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Active Learning of Nonlinear Operators for Forecasting Extreme and Rare Events THEMISTOKLIS SAPSIS, Massachusetts Institute of Technology MIT, GEORGE KARNIADAKIS, Brown University — We formulate algorithms capable of predicting rare extreme events occurring in complex dynamical systems using only scarce, but carefully chosen, data-points produced by an accurate (but expensive) model or experiment. For these problems modern machine-learning methods have very limited capability as the phenomena of interest are typically transient, i.e. they 'live' away from the statistical steady state of the chaotic attractor. This feature combined with the fact that the majority of machine-learning schemes have non-guaranteed generalization properties leads to limited applicability to these problems. We utilize machine learned representations of operators (in contrast to functions) and train those using carefully chosen datasets. In particular, we follow the paradigm of active learning, whereby existing samples of a black-box function are utilized to optimize the next most informative sample. We develop a new class of acquisition functions for sample selection that leads to faster convergence in applications related to statistical quantification of rare events. The proposed method relies on the fact that some directions of input functional space have a larger impact on the output than others, which is important especially for systems exhibiting rare and extreme events.

Themistoklis Sapsis
Massachusetts Institute of Technology

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