Generation of irregular activity in an excitatory-inhibitory network

Choongseok Park

Department of Mathematical Sciences, Indiana University-Purdue University, Indianapolis

Excitatory-inhibitory networks arise in many regions throughout the central nervous system and display complex spatio-temporal firing patterns. These neuronal activity patterns (of individual neurons and/or the whole network) are closely related to the functional status of the system and differ between normal and pathological states.

For example, neurons within the basal ganglia, a group of subcortical nuclei that are responsible for the generation of movement, display a variety of dynamic behaviors such as correlated oscillatory activity and irregular, uncorrelated spiking. Neither the origins of these firing patterns nor the mechanisms that underlie the patterns are well understood. I consider a biophysical model of an excitatory-inhibitory network in the basal ganglia and explore how specific biophysical properties of the network contribute to the generation of irregular spiking. I use geometric dynamical systems and singular perturbation methods to systematically reduce the model to a simpler set of equations, which is suitable for analysis. The results specify the dependence on the strengths of synaptic connections and the intrinsic firing properties of the cells in the irregular regime when applied to the subthalamopallidal network of the basal ganglia.