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Predicting long-term dynamics of chaotic systems with hybrid machine learning[1] SREETEJ LAKKAM, BALAMURALI B T, Singapore University of Technology and Design, JURRIAAN J J GILLISSEN, Department of Mathematics, University College London,, ROLAND BOUFFANAIS, Singapore University of Technology and Design — Forecasting of chaotic systems relies on estimating long-term dynamics of the system to make reasonable predictions. Our work aims to use an efficient hybrid machine learning technique to improve the estimation of long-term statistics while being resilient to short-term anomalies in determining future states of the system. Our hybrid machine learning technique combines a Long Short Term Memory (LSTM) architecture and ensemble modeling. LSTM is used to extract the long-term dependencies in the chaotic system data, while ensembling perturbs and combines multiple LSTMs to obtain better predictive performance compared to any of the constituent LSTM alone. We demonstrate the forecasting capability of this framework using time-series data from a Lorenz system and subsequently apply it to planar homogeneous turbulence flow field. Using visual verification and power spectra analysis, we conclude that our model can learn and predict the long-term dynamics even when short-term forecasting fails owing to the inherent unpredictability of chaotic systems. These results have far-reaching implications for the use of machine learning in fluid mechanics. Moreover, this approach is completely data-driven and relies on the LSTM capability to capture the long-term statistics of a chaotic system.

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