



TIBERIU POPOVICIU
INSTITUTE OF NUMERICAL ANALYSIS
ROMANIAN ACADEMY



TIBERIU POPOVICIU INSTITUTE OF NUMERICAL ANALYSIS
ROMANIAN ACADEMY, CLUJ-NAPOCA BRANCH

Numerical Analysis, Numerical Modeling, Approximation Theory

NANMAT 2025

Book of Abstracts

- version of November 1, 2025 -



Cluj Academic Days
Edition XXXVIII
November 3 – 6, 2025



Scientific Committee:

- Radu Bălan (University of Maryland, USA)
- Coralia Carțiș (University of Oxford, UK)
- Dan Crișan (Imperial College, UK)
- Victorița Dolean-Maini (TU Eindhoven, The Netherlands)
- Traian Iliescu (Virginia Tech, USA)
- Adrian Muntean (Karlstads Universitet, Sweden)
- Sorin Pop (Hasselt University, Belgium)
- Florin Radu (University of Bergen, Norway)
- Gabriel Turinici (Université Paris Dauphine, France)



Generalizations of approximation processes based on squared binomial polynomial bases functions

Octavian Agratini, Maria Crăciun

Tiberiu Popoviciu Institute of Numerical Analysis, Romanian Academy, Cluj-Napoca

Abstract

In this talk, we emphasize the role of binomial polynomials in constructing classes of positive linear approximation operators on Banach spaces. We develop a Kantorovich-type integral extension of these operators, designed for effective signal approximation in $L_p([0, 1])$ spaces, $p \geq 1$. Inspired by concepts from entropy theory, specifically the coincidence index, we also propose a broader class of discrete operators built on squared binomial fundamental basis functions. Error analysis is carried out using smoothness moduli and Peetre's K-functionals, offering insights into the approximation behavior of the proposed schemes. Numerical examples are included to demonstrate the practical relevance and performance of these operators. The conclusion is that the modified binomial operators are more efficient than the classical ones for approximating functions with specific characteristics, particularly those that exhibit slower variation near the ends of the interval and have fluctuations in the rest. For other functions, the results may vary, and further analysis is needed to determine the best operator choice for specific applications.



Systems of first order hyperbolic equations. A semigroup approach

Sebastian Anița

Alexandru Ioan Cuza University, Iași

Abstract

In epidemics, waning immunity is common after infection or vaccination of individuals. Immunity levels are highly heterogeneous and dynamic. This work presents an immuno-epidemiological model that captures the fundamental dynamic features of immunity acquisition and wane after infection or vaccination.

The model consists of two first order partial differential equations with different transfer velocities. We derive the basic properties of the solutions via a semigroup approach.

Quantitative bounds for sorting based permutation invariant embeddings

Radu Bălan

University of Maryland, USA

Abstract

We study the sorting-based embedding $\beta_{\mathbf{A}}: \mathbb{R}^{n \times d} \rightarrow \mathbb{R}^{n \times D}$, $\mathbf{X} \mapsto \downarrow(\mathbf{X}\mathbf{A})$, where $\downarrow$ denotes column wise sorting of matrices. Such embeddings arise in graph deep learning where outputs should be invariant to permutations of graph nodes. Previous work showed that for large enough D and appropriate $\mathbf{A}$, the mapping $\beta_{\mathbf{A}}$ is injective, and moreover satisfies a bi-Lipschitz condition. However, two gaps remain: firstly, the optimal size D required for injectivity is not yet known, and secondly, no estimates of the bi-Lipschitz constants of the mapping are known. In this paper, we make substantial progress in addressing both of these gaps. Regarding the first gap, we improve upon the best known upper bounds for the embedding dimension D necessary for injectivity, and also provide a lower bound on the minimal injectivity dimension. Regarding the second gap, we construct matrices $\mathbf{A}$, so that the bi-Lipschitz distortion of $\beta_{\mathbf{A}}$ depends quadratically on n , and is completely independent of d . We also show that the distortion of $\beta_{\mathbf{A}}$ is necessarily at least in $\Omega(\sqrt{n})$. Finally, we provide similar results for variants of $\beta_{\mathbf{A}}$ obtained by applying linear projections to reduce the output dimension of $\beta_{\mathbf{A}}$. This is joint work with Nadav Dym, Matthias Wellershoff, Efstratios Tsoukanis, and Daniel Levy.



Optimization of space-time periodic eigenvalues

Beniamin Bogosel

Aurel Vlaicu University OF Arad

Abstract

We consider the problem of optimizing the principal eigenvalue of a parabolic system associated to the Laplace operator with periodic space-time conditions. In this presentation I will focus on the numerical aspects involved in the simulation of such systems, including the computation and optimization of the fundamental eigenvalue with respect to the coefficients of the equations. The theoretical considerations will lead us to develop numerical methods for handling various constraints of interest, including rearrangement constraints, which is a novel aspect compared with the literature.



A posteriori error analysis based on equilibrated flux for a CutFEM interface problem

Daniela Căpățînă

Université de Pau et des Pays de l'Adour, France

Abstract

In this talk, we consider an elliptic interface problem with discontinuous diffusion coefficients on unfitted meshes, approximated by means of the CutFEM finite element method. The main contributions are the reconstruction of a conservative flux from the CutFEM solution and its use in the a posteriori error estimation. We first introduce a hybrid mixed formulation with locally computable Lagrange multipliers and reconstruct an equilibrated flux in the immersed Raviart-Thomas space. Based on this, we propose a new a posteriori error estimator that includes both volume and interface terms. We establish sharp and robust reliability as well as local efficiency of this error estimator, carefully tracking the dependence of the efficiency constants on the diffusion coefficients and the mesh/interface configuration. Finally, we validate the approach through numerical experiments, highlighting its robustness.



A regularising iterative algorithm for the Cauchy problem in elasticity

Andrei Cațaron
University of Bucharest

Abstract

The numerical reconstruction of the solution to the system of linear (an)isotropic elasticity in a doubly-connected three-dimensional domain from overdetermined data, also referred to as Cauchy data, available on a part of the boundary is investigated. A regularising iterative method is employed to generate a stable numerical approximation to this severely ill-posed inverse problem. The method proposed herein is an extension of the Landweber iteration for an operator equation equivalent to the Cauchy problem. Numerical examples are presented in order to confirm the accuracy, convergence, stability and robustness of the algorithm

Computing the functions of matrices

Emil Cătiņaș

Tiberiu Popoviciu Institute of Numerical Analysis, Romanian Academy, Cluj-Napoca

Abstract

The well known definition of the classical (C -)quadratic order of a sequence $x_k \rightarrow x^* \in \mathbb{R}^N$ is that its errors $e_k = \|x^* - x_k\|$ satisfy

$$\lim_{k \rightarrow \infty} \frac{e_{k+1}}{e_k^2} = Q_2 \in (0, +\infty),$$

which we prove that is equivalent to: $\exists \rho \in (0, 1)$ and $c_k \rightarrow c \in (0, +\infty)$ such that

$$e_k = c_k \cdot \rho^{2^k}, \quad k \geq 0.$$

The result is extended to orders $p_0 > 1$.

When the new asymptotic constants c and ρ are known in closed form, we get a priori evaluation of the errors and also of the number of steps required to attain a given error.

We give some a posteriori formulae for evaluating c and ρ , which we illustrate on matrix equations. We illustrate the results on a number of iterations for computing the following matrix functions: the matrix sign, the square root and the polar decomposition. We show that after a few steps we obtain sufficiently good approximations for the new asymptotic constants, which give accurate predictions for the number of steps to attain a given accuracy. We consider the Advanpix toolbox for increased precision.

[1] E. Cătiņaș, How many steps still left to x^* ?, SIAM Rev., 63 (2021) no. 3, pp. 585–624, doi.org/10.1137/19M1244858.

[2] E. Cătiņaș, Characterizations of the classical convergence orders and applications to matrix functions, manuscript.

Nonlinear control of falling liquid films

Radu Cîmpeanu

University of Warwick, UK

Abstract

Falling liquid films represent a canonical physical scenario underpinned by complex physical processes that can be modelled by infinite-dimensional dynamical systems. The interfacial behaviour is characterised by the Reynolds number, a nondimensional parameter; above a critical value the uniform film becomes unstable, leading to the emergence of nonlinear travelling waves. By injecting and removing fluid from the base at discrete locations, we aim to stabilise otherwise unstable flat interfaces, with the additional limitation that observations of the state are restricted to finitely many measurements of the film height. Successful feedback control has recently been achieved in the case of full observations using linear-quadratic regulator controls coupled to asymptotic approximations of the Navier-Stokes equations (Holroyd, Cîmpeanu & Gomes, SIAM J. Appl. Math., 2024), but restricted observations severely curtailed their performance. In this study we couple the well-understood full-information feedback control strategy to a nonlinear estimator. The dynamics of the estimator are designed to approximate those of the film, and we apply a forcing term chosen to ensure that measurements of the estimator match the available measurements of the film. Using this method, we restore the performance of the controls to a level approaching their full-information counterparts, even at moderately large Reynolds numbers. We also briefly investigate the effects of noise and the relative positioning of actuators and observers on the resulting dynamics. The work has been recently accepted for publication in Royal Society Proceedings A, with an associated preprint available on arXiv: 2506.16987



Some remarks on high-order finite differences schemes. Consequences on the observability of the wave equation discretized by finite differences

Nicolae Cîndea

Université Clermont Auvergne, France

Abstract

The aim of this talk is to present some new results concerning the uniform observability of the semi-discretization in space of the one-dimensional wave equation and of the clamped Euler-Bernoulli beam equation using high-order compact centered finite-differences. We mainly prove that high-order approximations do not fundamentally change the issues due to the spurious high-frequencies which are not uniformly observable with respect to the discretization parameter. Nevertheless, filtering the high-frequencies at an optimal range allows us to restore the uniform observability of these more precise approximations. The proof is based on the explicit knowledge of the eigenvectors and eigenvalues of the discretization matrices, a discrete multiplier method and Ingham's inequality. These results are the object of a submitted work in collaboration with Ana-Maria Orita and Ionel Roventa.



Mass-conserving solutions of coagulation models

Iulia Cristian

Sorbonne Université, Paris, France

Abstract

Coagulation equations describe the evolution in time of a system of particles that are characterized by their volume. In this talk, we introduce the standard coagulation model. Depending on the interaction speed of the particles, solutions may lose mass instantaneously. We then analyze alternative frameworks and see how this property changes.



Modeling geophysical fluid dynamics models with fractional Brownian motion

Dan Crişan

Imperial College London, UK

Abstract

I will present some results related to the local/global wellposedness results for the vorticity equation associated to a viscous ideal fluid with transport noise driven by a fractional Brownian motion with Hurst parameter greater than $1/2$. The analysis is based on a pathwise analysis for stochastic transport-type integrals driven by fractional Brownian motion. A sewing lemma is established in a setting where both the semigroup and the integrand depend on time. The combination of semigroup smoothing, the Biot–Savart structure, and the new sewing estimates yields a contraction principle that ensures local well-posedness. A continuation argument then leads to global existence of solutions. I will also present an estimator for the Hurst parameter based on observing a single Fourier coefficient of the solution. This talk is based on joint work with Oana Lang (University Babeş-Bolyai) and Alexandra Blessing (University of Konstanz).



How to use synthetic data for improved statistical inference?

Edgar Dobriban

University of Pennsylvania, USA

Abstract

The rapid proliferation of high-quality synthetic data – generated by advanced AI models or collected as auxiliary data from related tasks – presents both opportunities and challenges for statistical inference. This paper introduces a GEneral Synthetic-Powered Inference (GESPI) framework that wraps around any statistical inference procedure to safely enhance sample efficiency by combining synthetic and real data. Our framework leverages high-quality synthetic data to boost statistical power, yet adaptively defaults to the standard inference method using only real data when synthetic data is of low quality. The error of our method remains below a user-specified bound without any distributional assumptions on the synthetic data, and decreases as the quality of the synthetic data improves. This flexibility enables seamless integration with conformal prediction, risk control, hypothesis testing, and multiple testing procedures, all without modifying the base inference method. We demonstrate the benefits of our method on challenging tasks with limited labeled data, including AlphaFold protein structure prediction, and comparing large reasoning models on complex math problems.

Local feature filtering for scalable and well-conditioned domain-decomposed random feature methods

Victorița Dolean

TU Eindhoven, The Netherlands

Abstract

Random Feature Methods (RFMs) and their variants such as extreme learning machine finite-basis physics-informed neural networks (ELM-FBPINNs) offer a scalable approach for solving partial differential equations (PDEs) by using localized, overlapping and randomly initialized neural network basis functions to approximate the PDE solution and training them to minimize PDE residuals through solving structured least-squares problems. This combination leverages the approximation power of randomized neural networks, the parallelism of domain decomposition, and the accuracy and efficiency of least-squares solvers. However, the resulting structured least-squares systems are often *severely ill-conditioned*, due to local redundancy among random basis functions and correlation introduced by subdomain overlaps, which significantly affects the convergence of standard solvers. In this work, we introduce a block rank-revealing QR (RRQR) filtering and preconditioning strategy that operates directly on the structured least-squares problem. First, local RRQR factorizations identify and remove redundant basis functions while preserving numerically informative ones, reducing problem size, and improving conditioning. Second, we use these factorizations to construct a right preconditioner for the global problem which preserves block-sparsity and numerical stability. Third, we derive deterministic bounds of the condition number of the preconditioned system, with probabilistic refinements for small overlaps.

We validate our approach on challenging, multi-scale PDE problems in 1D, 2D, and (2+1)D, demonstrating reductions in condition numbers by up to eleven orders of magnitude, LSQR convergence speedups by factors of 10–1000, and higher accuracy than both unpreconditioned and additive Schwarz-preconditioned baselines, all at significantly lower memory and computational cost. These results establish RRQR-based preconditioning as a scalable, accurate, and efficient enhancement for RFM-based PDE solvers.

Real-time prediction of plasma instabilities with sparse-grid-accelerated optimized dynamic mode decomposition

Ionuț Farcaș
Virginia Tech, USA

Abstract

Parametric data-driven reduced-order models (ROMs) that embed dependencies in a large number of input parameters are crucial for enabling many-query tasks in large-scale problems. These tasks, including design optimization, control, and uncertainty quantification, are essential for developing digital twins in real-world applications. However, standard training data generation methods are computationally prohibitive due to the curse of dimensionality, as their cost scales exponentially with the number of inputs. This presentation focuses on efficient training of parametric data-driven ROMs using sparse grid interpolation with (L)-Leja points, specifically targeting scenarios with higher-dimensional input parameter spaces. (L)-Leja points are nested and exhibit slow growth, resulting in sparse grids with low cardinality in low-to-medium dimensional settings, making them ideal for large-scale, computationally expensive problems. Focusing on gyrokinetic simulations of plasma micro-instabilities in fusion experiments as a representative real-world application, we construct parametric ROMs for the full 5D gyrokinetic distribution function via optimized dynamic mode decomposition (optDMD) and sparse grids based on (L)-Leja points. We perform detailed experiments in two scenarios: First, the Cyclone Base Case benchmark assesses optDMD ROM prediction capabilities beyond training time horizons and across variations in the binormal wave number. Second, for a real-world electron temperature gradient driven micro-instability simulation featuring six input parameters, we demonstrate that an accurate parametric optDMD ROM can be constructed at a cost of only 28 high-fidelity gyrokinetic simulations thanks to sparse grids.

Complex singularities of an initial-boundary value problem modelling viscous film flow

Călin-Ioan Gheorghiu

Tiberiu Popoviciu Institute of Numerical Analysis, Romanian Academy, Cluj-Napoca

Abstract

We are concerned with a fourth-order nonlinear degenerate parabolic equation defined on the entire real axis. The initial-boundary value problem attached describes the flow of a thin liquid film under the coupled action of gravity, viscous and surface tension forces. First, we solve this problem using Chebfun involving the `pde15s` routine. Then we try to find its travelling wave solutions. In both cases, we extend the real solution in the complex plane using the AAA (adaptive Antoulas-Anderson) interpolation algorithm and pay attention to complex singularities close to the real axis. Actually, we find the zeros and poles along with the Bernstein ellipse and comment on their significance on the extent to which the analytic continuation of the solution is feasible. We conjecture that only the real poles lead to significant singularities (branch points). We would also like the analytical continuation to provide us with some clues about the length of the finite integration interval at which the real axis is truncated. Studying is in progress.



A fresh look at algorithms for solving smooth multiobjective optimization problems

Sorin Grad

ENSTA Paris, France

Abstract

We propose a new approach for constructing practical algorithms for solving smooth multiobjective optimization problems based on determining decreasing directions via suitable linear programming problems. The presented iterative method is specialized for unconstrained and linearly constrained multiobjective optimization problems. In all cases, the objective function values sequence is decreasing with respect to the corresponding nonnegative orthant, and every accumulation point of the sequence generated by the algorithm is a substationary point to the considered multiobjective optimization problem, becoming, under convexity assumptions, a weakly Pareto efficient solution. Different from similar algorithms from the literature, the ones proposed in this work involve decreasing directions that are easily computable in polynomial time. The talk is based on joint work with Tibor Illés and Petra Renáta Rigó (CCOR, CIAS, Corvinus University of Budapest).



A Monte Carlo discretization method for nonlinear variational PDEs

Andreea Grecu

University of Bucharest

Abstract

We introduce and test a numerical method for solving boundary value problems for some classes of second order partial differential equations in a bounded open set in $D \subset \mathbb{R}^d$, including, for example, those that arise as the Euler-Lagrange equation associated to some energy functional of the type $J(u) = \int_D F(x, u(x), \nabla u(x)) \, dx$, $u \in D(J) \subset W^{1,2}(D)$, with prescribed boundary conditions $u = g$ on ∂D . Our approach is based on the orthogonal decomposition of $H^1(D)$, probabilistic representations and the Monte Carlo method. We test our method for solving various PDEs, such as (non-)symmetric second order linear elliptic PDEs, semilinear PDEs that admit multiple solutions, quasilinear PDEs such as Poisson problems for the $p(x)$ -Laplace equation, or solving the first eigen-value problem for the p -Laplace equation. Some of these examples will be presented in this talk. Based on an ongoing work, jointly with I. Cîmpean and A. Zărnescu.

A Stancu-Schurer type extension of higher order of the Cheney-Sharma operators

Eduard Grigoriuc

Tiberiu Popoviciu Institute of Numerical Analysis, Romanian Academy, Cluj-Napoca

Abstract

We discuss a Stancu-Schurer type extension of higher order of the Cheney-Sharma operators. Starting from the operators studied by Bostanci and Başcanbaz-Tunca, respectively by Cătinaş and Buda (in the form of a Stancu operator with generalized Bernstein polynomials) we extend the convex combination of two terms which appears in the expression of the operator to a convex combination of m terms, where $m \in \mathbb{N}$, with $m \geq 1$. We called these new operators the Stancu-Schurer type extension of order m of the Cheney-Sharma operators (of first, respectively second kind). For these operators we study some approximation and convexity properties, modulus of continuity and Korovkin-type theorems. This is a joint work with Andra Malina.



Data-driven operators for reduced order model stabilization

Traian Iliescu
Virginia Tech, USA

Abstract

One of the most popular strategies for reduced order model (ROM) stabilization is to use spatial filtering to smooth out the ROM approximation and alleviate the spurious numerical oscillations generally displayed by the standard ROM. In this talk, we propose a fundamentally new strategy: Instead of using classical ROM filters, we use data to construct ROM operators that yield the most accurate ROMs. To assess the new data-driven ROM, we compare it with a classical ROM stabilization in the numerical simulation of under-resolved, convection-dominated flows. Our numerical investigation shows that the new data-driven ROM is more accurate than the standard ROM stabilization with an optimal filter radius. We also investigate if the novel data-driven ROM operator represents a ROM spatial filter, and we compare it with the existing ROM spatial filters.

Water soil erosion. Numerical methods

Stelian Ion

ISMMA, Romanian Academy, Bucharest

Abstract

The water erosion is a complex process whose intensity strongly depends on the soil properties and the hydrodynamic forces involved. Given the large variability of the soil composition or of the topographic configurations, one can deal with different mathematical models having as subject the soil erosion. The model we present is intended to predict the fluid flow characteristics and the mass of sediment eroded and transported by the fluid. The fluid flow and soil erosion are thought of as a phase transition process between a solid phase, soil, and a fluid phase.

The soil surface is a mobile surface that separates the two phases. But, not any water flow implies soil erosion, or if there is some soil erosion, it is up to a degree that does not significantly influences the flow characteristics. If one thinks about the soil particle density in the fluid phase as a measure of the soil erosion intensity, then one can speak about a scale of soil erosion intensity. This scale starts from the clear water flow, passes through the state of mixture of water with sediment and ends with the no fluid phase state.

By asymptotic analysis of the complex erosion model, we show how one can obtain two classes of models widely used, namely: water flow without erosion and a decoupled model of water flow with soil erosion.

The equations describing these phenomena are of hyperbolic type. Finally we present certain qualitative properties and some numerical results. Joint work with Stefan-Gicu Cruceanu, Dorin Marinescu.



Approximation of nonlinear stochastic Schrödinger equations

Hannelore Lisei

Babeş-Bolyai University, Cluj-Napoca

Abstract

This talk examines stochastic nonlinear Schrödinger equations driven by fractional Brownian motion. A linearization technique is proposed to approximate variational solutions, and related stochastic control problems are studied, with emphasis on the existence and approximation of optimal controls.



Methods for interpolating scattered data

Andra Malina, Teodora Cătiņaș

Tiberiu Popoviciu Institute of Numerical Analysis, Romanian Academy, Cluj-Napoca

Abstract

The Shepard operator is an interpolation method that reconstructs the values of an unknown function from scattered data points using weighted averages based on the distances to those points. Although useful in practice, the classical Shepard operator has some limitations. To address these, it is often combined with other operators to improve accuracy while maintaining stability and smoothness. This work revisits some theoretical results for this method and presents numerical tests that both support the theory and demonstrate its application to real data problems.



Adaptive information refinement for active media

Sorin Mitran

University of North Carolina at Chapel Hill, USA

Abstract TBA

A hybrid evolution model for preservation of cultural heritage: stochastic particles in a random continuum environment

Adrian Muntean

Karlstads Universitet, Sweden

Abstract

Mathematics can contribute meaningfully with suggesting smart, non-invasive ways to maintain cultural heritage. In this context, we propose a well-posed hybrid stochastic-continuum evolution model to explore by means of numerical simulations the speed of marble corrosion. Specifically, we look closely at the sulphation of calcium carbonate and at the consequent formation of gypsum, a key phenomenon driving marble deterioration. While calcium carbonate and gypsum are continuous random fields evolving according to random ordinary differential equations, the dynamics of sulfuric acid particles follows Itô-type stochastic differential equations. The particle evolution incorporates both strong repulsion between particles via the Lennard-Jones potential, and non-local interactions with the continuum environment. The particle-continuum coupling is achieved through the chemical reaction, described as a Poisson counting process. We simulate numerically the spatio-temporal evolution of this corrosion process using the Euler-Maruyama algorithm with varying initial data combined with finite volumes to take care of the spatial discretization. Finally, we list a couple of open mathematical questions connected to this research. We report on joint work with Daniela Morale, Giulia Rui, and Stefania Ugolini from University of Milan (Italy) and Nicklas Jävergård from Karlstad University (Sweden).



Topology optimization problems for clamped plates

Cornel Murea

Université de Haute Alsace, France

Abstract

Fixed domain approaches are used for some topology optimization problems of clamped Kirchhoff-Love plates: detection of a damaged zone using pointwise observation and the first eigenvalue maximization. We discuss the derivability with respect to functional variations of the geometry and some descent directions are proposed. Numerical tests are presented.



From conditional stability to optimal approximation for ill-posed elliptic PDEs

Mihai Nechita

*Tiberiu Popoviciu Institute of Numerical Analysis, Romanian Academy
& Babeş-Bolyai University, Cluj-Napoca*

Abstract

This talk addresses the numerical approximation of conditionally stable problems for elliptic PDEs, using the classical example of unique continuation from interior data. Following the standard error analysis for the well-posed Poisson problem, the goal is to establish a benchmark for the best possible error estimates of any numerical approximation of unique continuation, in terms of convergence with respect to discretization and perturbations in data.

We prove that no approximation method can achieve a faster convergence rate than the one given by our definition of *optimal convergence*, without simultaneously increasing sensitivity to perturbations in the data. A key result is an optimal three-ball inequality for harmonic functions, which quantifies conditional stability with explicit constants.

This is a joint work with Erik Burman and Lauri Oksanen, doi.org/10.1007/s10208-024-09655-w.

Effective interface laws of Navier-slip-type for Stokes flow through a thin elastic porous layer

Maria Neuss-Radu

Universität Erlangen-Nürnberg, Germany

Abstract

We present a rigorous derivation of an effective model for fluid flow through a thin elastic porous membrane separating two fluid bulk domains. The membrane is composed of a solid phase and fluid-filled pores, with thickness and periodicity of order ϵ . The microscopic model is governed by a coupled fluid-structure interaction system, with two distinct scalings of the elastic stress tensor. Using two-scale convergence techniques adapted to thin domains and oscillatory microstructures, the membrane is reduced to an effective interface across which transmission conditions are derived. The macroscopic model couples the fluid bulk domains via effective interface laws of Navier-slip-type including the dynamic displacement. This coupling depends critically on the scaling in the elastic stress tensor, leading to either a membrane equation or a Kirchhoff-Love plate equation for the effective displacement. The resulting interface conditions naturally admit mass exchange between the adjacent fluid regions. This is joint work with Markus Gahn (University of Augsburg, Germany).



The method of layer potentials for polygons and domains with cylindrical ends

Victor Nistor

Université Lorraine, France

Abstract TBA

Neuro-symbolic temporal encodings with adaptive logic constraints in transformer models

Darian Onchiş

West University of Timișoara

Abstract

We propose a novel neuro-symbolic framework that integrates a one-dimensional Transformer encoder with Logic Tensor Networks (LTN) and a dynamic rule-generation module. LTN instantiates a knowledge base whose satisfiability acts as a training signal (loss term), guiding the model. The Transformer extracts temporal and spectral features from raw vibration segments via multi-head attention, while logic rules enforce label consistency and similarity constraints that adapt to evolving cluster patterns. This work extends our prior LogicLSTM model where we noted the limitations of a fixed rule set. Here, rules are induced, merged, and pruned online from the evolving embedding (via class-wise prototypes), enabling dynamic knowledge adaptation and narrowing the gap to robust generalization under changing operating conditions



Learning with measures: The stochastic inverse problem

Maria Oprea
Cornell University, USA

Abstract TBA



Best Ulam constant of a partial differential operator

Diana Otrocol

*Tiberiu Popoviciu Institute of Numerical Analysis, Romanian Academy
& Technical University of Cluj-Napoca*

Abstract

In this talk, we give a characterization of Ulam stability for the linear partial differential operator $D: C^1(\mathbb{R}^2, X) \rightarrow C(\mathbb{R}^2, X)$ given by $Du = au_x + bu_y + cu$, where $a, b, c \in \mathbb{R}$ and X is a Banach space over $\mathbb{R}$. Moreover, we obtain the best Ulam constant of the operator D .



Generative assignment flows

Ștefania Petra

University of Augsburg, Germany

Abstract

In this talk we introduce a novel class of generative models for representing joint probability distributions of large numbers of discrete random variables. Employing closed-form geodesics on the underlying product manifold enables simulation-free learning via conditional Riemannian flow matching, using data encoded as geodesics on the assignment manifold with respect to the e-connection of information geometry. Numerical experiments on distributions of structured image labelings demonstrate the applicability to large-scale problems, which may include discrete distributions in other domains.



Optimization and separability problems in equivariant deep learning

Mircea Petrache

Pontificia Universidad Católica de Chile

Abstract TBA



Nash equilibria of fractional functionals via a Dinkelbach–Ekeland type approach

Radu Precup, Andrei Stan

Tiberiu Popoviciu Institute of Numerical Analysis, Romanian Academy, Cluj-Napoca

Abstract

We investigate the existence and localization of a Nash equilibrium for a system of two fractional functionals. The analysis adapts Dinkelbach’s parametric method to the equilibrium setting and develops a new parameter construction that ensures the monotonicity and convergence of the associated parameter sequences. The convergence of the approximate solutions is demonstrated through a technique based on matrices convergent to zero, combined with a convergence lemma derived from a recurrent inequality. Furthermore, the equilibrium components are individually localized within conical annular regions, which may reduce to a cone, the intersection of a cone and a ball, a single cone, or even the entire space. This localization relies on a careful application of Ekeland’s variational principle together with Leray–Schauder–type conditions on the boundaries of the conical regions.



Robust iterative schemes for Darcy and Darcy-Forchheimer flow in porous media

Florin Radu

University of Bergen, Norway

Abstract

We will present iterative schemes for simulating flow in porous media. There are plenty of societal relevant applications behind, e.g. CO₂ storage, enhanced geothermal energy extraction or soil pollution. The mathematical models considered are based on Darcy or Darcy-Forchheimer laws and mass conservation. L-scheme (stabilized Picard method) and Newton method, or adaptive combinations of them are involved for the linearization. The convergence of the iterative schemes will be discussed. Illustrative numerical examples will be presented.

On Tikhonov regularization for the elliptic Cauchy problem

Rareş Răhăian

*Tiberiu Popoviciu Institute of Numerical Analysis, Romanian Academy
& Babeş-Bolyai University, Cluj-Napoca*

Abstract

The elliptic Cauchy problem is a classical example of a severely ill-posed inverse problem, where the solution of a partial differential equation must be reconstructed from incomplete and noisy boundary data. Regularization is essential to ensure stability and obtain meaningful numerical results. This talk focuses on Tikhonov regularization for the elliptic Cauchy problem. The problem is expressed as a PDE-constrained regularized optimisation problem, with the weak form enforced by introducing the test function as a Lagrange multiplier. Two formulations are proposed: one imposing the Dirichlet condition strongly, and the other weakly. We present well-posedness results for a corresponding saddle-point system, whose stability follows from the Banach-Necas-Babuska conditions, and discuss finite element discretisation and numerical performance.



Three-dimensional explicit L scheme for Richards equation

Nicolae Suciu

Tiberiu Popoviciu Institute of Numerical Analysis, Romanian Academy, Cluj-Napoca

Abstract

We present a numerical approach to compute three-dimensional solutions for flow in variably saturated porous media. Richards equation is linearized by an explicit globally-convergent L-scheme. The convergence towards the exact solution is verified numerically. A benchmark study demonstrates the need of three dimensional solutions of Richards equation in modeling porous media with complex spatial structure. Joint work with Imre Boros, Mihai Nechita, Florin A. Radu.



Reconstruction of the conformal factor in a two dimensional anisotropic current density impedance imaging problem

Alexandru Tămășan
University of Central Florida, USA

Abstract TBA



H^1 stability for 2D Navier-Stokes equations

Cătălin Trenchea

University of Pittsburgh, USA

Abstract

We study the H^1 -stability for all positive time of a family of A-stable time-stepping methods for the 2D Navier–Stokes equations. More precisely, we discretize in time using one-leg second-order accurate A-stable methods, and with the aid of the discrete Gronwall lemma and of the discrete uniform Gronwall lemma we prove that the numerical scheme admits this stability.

Relaxation enhancement by controlled incompressible fluid flows

Marius Tucsnak

Université de Bordeaux, France

Abstract

We propose a PDE-controllability based approach to the enhancement of diffusive mixing for passive scalar fields. Unlike in the existing literature, our relaxation enhancing fields are not prescribed ab initio at every time and at every point of the spatial domain. Instead, we prove that time-dependent relaxation enhancing vector fields can be obtained as state trajectories of control systems described by the incompressible Euler equations either driven by finite-dimensional controls or by controls localized in space. The main ingredient of our proof is a new approximate controllability theorem for the incompressible Euler equations on the two dimensional torus, ensuring the approximate tracking of the full state all over the considered time interval. Combining this with a continuous dependence result yields enhanced relaxation for the passive scalar field. Another essential tool in our analysis is the exact controllability of the incompressible Euler system driven by spatially localized forces.



Regularized policy gradient algorithm for the Multi Armed Bandit

Gabriel Turinici

Université Paris Dauphine, France

Abstract

Multi Armed Bandit (MAB) on one hand and the policy gradient approach on the other hand are among the most used frameworks in Reinforcement Learning, however existing convergence proofs for policy gradient Multi Armed Bandit are often attached to an asymptotic setting. We discuss the convergence when a L2 regularization term is present in the 'softmax' parametrization and present numerical test to show that a time dependent regularized procedure can improve over the canonical approach especially when the initial guess is far from the solution.

Validation of a mathematical model of arterial wall mechanics against experimental results.

Marina Vidrascu
INRIA Paris, France

Abstract

This work is related to pharmacological studies. It aims to develop mathematical models that reproduce experimental data of arterial compliance. The ROTSAC experimental setup [1] investigates how arterial stiffness is influenced by vasoconstrictors and vasodilators. In this experiment, aortic segments are mounted on two parallel metal hooks and stretched with an imposed dynamic load.

I will present a first mathematical model based on 3d Shells [2] with active fibers describing the behavior of the tissue and validate it against experimental results. The model parameters involved in the constitutive laws are identified using real data by means of an optimization method. The resulting model is able to reproduce the experimental data and predict the system's behavior in different settings beyond those used for parameter estimation. This enables the assessment of different scenarios concerning the impact of the molecules on the active or passive contributions of the arterial wall.

I will then present a more complete mathematical model for simulating the aforementioned ex vivo setup. It includes a contact mechanics model to account for the interactions between the tissue and rigid components. This is a joint work with Sara Costa Faya, Damiano Lombardi and Miguel Fernandez. The experiments were performed at the University of Antwerp by Pieter-Jan Guns and Callan Wesley as part of the INSPIRE European Training Network.

[1] Leloup, A. J. A., Van Hove, C. E., De Moudt, S., De Meyer, G. R. Y., De Keulenaer, G. W., and Fransen, P. (2019). Vascular smooth muscle cell contraction and relaxation in the isolated aorta: a critical regulator of large artery compliance. *Physiol Rep*, 7(4):e13934.

[2] Chapelle, D., Ferent, A., and Bathe, K. J. (2004). 3D shell elements and their underlying mathematical model. *Math. Models Methods Appl. Sci.*, 14(1):105–142.