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Machine learning predictions from unpredictable chaos

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Chaos is omnipresent in nature, and its understanding provides enormous social and economic benefits. However, the unpredictability of chaotic systems is a textbook concept due to their sensitivity to initial conditions, aperiodic behaviour, fractal dimensions, nonlinearity and strange attractors. In this work, we introduce, for the first time, chaotic learning, a novel multiscale topological paradigm that enables accurate predictions from chaotic systems. We show that seemingly random and unpredictable chaotic dynamics counterintuitively offer unprecedented quantitative predictions. Specifically, we devise multiscale topological Laplacians to embed real-world data into a family of interactive chaotic dynamical systems, modulate their dynamical behaviours and enable the accurate prediction of the input data. As a proof of concept, we consider 28 datasets from four categories of realistic problems: 10 brain waves, four benchmark protein datasets, 13 single-cell RNA sequencing datasets and an image dataset, as well as two distinct chaotic dynamical systems, namely the Lorenz and Rossler attractors. We demonstrate chaotic learning predictions of the physical properties from chaos. Our new chaotic learning paradigm profoundly changes the textbook perception of chaos and bridges topology, chaos and learning for the first time.

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