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An efficient SpiNNaker implementation of the Neural Engineering Framework

Andrew Mundy, James Knight, Terry Stewart and Steve Furber

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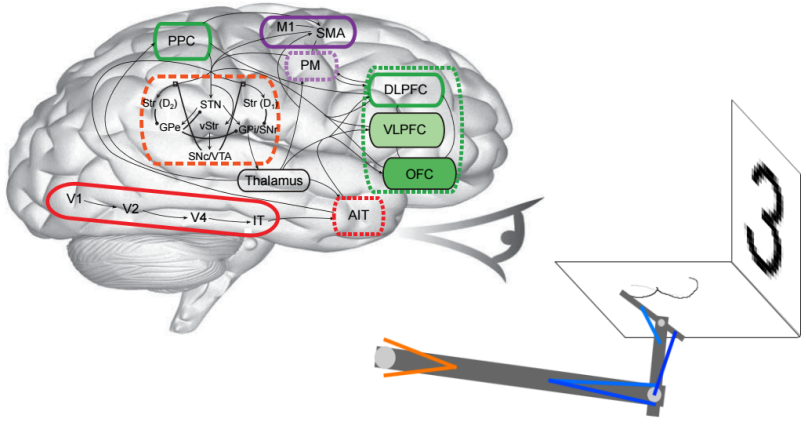
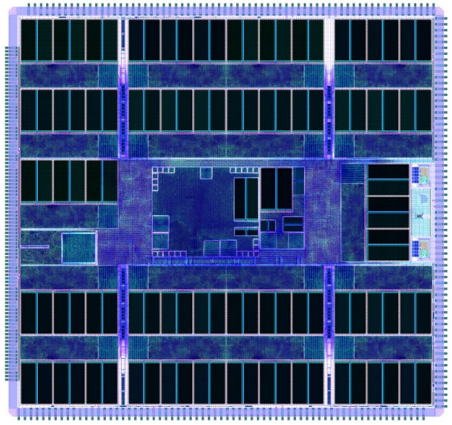


Spaun



SpiNNaker

2.5 h compute for 1 s simulation

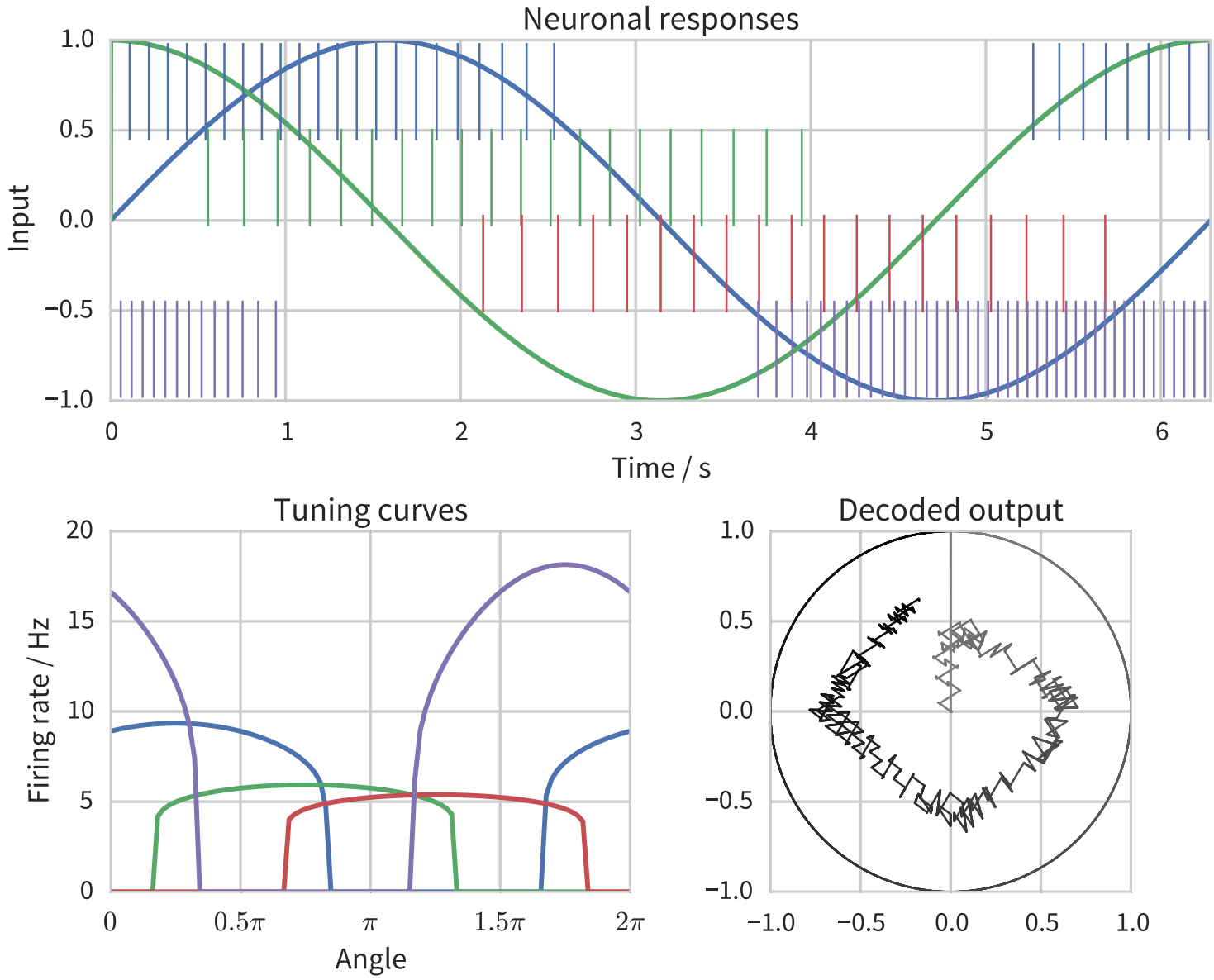
- Scales badly
- No real-world interaction

Low-power computing platform

- Scalable
- Real-time

A bad fit? Compute, memory and network load must be managed.

Neural Engineering Framework (NEF)



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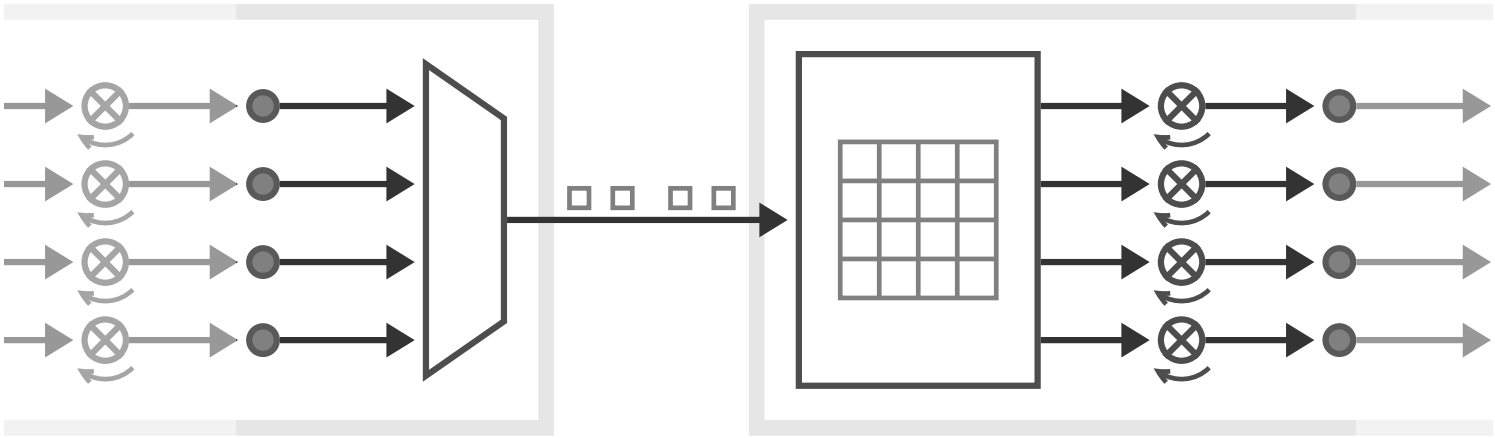
SpiNNaker – Neural Nets



Constrained by

Memory synaptic weight matrix

Compute incoming spike processing

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Analysis – NEF on SpiNNaker

Using parameters from Spaun

- 512D representational space
- 70 neurons per dimension

Limit of 5000 synaptic events per timestep
A 4D communication channel generates 5600 **events per timestep**

Each core has 8 MiB memory for weight matrices
One weight-matrix requires 2.28 GiB **must be split across cores – only 120 neurons per core**

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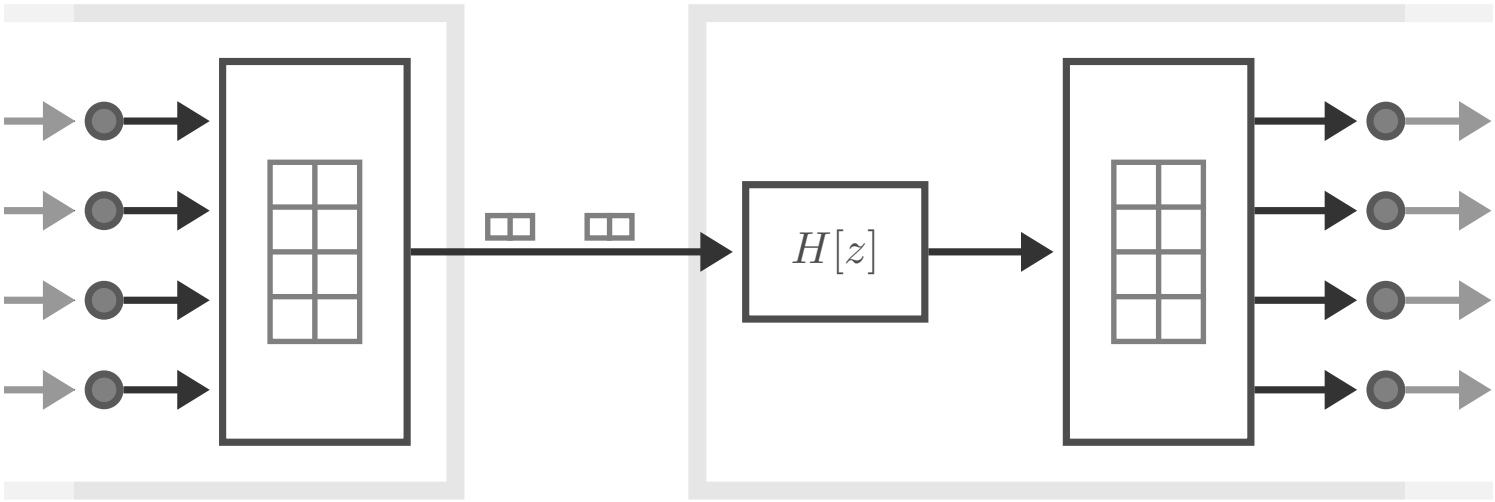
Efficient SpiNNaker implementation



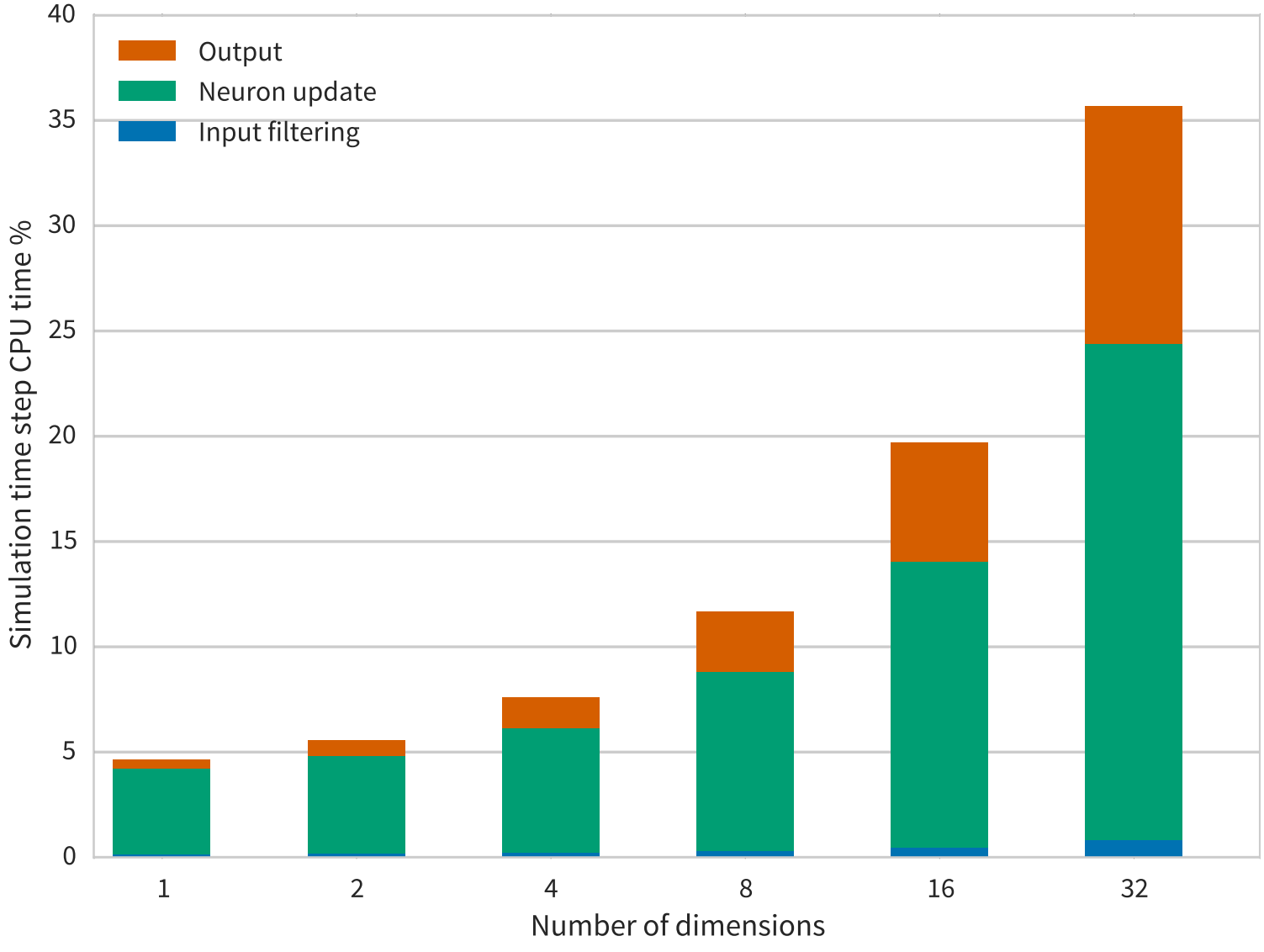
Less memory Use factored weight matrices

- Store locally

Less compute Represent activity with vectors

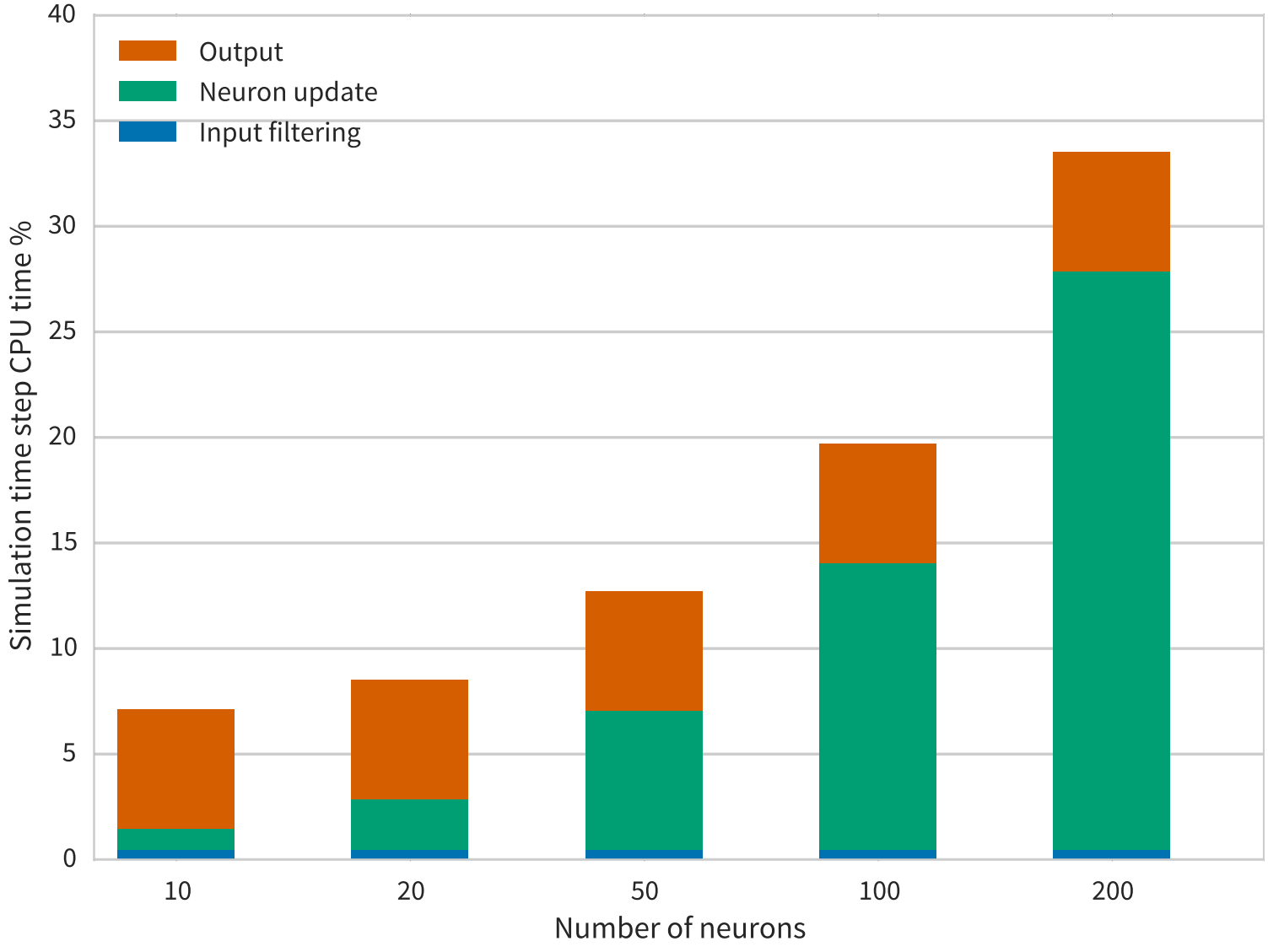
- Encoding/decoding cheap
- Synaptic filtering in vector-space

Results – CPU Usage – Dimension scaling



100 neurons, 200 MHz clock cycle with 1 ms simulation step

Results – CPU Usage – Neuron scaling



16-D representation, 200 MHz clock cycle with 1 ms simulation step

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Results

- Reduced compute cost scaling – $0.19N^2$ vs. $3N^2$ (fixing $D = \frac{N}{70}$)
  - Up to 2000 neurons per core – 2x target
- Memory usage reduced by 90 %+
  - Also affects load time

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In conclusion

NEF on GPU –

- 500 000 neurons in real-time (Radeon HD7970)
- Scaling beyond one GPU may be difficult
- Large power consumption

NEF on other neuromorphic hardware –

- Limited by number of available synapses
- *Brainstorm*[1] designed for the NEF
- SpiNNaker is very flexible

[1] http://brainstorm.stanford.edu/projects/

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In conclusion

Future work –

- Real-time Spaun
- Analyse effect on learning-rules
- Analyse effect on network loading

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Andrew Mundy
andrew.mundy@ieee.org