Introduction to data driven modeling and machine learning

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Abstract

Data-driven modeling and machine learning are redefining the art of what is possible across the scientific, technological, and industrial landscapes. Indeed, machine learning is one of the great technological developments of our generation, and it has led to undeniable success in traditionally challenging fields such as machine vision and natural language processing. However, physical systems present challenges that differ from those tackled in traditional applications of machine learning. Many physical systems, such as fluids flows, exhibit complex, multi-scale phenomena whose understanding and control remain to a large extent unresolved. Moreover, when applied to physical systems, it is essential that machine learning solutions are interpretable, explainable, and generalizable. It is thus important to balance excitement about the capabilities of machine learning with the considerable challenges required to leverage these techniques for problems in multiscale physics.

In this talk, I will present an introductory overview of data-driven modeling and machine learning for the physical sciences. In particular, I will highlight progress and challenges in a historical context and with examples from fluid mechanics. Many tasks in fluid mechanics, such as design optimization, sensor selection, modeling, and control, are challenging because fluids are nonlinear and exhibit a large range of scales in both space and time. We will explore a number of emerging techniques in machine learning and sparse optimization that complement existing numerical and experimental efforts to solve these problems in fluid mechanics.