Biophysical cortical column model for optical signal analysis

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We propose a biological cortical column model, at a mesoscopic scale, in order to explain and interpret biological sources of voltage-sensitive dye imaging signal. The mesoscopic scale, corresponding to a micro-column, is about 50 μm. The proposed model takes into account biological and electrical neural parameters of the laminar cortical layers. Thus we choose a model based on a cortical microcircuit, whose synaptic connections are made only between six specific populations of neurons, excitatory and inhibitory neurons in three main layers, following [1] and [2]. For each neuron, we use a conductance-based single compartment Hodgkin-Huxley neuron model [3].

We claim that our model will reproduce qualitatively the same results as the optical imaging signal based on voltage-sensitive dyes, which represents the summed intracellular membrane potential changes of all the neuronal elements at a given cortical site [4]. Furthermore, this voltage-sensitive dye imaging has a submillisecond temporal resolution that allows us to explore the dynamics of corti-

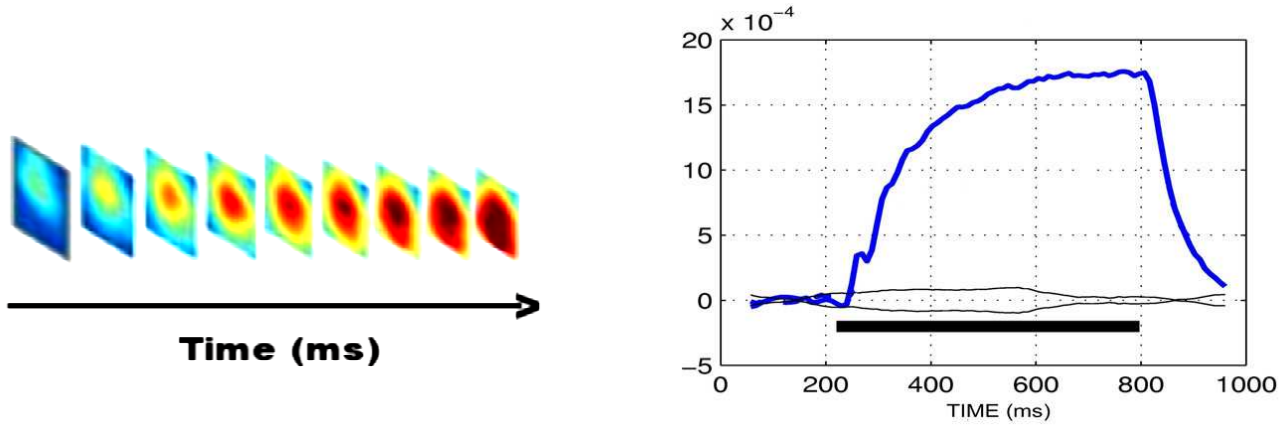

Figure 1
Voltage-sensitive dye optical imaging allows a real-time visualization of large neuron populations activity. Left: Temporal evolution of the dye optical signal. Right: Response curve in one position of the map, same time scale.

cal processing. An example of data of V1 dye-signal in a cat, after a visual local stimulation, is shown in Figure 1. Therefore, the temporal dynamics of the measured signal will be carefully studied as being of primary interest for the proposed model identification.

Methods

We use the NEURON software to implement our cortical column model of about 10^2 neurons and run simulations. Larger-scale models are going to be developed with the event-based simulator MVASPIKE, or with a specific optimal software, thanks to PyNN.

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