IMPROVEMENTS IN SPINNAKER SIMULATOR

SpiNNaker – a spiking neural network simulator developed by APT group – The University of Manchester

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11/03/2010

Research Areas

- Currently working on:
  - **Synaptic plasticity:** specifically a new version of the STDP algorithm which aims to simplify the original version;
  - **New simulator framework:** Porting Scott's simulator code onto the test chip;
  - **Graphical User Interface (spinnGUI)**: condensing all the tools in a nice front-end.

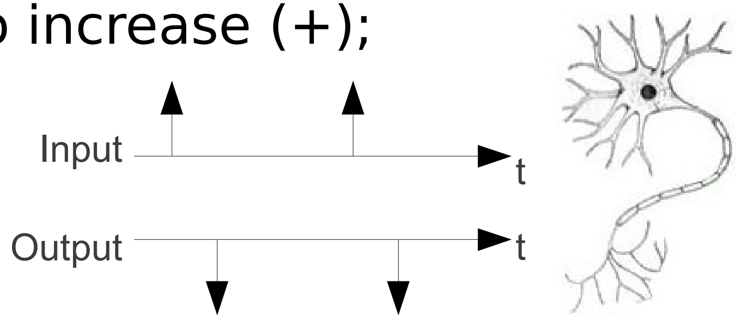
Synaptic plasticity

- Modification of synapse parameters (i.e.: weight);
- Deletion of synapses with a very low weight;
- Creation of new synapses for each removed synapse;

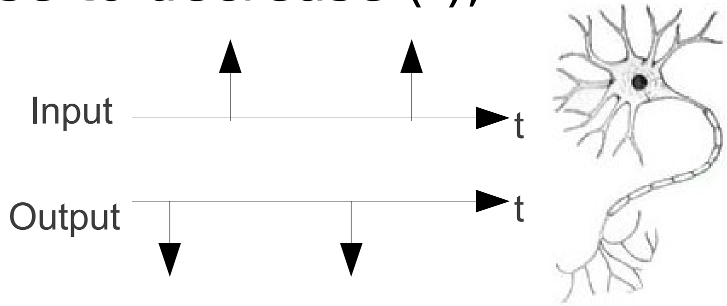
The last two events are generally referred to as “synaptic rewiring”.

Synaptic weight modification (1/3)

- Weight modification dependent on the sequence of spikes:
  - Causality in the input – output causes the weight of the input synapse to increase (+);

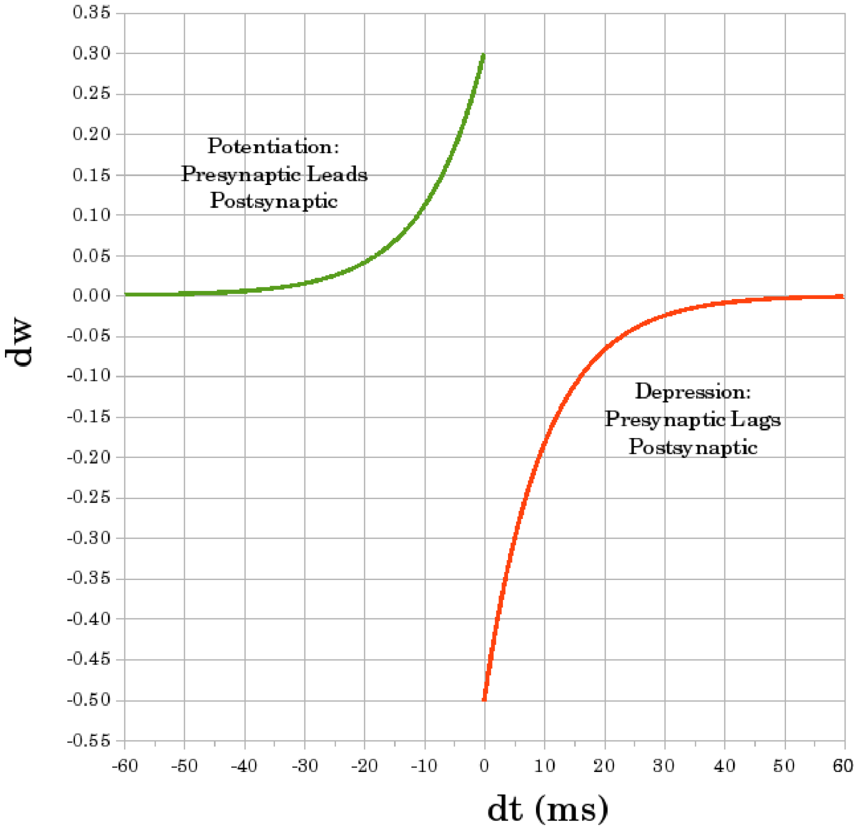


  - Anti-causality in the input – output causes the weight of the input synapse to decrease (-);



Synaptic weight modification (2/3)

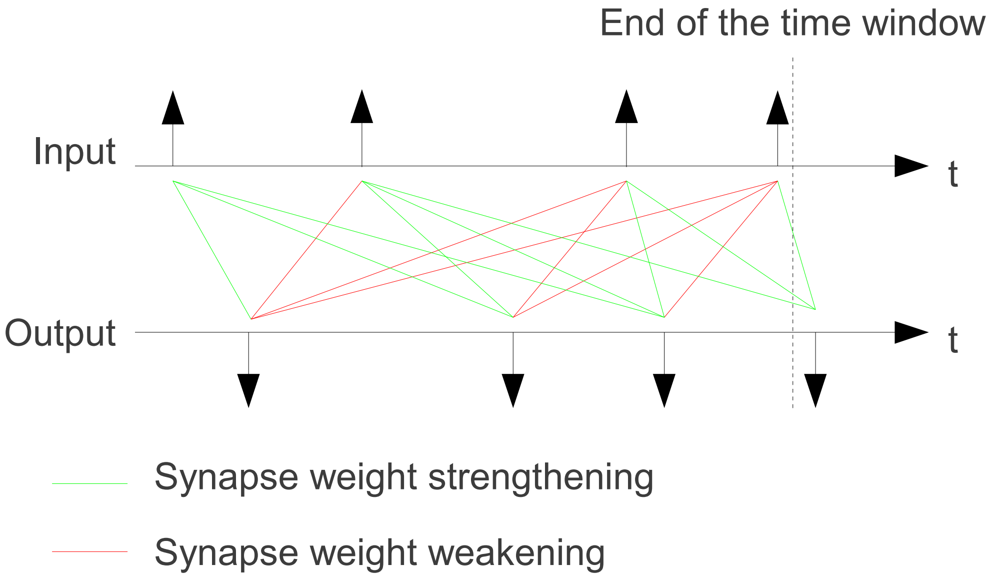
- The modification of the synaptic weight is described by an exponential law:



Synaptic weight modification (3/3)

"Spike-Timing-Dependent Plasticity" (STDP) to evaluate the weight of the synapse:

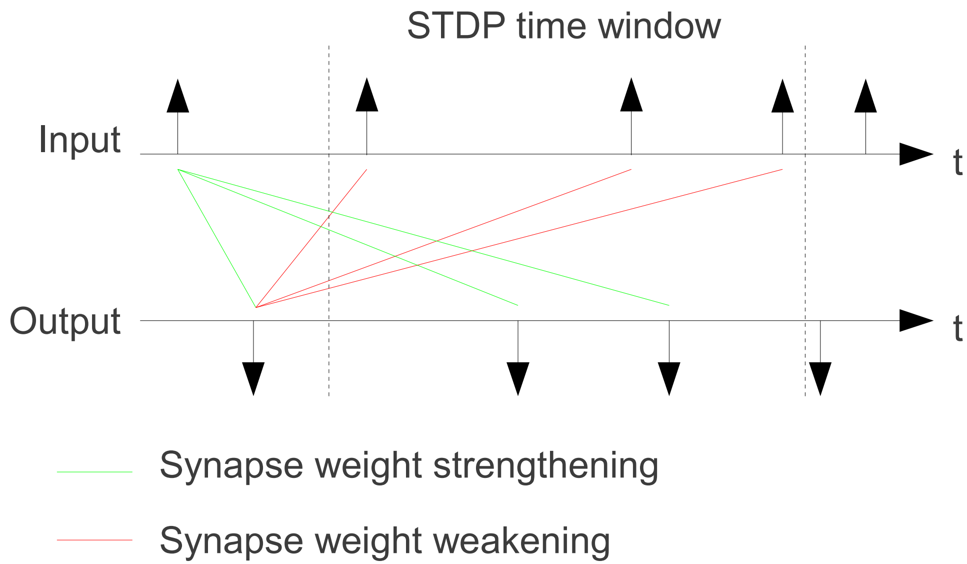
- The original algorithm computes the time difference between spikes for all the possible combination of input and output spikes (in a time window).



This algorithm is very complex and needs future information to compute the weight in a specific moment.

Deferred event-driven (DED) model

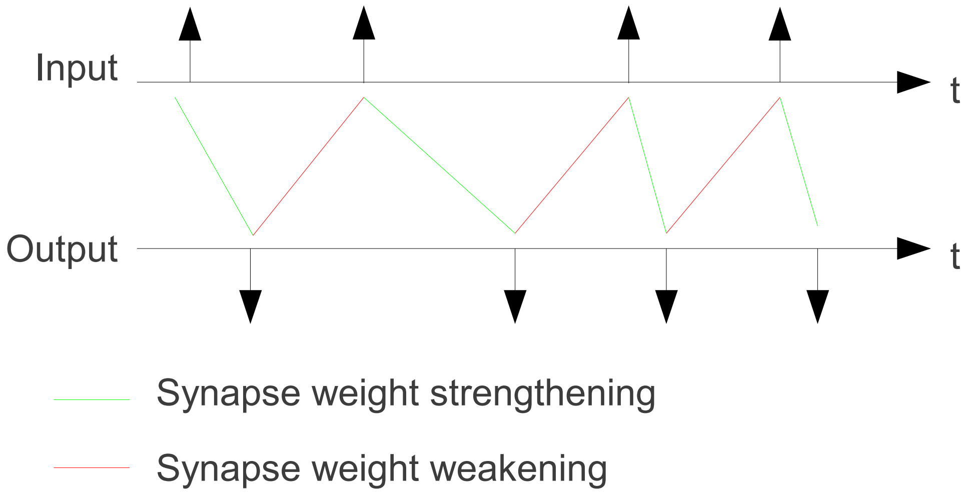
- To avoid the need of future parameters the deferred event-driven model has been implemented. The execution is triggered on the arrival of a pre-synaptic spike



- When some spikes are pushed out of the STDP time window, the STDP algorithm is triggered.

Simplified STDP

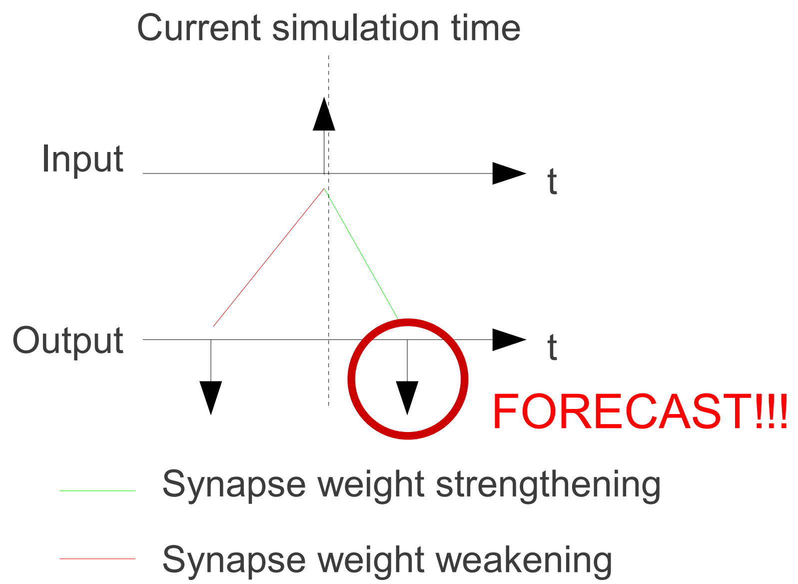
- Disadvantages of the standard STDP: computational power and memory.
- The first simplification takes into account only the nearest sequence of input – output spikes:



- Similar to the DED STDP model. Less computations, but similar amount of memory.

Forecast STDP

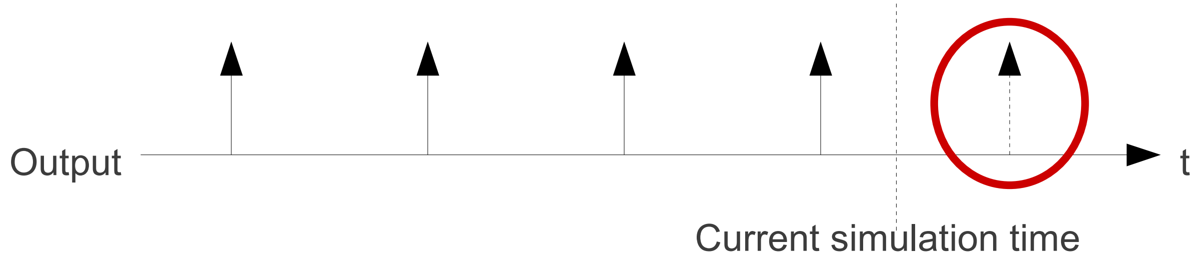
- To avoid the need of memory, a new model for the STDP algorithm has been proposed.



Running average STDP (1/2)

Forecast of the next outgoing spike:

- Running average historical spiking rate
- The future spike time-stamp of a neuron is computed according to an estimated firing rate.



Running average STDP (2/2)

The estimated firing rate is updated at every outgoing spike according to the previous estimated firing rate and the time between the last two spikes.

$$FR(n) = \frac{1}{2} FR(n-1) + \frac{1}{2} IST(n)$$

Where:

- FR(n): firing rate estimated after n outgoing spike
- IST(n): Inter Spike Time between spike n-1 and spike n

Sudden variation of spiking rate doesn't have an immediate effect.

Running average STDP Simulation

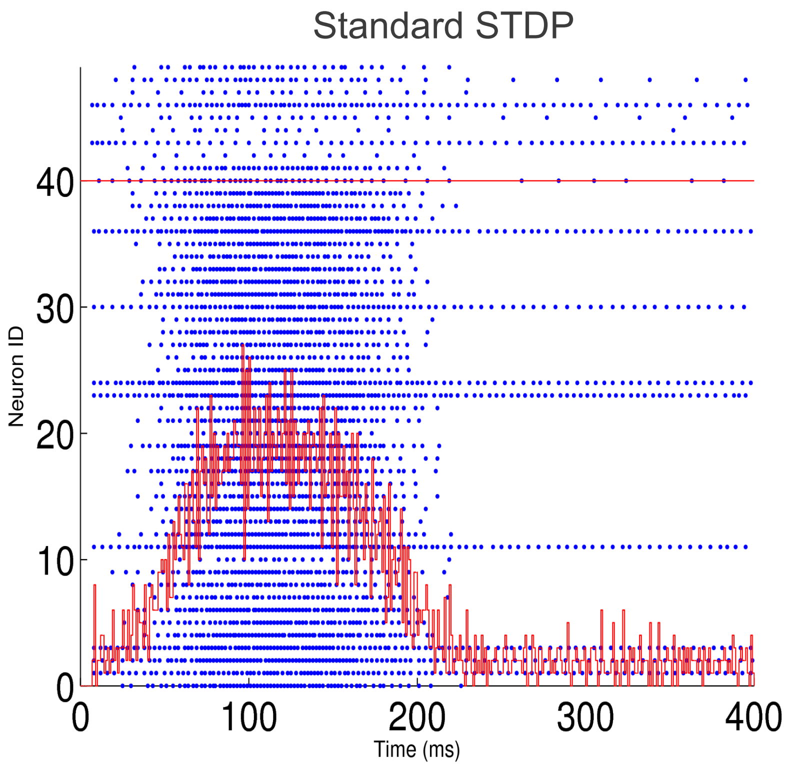
Before the simulator expired, there was the possibility to run only one simulation:

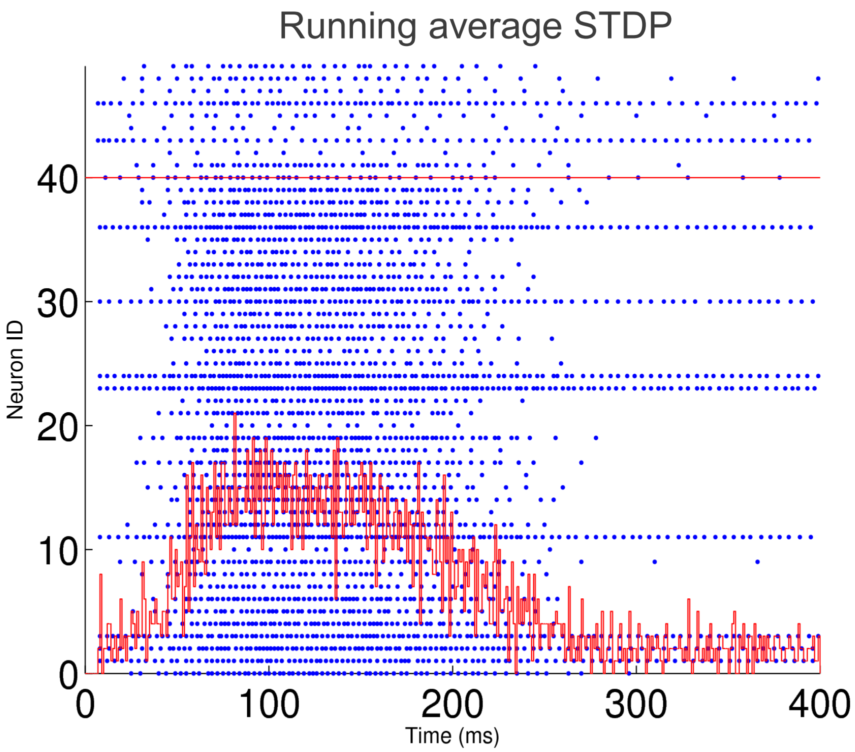
- The algorithm has been simulated and compared with the original STDP with a random network of 50 neurons with an input to 10 of these neurons.

- The input is characterized by fast and strong spikes.

Running average STDP Results (1/2)

Raster plots of the simulations:





Behaviour seems similar.

Running average STDP Results (2/2)

Numerical results of the simulation.

Values are ratio between the variation of the synaptic weights in both models.

	0	1	2	3	4	5	6	7	8	9	10	11	12
...													
25	0.71	0	0	1.07	0	0	0	0	0.64	0.57	0	0	0
26	0	0.62	0	0	0.43	0	0	0	0.98	0	0	0.5	0.67
27	0	0.93	0	0	0.83	0	0	0.8	0	0	0.97	0	0
28	0	0.72	0	1.08	0	0	0.43	0	0	0.65	0	0	0.66
29	0	0.54	0	0.67	0	0	0	0	0.9	0.44	0	0	0
30	0	0	0.76	1	0	0	0	0	1.13	0.95	0	0	0
31	0.68	0	0	0.6	0	0	0	0	1.03	0	0	1.1	0
32	0.75	0	0	0	0	0.6	0	0	0.76	0	0	0.76	0.77
33	0.51	0	0	0	0.68	0	0.54	0	0	0	0	0.47	0
34	0	0	0.48	0	0	0.75	0	0.68	0	0	0	-1.12	0
35	0	0	0.46	0	0.79	0	0.72	0	0	0	0	0.58	0
36	0.76	0	0	0	0	0.97	0	1.24	0	0	1	0	0.8
37	3	0	0	0	0	0.52	0.46	0	0	0	0	0.64	0
38	0.57	0	0	0	0	0.57	0	0	1	0	1.07	0	0.71
39	0	0	1.11	0	0	0.67	1.16	0	0	0	0	1.12	0

Running average STDP
Future work

- Raster plots indicate a comparable behaviour.
- Synapse weights table shows the opposite.

WHAT TO BELIEVE???

- We are more interested in the behaviour of the network
- More simulations and study of the parameter is necessary

New simulator

- SoC Designer has expired. Simulations running now on the test chip.

- Some adaptations are needed to load data into and to retrieve data from the simulator.

SpinnGUI

A new front-end for SpiNNaker simulator.

- Expandability for new future tools and modules
- Portability to various operating systems
- Controls the whole tool-chain: from the compilation to the retrieval of simulation results.

SpinnGUI explained

Expandability:

- Front-end is modular
- Modules of the simulator are described in XML.

Portability:

- The Qt framework supports multiple OS.
- The Xerces-C library as well.

SpinnGUI – State of development

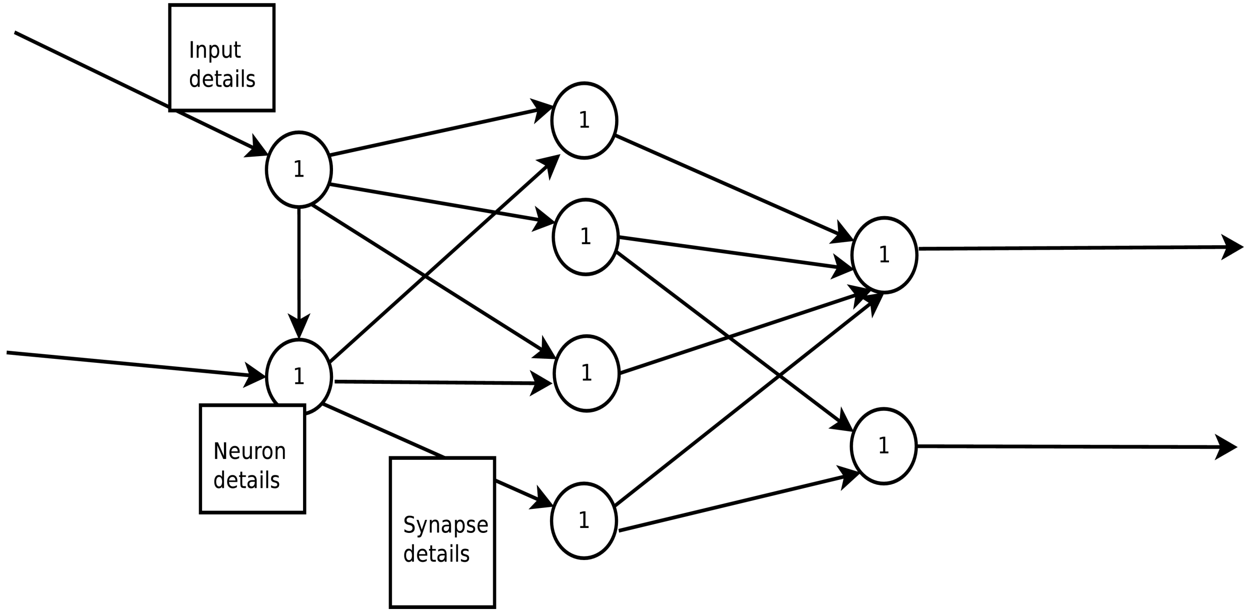
XSD Schema

XML Description

spinnGUI

SpinnGUI – Future work

- A graphical interface to describe the neural network



- Tools to configure the simulation on the chip
- Output analyser tools
- ...

Thank you!!!