# ICCM 2020 Online Series of Conferences on Applied Math

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## Section 2: July 2020

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| **Time:** July 2, 8:00-9:00 AM (Beijing time) Lecture No. 20200702-05 | | | |
| **Lecture website (zoom):** https://us02web.zoom.us/j/82212867797<br>**ID:** 82212867797 **Password:** 20200702 | | | |
| **Speaker** | Xue-Cheng Tai | **Affiliation** | Hong Kong Baptist University, China |
| **Title:** Deep neural networks for convex shape representations | | | |
| **Abstract:** Convex Shapes (CS) are common priors for optic disc and cup segmentation in eye fundus images. It is important to design proper techniques to represent convex shapes. So far, it is still a problem to guarantee that the output objects from a Deep Neural Convolution Networks (DCNN) are convex shapes. In this work, we propose a technique which can be easily integrated into the commonly used DCNNs for image segmentation and guarantee that outputs are convex shapes. This method is flexible and it can handle multiple objects and allow some of the objects to be convex. Our method is based on the dual representation of the sigmoid activation function in DCNNs. In the dual space, the convex shape prior can be guaranteed by a simple quadratic constraint on a binary representation of the shapes. Moreover, our method can also integrate spatial regularization and some other shape prior using a soft thresholding dynamics (STD) method. The regularization can make the boundary curves of the segmentation objects to be simultaneously smooth and convex. We design a very stable active set projection algorithm to numerically solve our model. This algorithm can form a new plug-and-play DCNN layer called CS-STD whose outputs must be a nearly binary segmentation of convex objects. In the CS-STD block, the convexity information can be propagated to guide the DCNN in both forward and backward propagation during training and prediction process. As an application example, we apply the convexity prior layer to the retinal fundus images segmentation by taking the popular DeepLabV3+ as a backbone network. Experimental results on several public datasets show that our method is efficient and outperforms the classical DCNN segmentation methods.<br>This talk is based on joint works with Jun Liu and S. Luo. | | | |
| **Short Bio:** Prof Tai Xue-Cheng is currently a full professor at the Department of Mathematics, | | | |

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| Hong Kong Baptist University. He received his Bachelor degree in Mathematical Science from Zhengzhou University, Licenciate and Ph.D. degrees from the University of Jyvaskyla. His research interests include Numerical PDEs, optimization techniques, inverse problems, and image processing. He has done significant research work in his research areas and published many research papers in top quality international conferences and journals. He served as organizing and program committee members for a number of international conferences and has been often invited speakers for international conferences. He has served as referee and reviewers for many premier conferences and journals. Dr. Tai is members of the editor boards for several international journals. |

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| **Time:** July 9, 8:00-9:00 AM (Beijing time) Lecture No. 20200709-06 | | | |
| **Lecture website (zoom):** https://us02web.zoom.us/j/87853763335<br>**ID:** 87853763335 **Password:** 20200709 | | | |
| **Speaker** | Kui Ren | **Affiliation** | Columbia University, USA |
| **Title:** Inverse problems with the quadratic Wasserstein distance | | | |
| **Abstract:** The quadratic Wasserstein distance has recently been proposed as an alternative to the classical $L^2$ distance for measuring data mismatch in computational inverse problems. Extensive computational evidences showing the advantages of using the Wasserstein distance has been reported. The objective of this talk is to provide some simple observations that might help us explain the numerically-observed differences between results based on the quadratic Wasserstein distance and those based on the $L^2$ distance for general linear and nonlinear inverse problems. | | | |
| **Short Bio:** Kui Ren received his PhD in applied mathematics from Columbia University. He then spent a year at the University of Chicago as a L. E. Dickson instructor before moving to University of Texas at Austin to become an assistant professor in the Department of Mathematics and the Institute for Computational Engineering and Sciences (the Oden Institute). He returned to Columbia University in 2018 as a professor in applied mathematics. Kui Ren's recent research interests include inverse problems, mathematical imaging, random graphs, fast algorithms, kinetic modeling, and computational learning. | | | |

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| **Time:** July 16, 8:00-9:00 AM (Beijing time) Lecture No. 20200716-07 | | | |
| **Lecture website (zoom):** https://us02web.zoom.us/j/83355453878<br>**ID:** 83355453878 **Password:** 20200716 | | | |
| **Speaker** | Qiang Ye | **Affiliation** | University of Kentucky, USA |
| **Title:** Numerical Linear Algebra Methods in Recurrent Neural Networks | | | |
| **Abstract:** Deep neural networks have emerged as one of the most powerful machine learning methods. Recurrent neural networks (RNNs) are special architectures designed to efficiently model sequential data by exploiting temporal connections within a sequence and handling variable sequence lengths in a dataset. However, they suffer from so-called vanishing or exploding gradient problems. Recent works address this issue by using a unitary/orthogonal recurrent matrix. In this talk. we will present some numerical linear algebra based methods to improve RNNs. We first introduce a simpler and novel RNN that maintains orthogonal recurrent matrix using a scaled Cayley transform. We then develop a complex version with a unitary recurrent matrix that allows direct training of the scaling matrix in the Cayley | | | |

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| transform. We further extend our architecture to use a block recurrent matrix with a spectral radius bounded by one to effectively model both long-term and short-term memory in RNNs. Our methods achieve superior results with fewer trainable parameters than other variants of RNNs in a variety experiments. |
| **Short Bio:** Prof. Qiang Ye is currently a full professor at the Department of Mathematics, University of Kentucky. He received his Bachelor degree from University of Science and Technology of China and Ph.D. degree from University of Calgary. His research interests include numerical analysis, numerical linear algebra, and machine learning algorithm. |

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| **Time:** July 23, 08:00-09:00 (Beijing time) Lecture No. 20200723-08 | | | |
| **Lecture website (zoom):** https://us02web.zoom.us/j/89288847777<br>**ID:** 89288847777 **Password:** 20200723 | | | |
| **Speaker** | Masahiro Yamamoto | **Affiliation** | The University of Tokyo, Japan |
| **Title:** Theory of the direct problem and inverse problems for time-fractional partial differential equations | | | |

**Abstract:**

We consider an initial/boundary value problem:

$$\begin{cases} \partial_t^\alpha u = -A(t)u(x,t) + F(x,t), \\ u|_{\partial\Omega} = 0, \quad u(\cdot,0) = a, \quad \partial_t u(\cdot,0) = b \quad \text{if } 1 \le \alpha < 2, \end{cases}$$

where $x = (x_1, ..., x_d) \in \mathbb{R}^d$, and $\partial_t^\alpha$, $0 < \alpha < 2$ denotes the Caputo derivative, $\Omega \subset \mathbb{R}^d$ is a smooth bounded domain, and $-A(t)$ is a uniform elliptic operator of the second order whose coefficients are time-dependent.

First we re-define $\partial_t^\alpha$ in Sobolev spaces to prove the unique existence of the solution to the initial/boundary value problem with regularity properties.

Second we apply such a result to several inverse source problems and establish the uniqueness and the stability. One of them is the determination of orders $\alpha$.

**Short Bio:** Prof. Masahiro Yamamoto is currently a full professor at the Graduate School of Mathematical Sciences, The University of Tokyo. He received his Bachelor degree, Master degree and Ph.D. degree from The University of Tokyo. His research interests include inverse problems and optimal control problems for partial differential equations, industrial mathematics, and fractional PDEs. He has done significant research works and published many research papers in top quality international journals. Prof. Yamamoto is members of the editor boards for several journals.

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| **Time:** July 30, 08:00-09:00 (Beijing time) Lecture No. 20200730-09 | | | |
| **Lecture website (zoom):** https://us02web.zoom.us/j/89953618967<br>**ID:** 89953618967 **Password:** 20200730 | | | |
| **Speaker** | Jin Cheng | **Affiliation** | Fudan University, China |
| **Title:** A Linear Time Delay Model for Outbreak of COVID-19 and Parameter Identification | | | |

Abstract: The novel corona virus pneumonia (COVID-19) is a major serious event in the world. Whether we can establish the mathematical models to describe the characteristics of epidemic spread and evaluate the effectiveness of the control measures we have taken is a question of concern. From January 26, 2020, our team began to conduct research on the modeling of new crown epidemic. A kind of linear nonlocal dynamical system model with time delay is proposed to describe the development of covid-19 epidemic. Based on the public data published by the government, the transmission rate and isolation rate, which may not be directly observed in the process of epidemic development are obtained by inversion method On the basis of that, a "reasonable" prediction of the development of the epidemic is made. These provide the reasonable data support for government decision-making and various needs of the public.

**Short Bio:** Dr. Cheng Jin, Professor of Fudan University and director of Shanghai Key Laboratory of Contemporary Applied Mathematics. He is also the president of Shanghai Society of Industry and Applied Mathematics, Fellow of Institute of Physics (UK) and the member of the Steering Committee of International Association of Inverse Problems. Prof. Cheng's main research field is inverse problems and ill posed problems of mathematical physics. He has published more than 100 papers in scientific journals and was invited to give the invited talks in Applied Inverse Problems and other important conferences. Prof. Cheng has cooperated with industry to work on the mathematical modelling and inverse problems in industry.