Low-dimensional model for adaptive networks of spiking neurons

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We investigate a large ensemble of quadratic integrate-and-fire neurons with heterogeneous input currents and adaptation variables. Our analysis reveals that, for a specific class of adaptation, termed quadratic spike-frequency adaptation, the high-dimensional system can be exactly reduced to a low-dimensional system of ordinary differential equations, which describes the dynamics of three mean-field variables: the population's firing rate, the mean membrane potential, and a mean adaptation variable. The resulting low-dimensional firing rate equations (FREs) uncover a key generic feature of heterogeneous networks with spike-frequency adaptation: Both the center and width of the distribution of the neurons' firing frequencies are reduced, and this largely promotes the emergence of collective synchronization in the network.