Learning in a Massively-Parallel Biologically-Inspired Architecture

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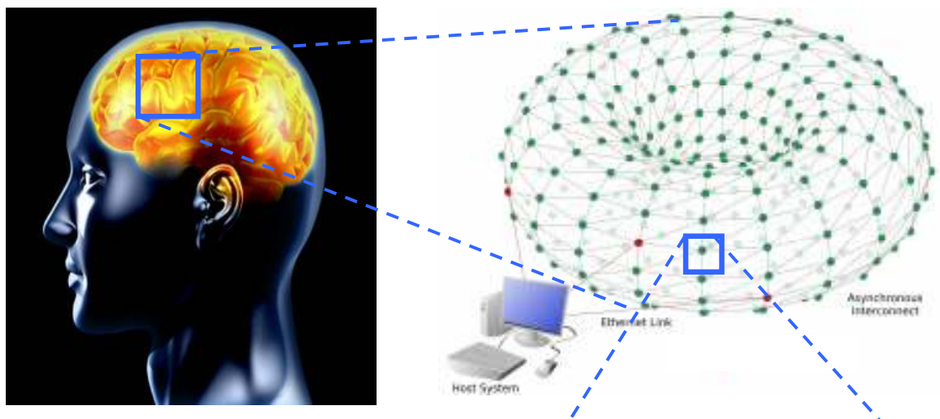
SpiNNaker

Optimised custom-designed integrated circuit inspired by the biological functions of the human brain.

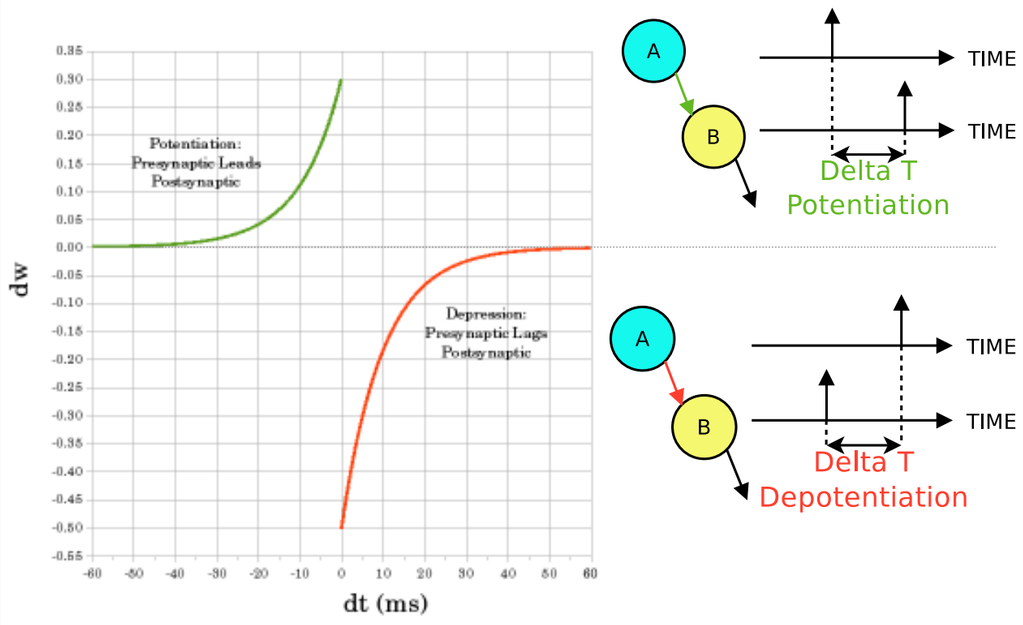


- 65,000+ SpiNNaker chips;
- Each chip contains 18 ARM9 cores each simulating ~1,000 neurons;
- Total: 1 billion+ neurons.
- SpiNNaker system is able to simulate ~1% of the brain;

SpiNNaker system

Spike Timing Dependent Plasticity (STDP)

- STDP exhibits some biological realism;
- Complex implementation on ANNs simulators;
- Find a trade-off between complexity and biological realism.



STDP basic rule

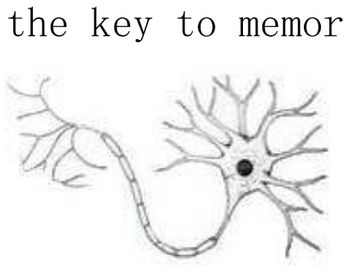
Features of SpiNNaker chip

SpiNNaker mimics the brain in numerous ways:

- Resilient to individual component failure;
- Maximum power efficiency;
- Asynchronous event based communication;
- High performance through many small elements.

Learning

- Synapse: main structure involved in learning;
- Synapse physiology modification is believed to be the key to memories and experience;



Example of a biological neuron

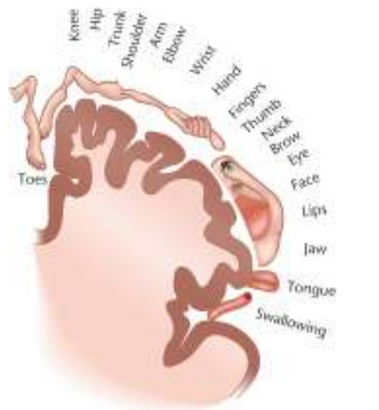
Example of synapses around one neuron

Research problems arising are:

- How can we provide learning features to Artificial Neural Network (ANN) simulators?
- How to store memories and experience in ANNs?
- How “synaptic rewiring” improves learning?

Synaptic rewiring

Biology shows new connections developing in brain areas that receive the largest amount of stimuli.
It is believed that synaptic weight modification and synaptic rewiring are the main processes for learning; through these features neural networks store “experiences” and adapt to the incoming stimuli.



Areas of the brain assigned to receive sensory stimuli: the size suggests processing complexity

The process is not yet completely understood in biology, and simulators help to improve this knowledge.

Further Information

SpiNNaker website:
http://intranet.cs.man.ac.uk/apt/projects/SpiNNaker/

Email: daviess@cs.man.ac.uk
SpiNNaker Line Following - YouTube video:
http://www.youtube.com/watch?v=ZQ7FdQ_VJNg

APT Group.
Supervised by:
Professor Steve B. Furber

SpiNNaker sponsors and collaborators

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