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Analysis of the Chaotic Itinerancy Phenomenon using Entropy and Clustering

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Chaotic itinerancy is a type of behavior observed in dynamical systems situated at the boundary between chaos and order. In this phenomenon, a trajectory is attracted to an ordered motion state and stays there for a while. Then, it departs from the ordered motion state and enters into high-dimensional chaotic motion. After some time, the trajectory returns to a different (or possibly the same) ordered state, and this process continues. Such ordered states are called attractor ruins, as they appear to originate from attractors that lost their stability due to bifurcation. The system's trajectory wanders unpredictably among these attractor ruins. Chaotic itinerancy is applied in diverse contexts, including the modeling of brain activity [1] and the simulation of spontaneity in artificial intelligence [2].

In this talk, I will present a method for detecting the chaotic itinerancy phenomenon based on machine learning and statistical measures of uncertainty [3]. I will demonstrate this method on a system of globally coupled logistic maps, which is a well-known example in the literature [1]. The use of the concept of entropy enables the identification of parameter ranges in which chaotic itinerancy can be observed. Applying a clustering algorithm to the trajectory points in phase space allows for the detection of dense regions as potential approximations of attractor ruins. For such identified clusters, transitions between them can be analyzed, and statistical tests of randomness can be performed to confirm the unpredictability of the dynamics, which is a key feature of this phenomenon.

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[2] Inoue, K., Nakajima, K., & Kuniyoshi, Y. (2020). Designing spontaneous behavioral switching via chaotic itinerancy. *Science Advances*, 6(46).

[3] Mierski, N., & Pilarczyk, P. (2025). Analysis of the chaotic itinerancy phenomenon using entropy and clustering. arXiv:2507.22643 [nlin.CD]