

MACHINE LEARNING FOR DIFFERENTIAL EQUATIONS: SENSING, STRUCTURE, AND GUARANTEES

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ABSTRACT

Solving differential equations using high-fidelity solvers incurs significant computational costs, especially for real-time and many-query applications. Motivated by this, machine learning models are increasingly used for the approximation, simulation, and analysis of systems governed by ordinary and partial differential equations. The scope ranges from purely data-driven approaches, e.g., neural operators, neural ODEs, and deep learning-based surrogate models and solvers, to methods that embed prior physical knowledge, such as structure-preserving architectures, symmetry- and conservation-aware models, and generative AI with geometric or variational priors. Such structural properties may enter at different levels: in the design of the model architecture, in the construction of the training data, or in the learning process itself. Of particular interest are contributions that address the role of partial observability and measurement design, including sparse and sensor-informed models where data limitations fundamentally shape model architecture and training strategy. This includes operator learning and surrogate modeling approaches that explicitly account for sensing limitations, and contributions that characterize how data quality, observability, and measurement design constrain the performance of learned models. Contributions of both theoretical and computational nature are welcome, with emphasis on approaches that go beyond black-box learning by leveraging the mathematical structure of the underlying problem.

REFERENCES

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