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Spectral Methods for Time Series Prediction with Application to Fluid Flows HENNING LANGE, STEVEN BRUNTON, NATHAN KUTZ, University of Washington — Forecasting the behavior of complex dynamical systems has a rich history in fluid dynamics. Here, we propose spectral forecasting algorithms for linear as well as non-linear ergodic dynamical systems. For linear (and slightly non-linear) systems, we propose an algorithm that exploits the relationship between the discrete Fourier Transform (DFT) and the squared error as a function of model parameters, and we break the periodicity assumptions inherent to the DFT by making use of gradient descent. Because of its similarities to the DFT, we refer to this algorithm as the Predictive Fourier Decomposition. Furthermore, for non-linear dynamical systems. we introduce a second algorithm that performs a frequency decomposition in a non-linear basis which is inspired by Koopman theory, which we refer to as Predictive Koopman Decomposition. The resulting algorithm jointly learns oscillatory non-linear basis functions and a least-squares fit to the signal. We will show that the Predictive Koopman Decomposition allows for forecasting of some signals with infinite frequency spectra with which the Predictive Fourier Decomposition struggles. The algorithms are evaluated in the context of predicting signals in the realms of power systems, meteorology and turbulent flow.

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