Human Brain Project

UNIVERSITÄT HEIDELBERG
ZUKUNFT SEIT 1386

BrainScaleS-1

neuromorphic physical model system

Heidelberg University

Emulation of networks of spiking point neurons and plastic synapses

TECHNOLOGY DESCRIPTION

The **BrainScaleS system** is based on physical (analog and mixed-signal) emulations of neuron, synapse and plasticity models with digital connectivity.

The BrainScaleS-1 system contains 20 uncut 8-inch silicon wafers in 180 nm CMOS process technology. Each wafer incorporates 50 x 10^6 plastic synapses and 200,000 point neurons.

The system does not execute pre-programmed code but evolves according to the physical properties of the electronic devices, running up to 10,000 times faster than real time. This allows for exploration of model time scales that are not accessible by numerical simulations.

A highly configurable research tool to emulate simplified spiking neuronal networks 10,000 times faster than real time

Closed loop operation for network parameter searches

AREAS

Neuromorphic computing | spiking neural network emulation

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COMPETITIVE ADVANTAGES

Performance

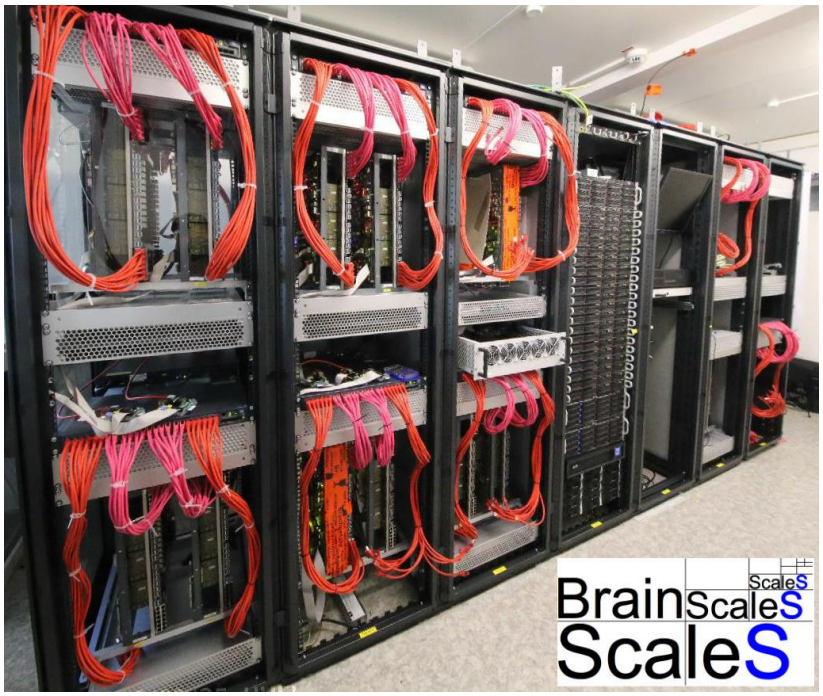
- continuous-time emulation with speed-up of up to 10^4 compared to biological real-time.
- approx. 10^{15} analog multiply-accumulate operations per second

Energy efficiency

- spiking neural networks
- less than 100pJ per synaptic transmission

Configurability

- short and long term synaptic plasticity
- networks of neurons with up to 15k synaptic inputs can be flexibly configured
- fast reconfiguration for e.g. in-the-loop training



TECHNOLOGY READINESS LEVEL

1 2 3 4 5 6 **7** 8 9

APPLICATION & MARKET POTENTIAL

- While the system is primarily made for basic research on understanding information processing in the (human) brain, efforts are being made to also implement machine learning tasks on it. Its speed and energy efficiency makes it well suited as inference accelerator.
- In the medium term, systems may be used to find hidden structures in complex data from science, finance, business and government.
  Based on such detected structures neuromorphic systems could be able to make predictions supporting human decision making.

REFERENCES

- Neuromorphic Hardware In The Loop: Training a Deep Spiking Network on the BrainScaleS Wafer-Scale System, https://doi.org/10.1109/IJCNN.2017.7966125
- Pattern representation and recognition with accelerated analog neuromorphic systems https://doi.org/10.1109/ISCAS.2017.8050530

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