Chaos and criticality in neural networks with Gaussian and power law random synaptic connections

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Abstract

Random neural networks are simplified models of nervous systems, which consist of neurons and asymmetric synaptic connections whose weights are randomly distributed. As the variance of the synaptic weights increases, for instance, the system exhibits a transition from non-chaos to chaos [1,2].
Studying the systems around the transition point, i.e., the edge of chaos, is important in the context of the out-of-equilibrium statistical physics for the disordered complex systems and for information processing capability of the neuronal systems [3,4].
In this talk, we firstly review the dynamical mean-field theory for the dense Gaussian [1-4] and effectively sparse non-Gaussian [5,6] random neural networks, and how to perform the stability analysis and compute the largest Lyapunov exponent as the indicator of chaos.
By using them, we look into the phase transition and critical phenomena. In particular, we show that external noise can induce the first-order transition from non-chaotic to chaotic state, the bistable chaotic state, and the suppression of the chaos.
Further, we examine the edge of chaos in a model with power-law-distributed random synaptic connections and study how neural avalanches emerge [6]. [1] H. Sompolinsky, A. Crisanti , and H. J. Sommerset, Phys. Rev. Lett. 61, 259 (1988).

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