MATH-IMS Joint Applied Mathematics Colloquium Series
The Chinese University of Hong Kong

This MATH-IMS Joint Colloquium Series is organized by Center for Mathematical Artificial Intelligence (CMAI), under Department of Mathematics and Institute of Mathematical Sciences (IMS) at The Chinese University of Hong Kong. The colloquium series focuses on mathematics and applications of artificial intelligence, big data and related topics.

Date: Dec 3, 2021 (Friday)
Time: 17:00-18:00 (Hong Kong Time)
Zoom Link: https://cuhk.zoom.us/j/92775210812

Quantitative Imaging: Physics integrated and machine learning based models in MRI

Speaker: Professor Michael Hintermüller
Humboldt University of Berlin

Abstract: Quantitative magnetic resonance imaging (qMRI) denotes the task of estimating the values of magnetic and tissue parameters, e.g., relaxation times T1, T2, proton density ϱ and others. Recently in [Ma et al., Nature, 2013], an approach named Magnetic Resonance Fingerprinting (MRF) was introduced, being capable of simultaneously recovering these parameters by using a two step procedure: (i) a series of magnetization maps are created and then (ii) these are matched to parameters with the help of a pre-computed dictionary (Bloch manifold). In this talk, we initially put MRF and its variants in the perspective of optimization and inverse problems, providing some mathematical insights into these methods. Motivated by the fact that the Bloch manifold is non-convex, and the accuracy of the MRF type algorithms is limited by the discretization size of the dictionary, we propose here a novel physics-oriented method for qMRI. In contrast to the conventional two step models, our model is dictionary-free and it is described by a single non-linear equation, governed by an operator for which we prove differentiability and other properties. This non-linear equation is efficiently solved via robust Newton type methods. The effectiveness of our method for noisy and undersampled data is shown both analytically and via numerical examples where also improvement over MRF and its variants is observed. The talk ends by highlighting the use of machine learning techniques for a data-driven identification of the underlying physics model.

Bio: Prof. Hintermüller is a Professor for Applied Mathematics at Humboldt University of Berlin. He is the director of the Weierstrass Institute, head of the Research Group "Nonsmooth Variational Problems and Operator Equations" and spokesman of The Berlin Mathematics Research Center MATH+. Prof. Hintermüller received his Diploma in Technical Mathematics and Dr. techn. Degree at University of Linz in 1994 and 1997. He got the Habilitation in Mathematics at University of Graz in 2003. Starting from an assistant professor at Department of Mathematics in University of Graz, Prof. Hintermüller became a MATHEON-Research Professor and W3-Professor in Applied Mathematics at Humboldt University of Berlin in 2008. His current research interests comprise the theory, design and analysis of algorithms in topics such as mathematical image processing, non-smooth and PDE-constrained optimization, with applications in image deblurring, denoising, modeling, simulation and optimization in gas networks, interface and free boundary problems, optimal control of multiphase flows, etc. Among his list of prestigious awards, Prof. Hintermüller became member of the 'Junge Kurie' of the Austrian Academy of Sciences in 2009, member of the council of the DFG-Research Center MATHEON in 2011, vice speaker of the Einstein-Center for Mathematics Berlin in 2013 and SIAM Fellow in 2016. Since 2020, he has also been the founding coordinator of Unit Technology and Engineering of Berlin's non-university research institutions initiative BR50.