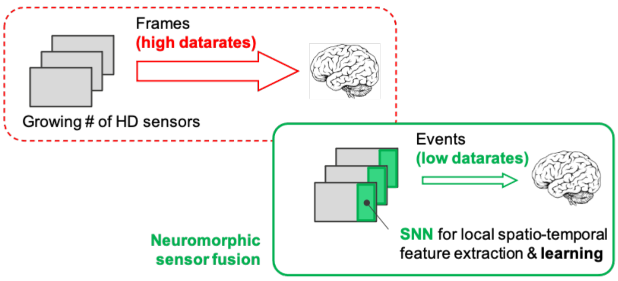
Boosting sensor fusion through spiking neural networks (SNN)
a new generation of neuromorphic AI hardware

Tomorrow's sensor systems are facing a serious challenge. Whether they drive health monitoring or perception for delivery robots, drones, and self-driving cars, the rising number of active and passive sensors should be able to extract spatio-temporal features on the fly to allow for quick and reliable decisions. Today, they manage only with high latency and by using a lot of energy, due in large part to the way data are collected, communicated, and processed centrally or in the cloud. Despite progress in machine-learning algorithms and hardware, massive amounts of raw sensor data still have to be shuttled around and processed once they leave the sensor. And as sensors are becoming ever-more powerful and faster, and have higher resolutions, this data flood will become even more overwhelming.

In a new collaborative R&D program, imec aims to mitigate this situation through the integration of neural feature extraction layers on the sensors themselves. As a result, only relevant features are sent downstream as opposed to the raw sensor data. To do so, imec is building sensor-fusion systems that emulate aspects of biological data processing and knowledge building. Using spiking neural networks (SNN), imec is developing a new generation of neuromorphic AI hardware with very short response times and low energy consumption, without sacrificing accuracy..

In its new program, imec approaches the challenge by first developing SNN algorithms for real-world datasets, and then hardwiring these algorithms in neuromorphic hardware. For the latter, we first focus on digital implementations in commercially available CMOS technology. For the longer term, we study mixed-signal solutions and emerging memory technologies to further boost performance.

If you are also working to improve your perception and health monitoring systems within a given data/energy/latency budget, we invite you to come and join us in this promising, high-value R&D.



Extreme edge AI for efficient sensor fusion

A successful proof of concept

In 2020, we've proven the feasibility of digital spiking neural networks with an SNN chip to process, among others, radar signals. The chip mimics the way groups of biological neurons operate to recognize temporal patterns. It consumes only a hundredth of the power of conventional neural network implementations while being ten times faster, allowing near-instantaneous decision-making.

With this chip, we have demonstrated that micro-Doppler radar signatures can be classified using only 70µW of power. For ECG sensors, we have even shown it to work with a mere 13µW. SNNs like these would therefore also be ideal to empower a new generation of wearables, insertables, and even ingestibles.

Toward deeply fused camera-radar modules for robotics and intelligent spaces

As a next R&D target, we now work on a processor for event-based sensor fusion. This chip will be the heart of smart, low-power perception systems for small delivery robots, drones, AGVs, cobots, etc.

These new perception systems will identify approaching objects in a complex, dynamic environment in a matter of milliseconds so that, for example, the robot or drone can react in time. The primary use cases that we will work on features small delivery robots in complex environments and autonomous indoor/outdoor drones.

In addition, processors like these could also be used to create intelligent, context-aware spaces. And when scaled, they could boost autonomous driving, where the problem of sensor data overload is acute.

Highlights

- Mimicking biology as engineering principle
- Co-designing of task datasets, algorithms, and hardware
- Training algorithms for spiking neural networks – accuracy on par with deep learning but with a potentially 100x lower energy consumption
- Digital spiking neural networks – optimized sync/async architecture
- Optimizing Joule-per-decision (instead of Joule-per-computation)

Applications

- Adding more powerful perception and sensing to:
  - Drones, rovers, Industry 4.0 platforms, autonomous vehicles, traffic infrastructure
  - Medical sensors, heart and brain monitoring, wearables, and ingestibles
  - Cameras, sonars, radars, lidars...
  - Smart spaces sensors
- Extreme edge computing
- Radar target classification based on micro-Doppler
- Sensor data pre-processing and fusion

Design targets

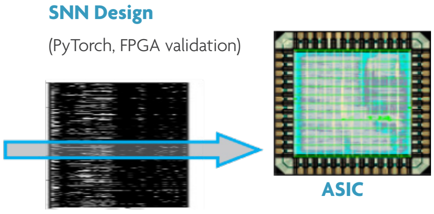
- Multicore, with fully connected cores
- Sparse synapse connectivity between cores
- Memory/compute optimization
- Adaptive neurons
- Microcolumn-like scalable architecture for higher dimensional input streams

Looking for collaboration with

- Sensor system developers and vendors
- Application builders
- System integrators
- Fab/fabless chip manufacturers

What imec offers

- Leader in technology and system co-optimization
- Leader in radar and biosensor technology
- In-house R&D, from design over modeling to actual prototyping
- Collaboration agreements tailored to your requirements:
  - Collaborative R&D
  - Project-based development on demand, from idea to prototype
  - IP licensing
  - Specialty components development with road to volume fabrication



R&D rationale – from datasets to algorithms to ASIC

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