COLLEGE OF ENGINEERING
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# Predictive Reduced Order Modeling for Multi-scale, Multi-physics Flow Problems


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4:00 PM to 5:00 PM
Room 2540 GGB

ME Seminar Link
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**Abstract:**
This talk presents advances towards the development of effective projection-based reduced order models (ROMs) for complex multi-scale problems. As a representative application, we consider combustion dynamics in a rocket engine, which is characterized by a complex coupling between

heat release, hydrodynamics and acoustics.

- The first part of the talk is focused on improving robustness and consistency: A structure-preserving transformation of the state variables is used along with a discretely consistent least squares formulation to yield symmetrized model operators. The resulting reduced order model is well-conditioned and globally stable.

- The second part of the talk is focused on accomplishing true predictivity: Dimension reduction approaches based on static manifolds - linear or non-linear - are not effective in predictive modeling of multi-scale problems with significant transport effects. To address this issue, we present an adaptive formulation in which the basis vectors and sampling points are adapted online using a novel non-local procedure, leading to ROMs that are demonstrated to be predictive in future state and parametric problems with negligible off-line training.

- The last part of the talk discusses tractability : ROMs are used to enable computations of problems for which full order models are not affordable. In particular, we develop a multi-fidelity framework in which component-level ROMs are trained on small domains, and integrated to enable full-system predictions in an affordable manner. This method is shown to enhance predictive capabilities and robustness of the resulting ROMs, including conditions outside the training range.

Taken together, these techniques represent significant progress towards the goal of achieving orders of magnitude reduction in the computational cost of solving complex problems. Opportunities for further improvement are also highlighted.

Bio:
Karthik Duraisamy is a Professor of Aerospace Engineering, Mechanical and Nuclear Engineering at the University of Michigan (U-M) where he also directs the Michigan Institute for Computational Discovery and Engineering (MICDE). His research interests are in various aspects of computational science and AI including data-driven and reduced order modeling, statistical inference, numerical methods and Generative AI for science. He is also the director of the multi-university Air Force Center of Excellence on Reduced Order modeling and PI of the U-M-Los Alamos Center on Advanced Computational Sciences. He is also the founder and chief scientist of the silicon-valley-based startup Geminus.AI, which is focused on developing digital twins for industrial processes.