30 – 13:00			**Jakub Kmec** (Palacký University in Olomouc) *Is continuum mechanics appropriate for modeling porous media flow?*
13:00 – 14:30	Lunch break		
14:30 – 17:30	Guided tours		

Thursday, July 7th

9:00 – 10:00	Plenary talk (Room A) **Lorena Bociu** (North Carolina State University) *Analysis and Control in Poroelastic Systems with Applications to Biomedicine* Chair: Arnd Rösch TALK ONLINE		
	Session talks (Room A) **Stochastic control and games** Chair: Said Hamadene	Session talks (Room B) **Numerics and analysis of optimal control problems with partial differential equations**	Session talks (Room C) **Inverse problems, Modeling and Analysis for Fractional PDEs**
10:00 – 10:30	**Maurycy Rzymowski** (Nicolaus Copernicus University in Toruń) *BSDEs with two optional barriers and extended Dynkin games*	**Constantin Christof** (Technische Universität München) *Semismoothness for solution operators of obstacle-type variational inequalities with applications in optimal control*	**Katarzyna Ryszewska** (Warsaw University of Technology) *A space-fractional Stefan problem*
10:30 – 11:00	**Tomasz Klimsiak** (Nicolaus Copernicus University in Toruń) *Non-semimartingale solutions to reflected BSDEs with applications to non-linear Dynkin games*	**Luis A. Fernández** (University of Cantabria) *Optimal control of a Gompertz-type model arising in chemotherapy for brain tumors*	**Masahiro Yamamoto** (The University of Tokyo) *Uniqueness for inverse source problem for time-fractional diffusion-wave equation without boundary conditions* TALK ONLINE
11:00 – 11:30	Coffee break		
	Session talks (Room A) **Stochastic control and games** Chair: Tomasz R. Bielecki	Session talks (Room B) **Numerics and analysis of optimal control problems with partial differential equations**	
11:30 – 12:00	**Said Hamadene** (Le Mans University) *Mean-field Doubly Reflected backward stochastic differential equations*	**Masoumeh Hashemi** (Heidelberg University) *Optimal Control of the Kirchhoff Equation*	
12:00 – 12:30	**Tyrone E. Duncan** (University of Kansas) *Absolute Continuity for Rosenblatt Measures* TALK ONLINE	**Dmitriy Leykekhman** (University of Connecticut) *Numerical Analysis of Sparse Initial Data Identification for Parabolic Problems from point measurements*	
12:30 – 13:00	**Bożenna Pasik-Duncan** (University of Kansas) *Stochastic Differential Games with Rosenblatt Processes*	**Annika Müller** (TU Dortmund University) *Finite element approximation of optimal control problems arising in data-driven analysis*	

13:00 – 14:30	Lunch break	
14:30 – 15:30	Plenary talk (Room A) **Michał Sierakowski** (IBM) *Cloud Native Machine Learning* **Piotr Biskupski** (IBM) *We're building the future of quantum together* Chair: Radosław Pytlak	
15:30 – 16:00	Coffee break	
	Session talks (Room A) **Machine learning based systems for articles classifications**	Session talks (Room B) **Numerics and analysis of optimal control problems with partial differential equations**
16:00 – 16:30	**Robert Waszkowski** (Military University of Technology, Tecna Ltd) *Machine learning based system supporting active learning approach in systematic literature reviews*	**Arnd Rösch** (Universität Duisburg-Essen) *Optimal control of a simplified mechanical damage model*
16:30 – 17:00	**Paweł Cichosz** (Warsaw University of Technology) *Text representation for classification models in systematic literature reviews*	**Fredi Troeltzsch** (Technische Universität Berlin) *On elliptic optimal control problems with control appearing nonlinearly in the state equation*
17:00 – 17:30	**Bogdan Jastrzębski** (Warsaw University of Technology) *Deep neural networks applied to text embeddings used in classifications processes*	**Max Winkler** (TU Chemnitz) *Finite element methods with boundary concentrated meshes for PDEs with irregular boundary*
17:30 – 18:00	**Radosław Pytlak** (Warsaw University of Technology) *Semantic approaches to articles representations used in classification processes*	**Irwin Yousept** (University of Duisburg-Essen) *Variational Source Conditions for Tikhonov Regularization with L^p-penalties*
19:00 – 23:00	Conference dinner „Zielony Niedźwiedź" Restaurant, Smolna 4	

Friday, July 8th

9:00 – 10:00	Plenary talk (Room A) **Birgit Rudloff** (Vienna University of Economics and Business) *Time (In)Consistency of multivariate Problems* Chair: Łukasz Stettner		
	Session talks (Room A) **Modeling in biosystems**	Session talks (Room B) **Multiple-criteria Analysis and Uncertainty Modelling in Energy Problems**	Session talks (Room C) **Stochastic control and games** Chair: Jan Palczewski
10:00 – 10:30	**Dominique Duncan** (University of Southern California) *Novel mathematical tools to study neurological diseases using multimodal data*	**Zixuan Zhang** (East China University of Science and Technology) *Model-based support for harmonization of investment and operation decisions in renewable energy systems* TALK ONLINE	**Tomasz R. Bielecki** (Illinois Institute of Technology *Time-inconsistent Markovian control problems under model uncertainty with application to the mean-variance portfolio selection*
10:30 – 11:00	**Piotr Regulski** (Medical University of Warsaw) *VisNow-Medical – A multi-platform modeling system for medical image processing* TALK ONLINE	**Bingqing Ding** (East China University of Science and Technology) *Hedging uncertainties in technological learning and exploring attainable goals for conflicting objectives in adopting new technologies* TALK ONLINE	**Łukasz Kruk** (Maria Skłodowska-Curie University) *A simple singular stochastic control problem with direction switching cost*
11:00 – 11:30	Coffee break		
	Session talks (Room A) **Modeling in biosystems**	Session talks (Room B) **Multiple-criteria Analysis and Uncertainty Modelling in Energy Problems**	
11:30 – 12:00	**Marek Niezgódka** **Artur Antoniewicz** (Multidisciplinary Hospital Warsaw Międzylesie) *A national modelling study of the impact of the COVID-19 pandemic on urological care in Poland*	**Zbigniew Nahorski** (Systems Research Institute Polish Academy of Sciences) *Effective handling of uncertain parameters in long-term technology-mix planning models* WITH STREAMING	
12:00 – 12:30	**Piotr Regulski** (Medical University of Warsaw) *Coronary Arteries Modelling and Visualization* TALK ONLINE	**Janusz Granat** (Warsaw University of Technology) *Multiple Criteria Analysis of Discrete Alternatives: Pairwise-outperformance based Approaches* WITH STREAMING	
12:30 – 13:00	Conference closing (Room A)		
13:00 – 14:30	Lunch break		

List of abstracts

Acoustic Full-Waveform Inversion via Optimal Control

Luis Ammann
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Full-waveform inversion (FWI) is a recent technique in seismic tomography to reconstruct physical parameters sampled by waves. Compared with other methods relying only on partial waveform information such as travel times or phase velocities, FWI exploits the entire waveform content. In this talk, we discuss an optimal control method for acoustic FWI. The aim is to reconstruct the speed wave parameter entering the hyperbolic PDE model in the coefficient of the second-order time derivative of the acoustic pressure. For the given optimization problem, we present necessary first-order optimality conditions based on adjoint techniques where the adjoint state has only low regularity properties. This is particularly favourable since then no Sobolev smoothing effect occurs in the optimal solution. Further, under specific regularity and compatibility assumptions, we present second-order sufficient optimality conditions. The talk will be concluded by numerical examples.

A national modelling study of the impact of the COVID-19 pandemic on urological care in Poland

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Piotr Regulski
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The COVID-19 outbreak has exposed major structural weaknesses in health, social, and financial policies and sectors. In Poland the outbreak impacted the resilience of the healthcare system, especially the urology. Our main focus was to estimate the burden of the SARS-CoV-2 pandemic on urological procedures and patient care in Poland. The model was trained and validated on the data aggregates containing the number of patients who underwent specific urological procedures before the pandemic, during lockdowns, and in-between the lockdown states. [1][2]

[1] A. Antoniewicz, W. Niemczyk, P. Regulski, M. Niezgodka, The impact of the COVID-19 pandemic on urological care in Poland - Post-COVID resilience scenarios and recommendations for healthcare system: A national population-based modelling study., *Archives of Medical Science*, 2021
[2] P. Regulski et al., Advanced methods of visual analysis and visualization of various aspects of the COVID-19 outbreak in Poland, *Procedia Computer Science*, 2021, 192, 4194-4199

Convergence of Deep Solvers for Semilinear PDEs

Christoph Belak
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We derive convergence rates for a deep solver for semilinear partial differential equations which is based on a Feynman-Kac representation in terms of an uncoupled forward-backward stochastic differential equation and a discretization in time. We show that the error of the deep solver is bounded in terms of its loss functional, hence yielding a direct measure to judge the quality in numerical applications, and that the loss functional converges sufficiently fast to zero to guarantee that the approximation error vanishes in the limit. As a consequence of these results, we show that the deep solver has a strong convergence rate of order 1/2.

Time-inconsistent Markovian control problems under model uncertainty with application to the mean-variance portfolio selection

Tomasz R. Bielecki
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In this talk we discuss a class of time-inconsistent terminal Markovian control problems in discrete time subject to model uncertainty. We combine the concept of the sub-game perfect strategies with the adaptive robust stochastic control to tackle the theoretical aspects of the considered stochastic control problem. As an important application of the theoretical results, by applying a machine learning algorithm, we solve numerically the mean-variance portfolio selection problem under the model uncertainty. The talk is based on [1]-[3].

[1] T.R. Bielecki, T. Chen and I. Cialenco, Time-inconsistent Markovian control problems under model uncertainty with application to the mean-variance portfolio selection, *International Journal of Theoretical and Applied Finance*, Vol. 24, No. 1 (2021)
[2] T.R. Bielecki, T. Chen, I. Cialenco, A. Cousin and M. Jeanblanc, Adaptive Robust Control Under Model Uncertainty, *SIAM Journal on Control and Optimization*, Vol. 57, No. 2 (2019)
[3] T.R. Bielecki, T. Chen and I. Cialenco, Recursive Construction of Confidence Regions, *Electronic J. of Stats*, Vol. 11, No. 2 (2017)

We're building the future of quantum together

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Analysis and Control in Poroelastic Systems with Applications to Biomedicine

Lorena Bociu
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Fluid flows through deformable porous media are relevant for many applications in biology, medicine and bio-engineering, including tissue perfusion, fluid flow inside cartilages and bones, and design of bioartificial organs. Mathematically, they are described by quasi-static nonlinear poroelastic systems, which are implicit, degenerate, coupled systems of partial differential equations (PDE) of mixed parabolic-elliptic type. We answer questions related to tissue biomechanics via well-posedness theory, sensitivity analysis, and optimal control for the poroelastic PDE coupled systems mentioned above. One application of particular interest is perfusion inside the eye and its connection to the development of neurodegenerative diseases.

Inverse Optimal Control Problems and Application to Modeling the Gait of Cerebral Palsy Patients

Hans Georg Bock
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We present numerical methods solving inverse optimal control problems as complex bi-level dynamic optimization problems: a nonlinear approximation problem on the upper level and a nonlinear optimal control problem (OCP) with discontinuities and mixed path-control constraints on the lower level. The OCP solution can be considered as a model that describes autonomous optimal processes in nature such as human gait. However, the optimal control model includes unknown parameters that need to be determined by fitting its solution to measurements in the upper level optimization. We develop a direct mathematical all-at-once approach for solving this new class of problems and apply this to derive biomechanical optimal control models for the gait of cerebral palsy patients from real-world motion capture data obtained by the Motion Lab of the Orthopedic University Hospital Heidelberg.

Nonlinear gas transport on a network of pipelines: analysis and control

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In this talk we present new results concerning the nonlinear transport of gas on a network of pipelines as well as PDE–contrained optimization problems with both control and state constraints arising from it. We model the gas dynamics on a given pipe via a suitable isothermal Euler semilinear system in one space dimension. Solutions satisfying the so called Kirchoff continuity condition at the nodes are constructed in the vicinity of an equilibrium state. Such solutions can be driven to a given target distribution by the means of suitable controls acting only at the boundary of the network.

Semismoothness for solution operators of obstacle-type variational inequalities with applications in optimal control

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Gerd Wachsmuth
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This talk is concerned with generalized differentiability properties of solution operators of elliptic obstacle-type variational inequalities. We prove that such operators are semismooth when considered as maps between suitable Lebesgue spaces and equipped with the strong-weak Bouligand differential as a generalized set-valued derivative. It is shown that this semismoothness allows to solve optimal control problems with H^1-cost terms and one-sided pointwise control constraints by means of a semismooth Newton method. The q-superlinear convergence of the resulting algorithm is established in the infinite-dimensional setting and its mesh independence is demonstrated in numerical experiments. The talk concludes with comments on further applications of the derived results in the context of quasi-variational inequalities and the optimal control of contact problems.

[1] C. Christof, G. Wachsmuth, Semismoothness for solution operators of obstacle-type variational inequalities with applications in optimal control, *preprint*, ArXiv:2112:12018

Text representation for classification models in systematic literature reviews

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This work investigates the utility of different types of text representations for creating classification models used as components of automated systematic literature review systems. The presented study uses the bag of words representation and selected representations based on word embeddings: *word2vec* [1], *GloVe* [2] and *fastText* [3]. Selected classification algorithms for tabular data are used: naive Bayes classifier, support vector machines, logistic regression, and random forest. Experiments are performed on datasets from systematic literature reviews in the medical domain [4]. The results confirm that the choice of text representation is essential for successful text classification. It turns out that while the standard bag of words representation is hard to beat, *fastText* word embeddings make it possible to achieve roughly the same level of classification quality with the added benefit of lower dimensionality and capability of handling out-of-vocabulary (previously unseen) words.

[1] T. Mikolov et al., Efficient estimation of word representations in vector space, *arXiv preprint*, 2013, arXiv:1301.3781

[2] J. Pennington et al., GloVe: Global vectors for word representation, *Proceedings of the 2014 Conference on Empirical Methods in Natural Language Processing (EMNLP-2014)*, 2014

[3] P. Bojanowski et al., Enriching word vectors with subword information, *arXiv preprint*, 2016, arXiv:1607.04606

[4] A. M. Cohen et al., Reducing workload in systematic review preparation using automated citation classification, *Journal of the American Medical Informatics Association*, 2006, 13, 206–219

Some Optimisation Problems in Insurance with a Terminal Distribution Constraint

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We study two optimisation settings for an insurance company, under the constraint that the terminal surplus at a deterministic and finite time T follows a normal distribution with a given mean and a given variance. In both cases, the surplus of the insurance company is assumed to follow a Brownian motion with drift.
First, we allow the insurance company to pay dividends and seek to maximise the expected discounted dividend payments or to minimise the ruin probability under the terminal distribution constraint. Here, we find explicit expressions for the optimal strategies in both cases: in discrete and continuous time settings.
Second, we let the insurance company buy a reinsurance contract for a pool of insured or a branch of business. To achieve a certain level of sustainability (i.e. the collected premia should be sufficient to buy reinsurance and to pay the occurring claims) the initial capital is set to be zero. We only allow for piecewise constant reinsurance strategies producing a normally distributed terminal surplus, whose mean and variance lead to a given Value at Risk or Expected Shortfall at some confidence level α. We investigate the question which admissible reinsurance strategy produces a smaller ruin probability, if the ruin-checks are due at discrete deterministic points in time. The talk is based on [1].

[1] K. Colaneri, J. Eisenberg, B. Salterini, Some Optimisation Problems in Insurance with a Terminal Distribution Constraint, *preprint*, ArXiv:https://arxiv.org/abs/2206.04680

Hedging uncertainties in technological learning and exploring attainable goals for conflicting objectives in adopting new technologies

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This paper describes a model for analyses of the technology adoption strategies for hedging uncertainties in technology learning and support analysis of simultaneously attainable goals for conflicting objectives. Technological learning is an endogenous mechanism of new technologies diffusion. Historical observations show that technological learning is uncertain. If decisions are based on deterministic learning rates, there is likely that future costs of technologies are underestimated. Therefore, the expected risk costs resulted from overestimating learning rates is represented by the corresponding criterion. Thus the considered criteria include the total cost, the CO2 emission, the risk measure, and the costs of promoting new technologies.

Novel mathematical tools to study neurological diseases using multimodal data

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The development of epilepsy after traumatic brain injury is a multifactorial process and crosses multiple modalities. Without a full understanding of the underlying biological effects, there are currently no cures for epilepsy. We have built a centralized data archive to house human and animal data post-traumatic brain injury that will allow the broader research community to access these shared data. We have also developed novel mathematical tools to identify and validate biomarkers of epileptogenesis in imaging and electrophysiology as well as in molecular, serological, and tissue data. Furthermore, we have developed other large-scale multimodal data archives, including the Data Archive for the BRAIN Initiative (DABI) and the COVID-19 Data Archive (COVID-ARC) to encourage collaboration and expedite research in these areas. The data archives that are described include efforts to standardize and harmonize the different data types to aid researchers in performing data analyses across different projects and data collection sites. Moreover, innovative mathematical methods are needed for the complex problems being studied associated with the various neurological diseases, such as epilepsy and traumatic brain injury.

Absolute Continuity for Rosenblatt Measures

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Rosenblatt measures describe the probability measures for Rosenblatt processes which can be considered as a non-Gaussian generalization of fractional Brownian motions and seem useful for noise models that require non-Gaussian distributions for the noise. Many applications of Brownian motions have used the absolute continuity of Wiener measures in an essential role for solutions. Thus it seems useful to obtain explicit Radon-Nikodym derivatives for some transformations of Rosenblatt processes. Some explicit Radon-Nikodym derivatives are described for affine and linear transformations of Rosenblatt processes.

Long time behavior of solutions to a nonlinear beam transmission problem

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Problems related to the study of stabilization and long-time behavior of transmission problems in elasticity with different properties of materials and nonlinear terms can be rarely found in the literature [1,3]. We discuss the well-posedness and qualitative properties of solutions related to the long-time behaviour of an elastic beam problem described by the full von Karman model whose part is subjected to a structural damping. The main aim of the present paper is to investigate the asymptotic behavior of the solutions to the problem considered no matter how small the dissipative part of the beam is [2].

[1] T. Fastovska, Decay rates for Kirchhoff-Timoshenko transmission problems, *Communications on Pure and Applied Analysis*, 2013, 12(6), 2645–2667
[2] T. Fastovska, Global attractors for a full von Karman beam transmission problem, *Communications on Pure and Applied Analysis*, submitted
[3] M. Potomkin, A nonlinear transmission problem for a compound plate with thermoelastic part, *Math. Meth. Appl. Sci.*, 2012, 35, 530–546

Optimal control of a Gompertz-type model arising in chemotherapy for brain tumors

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We introduce a system modeling drug concentration and tumor growth associated with chemotherapy treatments for brain tumors, including different pharmacodynamics. It consists of a second order linear ODE and a non-linear parabolic PDE of Gompertz-type (including the classical Fisher-KPP PDE). First, we establish that the system is well-posed in an appropriate setting. Secondly, we study several associated optimal control problem, showing the existence of solution and deriving the first order necessary optimality conditions.

Controllability and stabilization for a degenerate wave equation in non divergence form with drift

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We consider the problem

$$\begin{cases} u_{tt} - a(x)u_{xx} - b(x)u_x = 0, & (t,x) \in Q, \\ u(t,0) = 0, & t \in [0,+\infty), \\ u(0,x) = u_0(x), \quad u_t(0,x) = u_1(x), & x \in (0,1), \end{cases} \tag{1}$$

where $Q = (0,+\infty) \times (0,1)$, $f \in L^2_{\mathrm{loc}}[0,+\infty)$, $a, b \in C^0[0,1]$, $a > 0$ on $(0,1]$ and $a(0) = 0$. At $x = 1$ we consider different boundary conditions according to the considered problem. If we are interested in a controllability problem (see [2]), we assume

$$u(t,1) = f(t), \quad t \in [0,+\infty);$$

thus the function f acts as a boundary control and it is used to drive the solution to 0 at a given time T.

If we are interested in the stabilization problem (see [3]) we consider as a boundary condition the following damping one

$$u_t(t,1) + \eta u_x(t,1) + \beta u(t,1) = 0, \quad t \in [0,+\infty),$$

where η is a given function and β is a nonnegative constant. Clearly the presence of the drift term and the nondivergence form lead to a different setting with respect to the one in [1] and they give rise to some new difficulties. However, thanks to some suitable assumptions on the drift term, one can prove some estimates on the associated energy that are crucial to drive the solution to 0 at time T or to obtain a uniform exponential decay as $t \to +\infty$.

[1] F. Alabau-Boussouira, P. Cannarsa, G. Leugering, Control and stabilization of degenerate wave equations, *SIAM J. Control Optim.*, 2017, 55, 2052–2087
[2] I. Boutaayamou, G. Fragnelli, D. Mugnai, Boundary controllability for a degenerate wave equation in non divergence form with drift, *submitted*, pages 36
[3] G. Fragnelli, D. Mugnai, Linear stabilization for a degenerate wave equation in non divergence form with drift, *preprint*, pages 30

Finite-time blow-up in chemotaxis systems with a logistic source

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The possibility of finite-time blow-up is certainly one of the most striking features of the models for chemotactical behavior introduced by Keller and Segel in the 1970s. However, such a drastic form of pattern formation is not always desired from a modelling point of view and one way to counter the destabilizing effect of the taxis term is to add quadratic degradation terms modelling population growth. While it is well known that these modified systems admit global classical solutions in the two-dimensional settings, a recent result [1] shows that this is no longer the case (for a simplified system) in high dimensions.

After a brief introduction to chemotaxis systems (mainly with a logistic source), the talk will focus on the main ideas of the finite-time blow-up proof and discuss various challenges. The arguments employed are rather elementary and in particular familiarity with chemotaxis systems is not a prerequisite for this talk.

[1] M. Fuest, Approaching optimality in blow-up results for Keller-Segel systems with logistic-type dampening, *Nonlinear Differential Equations and Applications NoDEA*, 2021, 28, article no. 16

Optimal Control in Machine Learning to Model Approximation of Neural Network

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In the paper we present an optimal control approach to approximate a model defined by the neural network learned on a given empirical data (set of observations). Neural networks often are described as black-boxes which are difficult to evaluate – it is hard to say something different about their properties than very general results obtained on test data set. In some applications, like medicine or autonomous vehicles, it seems to be essential to be able to say not only that on test data we get some error but rather that error is constrained by ε for *every* data we can input to our system. To derive required theory and numerical algorithm, we use Vapnik's learning model [1] focusing on its crucial component: the machine learning block. We apply an optimal control theory to this block, which guarantees results correctness in terms of strict mathematical formulations as well as correct (optimal) model approximation with respect

to some defined functional. We propose a method of construction of a machine learning block to find an approximation of a model by using the system of semilinear elliptic differential equations with added a function describing systems uncertainties. It is well known that the set of observations for supervised learning of a neural network is generally insufficiently rich to ensure that trained neural network has a good answer for new, unknown, empirical data. On the other hand, very often we have additional information or knowledge on the problem the data represent. Our approach allows to include these information and knowledge in the construction of the model. We apply a modification of dual dynamic programming ideas to formulate a new optimization problem. Then we state and prove sufficient optimality conditions for an approximate solution to unknown function represented by neural network. As a result, we get that a neural network, represented as a function being a solution of the elliptic equation in machine learning block, satisfying the sufficient optimality conditions, approximate the best possible model with respect to the knowledge (information) implemented to the functional and given empirical data with error less than ε.

[1] Vapnik, Vladimir, The Nature of Statistical Learning Theory, *Springer New York*, 2000

Nonlocal Calderón Problem

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In this talk, we will discuss the Calderón type inverse problem of determining the coefficients of the nonlocal operators. In the mathematical literature, the method of Electrical Impedance Tomography which consists in determining the electrical properties of a medium by making voltage and current measurements at the boundary of the medium is known as Calderón's problem. We will introduce the nonlocal analog of it and further study the connection with the local analog as well.

Multiple Criteria Analysis of Discrete Alternatives: Pairwise-outperformance based Approaches

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This paper deals with new methods of multiple-criteria analysis of discrete alternatives based on the outperformance aggregations that take into account inter-alternative factors. The methods were developed and applied for analysis of future energy technologies. The analysis involved large numbers of both alternatives and criteria. Moreover, the analysis was made by a large number of stakeholders without experience in analytical methods. Therefore, a simple method for interactive preference specification was a condition for the analysis. A comparison of the methods and experience of using them will be discussed.

Crossing concave curves - first hitting times of Brownian motion via Linear Programming

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Boundary hitting of a Brownian motion (W_t) to a boundary b has been a topic of interest for many decades and could be considered a classic. One approach to this problem is the so called method of images, which, for a arbitrary given measure μ, considers boundaries b that are implicitly given as solutions to $\int r_\theta(t, b(t))\mu(d\theta) = 1$ for a given function r_θ. All b generated by this method are concave and analytical and their hitting distribution can be found explicitly in terms of μ. As the boundary b can in most cases not be recovered analytically, the inverse method of images tries to invert the process and find the measure μ for a given concave, analytical boundary b such that the above equality is fulfilled. In our talk we give a linear programming approach and use a duality argument from classic optimisation theory in order to derive sufficient conditions for a boundary b such that a representing measure μ exists. We also demonstrate a numerical implementation of this problem.

Mean-field Doubly Reflected backward stochastic differential equations

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We study mean-field doubly reflected BSDEs. Using the fixed point method, we show existence and uniqueness of the solution when the data which define the BSDE are p-integrable with $p = 1$ or $p > 1$. The two cases are treated separately. The talk is based on [1].

[1] Yinggu Chen, Said Hamadene, Tingshu Mu, Mean-Field Doubly Reflected Backward Stochastic Differential Equations, *preprint*, arXiv:2007.04598 (to appear in NACO)

[2] Djehiche, Boualem and Elie, Romuald and Hamadène, Said , Mean-field reflected backward stochastic differential equations, *preprint*, arXiv:1911.06079 (to appear in AAP)

[3] Djehiche, B., Dumitrescu R. , Zero-sum mean-field Dynkin games: characterization and convergence, *preprint*, arXiv:2202.02126

Optimal Control of the Kirchhoff Equation

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We consider an optimal control problem for the steady-state Kirchhoff equation, a prototype for nonlocal partial differential equations, different from fractional powers of closed operators. Existence and uniqueness of solutions of the state equation, existence of global optimal solutions, differentiability of the

control-to-state map and first-order necessary optimality conditions are established. The aforementioned results require the controls to be functions in H^1 and subject to pointwise upper and lower bounds. In order to obtain the Newton differentiability of the optimality conditions, we employ a Moreau-Yosida-type penalty approach to treat the control constraints and study its convergence. The first-order optimality conditions of the regularized problems are shown to be Newton diffentiable, and a generalized Newton method is detailed. A discretization of the optimal control problem by piecewise linear finite elements is proposed and numerical results are presented.

The talk is on joint work with Roland Herzog (Heidelberg).

Quasilinear Obstacle Problems in Ferromagnetic Shielding: Analysis and Optimal Control

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In this talk, we aim to discuss the analysis and optimal control of a quasilinear first kind variational inequality (VI) in magnetostatics, in which first order differential constraints are imposed. Based on a Moreau-Yosida approximation for the indicator function of a specific underlying zeroth order obstacle set, we construct a sequence of approximating quasilinear variational problems where the occurring max-operation is smoothed. The corresponding limiting analysis leads to a well-posedness result and entails a dual formulation for VI.

More importantly, our construction comprises sufficient regularity, providing a suitable tool for studying optimality conditions corresponding to the optimal control of VI. Here, due to the character of the first order constraint, the main difficulty is that the sequence of Lagrangian multipliers appearing in the smoothed problems is suffering from poor stability properties. Thus, the characterization of the limiting (dual) multiplier needs a detailed investigation in which projection arguments play a crucial role.

L^2 Regularized Control of Kantorovich Problems

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We study the effect of an L^2 regularization in a control problem that is constrained by a Kantorovich problem. We present a class of possible applications by means of a toy problem. Using a reverse approximation argument, we discuss the approximability of solutions of the unregularized problem by a sequence of solutions of the regularized problems. Under a set of mild assumptions, we present a sketch of proof for the discrete case and give an intuition of how this may help in solving the continuous case.

Feedback Control of Flow-Transport Systems

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In this talk, we mainly discuss the feedback control designs for flow-transport systems motivated by fluid mixing problems. The feedback laws are constructed based on the ideas of instantaneous control as well as a direct approximation of the optimality system derived from an optimal open-loop control problem. It can be shown that under appropriate numerical discretization schemes, two approaches generate the same sub-optimal feedback law. On the other hand, different discretization schemes may result in feedback laws of different regularity, which determine different mixing results. One of the major challenges is encountered in the analysis of the asymptotic behavior of the closed-loop systems, due to the absence of diffusion in the transport equation together with its nonlinear coupling with the flow equations. To address these issues, we first establish the decay properties of the velocity, which in turn help obtain the estimates on scalar mixing and its long-time behavior. Numerical experiments are conducted to demonstrate our ideas and compare the effectiveness of different feedback laws.

Distribution of local time of regular diffusions

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A new probabilistic insight into the structure of local time is presented. A convolution formula for the local time at 0 of Itô diffusions reflecting at 0 is obtained. A simple integro-differential equation for the cumulative distribution function of the local time is given. Finally, we give a probabilistic representation of a generalized Stroock-Williams equation.

On some inverse problems that use nonlocality of fractional derivatives

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We consider four inverse problems for time-fractional diffusion equation of the order $\alpha \in (0, 1)$ with final overdetermination. These are a problem to determine a time-dependent factor of a source term, a problem to reconstruct two time-dependent source components, a problem to identify a location and time history of a point source and a problem with unknown boundary conditions. A common feature of all these problems is that proofs of uniqueness use slow power-type asymptotics of Mittag-Leffler functions involved in solution formulas of corresponding direct problems. This is due to the nonlocality of the fractional derivative included in the diffusion equation.

Deep neural networks applied to text embeddings used in classifications processes

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The paper concerns an approach for the automation of systematic literature review (SLR) process. The aim of SLR process is to classify a set of articles on relevant and irrelevant according to a query formulated in the begininig of the process. SLR process is done manually be experts from the domain in which the query lies. Here, we propose to semi–automate the process by applying active learning approach which is based on machine learning classification models and on manual screening by experts a subset of articles ([1]). Using the classification model requires numerical representations of articles. The paper examines the justification for using, in semi–automated SLR process, representations based on a domain-specific language representation model pre-trained on large-scale biomedical corpora ([2],[3]).

[1] B.C. Wallace, et al., Semi-automated screening of biomedical citations for systematic reviews, *BMC Bioinformatics*, 2010, 11(55), 1–11
[2] J. Lee, et al., BioBERT: a pre-trained biomedical language representation model for biomedical text mining, *Bioinformatics*, 2020, 36 (4), 1234-–1240
[3] N. Warikoo, et al. , LBERT: Lexically aware Transformer-based Bidirectional Encoder Representation model for learning universal bio-entity relations, *Bioinformatics*, 2021, 37(3), 404—412

Long-run impulse control in the risk-sensitive framework

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We present some new results concerning the long-run impulse control problem with the risk-sensitive optimality criterion. Using purely probabilistic methods, we construct a solution to the optimality equation and characterise an optimal impulse control strategy for a wide class of continuous-time Feller-Markov processes. In the construction, we use some new results related to the risk-sensitive optimal stopping problems, discussed in [2]. The talk is based on the joint work with Marcin Pitera and Łukasz Stettner, published in [1].

[1] D. Jelito, M. Pitera, Ł. Stettner, Long-run risk sensitive impulse control, *SIAM Journal on Control and Optimization*, 2020, 58(4), 2446–2468
[2] D. Jelito, M. Pitera, Ł. Stettner, Risk sensitive optimal stopping, *Stochastic Processes and their Applications*, 2021, 136, 125–144

On the inverse problem of nonlinearity parameter imaging with ultrasound

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The importance of ultrasound is well established in the imaging of human tissue. In order to enhance image quality by exploiting nonlinear effects, recently techniques such as harmonic imaging and nonlinearity parameter tomography have been put forward. These lead to coefficient identification problems for quasilinear wave equations. Another characteristic property of ultrasound propagating in human tissue is frequency power law attenuation leading to fractional derivative damping models in time domain. In this talk we first of all dwell on modeling of nonlinearity on one hand and fractional damping on the other hand. Then we discuss the inverse problem of nonlinearity parameter imaging, that is, the recovery of the nonlinearity coefficient commonly labeled as B/A in the literature, which is part of a space dependent coefficient κ in fractionally damped versions of the Westervelt equation. Corresponding to the typical measurement setup, the overposed data consists of time trace measurements on some zero or one dimensional set Σ representing the receiving transducer array.

The talk is based on joint work with Bill Rundell, Texas A&M University [1], [2].

[1] Barbara Kaltenbacher, William Rundell, On the identification of the nonlinearity parameter in the Westervelt equation from boundary measurements, *Inverse Problems & Imaging*, 2021, 15, 865–891

[2] Barbara Kaltenbacher, William Rundell, On an inverse problem of nonlinear imaging with fractional damping, *Mathematics of Computation*, 2022, 91, 245–276

Inverse problems for diffusion equations using single measurement

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We consider the inverse problem of determining different type of information about a diffusion process, described by ordinary or fractional diffusion equations stated on a bounded domain, like the density of the medium or the velocity field associated with the moving quantities from a single boundary measurement. This properties will be associated with some general class of time independent coefficients that we recover from a single Neumann boundary measurement, on some parts of the boundary, of the solution of our diffusion equation with a suitable boundary input, located on some parts of the boundary. This talk is based on a joint work with Yikan Liu, Zhiyuan Li and Masahiro Yamamoto.

On a time-inconsistent optimal stopping problem with expectation constraint

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We consider the problem of optimally stopping a continuous-time process with a stopping time satisfying an expectation constraint, which turns out to be a time-inconsistent optimal stopping problem.

We first deal with precommitment strategies and transform the problem into an unconstrained control problem. This allows to characterize the value function in terms of the dynamic programming equation, which is here an elliptic, fully non-linear partial differential equation of second order.

Secondly, we present a game-theoretic approach and introduce mixed strategy stopping times as well as equilibrium strategies.

This talk is based on a joint work with Stefan Ankirchner, Sören Christensen, Thomas Kruse, and Boy Schultz.

Non-semimartingale solutions to reflected BSDEs with applications to non-linear Dynkin games

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Suppose we are given a probability space $(\Omega, \mathcal{F}, P)$ equipped with a right-continuous filtration $\mathbb{F} = \{\mathcal{F}_t, t \geqslant 0\}$ that satisfies usual conditions, and (possibly infinite) $\mathbb{F}$-stopping time T. Let ξ be an $\mathcal{F}_T$-measurable, integrable random variable, $\Omega \times \mathbb{R}_+ \times \mathbb{R} \ni (\omega, t, y) \mapsto f(\omega, t, y) \in \mathbb{R}$ be a function, which is $\mathbb{F}$-progressively measurable with respect to (ω, t), and L, U be $\mathbb{F}$-adapted càdlàg processes of class (D) that satisfy $L \leqslant U$ and

$$\limsup_{a\to\infty} L_{T\wedge a} \leqslant \xi \leqslant \liminf_{a\to\infty} U_{T\wedge a}.$$

The talk will be concerned with reflected backward stochastic differential equations (RBSDEs) of the form

$$dY_t = -f(t, Y_t)\,dt - dR_t + dM_t,\ L \leqslant Y \leqslant U,\ \lim_{a\to\infty} Y_{T\wedge a} = \xi, \tag{1}$$

and their connections with Dynkin games. A triple (Y, M, R) of $\mathbb{F}$-adapted càdlàg processes is called a solution to (1) if Y is of class (D), M is a local martingale with $M_0 = 0$, R is a predictable process of finite variation with $R_0 = 0$, and (1) is in force. In general, there is infinitely many solutions to (1). In order to get the uniqueness, an additional condition, called the minimality condition, is needed. It admits the following form

$$\int_0^T (Y_{t-} - L_{t-})\,dR_t^+ = \int_0^T (U_{t-} - Y_{t-})\,dR_t^- = 0. \tag{2}$$

In the first part of the talk, we will focus on the link between solutions to RBSDEs (1)–(2) and value processes in nonlinear Dynkin games, which is expressed via the following relation: for any stopping time $\alpha \leqslant T$,

$$Y_\alpha = \operatorname*{ess\,sup}_{\sigma\geqslant\alpha} \operatorname*{ess\,inf}_{\tau\geqslant\alpha} \mathbb{E}^f_{\alpha,\tau\wedge\sigma}\Big(L_\sigma \mathbf{1}_{\{\sigma<\tau\}} + U_\tau \mathbf{1}_{\{\tau\leqslant\sigma<T\}} + \xi \mathbf{1}_{\{\sigma=\tau=T\}}\Big), \tag{3}$$

where $\mathbb{E}^f$ is the nonlinear expectation generated by f.

In the second part of the talk, we will focus on the notion of RBSDEs. The crucial part of the definition of a solution to (1)–(2) is the minimality condition (2) (also called the Skorokhod condition). It involves the predictable finite variation part of Y, which forces the semimartingale structure of solutions. In consequence, the theory of RBSDEs is well-posed under Mokobodzki's condition on the barriers L, U. On the other hand, it is well known that in some instances the family of random variables given by the right-hand side of (3) may be aggregated to a cádlág process even if Mokobodzki's condition does not hold, and so, there arises a natural question whether such a process is related to some unique solution to (1). Our goal is

to extend the notion of RBSDEs and provide the existence and uniqueness results in order to get one-to-one correspondence between solutions to RBSDEs (1) and value processes in nonlinear Dynkin games (3).

[1] T. Klimsiak, Non-semimartingale solutions of reflected BSDEs and applications to Dynkin games, *Stochastic Process. Appl.*, 2021, 134, 208–239

Is continuum mechanics appropriate for modeling porous media flow?

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Continuum modeling assumes that the porous medium is treated as continuum using the concept of a representative elementary volume (REV). Thus, the main assumption of continuum modeling is not valid when continuum-based models are used to describe flows with sizes smaller than REV. However, in the case of a porous medium, the REV has size of centimeters. Below the REV, all the physical properties depend on the sample dimension, which is not considered in continuum models. We introduce a new approach: semi-continuum modeling. The basic idea of the semicontinuum model is to account for the sample size. The retention curve (saturation-pressure relationship) scales with the sample size and becomes in the limit a Prandtl-type hysteresis operator used in elastoplasticity. The formal limit of the semi-continuum model switches between parabolic and hyperbolic partial differential equations. Most of the talk is based on [1].

[1] R. Vodák, T. Fürst, M. Šír, J. Kmec, The difference between semi-continuum model and Richards' equation for unsaturated porous media flow, *Scientific Reports*, 2022, 12(7650)

A simple singular stochastic control problem with direction switching cost

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In singular stochastic control problems, one attempts to control an n-dimensional diffusion (e.g., the Brownian motion) by adding a process with paths of locally bounded variation. The corresponding control cost is proportional to the variation of the used control. Problems of this kind have found numerous applications in engineering, communications, queueing systems, mathematical biology and finance. See [1], Chapter VIII, for an introduction to this area and references.

The aim of this talk is to introduce, by means of a relatively simple one-dimensional example, an apparently new class of singular stochastic control problems in which the process controller not only chooses the push intensity, at a price proportional to the displacement caused by his action, but he can also change the allowable control direction, paying a fixed cost for each such switching.

[1] Fleming, W. H., Soner, H. M., Controlled Markov Processes and Viscosity Solutions, 2nd Edition, *Springer, New York*, 2006

Nonlinear and linearized models in thermoviscoelasticity

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We consider a quasistatic nonlinear model in thermoviscoelasticity at a finitestrain setting in the Kelvin-Voigt rheology where both the elastic and viscous stress tensors comply with the principle of frame indifference under rotations.

The force balance is formulated in the reference configuration by resorting to the concept of nonsimple materials whereas the heat transfer equation is governed the Fourier law in the deformed configurations. Weak solutions are obtained by means of a staggered in-time discretization where the deformation and the temperature are updated alternatingly. Afterwards, we focus on the case of deformations near the identity and small temperatures, and we show by a rigorous linearization procedure that weak solutions of the nonlinear system converge in a suitable sense to solutions of a system in linearized thermoviscoelasticity. The same property holds for time-discrete approximations and we provide a corresponding commutativity result. This is a joint work with R. Badal and M. Friedrich (both Erlangen).

Boundary feedback stabilization of a critical nonlinear JMGT equation with Neumann-undissipated part of the boundary

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The JMGT [Jordan-Morse -Gibbson -Thompson] equation is a Partial Differential Equation (PDE) model introduced to describe a nonlinear propagation of sound in an acoustic medium. The interest in studying this type of problems is motivated by a large array of applications arising in engineering and medical sciences-including high intensity focused ultrasound [HIFU] technologies. The important feature is that the model avoids the infinite speed of propagation paradox associated with a classical second order in time equation referred to as Westervelt equation. Replacing Fourier's law by Maxwell-Cattaneo's law gives rise to the third order in time derivative scaled by a small parameter $\tau > 0$, the latter represents the thermal relaxation time parameter and is intrinsic to the medium where the dynamics occurs. In this talk we will present several results pertinent to the model, mostly from the point of view of boundary control and stabilization. These include: (i) local and global wellposedness of the nonlinear JMGT model, (ii) asymptotic analysis of the model when the parameter of relaxation goes to zero, (iii) boundary stabillizability of JMGT in the critical and degenerate case, (iv) feedback boundary control for infinite horizon optimal control problem.

On some properties of the Riemman ζ function

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We consider infinite programming problems with constraint sets de-fined by systems of infinite number of inequalities and equations given by continuously differentiable functions defined on Banach spaces. In the approach proposed here we represent these systems with the help of coefficients in a given Schauder basis. We prove the Abadie condition under the new infinite-dimensional Relaxed Constant Rank Constraint Qualification Plus and we dis-cuss the existence of Lagrange multipliers. The main tools are: Rank Theorem and Ljusternik Theorem.

[1] E. Bednarczuk, K. Leśniewski, K. Rutkowski, Abadie condition for infinite programming problems under Relaxed Constant Rank Constraint Qualification Plus, *preprint*, arXiv:2112.07460

Numerical Analysis of Sparse Initial Data Identification for Parabolic Problems from point measurements

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We are given a set of points $\{\xi_i \in \Omega : \ i = 1, ..., M\}$ for a given number M of pointwise evaluations. Furthermore, we are given the evaluations $\mathcal{U}_i \in \mathbb{R}, i = 1, ..., M$ of the state at the end time in these points. With the space $\mathcal{M}$ defined, we consider the following problem formulation:

$$\min_{q\in\mathcal{M}(\Omega)} \frac{1}{2}\left(\sum_{i=1}^{M} \left(u(\xi_i) - \mathcal{U}_i\right)^2\right) + \alpha\|q\|_{\mathcal{M}(\Omega)}, \tag{1}$$

where the state u and the control q are coupled by the heat equation

$$\begin{cases} \partial_t u - \Delta u = 0 & \text{in} \quad (0,T)\times\Omega, \\ u = 0 & \text{on} \quad (0,T)\times\partial\Omega \\ u(0) = q & \text{in} \quad \Omega, \end{cases} \tag{2}$$

In particular we are interested in pointwise error estimates in the case when the initial condition q is a measure $q \in \mathcal{M}(\Omega)$ compactly supported in Ω, for example a linear combination of Dirac delta functions, i.e $q = \sum_j \beta_j \delta_{x_j}$. Our main result of this paper is the establishment of the fully discrete error estimates of the form

$$\|(u - u_{kh})(T)\|_{L^\infty(\Omega_0)} \leqslant C(T)\left(k^{2r+1} + \ell_{kh}h^{s+1}\right)\|u(0)\|_{\mathcal{M}(\Omega)}, \tag{3}$$

where $\operatorname{supp} q \subset \Omega_0 \subset\subset \Omega$, $r \geqslant 0$ is the order time discretization, and $s = 1, 2$ is the order of the space discretization, and ℓ_{kh} is a logarithmic term that depends on the mesh size h and time the maximum time step k. The piecewise linear case $s = 1$ does not require any additional smoothness assumptions beyond regularity results available on convex domains Ω, the higher order convergence $r = 2$ requires some additional smoothness assumptions which are available for example on rectangular domains

Under some additional structure assumptions, we will prove convergence rates for the positions of the support points and of the corresponding coefficients. We will describe the numerical solution algorithm and illustrate the theoretical results with several numerical examples.

How to detect a salami slicer: a stochastic controller-and-stopper game with unknown competition

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A stochastic controller-and-stopper game for fraud detection is introduced. A process

$$X(t) = -\theta\Lambda(t) + W(t)$$

represents the holdings of an account holder (player 1), where $\theta\Lambda(t)$ is the accumulated amount stolen by a fraudster (player 2) and θ is a Bernoulli random variable indicating whether the fraudster is active or not, and $W(t)$ is a Brownian motion. The fraudster seeks to choose the fraud strategy process $\Lambda(t)$ that maximizes the expected discounted amount stolen whereas the account holder—who observes only the path of $X(t)$ and hence cannot know if fraud occurs—seeks to choose a stopping time that deactivates the fraudster, at cost $M > 0$, and minimizes the expected discounted cost of fraud and deactivation. By developing a stochastic filtering method, we find explicit Nash equilibria of both pure and mixed type. The talk is based on [1].

[1] E. Ekström, K. Lindensjö, M. Olofsson, How to detect a salami slicer: a stochastic controller-and-stopper game with unknown competition, *SIAM Journal on Control and Optimization*, 2022, 60(1), 545–574

Mixed strategies for time-inconsistent stopping

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Standard Markovian optimal stopping problems are consistent in the sense that the optimal stopping rule 'stop the first time the state process enters the stopping region' is independent of the starting value of the state process. Problems without this consistency property are known as time-inconsistent. We have developed a game-theoretic framework for time-inconsistent stopping problems relying on mixed (i.e., randomized) stopping strategies.

Based on joint work with Andi Bodnariu & Sören Christensen.

Optimal control using to approximate probability distribution of observation set

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We discuss the problem of an approximate calculation of unknown probability distribution function defining an observation set. The observation set is usually used as a supervised set to train a neural network or to build functions for machine learning. In order to solve the problem, we propose applying optimal control tools. To this effect following Vapnik, we define the risk functional depending on probability distribution functions, and we construct a set of functions based on the observation set. The construction draw on using only those functions that satisfy some differential equation with suitable properties as it

is usually done in optimal control theory. Next, we apply a dual dynamic programming to formulate a new optimal control problem. As a consequence, we state and prove a verification theorem for an approximation of an unknown probability distribution function defining the observation set. We estimate the difference between the approximate probability distribution function and the best probability distribution with distance defined by the risk functional.

Improved Regularity for Sequential Linear Integer Programming for Integer Optimal Control

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We consider optimal control problems, where the controls act on one-dimensional domains and may attain only finitely many different integer values. The considered optimal control problems are regularized with a switching cost penalty term in the objective. In order to solve these problems, a trust-region algorithm that solves a sequence of linear integer programs (after discretization) has been proposed recently in [1]. We discuss several seemingly restrictive assumptions on the problem in [1], how they may be overcome with suitable smoothing, and give an outlook on the two-dimensional case.

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Mathematical hematology: Model-based approach to understand cancer heterogeneity and resistance to therapy

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The talk is devoted to mathematical modelling of acute leukemias that are cancerous diseases of the blood forming (hematopoietic) system. They are derived from a small population of leukemic stem cells (LSC) that out-compete hematopoietic stem cells (HSC) which are required for blood cell formation. Experiments suggest that differences in the interaction between healthy and malignant cells contribute to the observed inter-patient heterogeneity. These interactions include leukemic cell response to long-range feedbacks, e.g., hematopoietic growth factors and competition of stem cells for spaces in a supportive stem cell niche. We use a combination of analytical results, computer simulation and patient data analysis to provide insights into clinically relevant questions regarding inter-patient and inetr-cellular heterogeneity of the disease and its impact on the patient prognosis.

Fixed-time anti-synchronization for reaction-diffusion neural networks

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Artificial neural networks are described mathematically usually by ordinary differential equations. However, if we want to take into account in a model characteristics of particular neurons e.g. spatiotemporal

memories, then it is necessary to extend the time variable t on a space variable x. In such cases reaction-diffusion neural networks (RDNNs) are of particular interest (see e.g. [3]), which have also great usefulness in bioscience, physics or chemistry (compare e.g. [2], [8], [9], [12]). Hence in last ten years many papers have been appeared, investigated different problems related to RDNNs. The most important results concern synchronization, stability and passivity. The results in those papers have been based on Lyapunov stability (see e.g. [6]). It should be noted that in all mentioned articles the coefficients appearing in the modeled networks are independent of time and spatial variables. In [10] the model of RDNNs contains coefficients depending on time and discontinuous neuron functions. We consider more general model: our coefficients and non-linearity depend not only on time, but also on spatial variable. However, we do not consider discontinuous neuron function, as we concentrate on a new approach to study fixed-time stability or anti-synchronization. In last ten years articles related to synchronization, anti-synchronization and fixed-time synchronization, investigate multiple RDNNs with different terms and different kinds of coupling topologies [7], [11], [13]. It should be stressed that in those articles we find also a strong concernment for real using of anti-synchronization and fixed-time synchronization. Traditionally, to prove the fixed-time synchronization or anti-synchronization suitable convergence lemmas are used. But they work only for parameters of the system being constants or in the case of their modifications to be dependent only on time t (see [10]). Because we work with parameters and neuron functions dependent on time and spatial variables, we develop quite new approach to study fixed-time synchronization and anti-synchronization. Lastly both finite-time synchronization and fixed-time synchronization are studied as a unified framework (see e.g. [4], [5]). We follow the same way. But contrary to those papers we are not base on Lyapunov's stability method. The new optimal control approach to finite-time synchronization allows to give up on Lyapunov's function method. It is well known that studying finite-time synchronization alternative controls were developed (see e.g. [1], [7], [13]). Using of control strategies to attain the fixed-time synchronization have been our motivation to try to apply and develop optimal control theory for getting the best fixed-time synchronization.

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Normalized ground states of the nonlinear Schrödinger equation with at least mass critical growth

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We present a simple minimization method to show the existence of normalized ground state solutions to the nonlinear Schrödinger equation with at least mass critical and Sobolev-subcritical growth. Our approach is based on the direct minimization of the energy functional on the linear combination of Nehari and Pohozaev constraints. A crucial step is the application of the profile decomposition theorem involving a general Sobolev-subcritical nonlinearity. The talk is based on [1,2].

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The de Finetti problem with unknown competition

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We consider a resource extraction problem which extends the classical de Finetti problem for a Wiener process to include the case when a competitor, who is equipped with the possibility to extract all the remaining resources in one piece, may exist; we interpret this unknown competition as the agent being subject to possible fraud. This situation is modelled as a controller-and-stopper nonzero-sum stochastic game with incomplete information. In order to allow the fraudster to hide his existence, we consider strategies where his action time is randomised. Under these conditions, we provide a Nash equilibrium which is fully described in terms of the corresponding single-player de Finetti problem. In this equilibrium, the agent and the fraudster use singular strategies in such a way that a two-dimensional process (X, Π), which represents available resources and the filtering estimate of active competition, reflects in a specific direction along a given continuous and monotone boundary.

Finite element approximation of optimal control problems arising in data-driven analysis

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We consider a data-driven approach for the identification of a conductivity material law from discrete measurements. The problem is reformulated as an optimal control problem and discretized by Raviart-Thomas finite elements. We show the convergence of the discretized solutions to a so-called data-driven limit as the mesh size tends to zero and the data set becomes more and more accurate. Numerical experiments illustrate our theoretical findings.

Topology optimization for static contact in elastoplasticity

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Topology optimization problem is considered for the contact between elasto-plastic rather than elastic structures and the foundation. This contact phenomenon with a given friction is described by the system of the coupled variational inequalities in terms of the displacement and the generalized stress of the structure. The domain occupied by the structure is the control variable. The structural optimization problem consists in finding such material distribution inside the domain occupied by the structure in contact to minimize the normal contact stress. The system of variational inequalities is approximated by the system of nonlinear equations. The existence of solutions to the state system is shown. The differentiability of the control-to-state map is proved. The shape differentiability of the cost functional is shown. First-order necessary optimality conditions are formulated. Generalized Newton as well as the level set methods are used to solve numerically this optimization problem. Numerical results are provided.

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[2] A.Myśliński, Topology Optimization of Elasto-Plastic Structures in Contact, *SCIPEDIA*, 2021, DOI: 10.23967/wccm-eccomas.2020.346

Effective handling of uncertain parameters in long-term technology-mix planning models

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The presentation focuses on methodology of effective treatment of uncertain parameters of deterministic models characterized by: (i) a long (e.g., at least 50 years) planning horizon of investments, and the corresponding use of resources, (ii) a small number of considered uncertain parameters. Each such parameter is evaluated using the corresponding long time-series of data that are typically characterized by a multi-modal distribution and a large range of values. The problem is to select future values of the parameters. The proposed approach consists of choice of the parameter values that minimizes the cost risk. The approach is illustrated by the model developed for analysis of technology pathway of China liquid fuel production with consideration of uncertain price of the imported crude-oil, which determines the largest cost-component of the currently dominant technology of producing liquid fuel.

Multivariate Markovian Hawkes processes

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A very interesting and important class of stochastic processes was introduced by Alan Hawkes in [1]. These processes, called now Hawkes processes, are meant to model self-exciting and mutually-exciting random phenomena that evolve in time. The self-exciting phenomena are modeled as univariate Hawkes

processes, and the mutually-exciting phenomena are modeled as multivariate Hawkes processes. In this talk we provide some results on markovianity of the Generalized Multivariate Hawkes Processes (GMHP) introduced in our earlier papers. GMHP are multivariate marked point processes that add an important feature to the family of the (classical) multivariate Hawkes processes: they allow for explicit modelling of simultaneous occurrence of excitation events coming from different sources, i.e. caused by different coordinates of the multivariate process. It is well known that classical multivariate Hawkes processes with exponential kernels leads to some multivariate Markov processes. We provide results which goes far beyond exponential kernels and show that under some conditions on kernels the intensities of GMHP's are functions of Markov processes. Moreover we show that it is possible to compute their Laplace transform by means of system of ODE's.

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[3] T.R. Bielecki, J. Jakubowski, M. Niewęgłowski, Structured dependence between stochastic processes, *Cambridge University Press*, 2020

[4] T.R. Bielecki, J. Jakubowski, M. Niewęgłowski, Multivariate Markovian Hawkes processes with applications, *Preprint*, 2022

A phase-field approach to shape and topology optimization of acoustic waves in dissipative media

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We discuss the problem of finding the optimal shape and topology of a system of acoustic lenses in a dissipative medium, where the sound propagation is governed by a general semilinear strongly damped wave equation. We introduce a phase-field formulation of this problem through diffuse interfaces between the lenses and the surrounding fluid. The resulting formulation is shown to be well-posed and we rigorously derive first-order optimality conditions for this problem. Additionally, we establish a relation between the diffuse interface problem and a perimeter-regularized sharp interface shape optimization problem via the Γ-limit of the reduced objective. The talk is based on [1].

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Nonlinear acoustic modeling based on fractional heat flux laws

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In this talk, we will discuss mathematical modeling of nonlinear sound propagation based on using the fractional Compte–Metzler heat flux laws [1] within the system of governing equations. The order in time of the resulting acoustic equations depends on whether these laws are used in their original form or recast as Gurtin–Pipkin flux laws. Besides discussing the modeling aspects, we will also touch upon the well-posedness analysis of the resulting nonlinear wave equations on finite time intervals. The talk is based on [2] and ongoing joint work with Barbara Kaltenbacher (University of Klagenfurt) and Mostafa Meliani (Radboud University).

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Approximate optimality conditions for control of coefficients in parabolic free boundary problem

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We investigate the identification problem for the one-phase Stefan problem. As the inverse Stefan problem is not well posed an optimal control problem is considered instead. In the paper we develop a dual dynamic programming approach to derive approximate optimality conditions for that optimal control problem. As a next step we formulate and prove a verification theorem for approximate solutions. The verification theorem is a basis to develop numerical algorithm. Having the verification theorem we do not need a convergence of our algorithm.

Non-zero sum game of exit from a stochastic market

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The timing of strategic exit is one of the most important but difficult business decisions, especially under competition and uncertainty about future profits. We examine a game of exit in a stochastic market when firms, additionally, do not know their competitor's exit barrier. Because a competitor's exit improves a firm's profit, the exit decision is beset with a free-rider problem. Mathematically, the problem is described by a non-zero sum stopping game with asymmetric information. The market uncertainty, observed by both players, is represented by a general one-dimensional diffusion. Under the condition that a single player exit problem has a solution of a threshold type, we construct a symmetric equilibrium in randomised strategies. This equilibrium is further shown to be unique in a certain class of symmetric strategies.

Stochastic Differential Games with Rosenblatt Processes

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In many physical systems, empirical analysis shows that the noise in these systems cannot be reasonably modeled by a noise having a Gaussian distribution. Rosenblatt processes are a family of non-Gaussian processes that have a useful stochastic calculus that allows for the explicit solution of some stochastic differential games. Some examples are given for linear systems with Rosenblatt noise and long range quadratic cost criteria where explicit optimal strategies can be obtained.

Coupled systems across the scales in the subsurface. Models or data?

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The subsurface under the Earth's crust is the region where the coupled processes of flow, reactive transport with phase change, heat conduction and mechanical deformation work silently together from the nanometer scale of the micropores to the kilometer scale of the Arctic and subsea sediments and react to human activity over the time scales from seconds to kiloyears. There is clear motivation to develop scientific tools to support the data collection and to inform the decision making. Yet we may be at a crossroads.

In the presentation we first describe some successes towards the understanding of this coupled multiscale dynamics when the pore scale domain is changing during (i) thawing permafrost, (ii) methane hydrate destabilization, or (iii) microbial plugging. We follow the traditional route involving partial differential equations modeling, analysis, and simulation: we identify and address the challenges including the multivalued semismooth nonlinearities and heterogeneity. We work closely with data and realistic scenarios, but the complexity is overwhelming.

Recently, spectacular successes are reported for input-output algorithms which aim to replace the complex continuum models. These require a paradigm shift in the training of next generation scientists, while the training of the models themselves likely requires blending an in-depth domain knowledge with the data-born algorithms. In this direction, we present some of our recent work towards the adaptive and reduced modeling approaches for the applications (i-iii). The research involves many collaborators who have inspired and advanced this work and who will be acknowledged in this talk.

Long-run risk-sensitive stochastic control: entropic formulation and MPE existence

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In this talk we discuss long-run risk sensitive control problems in discrete time. We discuss entropic problem formulation and show why it leads to a natural problem statement in various financial applications. Also, using the span-contraction approach, we show how the underlying reward function span-norm in

linked to the entropic risk-aversion and to the existence of the solution to the underlying Multiplicative Poisson Equation.

Semantic approaches to articles representations used in classification processes

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The paper presents an approach for articles representations with the help of of ontologies. The approach uses text annotation based on given ontologies. Dictionary based annotators are used in order to tag text with concepts from the ontologies. On that basis the bag of concepts is created which can be used to define numerical representation of articles in a similar way it is done in the bag of words approach ([1]). The paper discusses several versions of the bag of concepts approach including the one in which the bag of concepts is extended by the concepts which lie by a given distance on paths from the originally identified concepts to the root of the ontology tree ([2]).

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Highly risk-averse investors in mean-reverting market models

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We support the the common advice of "reduce risk with age" by rigorous mathematics. We show that, in a mean-reverting market, it is asymptotically optimal for investors with exponential utility to keep less and less in the risky asset. This is in contradiction with Merton's finding in the Black-Scholes model, where a constant position is optimal. The strength of the mean reversion determines the rate of liquidating the positions. Our results apply, in particular, to commodity markets. Joint work with Paolo Guasoni and Lorant Nagy.

VisNow-Medical – A multi-platform modeling system for medical image processing

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VisNow-Medical platform contains a set of specific algorithms for visual analysis of medical data and is a plugin for VisNow platform used for image processing and visualization. VisNow-Medical platform accentuates on the ease of development of case-specific, multi-platform medical applications, with the opportunity of processing 1D, 2D, and 3D data in terms of filtering, segmentation, denoising, classification, mapping, qualitative and quantitative visual processing. VisNow-Medical facilitates the research process in medical field. We present several applications of VisNow-Medical platform for computed tomography, magnetic resonance, and image processing applications. [1][2][3]

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Coronary Arteries Modelling and Visualization

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The main causes of death in many countries, including Poland, are heart and circulatory system diseases. Among them, the highest risk of death is coronary heart disease and its complications. The diagnosis is based on the detection of atherosclerotic changes in the coronary arteries (CA), causing narrowing of the vessel lumen or changes causing blood clots. CA stenosis leads to reduced blood supply to the heart muscle. The essence of this disease is usually a periodic imbalance between the heart muscle's demand for oxygen and the possibilities of oxygen supply. When significant stenosis (SSt) is detected that causes perfusion disorders (ischaemia) of the heart muscle, the treatment of choice is percutaneous coronary intervention (PCIs), including percutaneous coronary angioplasty or surgical bypass surgery. Treatment of SSt differs in the degree of difficulty of the procedure and the likelihood of complications. A great facilitation in PCI procedures is the ability to accurately reproduce the 3D anatomy of the CA's system before the planned intervention. We would like to present the possibilities of mathematical modelling and visual analysis in accurate reconstruction of coronary arteries and blood flow simulation. This research was funded in whole or in part by National Science Centre, Poland, 2021/43/D/NZ5/02012. For the purpose of Open Access, the author has applied a CC-BY public copyright licence to any Author Accepted Manuscript (AAM) version arising from this submission.

Two-sided Singular Control of an Inventory with Unknown Demand Trend

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We study the problem of optimally managing an inventory with unknown trend. Our formulation leads to a stochastic control problem under partial observation, in which a Brownian motion with non-observable drift can be singularly controlled in both an upward and downward direction. After first deriving the equivalent Markovian problem, we then aim at solving this completely. We show substantial regularity of its value function, we construct an optimal control rule, and we show that the free boundaries delineating action and inaction regions are Lipschitz continuous. Our approach uses the transition amongst three different but equivalent problem formulations and a link between two-dimensional bounded-variation stochastic control problems and games of optimal stopping. In order to show that the value function of the control problem possesses the sufficient regularity needed to perform a verification theorem, we develop a probabilistic method in combination with refined viscosity theory arguments. This is joint work with Giorgio Ferrari and Salvatore Federico.

Optimal control of a simplified mechanical damage model

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We introduce a mechanical damage model with two damage variables. One of them describes the propagation of the damage in space, the other one in time. This leads to a coupled system of an elliptic PDE for every time point and an ODE for every point in the spatial domain. We discuss a simpler model which still contains the main difficulties of the problem and present new theoretical results. The main topic will be the existence of an optimal control. This talk is joint work with Marita Holtmannspötter.

Time (In)Consistency of multivariate Problems

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In several time-inconsistent problems, the time-inconsistency is due to the fact that the underlying problem is multi-variate in some sense. Examples include the multi-objective problems like the mean-risk problem, Nash equilibria in a dynamic game, or dynamic risk measure in a market with frictions. What unifies these examples is that one can formulate these problems with a set-valued value function.

In this talk, the Bellman's principle is extended to value functions that are set-valued. It is shown that the problems mentioned above do satisfy this Bellman's principle under reasonable assumptions and are thus actually time-consistent in a set-valued sense. That means, that problems that were previously thought to be time in-consistent, are in fact time-consistent in a sense that takes the multi-variateness of the underlying problem into account, and thus provides a more appropriate concept of time-consistency. Practical implications, economic interpretations, and the connection to the scalar time-(in)consistency are discussed. Numerical examples are given which lead in the discrete time setup to a sequence of vector optimization problems solved backwards in time.

Even a dynamic game fits into this structure, as we can shown that the set of all Nash equilibria of a non-cooperative game coincides with the set of all Pareto solutions of a certain vector optimization problem. This is true for all shared constraint games, and in a similar form also for generalized games and vector-valued games.

This is joint work with Zachary Feinstein and Gabriela Kovacova.

On Recovering the Fractional Damping Operator in a Wave Equation from Time Trace Data

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This paper deals with the inverse problem of recovering an arbitrary number of fractional damping terms in a wave equation. We develop several approaches on uniqueness and reconstruction, some of them relying on Tauberian theorems that provide relations between the asymptotic behaviour of solutions in time and Laplace domains. The possibility of additionally recovering space-dependent coefficients or initial data is discussed. The resulting methods for reconstructing coefficients and fractional orders in these terms are tested numerically and we give an indication of the underlying analysis of both the forwards and the inverse problem. The talk is based on [1].

[1] B. Kaltenbacher and W. Rundell, Determining damping terms in fractional wave equations, *Inverse Problems*, 2022, 38 075004

Dynamical system related to a class of primal-dual algorithms for convex optimization

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In this talk we discuss an autonomous ordinary differential equation related to the Haugazeau algorithm for finding a fixed point of an operator, including fixed points of primal-dual inclusion problems, i.e., Kuhn Tucker set of solutions. From the geometrical properties of vecor field related to Haugazeau step we show that the solution of proposed ODE exists and is unique on the half-line. We also relate the trajectory of ODE as the limiting case of relaxed version of Haugazeau algorithm.

The talk is based on the common work [1].

[1] E. M. Bednarczuk, R. N. Dharam K. E. Rutkowski, Dynamical System Related to Primal–Dual Splitting Projection Methods, *Journal of Dynamics and Differential Equations*, 2021

On utility based pricing of contingent claims in finite discrete time

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We study the problem of maximizing expected utility of terminal wealth for an agent whose income is represented as a random bounded endowment. We want to characterize the marginal utility-based prices in a discrete time model of an incomplete financial market. For this purpose we use a duality approach and extend the dual domain to an appropriate subset of $(\mathbb{L}^\infty)^*$, the dual space of $\mathbb{L}^\infty$. Also, we comment a lack of uniqueness of conditional Davis price when the dual utility problem admits a non-σ-additive optimizer, and show that marginal utility-based price is always arbitrage-free.

A space-fractional Stefan problem

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In this talk we will consider a non-local in space, one-phase one-dimensional Stefan problem, where the diffusive flux takes the form of the fractional Caputo derivative. The motivation for studying such a problem originates from modelling the diffusion and mass transport in heterogeneous media. A typical example of such phenomenon is a sub-surface water motion. During the talk we will present the result concerning existence of solution to this problem in the case when initially the domain consists of liquid and solid part. Then, we will construct a solution to the problem with no liquid initial domain. The results presented during the talk come from [1] and [2].

[1] K. Ryszewska, A space-fractional Stefan problem, *Nonlinear Analysis*, 199:112027, 2020
[2] S.Roscani, K. Ryszewska, L. Venturato, A one-phase space–fractional Stefan problem with no liquid initial domain, *preprint*, arXiv:2111.06690.

On an attractor for smooth solutions to the interactive system of the fluid and the full von Karman shell without rotational inertia

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The interactive system, consisting of the linearized Navier-Stokes equation and full von Karman equation with rotational inertia accounted for was proved to be well-posed and have (under certain conditions) a global attractor [1]. However, if we do not account for the rotational inertia, the uniqueness of weak solutions is not proved yet. In [2] I have managed to prove well-posedness of smooth solutions to this system and established and established its uniform stability in the homogeneous case. Now I present new results on attractors in non-homogeneous case. The viscose dissipation in the fluid is sufficient to make the system dissipative, we need no mechanical dissipation in the plate component.

[1] Igor Chueshov and Iryna Ryzhkova, Unsteady interaction of a viscous fluid with an elastic shell modeled by full von Karman equations, *J. Differential Equations*, 2013, Vol. 254, 1833-1862
[2] Iryna Ryzhkova-Gerasymova, ong time behaviour of strong solutions to interactive fluid-plate system without rotational inertia, *DCDS-B*, 2018, 23(3), 1243-1265

BSDEs with two optional barriers and extended Dynkin games

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Let B be a standard d-dimensional Brownian motion and $\mathbb{F} = \{\mathcal{F}_t\}_{t\geqslant 0}$ be a standard augmentation of the filtration generated by B. We present results on Reflected Backward Stochastic Differential Equations (RBSDE for short) of the following form

$$\begin{cases} Y_t = \xi + \int_t^T f(r, Y_r, Z_r)\, dr + \int_r^T dR_r - \int_t^T Z_r\, dB_r, \quad t \in [0,T], \\ L_t \leqslant Y_t \leqslant U_t, \quad t \in [0,T], \quad (Y,Z,R) \in Prog(\mathcal{F}_t) \\ dR - \text{"}minimal\text{"}, \quad \int_0^T |Z_r|^2\, dr < \infty, \end{cases} \tag{A}$$

where ξ (terminal time) is $\mathcal{F}_T$-measurable random variable, mapping $f : \Omega \times [0,T] \times \mathbb{R} \times \mathbb{R}^d \to \mathbb{R}$ (generator) is $\mathbb{F}$-progressively measurable with respect to the first two variables and L, U (barriers) are optional processes satisfying some separation condition.

Reflected BSDEs have many applications in various, important mathematical fields (e.g. optimal stopping problem, Dynkin games, stopping and control games, switching problem etc.). The other crucial application of RBSDEs is their connection with viscosity and weak solutions to a wide class of variational inequalities. It turns out that for more complicated, general situations there is need to consider more extensive than càdlàg-barriers case- so far, the main direction in developing this theory. There is only a few papers treating about non-càdlàg barriers (see e.g. [1],[2],[3],[4],[5],[6])). It is caused by the fact that in such case the main component of the solution, process Y, do not have to be càdlàg process, what complicates the problem significantly. There is need of using more sophisticated methods of proving, what is more, in the case of optional barriers, many classical intuitions seem to be deceptive.

We will present the results on the existence and uniqueness of solution to the problem (A). We assume that generator f is only monotone and continuous with respect to y (without any growth condition), satisfies Lipschitz condition on z and data are in L^1. We also present the link between solution of RBSDE with optional barriers and the value process of nonlinear Dynkin game.

The presented results were obtained in cooperation with Tomasz Klimsiak.

[1] M. Grigorova, P. Imkeller, Y. Ouknine, M.C. Quenez, Doubly Reflected BSDEs and $\mathcal{E}^f$-Dynkin games: beyond the right-continuous case, *Electronic Journal of Probability*, 2018, 23, Paper No. 122, 38 pp
[2] M. Grigorova, P. Imkeller, Y. Ouknine, M.C. Quenez, Optimal stopping with f–expectations: the irregular case, *Stochastic Processes and Their Applications*, 2020, 130(3), 1258-1288
[3] T. Klimsiak, M. Rzymowski, Nonlinear BSDEs with two optional Doob's class barriers satisfying weak Mokobodzki's condition and extended Dynkin games, *preprint*, ArXiv:2205.06222
[4] T. Klimsiak, M. Rzymowski, L. Słomiński, Reflected BSDEs with regulated trajectories, *Stochastic Processes and Their Applications*, 2019, 129, 1153-1184
[5] T. Klimsiak, M. Rzymowski, L. Słomiński, Reflected backward stochastic differential equations with two optional barriers, *Bulletin des Sciences Mathématiques*, 2020, 158, 102820, 49 pp
[6] M. Marzougue, M. El Otmani, BSDEs with right upper-semicontinuous reflecting obstacle and stochastic Lipschitz coefficient, *Random Operators and Stochastic Equations*, 2019, 27, 27-41

Orbital stability of ground states to Schrödinger equations with mass constraints

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We discuss the existence of standing waves solutions to

$$\mathrm{i}\partial_t \Phi - \Delta \Phi = F'(\Phi),$$

i.e., $\Phi(t,x) = e^{-\mathrm{i}\lambda t} u(x)$. Since the mass $\int_{\mathbb{R}^N} |\Phi(t,x)|^2\, \mathrm{d}x$ and the energy

$$\int_{\mathbb{R}^N} \frac{1}{2} |\nabla \Phi(t,x)|^2 - F\big(\Phi(t,x)\big)\, \mathrm{d}x$$

are conserved in time if $F(\Phi) = F(|\Phi|)$, such standing waves are sought as *normalized solutions*, i.e., solving

$$\begin{cases} -\Delta u + \lambda u = F'(u) \\ (\lambda, u) \in \mathbb{R} \times H^1(\mathbb{R}^N) \\ \int_{\mathbb{R}^N} |u|^2 \, \mathrm{d}x = a^2 \end{cases}$$

for some prescribed $a > 0$, where λ is part of the unknown. Exploiting a recent idea introduced in [1], we show that when the energy is bounded below over the set

$$\{u \in H^1(\mathbb{R}^N) : \|u\|_{L^2(\mathbb{R}^N)} \leqslant a\}$$

and its infimum is negative, the set of ground state solutions to the elliptic problem above is orbitally stable. The talk is based on [2].

[1] B. Bieganowski, J. Mederski, Normalized ground states of the nonlinear Schrödinger equation with at least mass critical growth, *J. Funct. Anal.*, 2021, 280(11), Paper No. 108989, 26 pp.
[2] J. Schino, Normalized ground states to a cooperative system of Schrödinger equations with generic L^2-subcritical or L^2-critical nonlinearity, *Adv. Differential Equations*, 2022, 27(7-8), 467–496

Cloud Native Machine Learning

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The use of different cloud services models has become nearly a *de facto* standard across industries although its adoption varies based on the operational features and cost optimization. We will focus just on the pragmatic reasons to use cloud services for machine learning and its advantages over the proprietary variant. Also, some alternatives for application modernization to achieve cloud native operability will be discussed.

On optimal Harnack bounds for a non-local heat equation

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In this talk I will present a recent sharp result concerning Harnack bounds for nonnegative solutions of the fractional heat flow

$$u_t + (-\Delta)^{1/2} u = 0 \quad \text{in} \quad \mathbb{R}.$$

While solutions of the standard heat flow enjoy only lower bounds the non-local setting permits both lower and upper bounds and for fixed $x_1, x_2 \in \mathbb{R}$ and $0 < t_1, t_2 < \infty$ the estimate takes the form

$$M_*\Big(|x_2 - x_1|, t_1, t_2\Big) \leqslant \frac{u(x_2, t_2)}{u(x_1, t_1)} \leqslant M^*\Big(|x_2 - x_1|, t_1, t_2\Big),$$

where constants M_* and M^* are explicitly computed. Also, in contrast to the local heat flow the case of equal times $t_1 = t_2$ is admissible. Time permitting, I will touch on the possible implications that these bounds may have on the problem of extending the classical Li-Yau estimate associated with the standard heat flow to non-local settings.

On an approximation of average cost per unit time impulse control of Markov processes

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In the talk impulse control of continuous time Markov processes with average cost per unit time functional will be considered. This problem is approximated using impulse control problems stopped at the first exit time from increasing sequence of open sets. We find solution to Bellman equation corresponding to the original problem and show that stopped impulse control problems approximate optimal value of the cost functional. The talk is based on [1] and can be considered as a continuation of the paper [2].

[1] Ł. Stettner, On an approximation of average cost per unit time impulse control of Markov processes, *SIAM J. Control Optim.*, 2022 to appear
[2] J. Palczewski, Ł. Stettner, Impulse control maximising average cost per unit time: a non-uniformly ergodic case, *SIAM J. Control Optim.*, 2017, Vol. 55, No. 2, pp. 936-960

Optimal Control in Fluid Flows through Deformable Porous Media

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We consider an optimal control problem subject to an elliptic-parabolic coupled system of partial differential equations that describes fluid flow through biological tissues. Our goal is to optimize the fluid pressure and solid displacement using distributed or boundary control. We first show results on the existence and uniqueness of optimal controls and then present necessary optimality conditions. The optimal controls can be approximated numerically.

[1] L. Bociu, S. Strikwerda, Poro-Visco-Elasticity in Biomechanics - Optimal Control, *AWM: Research in the Mathematics of Materials Science, Springer*, 2022
[2] L. Bociu, S. Strikwerda, Optimal Control in Poroelasticity, *Applicable Analysis*, 2022, 101(5), 1774–1796

A time-inconsistent variation of the dividend problem

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The goal of the dividend problem with a ruin penalty is to maximize expected cumulated discounted dividends until ruin. In case of ruin a discounted penalty is charged to incentivize keeping the business alive for a longer time. Whereas typically dividends and penalty are discounted in the same way, we consider different values for the respective discount rates. This causes the time-inconsistency of the stochastic optimal control problem and we apply a game-theoretic approach for its solution. Using a diffusion process with constant coefficients to model the surplus, we are able to derive an explicit solution. This particular formulation of the problem is motivated by the task of optimal consumption under a constraint on the Laplace transform of the time of ruin. This is joint work with Stefan Thonhauser.

Numerical approximation of a stationary case of hinged-free plate under non-conservative forces

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In the paper the numerical solution to the linearized model of a partially hinged partially free rectangular plate is considered. Such structure is exposed to the action of an external force that represents a cross-wind. The motivation is to model a suspending bridge in order to consider the long-time behavior of nonlinear elastic structure forced by external/internal inputs. Since the external force is periodic in time and causes the vortex shedding on the a structure (on the deck of bridge) thus it may causes a damage of the material. The latter leads to the collapse of the structure as it was observed in the typical example: Tacoma Narrow Bridge disaster. The main objective of this paper is the numerical illustration of the solutions to the linearized stationary problem. The non-conservative force acting upon the system and the resulting loss of dissipativity of the system are the major features. The dependence of the structure of stationary states on the values of the gas velocity will be analysed.

[1] D. Bonheure, F. Gazzola, I. Lasiecka, J. Webster, Long-time dynamics of a hinged-free plate driven by a non-conservative force, *Ann. Inst. H. Poincaré Anal. Non Linéaire*, 2022, 39(2), 457–500.

On elliptic optimal control problems with control appearing nonlinearly in the state equation

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An optimal control problem for a semilinear elliptic equation is discussed, where the control appears nonlinearly in the state equation but is not included in the objective functional. The existence of optimal controls is proved by a measurable selection technique. First-order necessary optimality conditions are derived and two types of second-order sufficient optimality conditions are established. A first theorem invokes a well-known assumption on the set of zeros of the switching function. A second relies on coercivity of the second derivative of the reduced objective functional. The results are applied to the convergence of optimal state functions for a finite element discretizion of the control problem.

The talk is on joint work with Eduardo Casas (Santander).

Output regulation of nonlinear infinite-dimensional systems

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The problem of output regulation consists in designing a feedback law which ensures that the output of a system tracks a given reference even in the presence of external disturbances. In this talk, which is based on [1], we are interested in constant output regulation of a class of abstract infinite-dimensional

systems governed by nonlinear contraction semigroups on Hilbert spaces. The approach we propose relies on the so-called forwarding methodology, which was originally developed in [2] for the stabilization of finite-dimensional nonlinear cascade systems. We give sufficient conditions for the existence of a dynamic control law that steers the system to some equilibrium at which the output coincides with the reference. These conditions are then investigated in the particular case of semilinear systems and illustrated by examples coming from partial differential equations.

[1] N. Vanspranghe, L. Brivadis, Output regulation of infinite-dimensional nonlinear systems: a forwarding approach for contraction semigroups, *preprint*, ArXiv:2201.10146
[2] F. Mazenc, L. Praly, Adding integrations, saturated controls, and stabilization for feedforward systems, *IEEE Transactions on Automatic Control*, 1996, 41(11), 1559–1578

Machine learning based system supporting active learning approach in systematic literature reviews

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The paper gives an overview of IT system for Systematic Literature Review (SLR). The objective of the system is to provide scientists and anyone else who gives scientific advice supporting policy development with a tool for literature search and appraisal that reduces human effort while still providing acceptable sensitivity and specificity ([1],[2]). In the paper, the structure of the system is presented along with the description of communication between modules and data storage methods. Kafka technology is used for communication between the modules and this enables sending asynchronous, short information between them. The REST API service is used to provide access to the data in the central database. The system consists of several independent modules and the system can be easily expanded with new modules without the need to introduce significant changes to the system. The independence of the modules from each other also allows the system to be independent of a specific programming language. A description of all the main REFSA modules is part of this study.

[1] B.C. Wallace, et al., Semi-automated screening of biomedical citations for systematic reviews, *BMC Bioinformatics*, 2010, 11(55), 1–11
[2] Ch.R. Norman, et al., Measuring the impact of screening automation on meta-analyses of diagnostic test accuracy, *Systematic Reviews*, 2019, 8(243), 1–18

Finite element methods with boundary concentrated meshes for PDEs with irregular boundary data

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We study the Poisson equation with inhomogeneous Dirichlet boundary conditions. There are many applications, where the boundary data are very irregular, belonging only to $H^t(\Gamma)$ with some $t \in [1/2, 3/2)$. This is for instance the case, when the boundary data are obtained from noisy measurements or are non-smooth for design or physical reasons. Similar effects arise when studying control-constrained Dirichlet boundary control problems. The reduced regularity of the data leads to a lower regularity of the PDE solution and results in a lower convergence rate of their finite element approximations.

We study an a-priori mesh refinement towards the boundary of the computational domain with the aim to restore the optimal convergence rates in the usual norms. Hereby, the computational effort will not significantly increase. We present sharp a-priori bounds for the refinement parameters depending solely on the regularity of the boundary data. These bounds a confirmed in numerical experiments.

Exact reconstruction and reconstruction from noisy data: Going beyond point sources?

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It is well-known that point sources with sufficient mutual distance can be reconstructed exactly from finitely many Fourier measurements by solving a convex optimization problem with Tikhonov-regularization (this property is sometimes termed superresolution). In case of noisy measurements one can bound the reconstruction error in unbalanced Wasserstein distances or weak Sobolev-type norms. A natural question is to what other regularizers or measurements the phenomenon of superresolution extends. We will discuss two examples. In one we show that also for anisotropic total variation, exact reconstruction results and L1 error bounds hold under sufficient mutual distance between the horizontal and vertical edges. In the other example we consider a reconstruction of linearly moving point sources. This is joint work with Martin Holler and Alexander Schlüter.

On certain integro-differential equations and local time of diffusions

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We find an explicit form of solution of a convolution type integro-differential equation of the first order

$$\frac{\partial Q(t,z)}{\partial z} = \alpha(t,z) - \int_0^t \beta(t-u)Q(u,z)du, \quad (t,z) \in (0,T) \times (0,T), \tag{1}$$

where $T > 0$, and α, β are two given locally integrable functions and Q satisfies a boundary condition $Q(t,0) = \gamma(t)$ for a locally integrable function γ. To achieve this goal we introduce the notion of a biconvolution algebra of locally integrable functions on $\mathbb{R}^2_+$. We investigate the properties of the biconvolution algebra and study the Volterra integral equations of the second kind associated with the biconvolution operation. We also show certain connections between convolution theory and the description of the distribution of local time L of a diffusion X. In particular we describe the local time in terms of convolution exponent and use the excursion theory to describe the bivariate distributions of the pair (X_t, L_t). We provide a simple connection formula for the distribution of excursions of a bivariate Itô-McKean diffusion from a hyperplane.The talk is based on [1] and [2].

[1] Jakubowski J., Wiśniewolski M., Explicit solutions of Volterra integro-differential convolution equations, *Journal of Differential Equations*, 2021, 292, 416-426
[2] Jakubowski J., Wiśniewolski M., On bivariate distributions of local time of Itô-McKean diffusions, *preprint*,

Uniqueness for inverse source problems for time-fractional diffusion-wave equations by data after incident

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Let $\Omega \subset \mathbb{R}^d$ be a bounded domain with smooth boundary $\partial\Omega$, $\nu(x) = (\nu_1(x), ..., \nu_d(x))$ be the unit outward normal vector to $\partial\Omega$ at x, and let $0 < \alpha < 2$ and $\alpha \neq 1$. Moreover we consider a regular elliptic operator: $(-Aw)(x) := \sum_{i,j=1}^d \partial_i(a_{ij}(x)\partial_j w(x)) + c(x)w(x)$ for $x \in \Omega$, and we set $\partial_{\nu_A} w(x) := \sum_{i,j=1}^d a_{ij}(x)(\partial_j w)\nu_i$ for $x \in \partial\Omega$.

We consider an initial boundary value problem for a fractional diffusion-wave equation whose source term is described by $\mu(t)f(x)$, where f is a spatial distribution of the source and μ is a temporally changing factor:

$$\begin{cases} \partial_t^\alpha u(x,t) = -Au(x,t) + \mu(t)f(x), \quad x \in \Omega,\ 0 < t < T, \\ u|_{\partial\Omega\times(0,T)} = 0, \\ u(x,0) = 0, \quad x \in \Omega \quad \text{if } 0 < \alpha < 1, \\ u(x,0) = \partial_t u(x,0) = 0, \quad x \in \Omega \quad \text{if } 1 < \alpha < 2. \end{cases}$$

Here ∂_t^α is a fractional derivative of Caputo type.

We assume that $0 < t_0 < T_0$ and a given function μ satisfies

$$\mu \in L^2_{loc}(0,\infty), \quad \mu \not\equiv 0 \quad \text{in } (0,\, t_0), \quad \mu(t) = 0 \quad \text{for } t_0 < t < T_0.$$

Then, given a subboundary $\Gamma \subset \partial\Omega$, we consider

Inverse source problem: *Determine* $f(x)$, $x \in \Omega$ *by* $\partial_{\nu_A} u$ *on* $\Gamma \times (t_0,\, T_0)$.

In our inverse problem, we assume only data after the incident producing diffusion source. In most of existing works, available data are assumed to be observed from $t = 0$. Since we cannot predict when the incident will happen, the formulation that we can start the observations exactly at $t = 0$, is not realistic.

We will prove the uniqueness. Moreover we will demonstrate the non-uniqueness in the case $d = 1$ for the case $\alpha = 1$.

[1] Z. Li, Y. Liu and M. Yamamoto, Inverse source problem for a one-dimensional time-fractional diffusion equation and unique continuation for weak solutions, *to appear in Inverse Problems and Imaging, arXiv:2112.01018*,

[2] C.L. Lin and G. Nakamura, Unique continuation property for multi-terms time fractional diffusion equations, *Math. Ann.*, 2019, 373, 929–952

[3] M. Yamamoto, Fractional calculus and time-fractional differential equations: revisit and construction of a theory, *Mathematics, Special issue Fractional Integrals and Derivatives: "True" versus "False"*, 2022
https://www.mdpi.com/2227-7390/10/5/698/pdf

Uniqueness for inverse source problem for time-fractional diffusion-wave equation without boundary conditions

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We consider

$$\partial_t^\alpha y(x,t) + Ay(x,t) = \rho(t)f(x), \quad x \in \Omega,\ 0 < t < T \qquad (*)$$

with the zero initial condition and $\alpha \in (0,2) \setminus \{1\}$. Here Ω is a bounded domain in $\mathbb{R}^d$, $d \in \mathbb{N}$, $-A$ is a uniform elliptic operator of the second order, ∂_t^α is the fractional derivative of Caputo type.

We assume that $\rho(0) \neq 0$ is given and $f \in L^2(\Omega)$. Then we discuss

Inverse source problem:

Let ω be a subdomain of Ω. Determine $f(x)$, $x \in \Omega$ by data $y|_{\omega\times(0,T)}$.

Our main interest is the uniqueness. In the existing works, it is further assumed that y satisfies boundary condition, for example, $y|_{\partial\Omega\times(0,T)} = 0$. However, in view of the unique continuation property for the partial differential equations, we should expect the uniqueness without any boundary condition, that is, $f = 0$ in Ω if y satisfies (*) and $y|_{\omega\times(0,T)} = 0$. More precisely, we will prove the uniqueness under the assumption that $\rho(0) \neq 0$.

[1] Z. Li, Y. Liu and M. Yamamoto, Inverse source problem for a one-dimensional time-fractional diffusion equation and unique continuation for weak solutions, *to appear in Inverse Problems and Imaging*, arXiv:2112.01018

[2] C.L. Lin and G. Nakamura, Unique continuation property for multi-terms time fractional diffusion equations, *Math. Ann.*, 2019, 373, 929–952

[3] M. Yamamoto, Fractional calculus and time-fractional differential equations: revisit and construction of a theory, *Mathematics, Special issue Fractional Integrals and Derivatives: "True" versus "False"*, 2022
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Variational Source Conditions for Tikhonov Regularization with L^p-penalties

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We propose and analyze variational source conditions (VSC) for the Tikhonov regularization method with L^p-penalties applied to an ill-posed operator equation in a Banach space. Our analysis is built on the celebrated Littlewood-Paley theory and the concept of (Rademacher) R-boundedness. With these two analytical principles, we validate the proposed VSC under a conditional stability estimate in terms of a dual Triebel-Lizorkin-type norm. We discuss an application of the developed theory to an inverse elliptic problem with measure data for the reconstruction of possibly unbounded diffusion coefficients. By means of VSC, convergence rates for the associated Tikhonov regularization with L^p-penalties are obtained. This talk is based on [1].

[1] D. Chen, I. Yousept, Variational source conditions in L^p-spaces, *SIAM J. Math. Anal.*, 2021, 53(3), pp. 2863–2889

Inverse source problem in (fractional) diffusion equation with sparse data

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We consider the inverse source problem in a two dimensional (fractional) diffusion equation. The unknown source term has a semi-discrete form, namely, it is discretized to a step function on time variable t. We assume that the spatial term and the time mesh are both unknown. The measurements we use are the boundary flux data generated from finite points on the boundary. This is where the terminology 'sparse data' comes from. With Laplace transform and the knowledge in complex analysis, we prove the uniqueness theorem, which says the sparse boundary data can uniquely determine multiple unknowns simultaneously. After that, we try several numerical experiments and the corresponding numerical results are given.

Model-based support for harmonization of investment and operation decisions in renewable energy systems

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Consistent planning of investments in capacities and operations of renewable energy generation (REG) plants requires harmonization of decisions for long- and short-term periods. Moreover, it faces challenges of high variability and uncertainty. Decisions that consider the development of the energy system over multiple decades under the uncertainty of parameters tend to neglect short term variability. In contrast, operation decisions that deal with short-term variability, such as balancing hourly energy generation with requirements on variability of outputs, don't consider planning the plant capacities which is done for long-term periods. Thus, harmonization of different time scales decisions is a key issue in modeling such systems. Such systems include energy generation devices (such as wind turbines, photovoltaic) and diverse devices for storing the energy, such as batteries, electrolyzes, hydrogen tanks, fuel cells, water-reservoirs, and several others. While the symbolic (abstract) model will be general, its instances for specific sites shall include only relevant devices and technologies. The model shall support analysis of various questions, including: 1) dealing with variability and uncertainty of the generated energy. 2) balancing the generated energy with the requirements for providing energy output of the given characteristics. 3) harmonization of different (short, medium, and long) time scales pertaining to diverse modeled decisions.

Inverse potential problem for subdiffusion: numerical approximation and error analysis

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In this talk, we consider the inverse problem of recovering a potential coefficient in the fractional subdiffusion model from the terminal observational data. We shall present a conditional stability estimate in Sobolev spaces which further inspires proper numerical algorithm and relevant error analysis. The argument relies on refined properties of solution operators involving two-parameter Mittagâ€“Leffler functions. The efficiency and accuracy of the proposed algorithm are illustrated with several numerical examples.