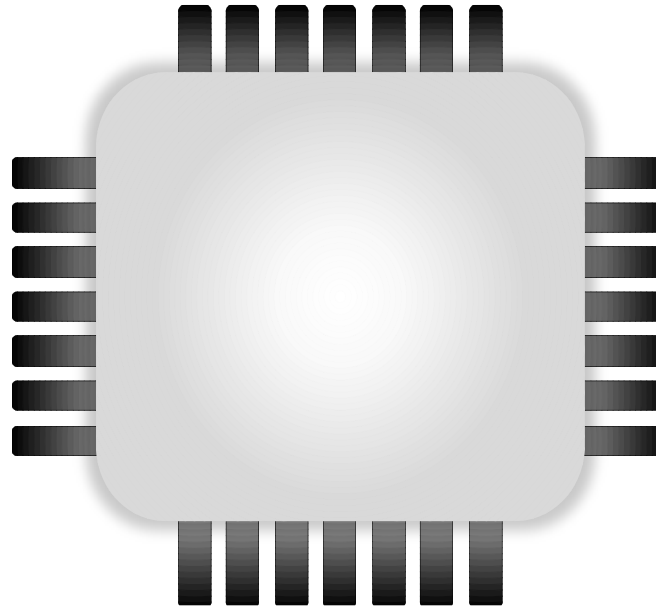


RISC-V Meets Brain-Inspired Intelligence

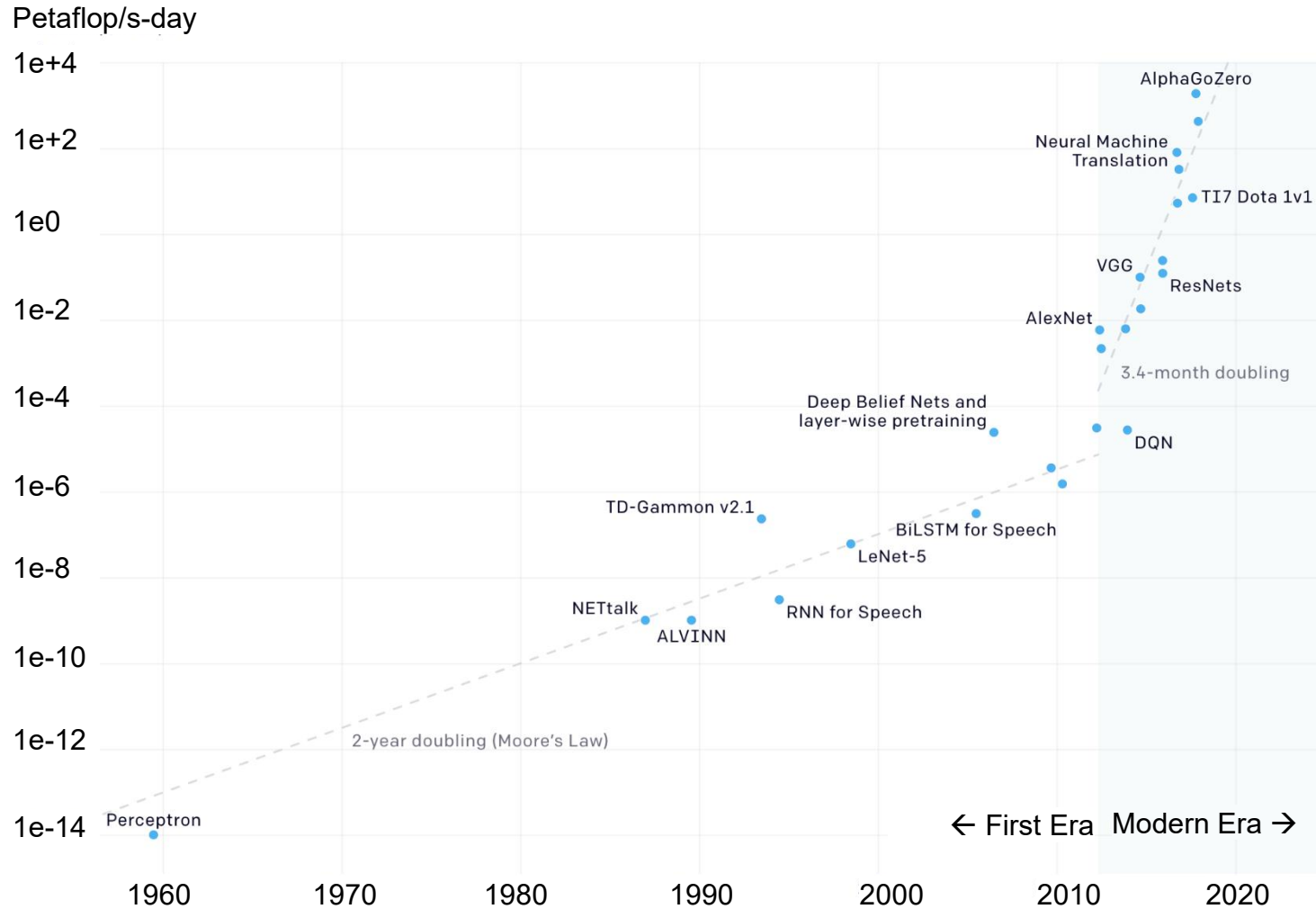
by Prof. Amrouch
Chair of AI Processor Design

Edge AI Chip for Training

**It necessitates → Advanced Technology
+ Novel Algorithm + Novel Architecture**



Classical AI Algorithms → Massive Computing Demands



**Computing
demand**

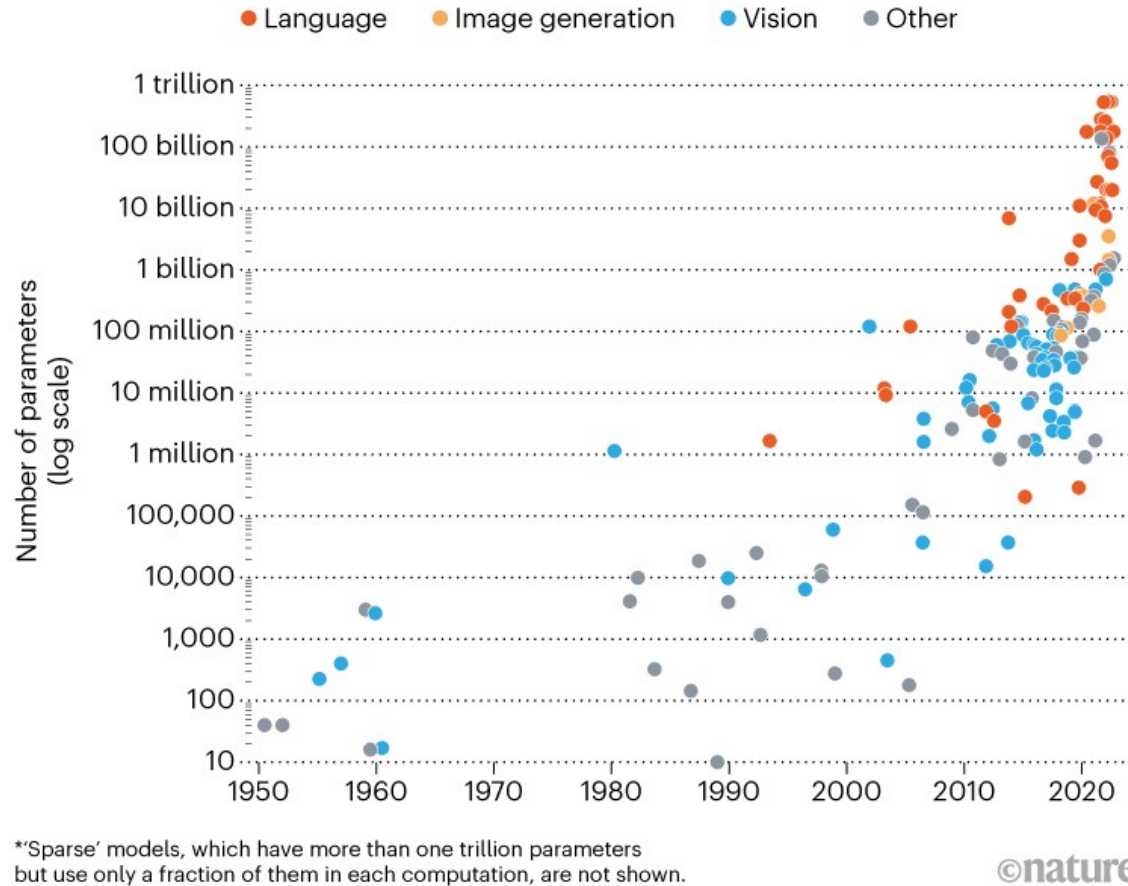
**3.4 months
doubling!**

Source: <https://openai.com>

Classical AI Algorithms → Massive Memory Demands

THE DRIVE TO BIGGER AI MODELS

The scale of artificial-intelligence neural networks is growing exponentially, as measured by the models' parameters (roughly, the number of connections between their neurons)*.



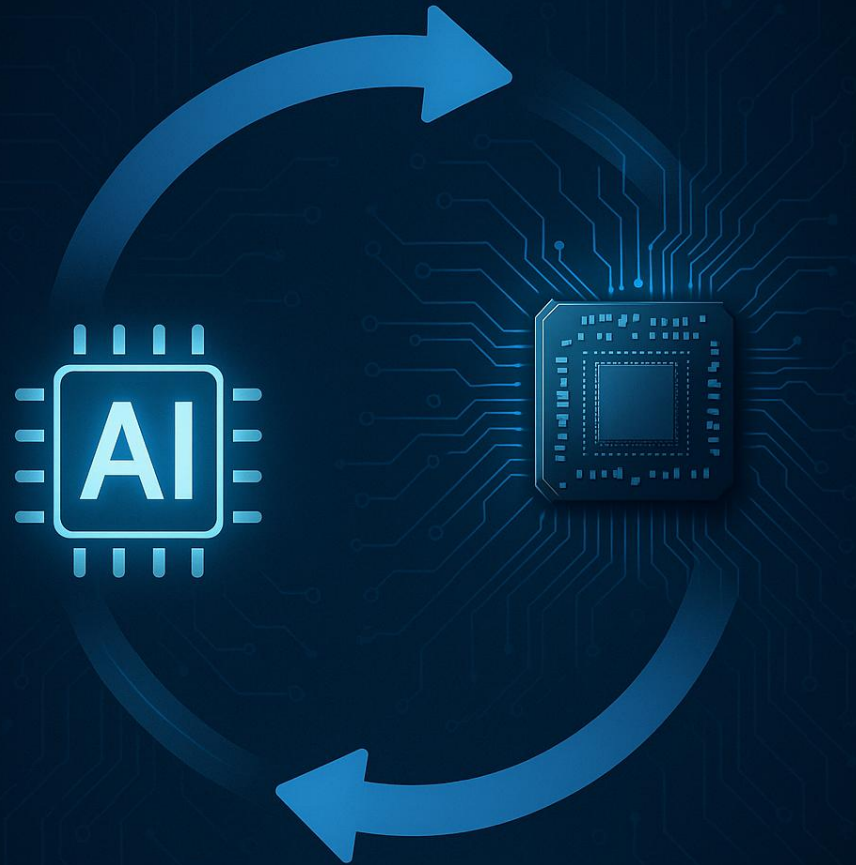
More Efficient HW for AI

- Larger and larger AI models
- Memory Bottleneck!
- **Significant Efficiency Loss**

DNN Alternative for Training at the Edge-AI

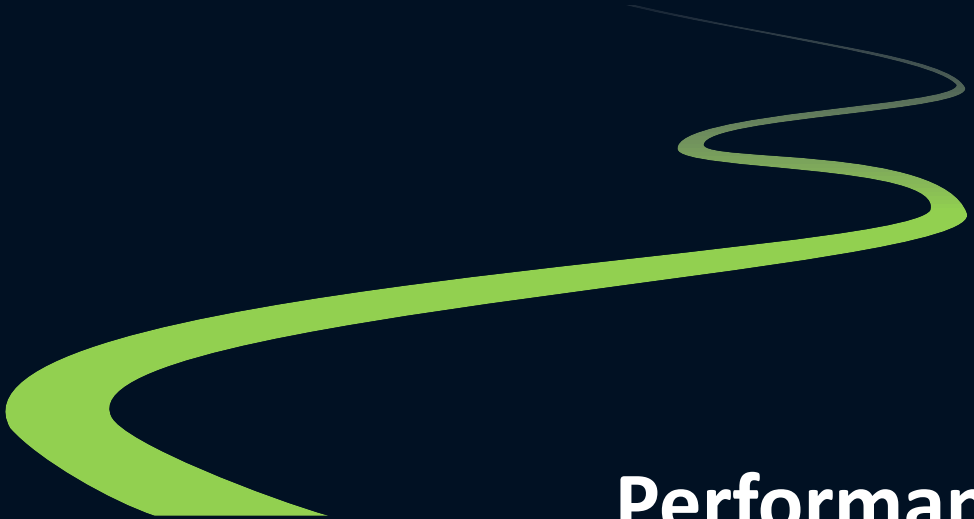


**Alternative for
Deep Neural Networks**



**Alternative for
von-Neumann Architecture**

Novel Algorithm-Architecture Co-Design for Edge AI



Performance and Power using 7nm TSMC

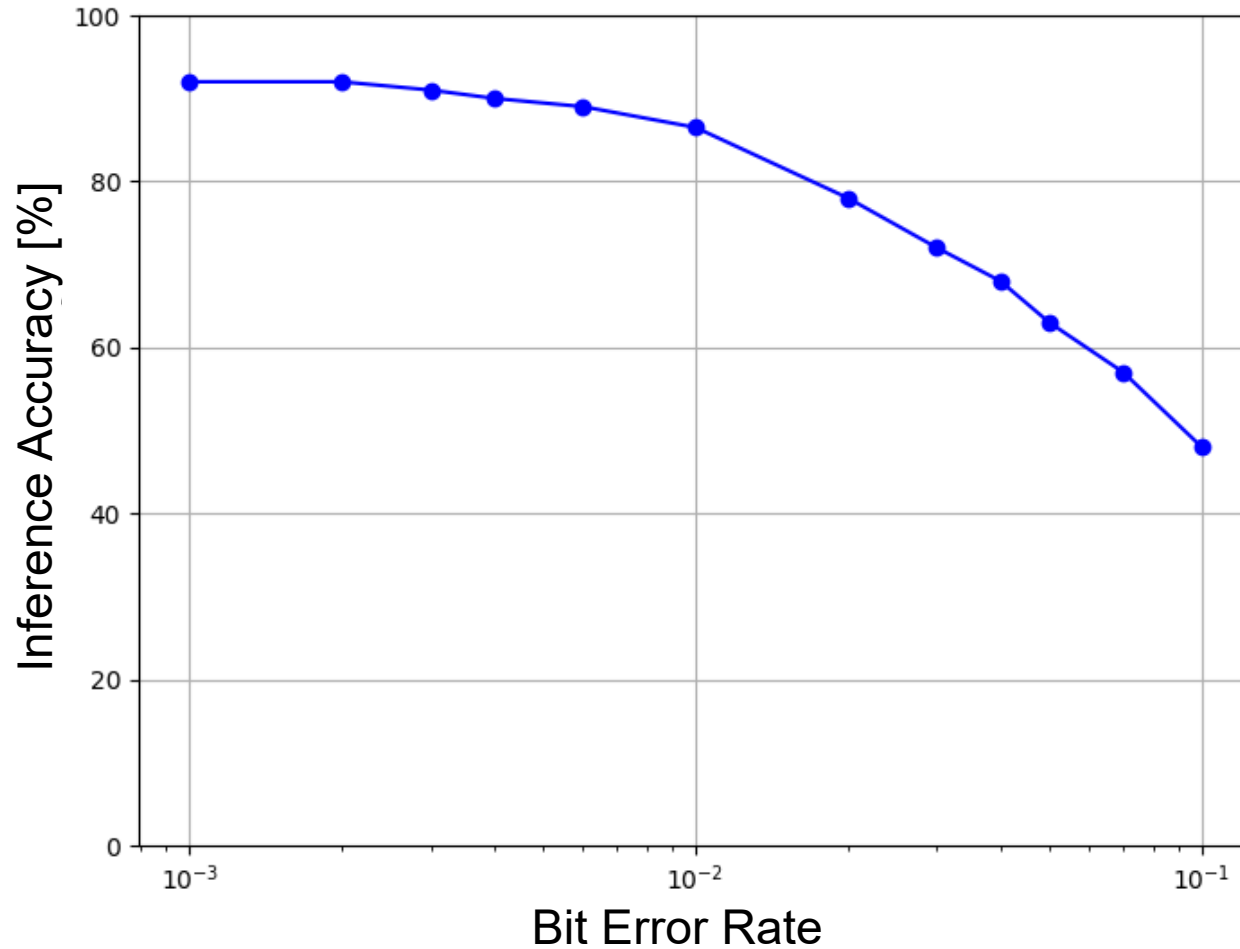
Multi-Core RISC-V for HDC Acceleration

RISC-V Customization for HDC

Brain-Inspired Hyperdimensional
Computing (HDC)



Hyperdimensional Computing: Robustness Errors

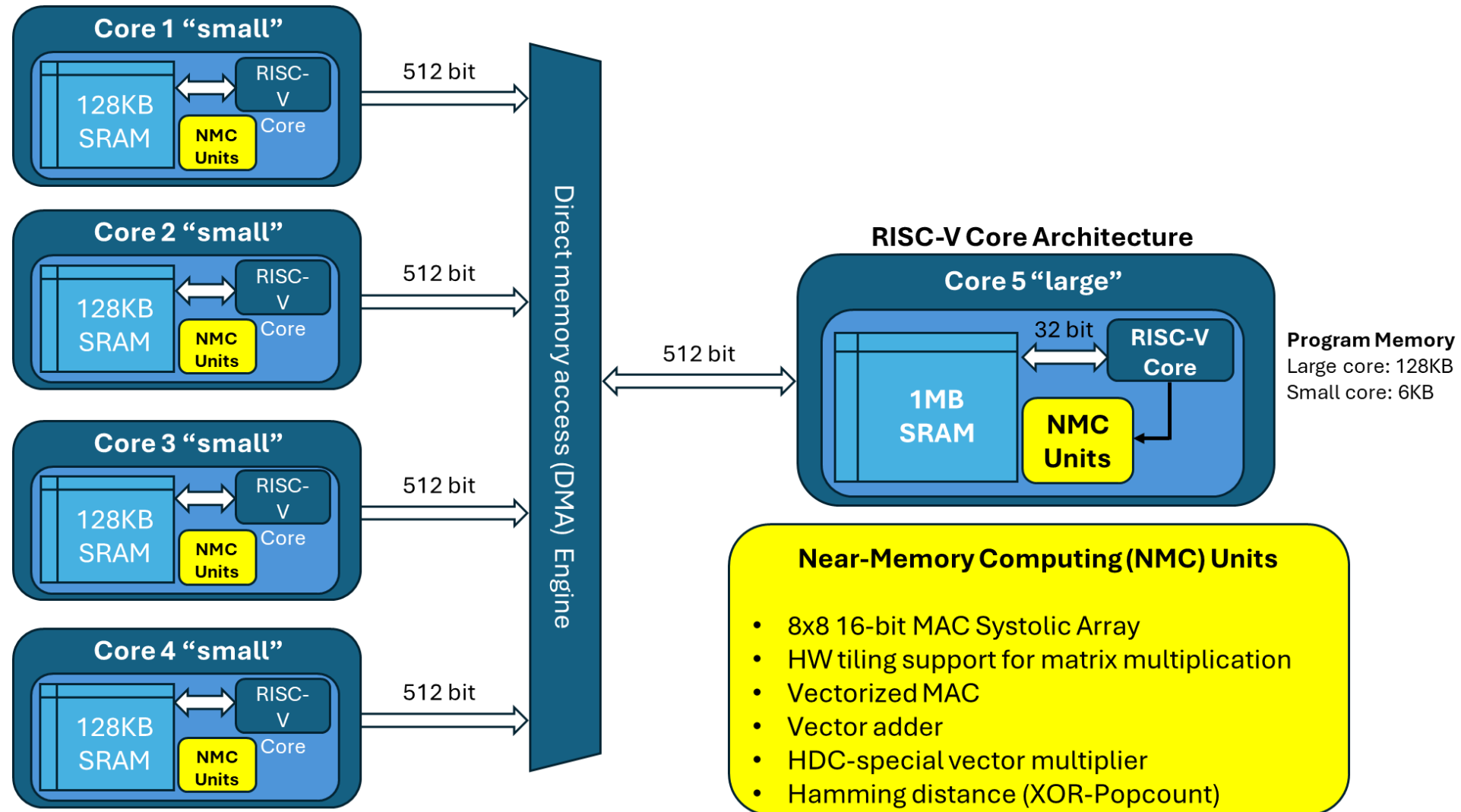


Errors injected in
the underlying HW
operations

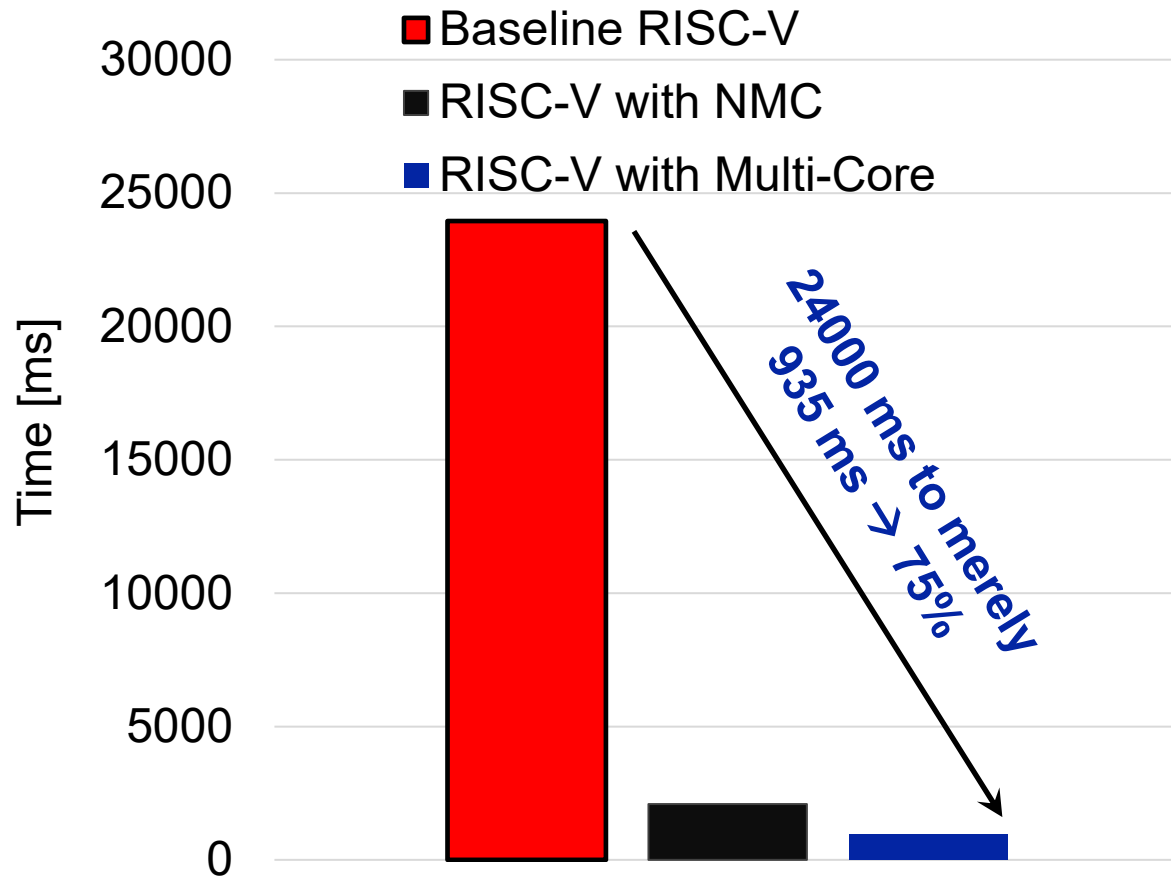
Edge-AI Processor: From Tradition to Customization



Multi-Core RISC-V: CPU Customization



RISC-V Customization for Edge AI: Training



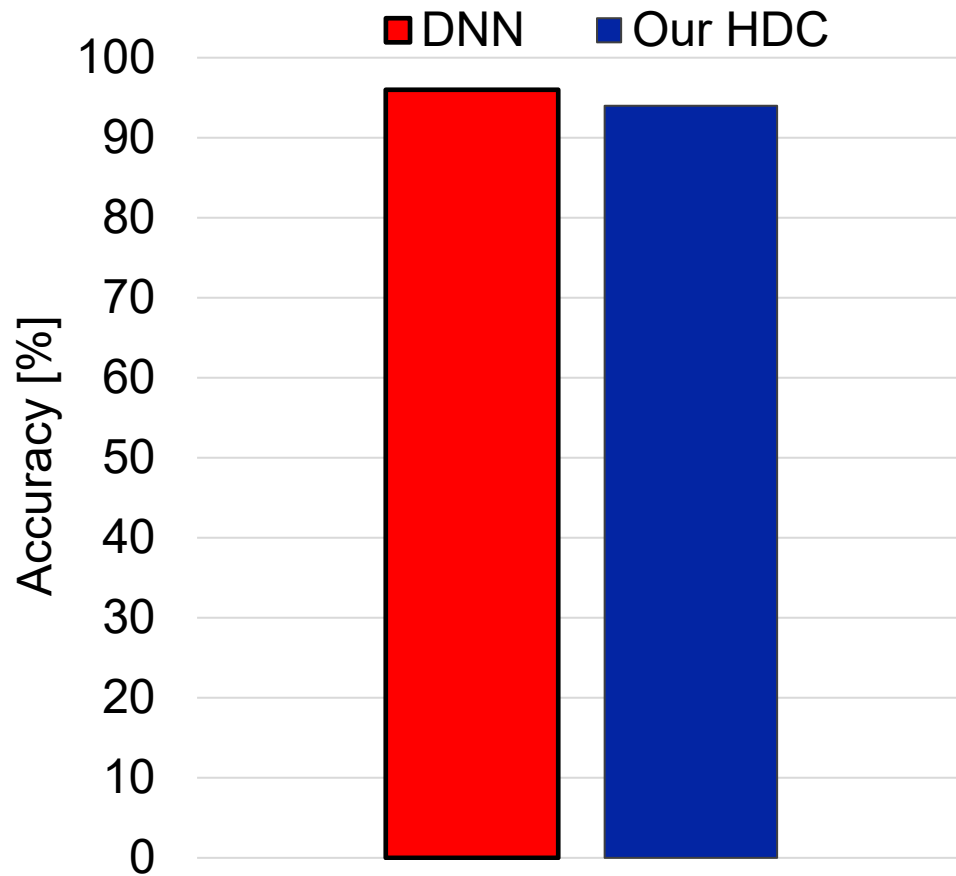
SYNOPSYS
ASIP Designer

Human activity dataset

1000 Samples for Training

- Training in **< 1s**
- Low Power: **23mW**
- Energy: **21.5 μ J**
- Frequency: **200 MHz**

RISC-V Customization for Edge AI: Training



SYNOPSYS®
ASIP Designer

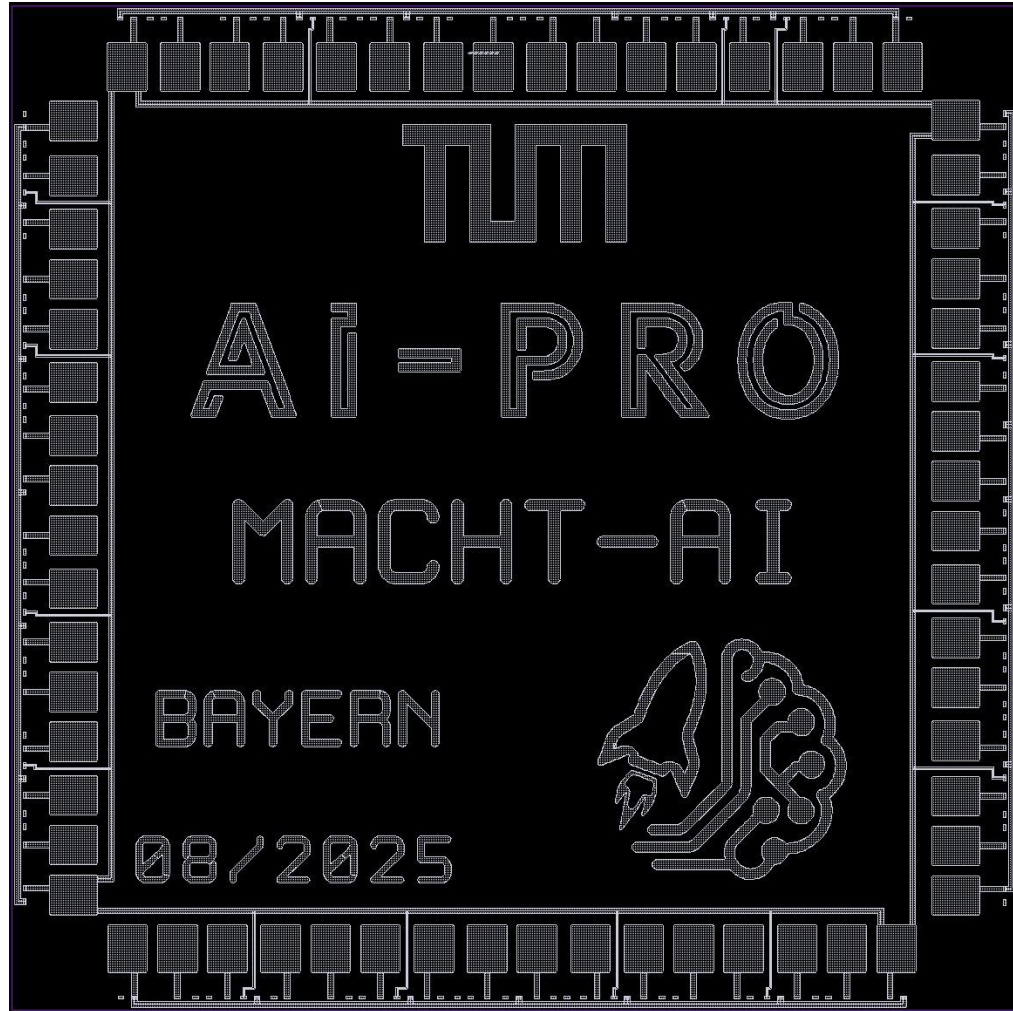
Human activity dataset

1000 Samples for Training

Similar Accuracy to exiting DNN

- **Our HDC Accuracy: 94%**
- **State-of-the-art DNN: 95% → but far from training at the edge**

TSMC 7nm → First Chip from Uni. in Germany and EU



Edge AI: Training

- ❑ 1000 samples in **< 1s**
- ❑ Power in **23 mW**
- ❑ Similar accuracy to Neural Networks

5x Full Custom RISC-V with
Near-Memory Computing

FinFET 7nm TSMC

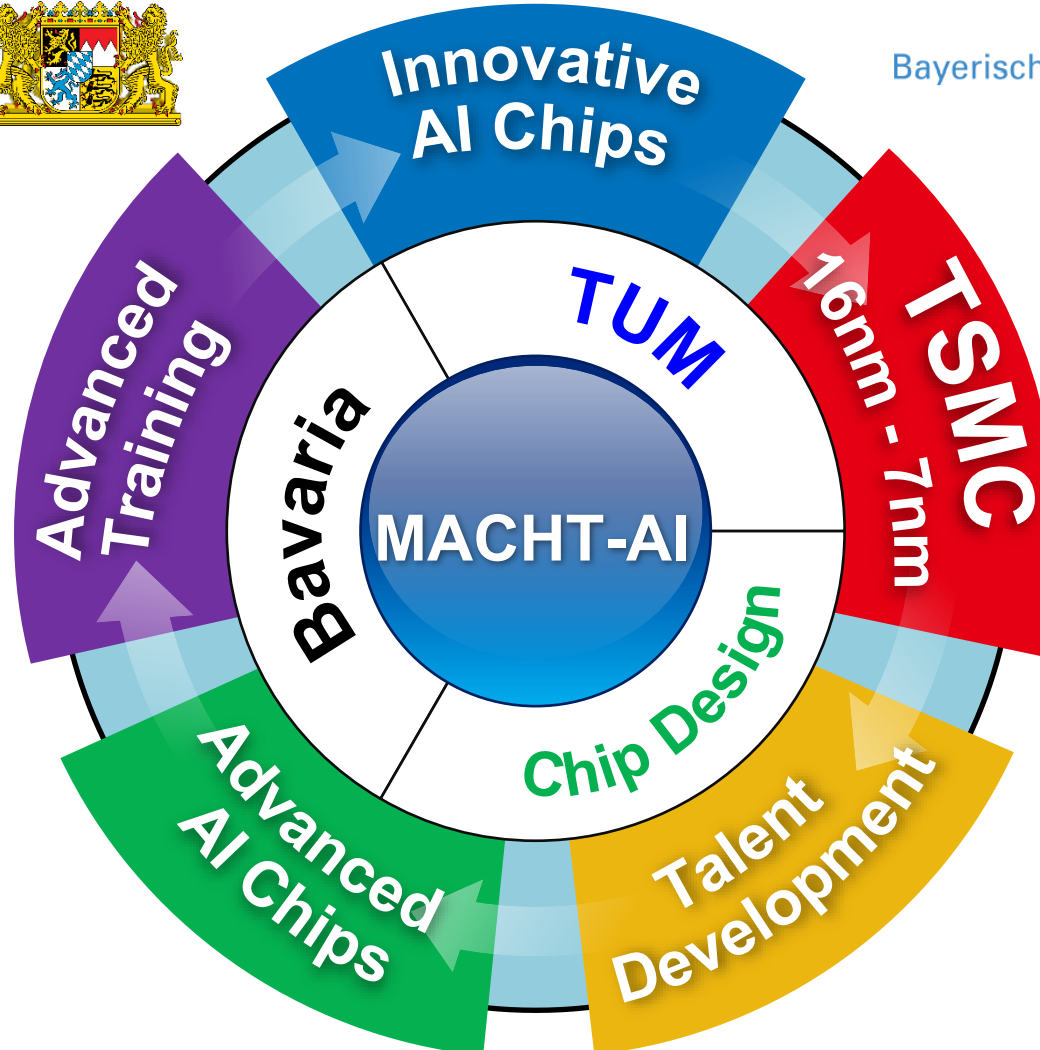
MACHT-AI Center

Munich Advanced-Technology Center for High-Tech AI Chips

Bayerisches Staatsministerium für
Wirtschaft, Landesentwicklung und Energie



Bayerisches Staatsministerium für
Wissenschaft und Kunst



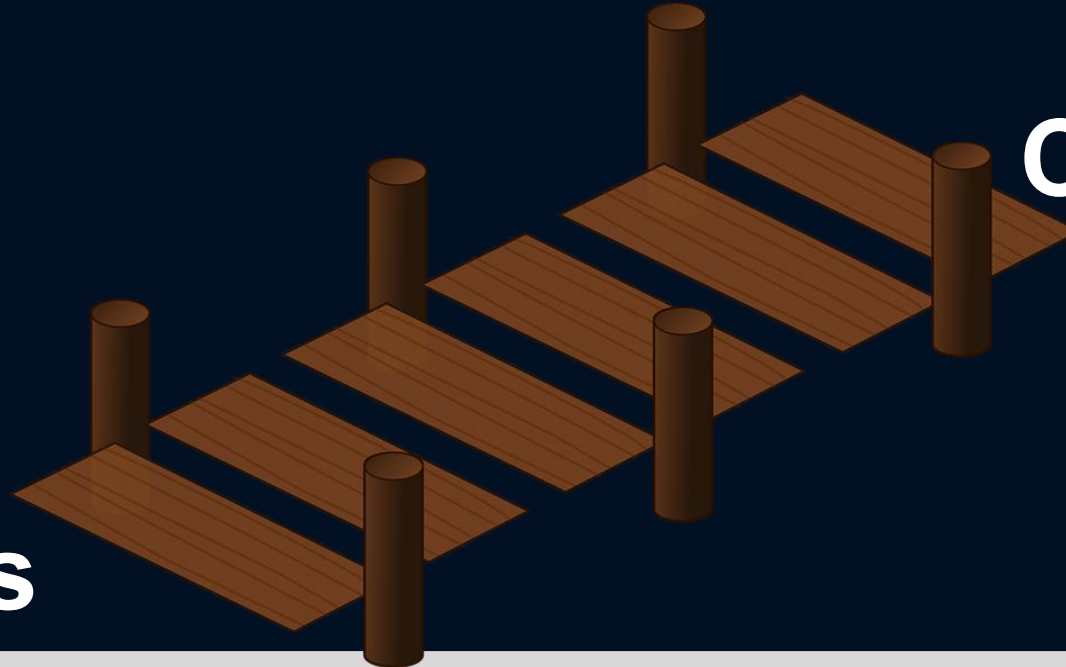
Launched in
September 2025

Edge AI for Training is Challenging



**Processor
Customization**

**Novel AI
Algorithms**



Technical
University
of Munich

