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Title:

Dynamical Machine Learning Models for Forecasting Spatio-Temporal Processes

Abstract:

Recurrent neural networks (RNNs) and echo state networks (ESNs) are two nonlinear dynamical models that are commonly used in the machine learning and dynamical systems literature to represent complex dynamical or sequential relationships between variables. More recently, as deep learning models have become more common, RNNs have been used to forecast increasingly complicated systems. Dynamical spatiotemporal processes represent a class of complex systems that can potentially benefit from these types of models. Although the ESN and RNN literature is currently growing at a rapid pace, uncertainty quantification is often ignored. Even when considered, the uncertainty is generally quantified without the use of a rigorous framework, such as a fully Bayesian setting. Here we attempt to quantify uncertainty in a more formal framework while maintaining the forecast accuracy that makes these models appealing. Additionally, we make simple modifications to the basic RNN and ESN model to accommodate the unique nature of nonlinear spatio-temporal data and show how these extensions lead to more accurate forecasts and quantifiably better uncertainty measures. The proposed models are applied to the classic 40-varible Lorenz system and to long-lead forecasting of tropical Pacific sea surface temperature.

This is joint work with Christopher K.Wikle, Department of Statistics, University of Missouri.