

学习与逼近青年学者研讨会

会议手册

复旦大学数学科学学院

2023年5月7日-6月10日

会议简介

会议时间: 2023年5月7日、5月13日、5月27日、6月10日

9:00-11:30; 14:00-16:30

会议地点: 在线腾讯会议

主办单位: 复旦大学数学科学学院

会议组织:

石磊 复旦大学

吴宗敏 复旦大学

周定轩 悉尼大学

参会人员:

拜锦辉 复旦大学

包承龙 清华大学

卜一凡 复旦大学

陈夏铭 汕头大学

成诚 中山大学

高钦姣 浙江工商大学

高文武 安徽大学

郭正初 浙江大学

胡婷 西安交通大学

黄收友 湖北师范大学

焦雨领 武汉大学

雷冠杭 复旦大学

李洽 中山大学

李雨泉 复旦大学

林俊宏 浙江大学

林绍波 西安交通大学

凌舒扬 上海-纽约大学

刘星瑀 复旦大学

娄凌清 复旦大学

沈益 浙江理工大学

沈益超 复旦大学

施梦娴 复旦大学

斯庭宇 复旦大学

孙正杰 南京理工大学

唐敖洋 复旦大学

王承 惠州学院

王宇光 上海交通大学
魏轲 复旦大学
吴羿 复旦大学
夏伟淳 复旦大学
夏羽 杭州师范大学
向道红 浙江师范大学
徐敏 大连理工大学
杨佳奇 复旦大学
杨建斌 河海大学

杨冉 复旦大学
杨苏雯 复旦大学
叶颀 华南师范大学
尹首怡 复旦大学
张海樟 中山大学
张娜 华南农业大学
郑世豪 复旦大学
周杰 复旦大学
庄恒峰 复旦大学

会议议程

2023年5月7日（周日） 腾讯会议号：750 516 256 密码：200433		主持人
9:00—10:00	报告人：成诚（中山大学） 题目：Graph Filters on Spatially Distributed Networks	石磊
10:00—11:00	报告人：高文武（安徽大学） 题目：Quasi-interpolation for Data Mining	
11:00—11:30	咨询与讨论	
14:00—15:00	报告人：胡婷（西安交通大学） 题目：Pairwise Learning Problems with Regularization Networks and Nystrom Subsampling Approach	高文武
15:00—16:00	报告人：焦雨领（武汉大学） 题目：Stochastic Interpolations, Lipschitz Mass Transportation and Generative Learning	
16:00—16:30	咨询与讨论	
2023年5月13日（周六） 腾讯会议号：498 149 942 密码：200433		主持人
9:00—10:00	报告人：李洽（中山大学） 题目：Smoothing Algorithms for Nonsmooth Optimization over the Stiefel Manifold with Applications to the Graph Fourier Basis Problem	沈益
10:00—11:00	报告人：林绍波（西安交通大学） 题目：Adaptive Distributed Learning System with Privacy Preservation	
11:00—11:30	咨询与讨论	
14:00—15:00	报告人：沈益（浙江理工大学） 题目：An Open Problem on Sparse Representations in Unions of Bases	胡婷
15:00—16:00	报告人：夏羽（杭州师范大学） 题目：Phase Retrieval and Blind Deconvolution Theory under Random Mask Assumption	
16:00—16:30	咨询与讨论	

2023年5月27日（周六） 腾讯会议号：668 261 449 密码：200433		主持人
9:00—10:00	报告人：王宇光（上海交通大学） 题目：Applied Harmonic Analysis and Particle Dynamics for Designing Neural Message Passing on Graphs	凌舒扬
10:00—11:00	报告人：杨建斌（河海大学） 题目：Approximation from Noisy Data	
11:00—11:30	咨询与讨论	
14:00—15:00	报告人：叶颀（华南师范大学） 题目：Machine Learning in Banach Spaces: A Black-box or White-box Method?	杨建斌
15:00—16:00	报告人：凌舒扬（上海-纽约大学） 题目：Near-optimal Spectral Methods in Community Detection, Object Matching, and Statistical Ranking	
16:00—16:30	咨询与讨论	
2023年6月10日（周六） 腾讯会议号：266 765 960 密码：200433		主持人
9:00—10:00	报告人：包承龙（清华大学） 题目：The Moments of Orientation Estimations under Molecular Symmetry in Cryo-EM	张海樟
10:00—11:00	报告人：魏轲（复旦大学） 题目：On the Linear Convergence of Policy Gradient under Hadamard Parameterization	
11:00—11:30	咨询与讨论	
14:00—15:00	报告人：张海樟（中山大学） 题目：Hierarchical Kernels in Deep Kernel Learning	魏轲
15:00—16:00	报告人：张娜（华南农业大学） 题目：First-order Algorithms for a Class of Fractional Optimization Problems Arising from Sparse Signal Recovery	
16:00—16:30	咨询与讨论	

报告摘要

报告人：成诚（中山大学）

题目：Graph Filters on Spatially Distributed Networks

摘要：Graph signal processing provides an innovative framework to process data on graphs. Graph filters and their inverses have been widely used in denoising, smoothing, sampling, interpolating and learning. Implementation of graph filter and its inverse filtering procedure on spatially distributed networks (SDNs) is a remarkable challenge, as each agent on an SDN is equipped with a data processing subsystem with limited capacity and a communication subsystem with confined range due to engineering limitations. In this talk, I will introduce the graph filter and the associated inverse filtering on a spatially distributed network. I will also introduce iterative distributed algorithms which are applicable for the implementation of inverse filtering on SDNs.

报告人：高文武（安徽大学）

题目：Quasi-interpolation for Data Mining

摘要：Quasi-interpolation has been a useful tool for data mining. In this talk, I shall introduce some recent developments of quasi-interpolation of our work team, including constructing kernels with higher-order generalized Strang-Fix conditions, meshless symplectic schemes for numerical solutions of partial differential equations based on quasi-interpolation, study and construction quasi-interpolation under the probabilistic numerical framework such as quasi-interpolation for irregularly spaced data, optimality and regularization properties of quasi-interpolation, and so on.

报告人：胡婷（西安交通大学）

题目：Pairwise Learning Problems with Regularization Networks and Nystrom Subsampling Approach

摘要：Pairwise learning usually refers to the learning problem that works with pairs of training samples, such as ranking, similarity and metric learning, and AUC maximization. To overcome the challenge of pairwise learning in the large scale computation, this paper introduces Nystrom sampling approach to the coefficient-based regularized pairwise algorithm in the context of kernel networks. Our theorems establish that the obtained Nystrom estimator achieves the minimax error over all estimators using the whole data provided that the subsampling level is not too small. We derive the function relation between the subsampling level and regularization parameter that guarantees computation cost reduction and asymptotic behaviors' optimality simultaneously. The Nystrom coefficient-based pairwise learning method does not require the kernel to be symmetric or positive semi-definite, which provides more flexibility and adaptivity in the learning process. We apply the method to the bipartite ranking problem, which improves the state-of-the-art theoretical results in previous works.

报告人：焦雨领（武汉大学）

题目：Stochastic Interpolations, Lipschitz Mass Transportation and Generative Learning

摘要：We construct a unit-time flow on the Euclidean space via stochastic interpolations, which unified recent ODE flows in generative learning. We study the well-posedness of the flow and establish the Lipschitz property of the flow map at time 1. We apply the Lipschitz mapping to several rich classes of probability measures on deriving functional inequalities with dimension-free constants, sampling and generative learning.

报告人：李洽（中山大学）

题目：Smoothing Algorithms for Nonsmooth Optimization over the Stiefel Manifold with Applications to the Graph Fourier Basis Problem

摘要：In this talk, we consider a class of nonsmooth and nonconvex optimization problems over the Stiefel manifold where the objective function is the summation of a nonconvex smooth function and a nonsmooth Lipschitz continuous convex function composed with a linear mapping. Besides, we are interested in its application to the graph Fourier basis problem. We propose three numerical algorithms for solving this problem, by combining smoothing methods and some existing algorithms for smooth optimization over the Stiefel manifold. In particular, we approximate the aforementioned nonsmooth convex function by its Moreau envelope in our smoothing methods, and prove that the Moreau envelope has many favorable properties. Thanks to this and the scheme for updating the smoothing parameter, we show that any accumulation point of the solution sequence generated by the proposed algorithms is a stationary point of the original optimization problem. Numerical experiments on building graph Fourier basis are conducted to demonstrate the efficiency of the proposed algorithms.

报告人：林绍波（西安交通大学）

题目：Adaptive Distributed Learning System with Privacy Preservation

摘要：In this talk, we propose a novel adaptive distributed learning system based on divide-and-conquer and local average regression for prediction and privacy preservation simultaneously. Different from the classical distributed learning strategy whose algorithmic parameters and patterns are given by the central agent, our approach provides autonomy to each local agent in terms of parameter selection, algorithm designation and data perturbation.

Such an adaptive manner significantly enhances the privacy preservation of the system. Our theoretical results demonstrate that the novel adaptive distributed learning system does not degrade the prediction performance of classical systems via presenting optimal learning rates in the framework of statistical learning theory. Our theoretical assertions are verified via numerous numerical experiments including both toy simulations and real data study. In our analysis, the new system also admits a certain perturbation of the test data via showing an almost comparable accuracy to that of the original data, which provides a realistic possibility for protecting privacy from both training and testing sides.

报告人：沈益（浙江理工大学）

题目：An Open Problem on Sparse Representations in Unions of Bases

摘要：We consider sparse representations of signals from redundant dictionaries which are unions of several orthonormal bases. The spark introduced by Donoho and Elad plays an important role in sparse representations. However, numerical computations of sparks are generally combinatorial. For unions of several orthonormal bases, two lower bounds on the spark via the mutual coherence were established in previous work. We constructively prove that both of them are tight. Our main results give positive answers to Gribonval and Nielsen's open problem on sparse representations in unions of orthonormal bases. Constructive proofs rely on a family of mutual unbiased bases which first appears in quantum information theory. It is joint work with Prof. Song Li, Dr. Yuan Shen and Chenyun Yu.

报告人：夏羽（杭州师范大学）

题目：Phase Retrieval and Blind Deconvolution Theory under Random Mask Assumption

摘要： Instead of traditional Gaussian random measurements, we focus on the phase retrieval problem under masked Fourier measurements. It is one of the phase retrieval settings which is realizable in real applications. We discuss some truncated Wirtinger flow algorithm and improve the sampling complexity, which partly answer the question raised by E. Candès. Furthermore, we also analyze the blind deconvolution problem with modulated inputs. It is a challenging problem as both the blur kernel and the input signal are not known. When the signal is sparse and the blur kernel is short-supported, we present some algorithm with the sampling complexity smaller than nuclear norm minimization and least square method.

报告人：王宇光（上海交通大学）

题目： Applied Harmonic Analysis and Particle Dynamics for Designing Neural Message Passing on Graphs

摘要： Graph representation learning has broad applications from recommendation systems to drug and protein designs. In this talk, I will talk about using harmonic analysis and particle systems to design useful neural message passing with theoretically guaranteed separability and efficient computation. These message passings are proved to have strictly positive lower bounded Dirichlet energy and thus to circumvent the oversmoothing problem appearing in many spatial GNNs, when the node features are indistinguishable as the network deepens.

报告人：杨建斌（河海大学）

题目：Approximation from Noisy Data

摘要：Approximation of functions from observed data is often needed. This has been widely studied in the literature when data is exact and the underlying function is smooth. However, the observed data is often contaminated with noise and the underlying function may be nonsmooth. To properly handle noisy data, any effective approximation scheme must contain a noise removal component. To well approximate nonsmooth functions, one needs to have a sparse approximation in, for example, the wavelet domain. This talk presents theoretical analysis and applications of such noise removal schemes through the lens of function approximation. For a given sample size, approximation from uniform grid data and scattered data is investigated.

报告人：叶颀（华南师范大学）

题目：Machine Learning in Banach Spaces: A Black-box or White-box Method?

摘要：In this talk, we study the whole theory of regularized learning for generalized data in Banach spaces including representer theorems, approximation theorems, and convergence theorems. Specially, we combine the data-driven and model-driven methods to introduce the new algorithms and theorems of the regularized learning. Usually the data-driven and model-driven methods are used to analyze the black-box and white-box models, respectively. With the same thought of the Tai Chi diagram, we use the discrete local information of multimodal data and multiscale models to construct the global approximate solutions by the regularized learning. The work of the regularized learning for generalized data provides another road to study the theory and algorithms of machine learning including

- the interpretability in approximation theory,
- the nonconvexity and nonsmoothness in optimization theory,
- the generalization and overfitting in regularization theory.

Moreover, based on the regularized learning, we will discuss the composite algorithms for hierarchical teaching and image registration of our current research projects of the big data analysis in education and medicine.

报告人：凌舒扬（上海-纽约大学）

题目：Near-optimal Spectral Methods in Community Detection, Object Matching, and Statistical Ranking

摘要：Spectral methods have been widely used to recover low-rank structures from noisy high-dimensional data. In this talk, we will discuss three different applications: community detection under stochastic block model, object matching and group synchronization, and statistical ranking. We will show that the spectral methods are able to recover the "signal" near-optimally in the information-theoretical sense. We establish the eigenvector perturbation bound under ℓ_{∞} -norm which significantly improves the classical Davis-Kahan perturbation theory under ℓ_2 -norm. The main technique uses the recently popular leave-one-out trick which overcomes the statistical dependence in providing the entry-wise perturbation bound. We will discuss the main idea of leave-one-out trick and some future directions.

报告人：包承龙（清华大学）

题目：The Moments of Orientation Estimations under Molecular Symmetry in Cryo-EM

摘要：Cryogenic electron microscopy (cryo-EM) is a powerful imaging tool in structural biology. Since the orientation information of each particle is unknown, the orientation estimation and its statistics are challenging in cryo-EM image processing. Existing approaches establish the orientation statistics in $SO(3)$ or S^2 , while the molecular symmetry is not fully explored. In this talk, we discuss a numerical method for estimating the mean and variance of orientations, including spatial rotations and projection directions, by considering molecular symmetry in cryo-EM. Using the tools from non-unique games, the proposed non-convex formulation can be relaxed as a semi-definite programming problem. Furthermore, we propose a rounding procedure for determining the representatives. Experimental results show that our method can obtain the global minima and the proper representatives with high probability. The code is released as an open-source Python package `pySymStat`.

报告人：魏轲（复旦大学）

题目：On the Linear Convergence of Policy Gradient under Hadamard Parameterization

摘要：The convergence of deterministic policy gradient under the Hadamard parametrization is studied in the tabular setting and the global linear convergence of the algorithm is established. To this end, we first show that the error decreases at an $O(\frac{1}{k})$ rate for all the iterations. Based on this result, we further show that the algorithm has a faster local linear convergence rate after k_0 iterations, where k_0 is a constant that only depends on the MDP problem and the step size. Overall, the algorithm displays a linear convergence rate for all the iterations with a loose constant than that for the local linear convergence rate.

报告人：张海樟（中山大学）

题目：Hierarchical Kernels in Deep Kernel Learning

摘要：Classical kernel methods enjoy a solid mathematical foundation while have difficulty handling very complicated learning problems. In contrast, deep learning based on deep neural networks has achieved great successes in complicated learning problems including face recognition, speech recognition, game intelligence, natural language processing, and autonomous navigation. However, current deep learning methods are not well understood mathematically, which hinders their interpretability. Recently, there have been efforts in developing deep kernel learning with the hope of combining the advantages of kernel methods and deep learning. Such approaches aim to construct hierarchical kernels via consecutive compositions from widely-used reproducing kernels. In this paper, we characterize the corresponding reproducing kernel Hilbert spaces of hierarchical kernels, and study conditions ensuring that the reproducing kernel Hilbert space will be expanding as the layer of hierarchical kernels increases. The results will yield guidance to the construction of hierarchical kernels for deep kernel learning.

报告人：张娜（华南农业大学）

题目：First-order Algorithms for a Class of Fractional Optimization Problems Arising from Sparse Signal Recovery

摘要：In this talk, we will discuss a class of fractional optimization problems that arise from L_1/L_2 (the ratio of L_1 and L_2 norms) and L_1/SK (the ratio of L_1 and the vector K norms) sparse signal recovery. We will first establish a first-order necessary optimality condition for the problem and propose the PGSA (proximity-gradient-subgradient algorithm) as well as its

line search counterpart (PGSA_L). The global convergence as well as the convergence rate of the entire sequences generated by PGSA and the monotone PGSA_L are analyzed under the KL assumption. Then, we consider utilizing the extrapolation technique to accelerate PGSA and propose PGSA with backtracked extrapolation (PGSA_BE). After that, with the help of the primal-dual formulation of the original problem, we propose a multi-proximity gradient algorithm, which performs better for solving the L1/SK sparse signal recovery problem in terms of the computational efficiency.