tinyML® Foundation

Enabling Ultra-low Power Machine Learning at the Edge

tinyML.edu 2.0 from the industry-academia perspective and Call to Action

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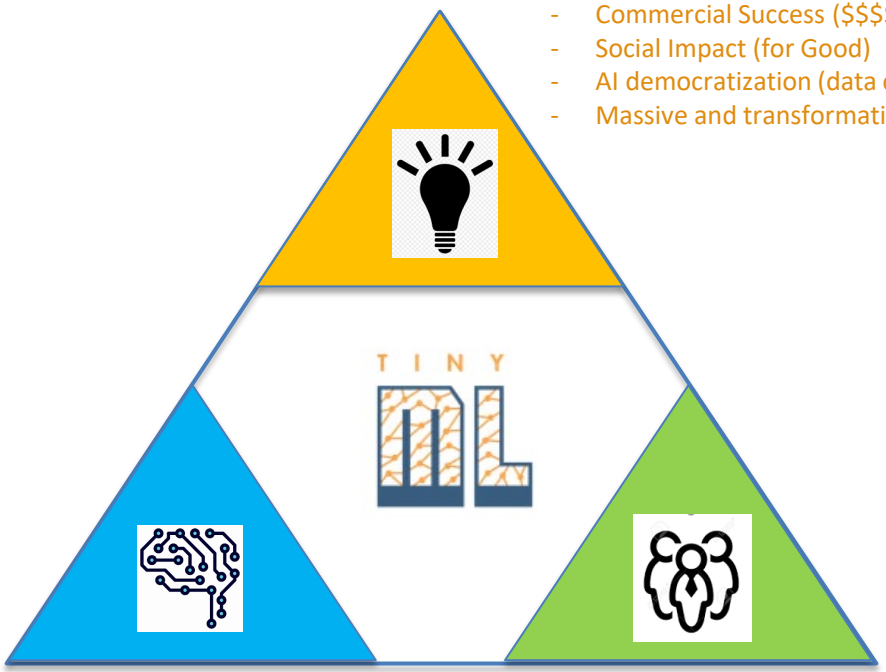
www.tinyML.org

Outline:

- tinyML Foundation and its ecosystem
- tinyML: from the industry perspective
- Call to Action for tinyML.edu 2.0

tinyML Phenomenon*:

Impact:
- Commercial Success ($$$$)
- Social Impact (for Good)
- AI democratization (data ownership)
- Massive and transformational !!!



Technology:
- Dedicated tinyML HW
- tiny NN models and algos
- tools and SW (autoML, NAS, etc.)
- Enabling tech (NVM, LP sensors, etc.)

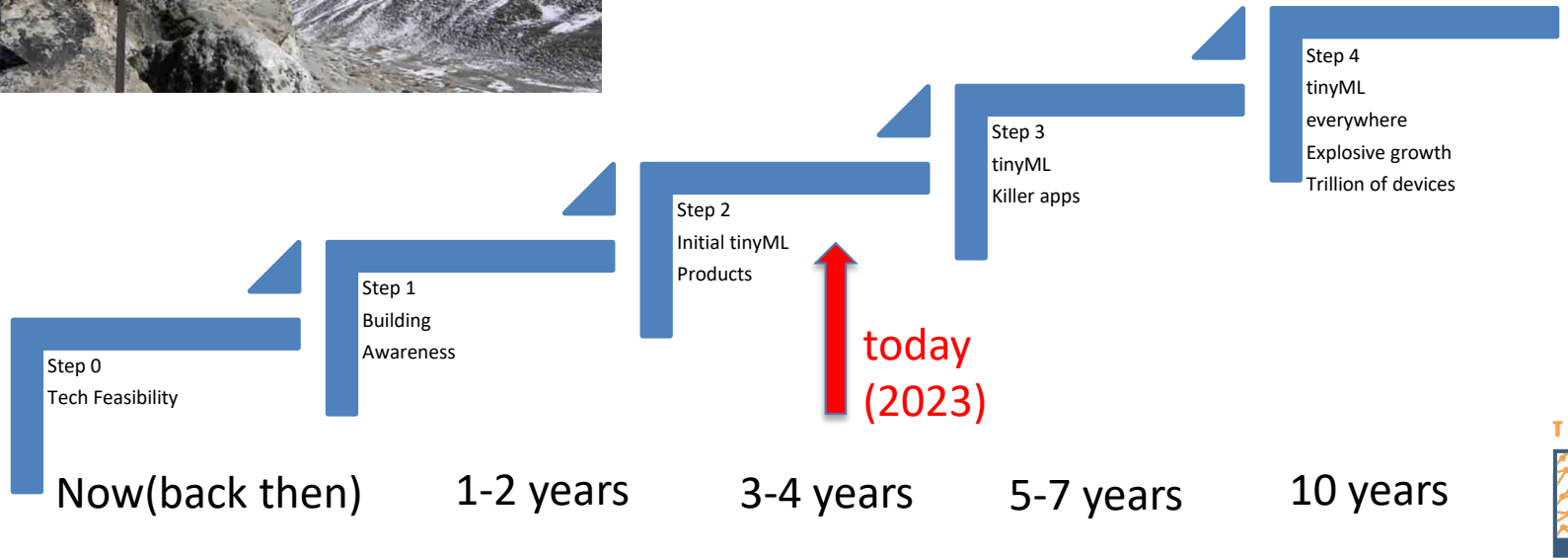
Talent:
- Global Community
- Diverse and interdisciplinary Ecosystem
- tinyMLedu
- Hi-energy & passion

** First voiced by Bryon Moyer, Technology Editor, Semiconductor Engineering, Aug. 2021*

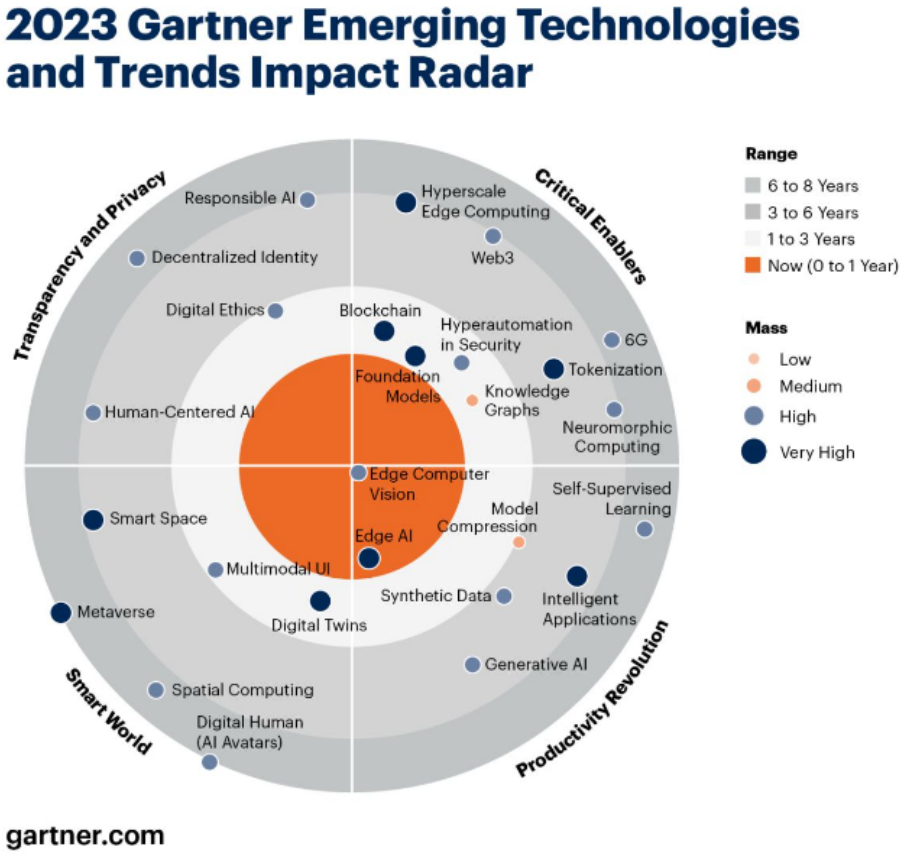
TINY ML SUMMIT

tinyML: Happy 5th Birthday !

Climbing up tinyML mountain *(from 1st, 2019 Summit)*



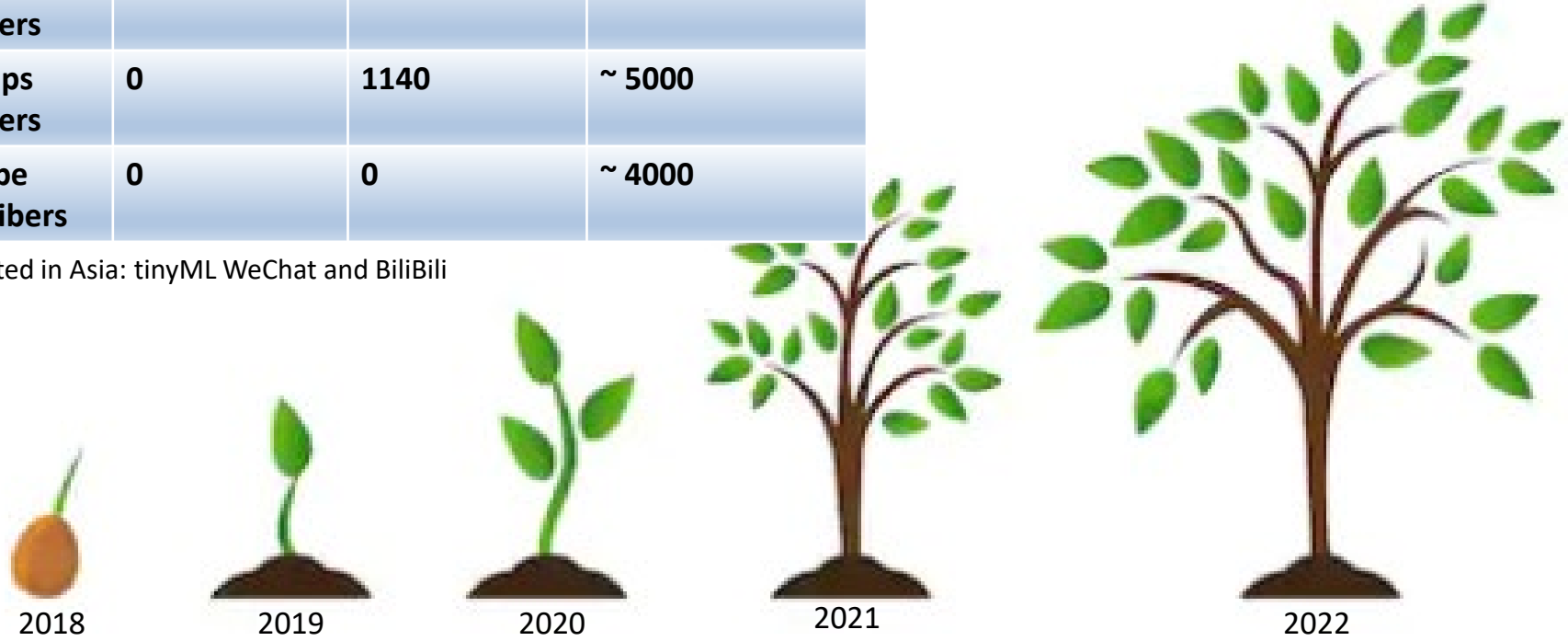
Edge AI is happening now!



tinyML Summits are growing fast

	2019 Summit *(March 2019)*	2020 Summit *(Feb 2020)*	2021 Summit *(March 2021)*
Attendees	**160**	**400+**	**5000+**
Companies	**90**	**172**	**1000+**
LinkedIn members	**0**	**798**	**~ 2000**
Meetups members	**0**	**1140**	**~ 5000**
YouTube subscribers	**0**	**0**	**~ 4000**

also started in Asia: tinyML WeChat and BiliBili



tinyML growth drivers:

- More developed energy efficient HW
- Energy efficient algos/NN
- More mature SW infrastructure and tools
- Diverse ecosystem
- Growing number of applications
- Corporate and VC investment
- Increased start-up and M&A activity

Interested in joining tinyML ecosystem?

www.tinyML.org

tinyML Foundation Vision*:

We see a new world with trillions of intelligent devices enabled by tinyML technologies that sense, analyze and autonomously act together to create a healthier and more sustainable environment for all

*adopted at tinyML Strategy leadership meeting on Dec 14, 2019

About us

tinyML Foundation is a non-profit organization* with the mission to accelerate the growth of a prosperous and integrated Global Community of HW, SW and SYS scientists, engineers, designers, product and business application people developing leading edge energy efficient machine learning computing. The goal is to connect various technologies and innovations in this domain of machine intelligence to enormous product and business opportunities and value creation across the whole ecosystem.

* tinyML Foundation is a non-profit, 501c3, organization registered in Los Altos, CA, USA

tinyML Foundation Mission:

- to grow a prosperous and integrated Global Community of HW, SW and SYS scientists, engineers, designers, product and biz people, both experts and newcomers, developing leading edge tinyML technologies
- to educate and to promote and stimulate knowledge exchange between tinyML researchers to allow the field to move ahead at a high pace
- to inspire on the capabilities of tinyML and its potential of changing the way machine intelligence and data analytics at the very edge of the physical and digital world occur
- to connect tinyML technologies and innovations to enormous product and business opportunities and value creation across the whole ecosystem and industry verticals

tinyML “DNA”

- Highest **Quality**: prime tinyML community, events and projects
- Industry focused & driven, with strong academic participation & influence
- “Full stack”/E2E coverage: HW-SYS-Algo-SW-Apps
- Deeply technical
- Diverse (in a very broad sense) and collaborative; all inclusive and non-discriminatory
- Open and transparent

tinyML Global Community

("snapshot" , as of July 1, 2023)

- 14.5k tinyML meetup members in 49 groups in 40 countries (~ 2x YoY)
- 10k youtube.com/tinyML subscribers, 589 videos, 345k views (~ 50% YoY)
- 3.7k members + 13k followers on LinkedIn (~ 2x YoY)
- WeChat group and Bilibili tinyML channel in Asia
- 3 major global events annually:
  - Summit in March (5K attended in 2021) , EMEA in June (1.6k in 2021), Asia in Nov. (1.8k in 2020)
- Almost weekly tinyML Talks, LIVE
- Massive educational initiative, tinyMLedu (e.g. 90k students enrolled, from 177 countries)
- Healthy M&A and VC activities
- 80+ sponsors; amazing diversity, 40 sponsors for the Summit
- 31 Companies have decided to join Strategic Partnership Program
- Partnerships with other orgs, non-profits, academia and NGOs underway
- tinyML Brand widely recognized in the industry !

tinyML meetups global growth

(15.5k members in 40 countries)

https://www.meetup.com/pro/tinyml/

tinyML

Members	Groups	Countries
15,486	49	40

tinyML Groups in Africa

3000+ members (as of 7/1/2023)

https://www.meetup.com/pro/tinyml/

tinyML Nigeria	827 members
tinyML Morocco	683 members
tinyML Kenya	752 members
tinyML Ghana	421 members
tinyML Rwanda	74 members
tinyML South Africa	133 members
tinyML Tanzania	102 members
tinyML Egypt	37 members

Key Dates 2023-4

Date	Event	Location
June 25, 2023	SPAB	in-person @ EMEA
June 26-28, 2023	tinyML EMEA	Amsterdam, The Netherlands
Sept 12-13, 2023	Vertical Focus - Consumer Electronics	virtual
Sept 14, 2023	SPAB meeting	in-person SF Bay Area?
Q4	tinyML4Good Forum	virtual
November 16, 2023	tinyML Asia	Seoul
Nov / Dec 2023	Vertical Focused Event	virtual
December 2023	SPAB meeting	virtual
April 9-11, 2024	embedded world	Nuremberg, Germany
April 22, 2024	SPAB	in-person @ Summit
April 22-24, 2024	tinyML Summit & Research Symposium	Burlingame, CA

tinyML Summit 2023

- March 27-29, 2023
- 3 days - **In-Person - Burlingame, CA**
  - Focused on tinyML end-users and applications
  - Mon Mar 27: Research Symposium & **demo tables** ("tinyML Open House" open to public)
  - Tues Mar 28 & Wed Mar 29: plenary keynotes & presentations; posters; **demo tables**

Chair: Davis Sawyer
Deeplite

Vice-Chair:
Elias Fallon
Qeexo/TDK

tinyML Summit 2022 – back to normal !

tinyML Applications, Products and End-Users

tinyML Pavilion @embedded world 2023

March 14-16, 2023, Nuremberg, Germany

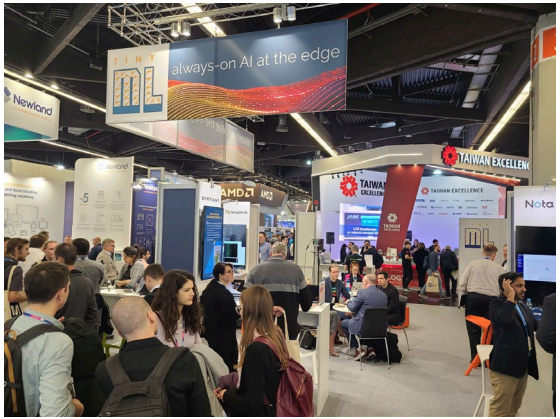
~10 Strategic Partners; Fully furnished podiums

Plus tinyML tech sessions

(chaired by Prof. Daniel Mueller-Gritschneder, TU-Munich)

~ 23k attendants at EW-2024

tinyML Pavillion committed at EW-2024, April 9-11



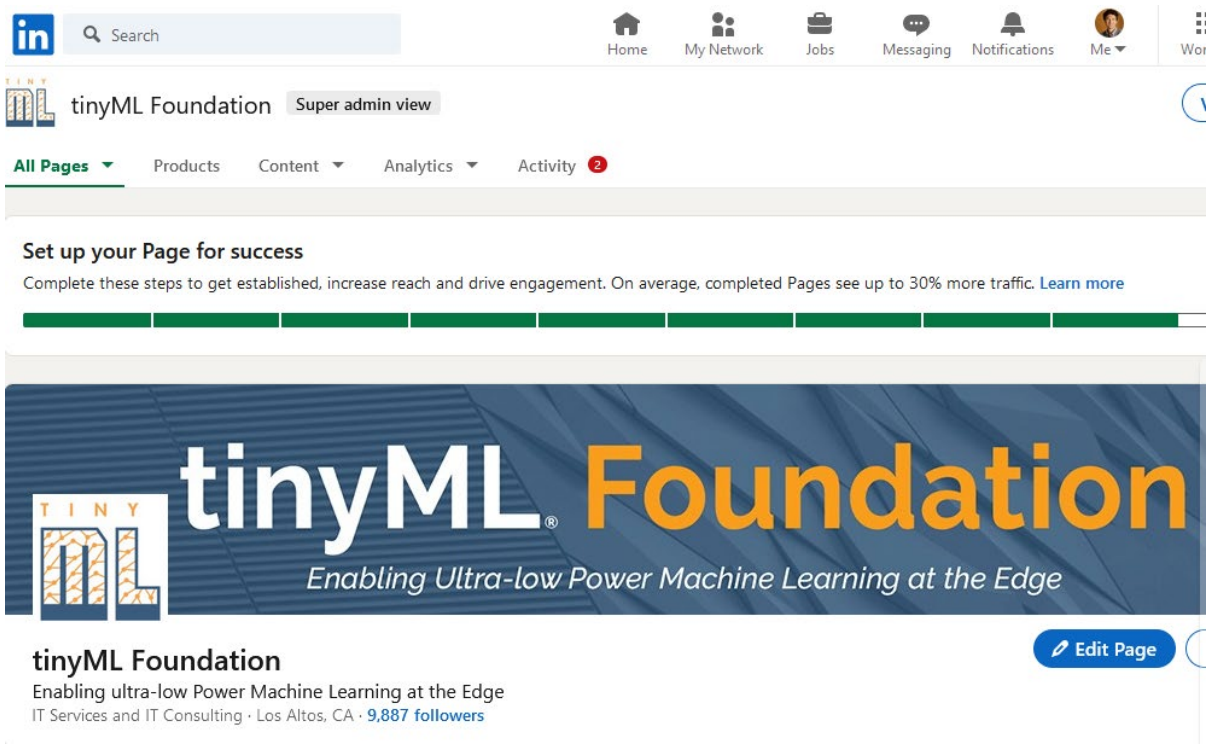
tinyML Community on LinkedIn

(~ 3.7k members & 13k followers)

tinyML Community

Listed group

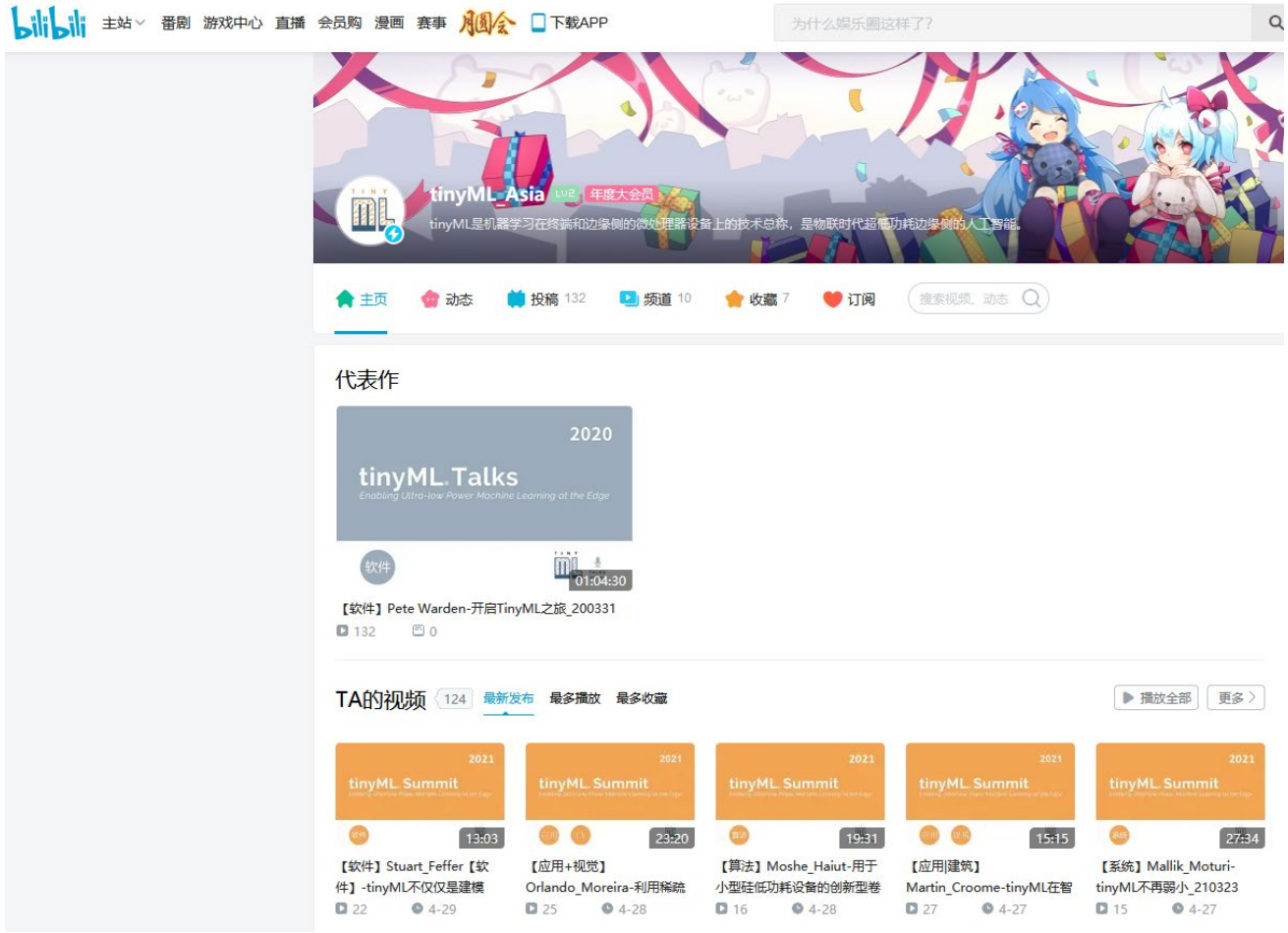
https://www.linkedin.com/groups/13694488/



tinyML YouTube Channel

www.youtube.com/tinyML

tinyML BiliBili Channel In Asia

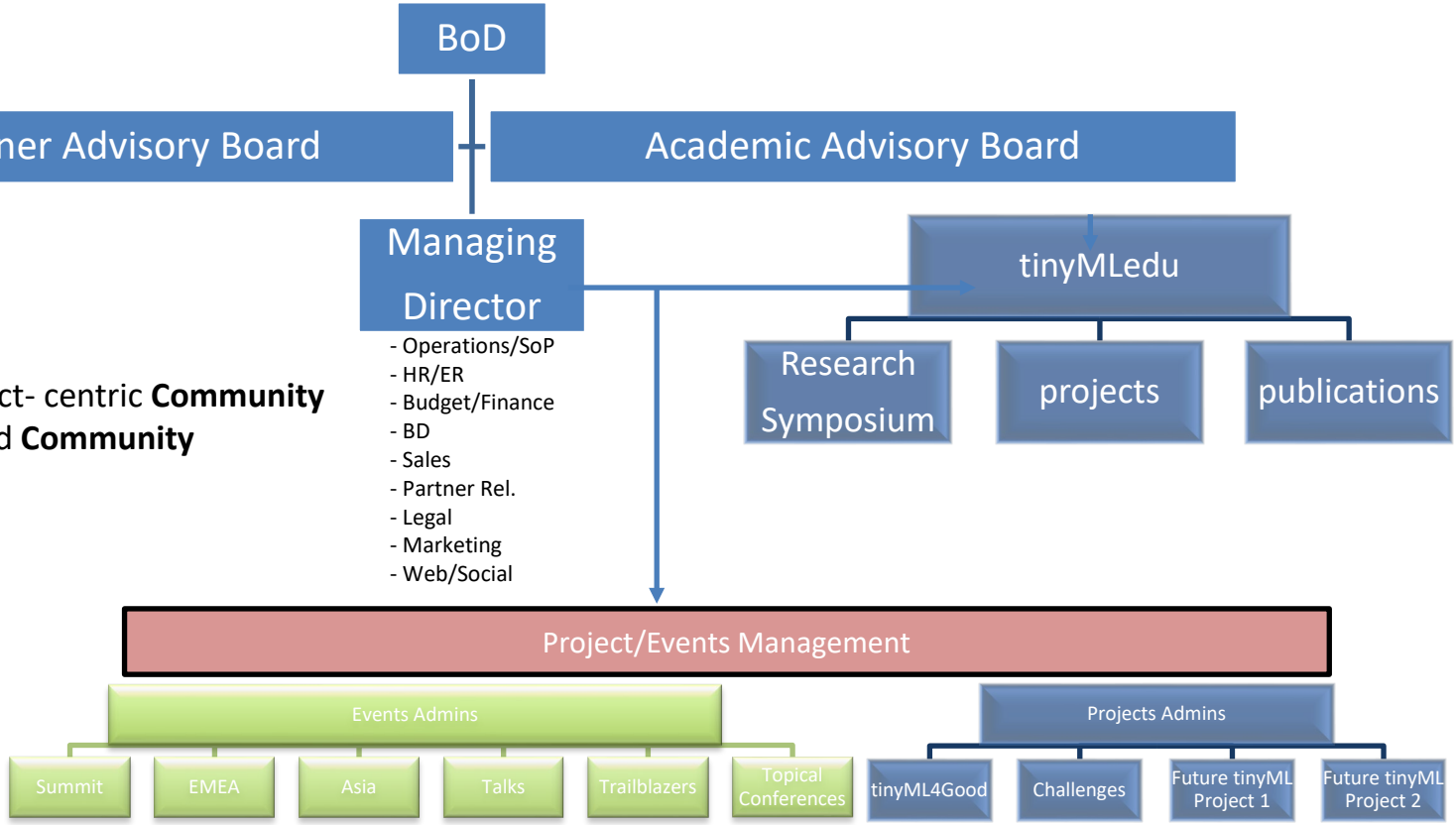


Industry Perspective
and
Industry-Academia Partnership


Industry
Academia

tinyML Org Dev't to support strategy and scale-up

Yesterday: Event-centric
Today: Event- & Project- centric **Community**
Future: Platform-based **Community**



tinyML Sponsors:

Thank you, **tinyML Strategic Partners***

** as of April 1, 2023; several more under final reviews*

Why tinyML opportunity is so enormous?

Data is a new oil(electricity) and ML is a way to produce it

Cloud ML

- DNN on the cloud
- HW: TPU, FPGA, GPU, CPU

Edge ML

- Optimized algos and CNN-light
- SoC (with NPUs/NSP accelerators)

tiny ML

- CNN-micro
- MCU w/ HW accelerators

CMOS cameras | IR cameras | IMUs | Audio mics | Environ/ chemical | Temperature | Optical sensors

Data Sources:

1%
Storage and sharing

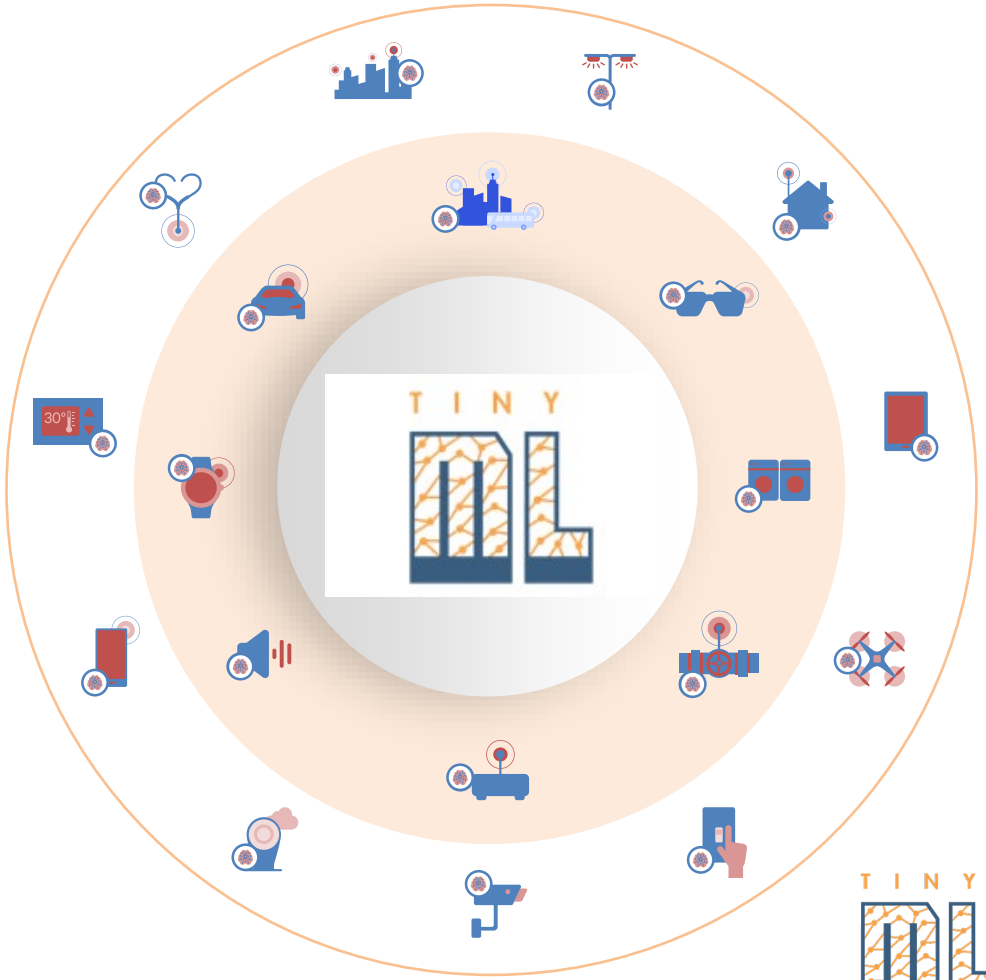
User provided: **4%**

1. Pics
2. Audio
3. Clicks/likes
4. GPS, Location based

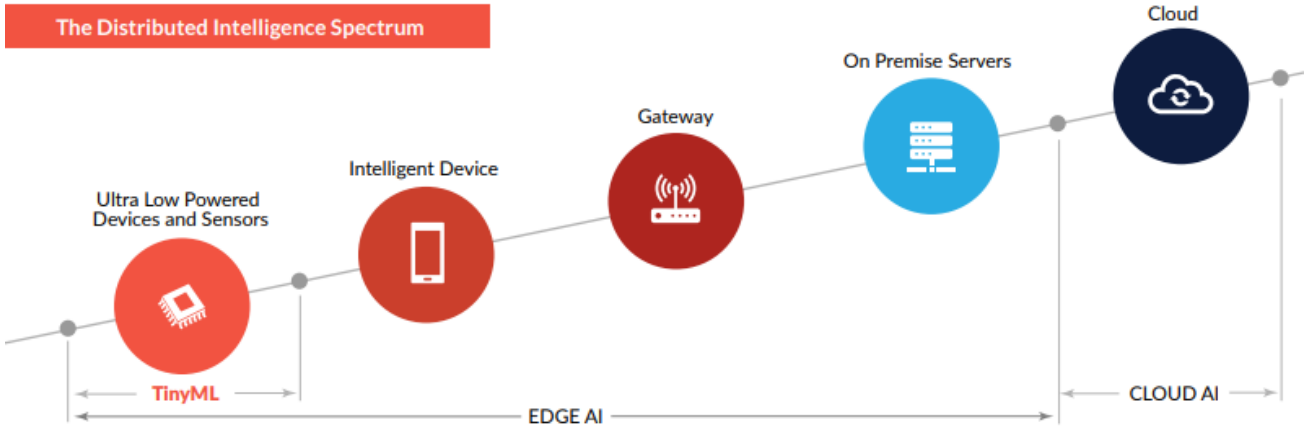
95%
Real-time in the physical world

TINY ML

Massive tinyML opportunities in all verticals where machine intelligence meets physical world



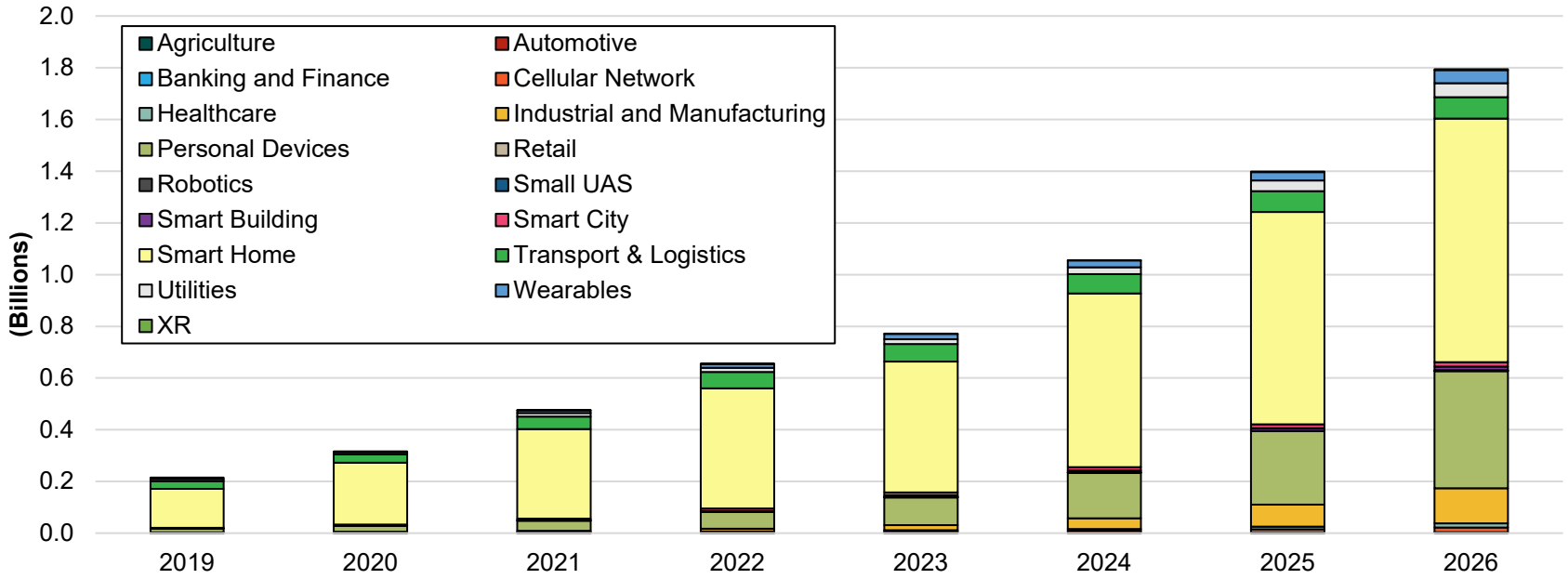
tinyML enabled DEVICES – 2030 Forecast



- tinyML is recognized as a separate market category
- 1B tinyML devices shipped in 2024, installed based of 5.4B tinyML devices in 2026
- High double-triple digit YoY growth
- Includes device shipment only; total value (incl. SW/services) 5-10x more

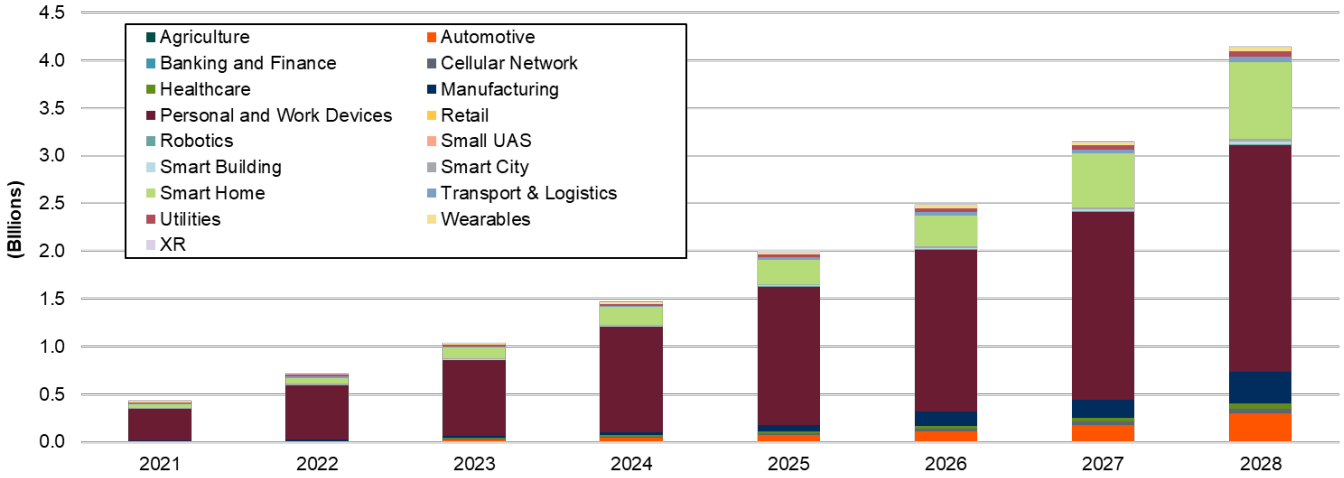
Source: ABI Research, TinyML: The Next Big Opportunity in Tech and MD-AIML-107, 2 QTR 2021

tinyML 2026 Forecast, by verticals



Source: ABI Research, Artificial Intelligence and Machine Learning, 2 QTR 2021

TinyML Device Shipment to Exceed 4 Billion/Y by 2028



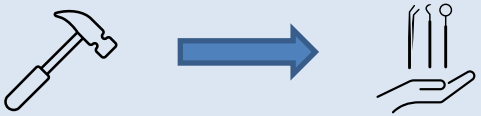
2022 forecast:
11B installed devices by 2030

Revised 2023 forecast:
16.1B devices by 2030

- **Consumer market remains the largest segment** – Lead by tinyML use cases in smartphone, hearables, laptops, and smart home devices. Wide range of use cases covering machine vision, sound and language processing, and ambient sensing.
- Automotive, smart building, and manufacturing could be the next big market due to the need for always-on machine vision, condition monitoring, and predictive maintenance.

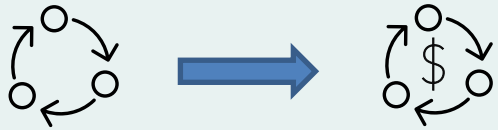
Evolution of Edge AI SaaS and Turnkey Service

Present vs. Future

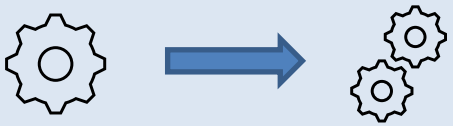


- **Tools to Vertical Solutions** – Offering bespoke models, tools and libraries highly targeted at specific verticals, such as automotive, robotics, and healthcare.

- **Expanded Edge AI Chipset Support** – Independent software vendors are supporting more edge AI chipsets beyond the traditional MCU, GPU, and FPGA.

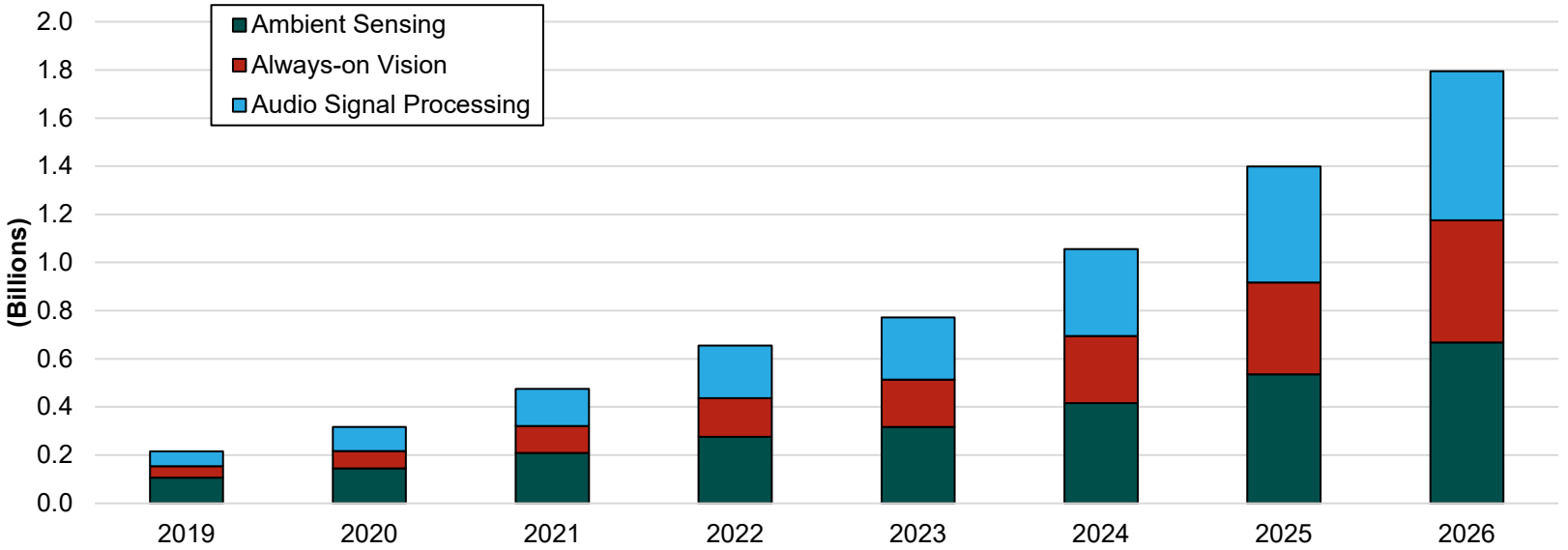


- **More to Focus on Monetization** – More edge AI chipset vendors to monetize their software capabilities, setting up potential clash with independent software vendors.



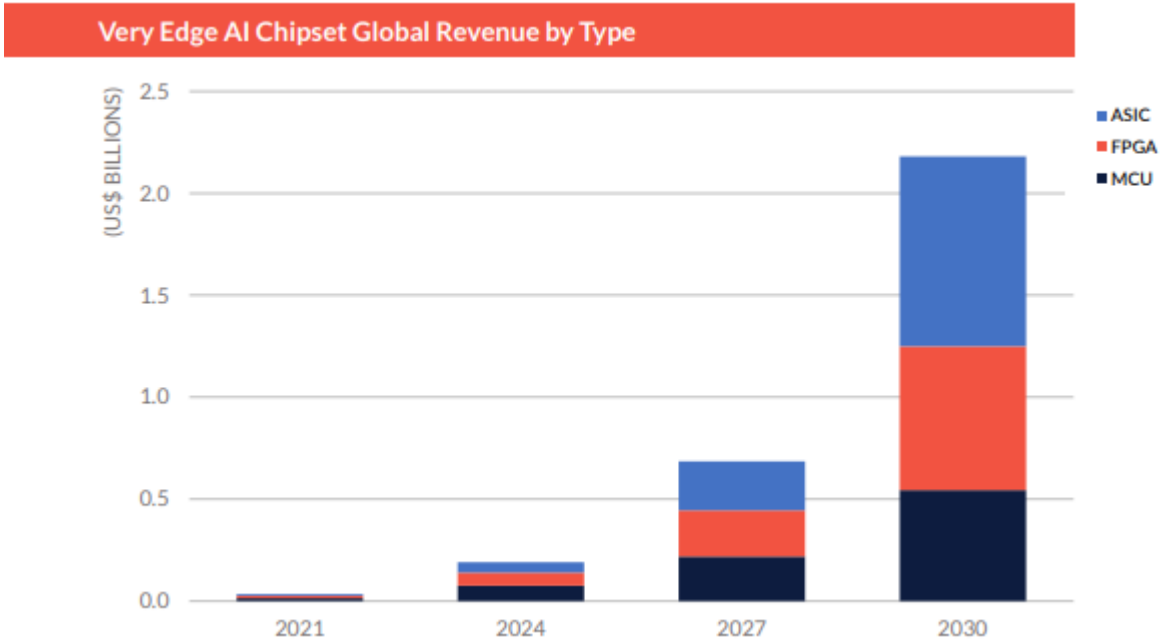
- **More Industry Partnerships** – Actively forging new partnership with distributors and system integrators with strong industrial connections.

tinyML 2026 Forecast by use cases



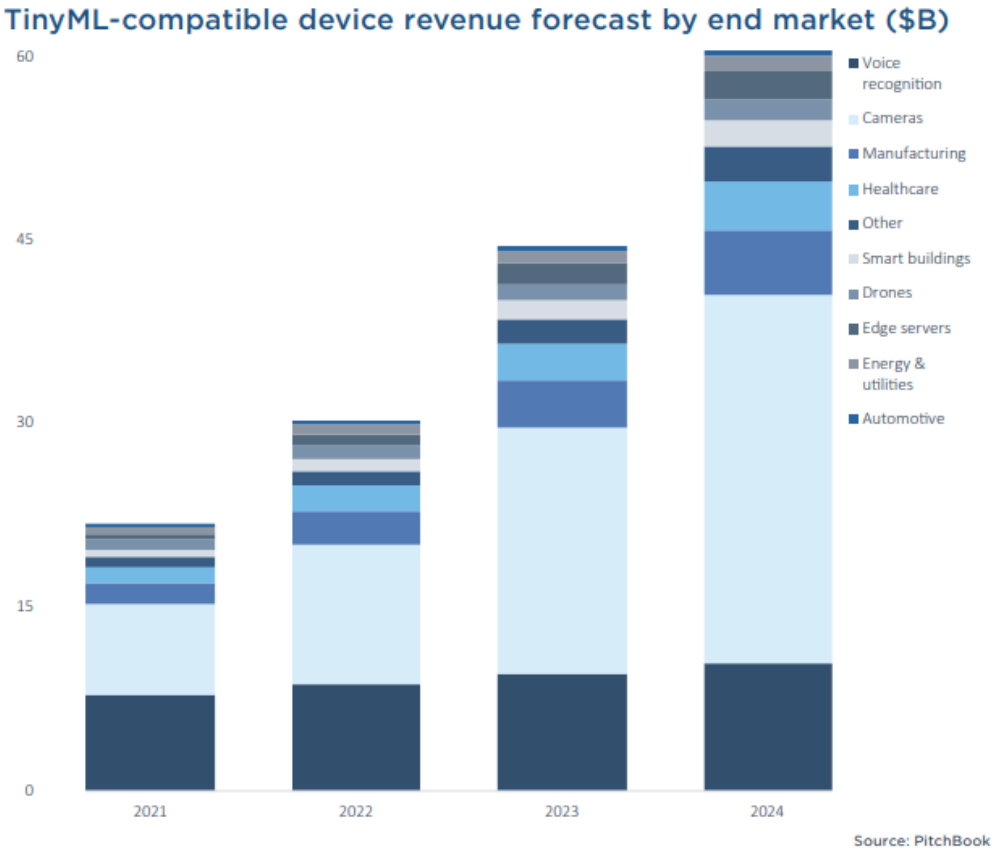
Source: ABI Research, Artificial Intelligence and Machine Learning, 2 QTR 2021

tinyML 2030 Forecast by processor type



Source: Lian Jye Su, Principal Analyst, ABI Research, 2020

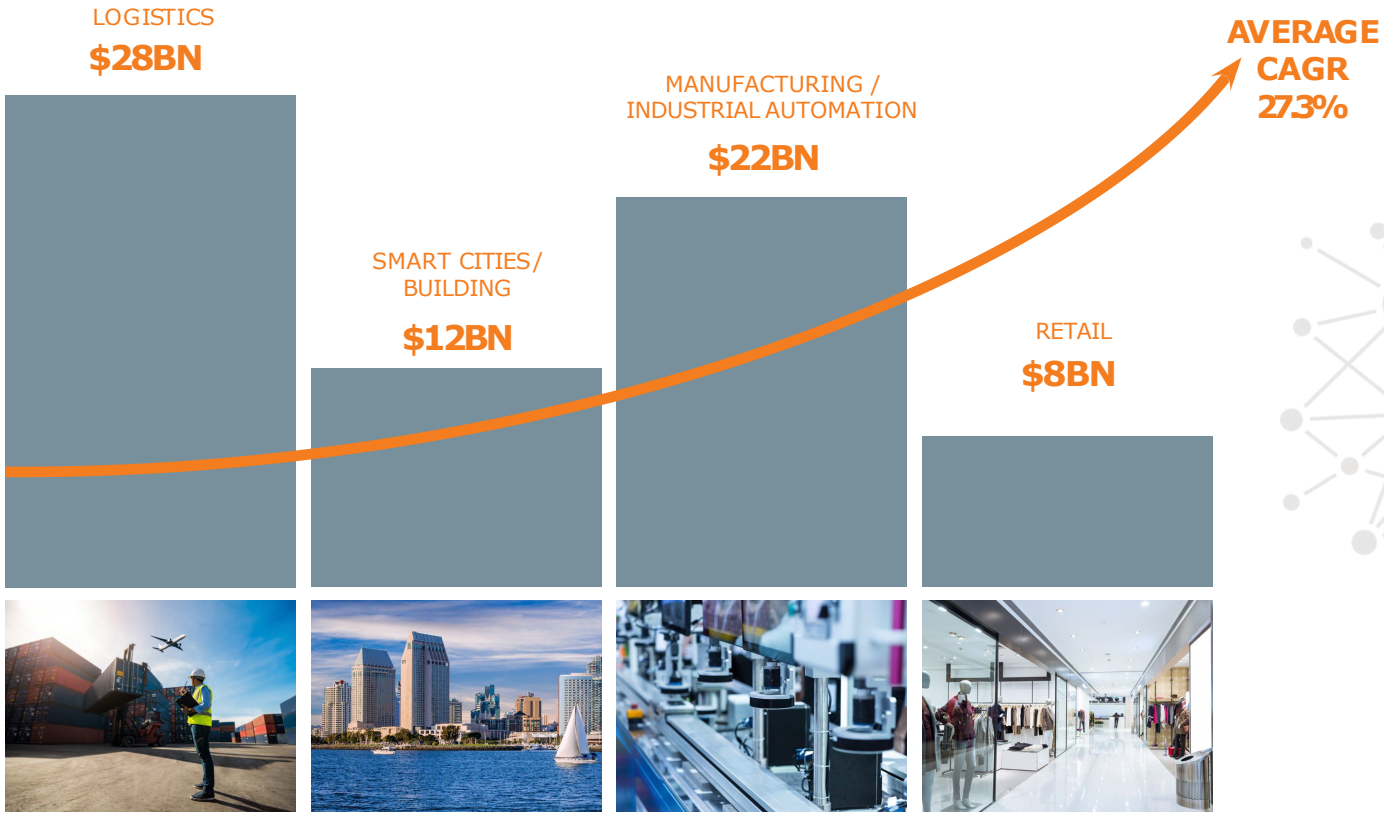
tinyML enabled DEVICES ($) –near-term forecast



- $60B market by 2024 (devices only)
- 41% CAGR growth

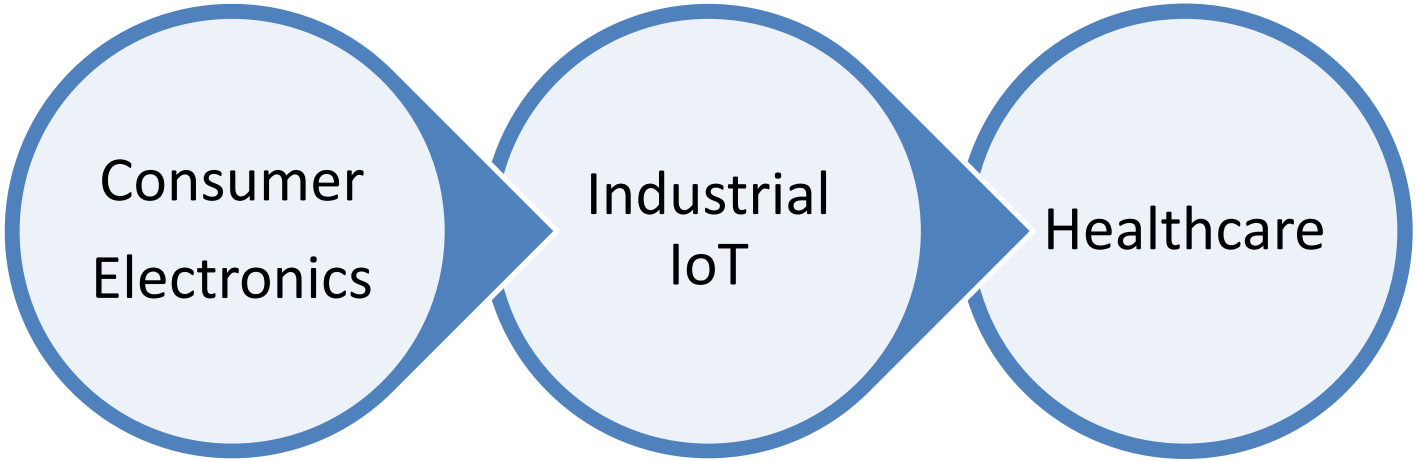
Source: Pitchbook, Emerging Tech, IoT, 2H-2020

In the next 5 years tinyML can unleash over $70BN* in economic value



*2019 market report

Leading use cases/verticals

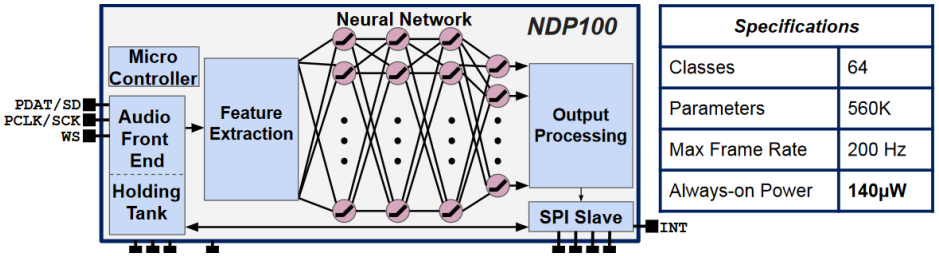


Phones
Laptops
XR

Predictive Maintenance/
Anomaly detection

Hearables
Wearables

Example: tinyML for Always-On Voice

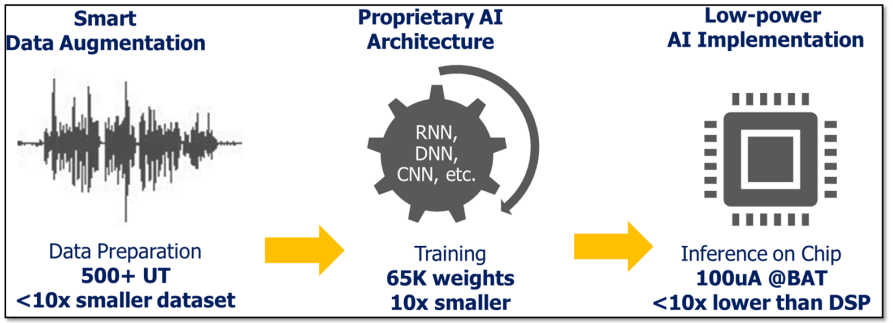


Specifications	
Classes	64
Parameters	560K
Max Frame Rate	200 Hz
Always-on Power	**140µW**

NDP100
1.4mm X 1.8mm

Courtesy: David Garrett, VP, HW

SYNTIANT



AONdevices
AI | DSP | ASIC

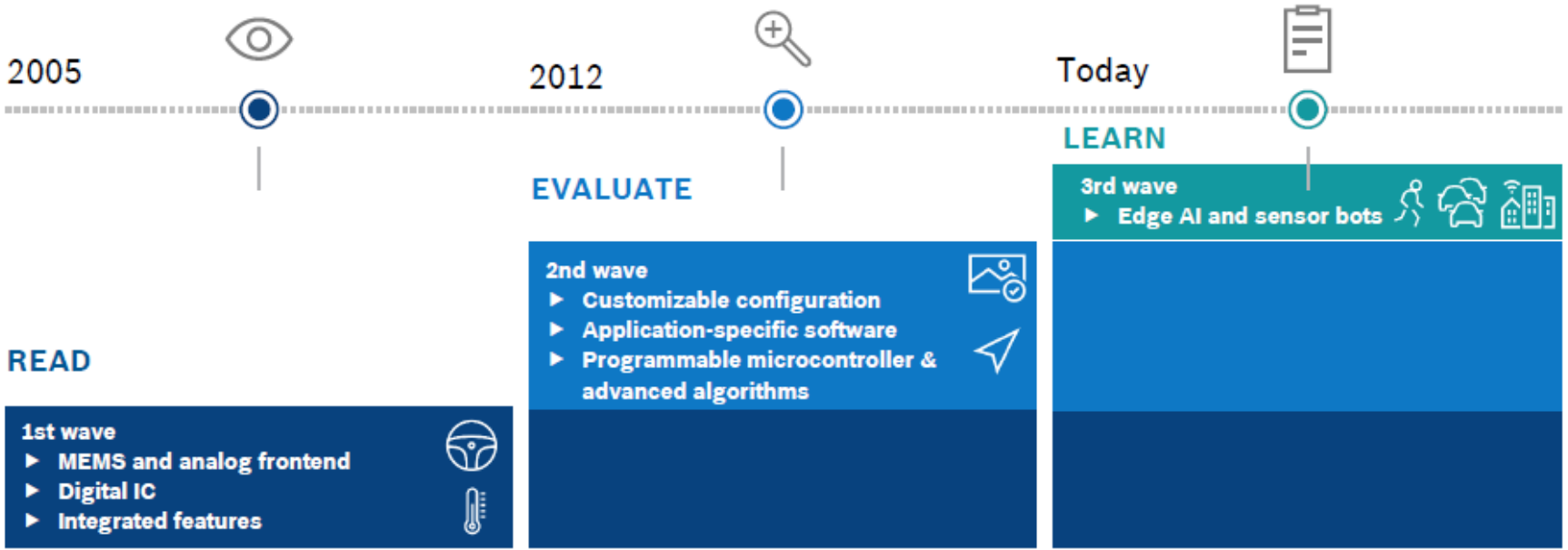
SAM: 8B Units devices by 2023

Courtesy: Mouna Elkhatib, CEO

TINY ML

Example: tinyML using MEMS sensors

Three waves of software evolution



- Software adds value not only to the sensor but also to the entire system.
- Software is becoming increasingly intelligent, enabling AI inside the sensor itself.

BOSCH

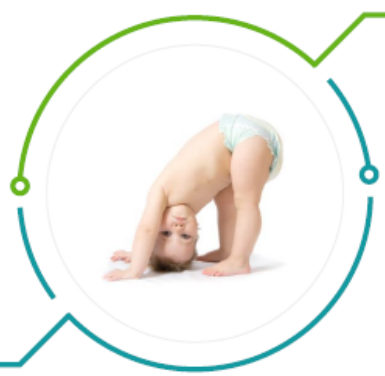
Courtesy: Stefan Finkbeiner*, CEO, Bosch Sensortec*

TINY ML

Example: tinyML using environmental sensors

What environmental sensor hardware in a diaper delivers

- Raw temperature
- Raw pressure
- Raw humidity
- Raw gas sensor signals



What the user wants

- Diaper state:
  - Clean
  - Dirty
  - Wet

What small sensor nodes can provide

- Temperature, pressure, humidity, air flow,...
- Gas sensor signals (from air quality up to smell patterns)
- Present devices (people!)

What the user wants

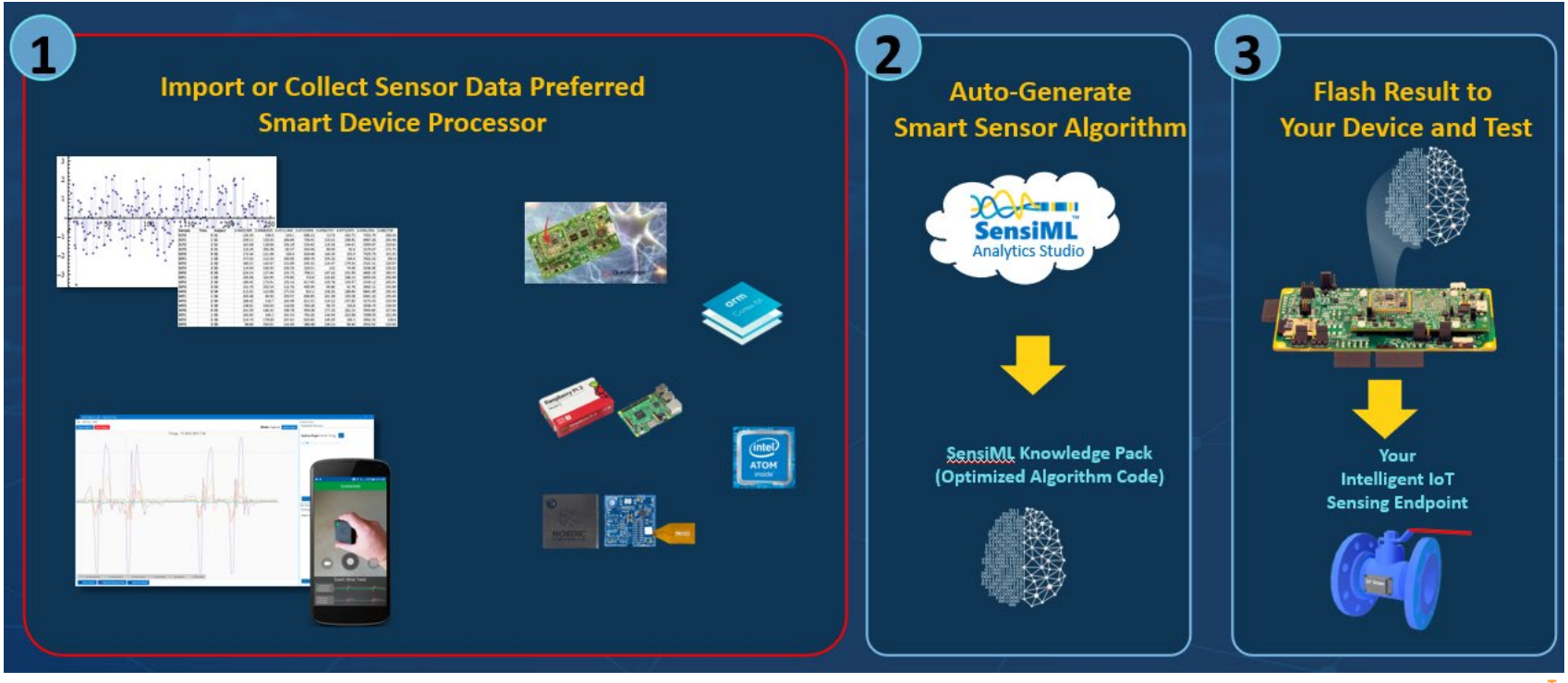
- Forest climate model
- Risk evaluation
- Early fire detection

BOSCH

Courtesy: Stefan Finkbeiner*, CEO, Bosch Sensortec*

TINY ML

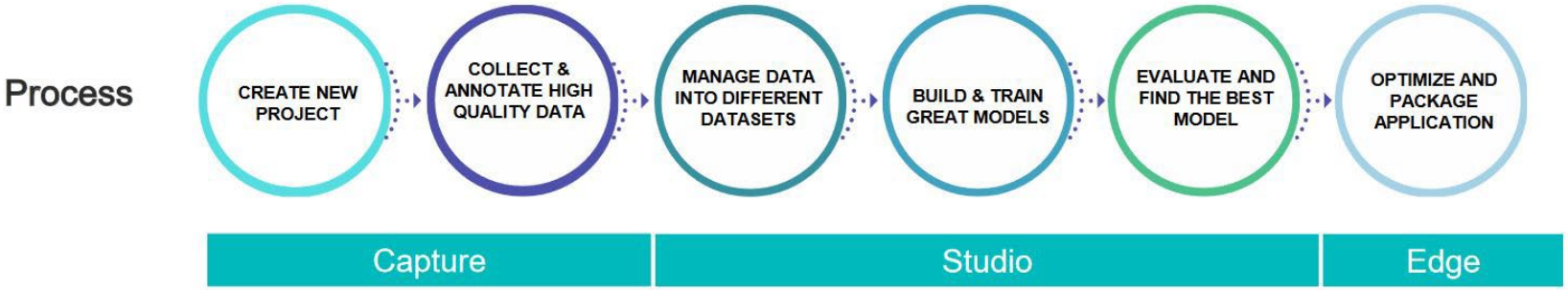
Example: tinyML for predictive maintenance (using IMUs)



Courtesy: Chris Knorowski, CTO

Example: tinyML for Gesture Control (using Radar)

- Proof-of-concept shown at CES 2020; Working prototype of gesture-controlled in-ear headphones will be demonstrated at CES 2021
- Application running in real time on the actual radar module
- ARM M4 processor, 256KB RAM (shared with BLE, FW and other apps)
- Impossible without Edge AI/tinyML
- Just sending the data off the device would drain the battery and impossible over BLE



imagimob

Courtesy: Alexander Samuelsson, CTO and Co-Founder

TINY ML

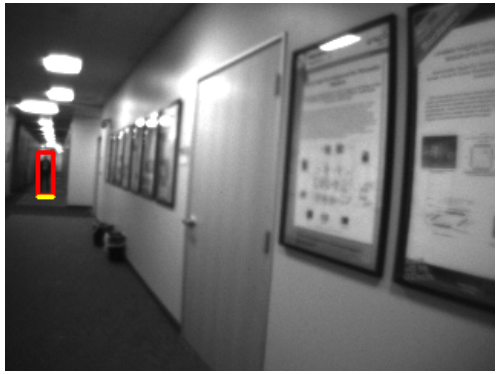
Example: tinyML for AR/VR applications

Yann LeCun (Facebook, Dec.2019): AR glasses will be the killer app of energy-efficient machine learning

Also watch: tinyML Talk by **Hans Reyserhove (Facebook Reality Lab): Embedded Computer Vision Hardware through the Eyes of AR/VR**
https://www.youtube.com/watch?v=c4g2zwFR3ps&t=1015s

tinyML Vision supports human detection cases

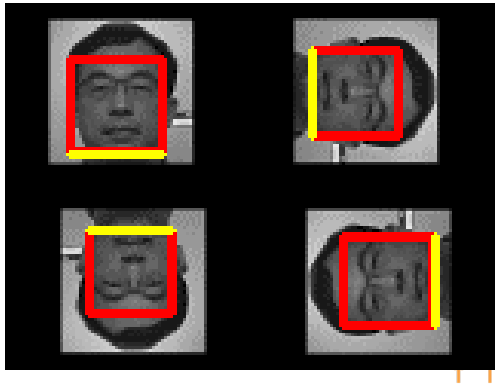
Half body



Full body

3/4 body

Change Detection



Multiple face orientation

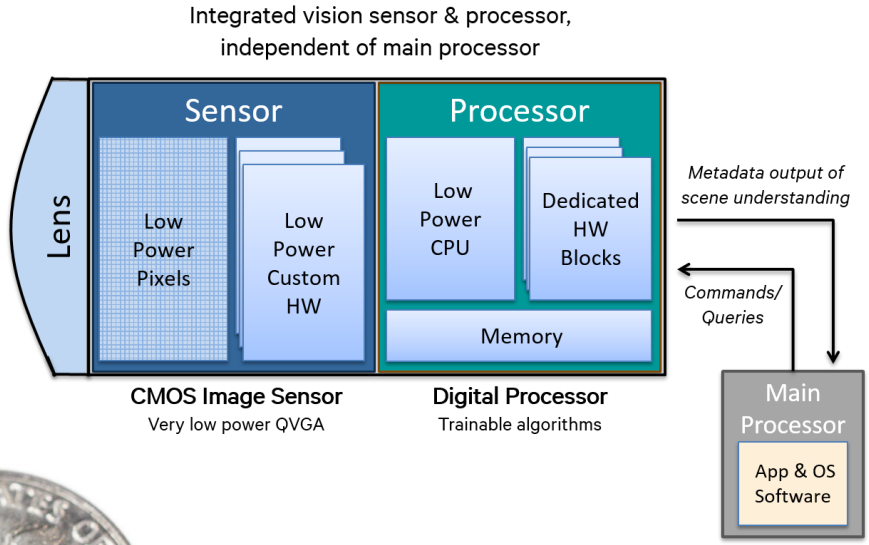
Qualcomm

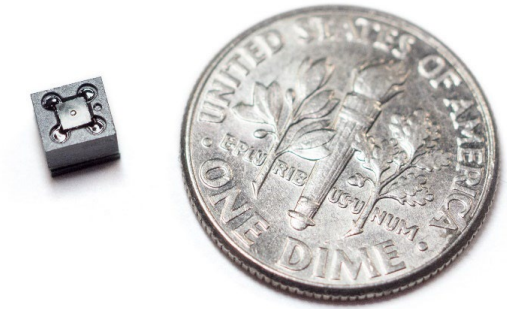
TINY ML

tinyML for Always-On Vision
Qualcomm always-on computer vision module

Key features:

- Ultra-low power, < 1 mW (end-to-end)
- Small size
- Privacy (output is metadata)
- Configurable for different use cases
- QVGA sensor, Near-IR compatible
- Low cost





Qualcomm

TINY ML

Vision will enhance many use cases across numerous verticals

Smartphone

- Face-based auto-wake and auto-sleep
- Always-on trigger for other use cases
- Always-on trigger for iris authentication (removes multiple steps and user initiation)

Smart watch

- Face-based auto-wake and auto-sleep
- Always-on gestures

Tablets

- Simple gaze tracking for advertising attribution
- Improved landscape/portrait screen orientation

Virtual reality

- Low power gaze tracking (foveated rendering)
- Low power visual odometry for 6 DoF

‘Intelligent’ occupancy trigger

- Distinguish humans from other objects
- Add data layer to trigger: How many? Where?
- Trigger on particular events or objects

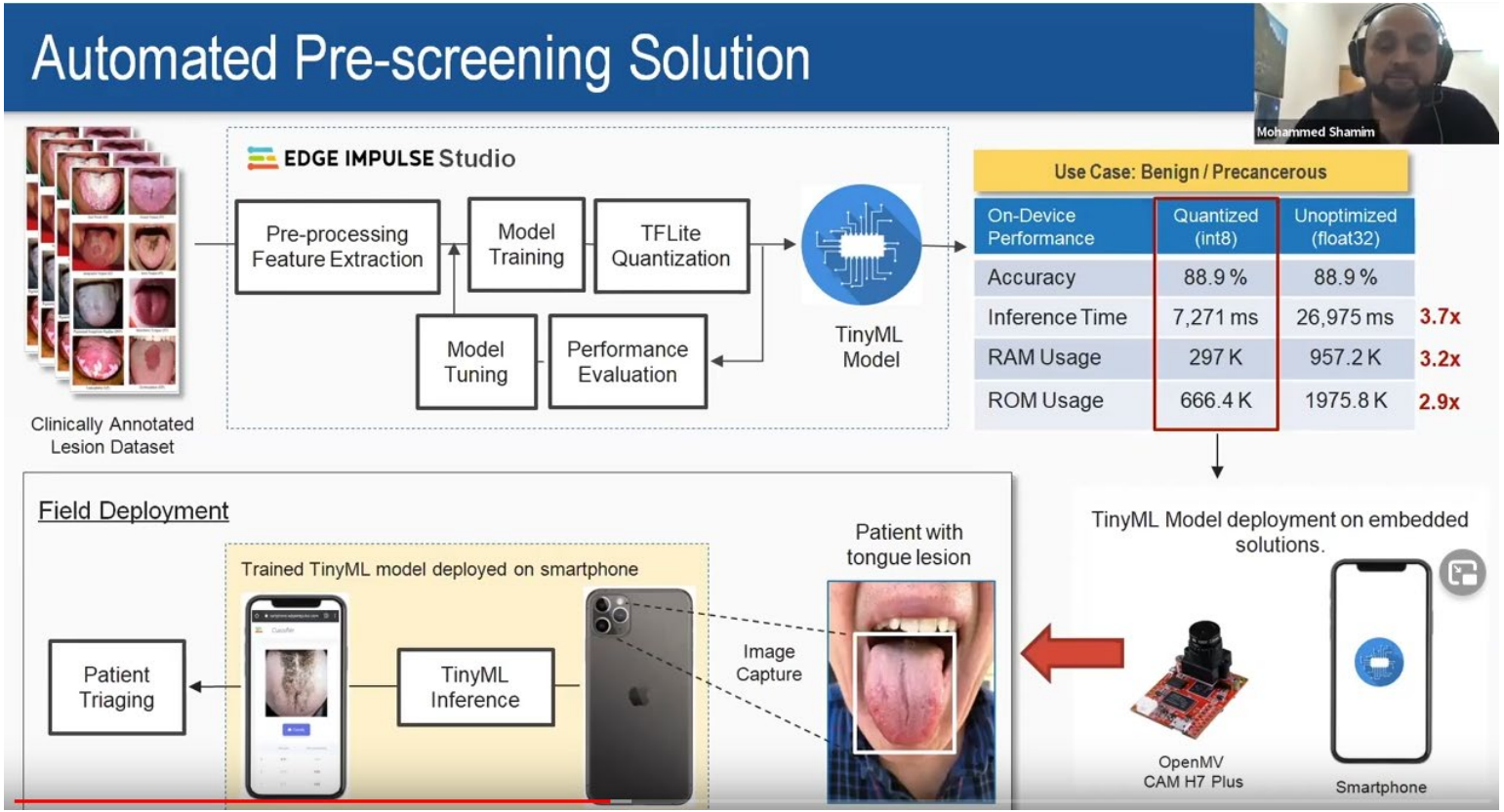
‘Intelligent’ interactivity trigger

- Face detection as a trigger for interactivity
- Smart appliance can react when a user approaches to engage it

Standalone intelligent data sensor

- Heat maps of how a space is occupied
- Privacy advantages – data only, no images captured

Example: Oral cancer detection using tinyML



Courtesy: Dr. Mohammed Zubair, King Khalid Univ, Saudi Arabia

Call to Action
for tinyML.edu 2.0

tinyML 2.0 Objective/"Products"

- Develop workforce for the industry (both tinyAI and bigAI)
- Educate educators
- Inspire future tinyML entrepreneurs
- Conduct research in energy efficient ML
- Promote collaborations/partnerships
- Build more awareness
- AI democratization and tinyML for Good

tinyML creates Jobs !

#hiring

Syntiant Corp.
4,336 followers
4mo • Edited • + Follow

We're hiring! From earbuds to automobiles, Syntiant is making #edgeAI a reality. So much so that we're looking for entrepreneurial-driven engineers to join our award-winning company. If you want to be part of a team that fosters an exciting culture of innovation, visit https://lnkd.in/gtg4CJk or send us your resume and cover letter to join@syntiant.com. We look forward to hearing from you! #culturematters #culturefirst #hiring #innovation #jobs #recruitment #engineering #engineeringjobs #careers

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Company:
Qualcomm Technologies, Inc.
Job Area:
Engineering Group, Engineering Group > Systems Engineering
About Us
Qualcomm

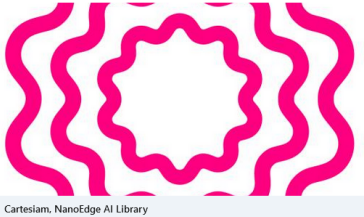
Audio Analytic
2,166 followers
5mo • + Follow

⭐EXCITING NEWS - We're recruiting! Join a dynamic team working on cutting edge AI sound recognition technology. Why not take a look at the open roles on our website? We look forward to hearing from you: https://aud.al/3igwDYj

... and more #hiring in #tinyML, this time with Cartesiam-ST
Marc Dupaquier Joel Rubino

Marc Dupaquier • 1st
Managing Director Artificial Intelligence Solutions , STMicroelectronics
2mo •

We are looking for great talent to join our Edge AI Teams across the World. If you love designing new devices, if you dream big and want to make your dreams a reality , if you want to join the Global Leader of Edge AI an ...see more



Cartesiam, NanoEdge AI Library
cartesiam.ai • 2 min read

GreenWaves Technologies
1,647 followers
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Audio talent is urgently needed. Greenwaves is hiring!
#hiring # #jobs #audioprocessor #audioengineer #tinyML
https://lnkd.in/dPvrS-m

Senior Embedded Software Engineer - Optimization of Computation of Audio Algorithm on GAP Architecture
greenwaves-technologies.com • 2 min read
As a member of the Audio team, you will contribute to port and optimize calculations an...

Zach Shelby • 1st
Hiring! Co-founder and CEO at Edge Impulse
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Now is your chance to join the startup democratizing machine learning for industrial, logistics and health. Edge Impulse is hiring full-stack developers, user success engineers and sales executives with more open positions con ...see more

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Edge Impulse enables developers to create the next generation of intelligent device...

GML
Senior Embedded System QA Engineer
GrAI Matter Labs · Paris, Île-de-France, France 4 months ago · 14 applicants
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11-50 employees
8 connections
See recent hiring trends for GrAI Matter Labs. Try Premium for free
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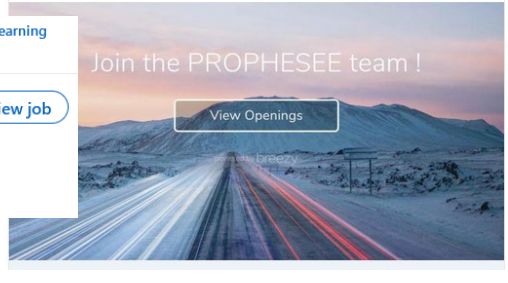
DO SOME OF THE MOST IMPACTFUL AI WORK OF YOUR CAREER
For us, it's about making deep learning real. We're producing software and technology that to enable AI in the things we use everyday.
What you develop, what you invent is not just going to be in labs and the hands of other engineers, but it's going to be in vehicles, in phones, in cameras - it's going to generate true change.
Want to see what you'll be working on? Check out the Deeplite Neutrino Community version on GitHub!

Qeexo is hiring - come make awesome products with me! #machinelearning #qeexoautoml #tinyML

Qeexo
Product Manager / Senior Product Manager
Job by Qeexo
Mountain View, California, United States
Medical, Vision, Dental, 401(k)
View job
3 connections work here

We are hiring in Grenoble and Paris.
Computer Vision and Image Processing specialists wanted!
Feel like interested? Please pay a visit to our offerings page



1. Make tinyML.edu 2.0 (HW and SW) agnostic and modular

for example, tinyML SW tools (e.g. tiny autoML)

State of the tinyAutoML Market **2022**

June 10, 2022

Featuring:

- Edge Impulse
- Greenwaves Technologies
- Newton.ai
- Nota.ai
- SensiML
- Deeplite
- Stream Analyze
- Qualcomm AiMET
- Qeexo
- Imagimob
- OmniML

https://www.tinyml.org/event/auto-ml-forum/

https://docs.google.com/document/d/1SDr6vgZOtpCtxX7s6IxfZB_V6ut7YSU6iCFwWgK_A8E/edit

HW space is also very diverse:

- Greenwaves Technologies (RISC-V)
- Syntiant
- ARM
- Alif
- ST Microelectronics
- NXP
- Qualcomm
- Bosch
- Infineon
- Silicon Labs
- TDK
- ….

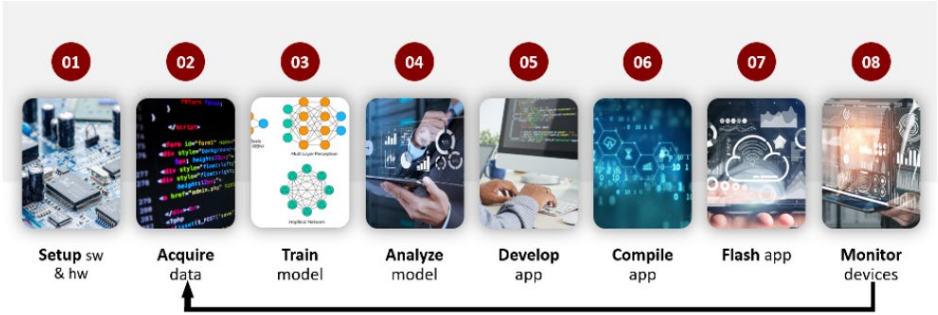
2. Real-world tinyML goes beyond ML model training – add deployment

tinyML Deployment Working Group White Paper #1

February 20, 2023

There is far more than "fit & predict" development required to deliver Tiny ML based products.

This is the first white paper in a series exploring challenges and solutions for deploying ultra-low power machine learning (ML) at the edge of the cloud. The authors are members of the tinyML® Foundation Deployment Working Group. The opinions expressed are not necessarily representative of the tinyML Foundation, its sponsors, or the authors' employers.



https://www.tinyml.org/static/98111ec2e44e63079e10872b485777a0/tinyML_Deployment_WG_White_Paper_1.pdf

3. Focus on solutions
not just (ML) models and tools

TINY ML FOUNDATION

collaboration with

hackster.io
AN AVNET COMMUNITY

Focus on:
(i) developing new use cases/apps for tinyML vision; and (ii) promoting tinyML tech & companies in the developer community

485 participants & 52 Submissions

https://www.hackster.io/contests/tinyml-vision

TINY ML

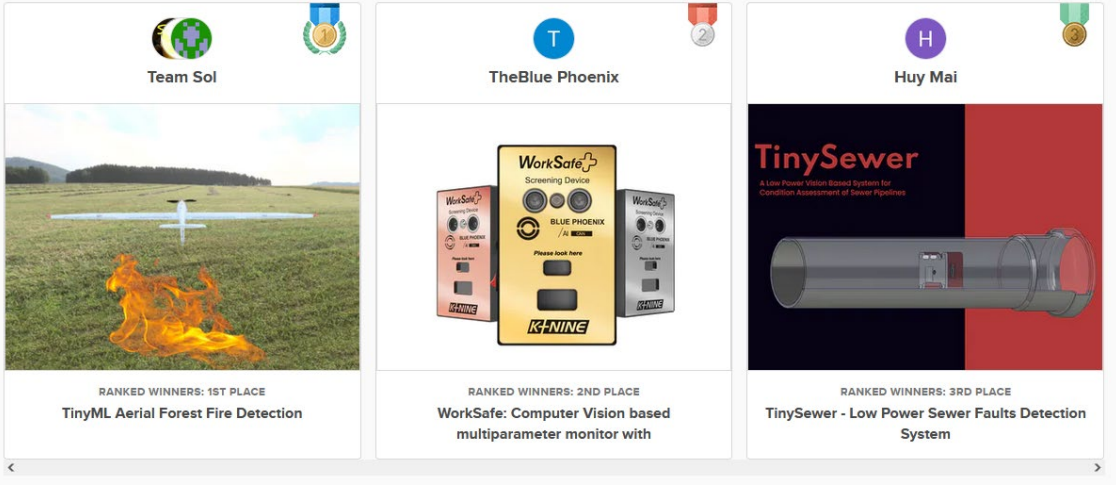
Vision Challenge-2021 Winners

Eyes on Edge: tinyML Vision Challenge!

with tinyML Foundation

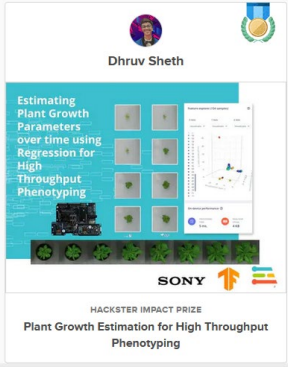
Congratulations to all the winners! Check out the winning projects below.

https://www.hackster.io/contests/tinyml-vision



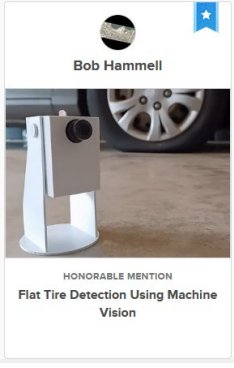
Hackster Impact Prize

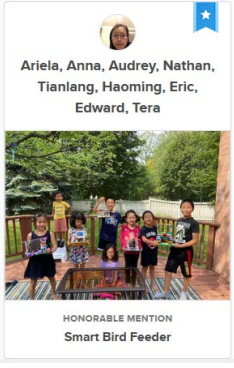
The winner was awarded a $250 Gift card + Video interview + More ($530 value)



Honorable Mention

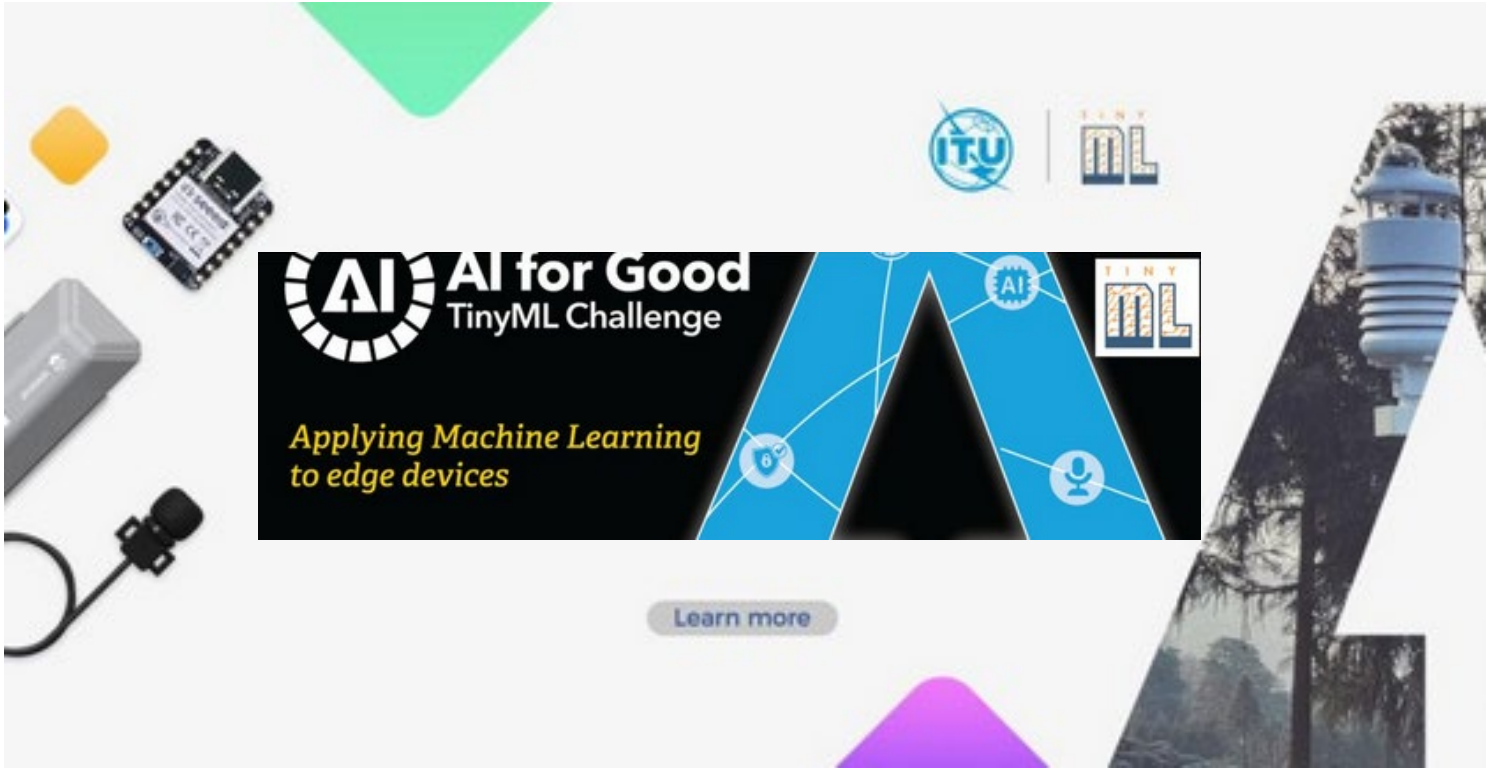
Each runner up was awarded a $500 Gift Card ($500 value)





TINY ML

Smart Weather Station Challenge-2022:
collaboration with UN/ITU



https://challenge.aiforgood.itu.int/match/matchitem/71

tinyML Challenge-2023 on pedestrian detection:

collaboration with City of San Jose

tinyML Pedestrian Hackathon Kickoff 2023 - Pedestrian Detection

https://www.youtube.com/watch?v=J1NYQaQe7M8&t=2s

tinyML BUILDS Series

- 1 hour on-line LIVE and interactive interviews with tinyML “Builders”
- Have you wondered what goes into building a REAL WORLD tinyML device/product? In this series, we discuss the details of how product developers and engineers built their tinyML devices, from early development phases to commercialization. The discussion is a deep dive into engineering and tech that these teams have developed and lessons learned.
- Started in April 2023
- Hosted by Venkat Rangan, Founder and President of tinyVision.ai

tinyML Success Stories Series

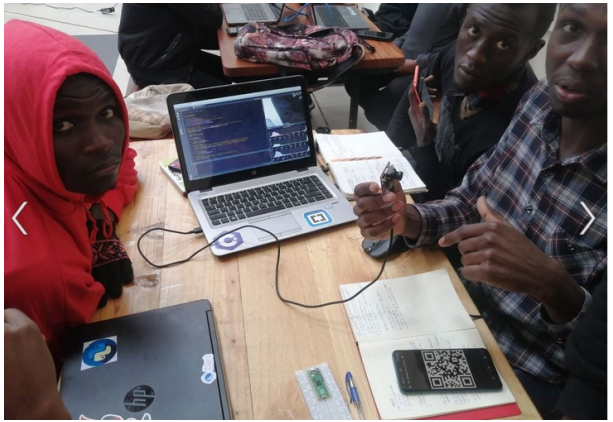
- Inspiration and educational series
- 1 hour on-line LIVE and interactive interviews with tinyML “movers and shakers”
- Recent M&A stories, VC views, new products, breakthrough research in the academia
- Started in December 2021
- Hosted by renowned entrepreneur Chris Rowen (CISCO)

tinyML Success Stories Series Guests

Pete Warden, Google https://www.youtube.com/watch?v=tlQcdhlN8q8&t=2999s
Kurt Busch, Syntiant co-founder and CEO, https://www.youtube.com/watch?v=ceT8LMUIiBU&t=112s
Joel Rubino, Cartesiam.ai co-founder and CEO, https://www.youtube.com/watch?v=NkT7rMiTQRk
Marian Verhelst, Prof at KU-Leuven and tinyML BoD, https://www.youtube.com/watch?v=COmoXOSQALY
Eric Pan, Founder and CEO, Seeed Studio, https://www.youtube.com/watch?v=DRfv-Rwy3Iw&t=1715s
Thierry Moreau, OctoML Co-Founder, https://www.youtube.com/watch?v=GaLJ47bmQ1I&t=129s
Mouna Elkhatib, Founder and CEO, AONDevices, tinyML Trailblazers Success Stories with Mouna Elkhatib - YouTube
Yoram Zylberberg, CEO, Emza Visual Sense, tinyML Trailblazers with Yoram Zylberberg - YouTube
Vijay Janapa Reddi, Prof. at Harvard University, https://www.youtube.com/watch?v=wk7bQvzR5Ik&t=18s
Zach Shelby, CEO and Co-Founder, Edge Impulse, https://www.youtube.com/watch?v=15GdPnoQhB8
Massimo Banzi, Co-Founder and CTO, Arduino, tinyML Trailblazers Success Stories with Massimo Banzi - YouTube
Chris Rogers, Co-Founder and CEO, SensiML, tinyML Trailblazers Success Stories with Chris Rogers - YouTube
Luca Verre, Co-Founder and CEO, Prophesee, tinyML Trailblazers with Luca Verre CEO Prophesee - YouTube
Loic Lietar, Co-Founder and CEO, Greenwave Tech, tinyML Trailblazers with Loic Lietar CEO from Greenwaves Technologies - YouTube
Sang Won Lee, Co-Founder and CEO, Qeexo, https://www.youtube.com/watch?v=NpO45JPVFIo

Kishore Manghnani, Co-Founder and CEO, Shoreline IoT

tinyML Kenya Developer Day, July 2022*

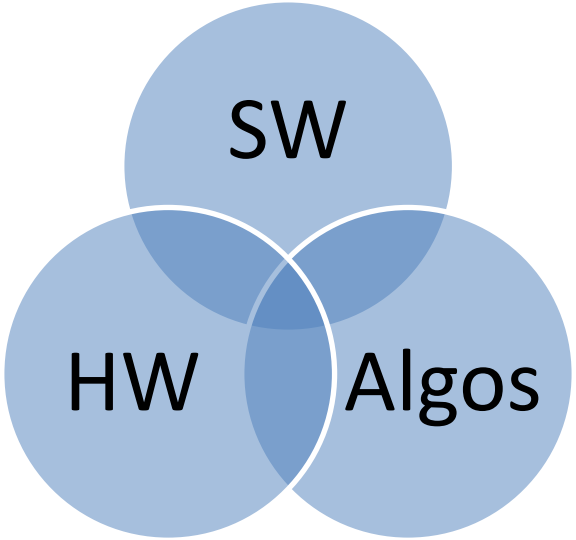


*100+ participants

4. Encourage & embrace holistic, systems/project based multi-disciplinary approach

How is tinyML Implemented ?

Key: - Holistic HW-SYS(algorithms/networks)-SW co-design
- Extreme optimization and innovation in all three areas

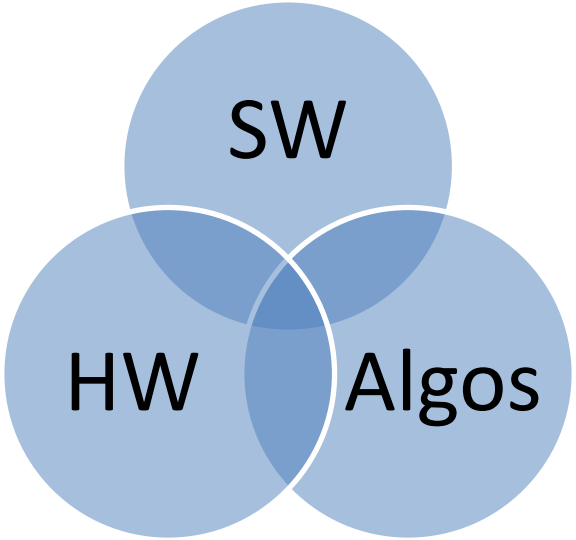


tinyML is “good enough” NOW

… *and more enhancements coming in the near future*

$$$ More tinyML apps and value creation

$ initial tinyML applications



HW accelerators (digital)

- *Compute in memory*
- *Analog compute*
- *Neuromorphic*

Quantization, compression
Smaller models (100s kB)

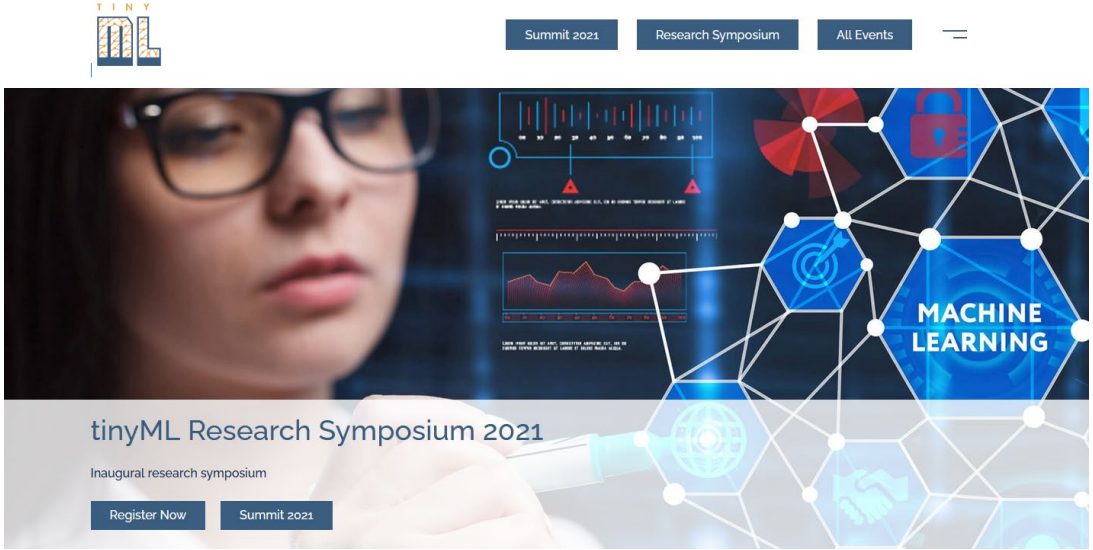
- *Novel algos/networks*
- *10s kB models*

Enabling technologies: ULP sensors, novel memories, 3D, energy scavenging, ULP radio

5. tinyML = embedded + ML

6. Conduct basic research

Inaugural tinyML Research Symposium (March 26, 2021)



Committee

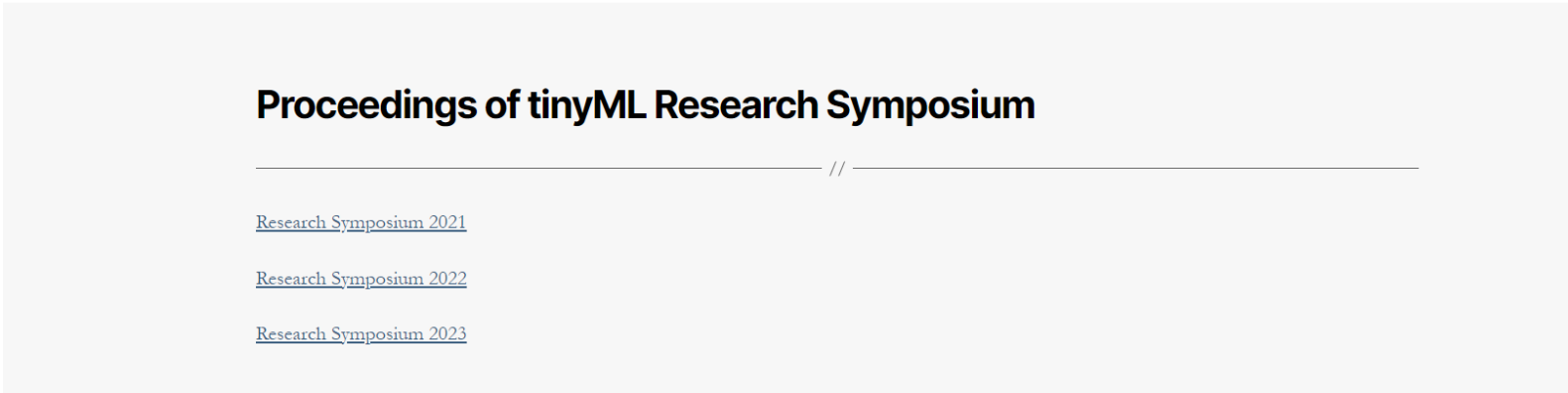
Boris MURMANN
Program Chair
Stanford University

Vijay JANAPA REDDI
Program Chair
Harvard University

Publications

Ultra-low power machine learning at the edge

Proceedings Research Symposium



www.proceedings.tinyML.org

Industry peer recognition Awards

2021 Winners

SYNTIANT

EDGE IMPULSE

Guangyuan HU

PRINCETON UNIVERSITY

2022 Winners

PROPHESEE

REXEN technology

Andrea BEJARNO-CARBO

UNIVERSITY OF MICHIGAN

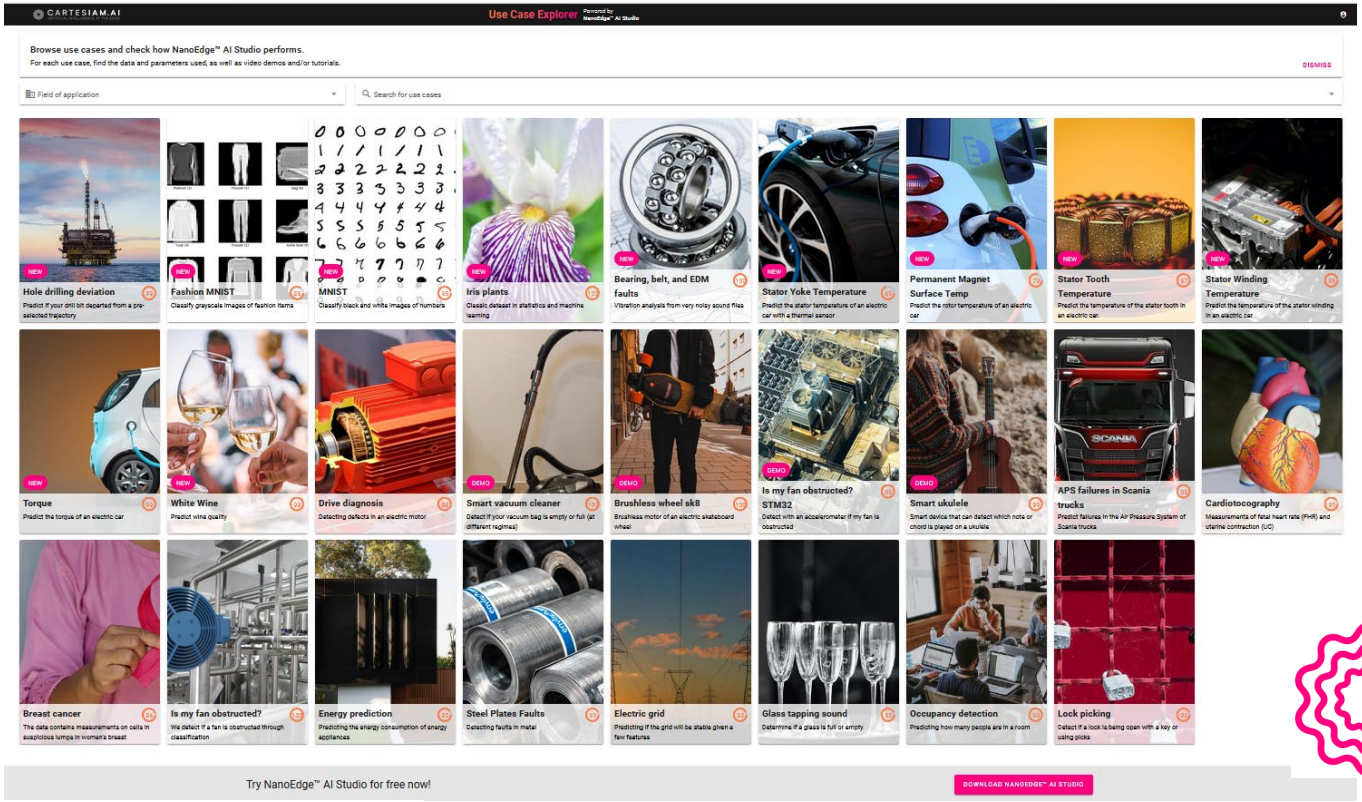
7. More attention to data engineering

https://www.tinyml.org/event/tinyml-dataset-benchmarking-working-group/

8. Promote tinyML impact and applications/use cases (e.g. tinyML application zoo)

- share known use cases
- inspire student to think out of the box
- don’t be shy to talk about positive impact

Plentiful tinyML use case: some more examples



Courtesy: life.augmented

TINY ML

Social impact: tinyML/tinyAI for Good

https://www.un.org/development/desa/disabilities/envision2030.html

tinyML/tinyAI will make significant contribution to major SDG goals:

- Good Health and Well-being
- Clean Water and Sanitation
- Affordable and Clean Energy
- Decent Work and Economic Growth
- Industry, Innovation and Infrastructure
- Sustainable Cities and Communities
- Responsible Consumption and Production
- Climate Action
- Life on Land
- Partnerships to achieve the Goal

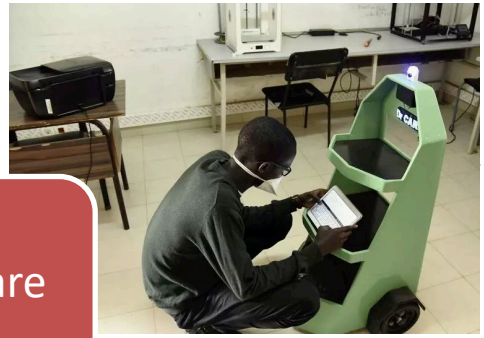
Strong differentiation and significant impact potential: unlike cloud based AI, tinyML is ultimately connected to LIFE via sensors and actuators in most/all verticals: environmental, smart agriculture, food, wellness/health, climate, education, etc.

Prof. Song Han at MIT has developed an AutoML approach, “Once-for-All”, allows to reduce carbon footprint by 1/1000th while designing a network wrt the conventional ML and improve inference time(energy) by about 2x.

https://www.youtube.com/watch?v=jsyHqDX5cU8&t=3s

Kate Kallot
NVIDIA
Head of Emerging Areas,
tinyML for Good Leader

STEM



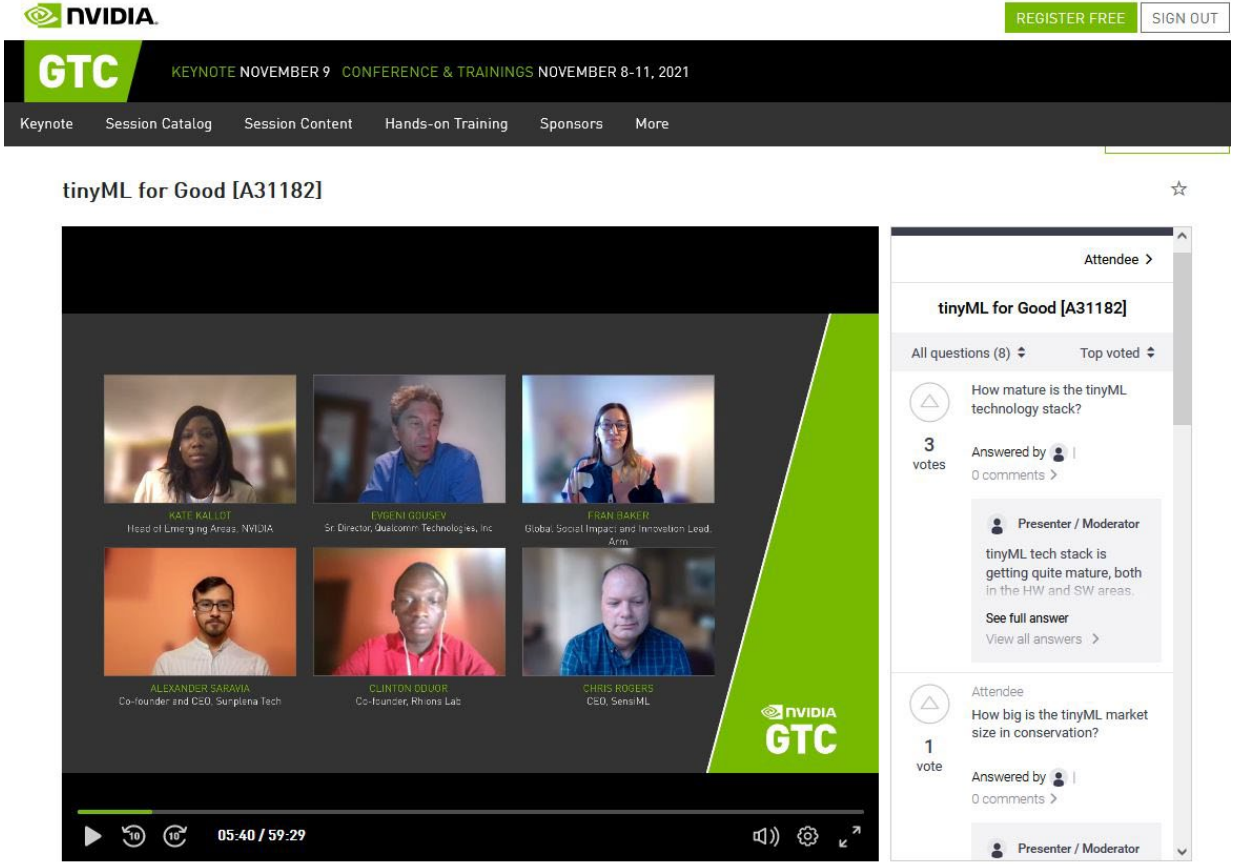
TINY ML For Good

Healthcare

Earth
Climate
Conservation

Contact: 4good@tinyML.org

tinyML for Good @ GTC2021*



tinyML is not tiny. It has a big impact on healthcare, education, conservation and climate change. In this panel discussion, our tinyML experts will share the tinyML for Good applications, opportunities, and how tinyML drives AI innovation in the emerging markets.

**210k attendees registered at GTC2021*

Inspirational tinyML for Good Workshop, Nov.17, 2021*

Very well presented on all fronts! Thanks everyone for the "education" and for sparking the urge to focus more on TinyML.

Get Inspired, Make Great Things Happen!

Thoroughly enjoyed thanks!

Massive inspiration and very helpful for useful idea generation, thank you!

Fantastic work Barke. Am glad that we can move forward the conversation and potential project with the Zanzibar Fisheries and Marine Resources Research Institute where you are also involved.

Fantastic workshop! Thanks a million for putting this together.

From Juan Diego Del... to Hosts and panelis

Thanks! Great inspiration

From Juan Diego Del... to Hosts and p

❤️❤️❤️❤️❤️

Thank you for this meeting and all local projects, many ideas to develop

Evgeni, thank you so much for including me today! I am even more inspired than ever to do something meaningful with you and TinyML

From Juan Diego Del... to Hosts and panelists:

Gracias!!

*600 registrated attendants

tinyML at AI for Good Global Summit 2023 (UN/ITU)

Geneva, Switzerland, July 6-7, 2023

2022 International Conference on Innovation and Intelligence for Informatics, Computing, and Technologies (3ICT)

How TinyML Can be Leveraged to Solve Environmental Problems: A Survey

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Yousra Chtouki
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Science-Policy Brief for the Multistakeholder Forum on Science, Technology and Innovation for the SDGs, May 2022

TinyML: Applied AI for Development

Marco Zennaro (ICTP/UNESCO), Brian Plancher (Harvard University), Vijay Janapa Reddi (Harvard University)

Abstract

Artificial intelligence (AI) will likely be an instrumental part of progress towards the United Nations' Sustainable Development Goals (SDGs). However, its adoption and impact are limited by the immense power consumption, strong connectivity requirements and high costs of cloud-based deployments. TinyML is a new technology that allows machine learning (ML) models to run on low-cost, low-power microcontrollers, circumventing many of these issues. We believe that TinyML has a significant role to play in achieving the SDGs and facilitating scientific research in areas such as environmental monitoring, physics of complex systems and energy management. To broaden access and participation and increase the impact of this new technology, we present an initiative that is creating and supporting a global network of academic institutions working on TinyML in developing countries. We suggest the development of additional open educational resources, South–South academic collaboration and pilot projects of at-scale TinyML solutions aimed at addressing the SDGs.

https://ieeexplore.ieee.org/document/9990661

Let's make tinyML BIG !
TOGETHER !!!