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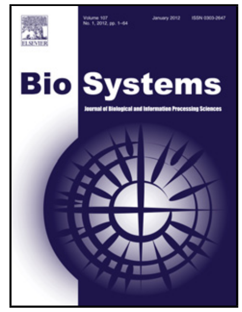

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Optimal decoding and information transmission in Hodgkin-Huxley neurons under metabolic cost constraints

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Abstract

Information theory quantifies the ultimate limits on reliable information transfer by means of the channel capacity. However, the channel capacity is known to be an asymptotic quantity, assuming unlimited metabolic cost and computational power. We investigate a single-compartment Hodgkin-Huxley type neuronal model under the spike-rate coding scheme and address how the metabolic cost and the decoding complexity affects the optimal information transmission. We find that the sub-threshold stimulation regime, although attaining the smallest capacity, allows for the most efficient balance between the information transmission and the metabolic cost. Furthermore, we determine post-synaptic firing rate histograms that are optimal from the information-theoretic point of view, which enables the comparison of our results with experimental data.

Keywords: Neuronal coding, Information transfer, Optimal decoding

1. Introduction

Neuroscience, in particular the neural coding problem, computer science and Shannon's information theory (Shannon and Weaver, 1949) are historically very closely related (McCulloch and Pitts, 1943; Wiener, 1948). In fact, the first studies on the information transfer in neurons appeared relatively shortly after Shannon published his theory (MacKay and McCulloch, 1952; Quastler, 1953). Early applications of the information theory to neurosciences, however, failed to provide the expected insight, mostly because of lack of understanding of the involved biological processes. Recently, as biologically relevant biophysical models of neurons are available and as experimental data from different sensory

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