Talk 201

Modeling Microcircuits of Realistic Hippocampal Neurons

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This project is a collaborative research program between experimental a cellular neurophysiologist and applied mathematicians. The central aim of the project is to develop detailed computational models of microcircuits composed of principal neurons and interneurons in the CA1 region hippocampus. In particular, these computational models will: 1) Be based on the latest data available from patch-clamp experiments dealing with ionic conductances, calcium and two-photon imaging, and cell morphology. 2) Use ionic channel models specifically designed to accurately reproduce the experimentally determined behavior. 3) Use full-cell morphologies; in particular, the same individual cells from which electrophysiology data have been taken will be digitized for the computational studies. 4) Develop new adaptive computational methods that can be used to speed up the computational simulations. A long-term goal of the project is to develop sufficiently accurate models of excitatory and inhibitory cell types in the hippocampus so that realistic simulations of small networks present in the hippocampus can be performed. These computational simulations are intended to be a tool to guide the development of new patch-clamp experiments that further explore the functional behavior of the hippocampal region.

Accomplishments to date include: 1) The training of two applied mathematics faculty and three applied mathematics graduate students in neuroscience. 2) A new computational method capable of more efficiently simulating dendritic branching structures. 3) A morphological and electrophysiological database of principle interneurons from the CA1 region of the hippocampus. 4) Combined simulation and experimental studies demonstrating that dendritic spikes generated distally by perforant path inputs in CA1 pyramidal cells can be gated as they propagate toward the soma by more proximal Schaeffer collateral inputs. 5) Combined simulation and experimental studies suggesting that the size of synapses in the dendrites of CA1 pyramidal neurons arises from the compartment-specific use of conductance scaling in more proximal dendrites and the initiation of dendritic spikes in more distal dendrites.

Project (or PI) Website

http://www.northwestern.edu/dendrite/sk_models

Publications

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4. Rempe MJ, Chopp DL. A predictor-corrector algorithm for reaction-diffusion equations associated with neural activity on branched structures." submitted to SIAM J. Sci. Comp., 2005.

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