عنوان مقاله:

External Electromagnetic Wave Excitation of a Pre-Synaptic Neuron Based on LIF model

محل انتشار:

پنجمین کنفرانس ملی تکنولوژی در مهندسی برق و کامپیوتر (سال: 1399)

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خلاصه مقاله:

Interaction of electromagnetic (EM) waves with human tissue has been a longstanding research topic for electrical and biomedical engineers. However, few numbers of publications discuss the impacts of external EM-waves on neural stimulation and communication through the nervous system. In fact, complex biological neural channels are a main barrier for intact and comprehensive analyses in this area. One of the ever-present challenges in neural communication responses is dependency of vesicle release probability on the input spiking pattern. In this regard, this study sheds light on consequences of changing the frequency of external EM-wave excitation on the post-synaptic neuron's spiking rate. It is assumed that the penetration depth of the wave in brain does not cover the post-synaptic neuron. Consequently, we model neurotransmission of a bipartite chemical synapse. In addition, the way that external stimulation affects neurotransmission is examined. Unlike multiple frequency component EM-waves, the monochromatic incident wave does not face frequency shift and distortion in dispersive media. In this manner, a single frequency signal is added as external current in the modified leaky integrated-and-fire (LIF) model. The results demonstrate existence of a node equilibrium point in the first order dynamical system of LIF model. A fold bifurcation (for presupposed LIF model values) occurs when the external excitation frequency is near ۲۰۰ Hz. The outcomes provided in this paper enable us to select proper frequency excitation for neural signaling. Correspondingly, the cut-off frequency reliance on elements' values in LIF circuit is found. In addition, the spontaneous and stimulated vesicle release effects on post-synaptic neuron's spiking rate are computed. It will be shown that the neurotransmission probability and output spiking rate can be optimized based on proper selection of excitation frequency.

کلمات کلیدی:

EM-wave excitation; neural stimulation; spiking rate; bipartite chemical synapse; vesicle release; LIF model; node equilibrium point; fold bifurcation.