“Advanced Anomaly Detection Made Easy”

Jenny Plunkett – Senior Developer Relations Engineer, Edge Impulse

February 15, 2022
tinyML Talks Strategic Partners

Additional Sponsorships available – contact Olga@tinyML.org for info
Executive Strategic Partners
Arm: The Software and Hardware Foundation for tinyML

1. Connect to high-level frameworks
2. Profile and debug at high level using Arm Keil MDK
3. Connect to Runtime

1. Application
2. Optimized models for embedded
3. 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

Stay Connected
- @ArmSoftwareDevelopers
- @ArmSoftwareDev

Resources: developer.arm.com/solutions/machine-learning-on-arm
The leading edge ML platform

www.edgeimpulse.com
Advancing AI research to make efficient AI ubiquitous

A platform to scale AI across the industry

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
SYNTIANT

Neural Decision Processors
- At-Memory Compute
- Sustained High MAC Utilization
- Native Neural Network Processing

ML Training Pipeline
- Enables Production Quality Deep Learning Deployments

Data Platform
- Reduces Data Collection Time and Cost
- Increases Model Performance

End-to-End Deep Learning Solutions for TinyML & Edge AI

partners@syntiant.com
www.syntiant.com
WE USE AI TO MAKE OTHER AI FASTER, SMALLER AND MORE POWER EFFICIENT

- **Automatically compress** SOTA models like MobileNet to <200KB with little to no drop in accuracy for inference on resource-limited MCUs

- **Reduce** model optimization trial & error from weeks to days using Deeplite’s design space exploration

- **Deploy more** models to your device without sacrificing performance or battery life with our easy-to-use software

BECOME BETA USER [bit.ly/testdeeplite]
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

- Pre-built 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
BROAD AND SCALABLE EDGE COMPUTING PORTFOLIO

Microcontrollers & Microprocessors

<table>
<thead>
<tr>
<th>Arm® Core</th>
<th>Renesas Core</th>
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<tbody>
<tr>
<td>Arm® Cortex®-M 32-bit MCUs</td>
<td>Ultra-low Energy 8 &amp; 16-bit MCUs</td>
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<tr>
<td>Arm ecosystem, Advanced security, Intelligent IoT</td>
<td>Bluetooth® Low Energy, SubGHz, LoRa®-based Solutions</td>
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<td>Arm®-based High-end 32 &amp; 64-bit MPUs</td>
<td>High Power Efficiently 32-bit MCUs</td>
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<td>High-resolution HMI, Industrial network &amp; real-time control</td>
<td>Motor control, Capacitive touch, Functional safety, GUI</td>
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<tr>
<td>Arm® Cortex®-M0+ Ultra-low Power 32-bit MCUs</td>
<td>40nm/28nm process Automotive 32-bit MCUs</td>
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<td>Innovative process tech (SOTB), Energy harvesting</td>
<td>Rich functional safety and embedded security features</td>
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</table>

Renesas Synergy™ Arm®-based 32-bit MCUs for Qualified Platform Qualified software and tools

Core technologies

AI
A broad set of high-power and energy-efficient embedded processors

Digital & Analog & Power Solution
Winning Combinations that combine our complementary product portfolios

Security & Safety
Comprehensive technology and support that meet the industry’s stringent standards

Cloud Native
Cross-platforms working with partners in different verticals and organizations

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Maxim Integrated: Enabling Edge Intelligence

**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](http://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](http://www.maximintegrated.com/microcontrollers)

**Sensors and Signal Conditioning**
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](http://www.maximintegrated.com/sensors)
LatentAI
Adaptive AI for the Intelligent Edge
Latentai.com
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
**SynSense** builds **sensing and inference** hardware for **ultra-low-power** (sub-mW) **embedded, mobile and edge** devices. We design systems for **real-time always-on smart sensing**, for audio, vision, IMUs, bio-signals and more.

https://SynSense.ai
Silver Strategic Partners
tinyML Summit 2022
Miniature dreams can come true...
March 28-30, 2022
Hyatt Regency San Francisco Airport
https://www.tinyml.org/event/summit-2022/

The Best Product of the Year and the Best Innovation of the Year awards are open for nominations between November 15 and February 28.

tinyML Research Symposium 2022
March 28, 2022
https://www.tinyml.org/event/research-symposium-2022

More sponsorships are available: sponsorships@tinyML.org
tinyML Trailblazers Series
Success Stories with Marian Verhelst
(Professor, EE Department of KU Leuven)

LIVE ONLINE March 2nd, 2022 at 8 am PST

Register now!
Join Growing tinyML Communities:

tinyML - Enabling ultra-low Power ML at the Edge

The tinyML Community
https://www.linkedin.com/groups/13694488/

8k members in 42 Groups in 33 Countries

2.6k members & 4.9k followers
Subscribe to tinyML YouTube Channel for updates and notifications (including this video)

www.youtube.com/tinyML
# Next tinyML Talks

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<th>Topic / Title</th>
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<td>Wednesday, February 16</td>
<td>Gian Marco Iodice, ML Tech Lead</td>
<td>TinyML: A practical analysis of the technology that will make AI ubiquitous</td>
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<td>Arm</td>
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Webcast start time is 8:00 am Pacific time

Please contact talks@tinyml.org if you are interested in presenting
Reminders

Slides & Videos will be posted tomorrow

Please use the Q&A window for your questions

tinyml.org/forums  youtube.com/tinyml
Jenny Plunkett is a Texas Longhorn and software engineer, working as a Senior Developer Relations Engineer at Edge Impulse. Since graduating from The University of Texas she has been working in the IoT space, from customer engineering and developer support for Arm Mbed to consulting engineering for the Pelion device management platform.
Advanced Anomaly Detection Made Easy

Jenny Plunkett, Senior DevRel Engineer
February 2022
Agenda

• What is Edge Impulse?
• Advanced Anomaly Detection
• Use Cases
• Live Demo 🚀
Edge Impulse
Go to market faster with confidence
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<td>Predictive healthcare</td>
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# Any sensor, any data, any use case

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<th>Use cases</th>
<th>Ultra low power</th>
<th>Low-end MCU</th>
<th>High-end MCU</th>
<th>NPU</th>
<th>CPU</th>
<th>GPU</th>
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<td>• Wake word smart helmet</td>
<td>• Glass breaking detection</td>
<td>• MCSA (motor)</td>
<td>• Smart kitchen visual aid</td>
<td>• Worker safety assembly line manufacturing</td>
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<td>• O&amp;G drill bit applied force prediction</td>
<td>• Pallet situation awareness</td>
<td>• Fire detection</td>
<td>• Fitness tracker</td>
<td>• QA food conveyor</td>
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<td>• Pump anomaly detection</td>
<td>• Washing machine load estimation</td>
<td>• KWS enterprise headsets</td>
<td>• Smart camera</td>
<td>• Crowd management</td>
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<td>• Multi-object detection</td>
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<td>• Traffic management</td>
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<td>Memory</td>
<td>Anomaly detection sensor classification 10kB</td>
<td>Anomaly detection sensor classification 10kB</td>
<td>Video keyword audio classification 50kB</td>
<td>Image classification 256kB</td>
<td>Object detection complex voice processing 1MB+</td>
<td>Video classification 10MB+</td>
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</tbody>
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### Sensor
- Low-end MCU
- High-end MCU
- NPU
- CPU
- GPU

### Audio
- Ultra low power
- Low-end MCU
- High-end MCU
- NPU
- CPU
- GPU

### Image
- Ultra low power
- Low-end MCU
- High-end MCU
- CPU
- GPU

### Video
- Ultra low power
- Low-end MCU
- High-end MCU
- NPU
- CPU
- GPU
Enabling all enterprises and developers with ML

40,000+ Developers
65,000+ Projects
100+ Enterprises

TRUSTED BY LEADING ENTERPRISES
Advanced MLOps infrastructure

- SSO for all your enterprise’s accounts
- Store, view and manage all your enterprise’s data, projects and users
- Unlock full team collaboration
- Turn raw data into an ML ready dataset
- Build advanced queryable datasets, with easy quality control
- Save time and cost by leveraging Edge Impulse’s public cloud integrations
- Use upload portals to allow customers or partners to upload data securely

Interested? Send us an email at hello@edgeimpulse.com
Advanced anomaly detection
What is advanced anomaly detection?

- Use machine learning on the edge to identify machine failures before they occur
- Expensive factory machines, robots, scientific equipment
- Repairing equipment is costly, time-consuming
- Repairs can sometimes impossible altogether
Why is anomaly detection important?

- Monitor the health of the equipment before it breaks
- Worker safety, reduce equipment maintenance costs, minimal overhead
- Algorithm detects data outside “nominal” range → anomaly detected
- Anomaly detected → notify operators, shut down equipment, perform maintenance
How do I make an anomaly detection model?

• Collect data for 2 classes “nominal operation” & “off”
• No need to break the equipment to obtain data for “broken”, “obstructed”, or “needs repairs” classes
• Extract important features from these classes via DSP
• Train algorithm on nominal data’s important features
Extract features with DSP blocks

- Edge Impulse provides many pre-written, freely available DSP blocks for extracting meaningful features from your data
- **No black boxes**, all DSP source code is available on our GitHub
Custom DSP blocks

- Write your own DSP code
- Deploy your DSP block in a Docker container
- Host your container, add URL to Studio
- Specify any number of input parameters
- Customize your feature output and labels
Feature importance

• Build advanced anomaly detection algorithms in minutes with Edge Impulse feature importance suggestions
K-means anomaly detection block

- K-mean anomaly detection pre-written and available to use in any sensor data project
- Use automatically suggested important features/axes to create your anomaly detection model
Test & refine your model

• Use Edge Impulse Studio’s built-in model testing tools to verify the accuracy of your model
• Test without writing any code or deploying to the edge device
• Calculate how abnormal each frequency band is per sample
Deployment

- Deploy to any edge device with ease
- No black boxes, access to full source code with DSP, NN, & anomaly detection C++ code
- Generate pre-built firmware for rapid prototype development on supported hardware

You can deploy your impulse to any device. This makes the model run without an internet connection, minimizes latency, and runs with minimal power consumption. Read more.

Create library

Turn your impulse into optimized source code that you can run on any device.

Build firmware

Or get a ready-to-go binary for your development boards, and run your impulse.

[Options for build firmware: C++ library, Arduino library, WebAssembly, TensorRT library, ST IoT Discovery Kit, Arduino Nano 33 BLE Sense]
Use cases
Smart Predictive Maintenance
Use Cases & Applications

Air Conditioner Filter Monitoring
In an air conditioning system, it is difficult to detect clogged filter, is clogged. When the filter is slightly obstructed, the shape of the high frequency current is distorted and detected by the microcontroller.

Circuit Breaker Ageing
Circuit breaker ageing can be analyzed from vibration pattern during switching. The mechanical ageing of circuit breakers is virtually impossible to anticipate, leading to untimely power outages, production stoppages.

Water or Hazardous Leak Detection
Vibration sensors placed on pipes can detect water dropping at several meters. Add-on device or existing hardware MCU with a vibration sensor near the valves can learn opened/flushed behavior and detect unexpected leaks.
Smart Predictive Maintenance
Use Cases & Applications

**Motor control & condition monitoring**
Measure the condition of a motor with multiple sensors to measure temperature, vibration, sound, and analyze all the sensor data to define the condition of a motor and to predict when the motor can fail.

**Ball bearings crack detection**
Analyze vibration on ball bearings to predict if the ball bearing will break. Ball bearings faults are one of the main causes of breakdown of rotating machines. Detection and diagnosis of mechanical faults is crucial for reliable operation.

**Gas leak detection**
Detect gas leakage with ultrasound inspection and condition monitoring.
Further resources
A few examples of cloneable and modifiable projects that contain the data set, the feature extraction stage and the pre-trained model, ready to be deployed on a device.

1. **Faucet Detection with Sound** - [Project](#)
2. **Hard Hat Detection** - [Project](#)
3. **Banana Ripeness Detection** - [Project](#)
4. **Smoke Detector using TVOC Sensor** - [Project](#)
5. **AC Motor Fault Detection** - [Project](#)
6. **Fan Failure/Anomaly Detection** - [Project](#)
Documentation & tutorials

• Advanced Anomaly Detection & Feature Importance blog
• Edge Impulse processing blocks documentation
• Building custom processing blocks tutorial
• Hosting custom processing blocks tutorial
• Building deployment blocks tutorial
Live demo 🚀
Thank you!
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