Information Entropy Production, Large deviations and Information Geometry of Maximum Entropy Processes from Spike Train

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Abstract

Experimental recordings of the collective activity of interacting spiking neurons exhibit random behavior and memory effects. Therefore, the stochastic process modeling this activity requires showing some degree of irreversibility. We use a generalization of the classical information theory called thermodynamic formalism to build a framework, in the context of spike train statistics, to quantify the degree of irreversibility of any parametric maximum entropy measure under arbitrary constraints. We provide an explicit formula for the information entropy production of the inferred Markov maximum entropy process. We provide examples to illustrate our results and discuss the importance of the irreversibility for modeling the spike train statistics. Additionally, we review large deviations and Information geometry techniques useful to accurately describe statistical properties in terms of sampling size and maximum entropy parameters. In particular, we focus on the fluctuation of average values of observables, irreversibility and the identifiability problem of maximum entropy Markov chains. We illustrate these applications using simple examples of relevance in this field.