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Reservoir Computing for Predicting Chaotic Dynamical Systems

Time series prediction is the process of forecasting future values of a system by analysing historical data to identify patterns, trends and variations. There are two main approaches to time series prediction: model-based and data-driven. Chaotic dynamical systems are often difficult to predict due to sensitive dependence on initial conditions leading to possible long-term divergence in trajectories. Data-driven models make use of machine learning methods for training. Reservoir computing, a type of recurrent neural network, makes use of an existing dynamical system as a reservoir to train the neural network instead of having numerous hidden layers. "Classical"machine learning models often require extensive data and computational resources for training, while reservoir computing achieves comparable results with less. Due to its design, reservoir computing excels in the prediction of chaotic time series arising from unknown dynamical systems. In order to demonstrate the predictive ability of reservoir computing, a reservoir computing model was trained on samples of time series from the Sine, Logistic and Hénon maps. The reservoir computing model was then used to predict both the time series and essential dynamics of the three dynamical systems. The reservoir computing model was only capable of performing short to medium term time series predictions. However the model was also capable of learning dynamical properties not found in the training data such as a systems fixed points, attractor, and Lyapunov exponents. The results demonstrate that reservoir computing can be used to successfully predict and analyse various chaotic dynamical systems.

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