Optimal signal and its estimation in neuronal models

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Abstract

In this contribution we address the question of how much information about the constant level of a signal is contained in a train of interspike intervals under the frequency coding schema. The firing rate is low for a weak signal, it increases with growing signal strength and finally it saturates. The curve describing this dependency is sigmoidal. We bring a new view on definition of the coding range, in traditional undestanding the region where the firing rate curve is steepest.

We study optimal estimation of an input signal from neuronal output interspike interval data under the condition that the frequency transfer function is sigmoidal. As a measure of information about the signal in the system output train of spikes we use normalised Fisher information or its approximation. The normalization is performed with respect to time and reflects the time required for sampling the input signal.

If the coefficient of variation of the interspike intervals is constant with respect to the signal, the Fisher information is unimodal and its maximum for the most estimable signal can be found. Such a relationship between the mean and variance of the interspike intervals reflects the dependency of the noise amplitude on the signal. We obtain a general result and compare the signal producing maximal Fisher information with the inflection point of the sigmoidal transfer function in several basic neuronal models.

Key words: Interspike interval, Fisher information, Coefficient of variation, Optimal signal, Frequency coding