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Temporal associative memory (TAM) by spike-timing dependent plasticity

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Spike-timing synaptic plasticity (STDP) describes the increase and decrease in synaptic strength depending on the relative arrival time of the pre- and post-synaptic spikes. The relative timing that determines whether the synapse is strengthened by long-term potentiation (LTP), or weakened by long-term depression (LTD) was first reported experimentally [1,2], and computationally [3]. Because of the asymmetry in timing, it is also called "temporally asymmetric Hebbian plasticity" theoretically [4]. Numerous studies on STDP had explored the biological mechanisms for induction of LTP and LTD. This paper will focus on the computational function of STDP in the formation of temporal associative memory (TAM). Traditionally, associative memory is often established relative to the spatial inputs, i.e., forming spatial memory. The formation of bidirectional associative memory [5] and spatiotemporal memory [6] using STDP has suggested that STDP can be used to encode spatiotemporal patterns. Our previous paper [7] also demonstrated that a time-delayed Hebbian associative network essentially computes the temporal relationship by the cross-correlation function between the pre- and post-synaptic input/output functions. The coefficients of cross-correlation can be retrieved by the final synaptic weights subsequent to the associative learning. The previous model only takes into account of Hebbian strengthening of synapses to establish the cross-correlation function. We will extend this model to include STDP in the cross-correlation function to establish temporal association with time-delayed signals. The result suggests that temporal associative memory can be established by the contrast created by LTP and LTD.

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