A real application of TinyML in Intelligent Building Sensors

Enabling AI

AT THE VERY EDGE

Martin Croome
VP Marketing
Real life applications of TinyML in building sensors

• What are the necessary trends that have enabled this?
• What is the customer motivation behind this use case?
• Where could it go in the future?
1. Internet of Things

- Was this really something new for buildings?
  - Some kind of building automation is old
  - BACnet was created in the 1980s
- Building automation systems greatly predate IoT
- But sensor and low power network availability motivated by IoT made a lot of new sensor types possible
2. Sensors

- Explosion of different types of sensor
- Each sensor with multiple use cases and possible metrics
- Low cost and power
- Miniaturization

3 key benefits sought:

Reduce building capital and operational costs

Increase / reduce cost of Safety and Security

Increase / reduce cost of occupant comfort
3. Breakthroughs in Artificial Intelligence / Machine Learning

Sensors could perceive

**Classification**
- Person present
- Computer present
- Plant present

**Detection**
- Four people are present
- Desks 2, 3, 4, and 5 are occupied
- Two computers are in use

Richer data processed on sensor: Images, Sounds, Infra-red Images, Radar, Fusions of sensors...

Any concerns?

Yes!

- Privacy
- Acceptability
- Accuracy
- Cost

Requirements

- No identifying data can move off the sensor
- Low cost sensors that are simple to install (no cables)
- High accuracy
GreenWaves Occupancy management reference platform

A wireless sensor with embedded AI / Neural Networks + IR camera

- GAP technology and advanced neural networks
- **Presence detection, people counting, social distance**
- 80 x 80 Bolometer IR Image
- **Anonymous**
- Image processing in the sensor
- **Only useful data is transferred**
- 62ms ~4.4mW / frame / second
- **Battery operated, easy installation**
- 99% accuracy on internally collected training set
- **Reliable**

A full solution for people counting on battery for > 5 years
But most customers do not have the needed expertise in house

- So ...

- Reference board to allow customers to evaluate the solution

- Reference firmware with full source code:
  - Operational firmware
  - Camera control
  - CNN SSD model
  - CNN Training data
  - CNN Fine tuning scripts

- Deployment information
  - Space planning
  - Overlapping sensor management
Our customers are already offering this as a packaged service

- An in-market solution with IR based occupancy sensor
- Emphasis on the real-time data and historical analytics

- Real-Time Occupancy Streaming
- Thermal Human Detection
- 5+ Year Battery Life
- Low-Power Bluetooth Beacon
- Mounts on Ceiling

- Live floorplan views
- Daily Cleaning Maps
- Alerts on unsafe occupancy levels
- Workplace Occupancy Analytics
Where does this lead?

Once you can accurately identify people’s (and thing’s) location in a building a lot of things become possible

- **Room utilization**
- **Crowding in shared spaces**
- **Usage Based Cleaning**
- **Shared resource demand** (e.g. Cafeteria)
- **Intruder Detection**

- **Count**
- **Position**

- **Desk Occupancy**
- **Social distancing**

- **Corridor flow**
  - Passage into / out of rooms

- **Detect path**
- **Detect pose**

- **Fall detection**

- **Add Images**
- **Detect other objects**

- **Meeting room tidiness**
- **Signs of occupancy**

- **Asset Tracking**
  - Chairs / Tables / Projector

- **Add Sounds**
- **Classify Sounds**

- **Detect distress**

and definitely more…
GAP8 -> GAP9

- GAP9 introduces a number of attributes that will further expand the opportunities in building sensors
- An order of magnitude improvement on latency and energy performance
- Direct benefits for occupancy sensors
  - 3X increase in sensor battery life
  - Higher resolution sensors for more detailed scene analysis
  - More complex networks for higher accuracy
  - Multiple sensor sources / Multiple networks
- These possibilities are already being explored by our lead customers
Tiny and not so tinyML

• Current exploration of TinyML is yielding real, high value applications
• But this is just the beginning
• TinyML application space is very large:
  • IoT Sensors – Sensor analysis
  • IoT Devices – Sensor fusions – hierarchical analysis
  • Hearables – Situation aware ANC, Voice enhancement, UI, bio-sensors
  • And much more …

Come to our breakout session at 13h00 in room 6 to discuss occupancy management with GAP8 and the new applications possible with GAP9
Thank you!

Questions?
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
2. Supported by end-to-end tooling
3. Connect to Runtime

1. Profiling and debugging tooling such as Arm Keil MDK
2. Optimized models for embedded runtime (e.g. TensorFlow Lite Micro)
3. Optimized low-level NN libraries (i.e. CMSIS-NN)
   RTOS such as Mbed OS
   Arm Cortex-M CPUs and microNPUs

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Reasoning
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Action
Reinforcement learning for decision making

A platform to scale AI across the industry

Qualcomm AI Research is an initiative of Qualcomm Technologies, Inc.
NEURAL PROCESSING

- 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.

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- Software Development Platform

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Speech recognition

Conferencing

Call centers

Digital Assistants

Calling

300 TFLOPS per engineer

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

Acquire valuable training data securely

Enrich data and train ML algorithms

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- Processing of low-res images
- Human detection and other classifiers

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.
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
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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

Target Markets/Applications

- Industrial Predictive Maintenance
- Smart Home
- Wearables
- Automotive
- Mobile
- IoT

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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

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