Decision Making Spike Time Dependent Plasticity (STDP) Based Neuronal Network Learning

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BACKGROUND

Biologically inspired neural networks are capable of performing sophisticated information processing. Information processing by the brain is multilayered and involves many sequential steps before sensory information can be interpreted and translated into a behavior or action. What makes this cascade powerful is its ability to learn and respond to an ever changing environment based on patterns. Eventually, information gathered from the senses may reach decision centers (such as lateral intra parietal cortex) that govern behavior and are under the influence of reward signals.

While a great deal of research has gone into understanding mechanisms of learning at the cellular level, there is still much to discover regarding how learning at the cellular level gives rise to learning on the level of animal behavior. One of the most promising mechanisms of synaptic change for learning is spike time dependent plasticity ("STDP").

TECHNOLOGY DESCRIPTION

Researchers at UC San Diego have developed a model to study how intelligent behavior emerges from the basic principles known at the cellular level of biological neuronal network dynamics. Compared to the approaches used in the artificial intelligence community, the researchers applied biologically realistic modeling of neuronal dynamics and plasticity. The building blocks of the model are spiking neurons, spike-time dependent plasticity (STDP) and homeostatic rules, known experimentally, which are shown to play a fundamental role in both keeping the network stable and capable of continous learning.

The network utilized both reward modulated and nonreward modulated STDP and implemented multiple mechanisms for homeostatic regulation of synaptic efficacy, including heterosynaptic plasticity, gain control, output balancing, activity normalization of rewarded STDP and hard limits on synaptic strength. The team found that addition of a hidden layer of neurons employing nonrewarded STDP created neurons that were responsive to the combinations of inputs and thus performed basic classification of the input patterns. When combined with a following layer of neurons implementing rewarded STDP, the network was able to learn discrimination between rewarding patterns and the patterns designated as punishing. The model predicts a minimal set of properties for the spiking neuronal network with STDP that was sufficient to solve a complex foraging tasks involving pattern classification.

APPLICATIONS

The primary application would be Robotics.

ADVANTAGES

Behind the model is a neural network which, compared to usual methods used in machine learning, uses only biologically known mechanisms on cellular level (neurons). The building blocks of the network are spiking neurons, (rewarded) spike timing dependent plasticity (STDP) and homeostatic rules.

STATE OF DEVELOPMENT

Computer Simulation Stage

INTELLECTUAL PROPERTY INFO

A PCT/US18/048984 patent has been submitted.

RELATED MATERIALS

- Sanda P, Skorheim S, Bazhenov M. Multi-layer network utilizing rewarded spike time dependent plasticity to learn a foraging task. PLoS Comput Biol. 2017 Sep 29;13(9):e1005705. doi: 10.1371/journal.pcbi.1005705. eCollection 2017 Sep. - 09/29/2017

PATENT STATUS

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OTHER INFORMATION

KEYWORDS

Robotics, Neural Networks, spike time dependent plasticity, STDP, machine learning, Neuronal Plasticity/physiology

CATEGORIZED AS

- Communications
  - Other
- Engineering
  - Other

RELATED CASES

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Additional Patent Pending

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