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Detecting early-warning signals of critical transitions for complex systems[1]

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Considerable evidence suggests that during the progression of complex diseases, the deteriorations are not necessarily smooth but are abrupt, and may cause a critical transition from one state to another at a tipping point. Here, we develop a model-free method to detect early-warning signals of such critical transitions, even with only a small number of samples. Specifically, we theoretically derive an index based on a dynamical network biomarker (DNB) for biological systems or dynamical network marker (DNM) for general systems that serves as a general early-warning signal indicating an imminent bifurcation or sudden deterioration before the critical transition occurs. Based on theoretical analyses, we show that predicting a sudden transition from small samples is achievable provided that there are a large number of measurements for each sample, e.g., high-throughput data. We employ microarray data of three diseases to demonstrate the effectiveness of our method for detecting "un-occurred" disease state. The relevance of DNBs with the diseases was also validated by related experimental data and functional analysis.

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