THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

DEPARTMENT OF APPLIED MATHEMATICS
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The Hong Kong Polytechnic University
Department of Applied Mathematics

Colloquium

Learning Stable, Accurate and Efficient Dynamics using a Generalized Onsager Principle and Deep Neural Networks with Rectified Power Units

By

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Abstract

With recent advancements in machine learning and growing availability of data, there is an increasing focus on developing machine-learning-based methods for building dynamical models from observations of natural processes. However, usual machine learning methods usually leads to black-box models, the learned mathematical models may lack a theoretical guarantee of long time stability. We propose a systematic method (OnsagerNet) for learning stable and interpretable low-dimensional dynamical models based on a generalized Onsager principle. The learned dynamics are autonomous ordinary differential equations parameterized by neural networks that retain clear physical structure information. The rectified power units(RePU) are used to ensure the smoothness of learned dynamics and good approximation capability. For high dimensional problems with a low dimensional slow manifold, an autoencoder with isometric regularization is proposed to find generalized coordinates on which we learn the generalized Onsager dynamics. The method exhibits clear advantages in several benchmark problems for learning ordinary differential equations. We also applied this method as a model reduction tool to learn Lorenz-like low-dimensional models for the Rayleigh-Benard convection problem and derive the moment-closure equation for the Fokker-Planck equation of liquid crystal polymer dynamics. Both qualitative and quantitative properties of the underlying dynamics are captured.

Bibliography

Yu Haijun is a Full Professor at the Institute of Mathematics and Systems Science, Chinese Academy of Sciences. His main research interests are spectral and high-precision computational methods, and their applications. His representative work includes the modeling and computation of liquid crystal and polymer dynamics, the analysis and computation of the phase field models of two-phase flow with contact lines, the sparse-grid spectral method for high-dimensional partial differential equations, and so on. Professor Yu has received a number of national research grants and awards（面上项目，重大研究计划培育项目，陈景润未来之星）. His academic achievements have been published in internationally renowned academic journals such as SIAM Journal on Scientific Computing, SIAM Journal on Numerical Analysis, Journal of Computational Physics, and so on.

Date: 17 February 2022 (Thursday)
Time: 14:30-15:30 (Hong Kong Standard Time GMT +8)
Venue: Online Talk via Zoom (Meeting ID: 946 9208 5782)
Speaker: Prof. Haijun Yu, Chinese Academy of Sciences
Host: Dr. Buyang Li, The Hong Kong Polytechnic University
Click to join:
https://polyu.zoom.us/j/94692085782?pwd=cFpmM3Yyb2lPSDVPYnJtTFhjN0ZYdz09

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