Title
Can fourier neural operators replicate the intrinsic predictability of spatiotemporal chaos?: for the Kuramoto-Sivashinsky system

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Abstract
The use of deep learning in global weather forecasting has shown significant promise in improving both forecasting accuracy and speed. Traditional numerical weather prediction models have gradually improved forecasting skills but at the cost of increased computational complexity. In contrast, new deep learning models, trained directly on reanalysis data, have demonstrated significant gains in forecasting accuracy, achieving competitive levels of performance.

However, the potential of deep learning in predicting spatiotemporal chaotic systems, such as weather patterns, remains unexplored. To address this gap, we investigate the efficacy of a data-driven Fourier neural operator Markovian forecaster to replicate the intrinsic predictability and the characteristic Lyapunov spectrum of the Kuramoto-Sivashinsky system.
FNO reproduces intrinsic predictability and precisely estimates the characteristic Lyapunov spectrum, even with a small dataset.
They cannot represent one of the invariant symmetries, a zero characteristic Lyapunov exponent in the spectrum.

Our findings suggest that deep learning can not only enhance the speed and accuracy of traditional numerical forecasting models but also replicate the weather's chaotic nature.
This has significant implications for generating large ensembles and improving overall probabilistic forecasts.

The research is limited to a deterministic system defined on a single process time scale surrogated by FNO.
The future merits a similar study to investigate if FNO models can perform similarly on larger, stochastic, coupled, and/or multiple time-scale spatiotemporal chaotic systems.