IEICE Proceeding Series

Optimal spike-based communication with internal fluctuation in cortical networks

Jun-nosuke Teramae, Tomoki Fukai

Vol. 2 pp. 349-349
Publication Date: 2014/03/18
Online ISSN: 2188-5079

Optimal spike-based communication with internal fluctuation in cortical networks

Jun-nosuke Teramae† and Tomoki Fukai‡

†Graduate School of Information Science and Technology, Osaka University
Yamadaoka, Suita, Osaka 560-0871, Japan
‡Brain Science Institute, RIKEN
Hirosawa, Wako, Saitama 351-0198, Japan
Email: teramae@ist.osaka-u.ac.jp, tfukai@riken.jp

Abstract– Cortical network retains irregular, asynchronous firings spontaneously at low firing rate even without sensory stimulus, which often referred as the internal noise in the brain. Reverberating synaptic activation in recurrent network is considered to generate the internal noise. However, underlying mechanism by which the cortical circuit maintains the low-rate irregular state remains elusive. Moreover, computational functional of the internal noise is also unclear. In the study, considering recently reported highly heterogeneous weight distribution, typically the lognormal distribution, among excitatory neurons [1][2], we show that a network of cortical neurons can robustly sustain the irregular spontaneous firing. The generated state well agrees with various reported biological characteristics of cortical spontaneous activity including conductance measurements of neurons [3][4]. To our surprise, the generated internal noise optimally enhances the response of individual neurons to spike input and optimizes spike transmission fidelity between neurons [5]. Strong-sparse and weak-dense synaptic weights play different roles for the precise spike information transmission. Thus, our results identify simple network mechanism for internal noise for both stability and optimal spike-based communication.

References

[1] S. Song, P. J. Sjostrom, M. Reigl, S. Nelson, and D. B. Chklovskii, “Highly nonrandom features of synaptic connectivity in local cortical circuits”, PLoS Biol. 3, 68 (2005).
[2] S. Lefort, C. Tomm, J.-C. Floyd Sarria, and C. C. H. Petersen, “The excitatory neuronal network of the C2 barrel column in mouse primary somatosensory cortex”, Neuron 61, 301–316 (2009).
[3] M. Rudolph, M. Pospischil, I. Timofeev, and A. Destexhe, “Inhibition determines membrane potential dynamics and controls action potential generation in awake and sleeping cat cortex”, 27, 5280-5290 (2007).
[4] A. Destexhe, “internal “noise””, Front. in Cellular Neurosci., 4, 9 (2010).
[5] J. Teramae, Y. Tsubo, and T. Fukai, “Optimal spike-based communication in excitable networks with strong-sparse and weak-dense links”, Sci. Rep., 2, 485 (2012).