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: October 9, 2020 (Friday)
Time: 4pm – 5pm (Hong Kong Time)
Zoom Link: https://cuhk.zoom.us/j/92775210812

Nonintrusive reduced order models using physics informed neural networks

Speaker: Professor Jan S Hesthaven
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Abstract: The development of reduced order models for complex applications, offering the promise for rapid and accurate evaluation of the output of complex models under parameterized variation, remains a very active research area. Applications are found in problems which require many evaluations, sampled over a potentially large parameter space, such as in optimization, control, uncertainty quantification, and in applications where a near real-time response is needed. However, many challenges remain unresolved to secure the flexibility, robustness, and efficiency needed for general large-scale applications, in particular for nonlinear and/or time-dependent problems. After giving a brief general introduction to projection based reduced order models, we discuss the use of artificial feedforward neural networks to enable the development of fast and accurate nonintrusive models for complex problems. We demonstrate that this approach offers substantial flexibility and robustness for general nonlinear problems and enables the development of fast reduced order models for complex applications.

In the second part of the talk, we discuss how to use residual based neural networks in which knowledge of the governing equations is built into the network and show that this has advantages both for training for the overall accuracy of the model. Time permitting, we finally discuss the use of reduced order models in the context of prediction, i.e. to estimate solutions in regions of the parameter beyond that of the initial training. With an emphasis on the Mori-Zwansig formulation for time-dependent problems, we discuss how to accurately account for the effect of the unresolved and truncated scales on the long term dynamics and show that accounting for these through a memory term significantly improves the predictive accuracy of the reduced order model.

Bio: Professor Jan Hesthaven obtained a Master of Science degree in computational physics from the Technical University of Denmark (DTU) in 1991. In 1995, he received a Ph.D. in Numerical Analysis from the Institute of Mathematical Modelling at DTU and in 2009 he was awarded the degree of Dr.Techn. from DTU for the substantial and lasting contributions that has helped to move his research area forward and penetrated into applications. He is currently a professor of Mathematics at EPFL in Switzerland and holds the Chair of Computational Mathematics and Simulation Science (MCSS). He is also serving as the Founding Academic Director of Scientific IT and Application Support (SCITAS) and Dean of the School of Basic Sciences with the responsibility for the Institutes of Mathematics, Physics, and Chemistry at EPFL. Before joining EPFL, he has been a professor of Applied Mathematics and served as the Founding Director of The Center for Computation and Visualization (CCV) at Brown University. Professor Hesthaven is particularly known for contributions to the development, analysis and application of high-order accurate computational methods for time-dependent partial differential equations. He has also contributed substantially to the development of reduced order models and the application of neural networks and machine learning techniques to problems in science and engineering. In 2014, Prof Hesthaven was elected as a fellow of SIAM for his contributions to high-order methods for partial differential equations