Poster | Computational Theories

[3P] Neuroinformatics and Large-scale Simulation

Fri. Jul 31, 2020 1:30 PM - 3:30 PM Poster Session

*Videos are available throughout the meeting period.

[3P-262] Resonant and synchronizing mechanisms in a hippocampal theta model

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Neuronal processing across multiple brain regions is typically revealed in rhythmic activity in the local field potential (LFP) or electroencephalograms (EEGs). Many studies involving rhythms show contribution of several rhythm generators, each likely mediated through a different neural micro-circuit. Considering the number of participating mechanisms in rhythm generation, elimination of circuit components can yield unintuitive results. In this study we use computational modeling to characterize the interaction between the components of neural circuits that contribute to generating theta rhythms in CA3 region of the rodent hippocampus. To further refine the interactions, we distinguish between resonant and synchronizing components and show that such a categorization can help predict what mechanisms will interfere or which ones can be substitute for another. Resonant mechanisms create rhythms through their inherent dynamics, including slow inhibition, spike-frequency adaptation, slow neuronal currents, and rhythmic external input. Synchronizing mechanisms support rhythm coordination and include non-rhythmic external input, inhibitory feedback, and recurrent excitatory connections. As is well known, robust rhythm generation requires at least one of each, resonant and synchronizing components. We found pyramidal cell adaptation to interfere with theta rhythms produced by slow inhibition and that fast inhibition can substitute for rhythm generation or interfere with it through slow inhibition depending on the level of acetylcholine. Our studies build on work by (Hummos et al. 2017) and reveal that effects of component removal can only be foreseen in the context of mechanisms present and on the neuromodulatory state of the system.
Another important goal of this study was to develop related software to facilitate analyses involving iterative automated development, especially for researchers with limited knowledge of advanced platforms such as high-performance computers (HPCs). To address this challenge, we used an established framework for modeling neurons titled Brain Modeling Tool Kit (BMTK) and developed online tools to support and programmatically explain the model. This significantly reduced the time required for training fellow researchers. We expect these generalized tools to be useful for other projects in computational neuroscience, and to also encourage usage of computation in general by neuroscientists with limited background in software.

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