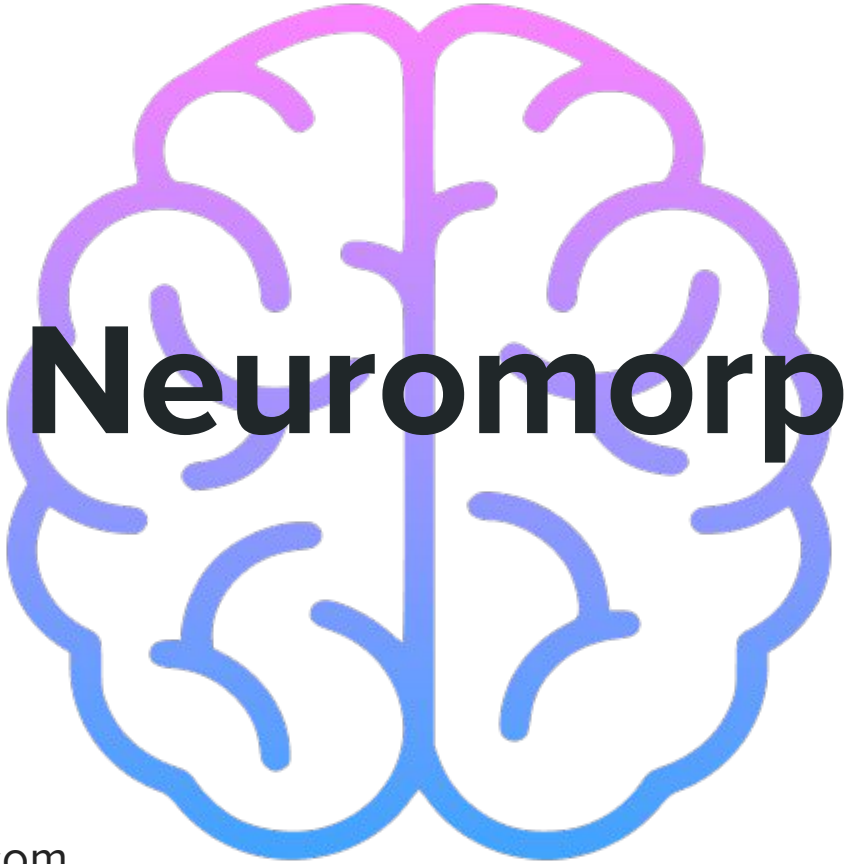
Open Neuromorphic



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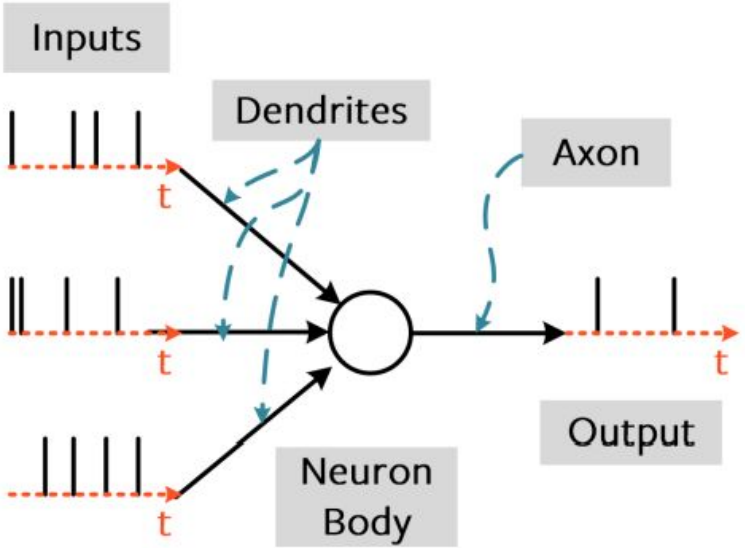
Open-source and AI research

- **Deep Learning** and **Machine Learning** open-source software are extremely popular (e.g. **PyTorch**, **TensorFlow**).
- Thanks to **open-source**, the ML research field has grown **tremendously**.
- Can we do the same for **neuromorphic computing**?

Neuromorphic Computing

What it is and why you should care about it

Spiking Neural Networks



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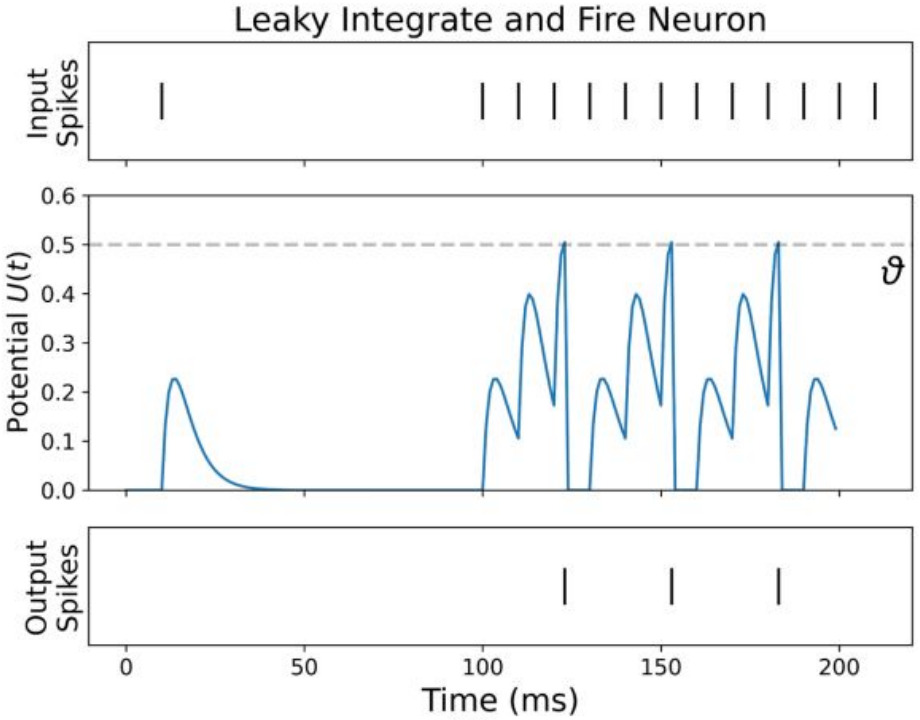

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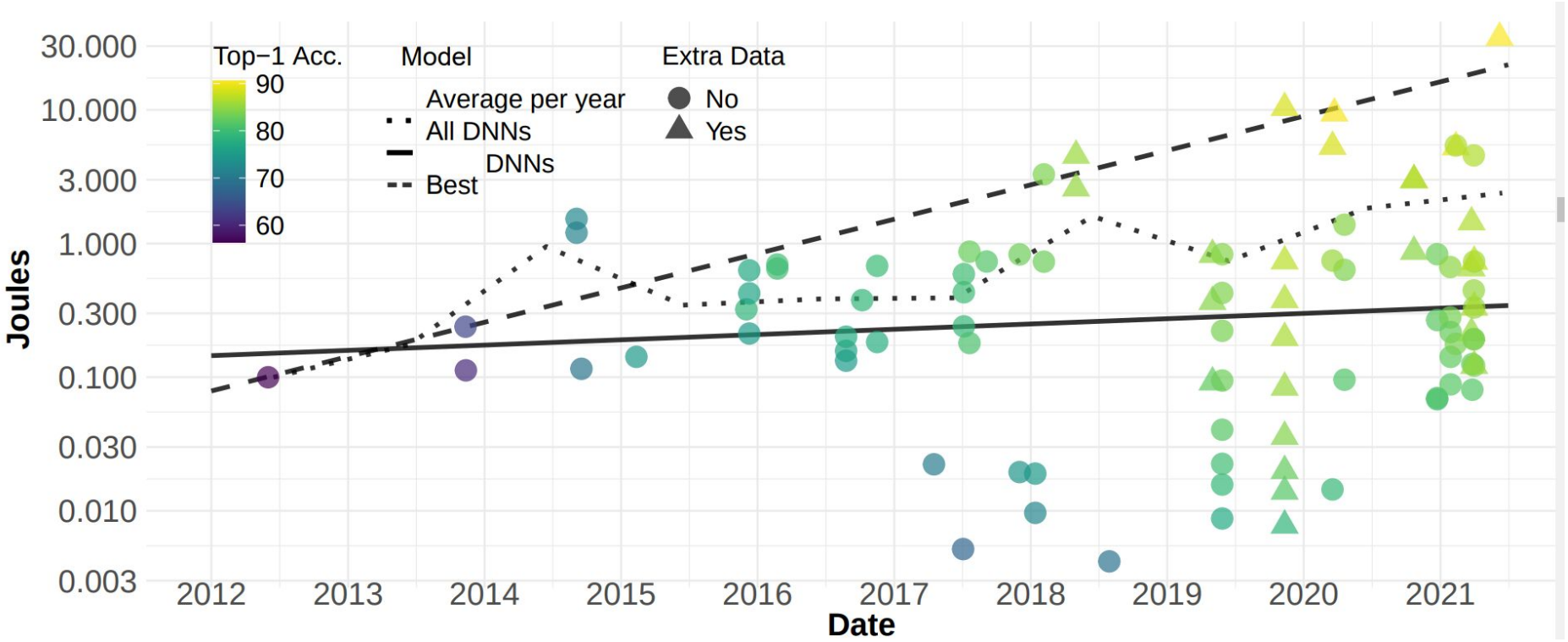
Training SNNs using lessons from Deep Learning, J.K. Eshraghian et al., 2022

Inference energy consumption – Imagenet



Compute and Energy Consumption Trends in Deep Learning Inference, Desislavov et al., 2021

What to do?

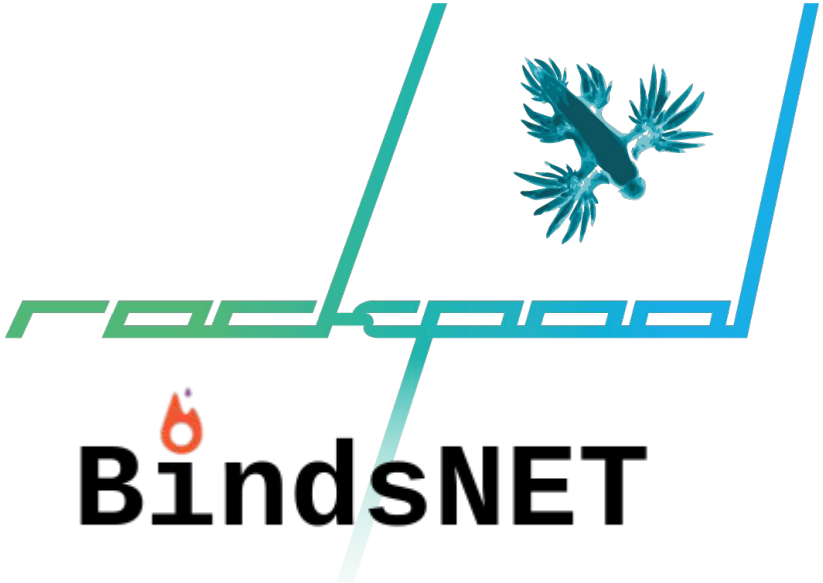
Paradigm shift:

- **algorithms**: **global** v.s. **local** error.
- **models**: **synchronous** v.s. **asynchronous**.
- **data**: **clocked** v.s. **information-driven**.
- **hardware**: **Von Neumann** v.s. **Beyond Von Neumann**.

Spiking Neural Networks Training

Open-source frameworks for Machine Learning tasks and Neuroscience

Open-source frameworks for ML



snnTorch

Norse

BindsNET

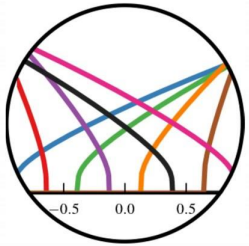
sinabs

SpikingJelly

Open-source frameworks for neuroscience

Some of the SNN frameworks available are focused on **neuron model customizability**, to allow **neuroscientist** to try out different models.

Open-source frameworks for ML and neuroscience



Nengo

Neural Development Environment

Other frameworks provide solutions for **both neuroscience and machine learning** applications, in order to give the researcher all the tools in **one place**.

Event-Based Sensing

Changing the way we sense the world

Event-based sensing

New ways to **sense** the world:

- silicon **retina**.
- silicon **cochlea**.
- silicon **skin**.
- silicon **olfactory** sensor.

The Silicon Retina

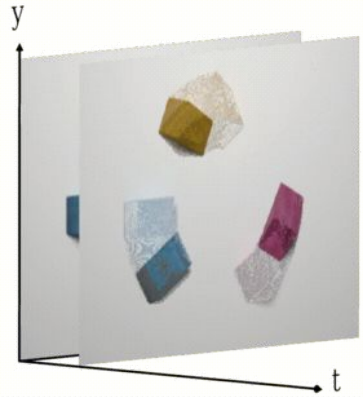
Misha Mahowald (circa 1992) in the Carverland laboratory at Caltech, testing her stereo correspondence chip. Photo credit: Rodney Douglas. https://lenzgregor.com/posts/event-cameras/

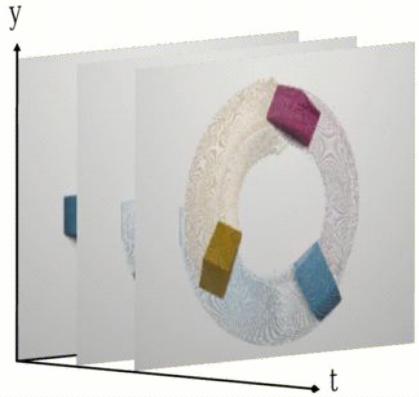
Towards the end of the ‘80s, **Misha Mahowald** developed a **new stereo vision system**.

Taking inspiration from the **human visual system**, she built the first **silicon retina** in the early ‘90s.

The pixels **emit spikes** independently and **asynchronously** depending on the **contrast pattern observed**.

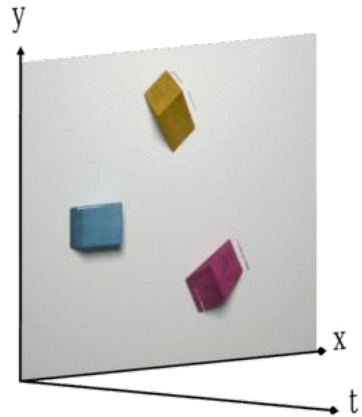
From frames to events

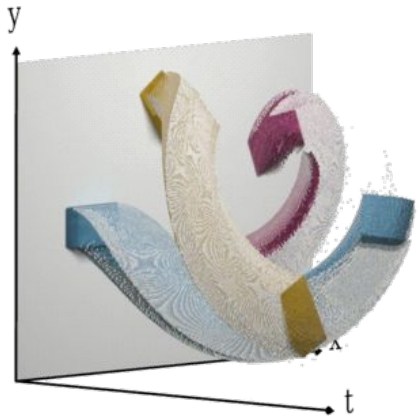


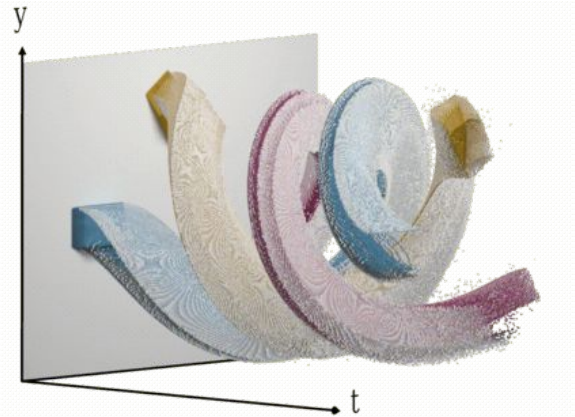


Current cameras acquire **frames** by periodically reading the brightness value of **all pixels**, ignoring if there is actual new information available.

An event-based camera only records **changes in brightness**, encoding these as **events** in **position** and **time**.







https://lenzgregor.com/posts/event-cameras/

Event-Based Software

Open-source software to deal with event-based cameras

Open-source software for event cameras

Tonic

Expelliarmus

neuromorphicsystems / aedat

AI algorithms need data, but also **data–handling software pipelines**.

- **Tonic**: event-based **datasets** and **transformations**.
- **Expelliarmus**: fast and easy reading of **Prophesee** cameras data.
- **aedat**: fast and easy reading of **Inivation** cameras data.

Hardware

Open-source hardware for neuromorphic applications

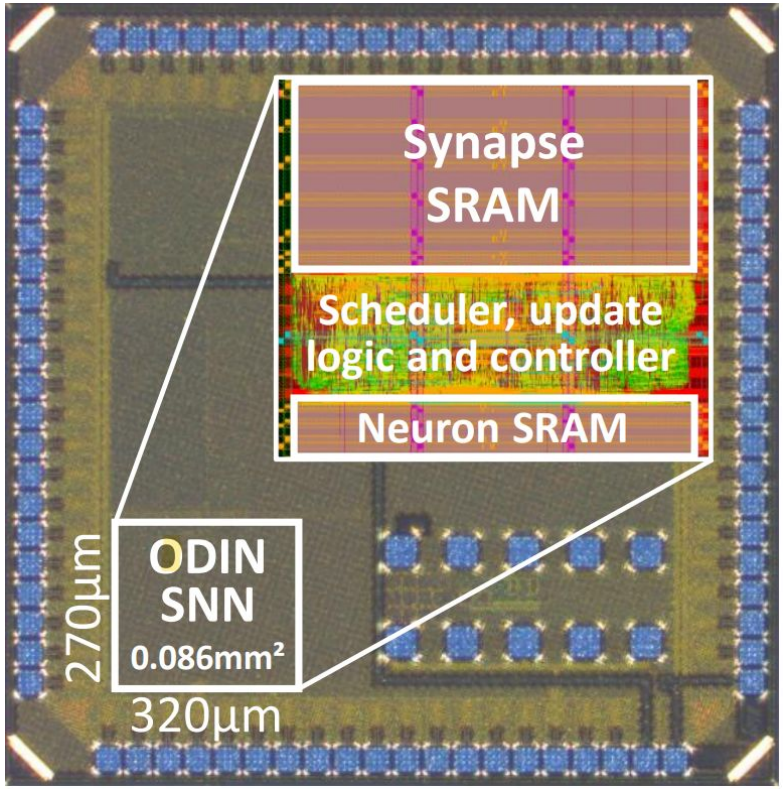
Why new hardware?

Current hardware (e.g. GPUs) is made for **dense** data and models (e.g. ANNs).

Brain-inspired data and **models** need **brain-inspired hardware**.

- **Mixed-signal** hardware to **emulate** the brain (also Beyond-CMOS) and achieve **maximum efficiency**.
- **Digital** hardware to **simulate** the brain and allow platform **reusability** and **programmability** for design exploration.

Open-source digital hardware

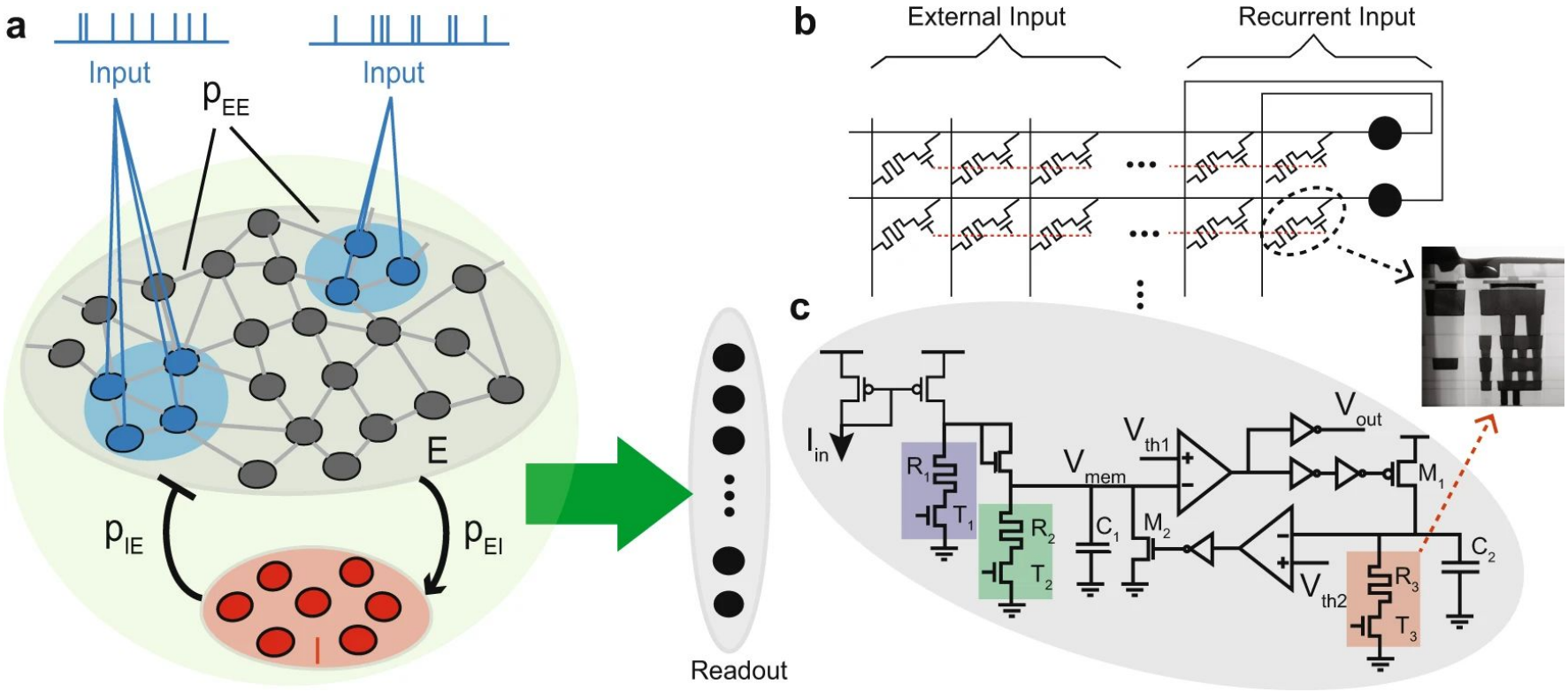


Releasing the HDL code for digital designs allows the community to **build on previous effort**.

It provides as many people as possible the ability to **construct**, **remix** and **share their knowledge** of hardware design and function.

*A 0.086-mm² 12.7 pJ/SOP 64k-Synapse 256-Neuron **O**nline-Learning **Di**gital Spiking **N**euromorphic Processor in 28nm CMOS, C. Frenkel et al.*

Mixed-signal hardware



Self-organization of an inhomogeneous memristive hardware for sequence learning, M. Payvand et al., 2022

Open Neuromorphic

httsp://github.com/open-neuromorphic

Thanks everyone!

Leaving the floor to the **speakers**.

Hoping you will enjoy it.