

tinyML® Talks

Enabling Ultra-low Power Machine Learning at the Edge

“tinyMLedu: widening access to tinyML education and resources”

Brian Plancher - Harvard John A. Paulson School of
Engineering and Applied Sciences

January 13, 2022



www.tinyML.org

tinyML Talks Strategic Partners

AONdevIces

arm

DeepIite

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emza
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GREENWAVES
TECHNOLOGIES

Grovety Inc.

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GLOBAL IOT SOLUTIONS

LatentAI
Adaptive AI for a Smarter Edge

maxim
integrated.

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technology

SAP

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The IoT Hardware Enabler

SensiML™

life.augmented

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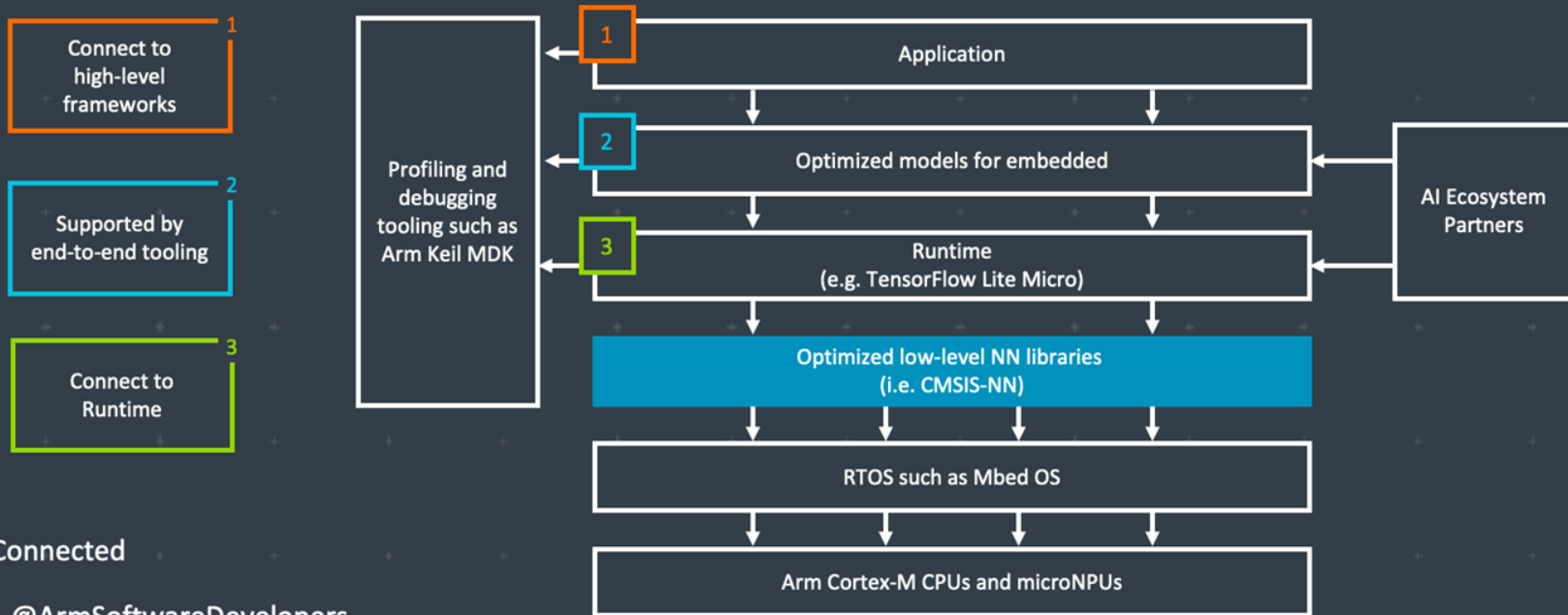
SynSense

SYNTIANT

Additional Sponsorships available – contact Olga@tinyML.org for info

Executive Strategic Partners

Arm: The Software and Hardware Foundation for tinyML



Stay Connected



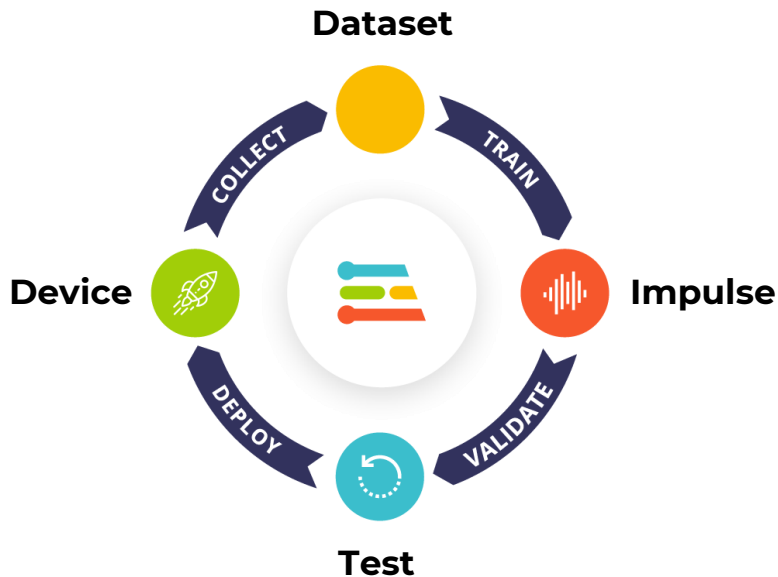
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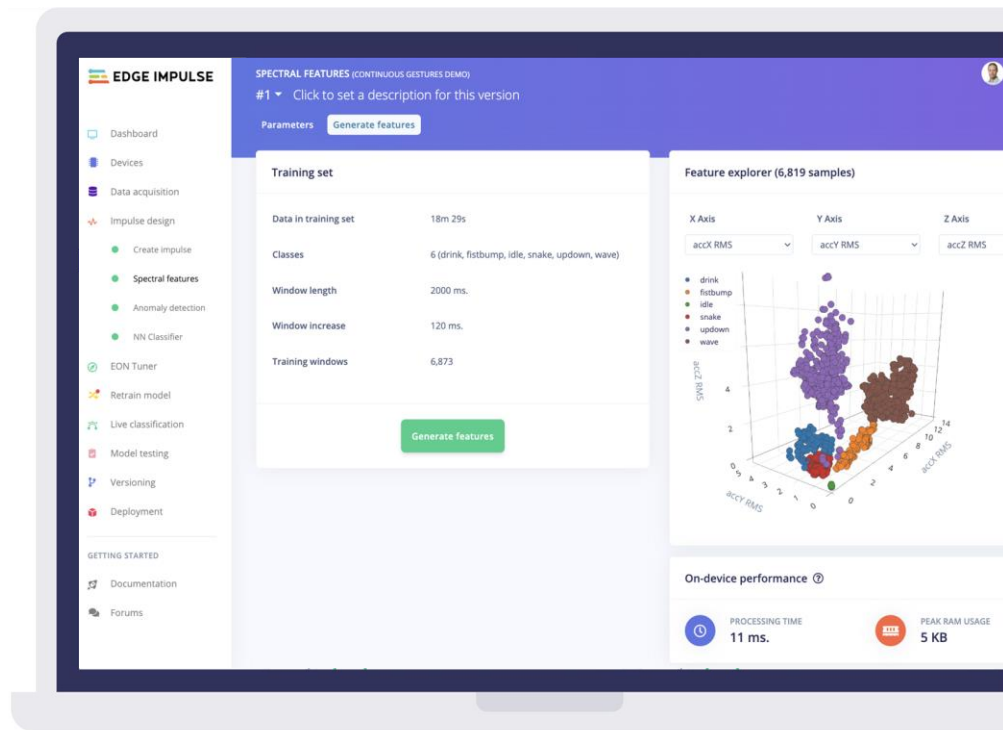
@ArmSoftwareDev

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

EDGE IMPULSE The leading edge ML platform



www.edgeimpulse.com



Qualcomm
AI research

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

A platform to scale AI across the industry



Perception

Object detection, speech
recognition, contextual fusion



Reasoning

Scene understanding, language
understanding, behavior prediction



Action

Reinforcement learning
for decision making



Edge cloud



Cloud



IoT/IIoT



Automotive



Mobile

SYNTIANT



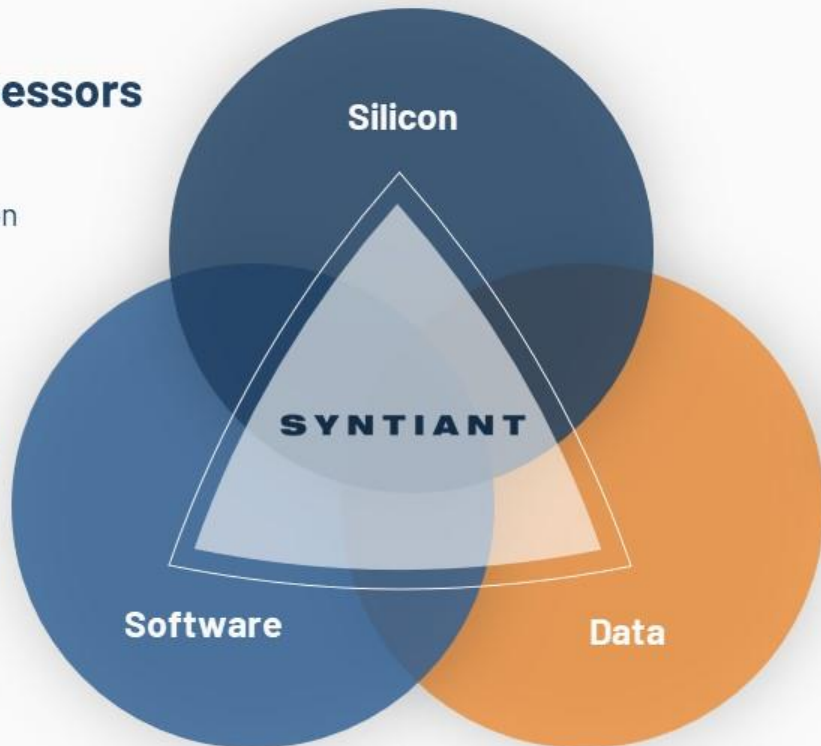
Neural Decision Processors

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



ML Training Pipeline

- Enables Production Quality Deep Learning Deployments



End-to-End
Deep Learning
Solutions

for

TinyML & Edge AI



Data Platform

- Reduces Data Collection Time and Cost
- Increases Model Performance



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

mobilityXlab

arm





KLIKA · TECH

GLOBAL IOT SOLUTIONS



Add Advanced Sensing to your Product with Edge AI / TinyML

<https://reality.ai>

 info@reality.ai

 [@SensorAI](https://twitter.com/SensorAI)

 [Reality AI](https://www.linkedin.com/company/reality-ai)

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

BROAD AND SCALABLE EDGE COMPUTING PORTFOLIO

Microcontrollers & Microprocessors

Arm® Core



Arm® Cortex®-M 32-bit MCUs
Arm ecosystem, Advanced security, Intelligent IoT



Arm®-based High-end 32 & 64-bit MPUs
High-resolution HMI, Industrial network & real-time control



Arm® Cortex®-M0+ Ultra-low Power 32-bit MCUs
Innovative process tech (SOTB), Energy harvesting

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

Renesas Core



Ultra-low Energy 8 & 16-bit MCUs
Bluetooth® Low Energy, SubGHz, LoRa®-based Solutions



High Power Efficiently 32-bit MCUs
Motor control, Capacitive touch, Functional safety, GUI



40nm/28nm process Automotive 32-bit MCUs
Rich functional safety and embedded security features

Core technologies

AI

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

Security & Safety

Comprehensive technology and support that meet the industry's stringent standards



Digital & Analog & Power Solution

Winning Combinations that combine our complementary product portfolios

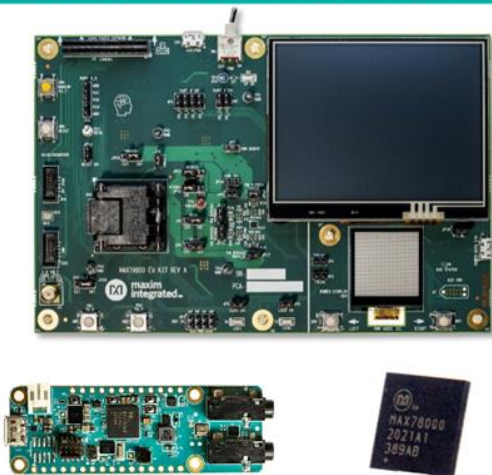
Cloud Native

Cross-platforms working with partners in different verticals and organizations

Gold Strategic Partners

Maxim Integrated: Enabling Edge Intelligence

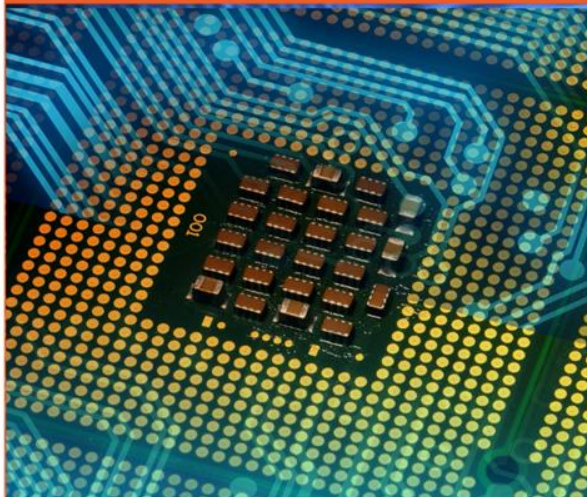
Advanced AI Acceleration IC



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

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

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



Latent AI

Adaptive AI for the Intelligent Edge

[Latentai.com](https://latent.ai)



Micr.ai



NEW



seeed studio
The IoT Hardware Enabler



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



life.augmented



SynSense

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

AONdevices



The logo for Grovetly Inc. features a green lightning bolt icon to the left of the company name "Grovetly Inc." in a green, sans-serif font.





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



Join Growing tinyML Communities:



7.7k members in
42 Groups in 33 Countries

tinyML - Enabling ultra-low Power ML at the Edge

<https://www.meetup.com/tinyML-Enabling-ultra-low-Power-ML-at-the-Edge/>



2.5k members
&
4.3k followers

The tinyML Community

<https://www.linkedin.com/groups/13694488/>





Subscribe to
tinyML YouTube Channel
for updates and notifications
(including this video)
www.youtube.com/tinyML

tinyML
4.33K subscribers

5.8k subscribers, 320+ videos with 166k views

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1:01:15

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18:26

tinyML Summit 2021 tiny Talks: Using Neural...
19:00

tinyML Summit 2021 Keynote: Adaptive Neural...
55:15

tinyML Summit 2021 Keynote: milijoules for...
9:40

tinyML Summit 2021 Market Opportunities for Edge AI
51:28



Next tinyML Talks

Date	Presenter	Topic / Title
Tuesday, January 18	Ashutosh Pandey, Infineon Technologies	Exploring techniques to build efficient and robust TinyML deployments

Webcast start time is 8:00 am Pacific time

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

Reminders

Slides & Videos will be posted tomorrow



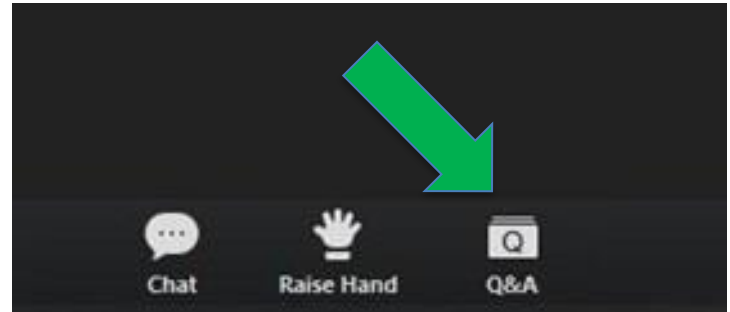
tinyml.org/forums



youtube.com/tinyml



Please use the Q&A window for your questions





Brian Plancher



Brian is a Ph.D. Candidate studying Robotics at Harvard University working with Vijay Janapa Reddi and Scott Kuindersma and co-chairs tinyMLedu. His research is focused on developing and implementing open-source algorithms for dynamic motion planning and control of robots by exploiting both the mathematical structure of algorithms and the design of computational platforms. As such, his research is at the intersection of Robotics and Computer Architecture / Embedded Systems, Numerical Optimization, and Machine Learning. He also wants to improve the accessibility of STEM education. He enjoys teaching and designing new interdisciplinary, project-based, open-access courses that lower the barrier to entry of cutting edge topics like tinyML. He also enjoys spending his free time with my wife, daughter, and puppy, and ski racing in the winters.

tinyMLedu: widening access to tinyML education and resources



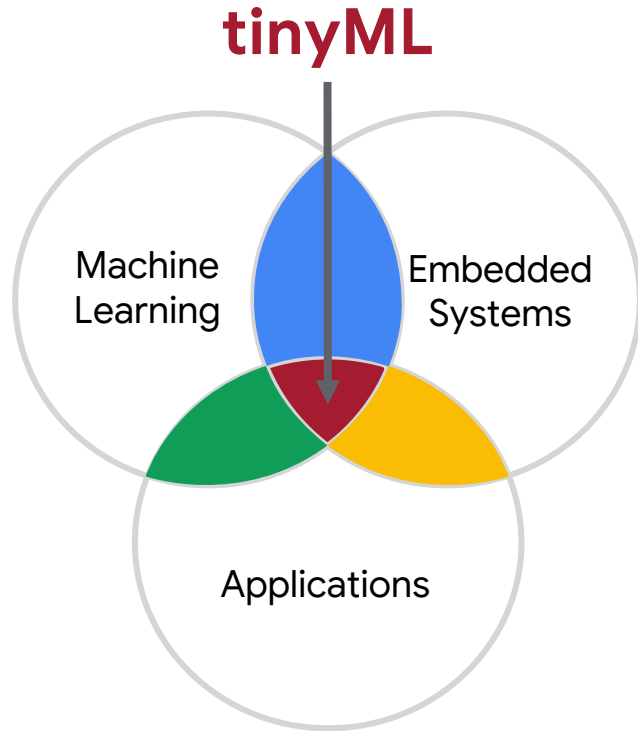
Brian Plancher
PhD Candidate
Harvard University
BrianPlancher.com



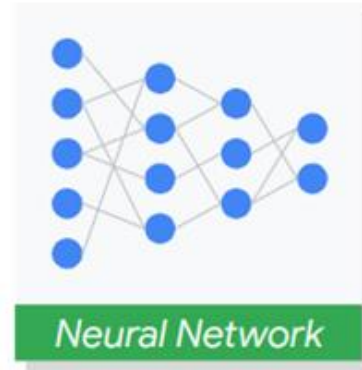
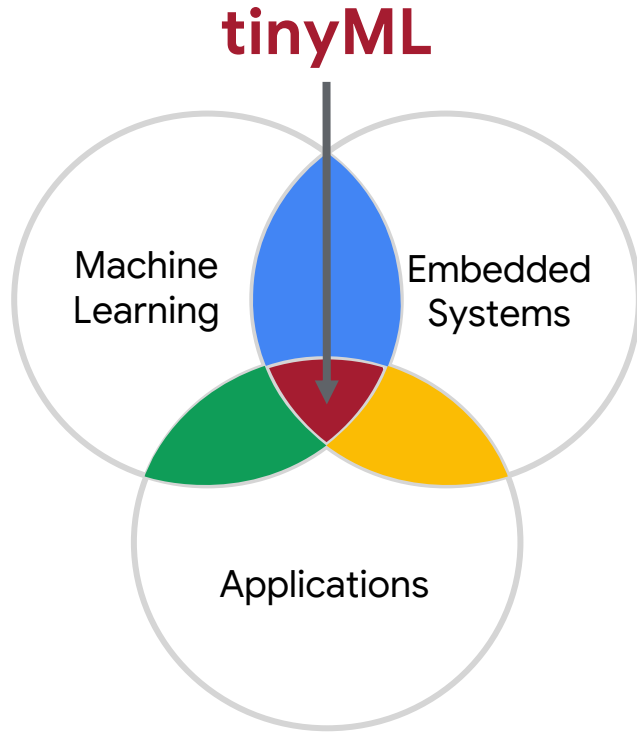
Harvard John A. Paulson
School of Engineering
and Applied Sciences



tinyML is a great **education tool**



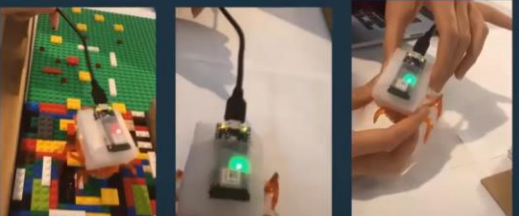
tinyML is a great **education tool**




Machine Learning **Workflow**

Project Based tinyML is a great education tool


RESULTS




Adjusted sampling rate: 200 ms (5 Hz)
Invoke time: 34 ms
Memory consumption: 6,848 bytes



Lego to Paper

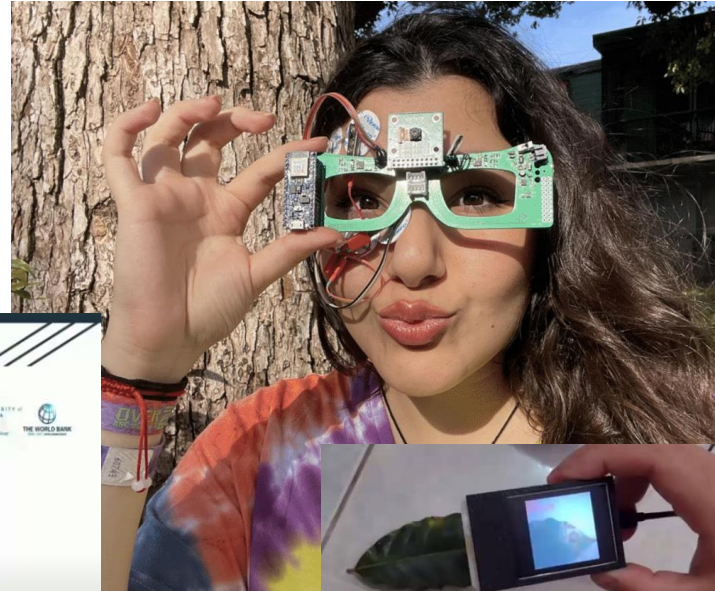


AFRICAN CENTER OF EXCELLENCE
IN
INTERNET OF THINGS

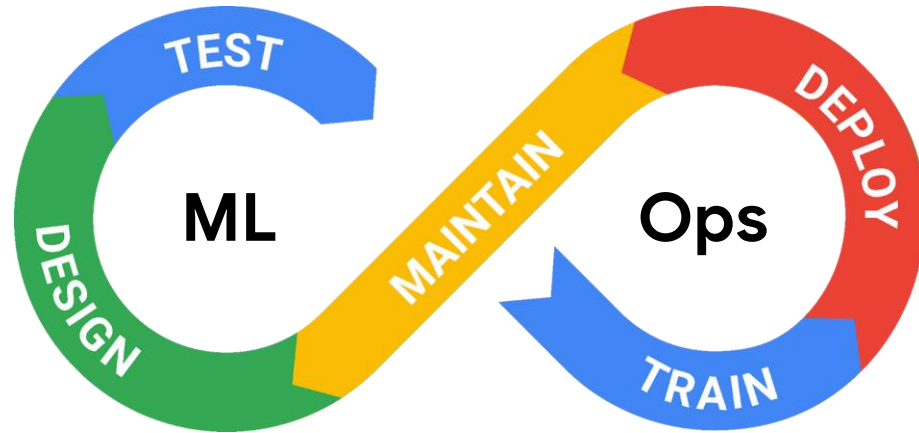


Offline Prediction of Cholera in Rural Communal Tap Waters Using Edge AI inference

Marvin Muyonga Ogore
Dr. NSENGA Jimmy
Dr. NKURIKIYEZU Kizito



tinyML is a great **education tool**



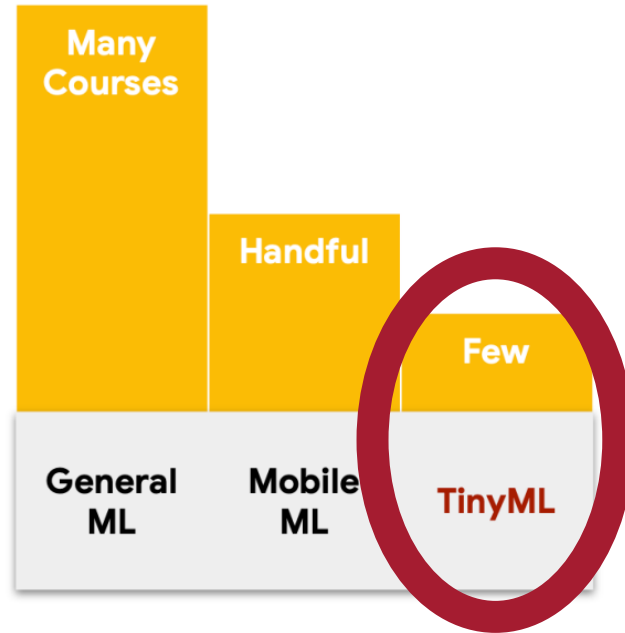
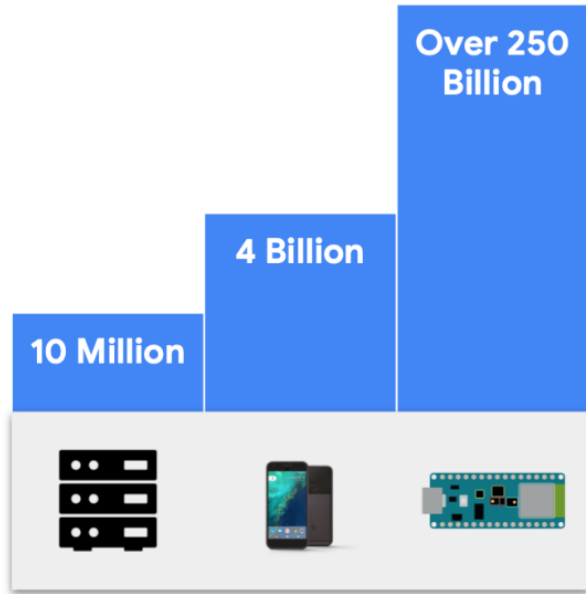
edX Course 4
Coming Soon!

tinyML can
also explore
deployments
at scale!

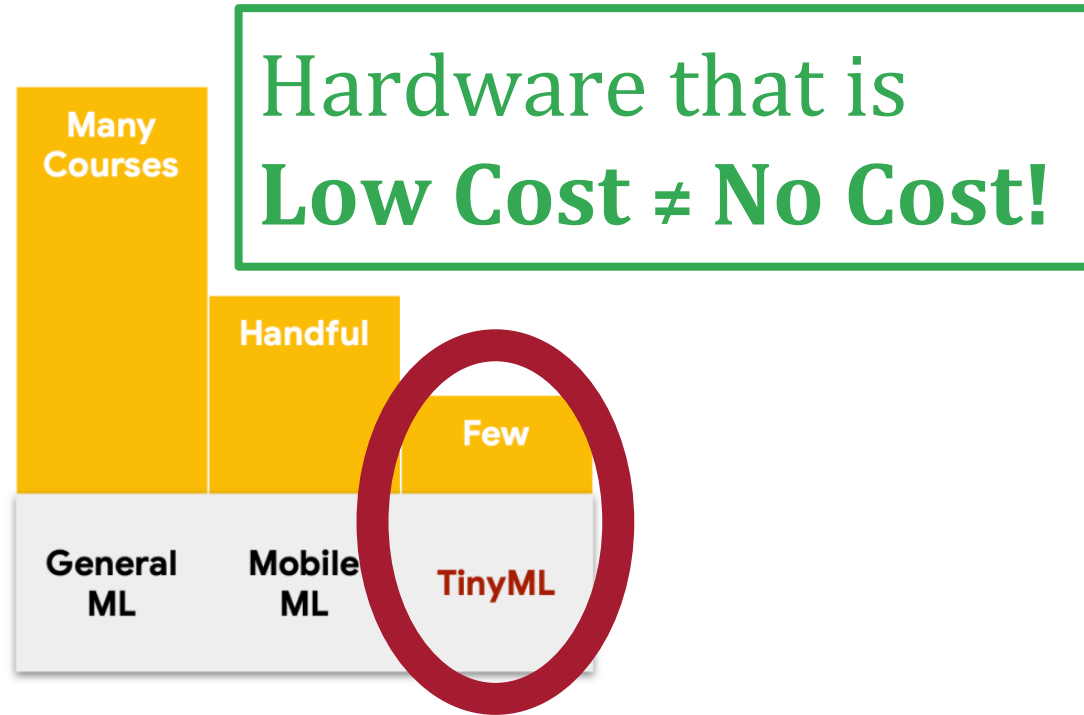
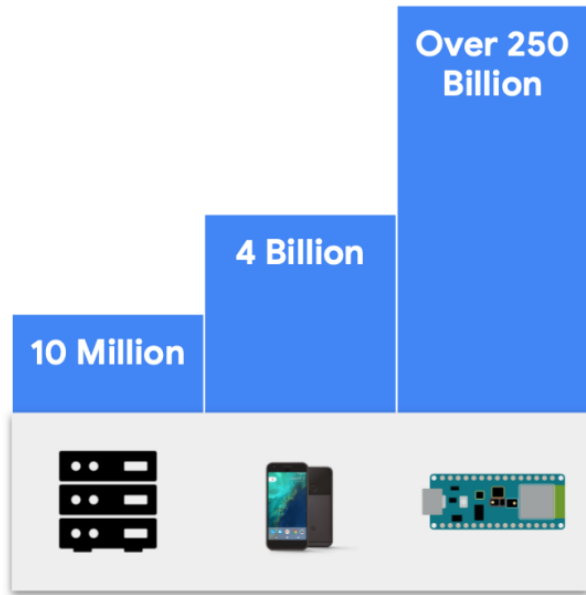


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education and resources

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tinyMLedu is structured as a series of working groups

tinyML4D

tinyML4K12

tinyML on edX

tinyML4Xlation

tinyML4STEM

Your Idea?

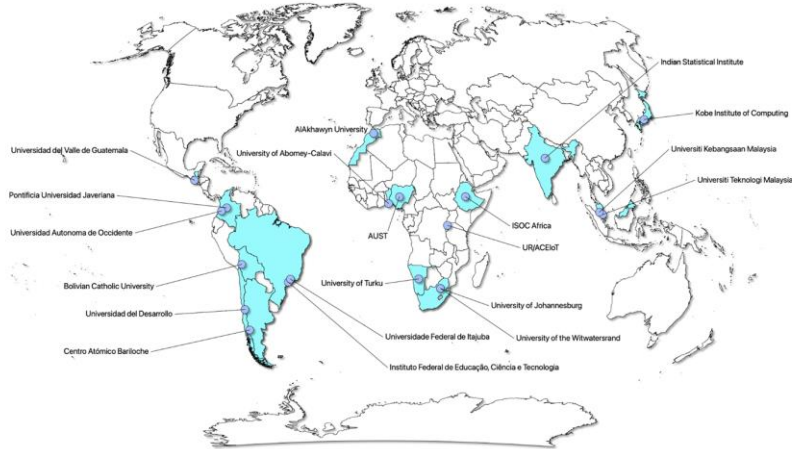
tinyMLedu has accomplished a lot
in its first year!

**Our edX courses have been taken by over
60,000 students from 176 countries!**



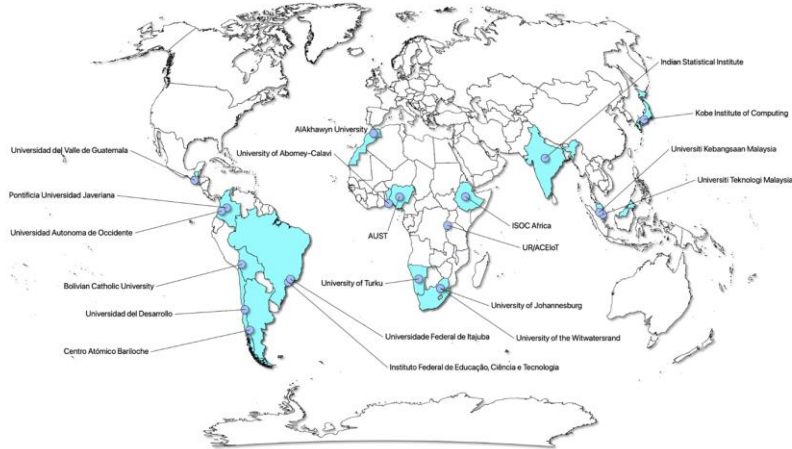
tinyMLedu has accomplished a lot
in its first year!

We **launched** our 4D Academic Network
of 20 Global Universities



tinyMLedu has accomplished a lot in its first year!

We launched our 4D Academic Network of 20 Global Universities



5-day Workshop

SciTinyML:
Scientific Use of
Machine Learning on
Low-Power Devices



18 - 22 October 2021
An ICTP Virtual Meeting
Trieste, Italy

Further information:
<http://indico.ictp.it/event/19022/>
ml@ictp.it

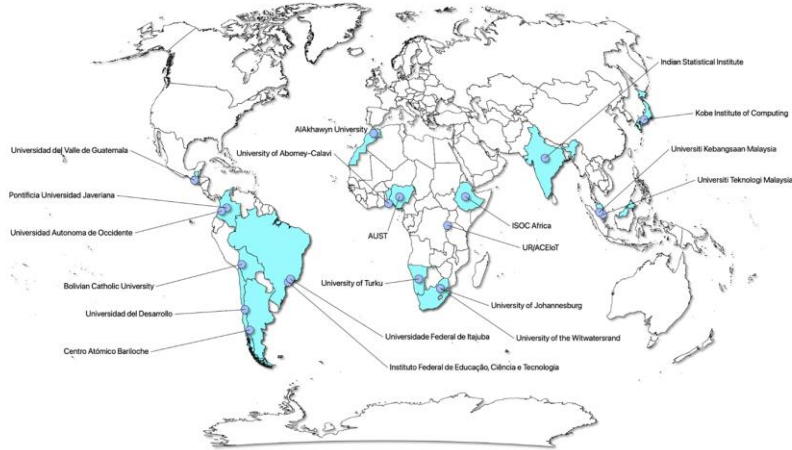
4 Seminars:

- “Why the Future of ML is Tiny and Bright”
- “Software Tools for TinyML”
- “Embedded ML Case Studies: Rwanda & Brazil”
- “Getting Started with the Wio Terminal and Edge Impulse”

Lots more planned for the new year!

tinyMLedu has accomplished a lot in its first year!

We **launched** our 4D Academic Network of 20 Global Universities

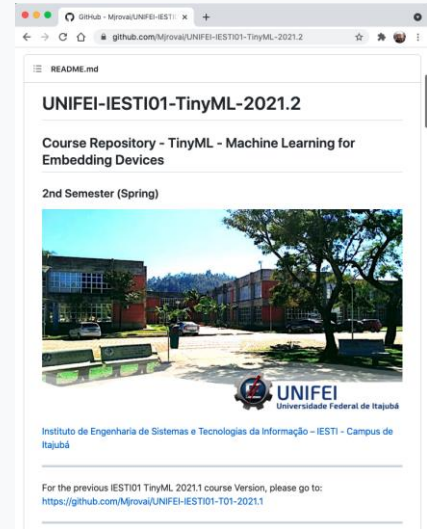


Hardware (finally) Coming Very Soon!



tinyMLedu has accomplished a lot
in its first year!

**Two Open-Source Courses
Taught in Portuguese in Brazil** and
more international courses on the way!



tinyMLedu has accomplished a lot in its first year!

A **Zero to tinyML Hero** workshop for middle and high school students and teachers

Yá'át'ééh

CREATING EFFECTIVE STEM LEARNING EXPERIENCES

with Navajo Tech

Harvard

Waiting

Yá'át'ééh

	NOISE	UNDERFLOW	OVERFLOW
241	0.02	0.06	0.92
240	0.07	0.03	0.90

Using machine learning to spot fake Native American jewelry

Two Open-Source Courses Taught in Portuguese in Brazil and more international courses on the way!

UNIFEI-UESTI01-TinyML-2021.2

Course Repository - TinyML - Machine Learning for Embedding Devices

2nd Semester (Spring)

UNIFEI
Universidade Federal de Itajubá

Instituto de Engenharia de Sistemas e Tecnologias da Informação - IESTI - Campus de Itajubá

For the previous IESTI01 TinyML 2021.1 course Version, please go to:
<https://github.com/Mrova/UNIFEI-UESTI01-T01-2021.1>

tinyMLedu has accomplished a lot
in its first year!

**And So
Much
More!**

BACKYARD  BRAINS



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School of Engineering
and Applied Sciences



TensorFlow Lite



<https://tinyMLedu.org>

TinyMLedu

The Tiny Machine Learning Open Education Initiative

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Welcome to the Tiny Machine Learning Open Education Initiative (TinyMLedu)

We are an international group of academics and industry professionals working to improve global access to educational materials for the cutting-edge field of TinyML. TinyML brings the transformative power of machine learning (ML) to the performance- and power-constrained domain of embedded systems. Successful deployment in this field requires knowledge of applications, algorithms, hardware, and software. TinyMLedu is hosted by the Harvard John A. Paulson School of Engineering and Applied Sciences in collaboration with the tinyML Foundation.

[Take a Free Online Course to Learn More](#)

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