“Building TinyML applications with Silicon Labs EFR32MG24 wireless SoC platform”

Andrew Halstead - Senior Field Applications Engineer, Silicon Labs

September 23, 2022
Thank you, tinyML Strategic Partners*, for committing to take tinyML to the next Level, together
Executive Strategic Partners
Arm AI Virtual Tech Talks

The latest in AI trends, technologies & best practices from Arm and our Ecosystem Partners.

Demos, code examples, workshops, panel sessions and much more!

Fortnightly Tuesday @ 4pm GMT/8am PT

Find out more: www.arm.com/techtalks
EDGE IMPULSE

The Leading Development Platform for Edge ML

edgeimpulse.com
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.
Accelerate Your Edge Compute

SYNTIANT

Making Edge AI A Reality

www.syntiant.com
Platinum Strategic Partners
Fastest Video Analytics Solutions on Arm CPUs
High-Value or Safety-Critical Use Cases?

For your most important projects, use

TinyML software that covers the full engineering lifecycle: Reality AI Tools®

- AutoML for non-visual sensing based on advanced signal processing math
- Hardware design analytics
- Explanation of TinyML models in terms of underlying physics
- Automated Data Readiness assessment

https://reality.ai/  @SensorAI  info@reality.ai
Renesas is enabling the next generation of AI-powered solutions that will revolutionize every industry sector.
Sony Semiconductor Solutions Corporation
Gold Strategic Partners
Witness potential made possible at analog.com.

Where what if becomes what is.
Making Over-the-Air Firmware and ML models Updates Simple and Accessible!

- Securely update your IoT devices regardless of their Hardware Platform (Silicon) Provider and physical location.
- Unlock TinyML business value through OTA Firmware and ML models update.
- Pay-as you-go

www.fotahub.com

contact@fotahub.com
TOGETHER, WE ACCELERATE THE BREAKTHROUGHS THAT ADVANCE OUR WORLD

www.nxp.com/ai
Deploy TinyML into the Real World - Plug and Play ML

Sensors:
- modulated and ready-to-use sensors to simplify the setup process
- support 500+ Grove modules

Codecraft:
- no code programming platform to get started with TinyML
- supports Arduino, Python, C or JavaScript etc.

Edge Impulse:
- to optimize data utilization and enable deploy machine learning model faster than ever

Wio Terminal:
- completed AI platform — integrated with a 2.4" LCD Screen, onboard IMU (LIS3DHTR), microphone, buzzer, microSD card slot, light sensor, infrared emitter (IR 940nm)

TensorFlow Lite:
- to easily train low memory usage machine learning models

Motion / Gesture / Speech / Smell / Sports
Barcode / Face / Image

Sense  Train  Inference  Applications

Artificial Nose
AI Thermal Camera for Safe Camping
Azure IoT Squirrel Feeder
The Right Edge AI Tools Can Make or Break Your Next Smart IoT Product

Analytics Toolkit Suite

AutoML

Data Collection

Test & Validation

Data Labeling

Code Writing

Version Control and Model Management

Team Collaboration

sensiml.com/tinyML
STMicroelectronics provides extensive solutions to make tiny Machine Learning easy
ENGINEERING EXCEPTIONAL EXPERIENCES

We engineer exceptional experiences for consumers in the home, at work, in the car, or on the go.

www.synaptics.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 Neuromorphic Engineering Forum
Chair: Prof. Charlotte Frenkel (TU-Delft)

September 27, 2022
https://www.tinyml.org/event/tinyml-neuromorphic-engineering-forum

tinyML is a fast-growing initiative around low-power machine-learning technologies for edge devices. The scope of tinyML naturally aligns with the field of neuromorphic engineering, whose purpose is to replicate and exploit the way biological systems sense and process information within constrained resources.

More sponsorships are available: sponsorships@tinymL.org
tinyML EMEA Innovation Forum 2022
Chair: Prof. Francesco Conti (Univ of Bologna)

Connect, Unify, and Grow the tinyML EMEA Community
October 10-12, 2022

https://www.tinyml.org/event/emea-2022
in person in Cyprus, Grand Resort, Limassol

Registration is open now (late fee after Sept 15)

Keynote speakers:

Massimo BANZI
CTO, Arduino

Alberto L. SANGIOVANNI-VINCENTELLI,
UC-Berkeley, Cadence & Synopsys

More sponsorships: sponsorships@tinyML.org
Join Growing tinyML Communities:

**Meetup**

11.3k members in 46 Groups in 37 Countries

**tinyML - Enabling ultra-low Power ML at the Edge**


**LinkedIn**

3.1k members & 8.4k followers

**The tinyML Community**

[https://www.linkedin.com/groups/13694488/](https://www.linkedin.com/groups/13694488/)
Subscribe to tinyML YouTube Channel for updates and notifications (including this video)
www.youtube.com/tinyML
Reminders

Slides & Videos will be posted tomorrow

tinyml.org/forums   youtube.com/tinyml

Please use the Q&A window for your questions
Andrew Halstead

Andrew is a Senior Field Applications Engineer at Silicon Labs. He has been at the company for 4 years, and has been in the semiconductor industry for 15. His background is in standards-based wireless protocols, in particular BLE and WiFi, although more recently he has been involved in embedded security and AI/ML.
Welcome

AI/ML: Building a TinyML application with Silicon Labs MG24

Andy Halstead
andy.halstead@silabs.com
The Leader in IoT Wireless Connectivity

100% IoT Focused

#1 Share in Mesh

1st To Market with Multiprotocol, BLE Mesh, BLE 5.1

Innovation

Breadth and Depth of Wireless IoT Protocols

ember 2012
Software ZigBee SoC

2013 Low-power 32-bit MCUs

2015 BT Smart Modules

2015 ZigBee/Thread Modules

Micrium 2016
Software RTOS

2017 Cloud Connected Wi-Fi

2018 Smart Home Protocol

2020 Ultra Low Power Wi-Fi

© 2022 Silicon Laboratories Inc.
### AI/ML on Wireless Gecko Series 1 and Series 2 in Production

#### Series 1 SoCs

- **High Performance Platform**
  - 32-bit ARM® Cortex®-M4 core (up to 40 MHz)
  - Line power/battery power

- **Battery Powered Mesh Devices**
  - EFR32xG12
    - Developer kit: Thunderboard Sense 2

- **AI Software**
  - TensorFlow Lite for Microcontrollers
  - 3rd Party end-to-end tools

- **All Series 1 SoCs support ML**

#### Series 2 SoCs

- **Higher Performance Platform**
  - ARM Cortex M33 (78 MHz)
  - Improved radio performance
  - Lower power (MCU active, TX/RX)

- **Battery Powered Mesh Devices**
  - EFR32xG24
    - Developer kit: xG24-DK2601B

- **Improved Security**
  - Secure Vault - Mid
  - Secure Vault - High (select OPNs)

- **Acceleration (xG24)**
  - AI/ML acceleration
  - Faster AoA/AoD calculation

- **AI Software**
  - TensorFlow Lite for Microcontrollers with accelerated kernels
  - 3rd Party end-to-end tools

- **All Series 2 SoCs support ML**

---

**Common Machine Learning software and tools on both Series 1 and Series 2 Wireless SoCs**

Use cases are dependent on RAM and wireless stack
Silicon Labs Machine Learning Solution Benefits

• Industry’s widest portfolio of wireless solutions combined with ML for Tiny Edge devices
  ▶ Bluetooth, 802.15.4/ZigBee/Thread, Matter, Z-Wave, Prop, Wi-Sun, Sidewalk

• Integrated ML hardware accelerator (xG24) provides 8X faster ML inferencing with 1/6th of energy
  ▶ Reduces BOM, footprint and design complexity while minimizing latency

• ML development tools and solutions for explorers to experts for faster application development
  ▶ TensorFlow Lite Micro supported in GSDK
  ▶ Partnerships with Edge Impulse, SensiML and MicroAI accelerate embedded ML development
  ▶ Silicon Labs’ ML Tool Kit on GitHub provides complete control & flexibility for the expert developers

• Wide range of use cases including low data rate sensors, audio/voice and low-res images
Software and Tool Support

**ML Expert**
- Python scripts
- TensorFlow
- TFLite Flatbuffer
- TFLite-micro Interpreter
- CMSIS-NN Kernels
- Cortex M
- NPU

**ML Explorer**
- GUI Developer Tools
- EDGE IMPULSE
- www.edgeimpulse.com
- SensiML
- www.sensiml.com
- TFLite-micro Interpreter
- CMSIS-NN Kernels
- Cortex M
- NPU

**ML Solutions**
- Anomaly Detection
  - Micro.ai
  - www.micro.ai
- Wake and Command word detection
  - Sensory
  - www.sensory.com
- Cortex M
Machine Learning Tools Workflow

ML Solutions bypasses the machine learning workflow, because it’s based on a pre-configured library easily integrated into GSDK

- Develop (wireless) embedded application
- Integrate Model
- Test & Run

Create Data Set → Train Model → Test Model → Convert Model

ML Explorer
- 3rd Party – GUI, cloud, end-to-end

ML Expert
- Bring your Own Data (BYOD)
- Silicon Labs MLTK (self-serve, community support, as-is)

ML Expert
- Bring your Own Model (BYOM)
- Model Profiler (from MLTK)

ML Experience
- Increasing Flexibility
- Series 1 and 2 (excluding xG24) can be seen on the left diagram.
- xG24 architecture can be seen on the right. Note use of the MVP is largely transparent, and operations when supported will be offloaded else they will fall back to the CMSIS-NN implementation.
Machine Learning Development Kits

**xG24-DK2601B Dev Kit (on MG24)**
- Wireless SoC with multi-protocol radio
- ARM® Cortex-M33 with TrustZone, 256 kB RAM and 1536 kB Flash, 80 MHz
- AI/ML Hardware Accelerator
- Broad Range of Sensors
  - 9-axis Inertial Sensor
  - 2 Digital Microphones
  - Pressure Sensor
  - Indoor Air Quality and Gas Sensor
  - Relative Humidity and Temperature Sensor Si7021
  - UV and Ambient Light Sensor
  - Hall-effect Sensor Si7210
- [https://www.silabs.com/development-tools/wireless/efr32xg24-dev-kit](https://www.silabs.com/development-tools/wireless/efr32xg24-dev-kit)

**Thunderboard Sense 2 (on MG12)**
- Wireless SoC with multi-protocol radio
- ARM® Cortex-M4 core with 256 kB RAM and 1024 kB Flash, 40 MHz
- Broad Range of Sensors
  - 6-axis Inertial Sensor
  - Digital Microphone
  - Pressure Sensor
  - Indoor Air Quality and Gas Sensor
  - Relative Humidity and Temperature Sensor Si7021
  - UV and Ambient Light Sensor
  - Hall-effect Sensor Si7210
**ML Partner: Edge Impulse**

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Edge Impulse</th>
<th>Product Name</th>
<th>Edge Impulse platform</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales Contact</td>
<td>Sally Atkinson</td>
<td>Pricing Structure</td>
<td>• Free developer tier</td>
</tr>
<tr>
<td>Website</td>
<td><a href="http://www.edgeimpulse.com">www.edgeimpulse.com</a></td>
<td></td>
<td>• Enterprise license – monthly fee per project (annual commitment)</td>
</tr>
<tr>
<td>Headquarters</td>
<td>San Jose, CA</td>
<td>Silicon Labs Support</td>
<td>EFR32, EFM32, xG24 Dev Kit, Thunderboard Sense 2</td>
</tr>
</tbody>
</table>

**The Edge Impulse approach:**

- **One platform** to manage all data engineering and edge machine learning development
- **Best-in-class solutions engineering** team to help validate and develop your use cases in months
- **Develop edge ML development skills** in-house over time

**One platform, custom models, hardware agnostic, short development timelines (3-6 months)**

**Product Description**

Edge Impulse enables advanced machine learning on edge devices, instead of sending data inefficiently to the cloud, maximizing privacy and energy efficiency. Unlike data science tools, Edge Impulse is designed for developers and engineers targeting a huge range of devices, from tiny microcontrollers to powerful edge devices for real-time sensor, audio and image data.

**Key Value Prop**

- Full end to end MLOps platform
- Any data with any device
- Time to market substantially decreased
- Low code and accessible for SMEs, no data science skills required
- Complete transparency, no black box approach, allowing your customers to create their own IP
# ML Partner: SensiML

<table>
<thead>
<tr>
<th>Company Name</th>
<th>SensiML</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales Contact</td>
<td>Chris Rogers <a href="mailto:chris.rogers@sensiml.com">chris.rogers@sensiml.com</a></td>
</tr>
<tr>
<td>Website</td>
<td>sensiml.com</td>
</tr>
<tr>
<td>Headquarters</td>
<td>Beaverton, Oregon</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Product Name</th>
<th>SensiML Analytics Toolkit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pricing Structure</td>
<td><a href="https://sensiml.com/plans/">https://sensiml.com/plans/</a></td>
</tr>
<tr>
<td>Silicon Labs Support</td>
<td>EFR32, EFM32, xG24 Dev Kit, Thunderboard Sense 2</td>
</tr>
</tbody>
</table>

---

**Product Description**

AutoML Software for Building Intelligence into the IoT Edge

---

**Key Value Prop**

- Complete end-to-end AI workflow.
- Full code transparency and greatest flexibility.
- Solution scalability with expansive AI and DSP libraries
- Built from the ground-up for commercial development teams

- Acoustic event detection
- Motion analysis
- Gesture & keyword recognition
- Anomaly detection
- Predictive maintenance
Resources - General

- **Silicon Labs AI/ML Resources:**
  - ML Web Landing Page
  - ML Doc Landing Page

- **Demos Available:**
  - Sensor Signal Processing
  - Audio Pattern Matching
  - Voice Command
  - Low Resolution Vision
  - MLTK + Command Word Detection

- **Partners’ Resources:**
  - Edge Impulse
  - SensiML
  - MicroAI
Resources – Labs/Further Info

- Edge Impulse:
  - https://github.com/edgeimpulse/firmware-silabs-xg24
  - https://github.com/edgeimpulse/workshop-silabs-xg24-dev-kit

- SensiML
  - https://github.com/sensiml?q=xg24&type=all&language=&sort=

- SiLabs
  - Machine Learning Fundamentals
  - https://www.silabs.com/support/training/mg24-tech-lab-workshop-series
  - https://github.com/SiliconLabs/training_examples/tree/master/mg24_tech_lab
Next Steps…

Silicon Lab’s Machine Learning PAC-MAN

INSTALLATION

1. Obtain a BRD2601 development board from [HERE] and connect to your computer.
2. Install the JLink driver by installing Simplicity Studio OR Segger J-Link.
3. Download the BRD2601 firmware image from [HERE].
4. Download the Silicon Labs Commander utility from [HERE].
5. Use Commander to program the firmware image to the development board.
6. Click [HERE] to open a bluetooth connection to development board.
7. Play Pac-Man using the keywords: Left, Right, Up, Down.

SEE THE MLTK documentation FOR MORE DETAILS.

This was adapted from a game created by Lucio Panipula.
View original source code on [GitHub].
Copyright Notice

This multimedia file is copyright © 2022 by tinyML Foundation. All rights reserved. It may not be duplicated or distributed in any form without prior written approval.

tinyML® is a registered trademark of the tinyML Foundation.

www.tinyml.org
Copyright Notice

This presentation in this publication was presented as a tinyML® Talks webcast. The content reflects the opinion of the author(s) and their respective companies. The inclusion of presentations in this publication does not constitute an endorsement by tinyML Foundation or the sponsors.

There is no copyright protection claimed by this publication. However, each presentation is the work of the authors and their respective companies and may contain copyrighted material. As such, it is strongly encouraged that any use reflect proper acknowledgement to the appropriate source. Any questions regarding the use of any materials presented should be directed to the author(s) or their companies.

tinyML is a registered trademark of the tinyML Foundation.

www.tinyml.org