Person Detection under Extreme Constraints: Lessons from the Field

Koen Helwegen - koen@plumerai.com
Plumerai is making deep learning tiny and radically more efficient to enable inference on low-power edge devices with the help of Binarized Neural Networks.
BNNs are the key to tiny ML

32-bit

8-bit

4-bit

2-bit

1-bit

common
BNNs are the key to tiny ML

32-bit

8-bit

4-bit

2-bit

1-bit → 32x less memory compared to 32-bit
Binary Convolution

32-bit $\times$ 1-bit $\rightarrow$ XNOR $\sum_{i,k} = \text{-5}$

1-bit $\times$ 1-bit $\rightarrow$ POPCOUNT $\sum_{i,k} = \text{-5}$
Person detection
Person Detection Demo

- STM32H7B3LI development board
- 280 MHz ARM Cortex-M7 core
- OmniVision 9655 1.3 Megapixel camera

- Model size: 275 kB
- Latency: 895 ms
- Also works on STM32L4R9AI (Cortex-M4)
Live Demo
Extreme performance requires integration

Plumerai
Data Pipeline
Plumerai BNN Models
Plumerai Inference Stack
Plumerai Hardware

We sell the full solution: our inference software with trained BNNs and where applicable with our IP-core for FPGAs.
Extreme performance requires integration

Our software solution for off-the-shelf microcontrollers.

Plumerai Data Pipeline

Plumerai BNN Models

Plumerai Inference Stack

Plumerai Hardware
Extreme performance requires **integration**

Plumerai

Data Pipeline

Plumerai BNN Models

Plumerai Inference Stack

Plumerai Hardware

1. Analysis and identification of failure cases
2. Collection and labeling of examples
3. Model training
4. Verify against previously collected test data

- Analysis and identification of failure cases
- Collection and labeling of examples
- Model training
- Verify against previously collected test data
Extreme performance requires integration

Model architectures are carefully optimized for each hardware platform [1].

Training strategies leverage a deep understanding of BNNs and sophisticated training algorithms [2].


Highly optimized for ARM Cortex-M, ARM Cortex-A and RISC-V architectures.
We will support specialized hardware

XMOS’ xcore.ai is optimized for BNNs

Plumerai IP-core for low-powered FPGAs

and are enlarging our collection of models

Person Presence Detection

Speech recognition

Hand gesture recognition
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

1. Connect to high-level frameworks
2. Supported by end-to-end tooling
3. 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

AI Ecosystem Partners

Supported by end-to-end tooling such as Arm Keil MDK

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

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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.
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- 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

AKIDA™ Enables Processing of All Sensor Modalities
BabbleLabs AI speech wizardry in Cisco Webex

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

Massive compute
- 300 TFLOPS per engineer

Novel deep neural networks
- Silicon-optimized software

Massive data corpus
- 40K hours of speech
- 15K hours of music
- 10K hour of noise
- 100K room models

Speech enhancement
- Conferencing
- Call centers

Speech recognition
- 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

Dataset

Enrich data and train ML algorithms

Impulse

Test

Test impulse with real-time device data flows

Edge Device

Real sensors in real time
Open source SDK

Embedded and edge compute deployment options

www.edgeimpulse.com
The Eye in IoT

Edge AI Visual Sensors

- Ultra Low power CMOS imager
- AI + IR capable

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

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

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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-1 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
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.

www.maximintegrated.com/MAX78000

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/microcontrollers

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.
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

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- Smart Home
- Wearables
- Automotive
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- IoT
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- 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
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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

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Performing inference on BNNs with xcore.ai
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TinyML: The power/cost conundrum
Thursday, March 25 at 12pm (PST)

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