Forschungsfabrik Mikroelektronik

Deutschland

Fraunhofer Group for Microelectronics in Cooperation with Leibniz Institutes FBH and IHP

Challenges and Trends in Neuromorphic Hardware

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Why Neuromorphic Hardware?

- **Power**
  - Dedicated ASICs accelerate inference of DNNs in comparison to CPU/GPUs by factors of 29 to 200
  - Cause: "von Neumann-bottleneck" of traditional computer architectures

- **Form factor**
  - Some applications demand very small form factors or e.g. bendable/printed electronics
  - 3D-integration and integration into sensor design are a means to reduce form factor <u>and</u> power

- **Latency**
  - High data-throughput from sensors (high resolution, high rates) needs to be managed locally
  - Industrial and automotive applications require latency of around and below 1ms
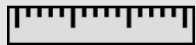
Use case 1: Hearing Aids

**Smart
Health**

- Audio source separation requires complex signal processing and AI to isolate one talker from background noise in different scenarios

- Form factor and power consumption are major challenge incl. wireless communication

- Fraunhofer FMD has 250+ engineers working on audio technology in Erlangen, Germany

- Home of mp3, AAC and mobile audio codec development

- Technology built into 10+ billion devices

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Use Case 2: Ultra-low-power Sensor Node

Smart Industry
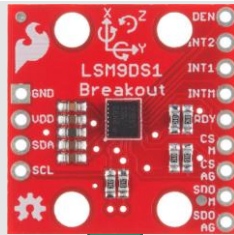
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- Example: **Anomaly detection** for a motor for predictive maintenance

- Measure vibrations and check, whether they are "normal"

- When strange vibrations occur, notify maintenance

- Communication by e.g. Fraunhofer MIOTY ™ Technology

- Transmission of raw data exceeds power budget by far

- ➔ AI-based signal processing has to be inside the node

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Use case 3: AI Processing in Wearables

Smart
Health

- Example: **Detection of Atrial Fibrillation in ECG signals**

- Integrated into Fraunhofer FitnessSHIRT

- Ultra-low power AI-based processing of ECG signals due to limited batteries

- On-line analysis to inform the consumer immediately and without delay about any potentially dangerous condition

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FMD Expertise and Impact

- European consortium for Next Generation Computing is addressing the challenges on the algorithmic, design and technology side, e.g.
    - analog cross-bar designs using memristors and in memory computing,
    - mixed analog-digital spiking neural network architectures for ultra-low-power
    - FeFET, OxRAM, RRAM

- FMD areas of expertise
    - Signal processing, codecs and AI, e.g.10+ billion devices equipped with FMD technology
    - Software and hardware IP design, e.g. millions of radio receivers are equipped with FMD technology
    - Semiconductor technology and (3D-)integration, e.g. 10+ million wafer moves per year in FMD facilities

- FMD and CEA-Leti are building a strong European supply and value chain for Next Generation Computing

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