SIAM Student Chapter @NUS

10^{th} Symposium on Applied and Computational Mathematics, 2021

SIAM Student Chapter @NUS

- Homepage: https://siamnus.github.io/website/

Committee Members

- Prof. Bao Weizhu (matbaowz@nus.edu.sg, Faculty Advisor)
- Ms. Su Xizhi (suxizhi@u.nus.edu, President)
- Mr. Guo Yichen (e0220147@u.nus.edu, Vice President)
- Mr. Yao Jin (yaojin@u.nus.edu, Secretary)

siam® Society for Industrial and Applied Mathematics

Date & Zoom Info

- 9 June 2021 Wed
- Part 1 Keynote speech
  https://nus-sg.zoom.us/j/84650886751?pwd=ZzRFM0NCT-lpkbTMwc2k3UEpVbFB6Zz09
  Meeting ID: 846 5088 6751 / Password: 146472
- Part 2
  https://nus-sg.zoom.us/j/81191858637?pwd=K3Z2elVVbjJoWVBTNks1RDMvcUt-LQT09
  Meeting ID: 811 9185 8637 / Password: 085322

Sponsors

- Society of Industrial and Applied Mathematics (SIAM)
- National University of Singapore (NUS)

Guest Speakers

- Prof. TANG Tao, BNU-HKBU United International College & Southern University of Science and Technology
- Chen Xiaoli, Department of Mathematics
- Zheng Huan, Department of Mathematics
- Gu Yiqi, Department of Mathematics
- Wang Boyi, Department of Mathematics
- Zhang Shijun, Department of Mathematics
- Li Yifei, Department of Mathematics

All are welcome!

Society for Industrial and Applied Mathematics

NUS National University of Singapore | Department of Mathematics Faculty of Science

NUS National University of Singapore | IMS Institute for Mathematical Sciences

Programme

Time	Guest Speaker	Talk Title/Topic Series
09:25-09:30		Opening Remarks
09:30-10:30	Prof. Tang Tao	(Keynote) Symmetry Breaking of phase field models • Computational physics • Partial differential equations
10:30-10:40		Q & A, Break
10:40-11:10	Chen Xiaoli	Data driven method to infer differential equation • Data science
11:10-11:40	Zheng Huan	Recorrupted-to-Recorrupted: unsupervised deep learning for image denoising • Image processing • Unsupervised learning
11:40-13:30		Lunch & Noon Break
13:30-14:00	Gu Yiqi	Efficient spectral methods for elliptic PDEs in complex domains • Computational mathematics • Partial differential equations
14:00-14:30	Wang Boyi	A close upper bound of energy dissipations for time-fractional phase-field models • Computational physics
14:30-15:00	Zhang Shijun	Deep neural network approximation via function compositions • Deep learning
15:00-15:30	Li Yifei	An energy-stable parametric finite element method for anisotropic surface diffusion • Computational physics

Symmetry Breaking of phase field models

Keynote speaker: Prof. TANG Tao

Abstract

This talk is concerned with numerical solutions for the Allen-Cahn equation. Surprisingly it is found that using standard numerical discretizations with high precision computational solutions may converge to completely incorrect steady states. This happens for very smooth initial data and state-of-the-art algorithms. We analyze this phenomenon and showcase the resolution of this problem by a new symmetry-preserving filter technique. We develop a new theoretical framework and rigorously prove the convergence to steady states for the filtered solutions.

About the speaker

Professor Tang Tao is the Chair Professor in Mathematics at the SUSTech International Center for Mathematics and a Member of the Chinese Academy of Science.

Prof. Tang obtained his Bachelor's degree in Mathematics from Peking University in 1984, followed by a PhD in Applied Mathematics from the University of Leeds in 1989. He was elected as Member of the Chinese Academy of Sciences in 2017.

Professor Tang taught at the University of Simon Fraser in Canada from 1990 to 1998 and obtained tenure there. He subsequently served at Hong Kong Baptist University from 1998 to 2015, in a variety of key roles, from Head of the Department of Mathematics, Dean of Science, Director of Graduate School, to Associate Vice-President. In May 2015, Professor Tang was appointed Vice-President of SUSTech as well as chair professor in the Department of Mathematics. He had been the Provost of SUSTech from 2018 to 2019. In February 2019, he became the Executive Director of SUSTech International Center for Mathematics.

Data driven method to infer differential equation

Chen Xiaoli

Abstract

Physics-informed neural networks are recently proposed as an alternative way to solve partial differential equations (PDEs). A neural network represents the solution, while a PDE induced neural network is coupled to the solution neural network, and all differential operators are treated using automatic differentiation. Here, we first employ the standard Physics-informed neural networks and a stochastic version, stochastic Physics-informed neural networks, to solve forward and inverse problems governed by a nonlinear advection–diffusion–reaction equation, assuming we have some sparse measurements of the concentration field at random or preselected locations. Then we will introduce how to use the physics-informed neural network method to infer the stochastic differential equation given the sample observation data.

Recorrupted-to-Recorrupted: Unsupervised Deep Learning for Image Denoising

Zheng Huan

Abstract

Deep denoiser, the deep network for denoising, has been the focus of the recent development on image denoising. In the last few years, there is an increasing interest in developing unsupervised deep denoisers which only call unorganized noisy images without ground truth for training. Nevertheless, the performance of these unsupervised deep denoisers is not competitive to their supervised counterparts. Aiming at developing a more powerful unsupervised deep denoiser, this paper proposed a data augmentation technique, called recorrupted-to-recorrupted (R2R), to address the overfitting caused by the absence of truth images. For each noisy image, we showed that the cost function defined on the noisy/noisy image pairs constructed by the R2R method is statistically equivalent to its supervised counterpart defined on the noisy/truth image pairs. Extensive experiments showed that the proposed R2R method noticeably outperformed existing unsupervised deep denoisers, and is competitive to representative supervised deep denoisers.

Efficient spectral methods for elliptic PDEs in complex domains

Gu Yiqi

Abstract

We apply the fictitious domain concept with circular embedding to solve elliptic boundary value problems in domains of complex geometry. The circular embedding enables us to transform two-dimensional problems in complex domains to a sequence of one-dimensional problems that can be efficiently solved by a spectral Petrov-Galerkin formulation. It is shown, at least in the special case, that this method is well-posed along with error estimates indicating spectral convergence. Ample numerical results are presented to demonstrate the effectiveness of this approach for problems with smooth solutions as well as singular solutions.

A close upper bound of energy dissipations for time-fractional phase-field models

Wang Boyi

Abstract

As gradient flows, energy dissipation law is an essential property for integer order phase-field equations. Even though numerous numerical investigations indicate that the classical energy decaying property is still true for time-fractional phase-field equations, despite great effort, the rigorous mathematical proof is still missing. In this article, an upper bound of energy is proposed for the time-fractional phase-field equations. We call it as a close upper bound because this upper bound is decaying as time goes, and coincides with the classical definition of energy for integer order phase-field equations at the beginning as $t = 0$ and also tends to the classical one when t goes to ∞. Hence, this upper bound can be viewed as a nonlocal-in-time modified energy for time-fractional phase-field equations. Moreover, on the discrete level, the first-order L1 and second-order L2 schemes for time-fractional phase-field equations preserve similar decreasing modified energy. Some numerical results using L1 scheme are provided to illustrate the behavior of this modified energy and to verify our theoretical results.

Deep Neural Network Approximation via Function Compositions

Zhang Shijun

Abstract

Deep neural networks are a powerful tool in many applications in sciences, engineering, technology, and industries, especially for large-scale and high-dimensional learning problems. This talk focuses on the mathematical understanding of the deep neural network. In particular, a relation of the approximation properties of deep neural networks and function compositions is characterized. The approximation rate of ReLU networks in terms of the width and depth is given for various function spaces, such as space of polynomials, continuous functions, or smooth functions on a hypercube. The optimality of the rate estimate is discussed via connecting the approximation property to VC-dimension. Finally, we will give an example of deep neural networks that provides a much better approximation rate than that of ReLU networks.

An energy-stable parametric finite element method for anisotropic surface diffusion

Li Yifei

Abstract

In this talk we consider sharp interface model for simulating the anisotropic surface diffusion. Traditional parametric finite element methods (PFEMs) for isotropic surface diffusion have a few good properties including unconditional stability, energy dissipation and asymptotic mesh equal distribution (AMED). Due to the high nonlinearity of the sur- face diffusion equation, these properties are lost for general anisotropic surface diffusion. By introducing an anisotropic surface energy matrix $G(\theta)$ depending on the anisotropic energy $\gamma(\theta)$, we propose an energy-stable parametric finite element method (ES-PFEM) for the anisotropic surface diffusion in two dimensions, which enjoys most good properties of traditional PFEMs. Numerical results are reported to demonstrate the efficiency and accuracy as well as energy dissipation of the proposed ES-PFEM.