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Learning noise-induced transitions by multi scaling reservoir computing

Noise is usually regarded as adversarial to extracting effective dynamics from time series, such that conventional approaches usually aim at learning dynamics by mitigating the noisy effect. However, noise can have a functional role in driving transitions between stable states underlying many stochastic dynamics. We find that leveraging a machine learning model, reservoir com puting, can learn noise-induced transitions. We propose a concise training protocol with a focus on a pivotal hyperparameter controlling the time scale. The approach is widely applicable, including a bistable system with white noise. or colored noise, where it generates accurate statistics of transition time for white noise and specific transition time for colored noise. Instead, the conventional approaches such as SINDy and the recurrent neural network do not faithfully capture stochastic transitions even for the case of white noise. The present approach is also aware of asymmetry of the bistable potential, rotational dynamics caused by non-detailed balance, and transitions in multi-stable systems. For the experimental data of protein folding, it learns statistics of transition time between folded states, enabling us to characterize transition dynamics from a small dataset. The results portend the exploration of extending the prevailing approaches in learning dynamics from noisy time series.

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