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DATA-DRIVEN METHODS FOR MODELING COMPLEX SYSTEMS

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MINISYMPOSIUM

Successful models of the natural world frequently share several mathematical features: they might be continuous, sparse, differentiable, integrable, generalizable, and parsimonious. Historically, such models have been derived from first principles and parameterized via experimental measurements. However, in the recent decades new theoretical approaches, abundant data, and cheap computational power have given rise to data-driven models of complex systems. Such modeling builds upon the theoretical results in dynamical systems, statistical mechanics, information theory, and machine learning. With data-driven techniques we can now extract the governing differential equations from empirical trajectory data, identify the dominant modes of collective behavior, infer the interaction networks from noisy observations, and reconstruct the full system state from a few localized measurements.

In this minisymposium we aim to bring together researchers working on both the theoretical basis and the applications of data-driven models. While many data-driven methods have been established, they call forth new questions. How much noise can a method tolerate and how exactly does the inference break down with high noise? How to integrate multiple data sources with varying degrees of accuracy into the model? How does one identify the best coordinates to express system dynamics concisely? What if not all of the relevant variables were measured? How do the dynamics depend on external parameters? Which variables causally affect the model outcome? How to validate the model form for problems without ground truth labels? When is model accuracy non-monotonic in model and data size, as in the double descent phenomenon? We welcome studies of physical phenomena such as hydro- and aerodynamics, elasticity, electromagnetism, and material properties, as well as biological, neural, ecological, and social behaviors.