A Stochastic Logic Neural Network as a Deterministic and Probabilistic Hopfield Network

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Abstract

We have studied ability of information processing of stochastic logic neural network, which is one of the pulse-coded artificial neural network families. This network realizes pseudo-analog performance with some local learning rules by using of digital circuit, and therefore it suits silicon technology. On the other hand, in the stochastic logic, synaptic weights and the output of neurons are represented by stochastic pulse sequence, so that these quantities are associated inevitably with non-deterministic coding noise and the limit of synaptic weights. We studied the effects of the coding noise and limited synaptic weights on the ability of association. We found analytically that the limited synaptic weights reduce coding noise and suppress the degradation of memory storage capacity.

To study the effect of coding noise on the optimization problem, we simulated a probabilistic Hopfield model (Gaussian machine), which has a continuous neuron output function and probabilistic behavior, with this architecture. The proper choice of coding noise or scheduled coding noise improved the solutions of traveling salesman problem (TSP). This results suggest the stochastic logic may be useful for implementing probabilistic dynamics as well as deterministic dynamics.

Real-time Unsupervised Neural Networks are Non-implementable in Natural Noise: a refutable hypothesis based on experiment.

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ABSTRACT

We report results of an analog computer implementation of an unsupervised neural network. Results indicate that the implementation of the nonlinear ordinary differential equations of Grossberg's Outstar learning model are destabilized by unavoidable multiplicative biases produced by physical circuitry - attributable to 1/f noise drift. A multiplicative offset perturbation model was developed, and shown numerically to simulate the instabilities discovered in the analog implementation. Analog and numerical data indicate that timing and scaling optimizations are required to enable stable learning of spatial patterns. We generalize these results with the hypothesis that Real-time Unsupervised Neural Networks are Non-implementable in Natural Noise (RUN^5), which includes Carpenter and Grossberg's ART systems, and all of Kosko's RABAM systems. The multiplicative perturbation model developed facilitates testing of this hypothesis. Evidence supports a conjecture that 1/f phenomena is teleologically related to physically occuring self-organizing systems. We suggest a fractional calculus Outstar generalization for incorporating nonzero mean "noise induced parameters" caused by multiple scales of self-organizing interactions.