Recent Advances in Physics-Informed Machine Learn and Data-Driven Computing

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While many machine learning algorithms have gained popularity in various real-world applications, pure black-box data-driven models require enormous datasets, limiting their applicability to problems with scarce measurable data. This presentation introduces recent advances in physics-informed machine learning approaches based on universal thermodynamics principles, where the internal state variables essential to the physics are inferred automatically from the hidden state of the deep neural network. An extension of this approach is using the machine learning algorithms to enhance the numerical solution of PDEs. In this approach, standard approximation spaces, such as those formed by the finite element or reproducing kernel basis functions, are enriched by the neural network constructed basis functions under a Partition of Unity framework. The proposed neural network enhanced Partition of Unity and the feature-encoded transfer learning form an adaptive approximation framework for solving PDEs. These unique combinations of machine learning techniques and advanced computational methods have expanded the horizon of scientific computing beyond what the conventional computational methods can offer.