Calculating Local Field Potential from Spiking Neural Network Model

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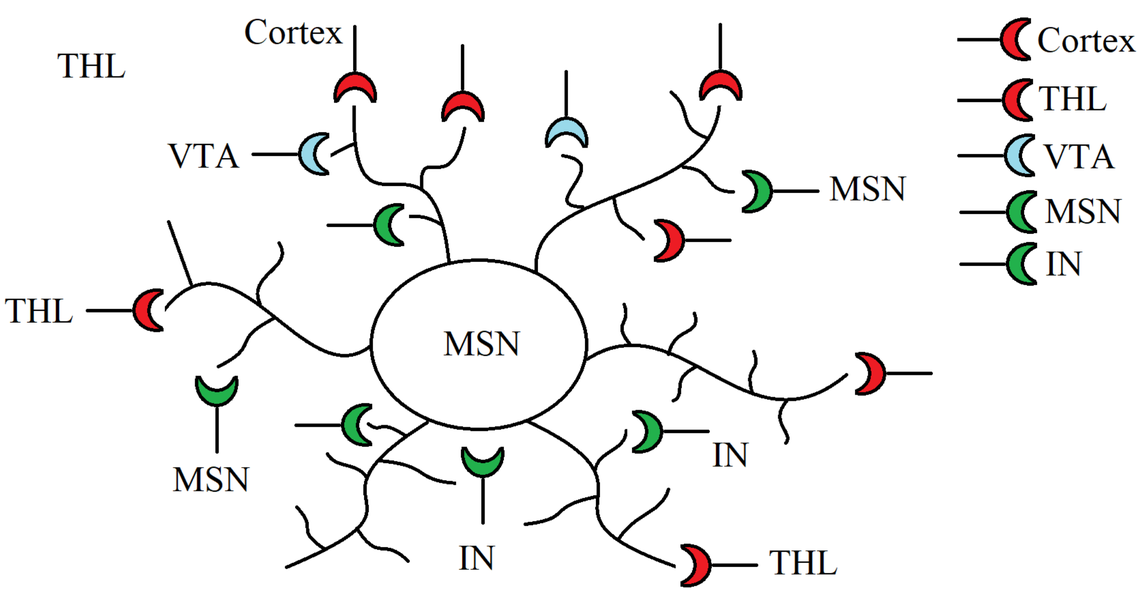
Aims

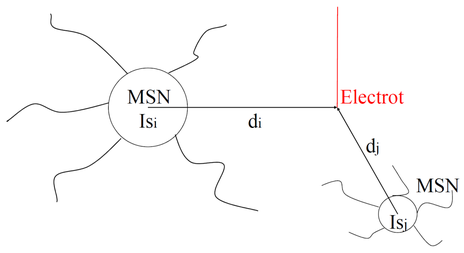
Local field potential (LFP) is electrophysiological signal that is used as a marker of cognitive processes and malfunctioning of neural structures in neuroscience. LFP is formed by currents and dipoles, and measured with array electrodes. In other words, they are created by the effect of synaptic currents due to the synaptic inputs to the dendrites, regardless of the neurons producing the spikes. The measurement results are generally interpreted using frequency analysis, as in EEG data [1, 2].
In order to obtain these empirical results with computational models, there has to be a method to calculate the LFP. Although there are some methods given in the literature, these methods are mainly focused on networks composed of morphologically modeled neurons [3, 4]. While some methods are designed for point neurons, they also try to model LFP data by segmenting the neurons [5, 6].

Model

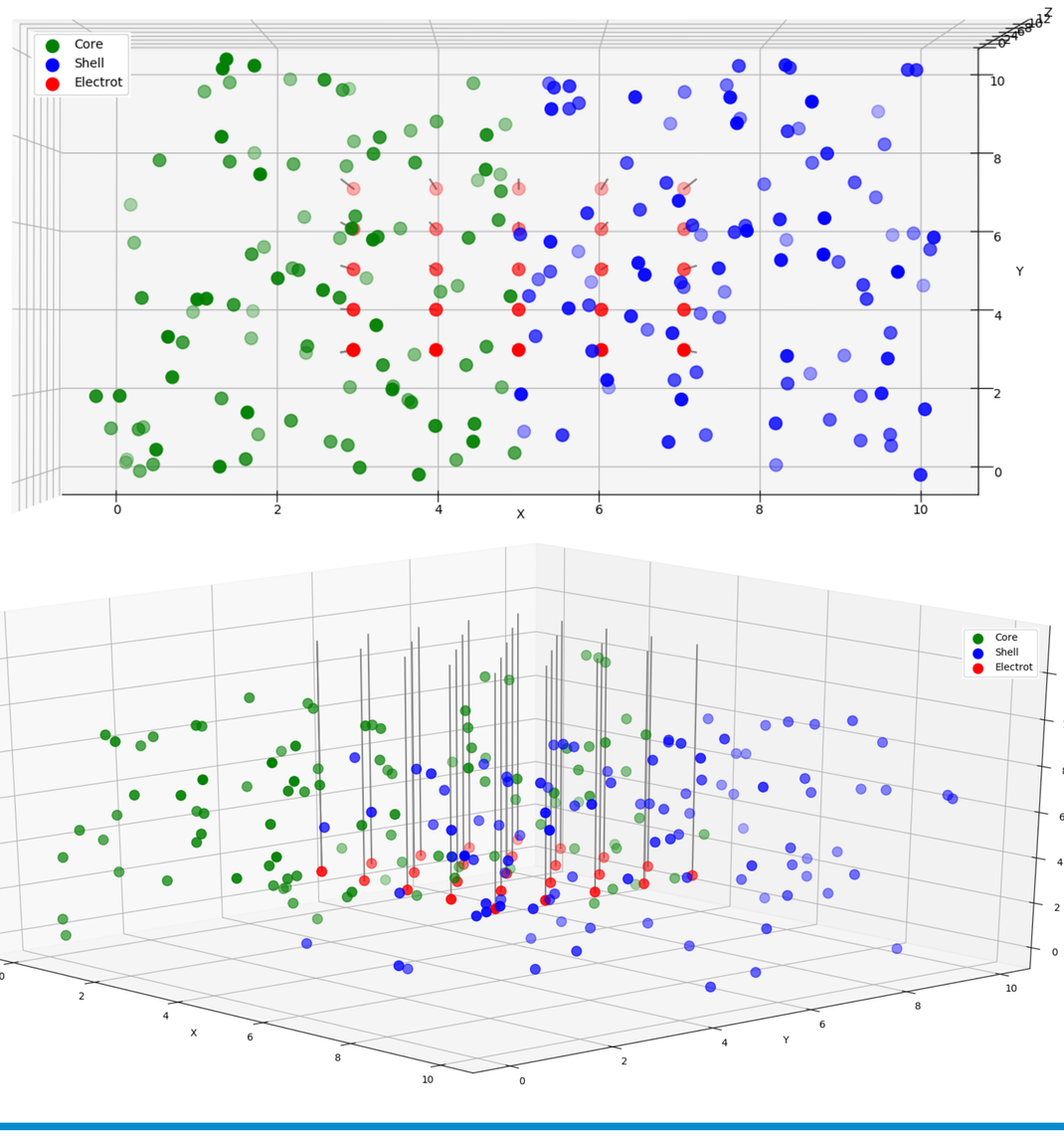


$$I_s = g_{Glu}(v - V_e) + g_{DA}(v - V_e) + g_{GABA}(v - V_i) + g_{Ach}(v - V_i)$$

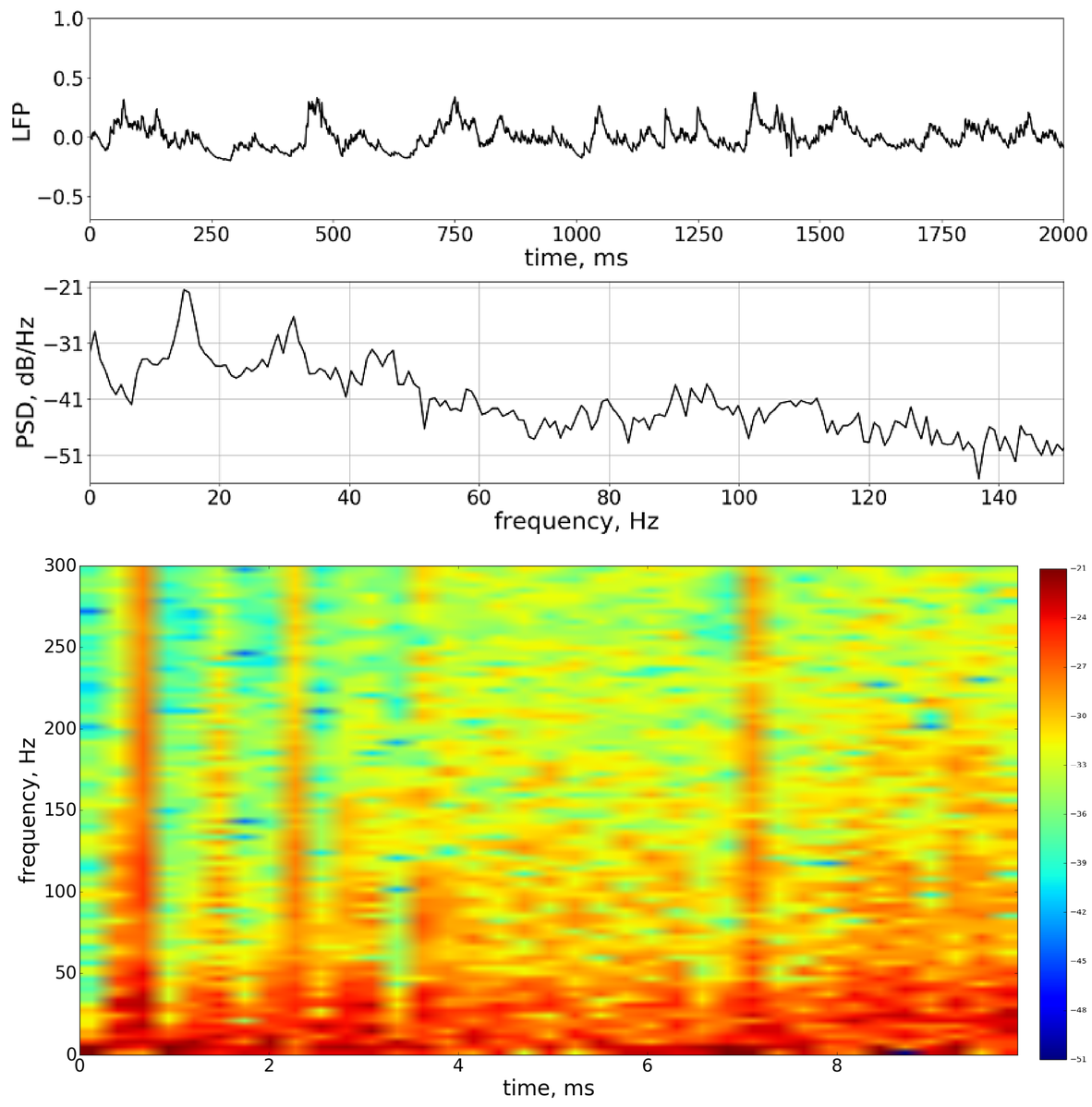
Model



$$e_{LFP} = \sum_{i=1}^{N} \frac{I_{s_i}}{d_i^2}$$



Results



Results

Here, we focus on obtaining results from computational models that can be compared with empirical LFP data. The computational model is formed as a spiking neural network consisting of point neurons. The spiking point neuron model is created in three dimensions. A random coordinate is assigned for each neuron that corresponds to their physiological dimensions. The distance of the neurons from the electrodes placed in the structure is determined. Then based on the distance of each neuron to electrodes and the total synaptic current for each neuron LFP values are obtained.
The proposed model for calculating LFP is tested on a computational model of nucleus accumbens where the role of dopamine from ventral tegmental area on LFP is investigated.

References

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