tinyML Talks
Enabling Ultra-low Power Machine Learning at the Edge

“TinyML 101 - the new area of AI inside the IoT”

Abraham Arce - Cloud Software Engineer, Intel
Sheratan Arevalo - SAP Team Lead, Global Company

February 24, 2022

www.tinyML.org
tinyML Talks Strategic Partners

Additional Sponsorships available – contact Olga@tinyML.org for info
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
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
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
Platinum Strategic Partners
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
- 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

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

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

### Core technologies

**AI**<br>A broad set of high-power and energy-efficient embedded processors

**Security & Safety**<br>Comprehensive technology and support that meet the industry’s stringent standards

**INNOVATION**

**Digital & Analog & Power Solution**<br>Winning Combinations that combine our complementary product portfolios

**Cloud Native**<br>Cross-platforms working with partners in different verticals and organizations

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Gold Strategic Partners
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

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

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
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**

8.3k members in 43 Groups in 34 Countries

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

2.6k members & 5.1k 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>Date</th>
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<tr>
<td>Friday, February 25</td>
<td>MB Jallow, MarsCrowd</td>
<td>Application of ultra-low-power and resource-constrained devices to improve health care delivery in resource-constrained communities</td>
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Webcast start time is 4:30 am Pacific time

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

Slides & Videos will be posted tomorrow

tinyml.org/forums  youtube.com/tinyml

Please use the Q&A window for your questions
Sheratan Arevalo

Sheratan Arevalo leads SAP Support and Functional Operation for a Global Company. He also has experience as software developer and hardware enthusiastic for more than 14 years. He has a passion for mentoring and coaching young people.
Abraham works at Intel as Cloud Software Engineer, contributing to GNU/Linux since 1996, HAM Amateur Radio operator, trainer and consultant in the Internet of Things space.
Code | Learn | Contribute

What will you create?
Network of physical objects—“things”—that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet.
IoT – High Level Architecture

Device → Gateway → Cloud → Analytics → UI
IoT – High Level Architecture - Health

- **Device**
- **Gateway**
- **Cloud**
- **UI**
- **Analytics**
IoT - End to End Solution

EYE OF THE IOT

Network Infrastructure

Central Management, Archive and Analytics
‘20 TAM: ~5Mu/year

Video Gateways, Servers & Recorders
‘20 TAM: >20Mu/year

Video & Data Analytics
Software & Services

Cameras
‘20 TAM: ~350Mu/year

Security & Surveillance
Public Safety

Traffic Control
ADAS

Smart Home & Building

Manufacturing Robotics

Retail Analytics

Healthcare

Infrastructure

VIDEO IS A PILLAR
OF THE IOT

MASSIVE MARKET OPPORTUNITY

A MARKET IN NEED
OF A LEADER

Multiple sources: IHS, Markets & Markets, Strategy Analytics, Intel research
IoT - End to End Solution – Bacab Home
Personal Project
IoT - End to End Solution – Bacab Home
Personal Project
IoT – Inside the Architecture

Edge Computing

Connectivity
- 5G
- LoRa
- zigbee

Communication Protocols
- MQTT
- zigbee

Embedded Devices

Software
- C++
- Python

Cloud

Security

AI
IoT – Inside the Architecture

**Connectivity**
- 5G
- LoRa
- Zigbee

**Communication Protocols**
- MQTT
- Zigbee

**Embedded Devices**
- C++
- Python

**Software**
- Sensors / Actuators

**Cloud**

**AI**

**Security**

**Edge Computing**
IoT – Sensors & Actuators

Sensor

Actuator

Sensor categories:
- Accelerometer: Measure acceleration & tilt or collision detection
- Analog inputs: Sensors with a variable voltage output
- Atmospheric pressure: Measure pressure and atmospheric conditions
- Button: Button, Switch or Toggle
- Color Sensor: Light sensors with special function: Color recognition
- Compass/Magnetometers: Measure magnetic field to give rotation or heading
- Digital Potentiometer: Resistive digital to analog convert (DAC)
- Displays: TFT, LCD, LED display elements
- Electricity: Measure electric current and ADC converters
- Flex/Force: Measure bending or detect vibration
- Gas: Measure substance concentrations in gases
- GPS: Provide positioning capabilities
- Gyroscopes: Measure rotation rate in one or more axes
- LEDs: LEDs, LED strips, LED matrix displays & controllers
- Light/Proximity/IR: Measure light intensity or distances
- Liquid Flow: Measure liquid flow rates or levels
- Medical: Sensors with specific medical application
- Motor: Various motors & controllers to get things moving
- Other: Other types of supported sensors
- Relay: Different low and high power relays
- RFID: Wireless sensors using RFID tags
- Serial: Sensors using serial communication
- Servo: Various servos motors & controllers
- Sound: Provide sound recording or playback
- Temperature/Humidity: Measure temperature & humidity
- Time: Real time clocks & time measurement
- Touch Sensor: Capacitive touch sensors
- Video: Provide video or video camera access
- Wireless Communication: Provide WiFi, Bluetooth, RF communication

Sensor framework for IoT developers
IoT – Inside the Architecture

- Connectivity
- Communication Protocols
- Embedded Devices
- Sensors / Actuators
- Software
- Cloud
- AI
- Security

- Edge Computing
- 5G
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- zigbee
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- Python
- C++
IoT – Embedded Devices
IoT – Inside the Architecture

Connectivity
- 5G
- LoRa
- Zigbee

Communication Protocols
- MQTT
- Zigbee

Embedded Devices

Software
- C++
- Python

Cloud

AI

Security

Sensors / Actuators

Edge Computing
IoT – Connectivity

WiFi

Bluetooth

Zigbee

Lower Power Area Network (LPWAN)
- LTE-M
- NB-IoT
- LoRa

Cellular
- LTE
- 2G
- 3G
- 4G
- 5G
IoT – Inside the Architecture

- Sensors / Actuators
- Embedded Devices
- Connectivity
- Communication Protocols
- Software
- Edge Computing
- Cloud
- AI
- Security
IoT - Communication Protocols

Some Popular Protocols

• MQTT – Message Queue Telemetry Transport Protocol
• COAP – Constrained Application Protocol
• AMQP – Advance Message Queuing Protocol
• DDS – Data Distribution Service
IoT – Inside the Architecture

- Sensors / Actuators
- Embedded Devices
- Connectivity
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- Edge Computing
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- AI
- Security
Arduino is a simple-to-use IoT platform, operates through an array of hardware specifications that can be given to interactive electronics.

IoT Platform based on Node.js. It is considered a complete toolkit to make HTTP API for devices. Zetta combines Rest API, websockets.

Visual tool for lining the Internet of Things, i.e., wiring together hardware devices, APIs, and online services in new way.
IoT – Inside the Architecture

- Sensors / Actuators
- Embedded Devices
- Connectivity
- Communication Protocols
- Software
- Cloud
- AI
- Security
The Internet of Things (IoT) has been associated with major cyberattacks, often involving the abuse of vulnerable connected devices, such as surveillance cameras, to facilitate malicious activities.
IoT – Inside the Architecture

Connectivity

Communication Protocols

Embedded Devices

Software

Sensors / Actuators

Cloud

AI

Security

Edge Computing
• **Google** Cloud Platform

• **IBM** Watson IoT

• **Amazon** AWS IoT Core

• **Digital Ocean**

• **Microsoft** Azure IoT Suite

• **Oracle** IoT

• **Cisco** IoT Cloud Connected
IoT – Inside the Architecture

- Connectivity
- Communication Protocols
- Embedded Devices
- Sensors / Actuators
- Software
- Cloud
- AI
- Security
IoT – Edge Computing
IoT – Inside the Architecture

- Sensors / Actuators
- Embedded Devices
- Connectivity
- Communication Protocols
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- Edge Computing
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- AI
- Security
IoT – AI
IoT – Inside the Architecture

Edge Computing

Connectivity
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Embedded Devices

Software
- C++
- Python

AI

Cloud

Security

Sensors / Actuators
IoT - End to End Solution – Bacab Home
Integrate tinyML
IoT – Call to Action
#tinyML #Latam

Edge Computing

- Connectivity
- Embedded Devices
- Sensors / Actuators
- Communication Protocols
- Software
- Cloud
- AI
- Security
Tiny Machine Learning (or TinyML) is a **machine learning** technique that integrates reduced and **optimized machine learning** applications that require “full-stack” (hardware, system, software, and applications) solutions, including machine learning architectures, techniques, tools, and approaches capable of performing on-device analytics at the very edge of the cloud.

TinyML can be implemented in low energy systems, such as sensors or **microcontrollers**, to perform automated tasks.

With TinyML, we can do more with less. The technique is still ML, but with less energy, costs, and without an internet connection.
What is TinyML?
Supply Chain Visibility – ERP Systems

- **Warehousing**: Opportunities to leverage TinyML in warehousing range from monitoring dock bottlenecks to identifying safety issues in the warehouse.

- **Inventory Management**: While smart edge devices that monitor and flag storage conditions are already being used on shop floors of many warehouses, opportunities to expand usage of TinyML are plenty.

- **Transportation**: Pattern recognition and incident detection are among the capabilities ML algorithms can help build and these can be leveraged in TinyML powered edge devices, can help study traffic patterns to optimize and plan routes based on peak traffic hours.
In 2022, IT spending on enterprise software is expected to amount to around 672 billion U.S. dollars worldwide, a growth of 11 percent from the previous year. Like nearly all sub-segments of the IT services industry, the enterprise software market has experienced high levels of growth in recent years, with market revenues more than doubling in the decade between 2010 and 2020.

Published by Lionel Sujay Vailshery Feb 21, 2022
Advantages

**Low Latency:** Since the model runs on the edge, the data doesn't have to be sent to a server to run inference. This reduces the latency of the output.

**Low Power Consumption:** As we discussed before, microcontrollers consume very little power. This enables them to run without being charged for a really long time.

**Low Bandwidth:** As the data doesn’t have to be sent to the server constantly, less internet bandwidth is used.

**Privacy:** Since the model is running on the edge, your data is not stored in any servers.
The future of ML is tiny and Bright.

Thank you
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