



# Developing Optimized Systems with Akida

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Todd Vierra – Director Customer Engagement

**February 24<sup>th</sup>, 2022**



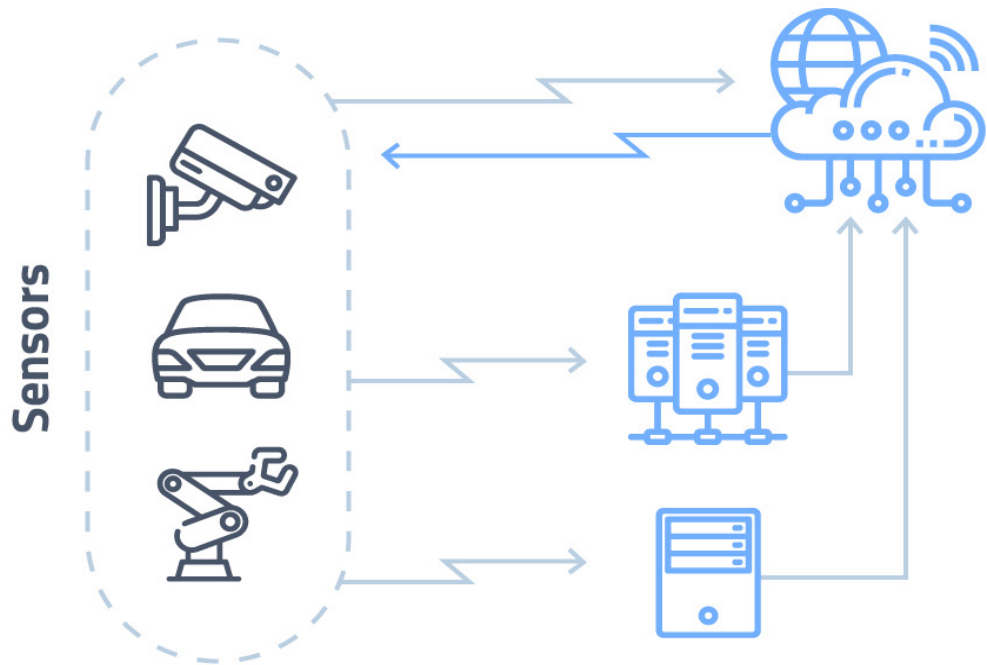
# About BrainChip – Founded 2013

- 15+ yrs fundamental AI architecture research & technologies
- 65+ data science, hardware & software engineers
- 21 Patents (pending included)
- Publicly traded:
  - ASX: BRN.AX
  - OTCX: BCHPY
- We make Sensors Smart- Simplicity for Edge AI Devices
  - Audio
  - Gustatory
  - Olfactory
  - Tactile
  - Vision



# What is Edge AI Computing?

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**Conventional AI** captures data from sensors and sends it to the cloud for processing.

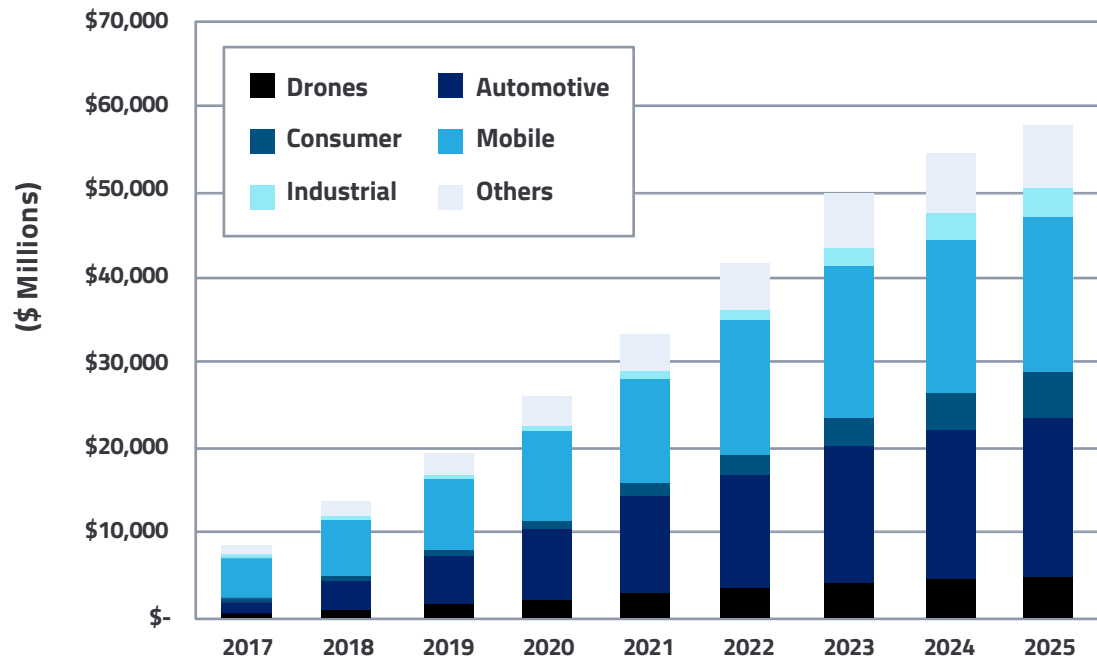
- \* Large Data Sets
- \* High Bandwidth
- \* Computationally Inefficient
- \* Power Intensive

**Edge AI with BrainChip Akida™** brings intelligence to the sensor in the device.

- \* Computes on-chip, in-device
- \* Order of magnitude less data & computation
- \* Fractional power
- \* Enables one-shot learning
- \* Device Personalization

# Edge Device Market Outlook

## Edge Based Devices requiring AI - \$60B by 2025



Source: Tractica

## Implications

- \* More capability
- \* More data
- \* More compute
- \* More bandwidth

## Call to action

- \* Current AI compute architecture is unsustainable
- \* Need to move AI to the Edge...

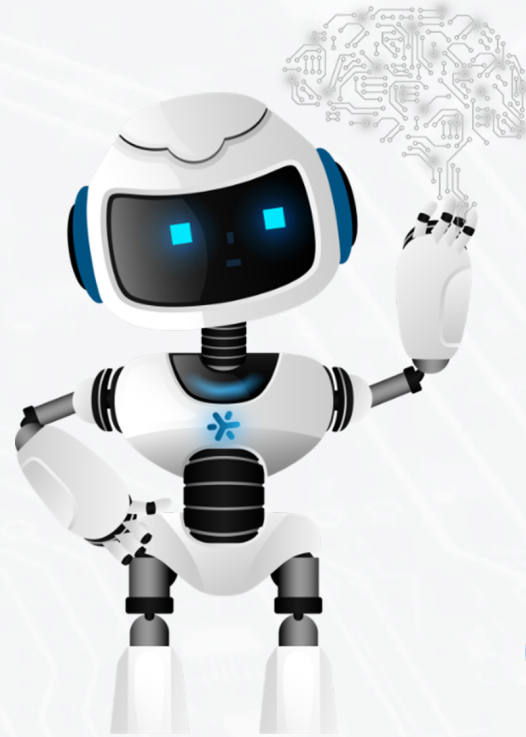


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**Akida™**

**Object Detection**

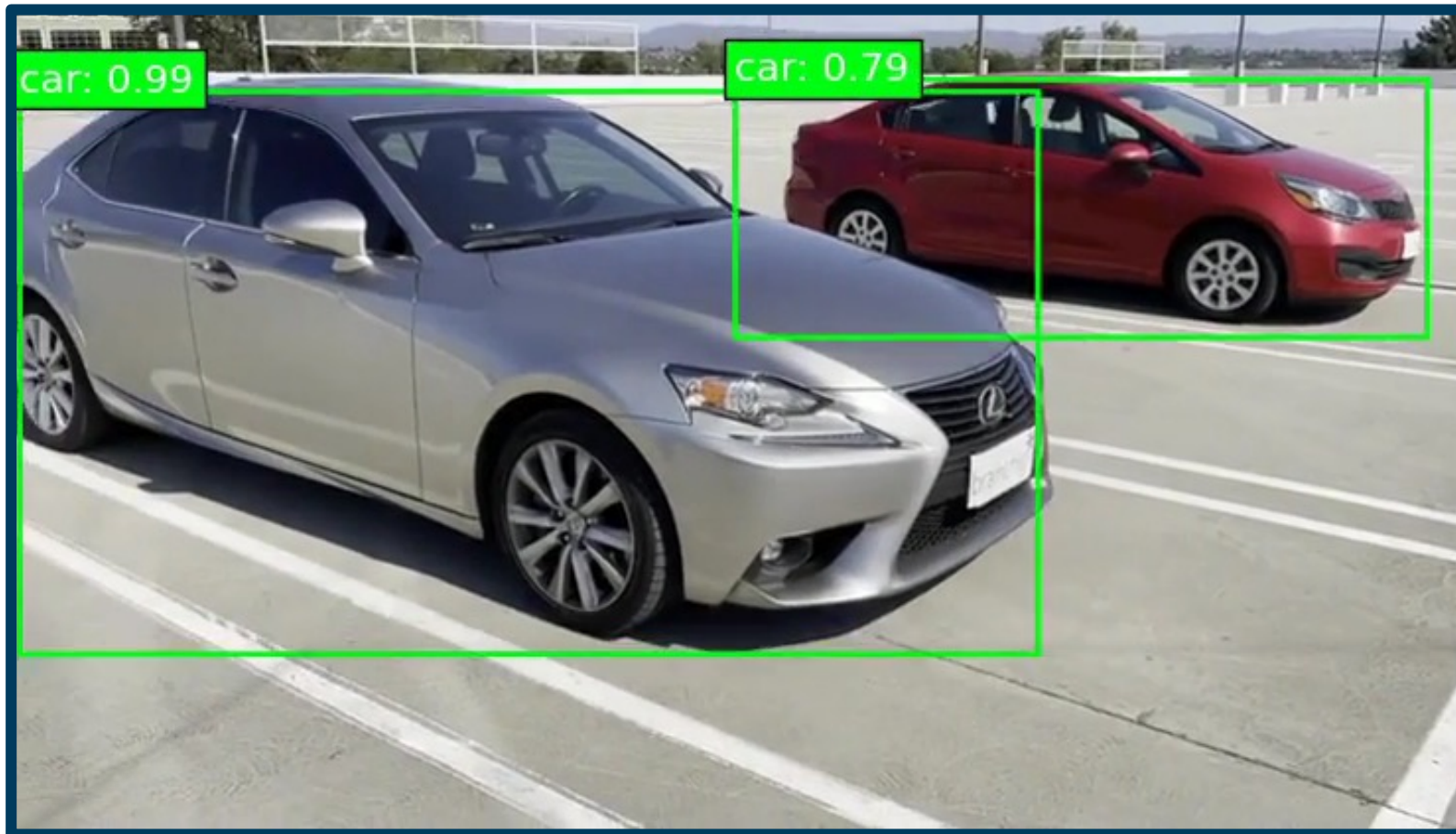
**Person Detection**



*Revolutionizing AI at the Edge*

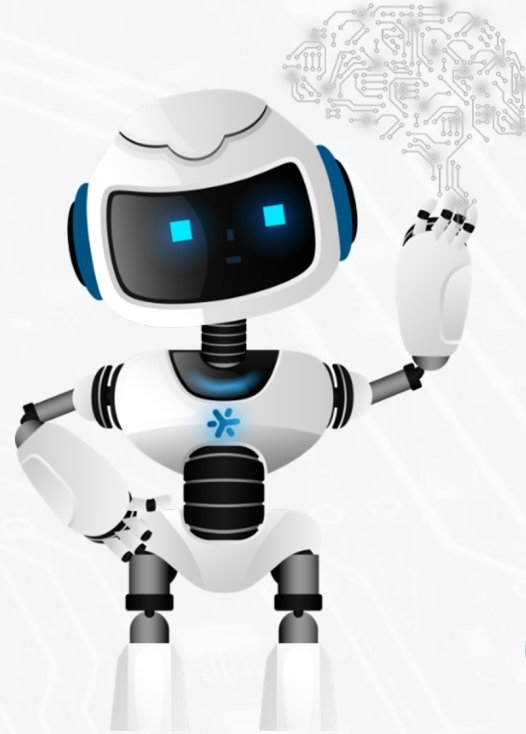
# Mobilenet SSD – Cars and People

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**Akida™**  
**Facial Recognition**  
**Keyword Spotting**  
**Visual wake**



*Revolutionizing AI at the Edge*



# Smart Automotive - In Cabin Experience

## Akida Face Recognition



Learn new people <sup>3/10</sup>

Facial Recognition: 22.6mW

brainchip

Keyword spotting: Hey Akida!



Keyword Spotting: 600uW

## Akida Visual Wake Word



Visual Wake: 6mW

# BrainChip's AKIDA Neuromorphic Design Principles



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## Distributed Computation

Computation spread across many cores (neural processing units – NPUs)

Each NPU has its own dedicated computational engine and memory, which reduces data movement

## Event-Based Processing

Non-zero activation map values are represented as multi-bit (1 to 4-bit) events

NPUs only perform computation on events, not activation maps

## Event-Based Communication

NPUs communicate by sending events to each other over a mesh network without host CPU intervention

Neural network connectivity is configurable in the field

## Event-Based Learning

AKIDA implements an on-chip, learning algorithm

No costly communication with cloud required

# Akida (AKD1000) Neuromorphic Processor

## Data Input Interfaces

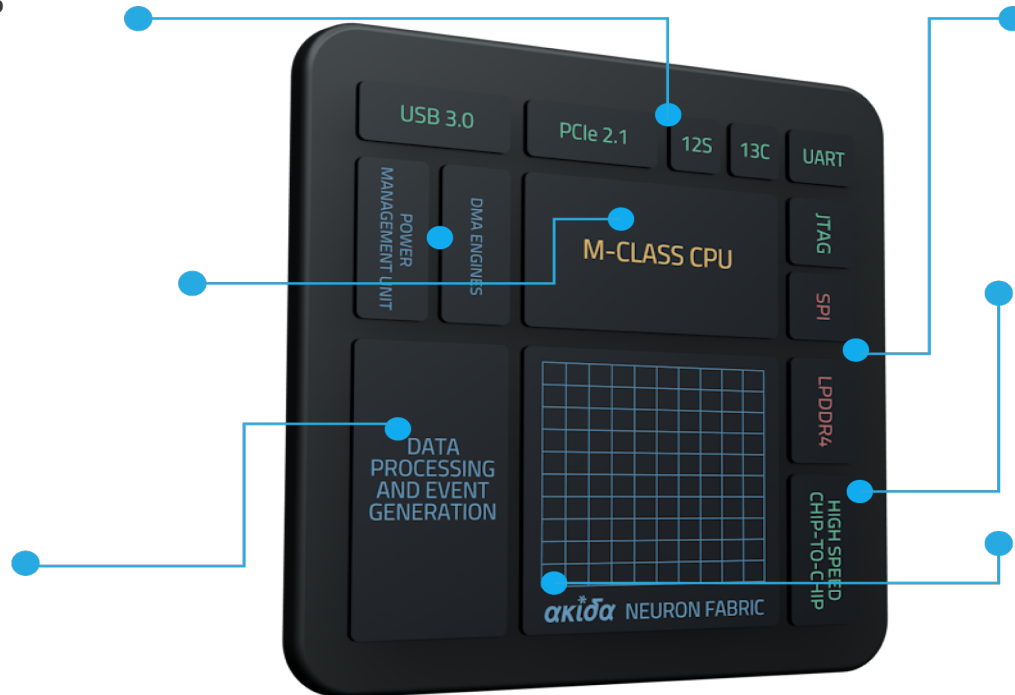
- PCI Express 2.1 x2 Lane Endpoint
- USB 3.0 Endpoint
- I3S, I2C, UART, JTAG

## On-Chip Processor

- M-Class CPU with FPU & DSP
- System Management
- Akida Configuration

## Data Processing

- Pixel-Event Converter
- SW Data-Event Encoder
- Any multivariable digital data
- Sound, pressure, temp., others



## External Memory Interfaces

- SPI FLASH for boot/storage
- LPDDR4 Program/Weights

## Multi-Chip Expansion

- PCIe 2.1 2 lane root complex
- Connects up to 64 devices

## Flexible Akida Neuron Fabric

- Implements 80 NPU
- All Digital logic with SRAM (8MB)
- Also Available as Licensed IP Core
- First Implementation: TSMC 28nm





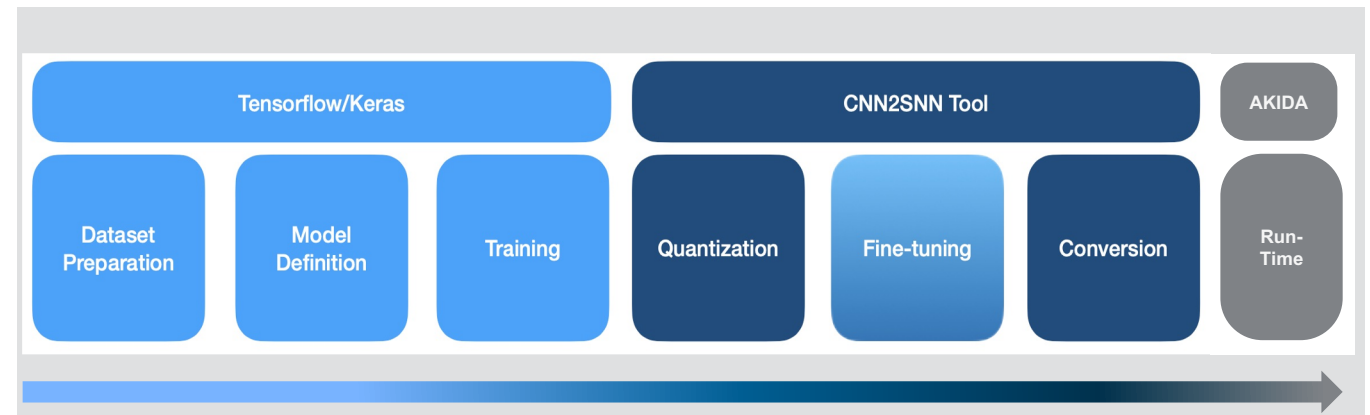
# MetaTF: Framework Structure and Workflow Saves Time

- \* Deep-learning professionals do not need to learn a new framework
- \* Start using **MetaTF** immediately
- \* Craft models in TensorFlow Keras
- \* Convert them for deployment on the AKIDA™ neural processor



All this in a few short steps:

1. **CNN design** (TensorFlow)
2. **CNN training** (TensorFlow)
3. **CNN quantization** (cnn2snn/quantize)
4. Optional **CNN tuning** (TensorFlow)
5. **SNN conversion** (cnn2snn/convert)
6. SNN deployment (akida/predict)



- \* The resulting **SNN model** runs on the AKIDA™ neural processor MetaTF Runtime
- \* Intuitive and automated network conversion flow = Deep Learning (DL- SNN)

**The MetaTF Development Framework: It's a simple environment leveraging standard CNN models design in TensorFlow.**

[www.brainchip.com/developer](http://www.brainchip.com/developer)

# MetaTF Development Environment

## \* Standard Tensor Flow environment

- \* Installation manual
- \* User Guide
- \* API reference
- \* Example/Workflows

## \* Network and Dataset samples

## \* Convert normal CNN to SNN

## \* ~5000 users in 2021

[www.brainchip.com/developer](http://www.brainchip.com/developer)

The screenshot shows the documentation page for MetaTF 1.9.0. The page title is "Overview" and the main heading is "The Akida Neural Processor". The text describes the processor as an ultra-low power, high performance, minimum memory footprint, event domain neural processor targeting Edge AI applications. It mentions that the architecture is based upon an event domain processor, leveraging fundamental principles from biological SNNs, and supports incremental learning. The processor eliminates the need for a CPU to run the neural network algorithm and in most cases eliminates the need for a DRAM external to the neural fabric. The elimination of external devices makes the Akida solution significantly more power efficient compared to deep learning accelerators which require both external CPU and memory.

The text further states that the architecture is highly scalable to meet the needs of a wide range of applications. The uniqueness of the BrainChip Akida Architecture lies in the ability of the hardware to run traditional feedforward, deeply learned CNN networks as well as native SNN networks. This documentation provides examples of how to develop both classes of solutions, using industry standard tool flows and networks, to solve a variety of application problems such as vision, acoustic, cybersecurity amongst others.

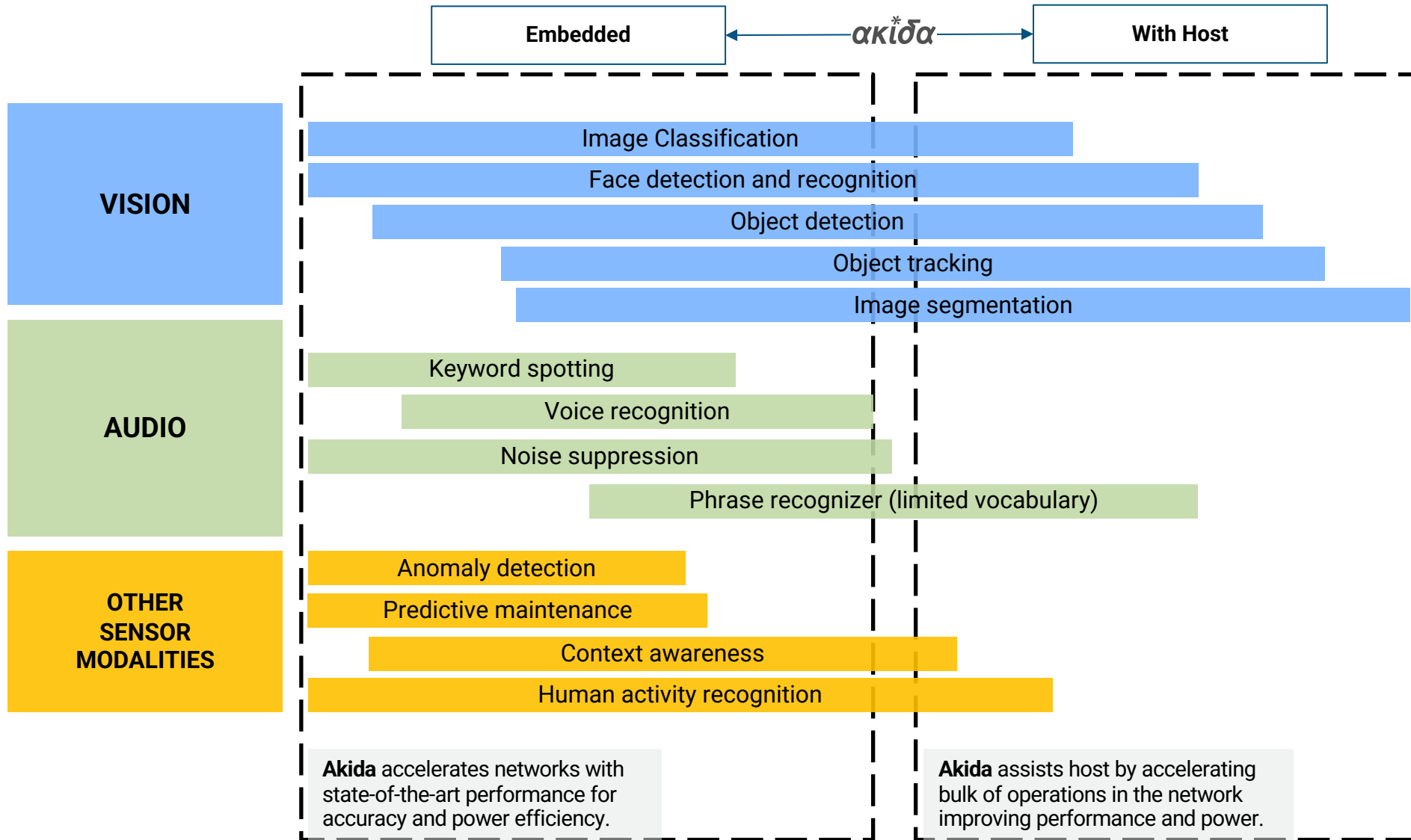
The Akida neural processor is available both as Intellectual Property (IP) circuit design for integration in ASIC products or as a System on a Chip (SoC) product.

As Figure 1 shows, the SoC is built around a core neural processor comprised of 80 neural processing units, it includes a conversion complex and allows one to run popular convolutional neural networks (CNNs) such as MobileNet<sup>1</sup>. Designers can use the Akida SoC to run industry standard CNNs, dramatically reducing power by changing convolutions to event based computations, or run native SNN solutions.

Figure 1 is a block diagram of the SoC architecture. It shows the following components:

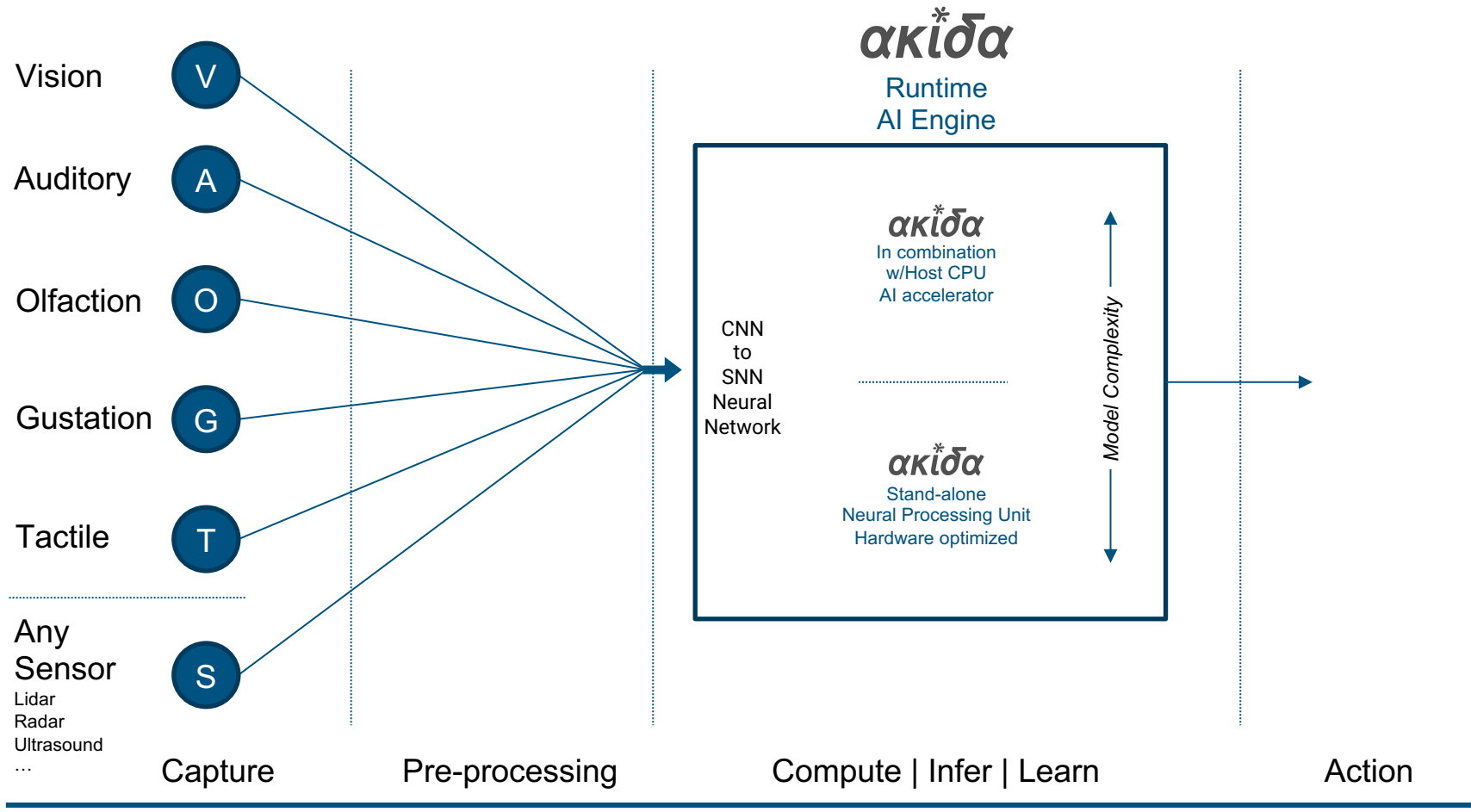
- Data input Interfaces:** PCI-Express 2.1 X2 Lane Endpoint, USB 3.0 Endpoint, I3S, I2C, UART, JTAG.
- Conversion Complex:** Pixel-Spike Converter, SW Data-Spike Encoder, Any multivariable digital data, Sound, pressure, temp. others.
- On-Chip Processor:** M-Class CPU with FPU & DSP, System management, Akida Configuration.
- External Memory Interfaces:** SPI FLASH for boot/storage, LPDDR4 Program/Weights.
- Other components:** USB 3.0, PCIe 2.1, I2S, I3C, UART, M-Class CPU, Programmable Pixel-Spike Converter, Power Management Unit, Data Engine, I2S, SPI, I3S.

# AI Processing in the Edge...



# From Sensor to Inference

## Performant and Efficient



- \* Akida supports output from any sensor, with its data and network, and applies in-chip neuromorphic AI to efficiently process and infer with radically reduced power consumption.
- \* Akida can also be deployed as an AI Accelerator to work in combination with a host CPU, still providing power consumption efficiencies.

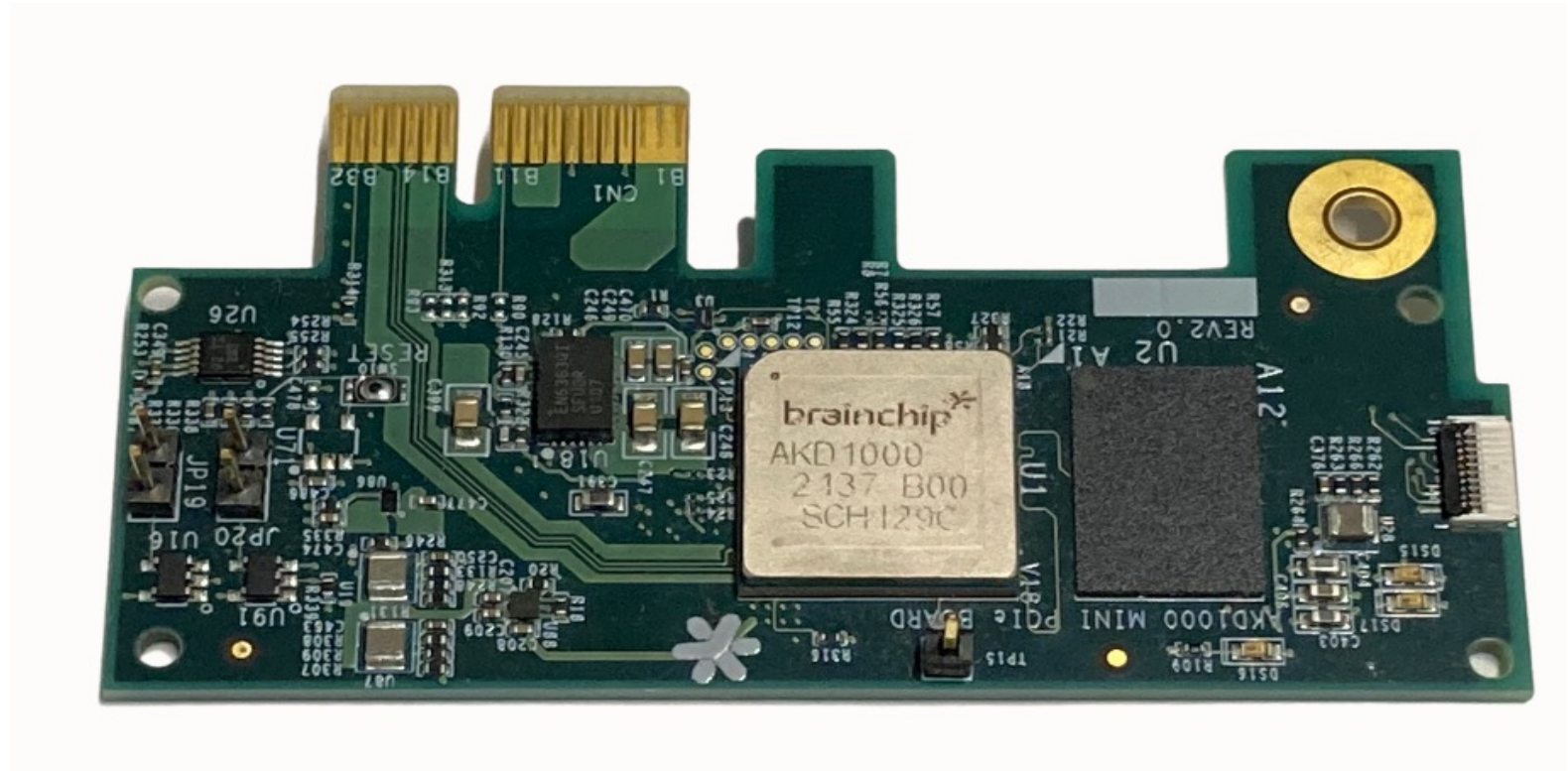
*Optimized compute, radically reduced power...*

# Akida AKD1000



## Full Commercialization...

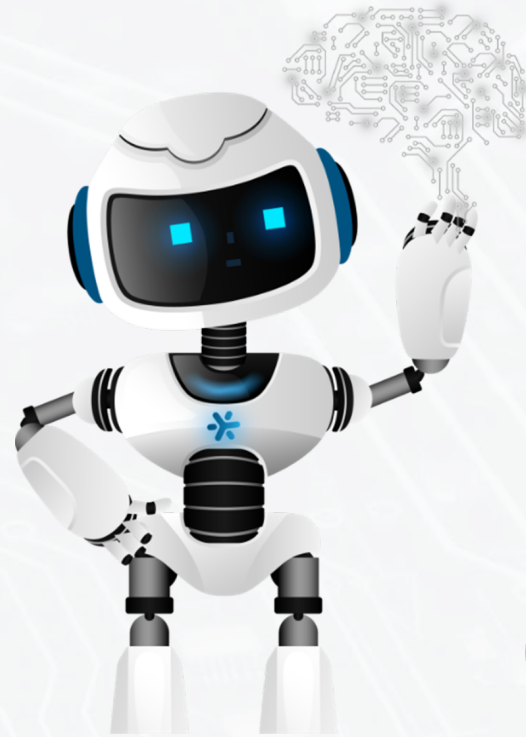
- \* AKD1000 Chip
- \* Shuttle PC Development Kit
- \* Raspberry Pi Development Kit
- \* AKD PCIe board
- \* Akida IP



[Order Online](https://shop.brainchipinc.com)  
[shop.brainchipinc.com](https://shop.brainchipinc.com)



brainchip\*



**Akida™**  
**Edge Based Learning**

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# Object Classification: Time for a Beer?



python3.6 May 25 14:45 Akida Live Demo

## Akida Edge Learning



Corona Premier <sup>1 shot</sup>

Learn new class <sup>3/10</sup> Corona Premier

The image shows a screenshot of a software interface for Akida Edge Learning. At the top, the title "Akida Edge Learning" is displayed in a dark blue font. Below the title is a central video frame showing a bottle of Corona Premier beer on a white surface. The bottle label is clearly visible, showing "Corona PREMIER" and "2.6g 90". Below the video frame, the text "Corona Premier" is shown in white, with a small "1 shot" label next to it. At the bottom of the interface, there is a dark blue bar with the text "Learn new class" and a progress indicator "3/10", followed by a light blue bar containing the text "Corona Premier". The background of the interface is a dark grey with a faint, light-colored circuit board pattern.

# ImageNet Mobilenet V1 Edge learning at High Speed



**Akida Edge Learning**

Car vs Bike: BMW Sauber F1 vs BMW S 1000 RR



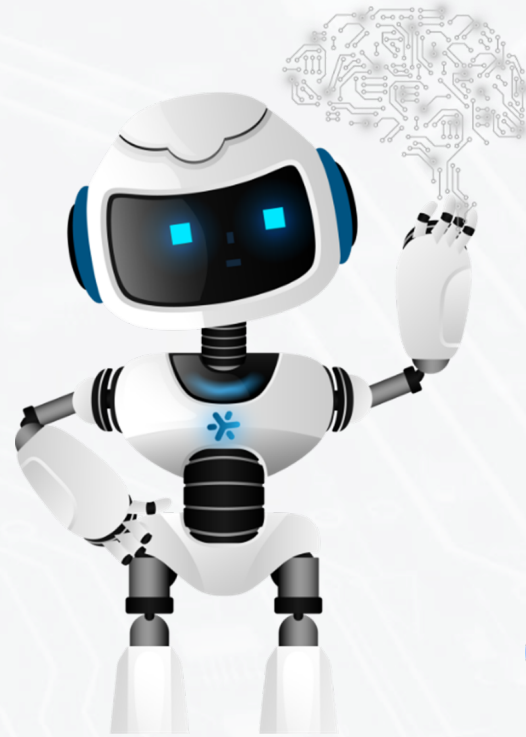
0:06 / 2:15

Pit Crew <sup>1 shot</sup>

The video player shows a race track scene with a BMW S 1000 RR motorcycle and a BMW Sauber F1 car. The motorcycle is on the left, and the F1 car is on the right. A pit crew member is visible near the F1 car. The video player interface includes a play button, a progress bar, and a volume icon.



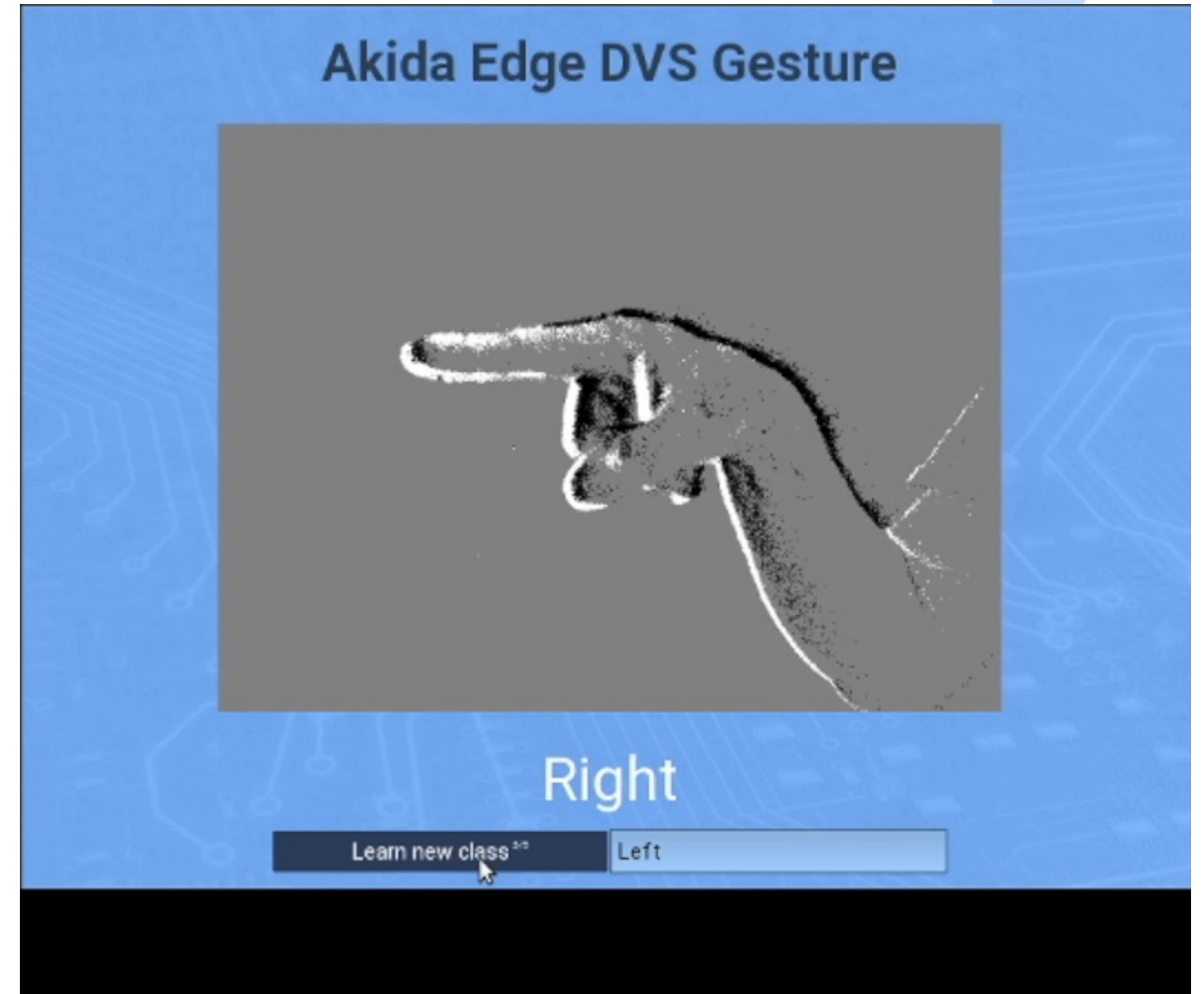
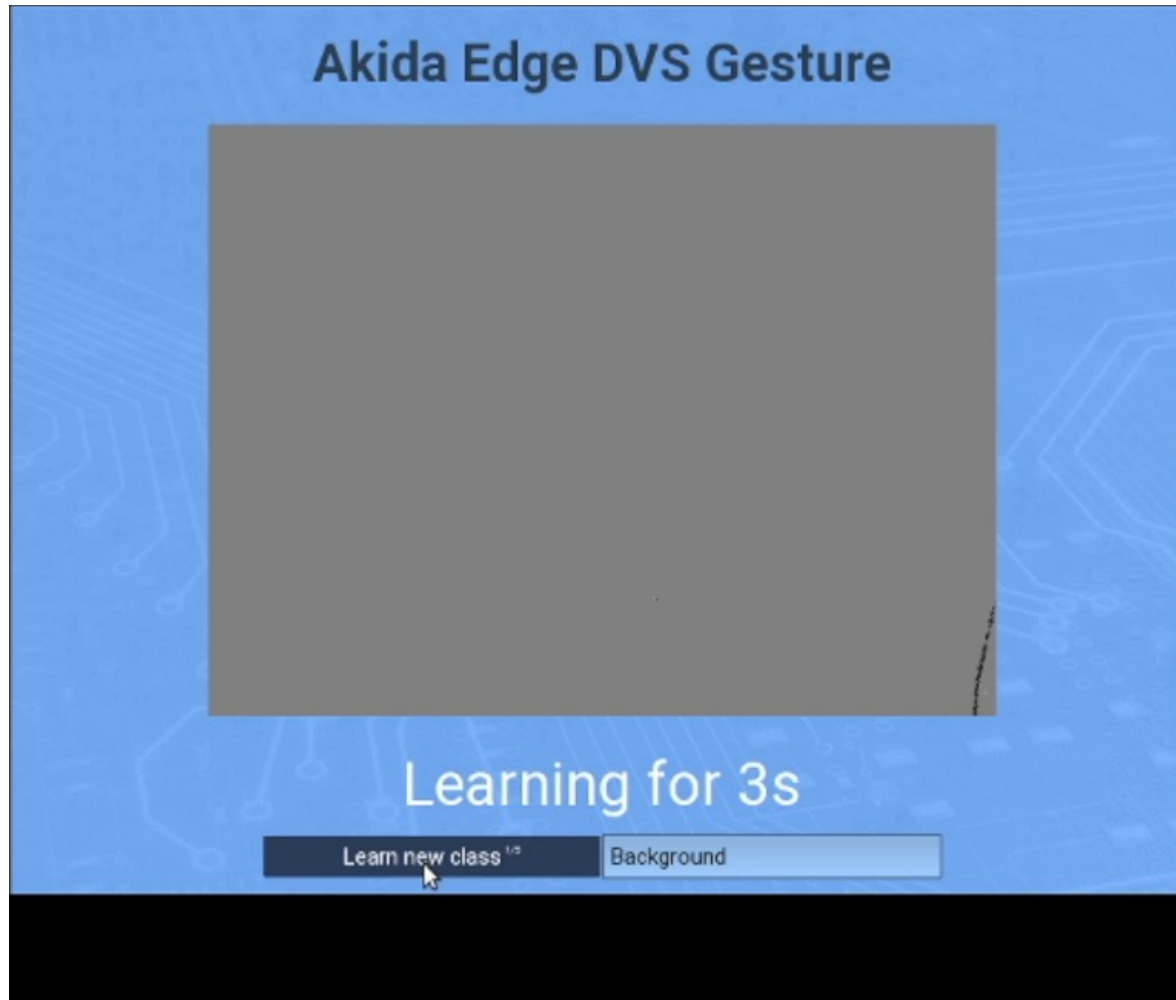
# brainchip\*



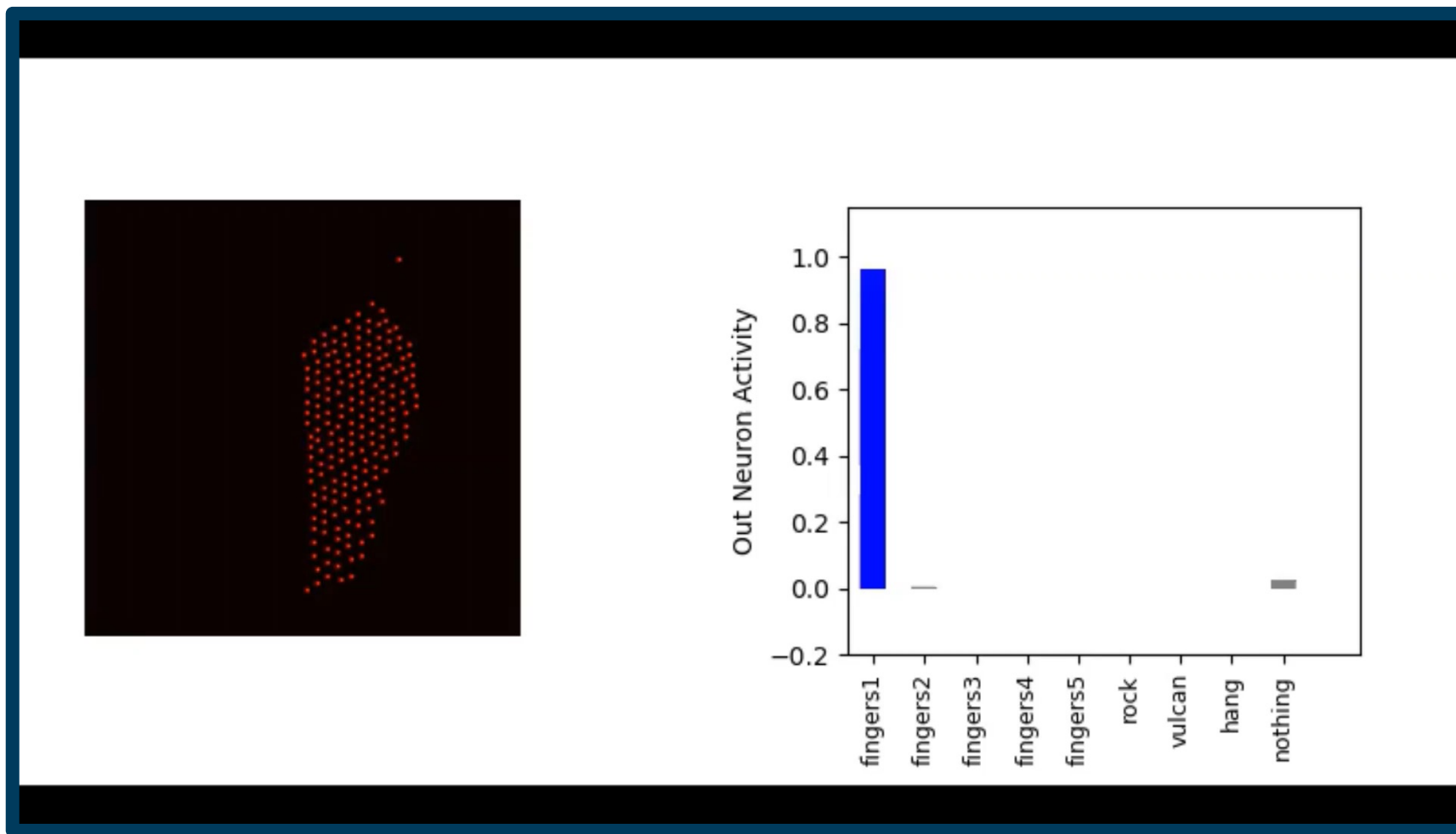
**Akida™**  
**Gesture Control**

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# DVS Gesture Learning & Recognition



# Gesture Classification





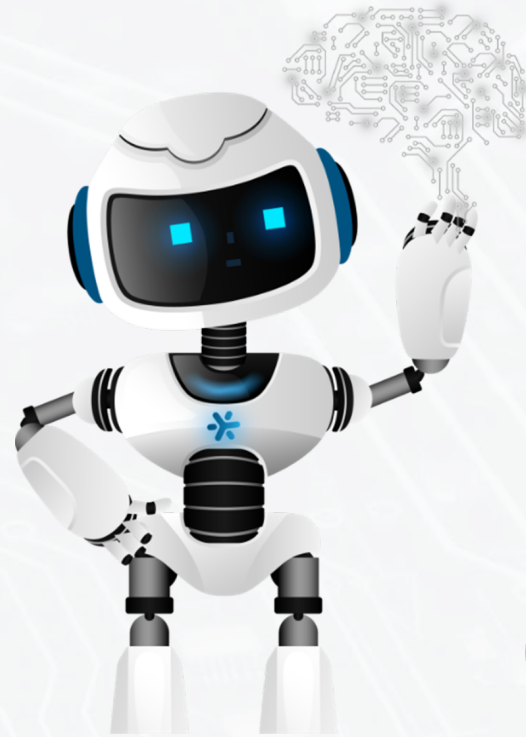
# Gesture

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brainchip\*



**Akida™**

**Benchmark Data**

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# Keyword Spotting (KWS) Model Benchmarking

- ✓ We used a variation of a popular KWS model\* that was compiled and optimized for
  - ✱ AKD1000 dev. board – 4-bit integer
  - ✱ Google Coral dev. board – 8-bit integer
  - ✱ Nvidia Jetson Nano – 16-bit floating point
- ✓ The KWS model was trained on the Google Speech Commands Data Set\*\*
- ✓ We presented 10k inputs (batch size = 1) to each system and measured the idle power, inference power, and dynamic power

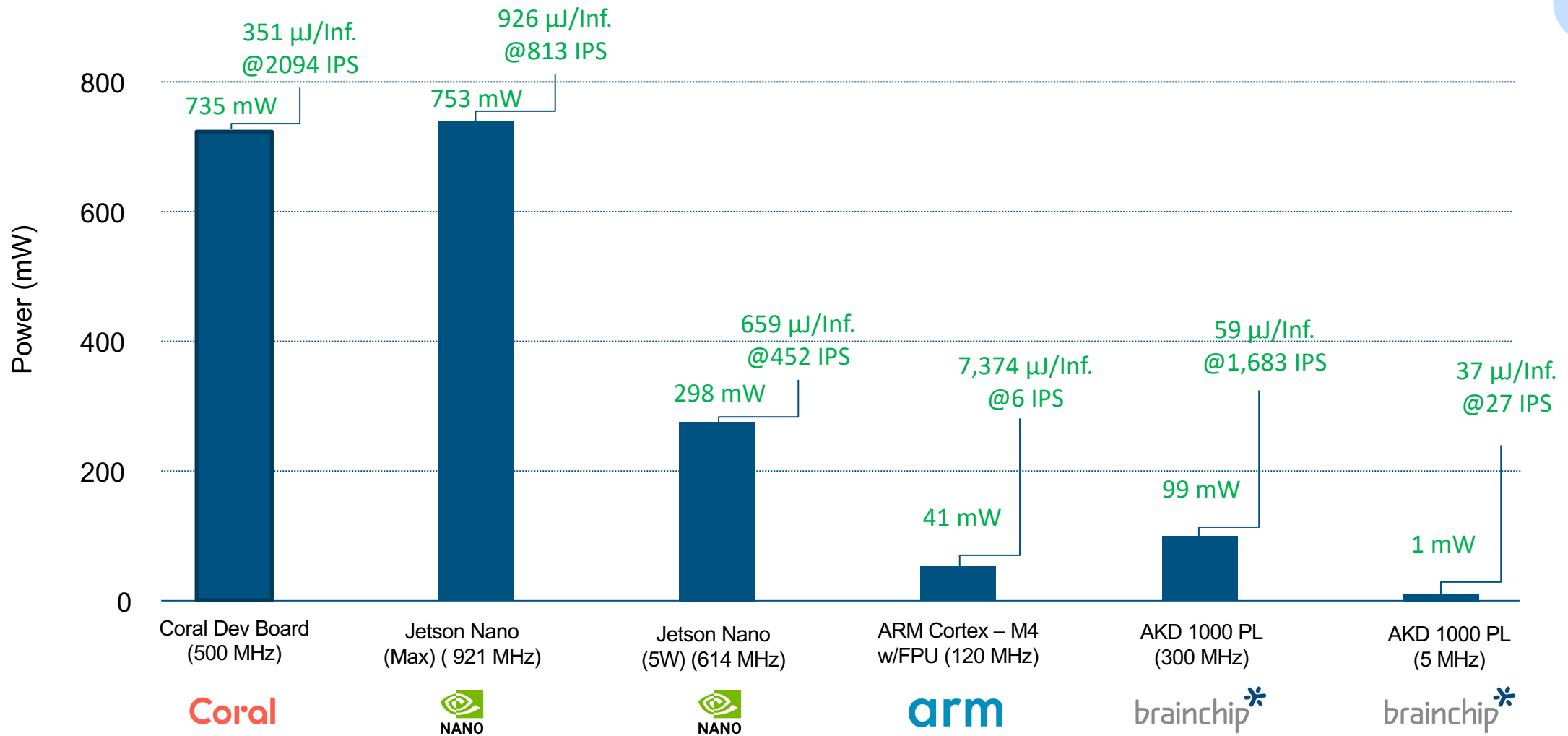
DS-CNN	
Layers	Output Dim
Input	49x10x1
Conv MP 5x5	25x5x32
DWS Conv 3x3	25x5x64
DWS Conv 3x3	25x5x64
DWS Conv 3x3	25x5x64
DWS Conv 3x3	25x5x64
DWS Conv 3x3	25x5x64
DWS Conv 3x3	25x5x64
GAP	1x1x64
DWS Conv 3x3	1x1x256
Dense	1x1x33

Total Params = 47,232    MACs/Inference = 2,538,112

\* Zhang, Yundong, Naveen Suda, Liangzhen Lai, and Vikas Chandra. 2018. ArXiv:1711.07128 [Cs, Eess].  
<http://arxiv.org/abs/1711.07128>.

\*\* Warden, Pete. 2018. ArXiv:1804.03209 [Cs], <http://arxiv.org/abs/1804.03209>.

# Power, Efficiency and IPS for Key Word Spotting (KWS)



# We are the New Standard for Edge AI



BrainChip is revolutionizing the future of in-device Artificial Intelligence (AI) and is the worlds first commercial producer of neuromorphic semiconductor chips and IP.



Mercedes-Benz  
Media Newsroom USA

Neuromorphic computing  
– a car that thinks like you



Another key efficiency feature of the VISION EQXX that takes its cue from nature is the way it thinks. It uses an innovative form of information processing called **neuromorphic computing**. The hardware runs spiking neural networks. Information is coded in discrete spikes and energy is only consumed when a spike occurs, which reduces energy consumption by orders of magnitude. **Working with California-based artificial intelligence experts BrainChip, Mercedes-Benz engineers developed systems based on BrainChip's Akida hardware and software.** The example in the VISION EQXX is the "Hey Mercedes" key-word detection. **Structured along neuromorphic principles, it is five to ten times more efficient than conventional voice control.**

Although neuromorphic computing is still in its infancy, systems like these will be available on the market in just a few years. When applied on scale throughout a vehicle, they have the potential to **radically reduce the energy needed to run the latest AI technologies.**

**VentureBeat**

**EE|Times**

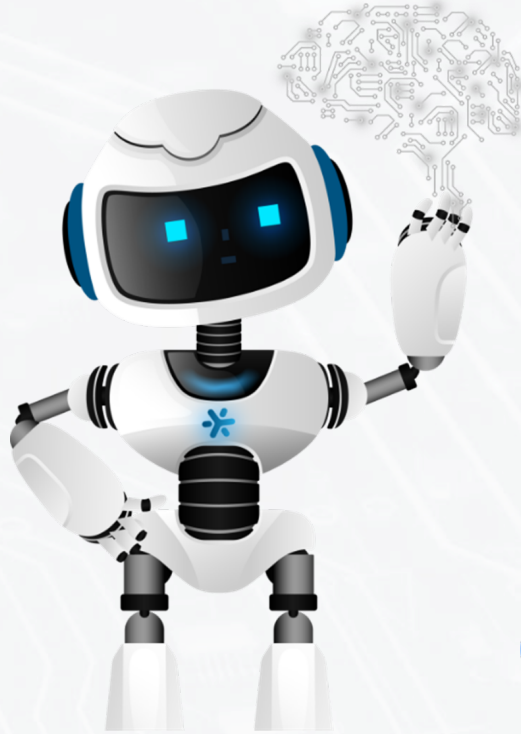
**Design  
& Reuse**

# brainchip\*

**Akida™**

**Vibration Analysis**

**Tactile Sensing**



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# ST-MNIST

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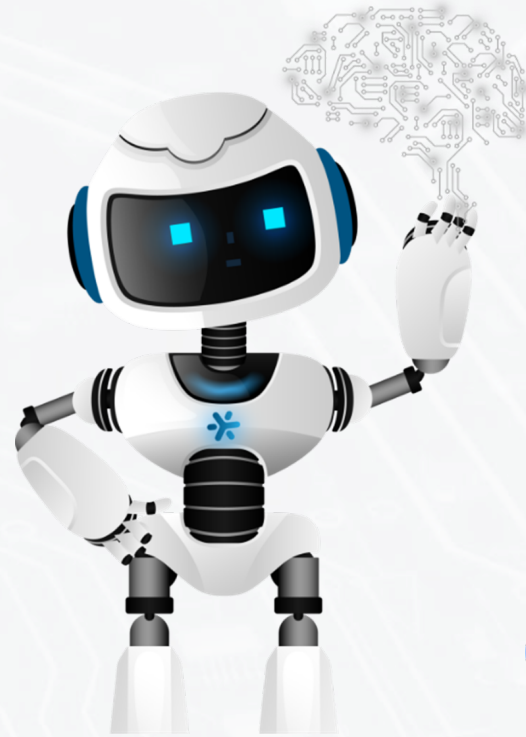
# Vibration Analysis

The image shows a software demo window titled "Vibration Analysis w/ Akida" with the "brainchip" logo in the top left. The window is split into two main sections. The left section features a graph with a light blue background and a dark blue grid. The y-axis is labeled "values" and the x-axis is labeled "time(s)". A blue waveform is visible at the bottom of the graph. The right section shows a photograph of a black circular fan on a stand, with a small sign in front of it that reads "brainchip ακτῶα Unlocking the future of AI". At the bottom of the window, the text "Prediction: off" is displayed in white and red.

**Prediction: off**

# brainchip\*

## Akida™ Gustatory Beer Tasting



*Revolutionizing AI at the Edge*

# Gustatory Sensing Demo

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# BrainChip - This is Our Mission

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- \* Traditional AI is compute intensive
- \* Traditional AI solutions do not address the future for Edge AI environments
  - Too much irrelevant data is being processed
  - Consuming too much power
  - Too many dollars are being spent in the wrong areas
- \* The key is not to process more data faster
- \* **Process Relevant Data Efficiently with Accuracy**
- \* Neuromorphic Computing is the next generation of AI
  - Processing the most relevant data: smarter, faster and most economical
- \* BrainChip is first to market and is leading the way!



# This is our Mission

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## We don't make the sensors

- We make them smart

## We don't add complexity

- We eliminate it

## We don't waste time

- We save it

## We solve the tough *Edge AI* problems

- Others do not or cannot solve







# Intelligent AI Everywhere This is our Mission

*[www.brainchip.com](http://www.brainchip.com)*

# Empowering Product Creators to Harness Edge AI and Vision



The Edge AI and Vision Alliance ([www.edge-ai-vision.com](http://www.edge-ai-vision.com)) is a partnership of 100+ leading edge AI and vision technology and services suppliers, and solutions providers

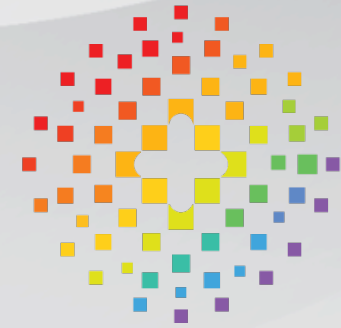
Mission: To inspire and empower engineers to design products that perceive and understand.

The Alliance provides low-cost, high-quality technical educational resources for product developers

**Register for updates at [www.edge-ai-vision.com](http://www.edge-ai-vision.com)**

The Alliance enables edge AI and vision technology providers to grow their businesses through leads, partnerships, and insights

**For membership, email us: [membership@edge-ai-vision.com](mailto:membership@edge-ai-vision.com)**



edge ai + vision  
ALLIANCE™



# Join us at the Embedded Vision Summit

May 17-19, 2022—Santa Clara, California



*The only industry event focused on practical techniques and technologies for system and application creators*

- *“Awesome! I was very inspired!”*
- *“Fantastic. Learned a lot and met great people.”*
- *“Wonderful speakers and informative exhibits!”*

## Embedded Vision Summit 2022 highlights:

- **Inspiring keynotes** by leading innovators
- High-quality, practical **technical, business and product talks**
- Exciting **demos, tutorials** and **expert bars** of the latest applications and technologies



Visit [www.EmbeddedVisionSummit.com](http://www.EmbeddedVisionSummit.com) to learn more



# BrainChip Demo Links- YouTube @BrainChipInc

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Wine Tasting: <https://youtu.be/RwWTietRioM?t=1>

Edge Based Learning: <https://youtu.be/912hYD1qJuk>

Keyword Spotting: <https://youtu.be/wDWHQqi69qo>

Visual Wake & Facial Recognition: [https://youtu.be/EoG0\\_AUv3Zo](https://youtu.be/EoG0_AUv3Zo)

Smart Automotive In Cabin Experience: [https://youtu.be/tin55B83r\\_M?t=107](https://youtu.be/tin55B83r_M?t=107)

Edge Based Learning (High Speed Environment): <https://youtu.be/GvfDKILlOk>

Gesture Control: <https://youtu.be/Rin5RGTHiOk>