Spatiotemporal Dynamics in Networks of Stochastic Integrate-and-Fire Neurons

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We study bifurcations in networks of integrate-and-fire neurons with stochastic spike emission, focusing on the effects of the spatial and temporal structure of the synaptic interactions. Performing bifurcation analysis of a deterministic mean-field approximation of the population dynamics, we understand the spatial, temporal, and spatiotemporal transitions between patterns of macroscopic activity. In the mean-field theory, synaptic delays give rise to uniform oscillations across the population through a subcritical Hopf bifurcation of the stationary uniform equilibrium. We confirm bistablility between the oscillatory and homogenous states of the network in the stochastic spiking network near this bifurcation. Additionally, we show that with particular spatial coupling profiles of neurons across the network--such as global uniform inhibition, local inhibition with long-range excitation, and others--the network undergoes a Turing bifurcation, resulting in a localized area of sustained activity, or stationary bump. We identify the locations of these instabilities in the phase diagram and the resulting regimes of different spatiotemporal dynamical patterns of network activity.