tinyML Summit

Enabling Ultra-low Power Machine Learning at the Edge

tinyML Summit 2021 Proceedings

March 22 – 26, 2021
Virtual Event

www.tinyML.org
CARTESIAM
WE HELP EMBEDDED DEVELOPERS MAKE OBJECTS SELF-AWARE

François de Rochebouët
CTO & co-founder
francois@cartesiam.com
CARTESIAM
WHO WE ARE

WHAT  Software company founded in 2016
WHERE  France / Germany / USA
MISSION  To help developers to easily and quickly create smart objects without AI skills
FOCUS  MACHINE LEARNING AT THE EDGE
INNOVATION  Training and inference exactly where data turn into a signal

PARTNERS

[Images of logos for ARM, Microchip, STMicroelectronics, Analog Devices, and Microsoft for Startups]
WE ARE THE AI POSTER CHILD FOR THE MICROCONTROLLER LEADERS... AND IT GOT NOTICED!

ANALYSTS

Gartner
TOP 3 EDGE AI VENDORS
2019 & 2020 :
• Hype Cycle for Semiconductors and Electronics. Technologies
2020
• Hype Cycle for Emerging technologies
• Hype Cycle for Embedded Software
• Cool Vendors in IoT Thingification

2019 WINNER Category ‘Technology Showcase of the year’

2019 WINNER Category ‘Most Innovative Technology’

2020 WINNER “Best start-up”

CUSTOMERS

On 5 continents, in one year
We are already applying **NanoEdge™ AI STUDIO** to **multiple industries** and data types.

**NavalGroup**
As part of the development of maintenance solutions for industry 4.0, Naval Group is one of the first companies to be equipped with the NanoEdge AI Studio technology.

**SMRI**
SMR is involved in high-tech industrial sites in France and abroad: it offers solutions adapted to the different phases of operations (planning, expertises, manufacturing).

**Lacroix-Electronics**
LACROIX Electronics is a premier provider of industrial IoT solutions.

**Schneider Electric**
We use Cartesiam’s solution to understand and anticipate the aging of mechanical contactors directly inside circuit breakers.

**NKE Watteco**
NKE WATTECO is one of the European leaders in wireless intelligent sensor solutions and multi-protocol remote data collection systems.

**Twimm**
Twimm is a specialized CMMS platform for the intelligent management of technical building assets.

**Bosch**
For Bosch Connected Devices and Solutions GmbH, Cartesiam’s NanoEdge AI™ Studio is a natural fit as it perfectly extends the major existing IoT product line — the Cross Domain Development Kit, the XDK.

**Crouzet**
Crouzet is an independent company developing and manufacturing mechatronic components.
Our Marketing budget

$0

“When the product is right, you don’t have to be a great Marketer.”

Lido Anthony "Lee" Iacocca October 15, 1924 – July 2, 2019) was an American automobile executive best known for the development of the Ford Mustang and Ford Pinto cars while at the Ford Motor Company in the 1960s, and for reviving the Chrysler Corporation as its CEO during the 1980s.
HOW DID WE DO IT?

NanoEdge™ AI Studio: REAL EDGE MACHINE LEARNING

We re-wrote (starting from the algebra) every single ML and signal processing algorithms so they can run inside a microcontroller (learning and inference).

- Ultra optimized / customized for optimal performance
- What is not used is not loaded
- Ultra memory efficient
- Super specialized models
- Learning and analysis inside the microcontroller

We created NANOEDGE AI studio, a software for embedded developers, running autonomously on a PC, and capable of simply generating the right learning machine library for your project from among 500 million possibilities.
WE CURRENTLY FOCUS ON:

- Vibrations
- Pressure
- (VOC) Volatile organic compound
- Current
- Magnetic
- Temperature
- Sound
- Ultrasound
- Multi signal sensor
...
# HOW FAST & LIGHT IS IT?

## TensorFlow Lite for Microcontrollers MINST Benchmark *

<table>
<thead>
<tr>
<th>Software</th>
<th>Hardware</th>
<th>Exec time (ms)</th>
<th>RAM</th>
<th>FLASH</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSF lite Micro (ML only)</td>
<td>Raspberry Pi 3 B+</td>
<td>13.47</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Jetson nano</td>
<td>9.34</td>
<td>~70kB</td>
<td>~500kB</td>
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<tr>
<td></td>
<td>Beaglebone Black</td>
<td>97.03</td>
<td></td>
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<tr>
<td></td>
<td>STM32F746 @ 216 MHz</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>STM32F746 @ 288 MHz</td>
<td>57.95</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NanoEdge AI Studio</td>
<td>STM32F405 @ 168 MHz</td>
<td>4.23</td>
<td>4.2 kB</td>
<td>37 kB</td>
</tr>
</tbody>
</table>

* https://www.cnx-software.com/2019/08/06/tensorflow-lite-for-microcontrollers-benchmarked-on-linux-sbecs/
HOW EASY TO USE IT IS?

Let me show you...
THANK YOU

SUMMARY:

- Commercially successful, fastest adoption rate in the market
- Best results on any Arm Cortex-M (M0 to M7)
- Anyone can use our software
We thank the authors for their presentations and everyone who participated in the tinyML Summit 2021.

Along with a special thank you to the sponsors who made this event possible!
Executive Sponsors
Arm: The Software and Hardware Foundation for tinyML

- Connect to high-level frameworks
- Supported by end-to-end tooling
- Connect to Runtime

Profiling and debugging tooling such as Arm Keil MDK

Application

Optimized models for embedded

Runtime (e.g. TensorFlow Lite Micro)

Optimized low-level NN libraries (i.e. CMSIS-NN)

RTOS such as Mbed OS

Arm Cortex-M CPUs and microNPUs

Stay Connected

@ArmSoftwareDevelopers

@ArmSoftwareDev

Resources: developer.arm.com/solutions/machine-learning-on-arm
Advancing AI research to make efficient AI ubiquitous

Power efficiency
Model design, compression, quantization, algorithms, efficient hardware, software tool

Personalization
Continuous learning, contextual, always-on, privacy-preserved, distributed learning

Efficient learning
Robust learning through minimal data, unsupervised learning, on-device learning

Perception
Object detection, speech recognition, contextual fusion

Reasoning
Scene understanding, language understanding, behavior prediction

Action
Reinforcement learning for decision making

A platform to scale AI across the industry

Qualcomm AI Research is an initiative of Qualcomm Technologies, Inc.
Samsung brings AI in the hands of everyone, with >300M Galaxy phones per year. Fingerprint ID, speech recognition, voice assistant, machine translation, face recognition, AI camera; the application list goes on and on.

In the heart of AI applications is the NPU, the neural processor that efficiently calculates AI workloads. Samsung NPU is a home grown IP that was employed since 2018 inside Samsung Exynos SoC.

Samsung NPU is brought by global R&D ecosystem that encompasses US, Korea, Russia, India, and China. In US, we are the fore-runner to guide the future directions of Samsung NPU, by identifying major AI workloads that Samsung’s NPU needs to accelerate in 3-5 years. For this, we collaborate with world-renowned academia research groups in AI and NPU.
Platinum Sponsors
Eta Compute creates energy-efficient AI endpoint solutions that enable sensing devices to make autonomous decisions in energy-constrained environments in smart infrastructure and buildings, consumer, medical, retail, and a diverse range of IoT applications.

www.etacompute.com
Lattice Semiconductor (NASDAQ: LSCC) is the low power programmable leader. We solve customer problems across the network, from the Edge to the Cloud, in the growing communications, computing, industrial, automotive and consumer markets. Our technology, relationships, and commitment to support lets our customers unleash their innovation to create a smart, secure and connected world. www.Latticesemi.com.
Gold Sponsors
AKIDA™ Neuromorphic Technology: Inspired by the Spiking Nature of the Human Brain

- Supports ultra-low power applications (microwatts to milliwatts)
- Edge capabilities: on-chip training, learning, and inference
- Designed for AI Edge applications: vision, audio, olfactory, and smart transducer applications
- Licensed as IP to be designed into SoC or as silicon
- Sensor inputs are analyzed at the point of acquisition rather than through transmission via the cloud to the data center. Enables real-time response for power-efficient systems
- Software Development Platform

brainchipinc.com  @BrainChip_inc  YouTube.com/BrainChipInc
BabbleLabs AI speech wizardry in Cisco Webex

AI meets speech - deep experience in speech science, AI/ML, embedded systems

Massive compute
- Novel deep neural networks
- Massive data corpus

300 TFLOPS per engineer

Silicon-optimized software

40K hours of speech
15K hours of music
10K hour of noise
100K room models

Speech enhancement
Speech recognition

Conferencing
Call centers
Digital Assistants
Calling
DSP Group, Inc. develops wireless communications and voice processing chipsets, algorithms, and software solutions for converged communications and smart-enabled devices. Core competencies include, but are not limited to, voice processing. Its technology supports the development and integration of voice user interfaces (VUIs) for applications ranging from smartphones to the smart home. Its Ultra-Low Energy (ULE, per the ULE Alliance) wireless solutions enable low-power, long-range, secure communication applications for the IoT and are distinguished by their native support of two-way voice communication. On-going development efforts include the application of machine learning (ML) and artificial intelligence (AI) hardware and algorithms to address the need for accurate AI solutions at the edge for applications such as sound detection, proximity detection, and acoustic beacons.
TinyML for all developers

Acquire valuable training data securely

Enrich data and train ML algorithms

Edge Device
Real sensors in real time
Open source SDK

Embedded and edge compute deployment options

Test impulse with real-time device data flows

Dataset

www.edgeimpulse.com
The Eye in IoT
Edge AI Visual Sensors

- Machine Learning algorithm
- <1MB memory footprint
- Microcontrollers computing power
- Trained algorithm
- Processing of low-res images
- Human detection and other classifiers

CMOS Imaging Sensor
- Ultra Low power CMOS imager
- AI + IR capable

IoT System on Chip
- Machine Learning edge computing silicon
- <1mW always-on power consumption
- Computer Vision hardware accelerators

Computer Vision Algorithms

info@emza-vs.com
GrAI Matter Labs has created an AI Processor for use in edge devices like drones, robots, surveillance cameras, and more that require real-time intelligent response at low power. Inspired by the biological brain, its computing architecture utilizes sparsity to enable a design which scales from tiny to large-scale machine learning applications.

www.graimatterlabs.ai
Enabling the next generation of **Sensor and Hearable products** to process rich data with energy efficiency.

- **Visible Image**
- **Sound**
- **IR Image**
- **Radar**
- **Bio-sensor**
- **Gyro/Accel**

**Wearables / Hearables**

**Battery-powered consumer electronics**

**IoT Sensors**
Himax Technologies, Inc. provides semiconductor solutions specialized in computer vision. Himax’s WE-I Plus, an AI accelerator-embedded ASIC platform for ultra-low power applications, is designed to deploy CNN-based machine learning (ML) models on battery-powered AIoT devices. These end-point AI platforms can be always watching, always sensing, and always listening with on-device event recognition.

Imagimob AI SaaS

- End-to-end development of tinyML applications
- Guides and empowers users through the process
- Support for high accuracy applications requiring low power and small memory
- Imagimob AI have been used in 25+ tinyML customer projects
- Gesture control

imagimob.com
LatentAI

Adaptive AI for the Intelligent Edge

Latentai.com
Health sensors measure PPG and ECG signals critical to understanding vital signs. Signal chain products enable measuring even the most sensitive signals.

Advanced AI Acceleration IC

The new MAX78000 implements AI inferences at low energy levels, enabling complex audio and video inferencing to run on small batteries. Now the edge can see and hear like never before.

www.maximintegrated.com/MAX78000

Low Power Cortex M4 Micros

Large (3MB flash + 1MB SRAM) and small (256KB flash + 96KB SRAM, 1.6mm x 1.6mm) Cortex M4 microcontrollers enable algorithms and neural networks to run at wearable power levels.

www.maximintegrated.com/microcontrollers

Sensors and Signal Conditioning

www.maximintegrated.com/sensors
Qeexo AutoML

Automated Machine Learning Platform that builds tinyML solutions for the Edge using sensor data

Key Features

- Supports 17 ML methods:
  - Multi-class algorithms: GBM, XGBoost, Random Forest, Logistic Regression, Gaussian Naive Bayes, Decision Tree, Polynomial SVM, RBF SVM, SVM, CNN, RNN, CRNN, ANN
  - Single-class algorithms: Local Outlier Factor, One Class SVM, One Class Random Forest, Isolation Forest
- Labels, records, validates, and visualizes time-series sensor data
- On-device inference optimized for low latency, low power consumption, and small memory footprint applications
- Supports Arm® Cortex™- M0 to M4 class MCUs

End-to-End Machine Learning Platform

For more information, visit: www.qeexo.com

Target Markets/Applications

- Industrial Predictive Maintenance
- Smart Home
- Wearables
- Automotive
- Mobile
- IoT
Pre-built Edge AI sensing modules, plus tools to build your own

Reality AI solutions

- Prebuilt sound recognition models for indoor and outdoor use cases
- Solution for industrial anomaly detection
- Pre-built automotive solution that lets cars “see with sound”

Reality AI Tools® software

- Build prototypes, then turn them into real products
- Explain ML models and relate the function to the physics
- Optimize the hardware, including sensor selection and placement

https://reality.ai  info@reality.ai  @SensorAI  Reality AI
Build Smart IoT Sensor Devices From Data

SensiML pioneered TinyML software tools that auto generate AI code for the intelligent edge.

- End-to-end AI workflow
- Multi-user auto-labeling of time-series data
- Code transparency and customization at each step in the pipeline

We enable the creation of production-grade smart sensor devices.

sensiml.com
Silicon Labs (NASDAQ: SLAB) provides silicon, software and solutions for a smarter, more connected world. Our technologies are shaping the future of the Internet of Things, Internet infrastructure, industrial automation, consumer and automotive markets. Our engineering team creates products focused on performance, energy savings, connectivity, and simplicity. silabs.com
**Syntiant Corp.** is moving artificial intelligence and machine learning from the cloud to edge devices. Syntiant’s chip solutions merge deep learning with semiconductor design to produce ultra-low-power, high performance, deep neural network processors. These network processors enable always-on applications in battery-powered devices, such as smartphones, smart speakers, earbuds, hearing aids, and laptops. Syntiant's Neural Decision Processors™ offer wake word, command word, and event detection in a chip for always-on voice and sensor applications.

Founded in 2017 and headquartered in Irvine, California, the company is backed by Amazon, Applied Materials, Atlantic Bridge Capital, Bosch, Intel Capital, Microsoft, Motorola, and others. Syntiant was recently named a **CES® 2021 Best of Innovation Awards Honoree**, shipped over **10M units worldwide**, and unveiled the **NDP120** part of the NDP10x family of inference engines for low-power applications.

[www.syntiant.com](http://www.syntiant.com)  
[@Syntiantcorp](https://twitter.com/Syntiantcorp)
TensorFlow is an end-to-end open source platform for machine learning. Our ecosystem of tools, libraries, and community resources help users push the state-of-the-art in building and deploying ML powered applications.
JOIN OUR SESSIONS DURING THE TINYML SUMMIT

Performing inference on BNNs with xcore.ai
Tuesday, March 23 at 12pm (PST)

TinyML: The power/cost conundrum
Thursday, March 25 at 12pm (PST)

VISIT XMOS.AI TO FIND OUT MORE
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