

# VESICULAR MECHANISMS AND ESTIMATES OF FIRING PROBABILITY IN A NETWORK OF SPIKING NEURONS

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## Abstract

Modelling of the neural networks plays its important role during the long lasting effort for better understanding the function of neural systems. Traditionally, the single components of the networks were some simple neuronal models of yes/no character and discrete time scale like the logical neuron of McCulloch and Pitts. However, during more recent period, the networks have become more realistic using as units the leaky-integrate-and-fire models or even the Hodgkin-Huxley type neurons which are able to mimic all the subtle differences in the activity of the neurons. One example of neural network created by excitatory connected simplified Hodgkin-Huxley neurons is studied in our contribution.

The model of single unit composing the network based on Morris-Lecar simplification of the Hodgkin-Huxley system is introduced. This system is studied at the scale of spike duration by describing the vesicular mechanism as an inhomogeneous jump process. For a postsynaptic neuron, the mean number of activated vesicles depends on the presynaptic spiking activity, each vesicle releasing a random number of quanta of neurotransmitter. To simplify the calculations, the diffusion approximation of the process describing the synaptic interaction at a fixed neuron is introduced. This step can be made because relatively high number of interacting processes ensures high rate of the input process and also each contribution of the released activated quanta is small.

Under all the above introduced conditions, the model is investigated within a short time window. The probability of firing evoked at a single neuron by the firing of other units in the network is evaluated analytically and it permits to estimate the level of synchronous firing in the network. The analytical results are illustrated and complemented by numerical simulations of networks of different sizes and characterized by different connectivities and other parameters.