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Stability and sensitivity analysis of reduced compartmental models of primary visual cortical neurons

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Primary visual cortical neurons can be classified into six electrophysiological classes [1-3]: regular spiking neurons (RSN), fast spiking neurons (FSN), intrinsic bursting spiking neurons (IBSN), chattering spiking neurons (CHSN), late spiking neurons (LSN), and non-late spiking neurons (NLSN). In a previous work, Oliveira and Roque [4] developed a large-scale realistic model of the primary visual cortex containing reduced compartmental, Hodgkin-Huxley type neuron models of these six electrophysiological classes. The six neural models have the same anatomical structure of five compartments (one representing the soma, two representing the apical dendrite and two representing the basal dendrite). Their passive and active membrane properties were taken from the literature and the values of their parameters were adjusted either by hand of via automatic fitting procedures so that the models reproduce well experimental data. Ionic current conductances were put only in the somatic compartments while synaptic current conductances were placed only in the dendritic compartments. The models consist of systems of differential equations, which describe the evolution of the membrane potential (of the soma and dendrites), of the variables associated with the ionic currents and, for some neurons, of the intracellular calcium concentration. In this work, we characterize each one of the six neuron models using stability analysis of dynamical systems theory [5], and use sensitivity analysis to study the effect of variations of some model parameters on their response properties. The neuron models were constructed under the GENESIS [6] simulation environment and, for their analyses, they were re-implemented in Matlab 7.0. The stability analysis was performed by determining and characterizing the equilibrium points of the models, both for the case of zero injected current and for the case of a depolarizing current of increasing amplitude injected into the soma (bifurcation parameter). This allowed a determination of the type of bifurcation that describes how the neuron model shifts from resting to firing state. These bifurcation types are saddle-node on invariant cycle (SNIC), saddle-node (SN), Andronov-Hopf subcritical (AHsub) and Andronov-Hopf supercritical (AHsup) [5]. Neurons that undergo SNIC bifurcation are of type I and neurons that undergo the other bifurcation types are of type II [5]. We also analyzed phenomena like adaptation, bursting behavior and first-spike latency, which originate from interactions between fast and slow subsystems of the systems of differential equations that describe the models [5,7]. Regarding the sensitivity analysis, we studied the excitability of the models by looking at the behavior of the rheobase current under variations of the passive parameters. For each model, a set of parameters was chosen (based on their properties reported in the literature and results from previous studies) and studied, allowing a characterization of the dependency and robustness of the models on these parameters.

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References
1. Nowak LG, Azouz R, Sanchez-Vives MV, Gray CM: **Electrophysiological classes of cat primary visual cortical neurons in vivo as revealed by quantitative analyses.** *J Neurophysiol* 2003, **89:**1541-1566.
2. Chu Z, Galarreta M, Hestrin S: **Synaptic interactions of late-spiking neocortical neurons in layer 1.** *J Neurosci* 2003, **23:**96-192.
3. Contreras D: **Electrophysiological classes of neocorticalneurons.** *Neural Networks* 2004, **17:**633-646.
4. Oliveira RF, Roque AC: **A large-scale realistic model of V1 exhibiting orientation selectivity diversity and laminar dependence.** *BMC Neurosci* 2007, **8(Suppl 2):**P36.
5. Izhikevich EM: *Dynamical systems in neuroscience: the geometry of excitability and bursting Cambridge, MA: MIT Press*; 2005.
6. Bower JM, Beeman D: *The Book of Genesis* 2nd edition. *NewYork: Springer-Verlag*; 1998.
7. Guckenheimer J, Harris-Warrick R, Peck J, Willms A: **Bifurcation, bursting, and spike frequency adaptation.** *J Comput Neurosci* 1997, **4:**257-277.