

SCIENTIFIC MACHINE LEARNING GUIDED BY SPECTRAL AND HIGH-ORDER NUMERICAL METHODS

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ABSTRACT

Scientific machine learning (SciML) has emerged as a promising framework for solving differential equations, inverse problems, multiscale models, and high-dimensional parametric systems. However, many SciML methods still face fundamental challenges in accuracy, stability, convergence, generalization, and computational efficiency, especially when data are sparse, noisy, or expensive to generate. This minisymposium will examine how numerical analysis, with particular emphasis on spectral and high-order methods, can guide the development of reliable and mathematically grounded SciML approaches. High-order finite element, spectral element, and discontinuous Galerkin methods provide accurate approximation spaces, structure-preserving discretizations, and rigorous tools for stability and error analysis. These principles can inform the design of network architectures, loss functions, training strategies, and validation procedures. Conversely, machine learning can enhance high-order simulations through operator learning, reduced-order modeling, adaptive discretization, closure modeling, preconditioning, and solver acceleration. The minisymposium will emphasize hybrid approaches that integrate data-driven models with numerical discretizations and governing physical laws rather than treating machine learning as a replacement for classical methods. Particular attention will be given to robustness across mesh resolutions and polynomial orders, conservation, and scalable implementation. Topics include physics-informed neural networks, neural operators, structure-preserving learning, inverse problems, uncertainty quantification, data assimilation, and applications to fluid mechanics and related scientific computing problems.

SPEAKERS

1. Sanghyun Lee (Florida State University): Discontinuous Galerkin finite element operator network for solving non-smooth PDEs
2. Min Wang (University of Houston): TBD
3. Youngjoon Hong (Seoul National University): Coefficient Learning: Data-Free Neural Operators with the Aid of Numerical Methods
4. Jae Yong Lee (Chung-Ang University): Finite element operator networks
5. Seungchan Ko (Inha University): Theoretical results for finite element operator networks
6. Dongwook Shin (Ajou University): Deep operator networks guided by high order methods.
7. Deep Ray (University of Maryland): TBD (proposed speaker)
8. Eric Chung (The Chinese University of Hong Kong): TBD (proposed speaker)