

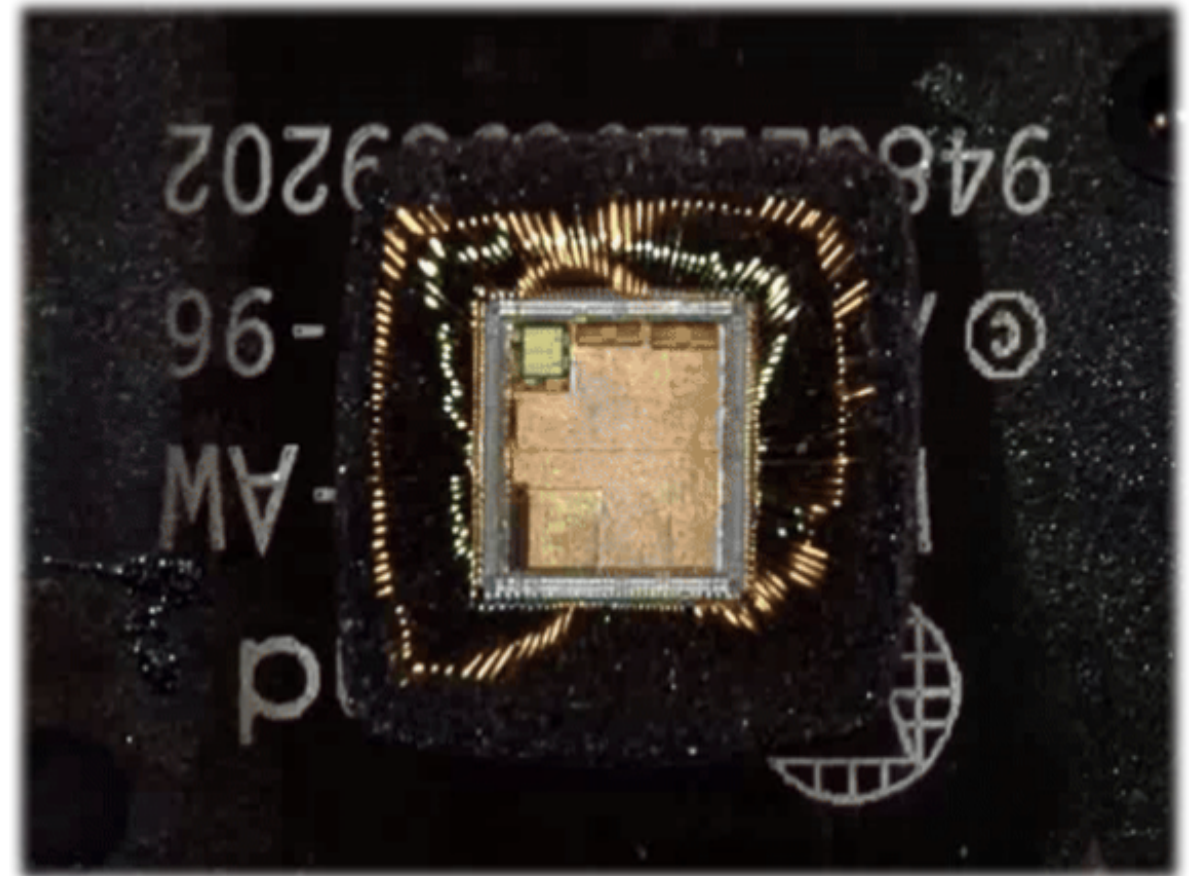
Neuromorphic Technology for Industrial Streamlined Solutions

Cristian Axenie, TH Nürnberg and Fraunhofer IIS



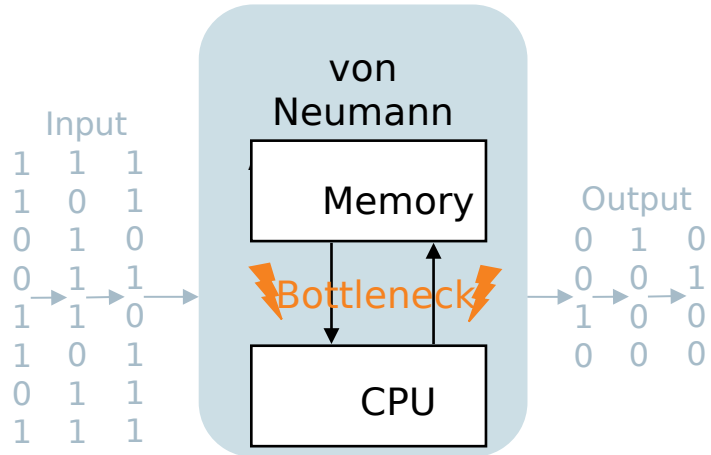
The model system

Evolution to neuromorphic



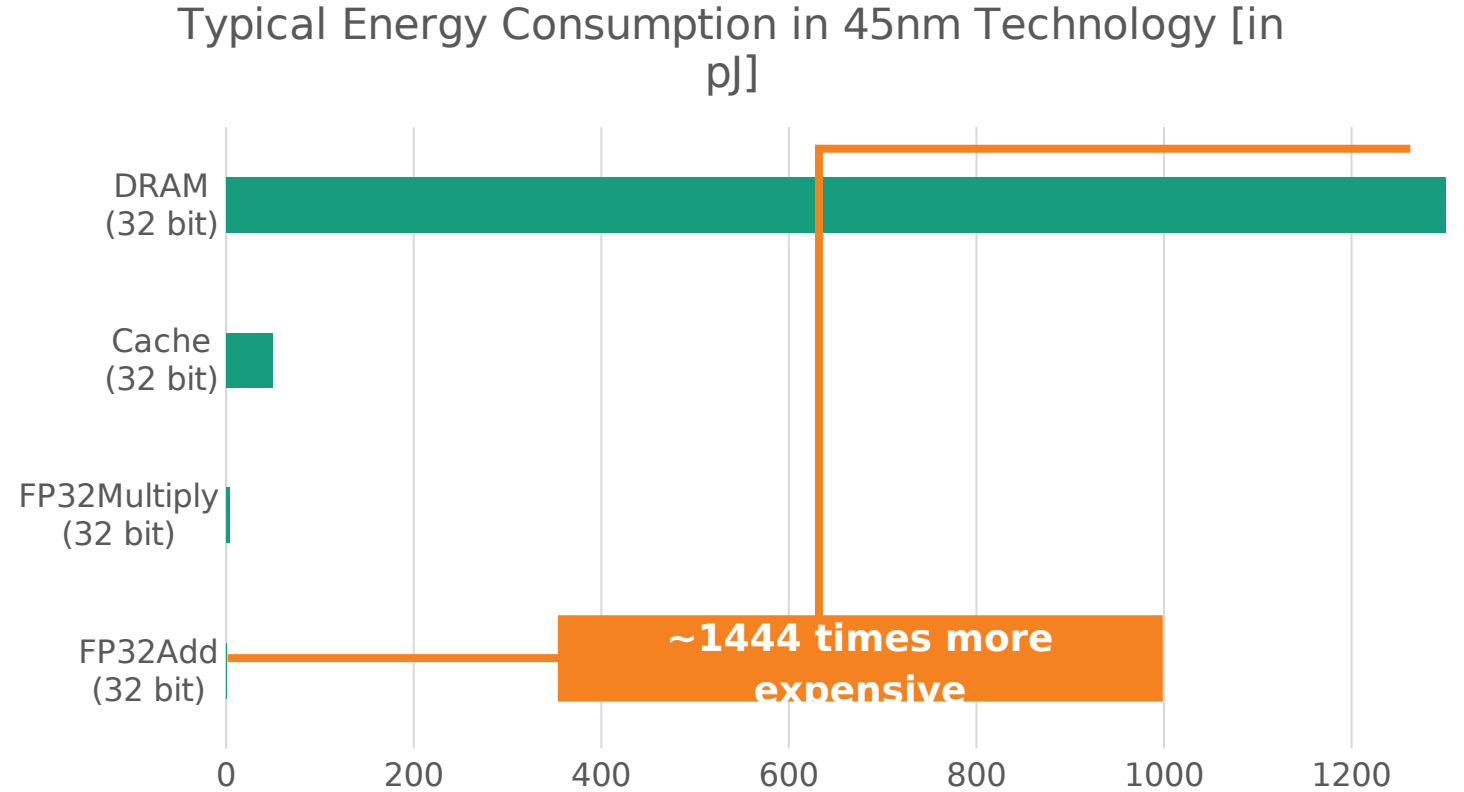
The Need for a New Way of Computing

Limits of Traditional Computation Paradigms



Traditional Computation Paradigm

- Separated computation and memory
- Limited compute parallelism
- Digital compute signals
- Dense data (continuous values and synchronous data stream)



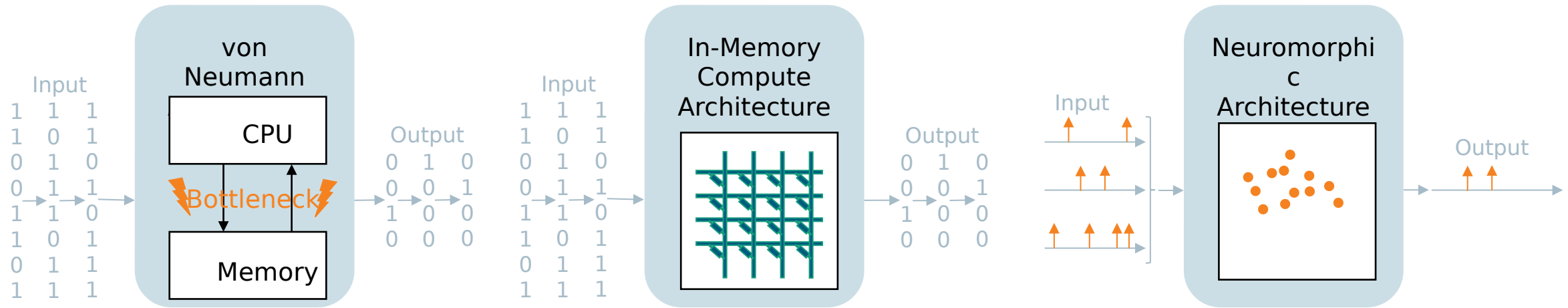
Source: Horowitz, M. *Computing's Energy Problem and What We Can Do About It*, ISSCC

2014

✉ Moving data from memory to CPU is energy intensive and limited by the bandwidth between memory and CPU

The Need for a New Way of Computing

Overcoming the von Neumann Bottleneck



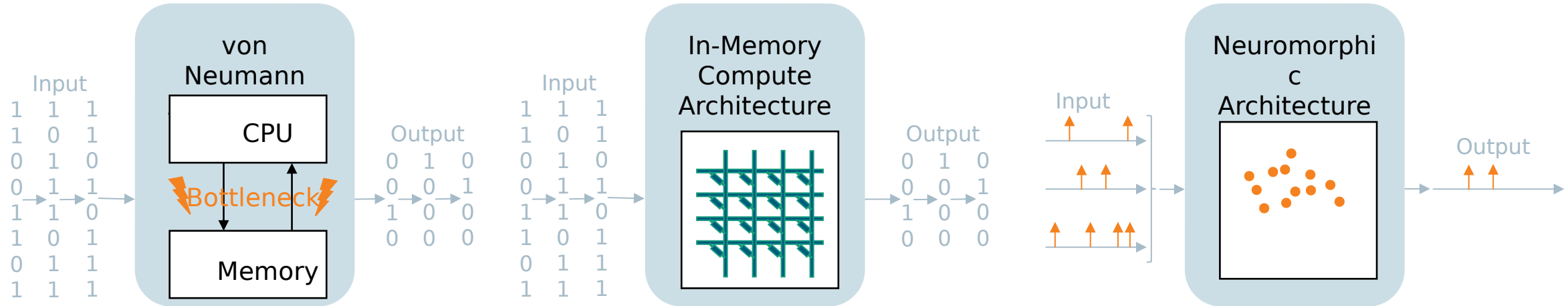
Traditional Computation Paradigm

In-memory Computing

Neuromorphic Architecture

The Need for a New Way of Computing

Key Differences between Compute Paradigms



Traditional Computation Paradigm

- Separated computation and memory
- Limited compute parallelism
- Digital compute signals
- Dense data (binary, continuous and synchronous data stream)

In-memory Compute

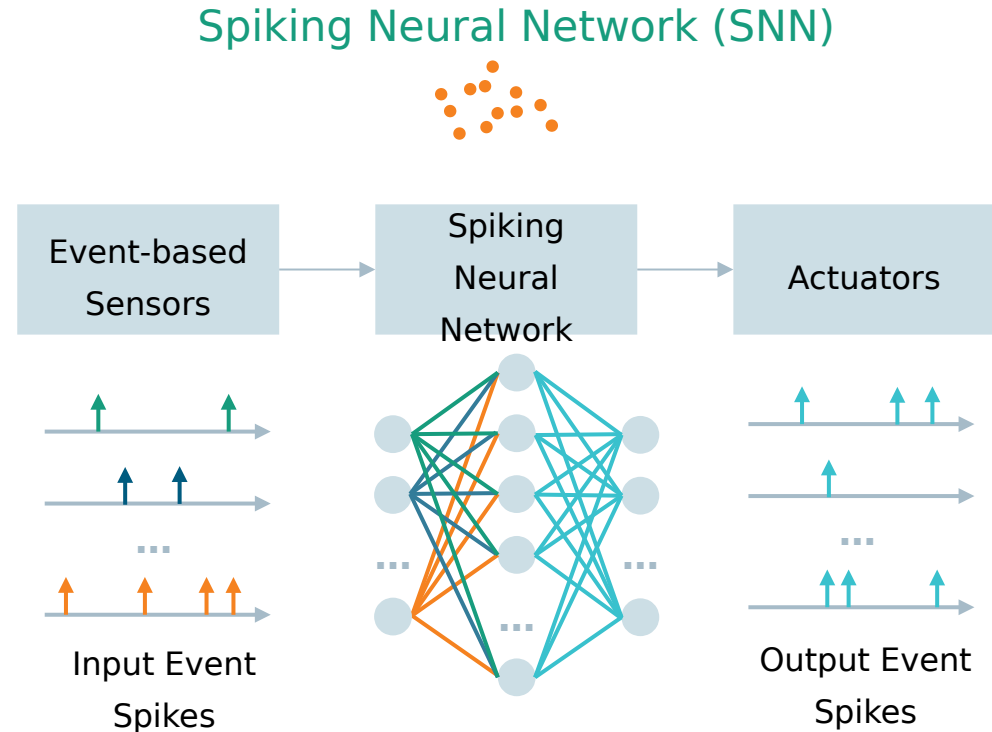
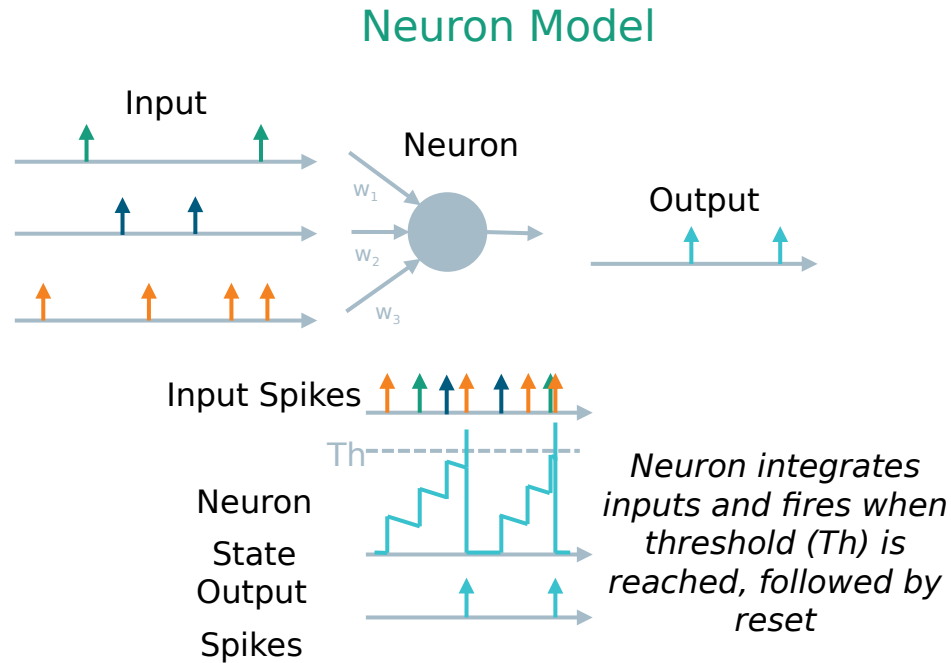
- Collocated computation and memory
- Massive compute parallelism
- Mixed-signal (digital/analog) compute signals possible
- Dense data (continuous values and synchronous data stream)

Neuromorphic Architecture

- Collocated computation and memory
- Massive compute parallelism
- Mixed-signal (digital/analog) compute signals possible
- Sparse data (spiking, event-based and asynchronous data stream)

The Need for a New Way of Computing

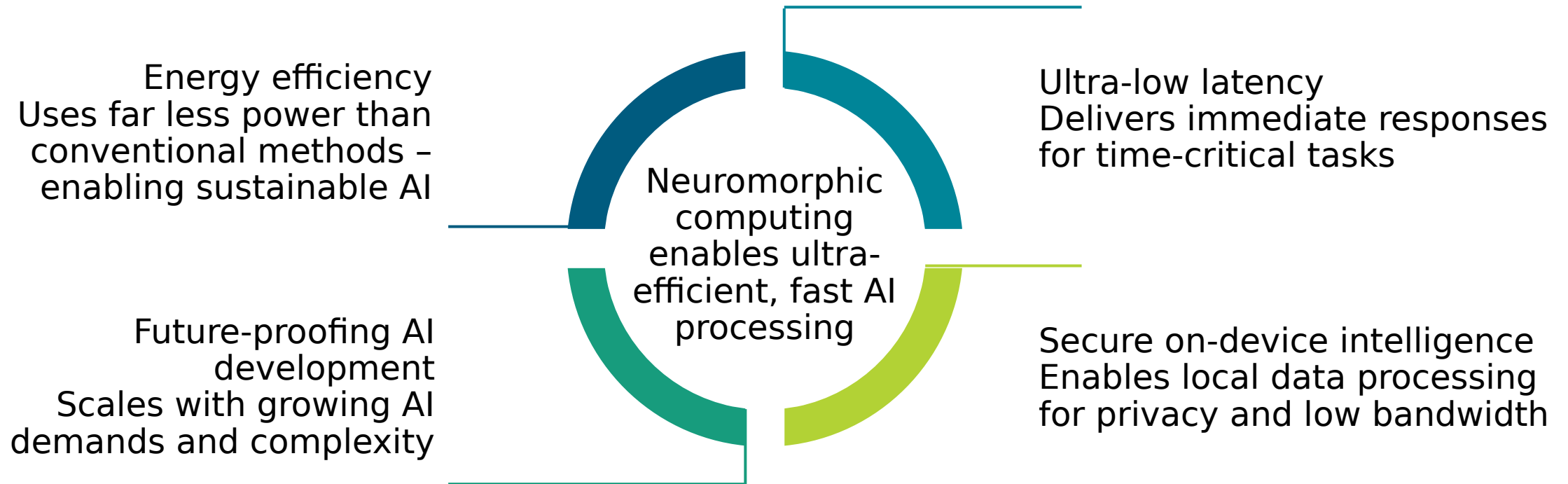
Neuromorphic Computing – Working Principle



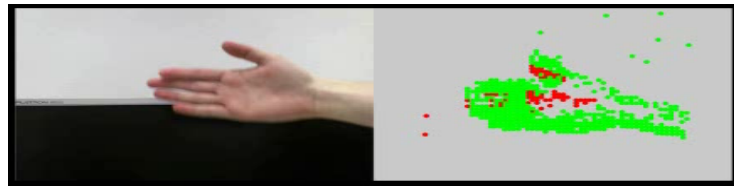
- Neurons collocate weights (w_i) and compute logic and allow mixed-signal implementations ✉ **SNNs allow increased power efficiency**
- SNNs exploit sparsity (inputs and weights are not dense) ✉ **SNNs require less data movement than DNNs**
- Bio-inspired compute algorithms allow beyond-Moore compute concepts (e.g. fully parallel designs) ✉ **Reduced reliance on Moore's law**

Motivation

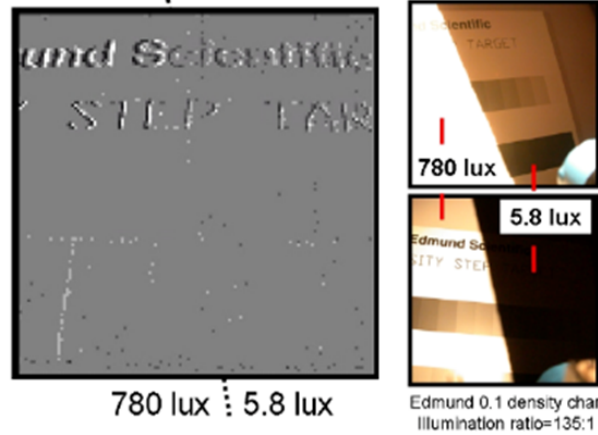
Why do we need Neuromorphic Computing?



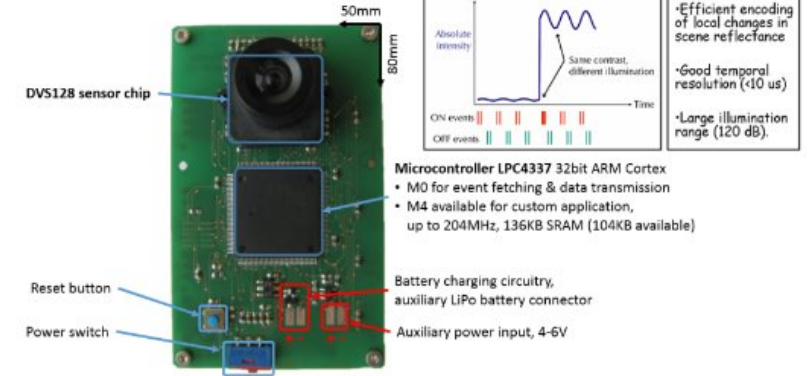
Neuromorphic Sensing Event-based Cameras



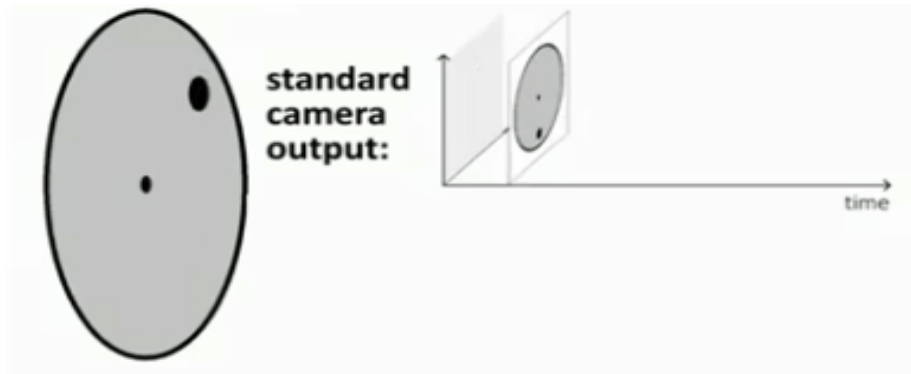
Contrast sensitivity under wide illumination.



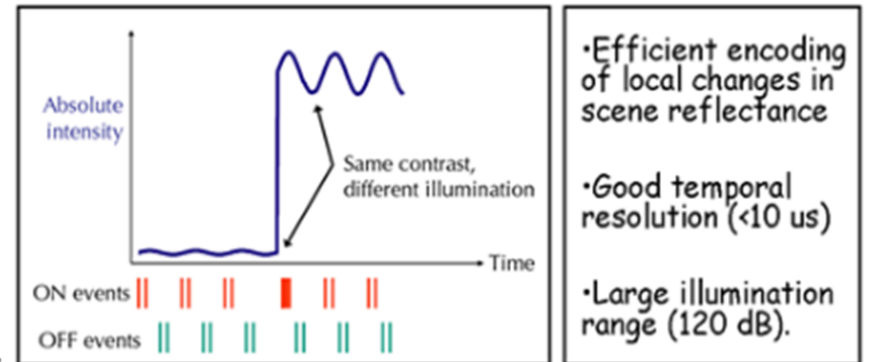
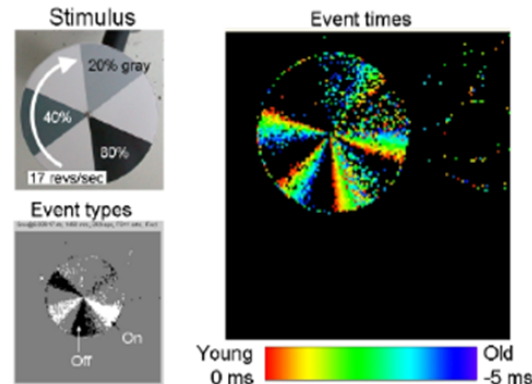
Hardware module



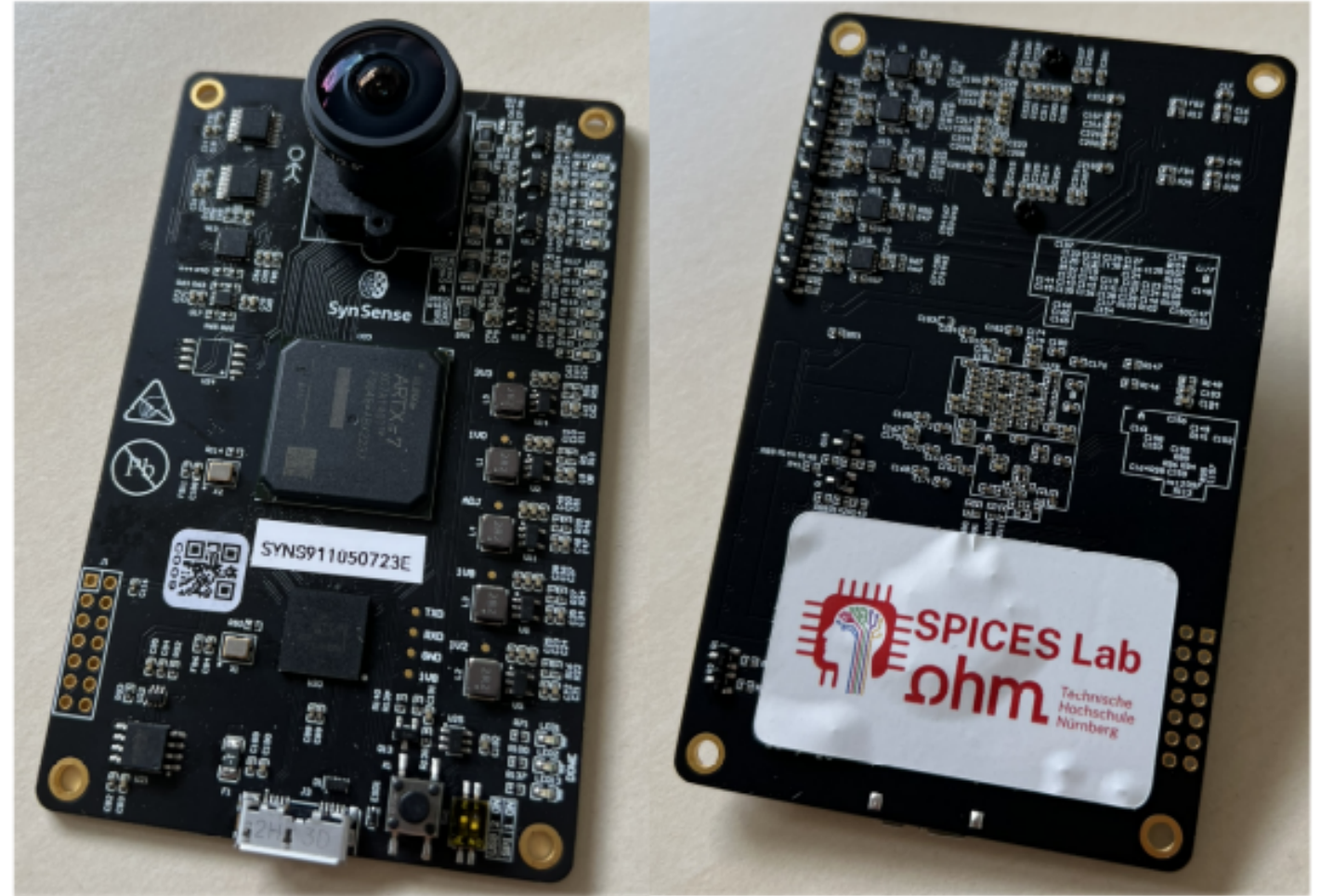
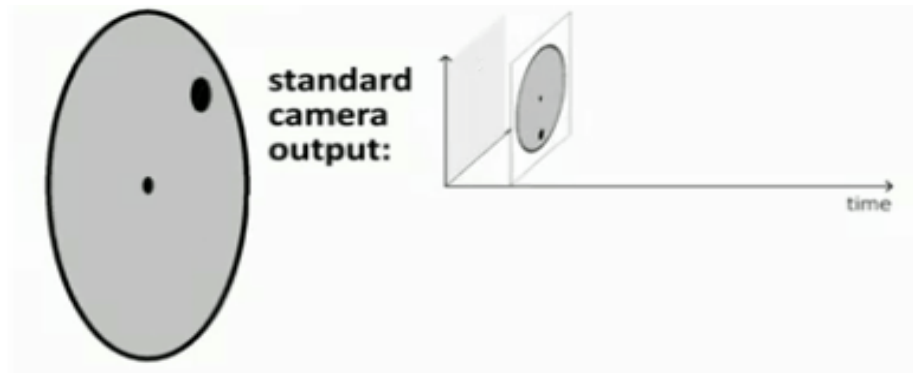
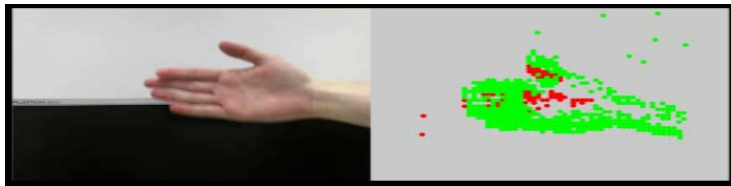
- Neuromorphic vision sensor (eDVS – embedded Dynamic Vision Sensor)
- individual sensor pixels react independently to changes in light intensity
 - individual sensor pixels spike asynchronously
 - spikes (events) contains information about its position, polarity, and a timestamp



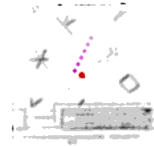
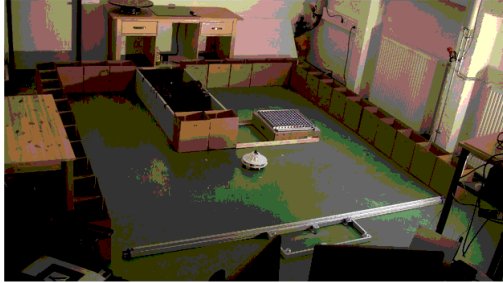
Time resolution of events.



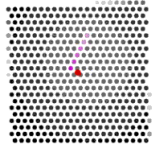
Neuromorphic Sensing Event-based Cameras



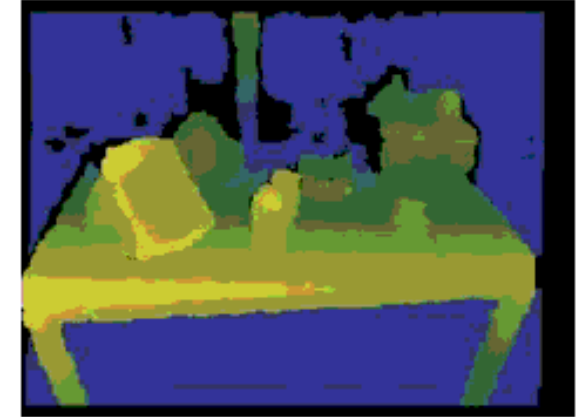
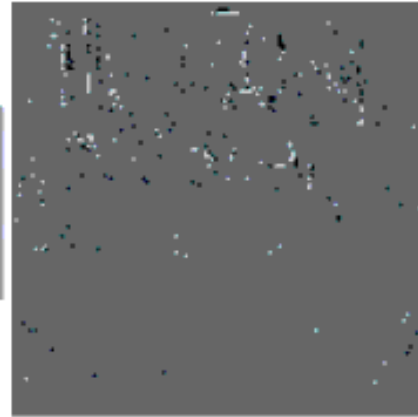
Neuromorphic Sensing Event-based Cameras Applications



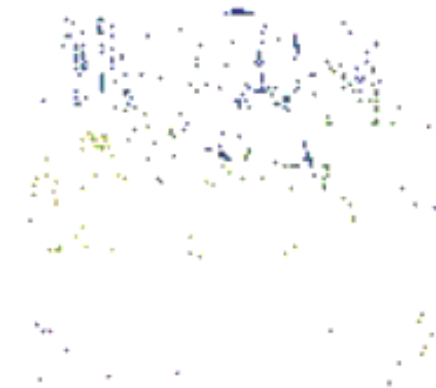
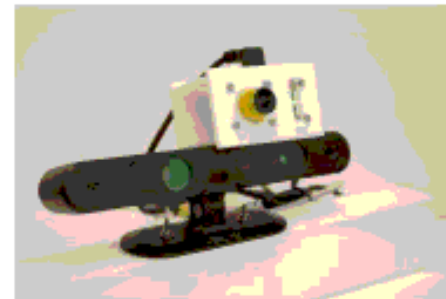
Neuromorphic vision for mobile robot SLAM



We combine a Dynamic Vision Sensor with a depth sensor

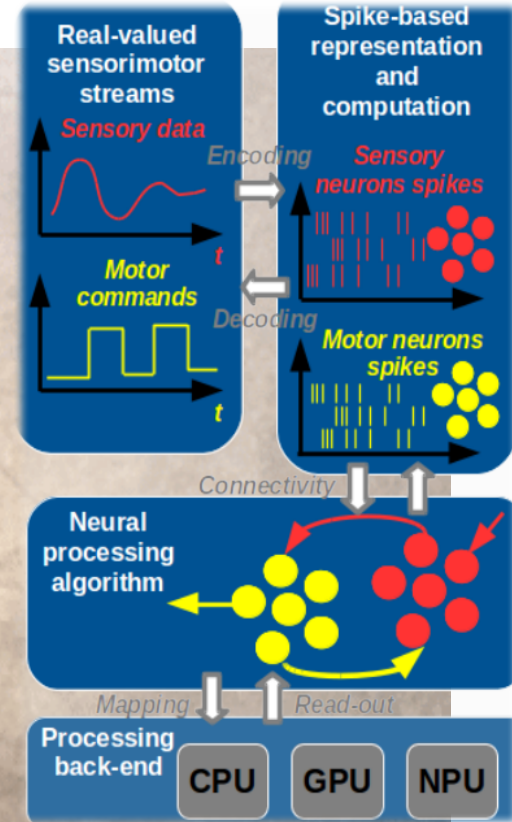
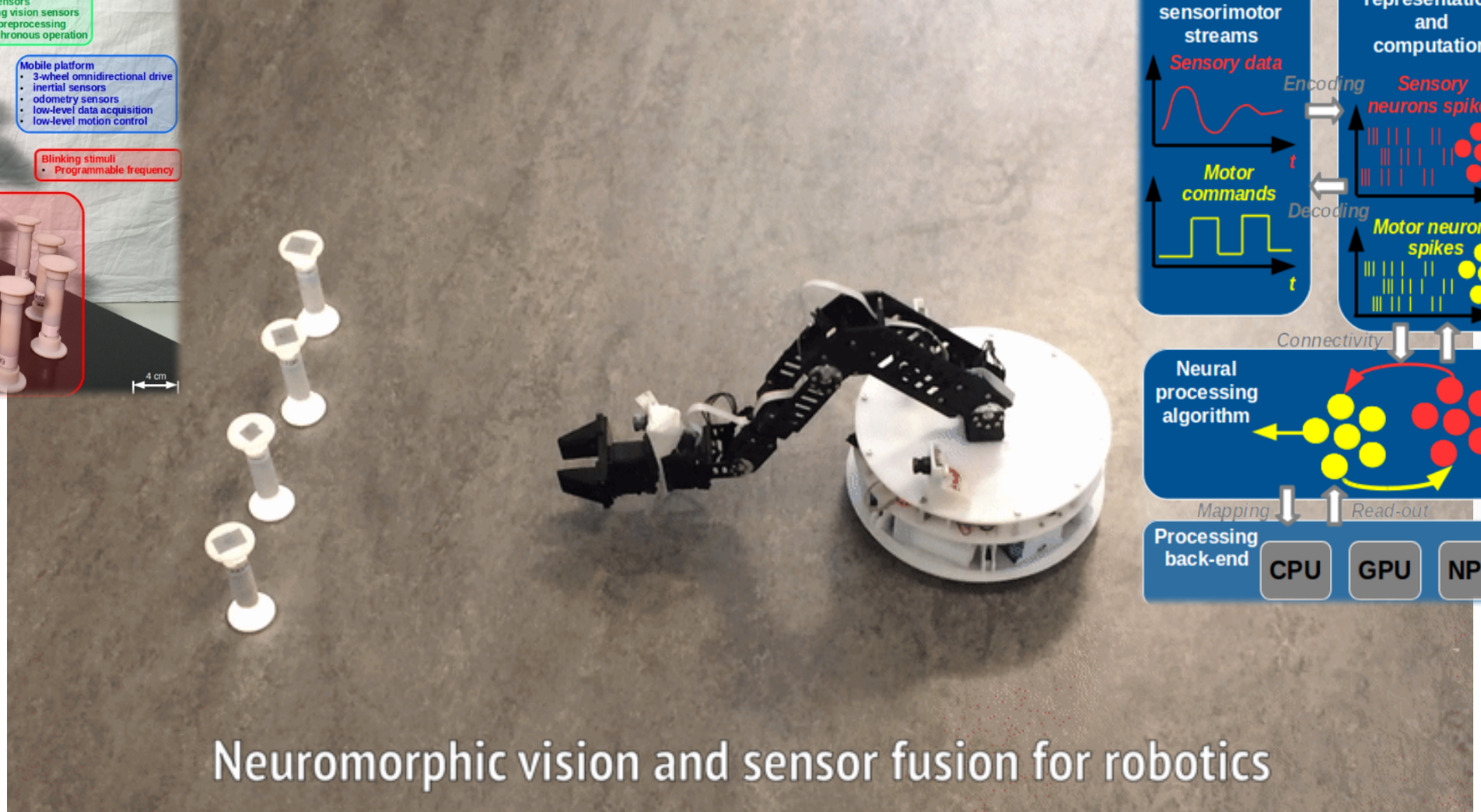
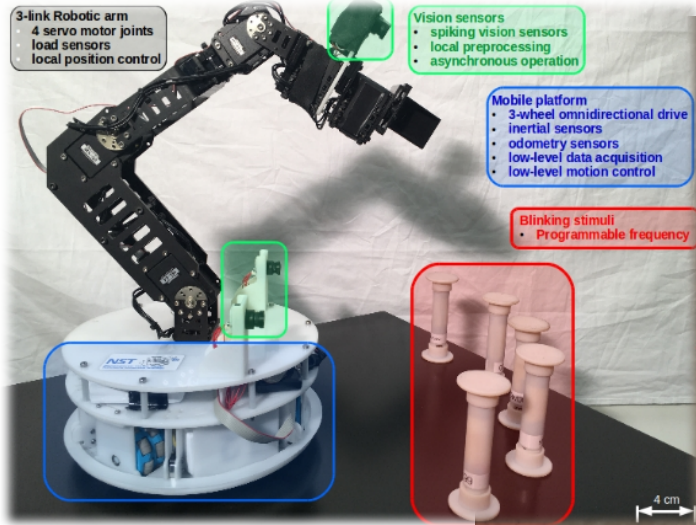


to an D-eDVS sensor producing a
sparse stream of 3D point events.



Industrial applications

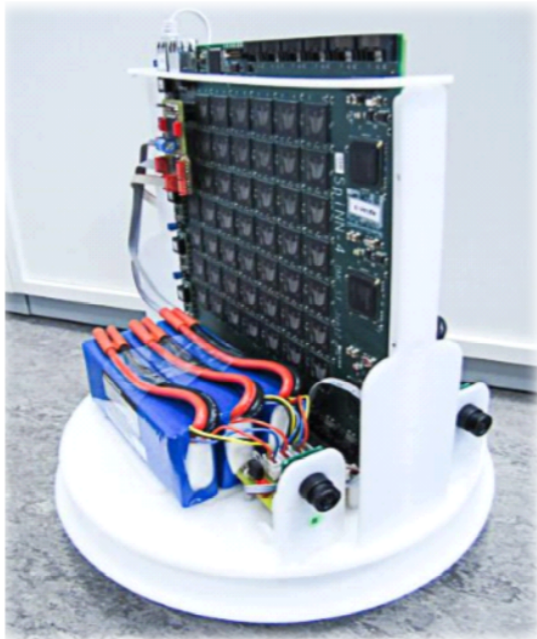
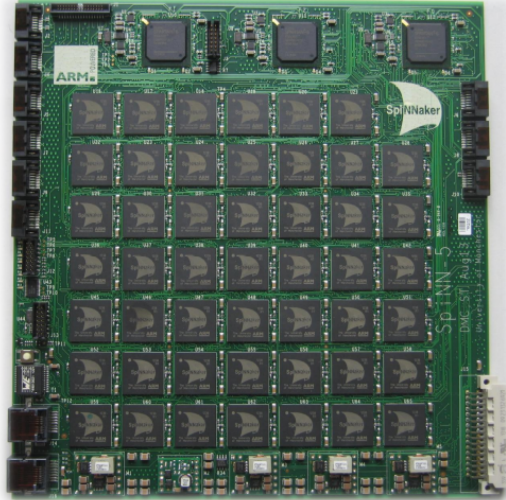
What can Neuromorphic Computing do?



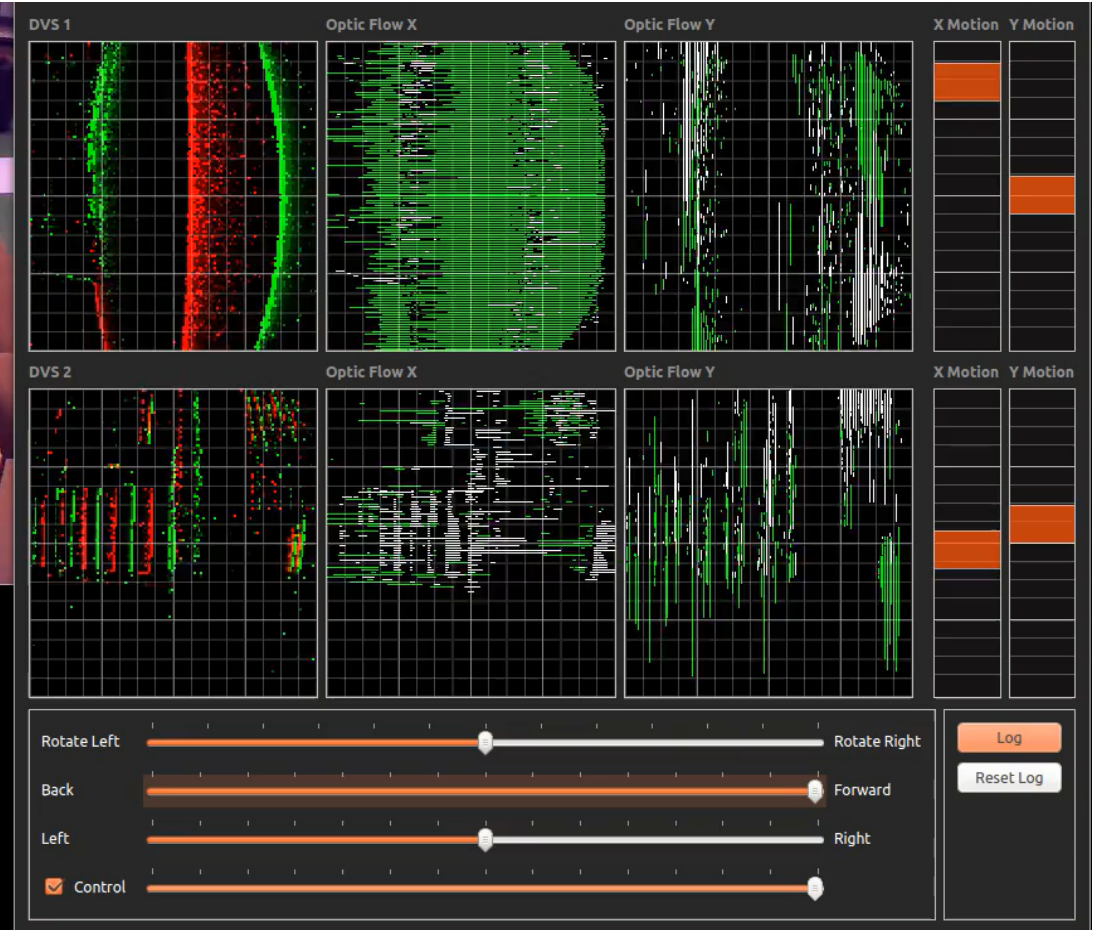
Neuromorphic vision and sensor fusion for robotics

Industrial applications

What can Neuromorphic Computing do?

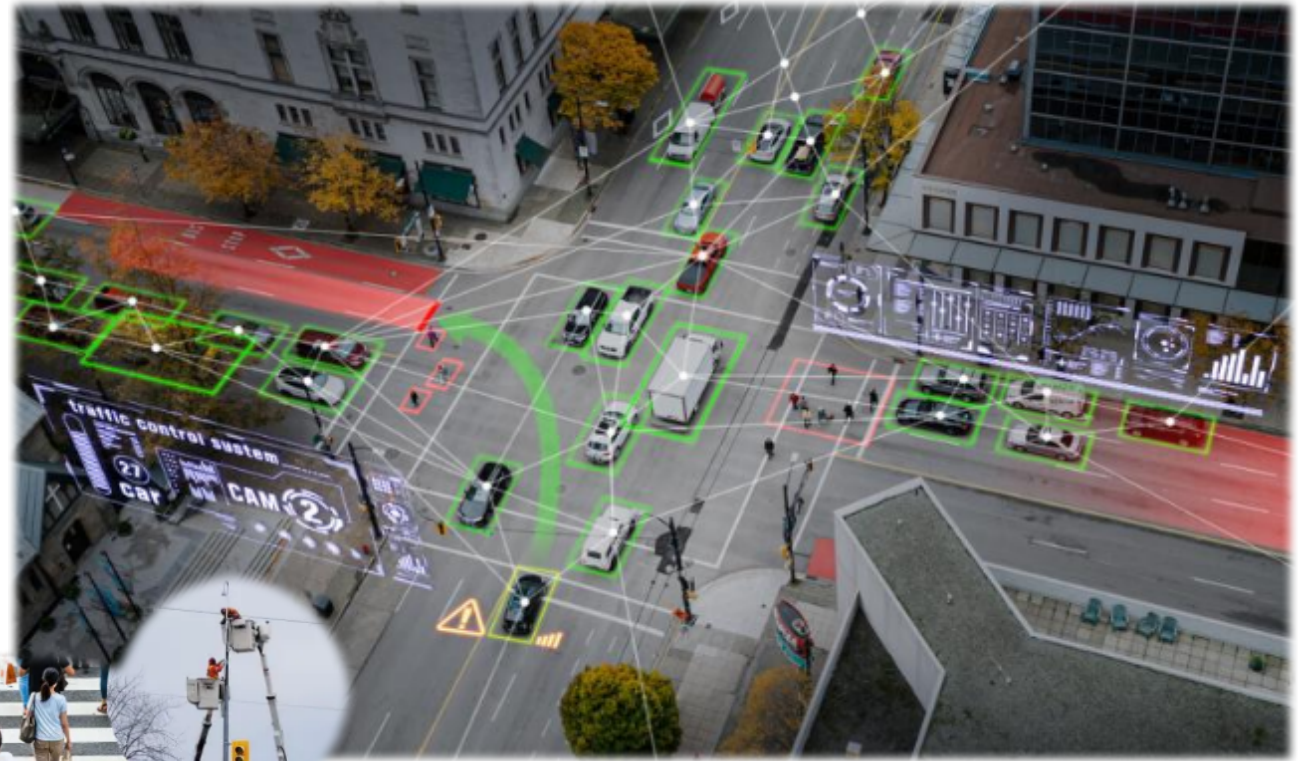


Trajectory stabilization
using event-based
optic flow



Industrial applications

What can Neuromorphic Computing do?

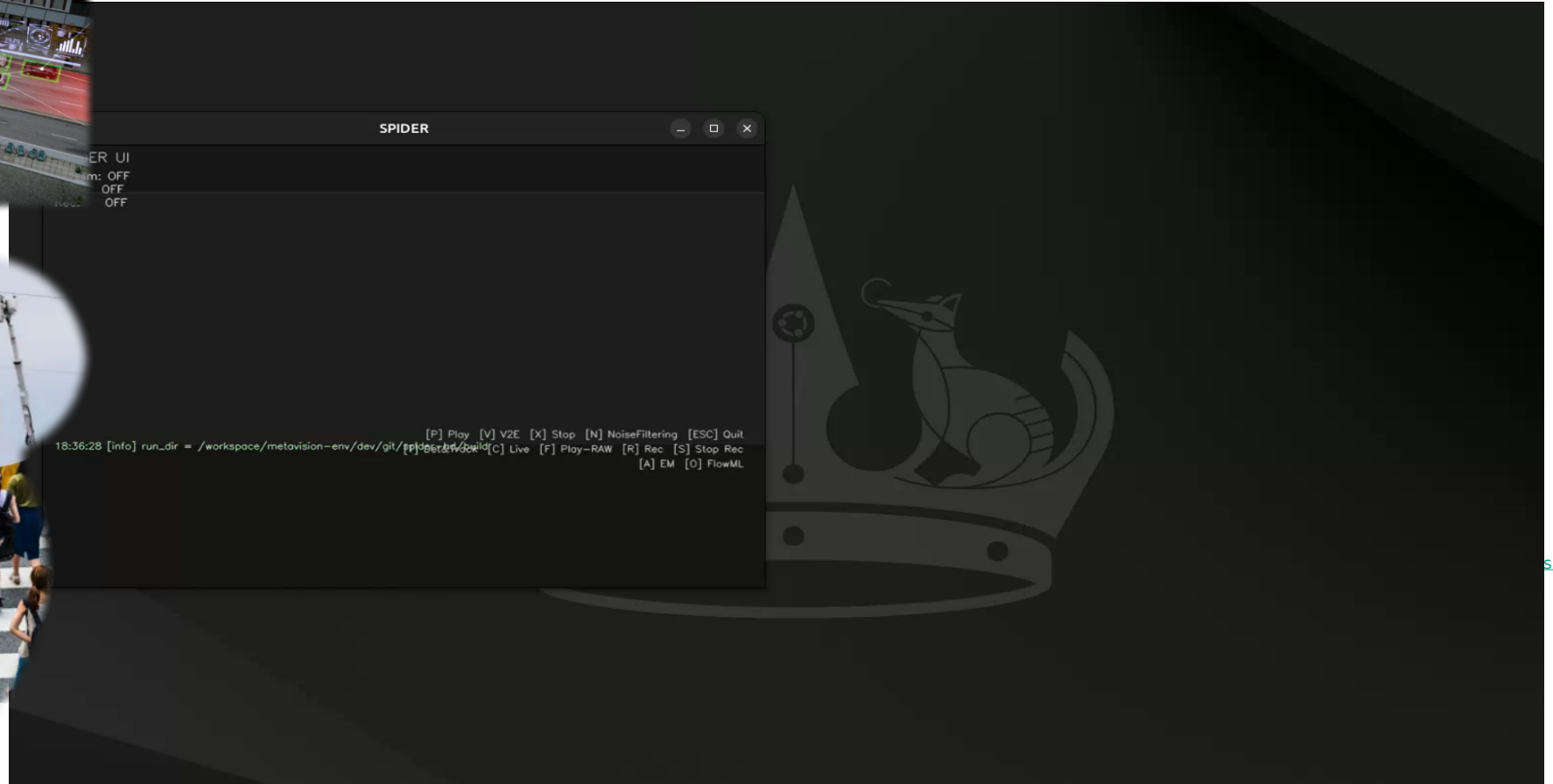
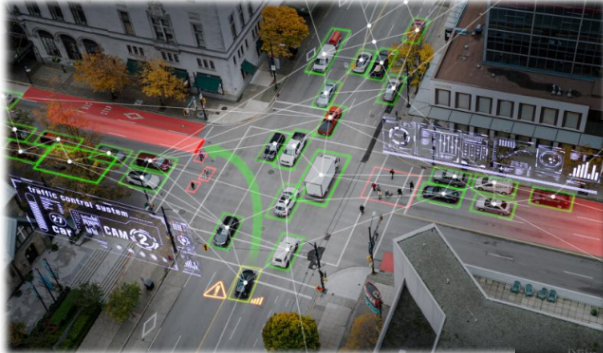


Source: <https://miovision.com>



Industrial applications


What can Neuromorphic Computing do?



SPIDER

ER UI
m: OFF
OFF
OFF

[F] Play [V] V2E [X] Stop [N] NoiseFiltering [ESC] Quit
18:36:28 [info] run_dir = /workspace/metavision-env/dev/git/ep16674401/c Live [F] Play-RAW [R] Rec [S] Stop Rec
[A] EM [O] FlowML



[s://miovision.com](https://miovision.com)

Industrial applications

What can Neuromorphic Computing do?

