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Spike-timing dependent plasticity in integrate-and-fire networks

CHUN-CHUNG CHEN, DAVID JASNOW, University of Pittsburgh — We study plastic integrate-and-fire networks with spike-timing dependent plasticity. Following recent experiments, the long-term potentiation (depression) for causal (anti-causal) spike pairs is assumed to be additive (multiplicative) with reference to the existing synaptic strength. Assuming realistic physiological parameters, for time scales of minutes, the synaptic strength can be assumed fixed while neural activities equilibrate. A mean-field analysis in this regime predicts a first order phase transition for the neural activity. As the constant synaptic strength is increased, the network goes from a quiescent phase with only noise triggered activities, to a phase of persistent activity. The number of synapses per neuron controls the transition point in the synaptic strength. However, the activity level of the network just above the transition point is insensitive to the synapse number and represents a neural firing rate of about 20 to 30 Hz for the set of physiological parameters we considered. Simulations on random networks with fixed connectivities agree well with the mean-field predictions for a per-neuron synapse number of 10 or larger. Applying the plasticity rules and performing simulations covering physical times of days, at fixed depression factor for anti-causal spike pairs, the networks develop a unimodal distribution of synaptic strengths at small potentiation values for causal pairs, while run-away synaptic strengths are observed at large values.

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