Statistical Modeling of Brains Dynamics in Free-moving Mice

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Characterizing the brain dynamics and understanding its relationship with animal behavior are important steps in solving the mystery of functioning brains. We apply statistical modeling to in-vivo-miniscope-recording data of CA1 calcium dynamics in free-moving mice under different environments. Pair-wise-coupled statistical model of spin glass is used to reproduce the statistical properties of the data allowing us to characterize the system with thermodynamic properties. Boltzmann learning with rate adaptive to both the size and direction of the cost-function gradient is aided by a convolutional neural network applied to the data covariance matrix to speed up the process of recovering the best-fitted model parameters. The resulting model well predicts the activation probabilities of neurons in different regions of interest of the recording. Combining with behavior data, we can characterize the neurons with the information they carry about the positions of the animals. This allows a classification of neurons into place neurons and non-place neurons. We find differences in the statistical properties of place and non-place neurons such as their coupling and predictability of their activation from the states of other neurons.

Keywords: spin-glass model, brain dyanmics, in vivo recording, statistical physics, place cells

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