tinyML Summit

Enabling Ultra-low Power Machine Learning at the Edge

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Virtual Event

www.tinyML.org
Introducing MetaTF

AKIDA Neuromorphic ML Framework

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Running ML Applications at the Edge

The problem of deploying ML models at the Edge is two-fold:

1. The only way to attain next-generation power/latency/size is to use domain specific-architectures (DSAs).
2. However, these DSAs have many significant constraints that make model compatibility, training, and deployment extremely challenging.

To solve problem #1, BrainChip has developed a powerful and efficient neuromorphic system-on-chip (NSoC) called AKIDA™.

To solve problem #2, BrainChip has developed MetaTF – An ML framework that takes the CNN ML models of today to the neuromorphic hardware solutions of tomorrow.
MetaTF: A Versatile ML Framework

- The MetaTF ML framework supports two main types of models:
  - DL (deep-learning) SNN models
  - Native SNN models

- **DL SNN models** are genuine CNN models converted to akida SNN models.

  DL CNN models are designed and trained using TensorFlow Keras and converted to AKIDA DL SNN models using the CNN2SNN seamless conversion tool.

- **Native SNN models** are typically composed of a few Dense layers. They often include a specific feature extractor.

  Native SNN models are constructed using the AKIDA native API, which is closely inspired from the Keras API.
Deep-learning professionals do not need to learn any new framework to start using the AKIDA™ ML framework, MetaTF. They can simply craft their models in TensorFlow Keras and convert them for deployment on the AKIDA™ neural processor in a few steps. The typical AKIDA™ deep-learning workflow is comprised of 5 or 6 steps:

- **CNN design** (TensorFlow),
- **CNN training** (TensorFlow),
- **CNN quantization** (cnn2snn/quantize),
- **Optional CNN tuning** (TensorFlow),
- **SNN conversion** (cnn2snn/convert),
- SNN deployment (akida/predict).

The resulting SNN model can then be ran on the AKIDA™ neural processor with a minimal loss in accuracy as compared to the CNN quantized model.
MNIST Example TensorFlow/MetaTF API & WorkFlow

<table>
<thead>
<tr>
<th>Step 1: CNN Design</th>
<th>Step 2: CNN Training</th>
</tr>
</thead>
</table>
| from cnn2snn import check_model_compatibility
  ... |
| check_model_compatibility(mnist_keras)
  ... |
| mnist_keras.compile(loss=..., optimizer=..., metrics=['accuracy'])
  ... |
| mnist_keras.fit(x_train, y_train, epochs=10, ...) |
| ... |
Step 3: CNN Quantization

```python
from cnn2snn import quantize, convert
...

mnist_quantized = quantize(mnist_keras,
    input_weight_quantization=8,
    weight_quantization=4,
    activ_quantization=4)
...

score = mnist_quantized.evaluate(x_test, y_test)
mnist_quantized.fit(x_train, y_train, ..., epochs=2)
...
```

Step 4: CNN Tuning

```python
...
```

Step 5: CNN Conversion

```python
mnist_akida = convert(model_quantized,
    input_scaling=(255, 0))
...
```

Step 6: CNN Deployment

```python
from akida import BackendType, Model

mnist_hw = Model(layers=mnist_akida, BackendType.Hardware)
results = mnist_hw.predict(x_test)
```
Summary

* MetaTF is an intuitive framework to train, convert, and deploy ML models to AKIDA™

* We have a quickly growing library of **DL SNN** and **Native SNN** models for a variety of applications that are freely available with many more under active development.

**DL SNN Models w/ Applications**

* Image Classification/Person Detection
  * Many MobileNet v1 resolution/size variants
* Face Detection & Classification
* Object Detection
  * Custom YOLO variant
* Keyword Spotting
* DVS Image Classification
* 3D Point-Cloud Image Classification

**Native SNN Models w/Applications**

* Fault Detection (accelerometer data set)
* E-Tongue Gustatory (taste) Classification
* E-Nose Olfactory Classification

* Our models come with single-shot edge learning enabled.

* Please visit our documentation website for more information: https://doc.brainchipinc.com/
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!
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Arm: The Software and Hardware Foundation for tinyML

1. Connect to high-level frameworks
   - Profiling and debugging tooling such as Arm Keil MDK

2. Supported by end-to-end tooling
   - Optimized models for embedded
   - Runtime (e.g. TensorFlow Lite Micro)

3. Connect to Runtime
   - Optimized low-level NN libraries (i.e. CMSIS-NN)
   - RTOS such as Mbed OS
   - Arm Cortex-M CPUs and microNPUs

AI Ecosystem Partners

Resources: developer.arm.com/solutions/machine-learning-on-arm

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Advancing AI research to make efficient AI ubiquitous

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Efficient learning
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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
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.
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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
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

Speech enhancement

Speech recognition

Conferencing

Call centers

Digital Assistants

Calling

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

Dataset

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

Test impulse with real-time device data flows

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

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

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

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

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

www.maximintegrated.com/sensors

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

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
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
Add Advanced Sensing to your Product with Edge AI / TinyML

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

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

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