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INEX – A binary neuronal model with inhibitory and excitatory synapses

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Our aim is to develop a simple model which is suitable to simulate concentration-response curves as observed in in-vitro experiments with multielectrode array (MEA) neurochips. In an in-vitro experiment approximately 10.000 neurons of the frontal cortex of embryonic mice [1] are cultivated on a MEA neurochip [2]. Neuro-active substances like bicuculline are added to the network. Based on the recorded data, various features [3] are calculated adapted from spikes and bursts. The features are separately displayed in concentration-response curves [4] which show the logarithm of the substance concentration and the chosen feature.

The developed INEX (inhibitory-excitatory) model is a cellular automaton whose cells are neurons with two possible states: ON or OFF. Each neuron obtains several inputs and produces exactly one output (respectively 0 or 1). Furthermore, it is phenomenological model where the neurons are described as black boxes. The probability if a spike occurs in time slice was calculated using a Poisson process [5]. Neurons are connected by either inhibitory or excitatory synapses with varying strength. The corresponding parameters are called weights. The network is fully connected and has direct feedbacks. Additionally, a spike time history was added. The aim was to vary the parameters of the model in such a way that we obtain a sigmoid concentration-response curve to simulate excitatory and inhibitory effects in neuronal networks.

A network with 100 neurons ran over 10 seconds with varying weights and Δt = 1 ms. Ninety inhibitory synapses with weights between -0.2 and 0 and ten excitatory synapses with weights between 0 and 0.7 are used. We detected spikes and bursts (figure 1) as known

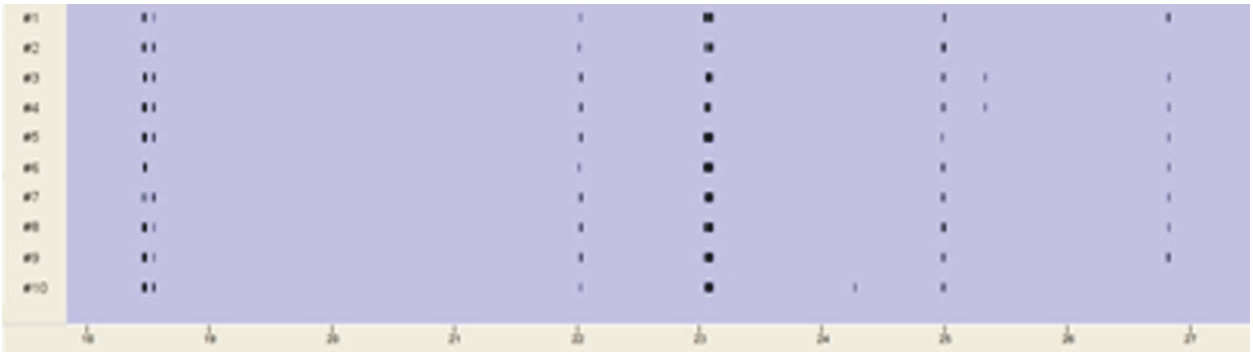

Figure 1 In each row, bursting spike trains of the first ten simulated neurons are displayed. Each dash marks a spike. The time scale (below) is in seconds.

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from experiments with MEA neurochips. Thereafter, the same network ran over 18 minutes. The excitatory weights are reduced in six steps respectively by 0.05 every 3 minutes. The mean spike rate for each step is calculated and displayed in a concentration-response curve [6].

The INEX model shows potential to simulate inhibitory and excitatory effects which are also observed in experiments with MEA neurochips. A sigmoid concentration-response curve can be obtained by the simulation. We will work on parallelisation of processes to decrease the run time of the algorithm.

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