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PhD Dissertation Presentation

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Capacity Analysis of Attractor Neural Networks with Binary Neurons and Discrete Synapses

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ABSTRACT

Inspired by the delay activity observed in numerous delayed match-to-sample (DMS) experiments, the attractor states of neural network dynamics are considered to be the underlying mechanism of memory storage in neural networks. For the simplest network with binary neurons and standard asynchronous dynamics, we show that the dynamics cannot be stable if all synapses are excitatory. With the introduction of inhibition, the dynamics can be stabilized, especially when the coding levels of patterns varies. The activity of neurons changes the efficacy of the synapses, and hence alters the attractor states. New memory is thus created and old memory are gradually erased. A computationally efficient and highly accurate approximation to the retrieval probability a learned pattern is first developed in binary synapse models and then extended to all finite state synapse models. With the retrieval probabilities, the memory capacity of any local learning rule can be evaluated. The method is applied to the sequential models (Fusi and Abbott, 2007) and meta-plasticity models (Fusi et al, 2005; Leibold and Kempter, 2008). We show that as the number of synaptic states increases, the capacity, as defined here, either plateaus or decreases. In the few cases where multi-state models exceed the capacity of binary synapse models the improvement is small. The method is partially verified in the case of binary synapse models and is extremely close to the retrieval probabilities estimated from simulations.

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