Deep neural assisted integro-difference equation statistical models for spatio-temporal forecasting

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4 p.m., (Pacific Time) Monday, May 10, 2021

ABSTRACT

Spatio-temporal data are ubiquitous in the sciences and engineering, and their study is important for understanding and predicting a wide variety of processes. One of the difficulties with statistical modeling of spatial processes that change in time is the complexity of the dependence structures that must describe how such a process varies, and the presence of high-dimensional complex datasets and large prediction domains. It is particularly challenging to specify parameterizations for nonlinear dynamic spatio-temporal models (DSTMs) that are simultaneously useful scientifically, efficient computationally, and allow for proper uncertainty quantification. Here we describe a recent approach that utilizes a deep convolutional neural network to learn the kernel mapping function in a state-dependent integro-difference equation (IDE) DSTM. We implement the approach using an ensemble Kalman filter for efficient computation. The model is trained on daily sea surface temperatures in the Atlantic Ocean and is used to generate forecasts. Importantly, the model has the remarkable “transfer learning” ability to predict a process (weather radar storm cell movement) completely different from the sea surface temperature data on which it was trained.

This is joint work with Andrew Zammit-Mangion, University of Wollongong, Australia.