Joint Fudan-Vienna Workshop on Applied Mathematics and Data Science

Conference in Shanghai, China
February 25–29, 2024

Scientific committees:

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Torsten Möller, *Speaker of the Research Network Data Science, University of Vienna, Austria*

Organized by: School of Mathematical Sciences, Fudan University

Address: No.220, Road Handan, Shanghai, China, 200433

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Joint Fudan-Vienna Workshop on Applied Mathematics and Data Science

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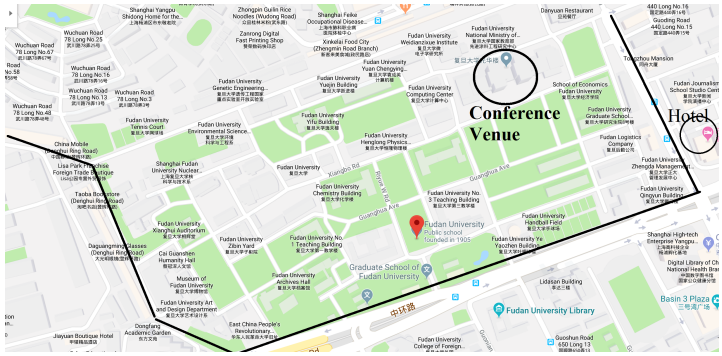
Venue information

The conference venue is at **Room 2201, East Guanghualou**, Fudan University. The address is No.220, Road Handan, Shanghai, China, 200433.



Map of the Fudan University (Handan Campus). The conference hotel (Fuxuan Hotel Shanghai) is located close to the Fudan University.

General schedule

	Sun, Feb. 25	Mon, Feb. 26	Tue, Feb. 27	Wed, Feb. 28	Thu, Feb. 29
08:00–09:00					
		Opening 08:30 - 9:00		**Weihong Yang** 08:30 - 9:00	
09:00–10:00		**Christa Cuchiero** 09:00 - 09:30	**Lukas Steinberger** 09:00 - 9:30	**Yurii Malitskyi** 09:00 - 9:30	Departure
		Lei Shi 09:30 - 10:00	**Shuangjian Zhang** 09:30 - 10:00	**Rujun Jiang** 09:30 - 10:00	
10:00–11:00		**Martin Ehler** 10:00 - 10:30	**Tatyana Krivobokova** 10:00 - 10:30	**Michael Sedlmayer** 10:00 - 10:30	
		Tea Break10:30-10:40	Tea Break10:30-10:40	Tea Break10:30-10:40	
		Yingzhou Li 10:40 - 11:10	**Tiandong Wang** 10:40 - 11:10	**Xudong Li** 10:40 - 11:10	
11:00–12:00		**Yllka Velaj** 11:10 - 11:40	**Vladimir Kazeev** 11:10 - 11:40	**Oliver Hahn** 11:10 - 11:40	
		Zhixu Li 11:40 - 12:10	**Tianyu Wang** 11:40 - 12:10	**Siming Chen** 11:40 - 12:10	
12:00–13:00	Arrival & Registeration 14:00 - 18:00	Lunch Break 12:10 - 14:00	Lunch Break 12:10 - 14:00	Lunch Break 12:10 - 14:00	
13:00–14:00					
14:00–15:00		**Jian Zhai** 14:00 - 14:30	**Campus and Austria Center tour** 14:00 - 17:00	**Cooperation discussion** 14:00 - 17:00	
		Volker Branding 14:30 - 15:00			
15:00–16:00		**Ke Wei** 15:00 - 15:30			
		Tea Break15:30-15:40			
		Peter Elbau 15:40 - 16:10			
16:00–17:00		**Xiahai Zhuang** 16:10 - 16:40			
		Clemens Kirisits 16:40 - 17:10			
17:00–18:00	Welcome dinner 17:00 - 20:00		Conference dinner 17:00 - 20:00		

2 Invited talks

All invited talks are scheduled at Room 2201, East Guanghualou, Fudan University.

- **Global universal approximation of functional input maps on weighted spaces and applications to signature methods**
  Christa Cuchiero, *University of Vienna*
  Monday, February 26, 09:00-09:30

- **Classification with deep neural networks**
  Lei Shi, *Fudan University*
  Monday, February 26, 09:30-10:00

- **Learn to sample and to project data**
  Martin Ehler, *University of Vienna*
  Monday, February 26, 10:00-10:30

- **Quantum orbital minimization method and optimal orbital selection for excited states calculation**
  Yingzhou Li, *Fudan University*
  Monday, February 26, 10:40-11:10

- **Embedding of attributed multiplex networks**
  Yllka Velaj, *University of Vienna*
  Monday, February 26, 11:10-11:40

- **Data-Centric AI practices with generative large language models**
  Zhixu Li, *Fudan University*
  Monday, February 26, 11:40-12:10

- **Inverse boundary value problems for nonlinear wave equations**
  Jian Zhai, *Fudan University*
  Monday, February 26, 14:00-14:30

- **An invitation to harmonic maps**
  Volker Branding, *University of Vienna*
  Monday, February 26, 14:30-15:00

- **Projected policy gradient converges in a finite number of iterations**
  Ke Wei, *Fudan University*
  Monday, February 26, 15:00-15:30

- **Imaging of trapped particles**
  Peter Elbau, *University of Vienna*
  Monday, February 26, 15:40-16:10

Invited talks

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- **BayeSeg: interpretable deep learning for medical image analysis**
  Xiahai Zhuang, *Fudan University*
  Monday, February 26, 16:10-16:40

- **Filtered backpropagation formulas for diffraction tomography**
  Clemens Kirisits, *University of Vienna*
  Monday, February 26, 16:40-17:10

- **Statistical efficiency in local differential privacy**
  Lukas Steinberger, *University of Vienna*
  Tuesday, February 27, 09:00-09:30

- **Recent advances in the monopolist's problem**
  Shuangjian Zhang, *Fudan University*
  Tuesday, February 27, 09:30-10:00

- **Iterative regularisation in ill-posed generalised linear models**
  Tatyana Krivobokova, *University of Vienna*
  Tuesday, February 27, 10:00-10:30

- **Testing strong and full dependence for multivariate extremes**
  Tiandong Wang, *Fudan University*
  Tuesday, February 27, 10:40-11:10

- **Leveraging hidden structure in PDE problems with stable low-rank tensor representation and approximation**
  Vladimir Kazeev, *University of Vienna*
  Tuesday, February 27, 11:10-11:40

- **Zeroth-order low-rank Hessian estimation via matrix recovery**
  Tianyu Wang, *Fudan University*
  Tuesday, February 27, 11:40-12:10

- **Proximal quasi-Newton method for composite optimization over the Stiefel manifold**
  Weihong Yang, *Fudan University*
  Wednesday, February 28, 08:30-09:00

- **Adaptive first-order methods for continuous optimization**
  Yurii Malitskyi, *University of Vienna*
  Wednesday, February 28, 09:00-09:30

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- **Decision making under cumulative prospect theory: an alternating direction method of multipliers**
  Rujun Jiang, *Fudan University*
  Wednesday, February 28, 09:30-10:00

- **A fast optimistic method for monotone variational inequalities**
  Michael Sedlmayer, *University of Vienna*
  Wednesday, February 28, 10:00-10:30

- **Quadratically convergent semismooth Newton methods for degenerate nonlinear SDP**
  Xudong Li, *Fudan University*
  Wednesday, February 28, 10:40-11:10

- **Decoding our cosmic origins from galaxy surveys**
  Oliver Hahn, *University of Vienna*
  Wednesday, February 28, 11:10-11:40

- **Human-AI collaboration for data analysis through visual interface: verification, explanation and storytelling**
  Siming Chen, *Fudan University*
  Wednesday, February 28, 11:40-12:10

3 Abstract of invited talks

Global universal approximation of functional input maps on weighted spaces and applications to signature methods

SPEAKER: Christa Cuchiero, *University of Vienna*

SCHEDULED: Monday, February 26, 09:00–09:30 at Room 2201

SESSION CHAIR: Shuai Lu, *Fudan University*

ABSTRACT: We introduce so-called functional input neural networks defined on a possibly infinite dimensional weighted space with values also in a possibly infinite dimensional output space. To this end, we use an additive family as hidden layer maps and a non-linear activation function applied to each hidden layer. Relying on Stone-Weierstrass theorems on weighted spaces, we can prove a global universal approximation result for generalizations of continuous functions going beyond the usual approximation on compact sets. As a further application we prove a global universal approximation result for linear functions of path signature which qualifies as well suited regression basis for path space functionals. We then apply these signature methods and corresponding approximation theorems to portfolio optimization in finance.

Classification with deep neural networks

SPEAKER: Lei Shi, *Fudan University*

SCHEDULED: Monday, February 26, 09:30–10:00 at Room 2201

SESSION CHAIR: Shuai Lu, *Fudan University*

ABSTRACT: Classification with deep neural networks (DNNs) has made impressive advancements in various learning tasks. Due to the unboundedness of the target function, generalization analysis for DNN classifiers with logistic loss remains scarce. Recent progress in establishing a unified framework of generalization analysis for both bounded and unbounded target functions is reported. The analysis is based on a novel oracle-type inequality, which enables us to deal with the boundedness restriction of the target function. In particular, for logistic classifiers trained by deep, fully connected neural networks, the optimal convergence rates are obtained only by requiring the Hölder smoothness of the conditional probability. Under certain circumstances, such as when decision boundaries are smooth and the two classes are separable, the derived convergence rates can be independent of the input dimension.

Learn to sample and to project data

Speaker:	Martin Ehler, *University of Vienna*
Scheduled:	Monday, February 26, 10:00–10:30 at Room 2201
Session Chair:	Shuai Lu, *Fudan University*

Abstract: We are producing and collecting more and more data in almost every part of our daily life. The vast size and complexity of data is often expressed in terms of high-dimensionality. However, analysis methods usually suffer from the curse of dimensionality. Here, we discuss effective dimension reduction.
- Sampling data along a curve reduces dimension to a one-parameter representation. We determine curves that optimally represent the data [1,3].
- Orthogonal projections naturally provide lower-dimensional data representation [2]. We make use of curves of orthogonal projectors [1, 3] to efficiently reduce dimension and to provide new data visualization.
This talk combines joint work with Karlheinz Gröchenig, Anna Breger, Clemens Karner, Manuel Gräf, Sebastian Neumayer, and Gabriele Steidl.
[1] Ehler, Gröchenig: t-design curves and mobile sampling on the sphere, Forum of Mathematics, Sigma, 2023.
[2] Breger, Karner, Ehler: visClust: A visual clustering algorithm based on orthogonal projections, Pattern Recognition, 2023.
[3] Ehler, Gräf, Neumayer, Steidl: Curve Based Approximation of Measures on Manifolds by Discrepancy Minimization, Found. Comput. Math. 2021.

Quantum orbital minimization method and optimal orbital selection for excited states calculation

SPEAKER: Yingzhou Li, *Fudan University*

SCHEDULED: Monday, February 26, 10:40–11:10 at Room 2201

SESSION CHAIR: Shuai Lu, *Fudan University*

ABSTRACT: We propose a quantum-classical hybrid variational algorithm, the quantum orbital minimization method (qOMM), for obtaining the ground state and low-lying excited states of a Hermitian operator. Given parametrized ansatz circuits representing eigenstates, qOMM implements quantum circuits to represent the objective function in the orbital minimization method and adopts a classical optimizer to minimize the objective function with respect to the parameters in ansatz circuits. We carry out numerical simulations that seek to find excited states of H2, LiH, and a square lattice of 4 hydrogen atoms with UCCSD ansatz circuits. Comparing the numerical results with existing excited states methods, qOMM is less prone to getting stuck in local minima and can achieve convergence with more shallow ansatz circuits.

We also propose incorporating an orbital optimization scheme into quantum eigensolvers to reduce the number of qubits required for a given problem. The optimal transformation is found by minimizing the ground state energy with respect to this partial unitary matrix. Through numerical simulations of small molecules up to 16 spin orbitals, we demonstrate that this method has the ability to greatly extend the capabilities of near-term quantum computers with regard to the electronic structure problem. We find that VQE paired with orbital optimization consistently achieves lower ground state energies than traditional VQE when using the same number of qubits and even frequently achieves lower ground state energies than VQE methods using more qubits.

Embedding of attributed multiplex networks

SPEAKER: Yllka Velaj, *University of Vienna*

SCHEDULED: Monday, February 26, 11:10–11:40 at Room 2201

SESSION CHAIR: Shuai Lu, *Fudan University*

ABSTRACT: Complex information can be represented as networks (graphs) characterized by multiple types of nodes and multiple types of relationships between them, i.e. multiplex networks. Additionally, these networks are enriched with different types of node features and labels.

In this talk, I will present an embedding approach for Attributed Multiplex Networks, to jointly embed nodes and node attributes of multiplex networks in a low dimensional space. This method integrates techniques from Spectral Embedding and Homogeneity Analysis to improve the embedding of nodes, node attributes, and node labels.

The experiments show that the proposed approach outperforms state-of-the-art methods for down-stream tasks such as semi-supervised node classification and node clustering.

Data-Centric AI practices with generative large language models

SPEAKER: Zhixu Li, *Fudan University*

SCHEDULED: Monday, February 26, 11:40–12:10 at Room 2201

SESSION CHAIR: Shuai Lu, *Fudan University*

ABSTRACT: Generative Large Language Models (LLMs) have triggered a new technological revolution and may lead to general Artificial Intelligence (AI). In the current situation, the development of AI needs to be more data-centric. How to prepare pre-training and fine-tuning data for LLMs and How can LLMs empower our data engineering have become key issues in the implementation of LLMs. In this talk, we will share some views on data engineering and application practices related to LLMs.

Inverse boundary value problems for nonlinear wave equations

SPEAKER: Jian Zhai, *Fudan University*

SCHEDULED: Monday, February 26, 14:00–14:30 at Room 2201

SESSION CHAIR: Radu Ioan Boţ, *University of Vienna*

ABSTRACT: I will discuss several inverse boundary value problems for wave equations. The main tool for the study is the analysis of nonlinear interactions of distorted plane waves or Gaussian beams.

An invitation to harmonic maps

SPEAKER: Volker Branding, *University of Vienna*

SCHEDULED: Monday, February 26, 14:30–15:00 at Room 2201

SESSION CHAIR: Radu Ioan Boţ, *University of Vienna*

ABSTRACT: Harmonic maps are a well-studied geometric variational problem for maps between Riemannian manifolds with many links to analysis, geometry and theoretical physics. The harmonic map equation is a non-linear partial differential equation of second order which, in its simplest form, reduces to the equation for geodesics describing the shortest path between two points in a Riemannian manifold. Due to their non-linear nature it is a challenging task to obtain general existence results for harmonic maps.
In the first part of the talk we will give a general introduction to the notion of harmonic maps and present a number of key results without assuming any prior knowledge on Riemannian geometry.
The second part of the talk will be concerned with harmonic self-maps which are harmonic maps for which domain and target manifold coincide. By imposing additional symmetry assumptions the equation for harmonic self-maps reduces to an ordinary differential equation allowing for the application of tools from dynamical systems. We will report on the existence of an infinite family of harmonic self-maps of ellipsoids in all dimensions. This is joint work with Anna Siffert.

Projected policy gradient converges in a finite number of iterations

Speaker:	Ke Wei, *Fudan University*
Scheduled:	Monday, February 26, 15:00–15:30 at Room 2201
Session Chair:	Radu Ioan Boţ, *University of Vienna*

Abstract: Reinforcement learning (RL) is a type of machine learning technique for solving sequential decision problems which has achieved great success in many areas. Overall, there are two typical categories of RL algorithms: valued based methods and policy optimization. In this talk, we will first give a brief introduction on RL and those methods. Then, we will focus particularly on policy optimization and report some recent progress on the convergence of the very basic projected policy gradient method.

Imaging of trapped particles

Speaker:	Peter Elbau, *University of Vienna*
Scheduled:	Monday, February 26, 15:40–16:10 at Room 2201
Session Chair:	Radu Ioan Boţ, *University of Vienna*

Abstract: When imaging microscopic samples, it is often necessary to fix the object in some way beforehand so that it does not move. We can achieve this in a non-invasive way by only holding it in place with appropriately adjusted acoustic or optical forces. By slightly adapting these forces, this setup also allows for rotating the object so that we can image it from different directions.
An interesting difficulty in this approach is, however, that we cannot predict the rotational motion of the object precisely, since its interior structure and therefore its reaction to the applied forces is not known in advance. This means that we acquire as measurements optical tomography data from many different, but unknown incident directions-similar to the situation in cryogenic electron microscopy.
In this talk, we want to show some ideas how to extract from this data the relative orientations of the object during the measurements and discuss under which conditions this is possible.

BayeSeg: interpretable deep learning for medical image analysis

Speaker:	Xiahai Zhuang, *Fudan University*
Scheduled:	Monday, February 26, 16:10–16:40 at Room 2201
Session Chair:	Radu Ioan Boţ, *University of Vienna*

Abstract: Artificial intelligence empowered medical imaging plays an important role in modern medicine, such as computer-assisted diagnosis and treatment. In these high-stakes scenarios, model generalizability and interpretability are crucial yet remains a challenge. To address this, we propose an interpretable framework (BayeSeg) via modeling of image and label statistics to enhance model generalizability for medical image segmentation. The framework is implemented with deep neural networks. Results have shown the effectiveness of the proposed method with interpretability and generalizability.

Filtered backpropagation formulas for diffraction tomography

Speaker:	Clemens Kirisits, *University of Vienna*
Scheduled:	Monday, February 26, 16:40–17:10 at Room 2201
Session Chair:	Radu Ioan Boţ, *University of Vienna*

Abstract: Diffraction tomography is an inverse scattering technique which can be used to reconstruct material properties of weakly scattering objects from recordings of the full scattered field. It can be seen as an extension of classical computerized tomography to situations where the straight ray assumption is no longer valid and, instead, a wave equation is used as forward model. The central result of diffraction tomography is the Fourier diffraction theorem, which directly relates the measurements to the scattering potential in the Fourier domain. In this talk we present a general version of this result and show how it gives rise to a large class of so-called filtered backpropagation formulas. These are explicit integral representations of low-pass filtered versions of the scattering potential, whose specific forms are determined by the imaging setup. We present numerical results, comparisons to alternative approaches and also discuss limitations as well as potential improvements.

Statistical efficiency in local differential privacy

Speaker:	Lukas Steinberger, *University of Vienna*
Scheduled:	Tuesday, February 27, 09:00–09:30 at Room 2201
Session Chair:	Wenlian Lu, *Fudan University*

Abstract: We develop the theory of asymptotically efficient statistical estimation for the case of local differential privacy. In this case the original data can not even be observed by the analyst, but are accessible only after a suitable randomization has been applied to protect data privacy. Hence, the problem consists not only of finding an (asymptotically) optimal statistical estimator for the unknown quantity of interest, but also of identifying an optimal randomization mechanism which introduces the least possible amount of extra variance needed to guarantee privacy.

We provide a general numerical scheme for finding this optimal randomization mechanism and derive explicit solutions in a few selected examples.

Recent advances in the monopolist's problem

Speaker:	Shuangjian Zhang, *Fudan University*
Scheduled:	Tuesday, February 27, 09:30–10:00 at Room 2201
Session Chair:	Wenlian Lu, *Fudan University*

Abstract: The principal-agent problem is one of the central problems in microeconomics with many applications. Existence, uniqueness, convexity/concavity, regularity, and characterization of the solutions have been widely studied after Mirrlees and Spence in the 1970s. Recently, the generalizations of convexity results for quasilinear utility functions to those of fully nonlinear served as the breakthrough in the past 20 years. Another recent work of the speaker characterizes the optimal solutions to this problem by identifying a dual minimization problem. This duality allows reducing the solution of the square example of Rochet-Choné to a novel free boundary problem, giving the first analytical description of an overlooked market segment, where the regularity built by Caffarelli-Lions plays a crucial role – an extension of their regularity work to the quasilinear case is also recently studied.

In this talk, I will first introduce the historical work on the principal-agent framework under the context of the monopolist problem before moving to the recent progress. The results profoundly connect with the Optimal Transport theory, a powerful tool with potential applications in many areas. This talk contains my joint work with Guillaume Carlier, Robert J. McCann and Cale Rankin.

Iterative regularisation in ill-posed generalised linear models

Speaker:	Tatyana Krivobokova, *University of Vienna*
Scheduled:	Tuesday, February 27, 10:00–10:30 at Room 2201
Session Chair:	Wenlian Lu, *Fudan University*

Abstract: We study the problem of regularized maximum-likelihood optimization in ill-posed generalized linear models with covariates that include subsets that are relevant and that are irrelevant for the response. It is assumed that the source of ill-posedness is a joint low dimensionality of the response and a subset of the relevant covariates in the sense of a latent factor generalized linear model (GLM). In particular, we propose a novel iteratively-reweighted-partial-least-squares (IRPLS) algorithm and show that it is better than any other projection or penalization-based regularisation algorithm. Under regularity assumptions on the latent factor GLM we show that the convergence rate of the IRPLS estimator with high probability is the same as that of the maximum likelihood estimator in our latent factor GLM, which is an oracle achieving an optimal parametric rate. Our findings are confirmed by numerical studies. This is a joint work with Gianluca Finocchio.

Testing strong and full dependence for multivariate extremes

Speaker:	Tiandong Wang, *Fudan University*
Scheduled:	Tuesday, February 27, 10:40–11:10 at Room 2201
Session Chair:	Wenlian Lu, *Fudan University*

Abstract: Preferential attachment models of network growth are bivariate heavy-tailed models for in- and out-degree with limit measures which either concentrate on a ray of positive slope from the origin or on all of the positive quadrant depending on whether the model includes reciprocity or not. Concentration on the ray is called full dependence. If there were a reliable way to distinguish full dependence from not-full, we would have guidance about which model to choose. This motivates investigating tests that distinguish between (i) full dependence; (ii) strong dependence (support of the limit measure is a proper subcone of the positive quadrant); and (iii) weak dependence (limit measure concentrates on positive quadrant). We give two test statistics, analyze their asymptotically normal behavior under full and not-full dependence, and discuss applicability using bootstrap methods applied to simulated and real data.

Leveraging hidden structure in PDE problems with stable low-rank tensor representation and approximation

SPEAKER: Vladimir Kazeev, *University of Vienna*

SCHEDULED: Tuesday, February 27, 11:10–11:40 at Room 2201

SESSION CHAIR: Wenlian Lu, *Fudan University*

ABSTRACT: The approximation of complex data in suitable low-dimensional subspaces is fundamental to scientific computing and data science: many applications exhibit hidden low-dimensional structure in some form, allowing for storage and computations in terms of relatively few parameters. In the context of PDEs, much of the work of traditional numerical analysts consists in proving the presence of such structure in specific classes of PDE problems. That is typically done in a constructive way: a numerical method (approximation subspaces) for the chosen problem class is designed, and the properties of the method (of the subspaces) with respect to approximation, stability and convergence are analyzed.

In contrast, low-rank tensor decompositions, relying on well-established techniques of numerical linear algebra and optimization, realize the adaptive low-parametric approximation of solutions. That allows for discovering efficient approximation subspaces computationally and thereby for dramatically reducing the complexity of numerical solvers. One such a decomposition was proposed under the names of *matrix product states* (MPS) in computational quantum physics and *tensor train* (TT) in computational mathematics. In particular, the multilevel MPS-TT representation, building on the classical idea of Kronecker-product multilevel approximation, allows to handle generic but extravagantly large discretizations and leads to data-driven computations based on effective discretizations adapted to the problem class and to the data instead of problem-dependent discretizations (approximation spaces) designed analytically. This approach has been shown, both theoretically and experimentally, to lead to the efficient approximation of algebraic singularities, boundary layers and high-frequency oscillations arising in multiscale diffusion problems, achieving root-exponential convergence with respect to the total number of representation parameters.

In this talk, we will give an overview of the approach and discuss the stability of low-rank MPS-TT representations and the quasi-optimality of the associated approximation algorithms. As we will show, these points extend to the recently proposed low-rank multilevel frame representation of functions. We will elaborate on its application for the numerical solution of PDE problems, where the low-rank adaptivity is used to resolve the multiscale structure of the data and of the solution.

Zeroth-order low-rank Hessian estimation via matrix recovery

SPEAKER: Tianyu Wang, *Fudan University*

SCHEDULED: Tuesday, February 27, 11:40–12:10 at Room 2201

SESSION CHAIR: Wenlian Lu, *Fudan University*

ABSTRACT: A zeroth-order Hessian estimator aims to recover the Hessian matrix of an objective function at any given point, using as few finite-difference computations as possible. This paper studies zeroth-order Hessian estimation for low-rank Hessians, from a matrix recovery perspective.

Existing matrix recovery methods can be divided into two categories: matrix regression-type methods, and matrix completion methods. Unfortunately, both classes of methods are unsuitable for low-rank Hessian estimation. For matrix regression-type methods, we aim to recover a matrix H based on linear measurements $\langle H, A\rangle$, where A is some measurement matrix. A typical choice of A is a matrix with *iid* Gaussian entries. However, this type of methods are not compatible with zeroth-order Hessian estimation tasks, since the measurement $\langle H, A\rangle$ cannot be obtained with $O(1)$ finite-difference operations, unless A is well-structured. Matrix completion methods are also unsuitable for Hessian estimation tasks, since success of matrix completion methods requires incoherence assumption. However, in zeroth-order optimization, one may need to estimate the Hessian at any given point. Imposing incoherence assumptions over all points in the function domain is excessively restrictive.

To this end, we study low-rank Hessian recovery methods that overcome the limitations of existing methods. We prove that for a Hessian matrix $H \in \mathbb{R}^{n\times n}$, if $C \cdot nr\log^2 n$ proper zeroth-order finite-difference calculations are obtained, an exact recovery of H is guaranteed with high probability. Here $r = rank(H)$ and C is an absolute constant. Compared to matrix regression-type methods, we use measurements that are compatible with zeroth-order Hessian estimators. Compared to matrix completion methods, we do not require any incoherence assumptions.

Downstream applications of our estimators to Newton's cubic methods will also be discussed.

Proximal quasi-Newton method for composite optimization over the Stiefel manifold

SPEAKER: Weihong Yang, *Fudan University*

SCHEDULED: Wednesday, February 28, 08:30–09:00 at Room 2201

SESSION CHAIR: Torsten Möller, *University of Vienna*

ABSTRACT: In this talk, based on a proximal gradient method, we present a Riemannian proximal quasi-Newton method, named ManPQN, to solve the composite optimization problems over the Stiefel manifold. The global convergence of the ManPQN method is proved and iteration complexity for obtaining an ϵ-stationary point is analyzed. Under some mild conditions, we also establish the local linear convergence result of the ManPQN method. Numerical results are encouraging, which show that the proximal quasi-Newton technique can be used to accelerate the proximal gradient method.

Adaptive first-order methods for continuous optimization

Speaker:	Yurii Malitskyi, *University of Vienna*
Scheduled:	Wednesday, February 28, 09:00–09:30 at Room 2201
Session Chair:	Torsten Möller, *University of Vienna*

Abstract: First-order methods play a crucial role in modern machine learning. In this talk, I will present a new way to make the gradient descent and proximal gradient method fully adaptive and at the same time without increasing their iteration cost. We don't need any additional assumptions and even relax the assumption of global Lipschitzness for the differentiable component. The stepsizes approximate the local curvature of the differentiable function and can increase from iteration to iteration. We will discuss some limitations and open problems. This is a joint work with Konstantin Mishchenko.

Decision making under cumulative prospect theory: an alternating direction method of multipliers

Speaker:	Rujun Jiang, *Fudan University*
Scheduled:	Wednesday, February 28, 09:30–10:00 at Room 2201
Session Chair:	Torsten Möller, *University of Vienna*

Abstract: In this talk, I will present a novel numerical method for solving the problem of decision making under cumulative prospect theory (CPT), where the goal is to maximize utility subject to practical constraints, assuming only finite realizations of the associated distribution are available. Existing methods for CPT optimization rely on particular assumptions that may not hold in practice. To overcome this limitation, we present the first numerical method with a theoretical guarantee for solving CPT optimization using an alternating direction method of multipliers (ADMM). One of its subproblems involves optimization with the CPT utility subject to a chain constraint, which presents a significant challenge. To address this, we develop two methods for solving this subproblem. The first method uses dynamic programming, while the second method is a modified version of the pooling-adjacent-violators algorithm that incorporates the CPT utility function. Moreover, we prove the theoretical convergence of our proposed ADMM method and the two subproblem-solving methods. Finally, we conduct numerical experiments to validate our proposed approach and demonstrate how CPT's parameters influence investor behavior using real-world data. I will also talk about an application of the algorithm to rank-based loss minimization in machine learning.

A fast optimistic method for monotone variational inequalities

Speaker:	Michael Sedlmayer, *University of Vienna*
Scheduled:	Wednesday, February 28, 10:00–10:30 at Room 2201
Session Chair:	Torsten Möller, *University of Vienna*

Abstract: We study monotone variational inequalities that can arise as optimality conditions for constrained convex optimization or convex-concave minimax problems and propose a novel algorithm that uses only one gradient/operator evaluation and one projection onto the constraint set per iteration. The algorithm, which we call fOGDA-VI, achieves a o(1/k) rate of convergence in terms of the restricted gap function as well as the natural residual for the last iterate. Moreover, we provide a convergence guarantee for the sequence of iterates to a solution of the variational inequality. These are the best theoretical convergence results for numerical methods for (only) monotone variational inequalities reported in the literature. To empirically validate our algorithm we investigate a two-player matrix game with mixed strategies of the two players. Concluding, we show promising results regarding the application of fOGDA-VI to the training of generative adversarial nets.

Quadratically convergent semismooth Newton methods for degenerate nonlinear SDP

Speaker:	Xudong Li, *Fudan University*
Scheduled:	Wednesday, February 28, 10:40–11:10 at Room 2201
Session Chair:	Torsten Möller, *University of Vienna*

Abstract: The non-singularity of generalized Jacobians in the Karush-Kuhn-Tucker (KKT) system is crucial for local convergence analysis in semismooth Newton methods. In this talk, we present a new approach that challenges this conventional requirement. Our discussion revolves around a methodology that leverages some newly developed variational properties, effectively bypassing the necessity for non-singularity of all elements in the generalized Jacobian. Quadratic convergence results of our Newton methods are established without relying on commonly assumed regularity conditions. This discussion may offer fresh insights into semismooth Newton methods, potentially paving the way for designing robust and efficient second-order algorithms for general nonsmooth composite optimizations.

Decoding our cosmic origins from galaxy surveys

SPEAKER: Oliver Hahn, *University of Vienna*

SCHEDULED: Wednesday, February 28, 11:10–11:40 at Room 2201

SESSION CHAIR: Torsten Möller, *University of Vienna*

ABSTRACT: The quest for physics beyond the standard models of cosmology and particle physics is one of the main motivations for upcoming observatories in space and on earth. The cosmic large-scale structure provides a unique testing ground for connecting fundamental physics to astronomical observations. In order to optimally exploit the upcoming large data sets, combinations of analytical, numerical, and data-driven techniques will be used. I will give a short overview of the exciting field of large-scale structure cosmology and discuss a few interesting recent developments on the modelling side.

Human-AI collaboration for data analysis through visual interface: verification, explanation and storytelling

SPEAKER: Siming Chen, *Fudan University*

SCHEDULED: Wednesday, February 28, 11:40–12:10 at Room 2201

SESSION CHAIR: Torsten Möller, *University of Vienna*

ABSTRACT: In data analysis tasks, collaboration between AI and humans has become increasingly important for problems that cannot be directly solved by AI alone. Visualization bridges the gap between data and human for in-depth analysis. In this talk, we discuss the collaboration between humans and AI through visual interface from three aspects: the validation of AI models, opening the "black box" of artificial intelligence to provide "explainability", and generate data story and conduct storytelling. We demonstrate interactive scenarios from social media visual analytics, autonomous driving visual evaluation, OpenQA, and digital humanity. Through the above cases, we discuss various key points of human-machine collaboration and summarize the effectiveness that intelligent human-machine interaction needs to achieve.

4 Important information: Wifi, connecting bus and meals

Wifi information

We have eduroam in Fudan Campus. In case you do not have such an account. Please do the following step:

- Choose 'fduwireless' and open any webpage, i.e www.bing.com which leads to the login page;
- Input UserID: mathguest
- Input Password: fudan201809

Attention: Google service might be unreachable during the conference time. Please be ready for this.

Meals

We provide the meals for all invited speakers during the conference. Further details will be filled soon.

February 25 (Welcome dinner): Buffet at Baolong Hotel (Yixian Road 180)

Shuttle bus provided

Meeting Point: Lobby of Fuxuan Hotel

Meeting Time: 17:00, Feb. 25

February 26-28 (Lunch): Lunch Box at Conference Venue;

February 26 (Supper): Dinner at Danyuan Hotel;

February 27 (Supper): Banquet at Danyuan Hotel.

5 Fudan University and School of Mathematical Sciences

Fudan University

Fudan University was established in 1905 as Fudan Public School. It was the first institution of higher education to be founded by a Chinese person, renowned modern educator Ma Xiangbo. The school's name was chosen from the "Biography of Yuxia" in the Classic of History, where the two characters fù ("return") and dàn ("dawn") are found in the famous lines "Brilliant are the sunshine and moonlight, again the morning glory after the night," signifying continuous self-renewal, and expressing the hope that China could become a country with a strong higher education system run by Chinese intellectuals. In 1917 the name was changed from Fudan Public School to Fudan Private School. After the nationwide restructuring of institutions of higher education in 1952, Fudan University became a comprehensive university of arts and sciences; in 1959 it became one of the first National Key Universities along with Shanghai First Medical College (later known as Shanghai Medical University).

Shanghai Medical University was founded in 1927. It was the first medical school to be founded by a Chinese person. It was originally named Fourth Sun Yat-sen University Medical College.

Fudan University was merged with Shanghai Medical University in 2000, forming a new, stronger Fudan University with a broader set of disciplines: medicine, sciences, and arts. As one of the first participants in the 211 and 985 Projects, Fudan has developed into a comprehensive research university, with Departments of Philosophy, Economics, Law, Education, Literature, History, Science, Engineering, Medicine, and Management.

Fudan is home to 14,100 undergraduates and associate degree candidates, 14,800 graduates including 3000 foreign degree candidates, 2,700 staff and 3,100 full-time teaching faculty members. Fudan hosts 46 members of Chinese Academy of Science and members of Chinese Academy of Engineering, 99 Chair Professors of Chang Jiang Scholars Program, and 30 National Key Basic Research Program of China (also named "973 Program") PIs. There are 28 schools and independent departments with 70 bachelor degree programs, 35 doctoral degree programs of Level I academic disciplines, 154 doctoral degree programs, 224 master degree programs, and 29 post-doctoral programs. There are 11 Level I national key academic disciplines and 19 Level II national key academic disciplines. Fudan hosts around 300 research institutes including 5 national key labs, 38 ministerial or provincial key labs and engineering centers, 5 "Project 985" Science and Technology Innovation Platforms and 7 "Project 985" Arts and Social Sciences Innovation Bases.

The campus is laid out as a main area consisting of the Handan Street Campus and Jiangwan New Campus areas, along with two side campuses, Fenglin Campus and Zhangjiang Campus, covering a total area of 2.4432 square kilometers. The total area of all school buildings is 1.4923 square kilometers. Eleven hospitals are also affiliated with the school, including Zhongshan Hospital and Huashan Hospital, with a total of 15,000 doctors, nurses, and personnel.

Fudan University celebrated its 100th anniversary in 2005. Chinese president Hu Jintao sent a letter of congratulations, expressing his hopes that the school will continue its tradition of excellence while developing and innovating into the future, building itself into a world-class comprehensive university, fostering development of persons of talent, ability, and integrity, and putting forth a new, even greater contribution towards building a prosperous society and realizing the Chinese people's great revival.

Over the past hundred years, the school has made outstanding contributions to the country by developing talent, innovating in science and technology, carrying forward civilization, and serving society. Students and teachers of Fudan always keep in mind the school motto "Rich in knowledge and tenacious of purposes, inquiring with earnestness and reflecting with self-

practice," maintain the school spirit of "civilized, healthy, united, rousing," practice the school traditions of being "hard working, rigorous, result-oriented, and innovative," and develop the Fudan spirit of "patriotic service, academic independence, a diversity of approaches, and pursuit of excellence." They make great contributions to the liberation and development of the people, the construction and development of the nation, and the civilization and progress of society.

School of Mathematical Sciences

Led by trail-blazing mathematicians represented by Prof. Buchin SU and Prof. Kien-Kwong CHEN and with joint efforts of all the faculty members for more than six decades, Mathematics discipline has made remarkable achievements in scientific research and talents cultivation, earning tremendous national and global prestige. In January 2005, the School of Mathematical Sciences was founded. It covers a broad range of mathematical disciplines, including department of mathematics, department of applied mathematics, department of financial mathematics and control sciences, department of information and computational sciences, department of probability statistics and actuary, and an Institute of Mathematics.

As a pioneering subject capable of providing all doctoral programs approved by Academic Degrees Committee of the State Council, Mathematics at Fudan University covers all five subdisciplines: fundamental mathematics, applied mathematics, operational research and control theory, computational mathematics, probability theory and mathematical statistics. The former three are among the first national key disciplines. In 2007, mathematics became the national first-level key disciplines and ranked the second in China Discipline Ranking (CDR) in 2002, 2007, and 2012. It also ranks within the first 3‰ in ESI index.

In 1993, the School of Mathematical Sciences was authorized by National Education Commission to set up a base for talents training which scored high in the evaluations launched in 1999 and 2004. Besides, the school was one of the first schools to provide postdoctoral programs in China. In 2009, the School of Mathematical Sciences was honored as one of the outstanding communities of the National Education System.