重慶理工大學|数学科学研究中心
Mathematical Science Research Center, CQUT

Applied Geometry for Data Sciences

Conference Guide

Chongqing, China
July 25-29, 2022

Contents

Introduction

Applied geometry for data sciences conference is going to be held in a hybrid form at Mathematical Science Research Center, Chongqing University of Technology, **July 25-29, 2022**.Data-driven sciences are widely regarded as the fourth paradigm that can fundamentally change sciences and pave the way for a new industrial revolution. The great success of AlphaFold 2 in protein folding ushers in a new era for machine learning models in natural sciences. However, efficient representations and featurization are still one of the central challenges for AI-based data analysis at present. Computational and discrete geometry has achieved great success in data characterization and modelling. In particular, geometric deep learning has significantly advanced the capability of learning models for data with complicated topological and geometric structures. The combination of geometric methods with learning models has great potential to fundamentally change the data sciences. As the field is driven by a combination of deep mathematical methods and challenging data, it is important to bring both sides together. This conference will focus on the recent progresses of geometric models in data applications.

Conference Time: July 25-29, 2022

Conference Venue: The Huaxi Campus of CQUT

Zoom Meeting: 825 9648 7514 (Code: 202207)

Website: index.html (ntu.edu.sg)

Sponsors:

Chongqing University of Technology, China

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Hong Su (CQUT, 13678428816@163.com)

Ming Li (CQUT, mingli@cqut.edu.cn)

Schedule

July 25, Monday			
Chair	**Time**	**Speaker**	**Title**
Areejit Samal (The Institute of Mathematical Sciences (IMSc))	11:45-12:00 (UTC) 19:45-20:00 (Beijing Time)	Kefeng Liu (CQUT and UCLA)	Opening remarks
	12:00-12:50 (UTC) 20:00-20:50 (Beijing Time)	Areejit Samal (The Institute of Mathematical Sciences (IMSc))	Forman-Ricci curvature: A geometry-inspired measure with wide applications in network science
	12:50-13:40 (UTC) 20:50-21:40 (Beijing Time)	Anna Wienhard (Heidelberg University)	Graph Embeddings in Symmetric Spaces
	13:40-14:00 (UTC) 21:40-22:00 (Beijing Time)	Tea break	
	14:00-14:50 (UTC) 22:00-22:50 (Beijing Time)	Chandrajit Bajaj (University of Texas, Austin)	Learning Optimal Control with Stochastic Models of Hamiltonian Dynamics for Shape and Function Optimization
	14:50-15:40 (UTC) 22:50-23:40 (Beijing Time)	Christian Kuehn (TUM)	Dynamical Systems for Deep Neural Networks

July 26, Tuesday			
Chair	Time	Speaker	Title
Hao Xu (Zhejiang University)	06:00-06:50 (UTC) 14:00-14:50 (Beijing Time)	Jia-Kun Liu (University of Wollongong)	Some applications of optimal transportation
	06:50-07:40 (UTC) 14:50-15:40 (Beijing Time)	Hong Van Le Prague (Kyoto University)	Supervised learning with probabilistic morphisms and kernel mean embedding
	07:40-08:00 (UTC) 15:40-16:00 (Beijing Time)	Tea break	
	08:00-08:50 (UTC) 16:00-16:50 (Beijing Time)	Norbert Peyerimhoff (Durham University)	A curvature flow for weighted graphs based on the Bakry-Emery calculus
	08:50-09:40 (UTC) 16:50-17:40 (Beijing Time)	Hao Xu (Zhejiang University)	Frobenius algebra structure of statistical manifold

July 27, Wednesday			
Chair	Time	Speaker	Title
Mustafa Hajij (Santa Clara University)	00:00-00:50 (UTC) 08:00-08:50 (Beijing Time)	Bobo Hua (Fudan University)	Curvature conditions on graphs
	00:50-01:40 (UTC) 08:50-09:40 (Beijing Time)	Alexander Strang (UChicago)	A Functional Theory for Principle Trade-off Analysis
	01:40-02:00 (UTC) 09:40-10:00 (Beijing Time)	Tea break	
	02:00-02:50 (UTC) 10:00-10:50 (Beijing Time)	Mathieu Desbrun (Caltech)	Connection-based Dimensionality Reduction
	02:50-03:40 (UTC) 10:50-11:40 (Beijing Time)	Mustafa Hajij (Santa Clara University)	A unifying deep learning framework with higher order attention networks
	03:40-06:00 (UTC) 11:40-14:00 (Beijing Time)	Lunch time	

July 27, Wednesday			
Chair	Time	Speaker	Title
Shiping LIU (USTC)	06:00-06:50 (UTC) 14:00-14:50 (Beijing Time)	Konrad Polthier (FU Berlin)	Boundary-sensitive Hodge decompositions
	06:50-07:40 (UTC) 14:50-15:40 (Beijing Time)	Parvaneh Joharinad (IASBS, Zanjan)	Curvature of data
	07:40-08:00 (UTC) 15:40-16:00 (Beijing Time)	Tea break	
	08:00-08:50 (UTC) 16:00-16:50 (Beijing Time)	Dong ZHANG (MPI-MIS)	Higher order eigenvalues for graph p-Laplacians
	08:50-09:40 (UTC) 16:50-17:40 (Beijing Time)	Shiping LIU (USTC)	Signed graphs and Nodal domain theorems for symmetric matrices

July 28, Thursday			
Chair	Time	Speaker	Title
Michael Farber (Queen Mary University of London)	06:00-06:50 (UTC) 14:00-14:50 (Beijing Time)	Shi-Bing Chen (USTC)	The optimal partial transport problem
	06:50-07:40 (UTC) 14:50-15:40 (Beijing Time)	Alexander Bobenko (TU, Berlin)	TBA
	07:40-08:00 (UTC) 15:40-16:00 (Beijing Time)	Tea break	
	08:00-08:50 (UTC) 16:00-16:50 (Beijing Time)	Junjie WEE (NTU)	Mathematical AI for Molecular Sciences
	08:50-09:40 (UTC) 16:50-17:40 (Beijing Time)	Michael Farber (Queen Mary University of London)	Algorithms for automated decision making and topology

July 29, Friday			
Chair	Time	Speaker	Title
Jie Wu (BIMSA)	06:00-06:50 (UTC) 14:00-14:50 (Beijing Time)	Emil Saucan (ORT Braude & Technion)	Discrete Morse Theory, Persistent Homology and Forman-Ricci Curvature
	06:50-07:40 (UTC) 14:50-15:40 (Beijing Time)	Marzieh Eidi (Max Planck Institute for Mathematics)	Seeing Data Thr3ough the Lens of Geometry (Ollivier-Ricci Curvature)
	07:40-08:00 (UTC) 15:40-16:00 (Beijing Time)	Tea break	
	08:00-08:50 (UTC) 16:00-16:50 (Beijing Time)	Ye Ke (Chinese Academy of Sciences)	Geometry of the convergence analysis for low rank partially orthogonal tensor approximation problem
	08:50-09:40 (UTC) 16:50-17:40 (Beijing Time)	Jie Wu (BIMSA)	Topological Approaches to Graph Data
	09:40-10:00 (UTC) 17:40-18:00 (Beijing Time)	Huitao Feng (Nankai University)	Closing remarks

Summary

1. Areejit Samal (The Institute of Mathematical Sciences (IMSc))

Title: Forman-Ricci curvature: A geometry-inspired measure with wide applications in network science

Abstract: In the last few years, we have been active in the development of geometry-inspired measures for the edge-based characterization of real-world complex networks. In particular, we were first to introduce a discretization of the classical Ricci curvature proposed by R. Forman to the domain of complex networks. Forman-Ricci curvature is an attractive tool in network science due to the following reasons. Firstly, most traditional graph-theoretic measures such as degree and clustering coefficient are vertex-specific, while Forman-Ricci curvature is edge-specific. Secondly, the mathematical formula of the Forman-Ricci curvature elegantly allows for the analysis of weighted and unweighted graphs. Thirdly, we have also extended the definition of Forman-Ricci curvature to the realm of directed graphs. Fourthly, an important distinguishing feature of the Forman-Ricci curvature, in contrast to the other well-known discretization, namely, Ollivier-Ricci curvature, is its simplicity and suitability from a computational perspective for analysis of very large networks. Fifthly, we have developed an augmented version of the Forman-Ricci curvature which is suitable for analysis of higher-order networks. In this talk, I will mainly focus on the successful applications of Forman-Ricci curvature to real-world networks across different domains including life science and finance. Specifically, I will present application of discrete Ricci curvatures to: (a) brain functional connectivity networks constructed from resting-state fMRI data for subjects with autism spectrum disorder, and (b) time-series of financial networks.

2. Anna Wienhard (Heidelberg University)

Title: Graph Embeddings in Symmetric Spaces

Abstract: Learning faithful graph representations has become a fundamental intermediary step in a wide range of machine learning applications. We propose the systematic use of symmetric spaces as embedding targets. We use Finsler metrics integrated in a Riemannian optimization scheme, that better adapt to dissimilar structures in the graph and develop various tools for computations as well as for the analysis of the embeddings. This is joint work with Federico Lopez, Beatrice Pozzetti, Michael Strube and Steve Trettel.

3. Chandrajit Bajaj (University of Texas, Austin)

Title: Learning Optimal Control with Stochastic Models of Hamiltonian Dynamics for Shape and Function Optimization

Abstract: Shape and Function Optimization can be achieved through Optimal Control over infinite-dimensional search space. All optimal control problems can be solved by first applying the Pontryagin maximum principle, and then computing a solution to the obtained Hamiltonian dynamical system. In this talk, we first show how to learn a correct reduced Hamiltonian of the controlled Hamiltonian dynamics obtained by application of the Pontryagin maximum principle, to the original optimal control problem. The reduced Hamiltonian deep network can be trained by going backwards in time and from minimizing a loss function deduced from the Pontryagin maximum principle's conditions. This new framework applies to not only optimal control problems and reinforcement learning with finite-dimensional state and action spaces but also ones with infinite-dimensional spaces. Moreover, the learning

process is improved through variational inference by progressively learning a posterior distribution of reduced Hamiltonians, which leads to a filtraton of the generalized Hamiltonian coordinates during the deep neural network training.This is joint work with Minh Nguyen, Mathematics and Oden Institute, UT Austin.

4. Christian Kuehn (Technical University of Munich)

Title: Dynamical Systems for Deep Neural Networks

Abstract: In this talk, I am going to explain several approaches to explain the geometry and dynamics of neural networks. First, I will show, why neural networks should always be viewed within the framework of dynamical systems. Then I am going to show how to employ rigorous validated computation to prove period dynamics of neural nets. Finally, I am going to prove, how we may be able to derive mean-field differential equations for neural networks including full coupling of learning and information propagation on the network. Joint work with: Marios, Gkogkas, Elena Queirolo, and Chuang Xu.

5. Jia-Kun Liu (University of Wollongong)

Title: Some applications of optimal transportation

Abstract: In this talk, we will introduce some interesting applications of optimal transportation in various fields including a reconstruction problem in cosmology; a brief proof of isoperimetric inequality in geometry; and an application in image recognition relating to a transport between hypercubes. Our research focuses on the regularity theory for Monge-Ampere type equations, in particular the recent established global regularity results. This talk is based on a series of joint work with

Shibing Chen, Xu-Jia Wang, and with Gregoire Loeper.

6. Hong Van Le Prague (Kyoto University)

Title: Supervised learning with probabilistic morphisms and kernel mean embedding

Abstract: In my talk I shall explain a unified model of supervised learning using the concept of probabilistic morphisms. Then I shall define an instantaneous least squares loss function for a unified model of supervised learning via kernel mean embedding, which coincides with the 0-1 loss function in the case of multi-classification supervised learning. Furthermore, true predictors of the model are the minimizers of the expected loss function, and Empirical Risk Minimization is a consistent learning algorithm for this loss function in a large class of generative and discriminative models of supervised learning. Our result generalizes a result due to Gr\"unewalder-Le
-ver-Baldassarre-Patterson-Gretton-Pontil in 2012.

7. Norbert Peyerimhoff (Durham University)

Title: A curvature flow for weighted graphs based on the Bakry-Emery calculus

Abstract: The aim of this talk is to introduce a time continuous curvature flow for Markovian weighted graphs and to discuss some of its properties. A weighted graph is Markovian if the weights on the directed edges represent transition probabilities of a (potentially lazy) random walk. We allow vanishing transition probabilities along edges, in which case we call the weighting scheme degenerate. The Bakry-Emery calculus, motivated by Bochner's formula for Riemannian manifolds, can be used to define a

natural Ricci curvature notion on the vertices of such a weighted graph. The problem of calculating this vertex curvature can be reformulated, in the case of a nondegenerate weighted graph, as the problem to calculate the smallest eigenvalue of a specific symmetric matrix. We use this matrix to introduce an associated curvature flow. By normalising this curvature flow such that it preserves the Markovian property, it turns out that the limits of this curvature flow (as time tends to infinity) are always curvature-sharp weighted graphs. This is joint work with D. Cushing, S. Kamtue, Sh. Liu, F. Muench, and B. Snodgrass.

8. Hao Xu (Zhejiang University)

Title: Frobenius algebra structure of statistical manifold

Abstract: In information geometry, a statistical manifold is a Riemannian manifold (M,g) equipped with a totally symmetric (0,3)-tensor. We show that the tangent bundle of a statistical manifold has a Frobenius algebra structure if and only if the sectional K-curvature vanishes. This gives a statistical-geometric curvature interpretation for WDVV equation. We study natural statistical structures on the tangent bundle of a statistical manifold and gave a new proof of Alekseevsky-Cortes' geometric construction of r-maps that associates a special real manifold to a special Kahler manifold. The application of information geometry in data science will be briefly indicated. This is joint work with Kefeng Liu and Yanhui Zhi.

9. Bobo Hua (Fudan University)

Title: Curvature conditions on graphs

Abstract: We will introduce various curvature notions on graphs, including combinatorial curvature for planar graphs, Bakry-Emery curvature, and Ollivier curvature. Under curvature conditions, we prove some analytic and geometric results for graphs with nonnegative curvature. This is based on joint works with Yanhui Su, Florentin Muench.

10. Alexander Strang (The University of Chicago)

Title: A Functional Theory for Principle Trade-off Analysis

Abstract: Principal Trade-off Analysis (PTA) is an data visualization and dimension reduction technique introduced by Google Deepmind to simplify complicated extensive form games. PTA is based on the real Schur form of skew symmetric matrices, and thus satisfies a close analogy with Principal Component Analysis (PCA). Like PCA, PTA produces a sequence of embeddings into a lower dimensional latent space, the sequence is low rank optimal, and each embedding map is orthogonal to the others. Also like PCA, PTA is widely applicable to pairwise comparison data between objects where dissimilarity, or preference, is measured instead of similarity. Through examples we demonstrate that PTA can indentify a sets of principal trade-offs that act like features vectors responsible for cyclic modes in a game or decision problem. Here we explore the functional theory underpinning PTA, show that the associated embedding scheme satisfies a universal approximation theorem, and that the differential geometry of each embedding map can be minded for useful information regarding the original game or decision problem.

11. Mathieu Desbrun (California Institute of Technology)

Title: Connection-based Dimensionality Reduction

Abstract: A common and oft-observed assumption for high-dimensional datasets is that they sample (possibly with added noise) a low-dimensional manifold embedded in a high-dimensional space. In this situation, Non-linear Dimensional Reduction (NLDR) offers to find a low-dimensional embedding of the data (i.e., unfold/unroll the original dataset in R^d for a small value of d) that creates little to no distortion so as to reduce the computational complexity of subsequent data processing. In this talk, we bring geometry processing to bear on manifold learning by introducing a new approach based on metric connection for generating a quasi-isometric, low-dimensional mapping from a sparse and irregular sampling of an arbitrary manifold embedded in a high-dimensional space. Geodesic distances of discrete paths over the input pointset are evaluated through ``parallel transport unfolding'' (PTU) to offer robustness to poor sampling and arbitrary topology. Our new geometric procedure exhibits the same strong resilience to noise as one of the staples of manifold learning, the Isomap algorithm, as it also exploits all pairwise geodesic distances to compute a low-dimensional embedding. While Isomap is limited to geodesically-convex sampled domains, parallel transport unfolding does not suffer from this crippling limitation, resulting in an improved robustness to irregularity and voids in the sampling. Moreover, it involves only simple linear algebra, significantly improves the accuracy of all pairwise geodesic distance approximations, and has the same computational complexity as Isomap. Finally, we show that our connection-based distance estimation can be used for faster variants of Isomap such as L-Isomap.

12. Mustafa Hajij (Santa Clara University)

Title: A unifying deep learning framework with higher order attention networks

Abstract: Over the past decade, deep learning has been remarkably successful at solving a massive set of problems on data types including images and sequential data. This success drove the extension of deep learning to other discrete domains such as sets, point clouds ,graphs ,3D shapes, and discrete manifolds. While many of the extended schemes have successfully tackled notable challenges in each particular domain, the plethora of fragmented frameworks have created or resurfaced many long-standing problems in deep learning such as explainability, expressiveness and generalizability. Moreover, theoretical development proven over one discrete domain does not naturally apply to the other domains. Finally, the lack of a cohesive mathematical framework has created many ad hoc and inorganic implementations and ultimately limited the set of practitioners that can potentially benefit from deep learning technologies. In this talk I will talk about a generalized higher-order domain called combinatorial complex (CC) and utilize it to build a new class of attention-based neural networks called higher-order attention networks (HOANs). CCs generalize many discrete domains that are of practical importance such as point clouds, 3D shapes, (hyper)graphs, simplicial complexes, and cell complexes. The topological structure of a CC encodes arbitrary higher-order interactions among elements of the CC. By exploiting the rich combinatorial and topological structure of CCs, HOANs define a new class of higher-order message passing attention-based networks that unify existing higher-order models based on hypergraphs and cell complexes. I will demonstrate the reducibility of any CC to a special graph called the Hasse graph, which

allows the characterization of certain aspects of HOANs and other higher order models in terms of graph-based models. Finally the predictive capacity of HOANs will be demonstrated in shape analysis and in graph learning, competing against state-of-the-art task-specific neural networks.

13. Konrad Polthier (The Freie University of Berlin)

Title: Boundary-sensitive Hodge decompositions

Abstract: We provide a theoretical framework for discrete Hodge-type decomposition theorems of piecewise constant vector fields on simplicial surfaces with boundary that is structurally consistent with decomposition results for differential forms on smooth manifolds with boundary. In particular, we obtain a discrete Hodge-Morrey-Friedrichs decomposition with subspaces of discrete harmonic Neumann fields $H_{h,N}$ and Dirichlet fields $H_{h,D}$, which are representatives of absolute and relative cohomology and therefore directly linked to the underlying topology of the surface. In addition, we discretize a recent result that provides a further refinement of the spaces $H_{h,N}$ and $H_{h,D}$, and answer the question in which case one can hope for a complete orthogonal decomposition involving both spaces at the same time. Exciting open questions are related to the so-called Poincaré-angle which appears as a feature of the decomposition on surfaces with positive genus. As applications, we present a simple strategy based on iterated L^2-projections to compute refined Hodge-type decompositions of vector fields on surfaces, which gives a more detailed insight than previous decompositions. As a proof of concept, we explicitly compute harmonic basis fields for the various significant subspaces and provide exemplary decompositions for two synthetic vector fields. All techniques

are essential for vector field analysis, surface parametrization, remeshing and others. We will show several applications.

14. Parvaneh Joharinad (Institute for Advanced Studies in Basic Sciences, University in Zanjan)

Title: Curvature of data

Abstract: How can one determine the curvature of data and how does it help to derive the salient structural features of a data set? After determining the appropriate model to represent data, the next step is to derive the salient structural features of data based on the tools available for that specific mathematical model. While in topological data analysis the objective is to extract qualitative features, the shape of data, geometric data analysis mainly deals with quantitative features of data. The most important quantitative measures that in a good extent reveal the geometry of a Riemannian manifold are its (sectional and Ricci) curvatures. Although, these quantities were originally defined infinitesimally through certain combinations of second and first derivatives of the Riemannian metric tensor, there is a way to define either these quantities themselves or a (lower or upper) bound for them that no longer need derivatives for their evaluation and is therefore generalizable to metric spaces and graphs. The aim of this presentation is to present a generalized sectional curvature and see which kind of relations between data points it evaluates and what kind of information it reveals.

15. Dong ZHANG (Max Planck Institute for Mathematics in the Sciences)

Title: Higher order eigenvalues for graph p-Laplacians

Abstract: The spectrum of the graph p-Laplacian is closely related to many properties of the graph itself. In particular, when p=1, the second eigenvalue coincides with the Cheeger constant. The p-Laplacian, for 1<p<2, can be seen as an extrapolation between the usual linear Laplacian and the 1-Laplacian. In this talk, I will present some recent developments on higher order eigenvalues for graph p-Laplacians. After recalling results about the variational eigenvalues of the graph p-Laplacian, I shall introduce the homological eigenvalues that are obtained by considering values of the p-Rayleigh quotient where locally there is a change in the homology groups of the sublevel sets. I will show some monotonicity properties of these p-Laplacian eigenvalues with respect to p, by which I completely solve an open problem raised by Amghibech in 2003.

16. Shiping LIU (University of Science and Technology of China)

Title: Signed graphs and Nodal domain theorems for symmetric matrices

Abstract: A signed graph is a graph whose edges are labelled by a signature. It serves as a simple model of discrete vector bundle. We will discuss nodal domain theorems for arbitrary symmetric matrices by exploring the induced signed graph structure. This is an extension of the nodal domain theorem of Davies, Gladwell, Leydold, and Stadler for symmetric matrices with non-positive off-diagonal entrices. With the fundamental concepts of balance and switching of signed graphs, our approach provides a more conceptual understanding of Fiedler’s results

on eigenfunctions of acyclic matrices. This new viewpoint further leads to a lower bound estimate for the number of strong nodal domains which generalizes and improves previous results of Berkolaiko and Xu-Yau. This talk is based on a joint work with Chuanyuan Ge (USTC).

17. Shi-Bing Chen (University of Science and Technology of China)

Title: The optimal partial transport problem

Abstract: In the optimal partial transport problem we are asked to find the most economical way to transport a portion of mass of the source domain to the target domain. It was proved by Caffarelli and McCann that there is a $C^{1,\alpha}$ hypersurface, called free boundary, separating the active region and the fixed region. A major problem left open in Caffarelli and McCann's work is the higher regularity of the free boundary. In this talk, we will discuss some recent progress on related problems. This is based on a joint work with Jiakun Liu and Xujia Wang.

18. Alexander Bobenko (TU, Berlin)

Title: TBA

Abstract: TBA

19. Junjie WEE (NTU)

Title: Mathematical AI for Molecular Sciences

Abstract: With great accumulations in experimental data, computing power and learning models, artificial intelligence (AI) is making great advancements in molecular sciences. Recently, the breakthrough of AlphaFold 2 in protein folding herald a new era for AI-based molecular

data analysis for materials, chemistry, and biology. A major challenge remains in AI-based molecular sciences which is to design and achieve effective molecular descriptors or fingerprints. In this talk, we propose several advanced mathematical based representations and featurizations. Molecular structures and their interactions can be represented by graphs, simplicial complexes (Rips complex, Neighborhood complex, Dowker complex, and Hom-complex) and hypergraphs. Molecular representations can be systematically featurized using various persistent invariants, including persistent homology, persistent Ricci curvature, persistent spectral, and persistent Tor-algebra. These features are combined with machine learning and deep learning models to form quantitative prediction models. Our models have demonstrated great advantage over traditional models in drug design, material informatics and chemical informatics.

20. Michael Farber (Queen Mary University of London)

Title: Algorithms for automated decision making and topology

Abstract: I will describe topological problems relevant to the task of creating algorithms for automated decision making. My main focus will be on motion planning algorithms in robotics although our mathematical tools are applicable to many other situations.

21. Emil Saucan (ORT Braude & Technion)

Title: Discrete Morse Theory, Persistent Homology and Forman-Ricci Curvature

Abstract: It was observed experimentally that Persistent Homology of networks and hypernetworks schemes based on Forman's discrete Morse

Theory and on the 1-dimensional version of Forman's Ricci curvature not only both perform well, but they also produce practically identical results. We show that this apparently paradoxical fact can be easily explained in terms of Banchoff's discrete Morse Theory. This allows us to prove that there exists a curvature-based, efficient Persistent Homology scheme for networks and hypernetworks. Moreover, we show that the proposed method can be broadened to include more general types of networks, by using Bloch's extension of Banchoff's work. We also point out a manner in which one can canonically associate a simplicial complex structure to a hypernetwork, directed or undirected. In particular, this allows for th extension and simplification of the geometric Persistent Homology methods of networks. Furthermore, such a construction allows for an easy investigation of the topological and geometric properties of hypergraphs.

22. Marzieh Eidi (Max Planck Institute for Mathematics)

Title: Seeing Data Through the Lens of Geometry (Ollivier-Ricci Curvature)

Abstract: Nowadays, we are encountering with huge and highly complex data, and one main challenge is to determine the "structure' of complex networks or ''shape'' of data. In the past few years, geometric and topological methods, as powerful tools that originated from Riemannian geometry, are becoming popular for data analysis. In this seminar, after introducing Ollivier-Ricci curvature for (directed) hypergraphs, as one of the main recent applications, I will present the result of the implementation of this tool for the analysis of chemical reaction networks. We will see that this notion alongside Forman-Ricci curvature are edge-based complementary tools for detecting some important structures in the network.

23. Ye Ke (Chinese Academy of Sciences)

Title: Geometry of the convergence analysis for low rank partially orthogonal tensor approximation problem

Abstract: Low rank partially orthogonal tensor approximation (LRPOTA) is an important problem in tensor computations and their applications (PCA, ICA, signal processing, data mining, latent variable model, dictionary learning, etc.). It includes Low rank orthogonal tensor approximation (LROTA) problem as a special case. A classical and widely used algorithm for the LRPOTA problem is the alternating least square and polar decomposition method (ALS-APD). In this talk, we will introduce an improved version ALS-iAPD of the classical ALS-APD, for which all the following three fundamental properties will be addressed: (i) the algorithm converges globally and the whole sequence converges to a KKT point without any assumption; (ii) it exhibits an overall sublinear convergence with an explicit rate which is sharper than the usual O(1/k) for first order methods in optimization; (iii) more importantly, it converges R-linearly for a generic tensor without any assumption. I will explain how algebraic and differential geometric tools are used to obtain these results in optimization theory. This talk is based on joint works with Shenglong Hu.

24. Jie Wu (BIMSA)

Title: Topological Approaches to Graph Data

Abstract: In this talk, we will discuss some topological approaches to graph data beyond classical persistent homology, including path homology and δ-homology introduced by S. T. Yau et al, and their generalizations such as hypergraph homology, weighted persistent

homology, and twisted homology with its connections to the simplicial theory of fibre bundles. In the final part of the talk, we will report our recent joint work with Jelena Grbic, Kelin Xia and Guo-Wei Wei for introducing a new theory which unifies various aspects of topological approaches for data science, by being applicable both to point cloud data and to graph data, including networks beyond pairwise interactions. Our new theory generalizes simplicial complexes and hypergraphs to super-hypergraphs and establish super-hypergraph homology as an extension of simplicial homology. Driven by applications, we also introduce super-persistent homology.

Introduction to Chongqing University of Technology

Founded in 1940, Chongqing University of Technology (CQUT) is a key university in Chongqing and the sole general higher education institution with a military background in southwest China. It currently has three campuses in Yangjiaping, Huaxi, and Liangjiang, covering a total area of more than 1.6 km^2, possessing more than 1,700 faculty members and 27,000 full-time students.

The university takes talent cultivation as its fundamental task and forms a multi-disciplinary system of science, engineering, management, economics, literature, and law. Currently, there are 62 undergraduate majors and 50 postgraduate majors. There are 4 provincial and ministerial-level talent platforms including Chongqing Talent Management Reform Testing Zone and Chongqing Academician and Expert Workstation, with nearly 200 provincial and ministerial-level talents including national candidates for the Hundred Thousand Talents Project and leading talents for the Ten Thousand Talents Program.

There is the first batch of provincial and ministerial collaborative innovation centers, key laboratories and international cooperation laboratories of the Ministry of Education, including 43 provincial and ministerial scientific research innovation platforms, and 4 national and municipal-level platforms including Chongqing Qingyan Institute of Technology Entrepreneurship Valley; through industry-university-research cooperation, 24 joint laboratories and research centers have been established with research institutes and large enterprises such as the Chinese Academy of Sciences, China Automotive Engineering Research Institute, Chongqing Changan Automobile (Group) Co., Ltd. The university was recognized by the Ministry of Education as the first batch of scientific achievements in transformation and technology transfer bases. The university has won honors such as the top 50 universities with typical employment experience, the 7th China Industry-University-Research Cooperation Promotion Award, and the top ten garden-style units in Chongqing.

After the persistent efforts of the "CQUTers" of the past decades, the university's competitiveness and social influence have been significantly enhanced. At present, "CQUTers" are adhering to the school motto of "virtue, honesty, self-improvement, and progress", forging ahead, pioneering and innovating, and striving to build the university into a first-class high-level research university in the west.

Introduction to Mathematical Science Research Center

The Mathematical Science Research Center (MSRC), Chongqing University of Technology was established at the end of 2018 and officially launched on September 22, 2019. The establishment of MSRC is an important measure for Chongqing University of Technology to attach great importance to mathematics and achieve leapfrog development in the new era.

The unveiling ceremony of MSRC

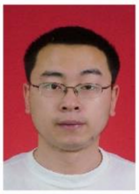
The Mathematical Science Research Center invites the internationally renowned mathematician Professor Kefeng Liu from the University of California, Los Angeles, as its first director. The task of MSRC is to base itself on Chongqing University of Technology, to carry out original research around core problems of pure mathematics and the application of mathematics in the economy and society. MSRC aims to provide solid mathematical support for the leap-forward development of Chongqing University of Technology and to provide assistance for the rapid economic and social development of Chongqing. With the fundamental purpose of producing first-class research achievements and cultivating a first-class talent team, MSRC will eventually become an important mathematical research and innovation center in southwest China, and an academic platform with important international influence.

Group photo at the founding conference of MSRC

Permement Members of MSRC

Name	**Kefeng Liu**	**Huitao Feng**	**Zhengyu Hu**	**Xueyuan Wan**	**Yong Luo**	**Jialin Zhu**
Research field	Complex geometry; Mathematical physics	Index Theorem	Algebraic geometry	Complex geometry	Geometric analysis	Index Theorem

Name	**Ming Li**	**Wei Xia**	**Fengjiang Li**	**Chien Lin**	**Yunan He**	**Liuyang Zhang**
Research field	Finsler geometry	Complex geometry	Differential geometry	Contact geometry	Data science; Topological data analysis	Geometric analysis