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Reward Modulated Spike Timing Dependent Plasticity Based Learning Mechanism in Spiking Neural Networks

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ABSTRACT

Spiking Neural Networks (SNNs) are one of the recent advances in machine learning that aim to further emulate the computations performed in the human brain. The efficiency of such networks stems from the fact that information is encoded as spikes, which is a paradigm shift from the computing model of the traditional neural networks. Spike Timing Dependent Plasticity (STDP), wherein the synaptic weights interconnecting the neurons are modulated based on a pair of pre- and post-synaptic spikes is widely used to achieve synaptic learning. The learning mechanism is extremely sensitive to the parameters governing the neuron dynamics, the extent of lateral inhibition among the neurons, and the spike frequency adaptation parameters. Hence, we explore a reward modulated learning methodology to further improve the synaptic learning efficiency. In our work, we define a target spiking pattern a priori for each neuron in the network. The primary objective is to cause the actual neuronal spiking pattern to converge to the desired pattern during the training phase. The STDP driven synaptic updates are modulated by a reward metric, which determines the distance between the actual and target spike train. We estimated the reward using the difference between the averaged version of the actual and desired spike train. Reward based semi-supervised learning scheme is implemented on a two layered SNN trained to classify handwritten digits from the MNIST image set. We obtained an accuracy of 73.16% on the testing image set for a network of 100 spiking neurons which helped learning better in case of supervision.

KEYWORDS

Spiking neural networks, reward based learning, machine learning, neural networks