TOWARDS THE COMPUTATION OF SIGNAL PROCESSING
IN A THREE-DIMENSIONAL CORTICAL COLUMN
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ABSTRACT

We present the concepts and tools for a numerical computation of a cortical proto-column. The aim is to make efficient simulations of the neuronal network available in order to study the signal processing in such a column due to realistic inputs and to compare the solutions with experimental results. To this end, we generate synthetically complex neurons with a three-dimensional structure which show realistic morphological properties as found for the different cell types in a cortical column. These cells are generated by a software program called NeuGen (see www.neugen.org). This software tool implements a concept to generate several classes of realistic cells. A concept for the synaptic connectivity within a cortical column has been developed and extracted from experimental findings. According to this concept the generated cells are connected to construct a three-dimensional synaptically connected network that resembles a cortical proto-column. The so generated column consists of up to 1000 complex neurons. For the electrophysiology of the cells, we implement a simple model as given by Mainen and Sejnowski (see ModelDB).

Due to the computational effort of the numerical simulation of these networks, we implement a new concept for solving the resulting equations given by a multi-compartmental model. The concept incorporates a new discretization approach which is similar to the standard Hines’ approach (see NEURON), but is more accurate, and leverages the concepts of parallelization. Therefore, we are able to simulate large networks as represented by a proto-column. We present numerical simulations for the cortical column with a stimulus given by the thalamus. We also show how to visualize the network in a three-dimensional dynamical setting.

REFERENCES