Time Decomposition Learning in Artificial Model of EC→CA3 Hippocampus Circuitry

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Synapses are dynamic; the synaptic response to impinging action potentials (APs) varies by an order of magnitude over the course of activity. Short-term changes (STP) of synaptic response build the physiological substrate for spatio-temporal processing of neural stimuli, whereas long-term changes (LTP) in the transmission properties of synapses is the foundation of learning and memory. Electrophysiological recording of hippocampus in vivo identifies different forms of activity-dependent plasticity including LTP and STP [1, 2, 3]. It is also theoretically proven that an artificial network built upon a biological synapse model is a universal approximator for time series computation [4]. We extend the synaptic adaptation - LTP and STP - to a more realistic neural model where there are two layers of neurons with dynamic synaptic connections (DSNN), in which neurons are communicating through APs. First, a generalized linear approximate model supporting both pre and post synaptic characteristics of synaptic response is demonstrated. Temporal processing capability of simple DSNN model in response to spike train will be analyzed. Then, topology of the two-layer DSNN model inspired by hippocampus neural circuitry is described [5]. Physiological finding of neural activity and synaptic adaptation in hippocampus neural circuitry emerges as a spike-domain learning algorithm capable of synaptic plasticity adaptation in both layers of the network [6]. Synaptic adaptation for interneuron is accomplished by decomposing the network task in time, in which each interneuron is trained to perform the task in its predefined time window. The proposed model has been examined in a couple of benchmark temporal processing tasks. Simulation result confirms the two-layer artificial model is capable of approximating a large class of spike-domain tasks, including classification and mapping, where the only biological driven model for solving these tasks utilize a reservoir of kernels. The DSNN model together with time decomposition learning rule, builds a versatile computation unit applicable in modeling nervous system models and spatio-temporal processing tasks.

References


