



**II CONGRESO INTERNACIONAL
DE INGENIERÍA 2026**

**LA INGENIERÍA SE
ENCUENTRA CON
LA HUMANIDAD**



TinyML y Edge AI: ingeniería al servicio de las comunidades

Prof. Marcelo J. Rovai

UNIFEI - Federal University of Itajubá, Brazil

AIEng4D - Academic Network Co-Chair

EdgeAIP - Academia-Industry Partnership Co-Chair



Vigilancia Mineducación

From Corp VP to Education Advocate

1980s-2010s

Engineer & Executive

Avibras Airspace, AT&T, NCR, Dell, Compaq, IGT

2015+

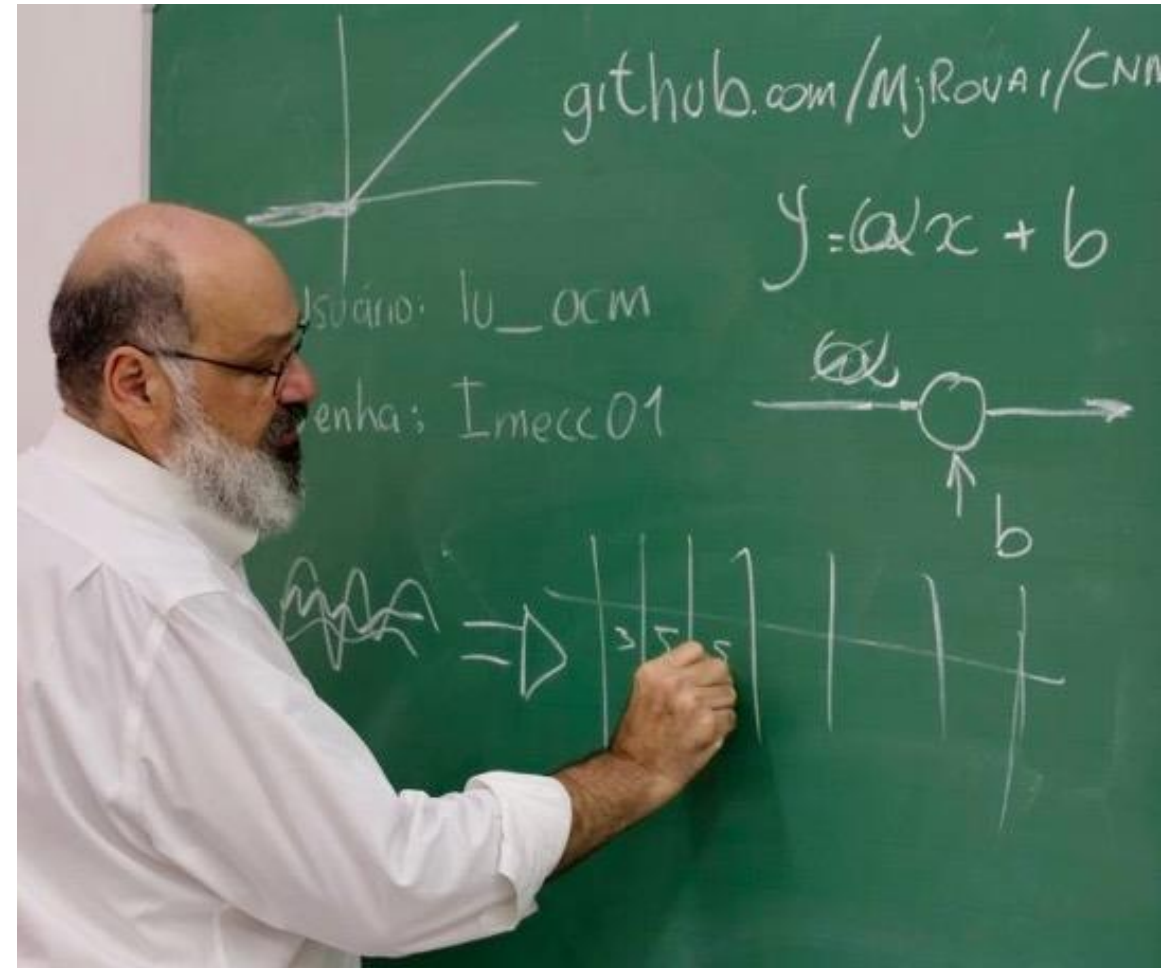
Maker, Professor & Volunteer

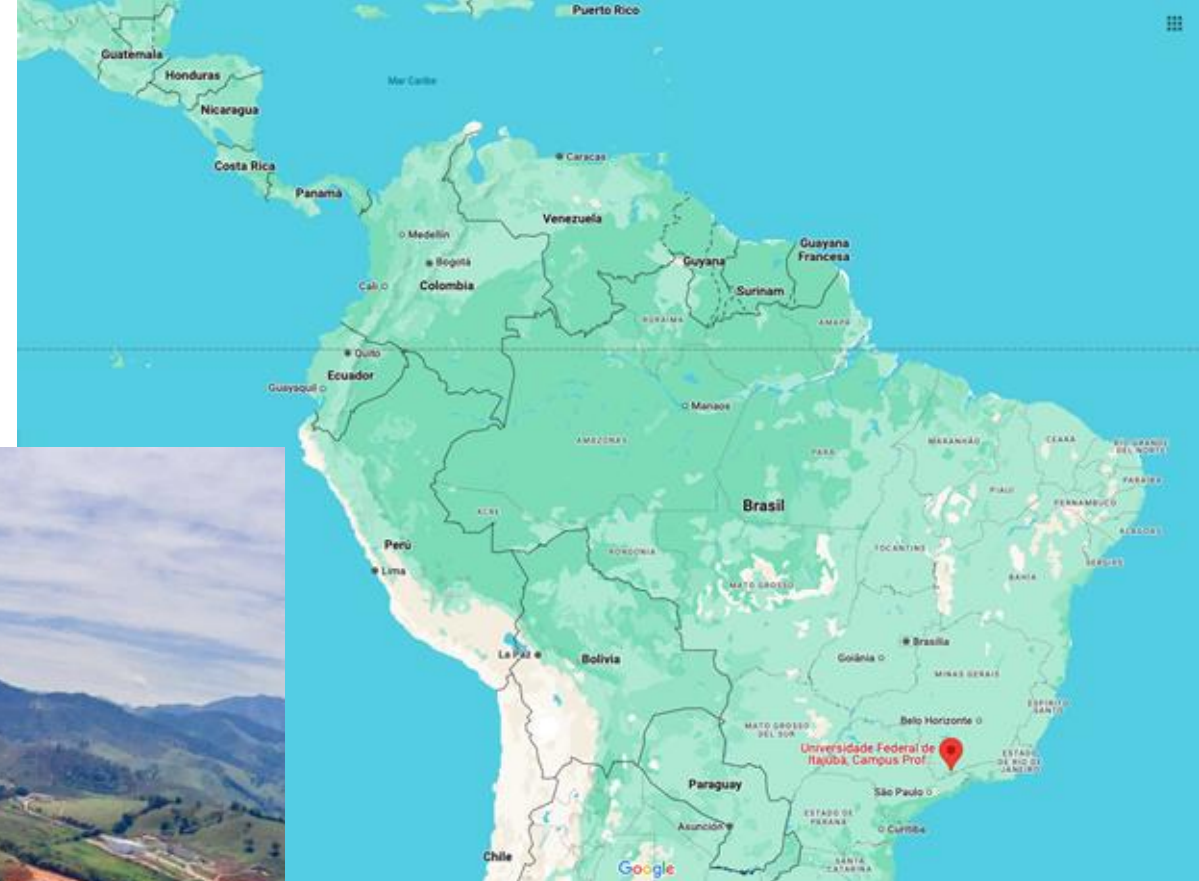
Democratizing AI Education

Today

AIEng4D & EdgeAIP Co-Chair

30+ countries, 5,000+ students

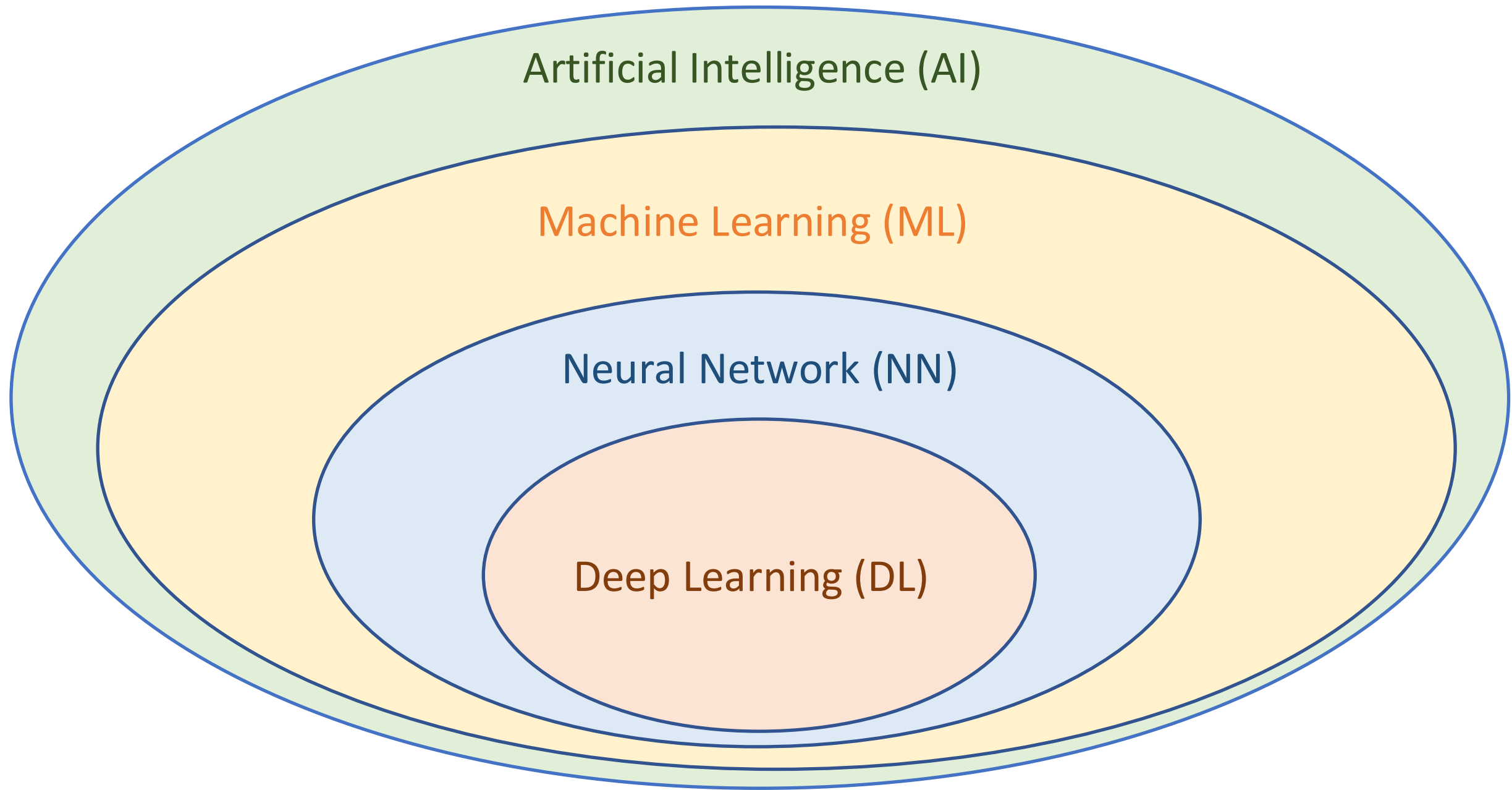




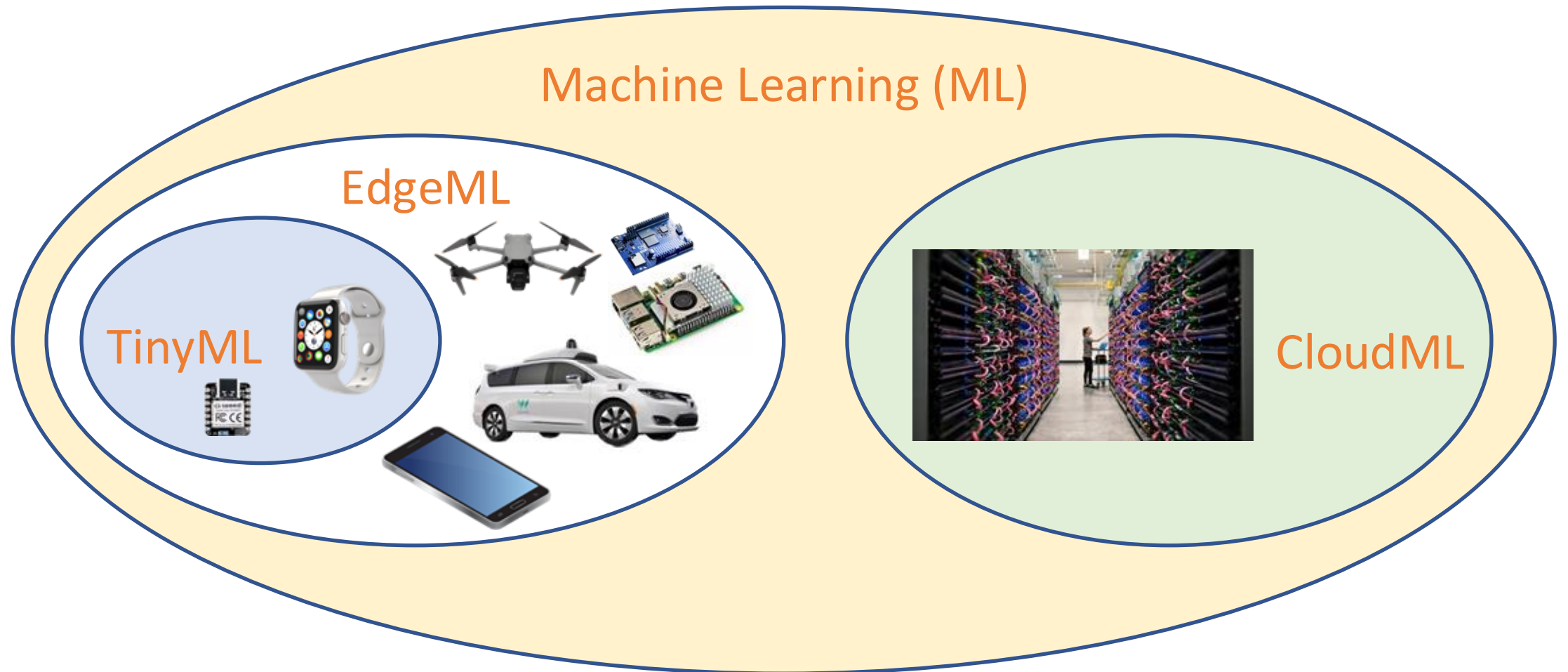
Itajubá,
Minas Gerais,
Brazil

Embedded ML (TinyML)

Introduction



From Tiny to Cloud: One AI, Many Scales



Sustainability Matters

0.5W



5W-



100W+

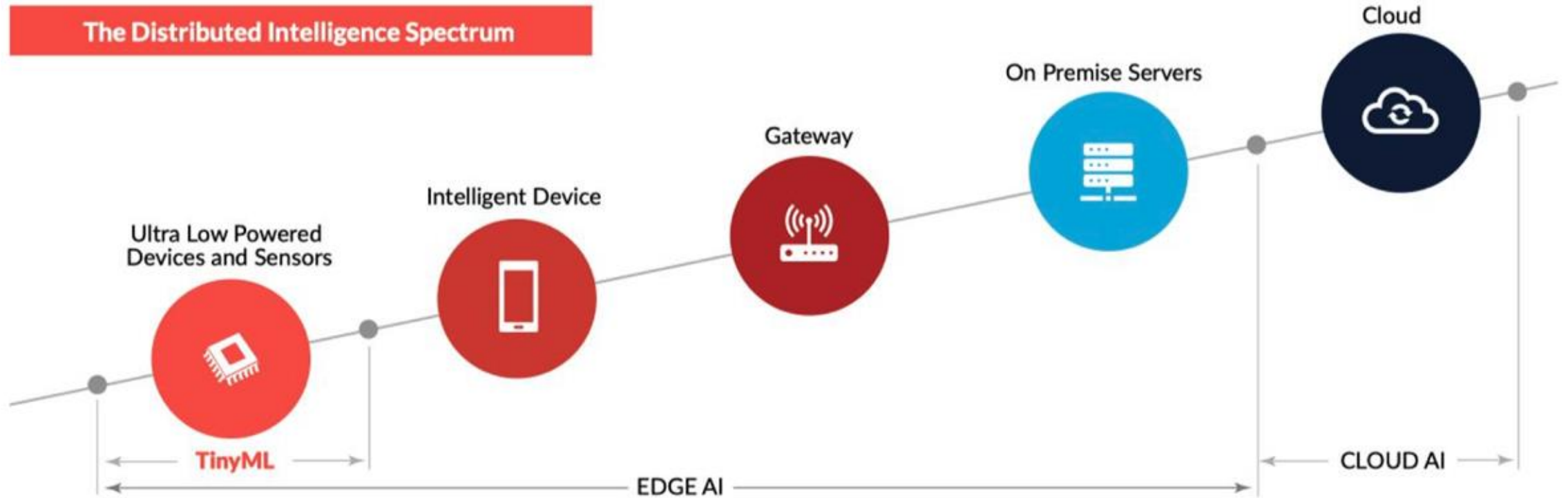
15W



20W+

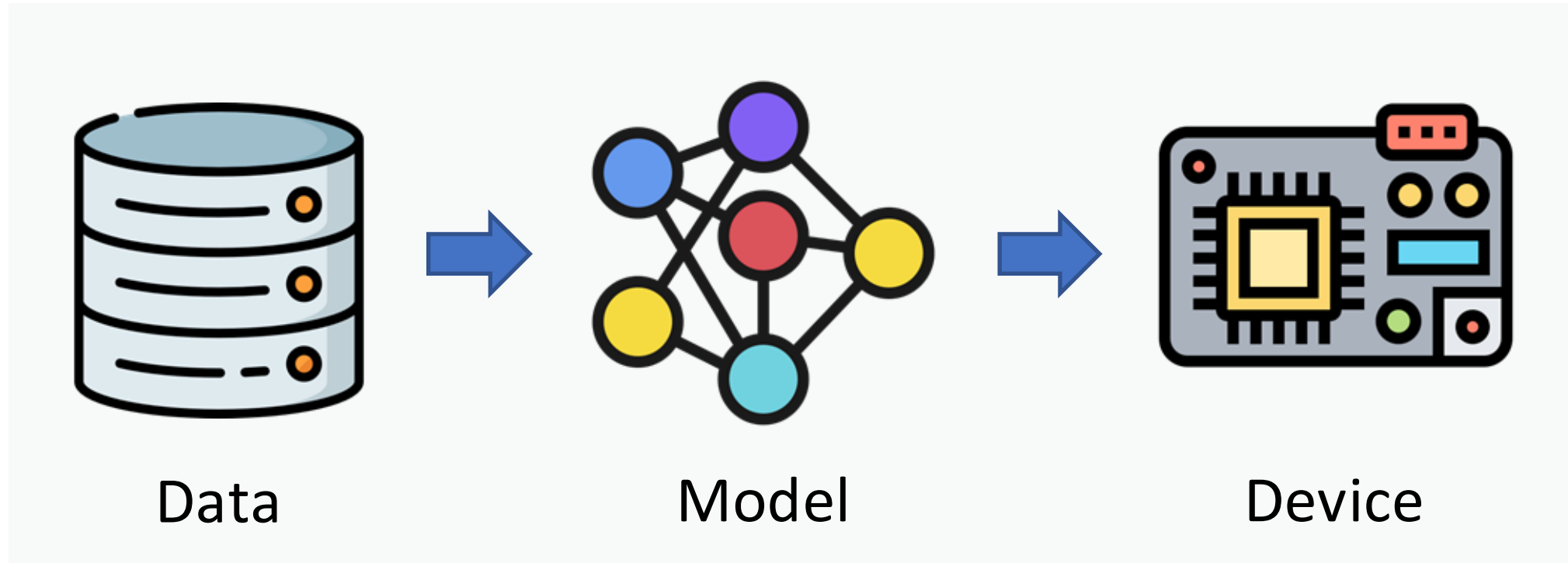


+200x more energy efficient than cloud AI

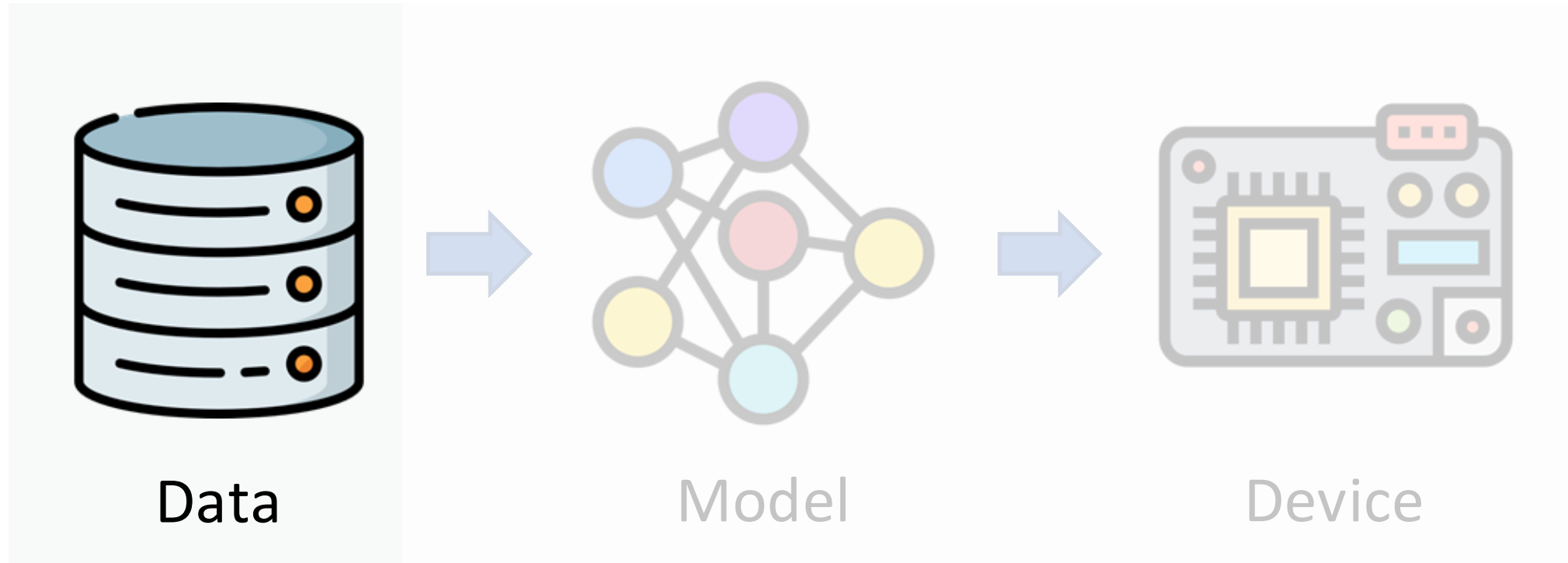


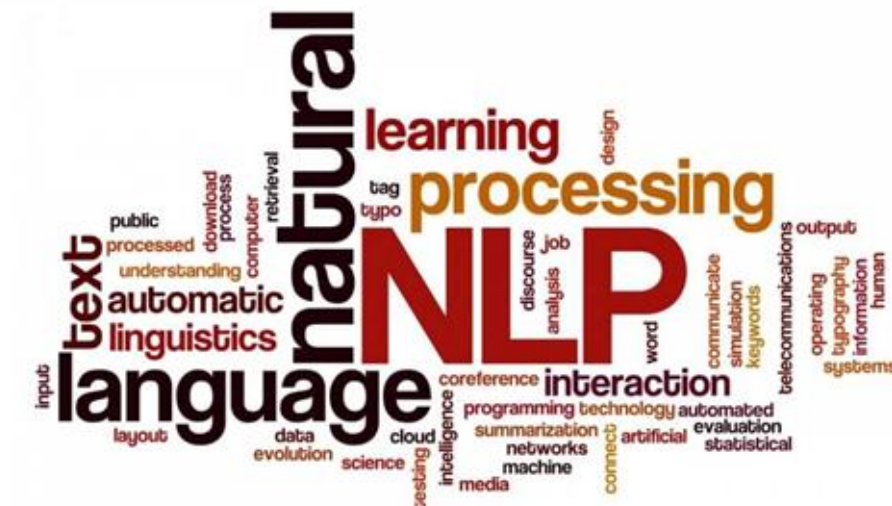
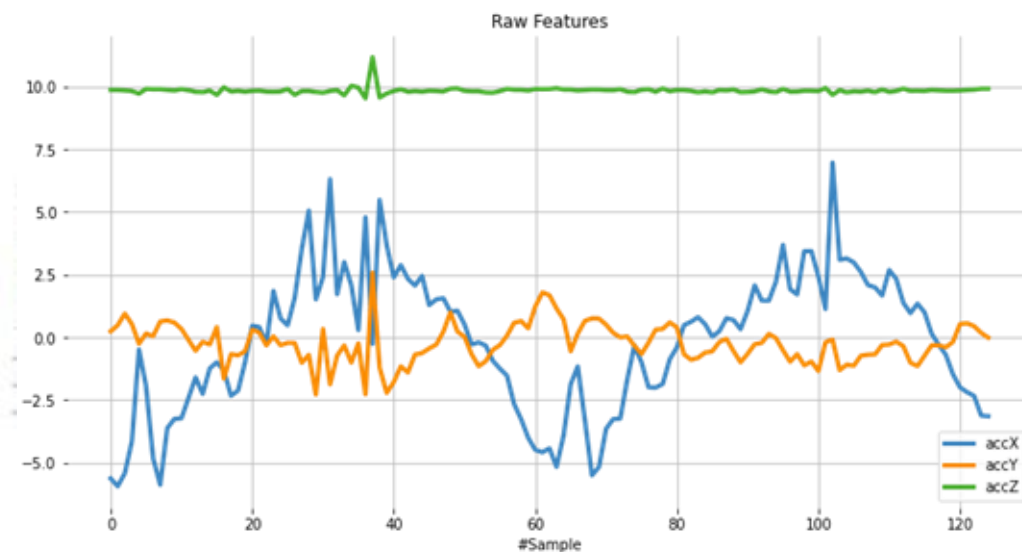
Challenges

ML Deployment Pipeline

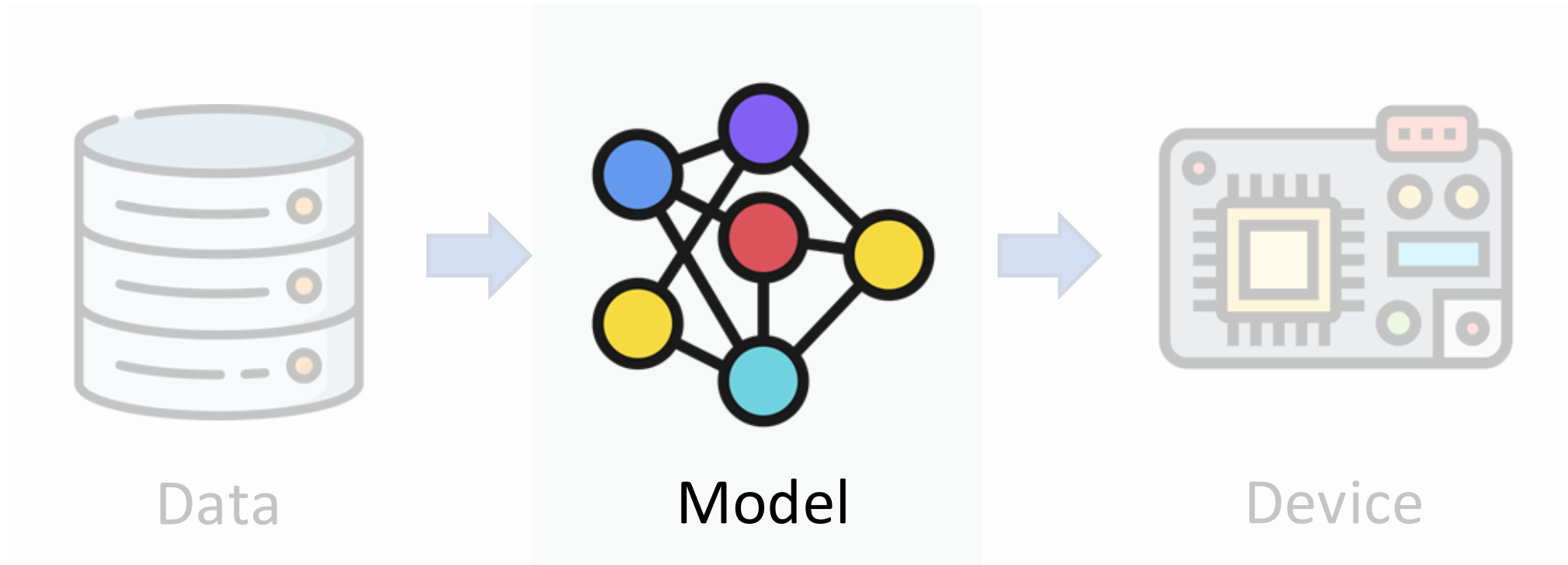


ML Deployment Pipeline





ML Deployment Pipeline





Vibration
Analysis

Image
Classification

Text
Generation

Image
Generation

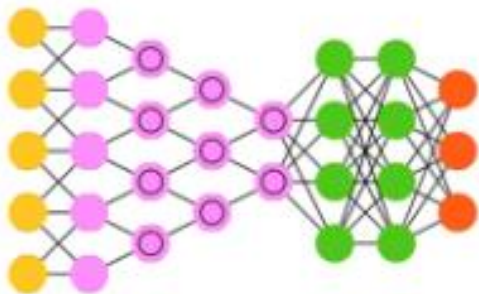
Large Language
Models- LLMs



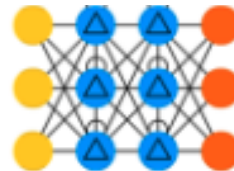
MLP - Deep Neural Network



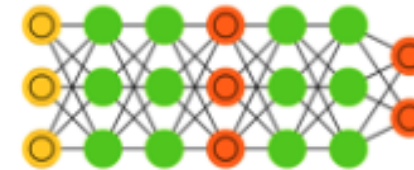
CNN - Convolutional NN



RNN - Recurrent NN (GRU/LSTM)



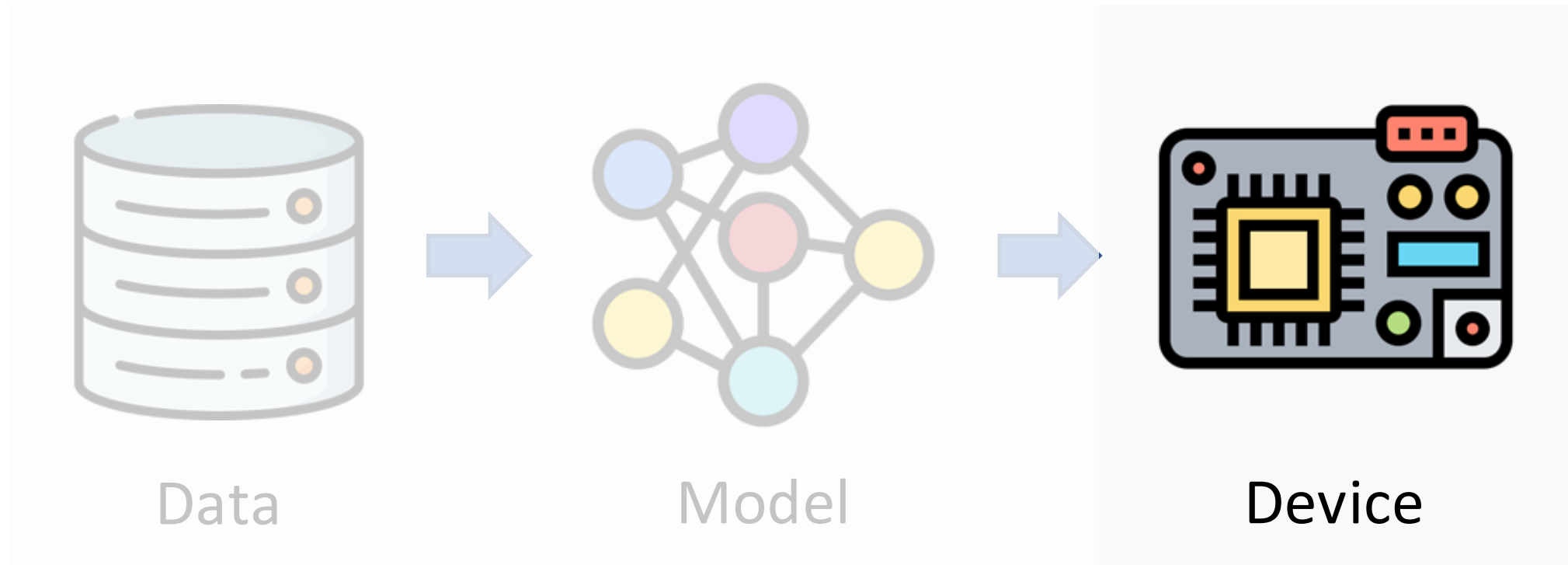
GAN - Generative Adversarial Net.



TF - Transformer (Attention)



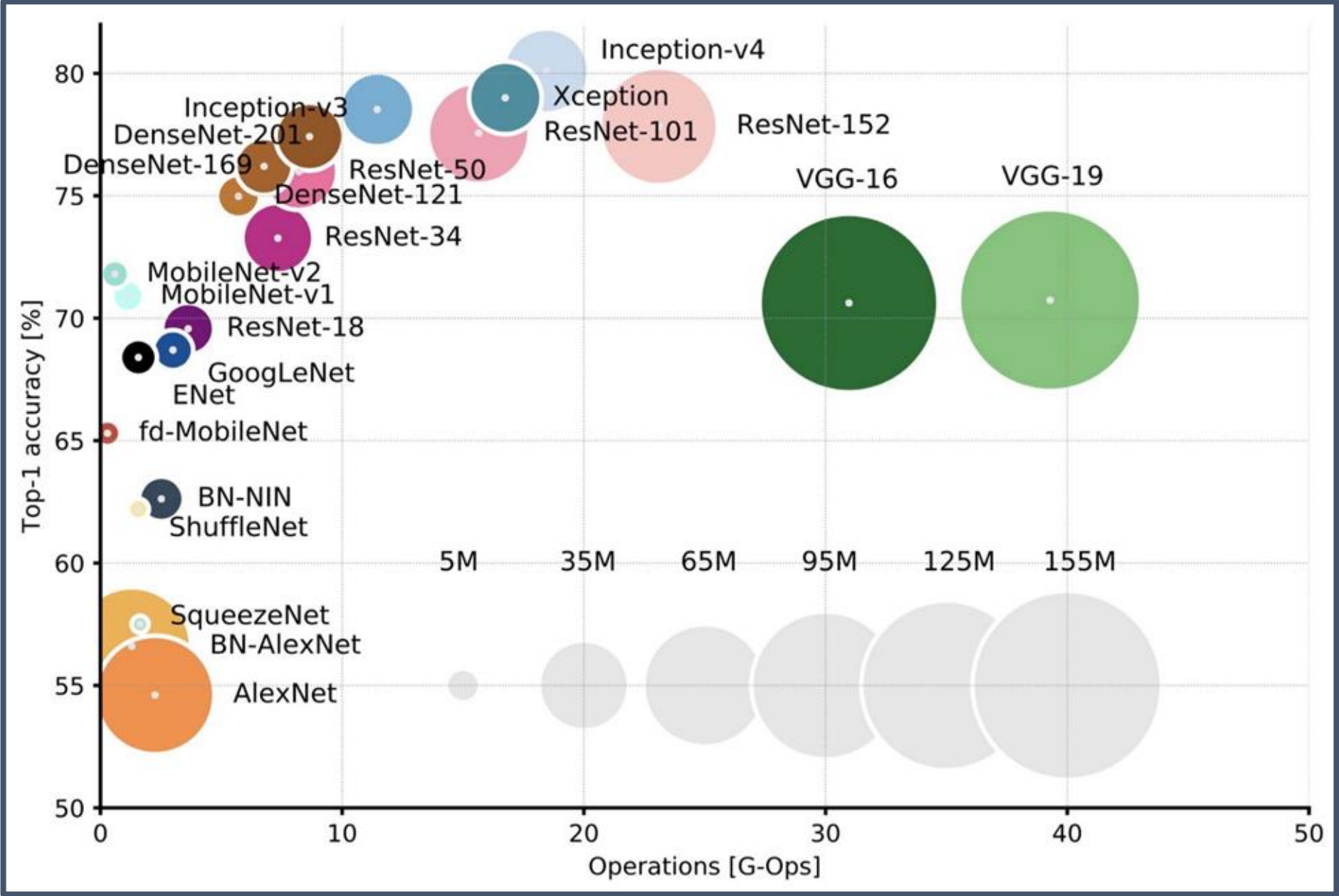
ML Deployment Pipeline



Hardware



	Raspberry Pico W	Arduino Nano Sense	ESP 32	Seeed XIAO Sense / ESP32S3	Arduino Pro
32Bits CPU	Dual-core Arm Cortex-M0+	Arm Cortex-M4F	Xtensa LX6 Dual Core	Arm Cortex-M4F (BLE) Xtensa LX7 Dual Core	Dual Core Arm Cortex M7/M4
CLOCK	133MHz	64MHz	240MHz	64 / 240MHz	480/240MHz
RAM	264KB	256KB	520KB (part available)	256KB / 8MB	1MB
ROM	2MB	1MB	2MB	2MB / 8MB	2MB
Radio	(Yes for W)	BLE	BLE/WiFi	BLE / WiFi (ESP32S3)	BLE/WiFi
Sensors	No	Yes	No	Yes (Sense)	Yes (Nicla)
Bat. Power Manag.	No	No	No	Yes	Yes
Price	\$	\$\$\$	\$	\$\$	\$\$\$\$\$



Solution

Datasets Preprocessing

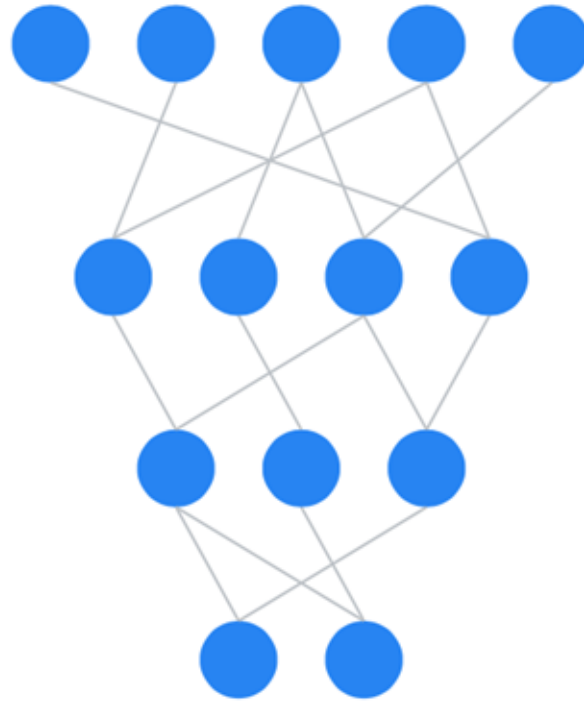
Sound

Vision

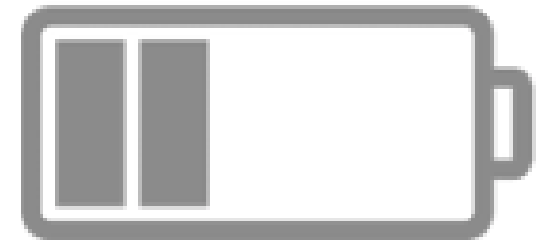
Vibration

Text

Quantization Pruning, Distillation



Resource constraints

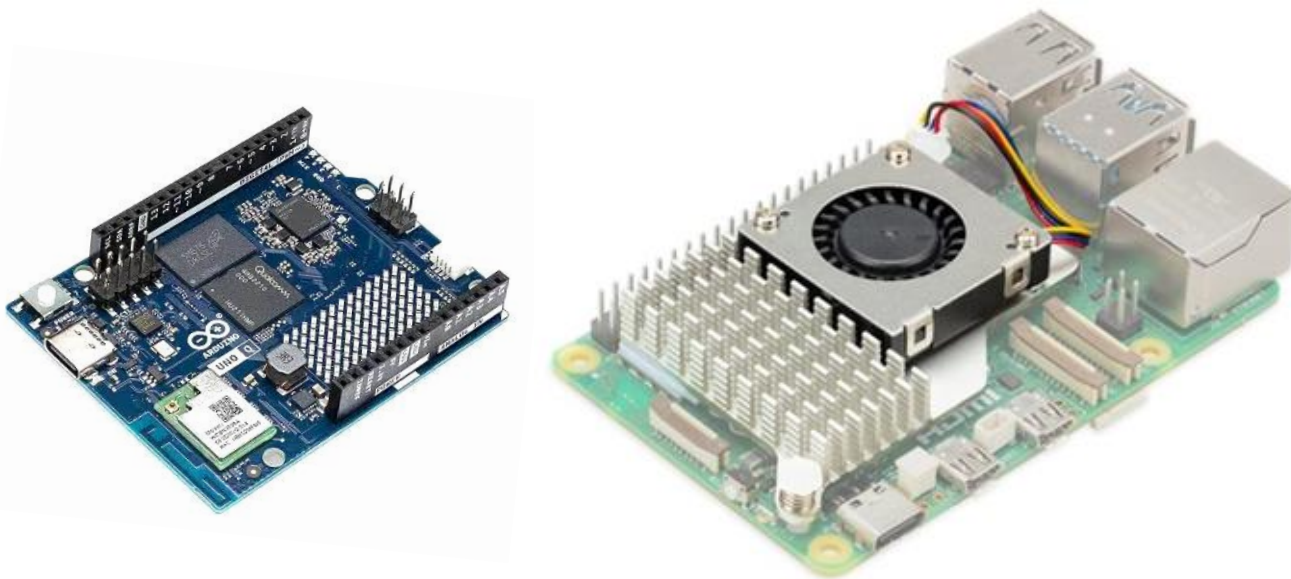


End-to-end TinyML/EdgeAI Application

GenAI at the Edge

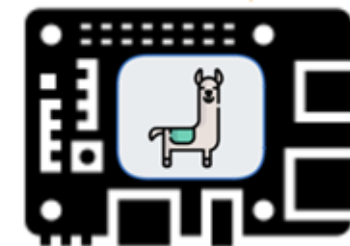
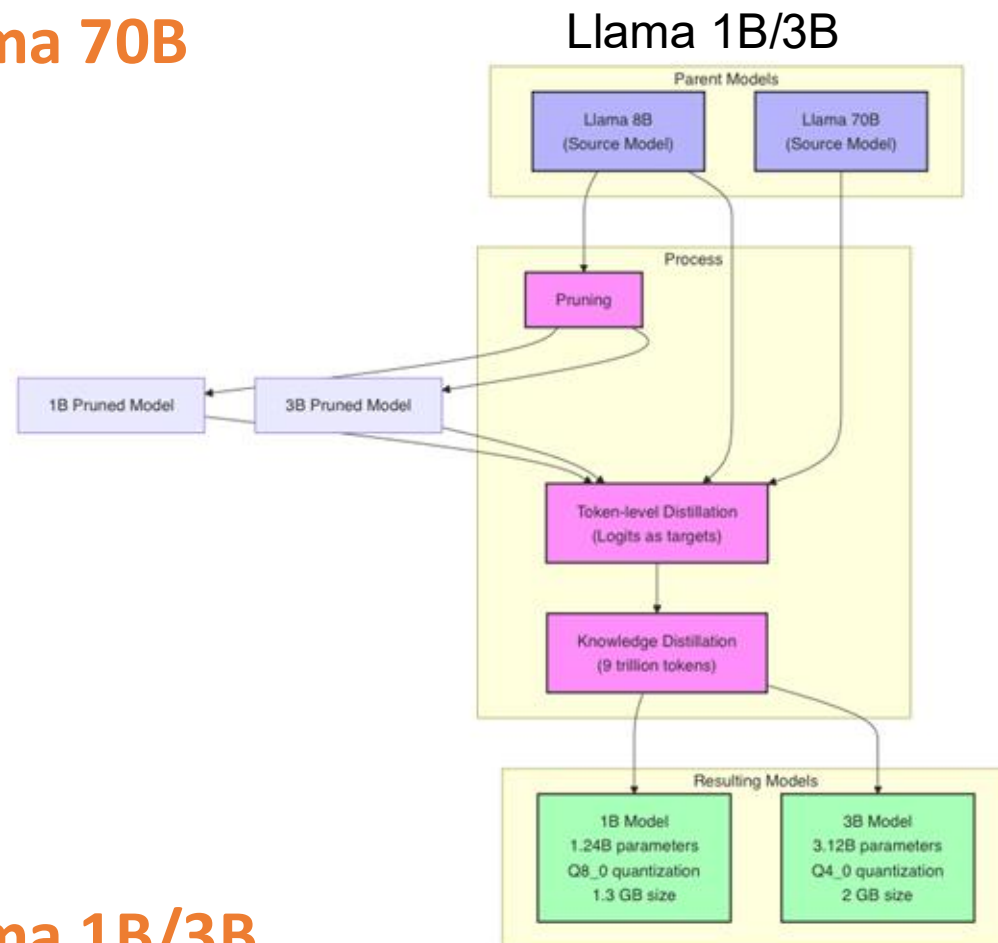
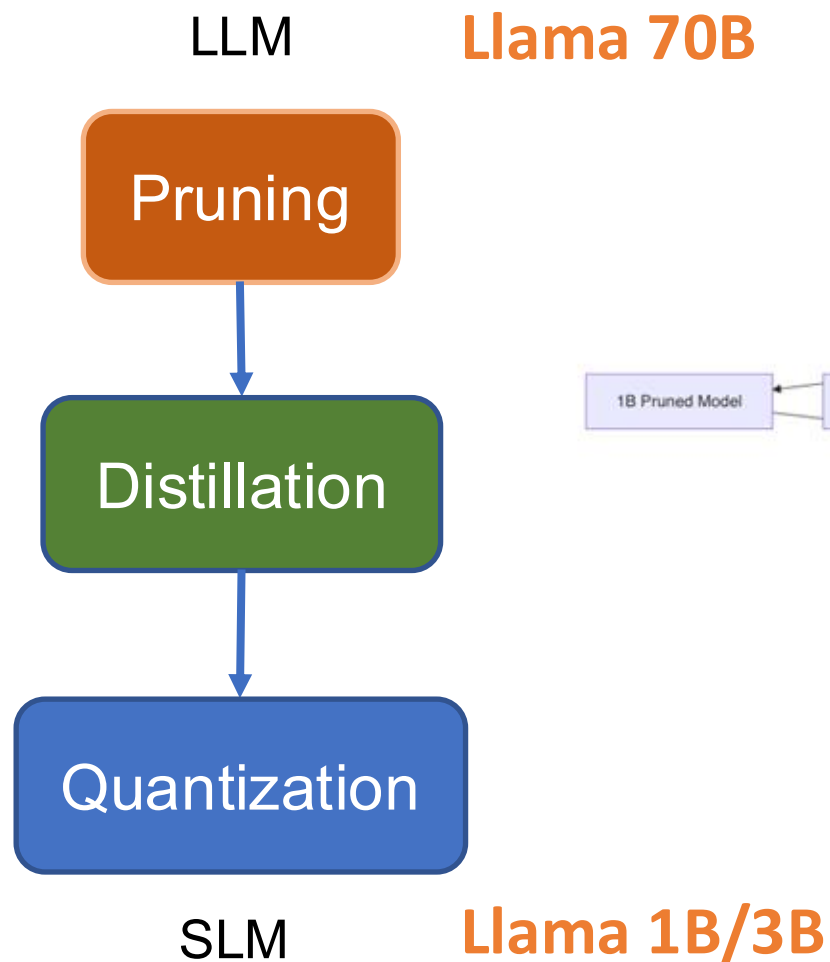
"GenAI at the Edge means the model lives on the device — not in a data center."

While LLMs typically require cloud infrastructure, compact SLMs* and small VLMs can run directly on edge devices.

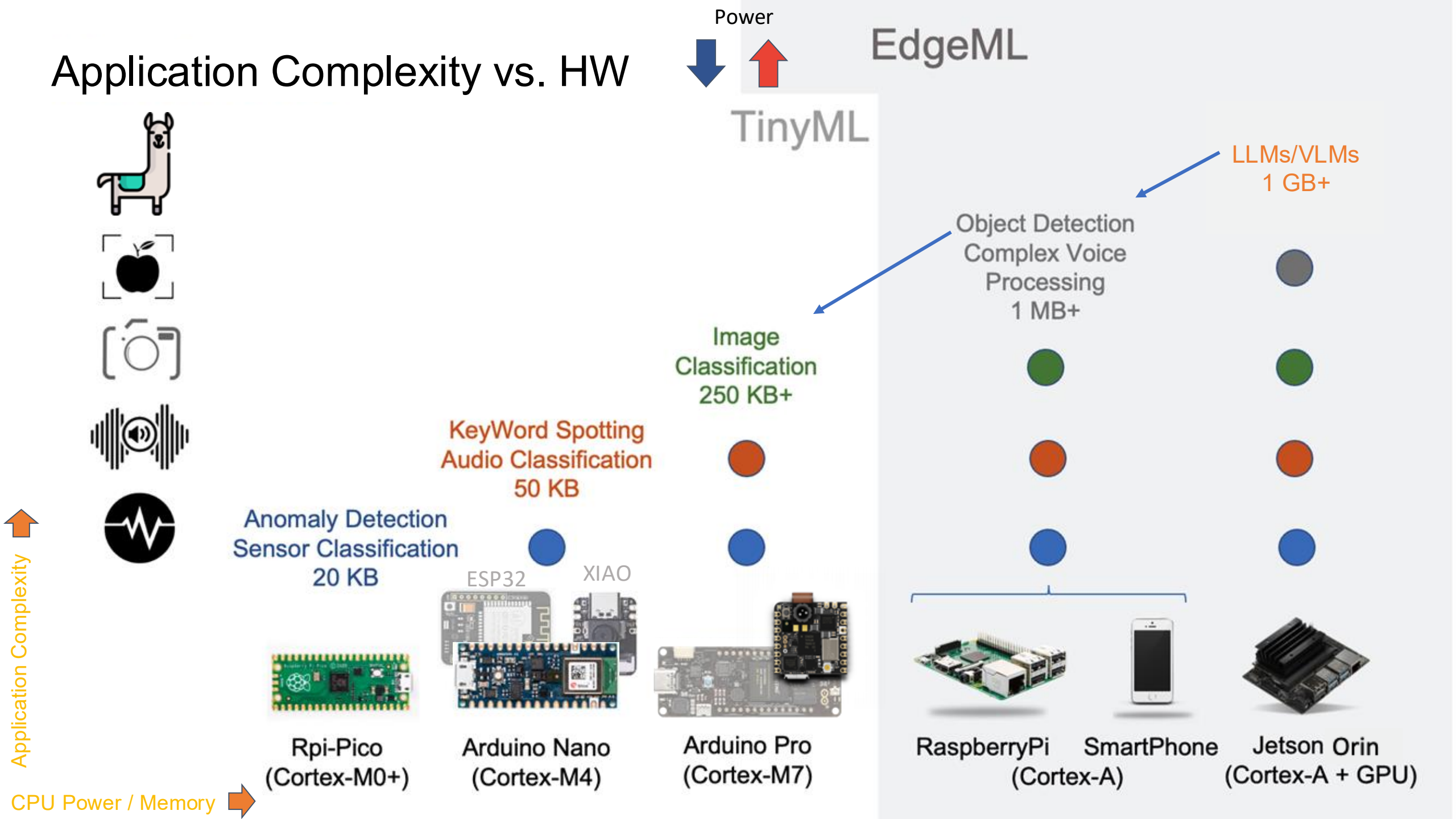


* Current trends point to 2026 as the year of SLMs (Models < 7B to 10B), with specialized models surpassing generalist ones in specific tasks, such as programming and medical diagnoses.

Small Language Models (SLMs)



Application Complexity vs. HW



Real-World Applications

Examples

Real-World Applications

Agriculture

Healthcare

Industry

Environment

Real-World Applications

Agriculture

Healthcare

Industry

Environment

Fighting Dengue and Malaria



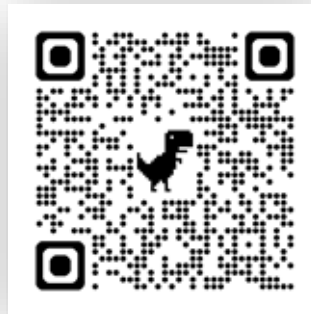
Challenge

Mosquito-borne diseases affect 700M+ people/year

Solution

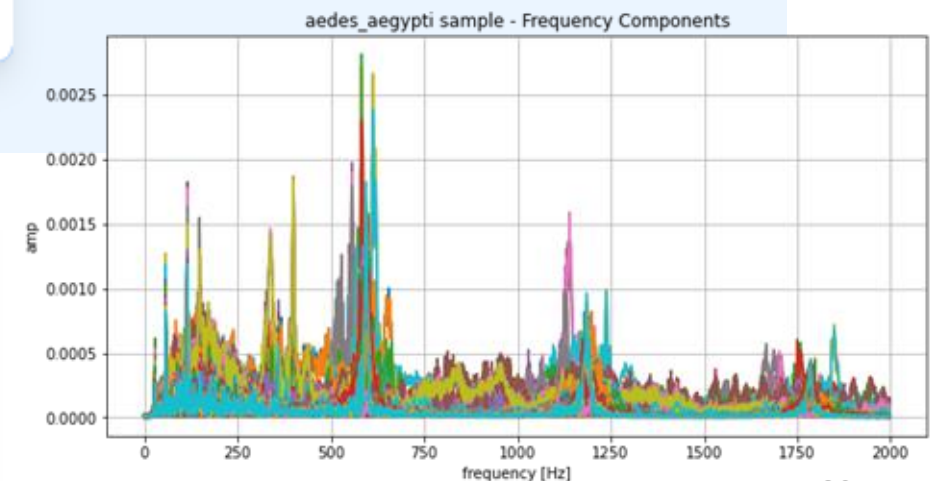
Audio classification of mosquito wingbeats

"TinyML where internet doesn't reach"

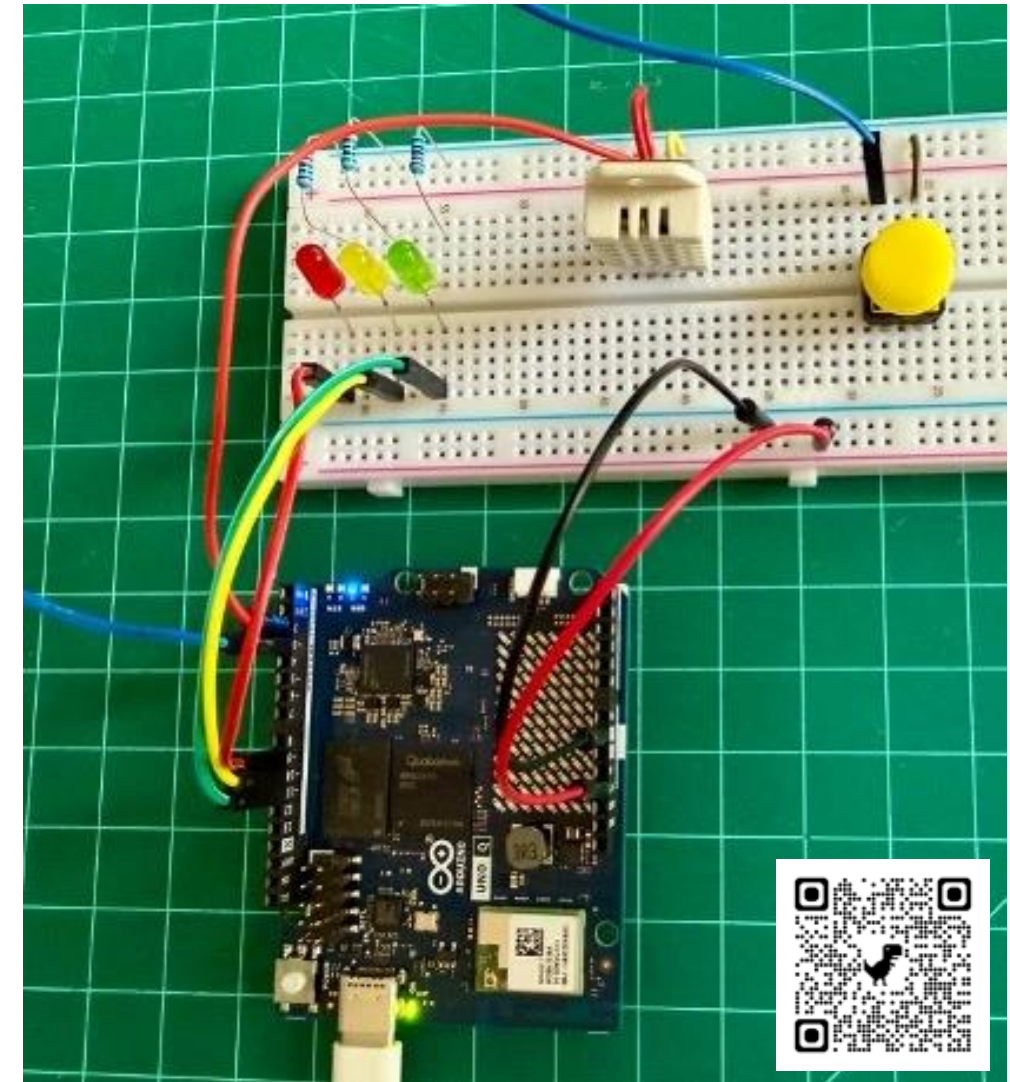
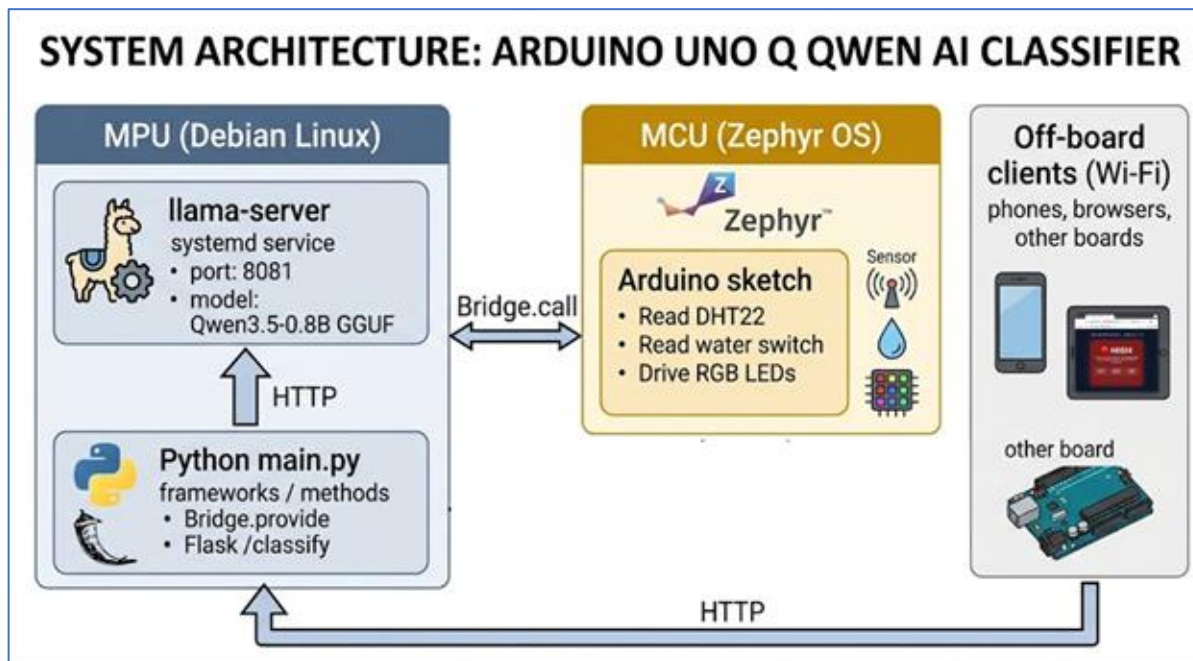
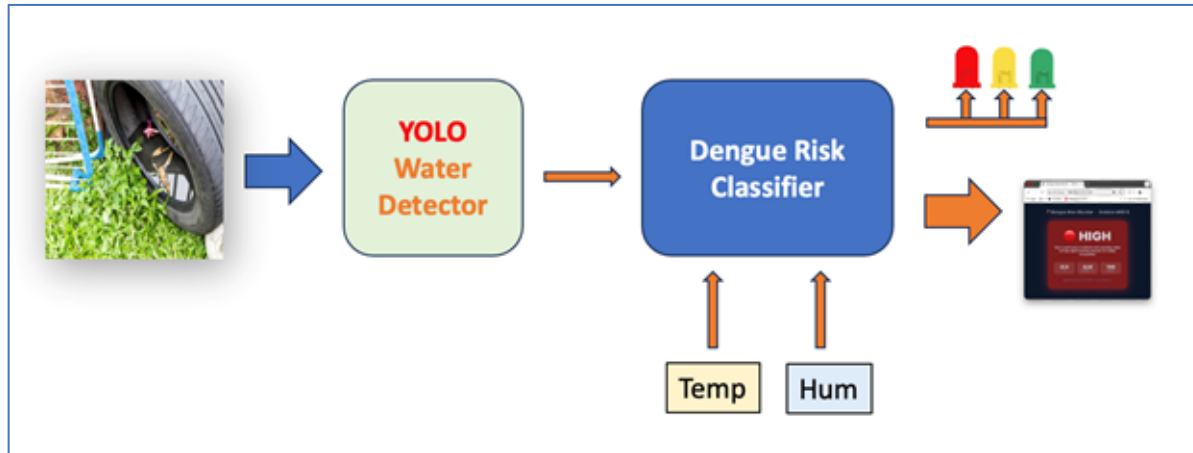


Impact

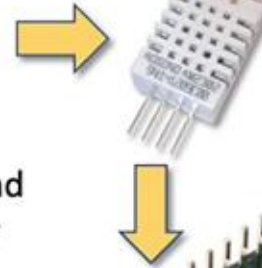
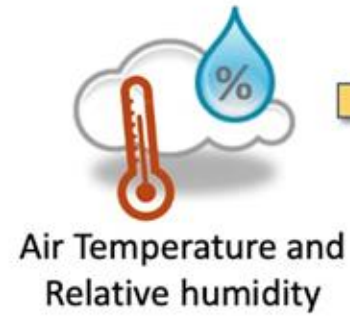
- Species identification
- Early warning system
- Works in the field
- Cited by Science Magazine



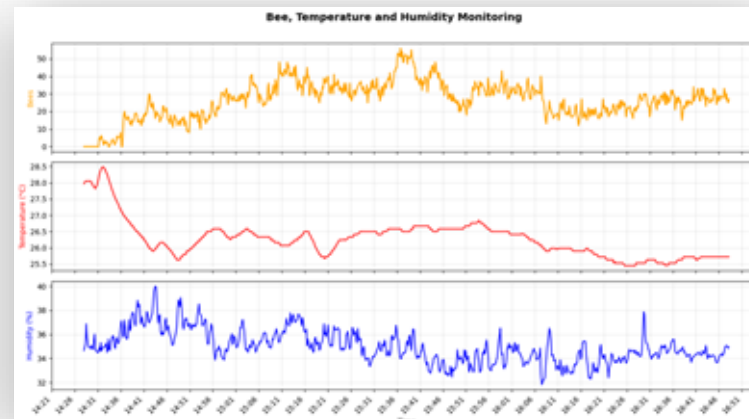
Dengue Risk Classifier



Bee Counting



DHT22
Sensor



sampleFreq → 10 s

José Anderson Reis
UNIFEI Master's Student

Guilherme Fernandes
UNIFEI Grad Student

Coffee Disease Classification



João Vitor Yukio Bordin Yamashita
Engenheiro - UNIFEI

<https://www.hackster.io/Yukio/coffee-disease-classification-with-ml-b0a3fc>

LSTM Phenolic Sponge Moisture



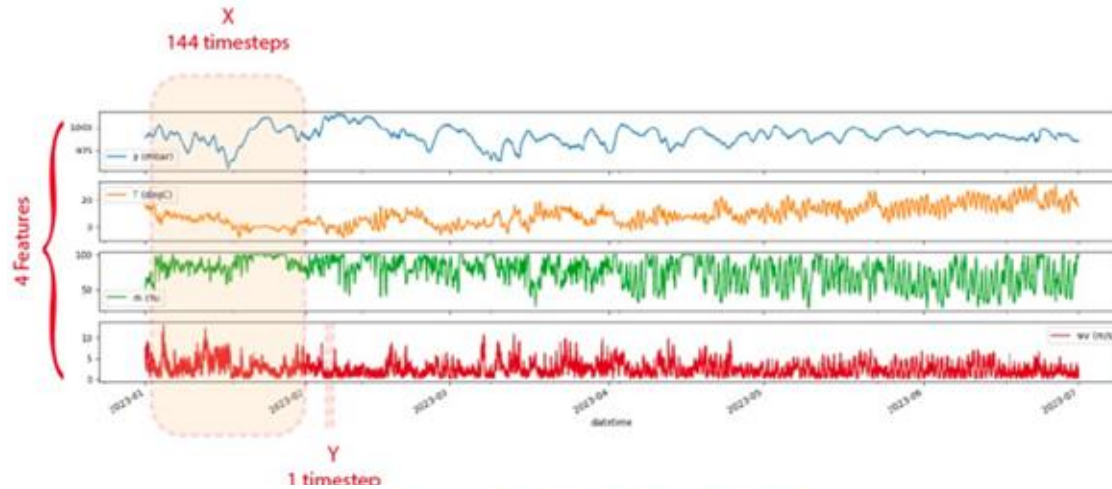
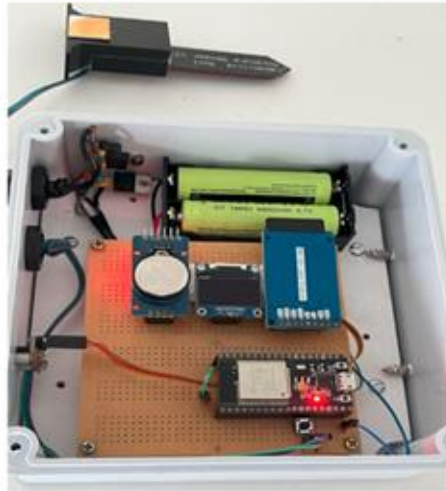
FURG



UTEC



UNRaf



Gustavo Pablo Castro Abdallah
PRIA

Ant Detection



FURG



UTEC



UNRaf



Juan Camilo Abedala
PRIA

Real-World Applications

Agriculture

Healthcare

Industry

Environment

Intelligent Colposcope Image Classification System



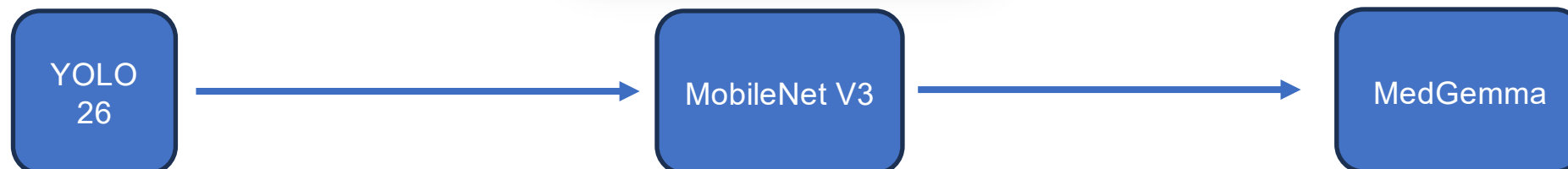
**BRUNA CUSTÓDIO ALVES,
VIVIAN LEITE FRAGOSO**
UNIFEI



Classe detectada : type1 (75.79%) | 147.2 ms
Enviando ao MedGemma...

Latência MedGemma : 63.0 s

1. ****Características esperadas da ZT1:**** A ZT1 é caracterizada por uma mudança de cor, geralmente de um tom rosado claro a um tom rosado mais escuro, com uma transição gradual entre as camadas epiteliais.
2. ****Visibilidade da JEC:**** A JEC deve ser visível, com uma transição clara entre o epitélio escamoso do ectocérvice e o epitélio colunar do endocérvice.
3. ****Risco associado:**** Risco baixo a moderado. A ZT1 é considerada um risco intermediário, com potencial de progressão para um câncer do colo do útero.
4. ****Conduta recomendada:**** Colposcopia com biópsia da ZT1 para avaliação histopatológica. Se a biópsia for negativa, acompanhamento com colposcopia em 6-12 meses. Se a biópsia for positiva, o tratamento (ex.: criocirurgia, laser, excisão cirúrgica) depende da extensão da lesão.

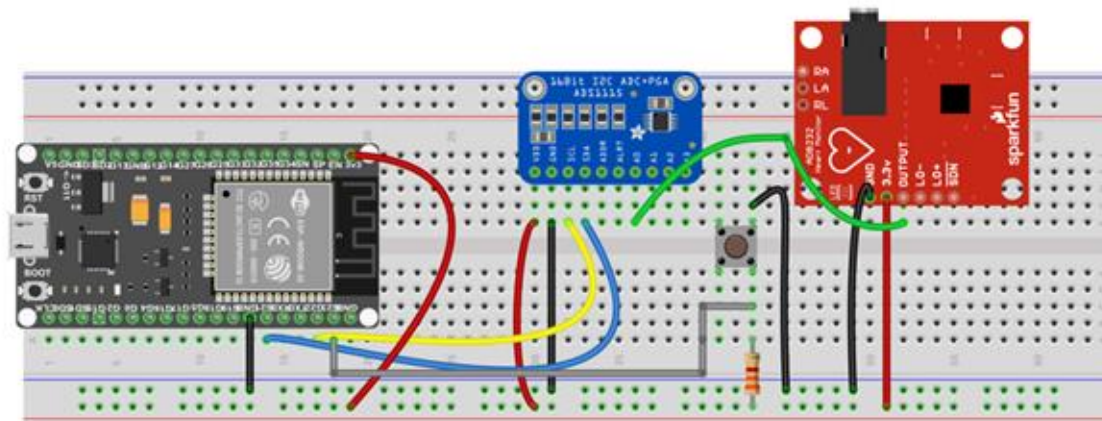




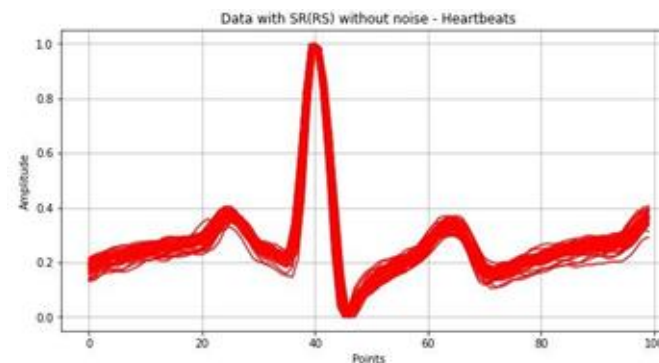
Single Lead Heart Rate Monitor



[Atrial Fibrillation Detection on ECG using TinyML](#)
[Silva et al. UNIFEI 2021](#)

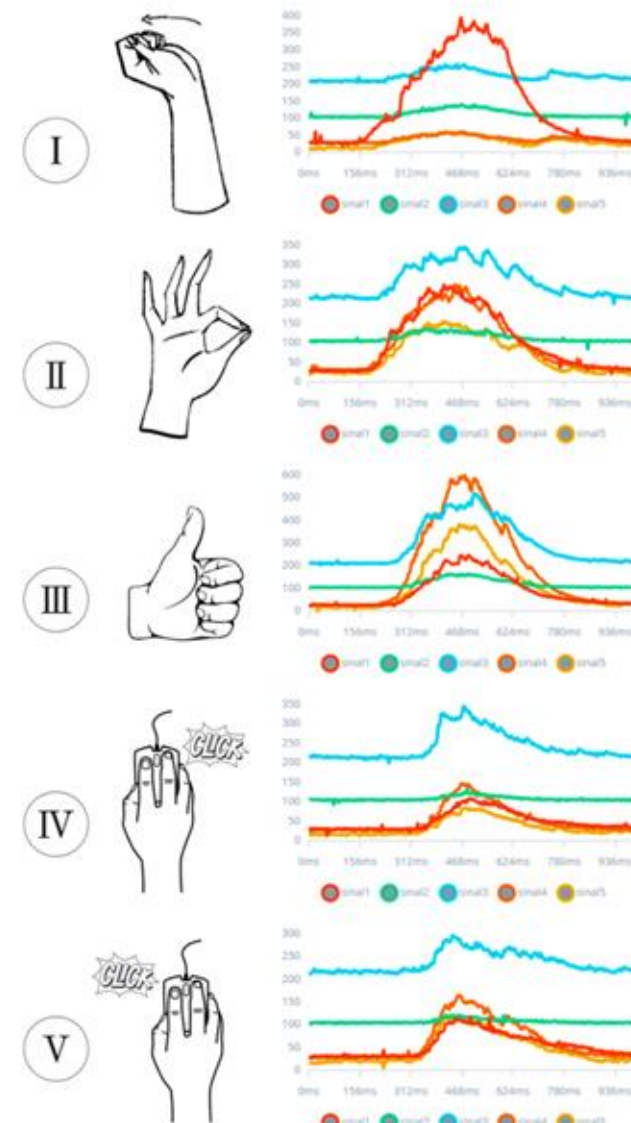
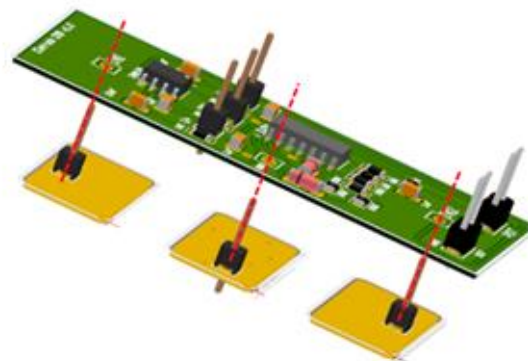
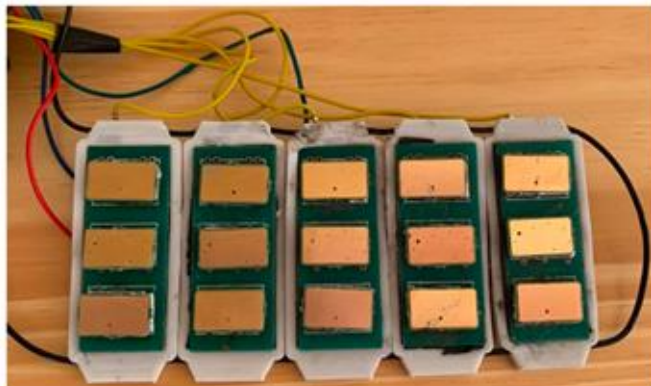
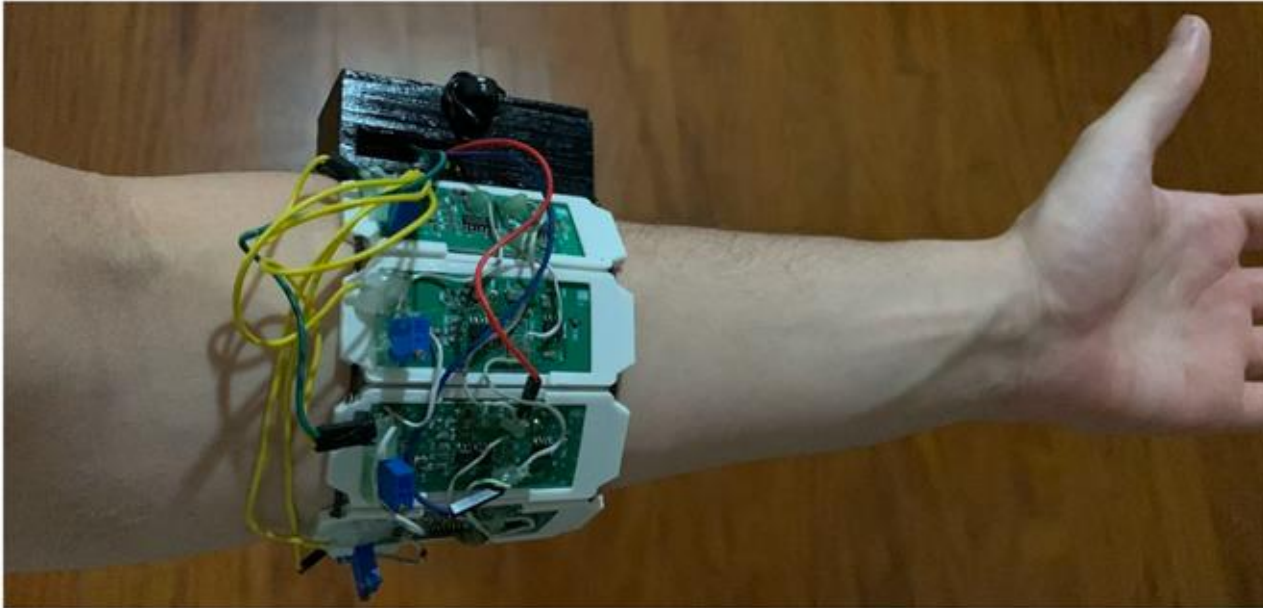


fritzing



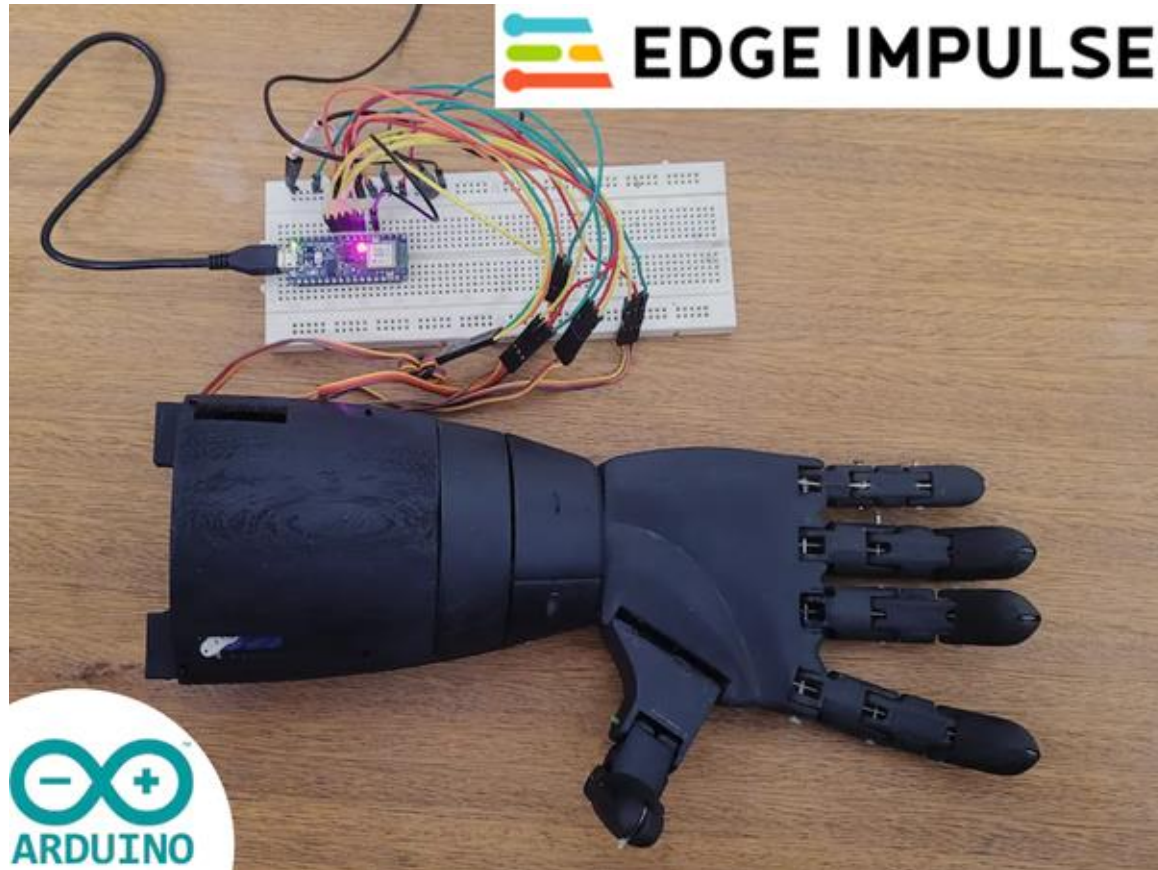
Guilherme Silva
Matheus Lima
Engenheiros - UNIFEI

Surface electromyography



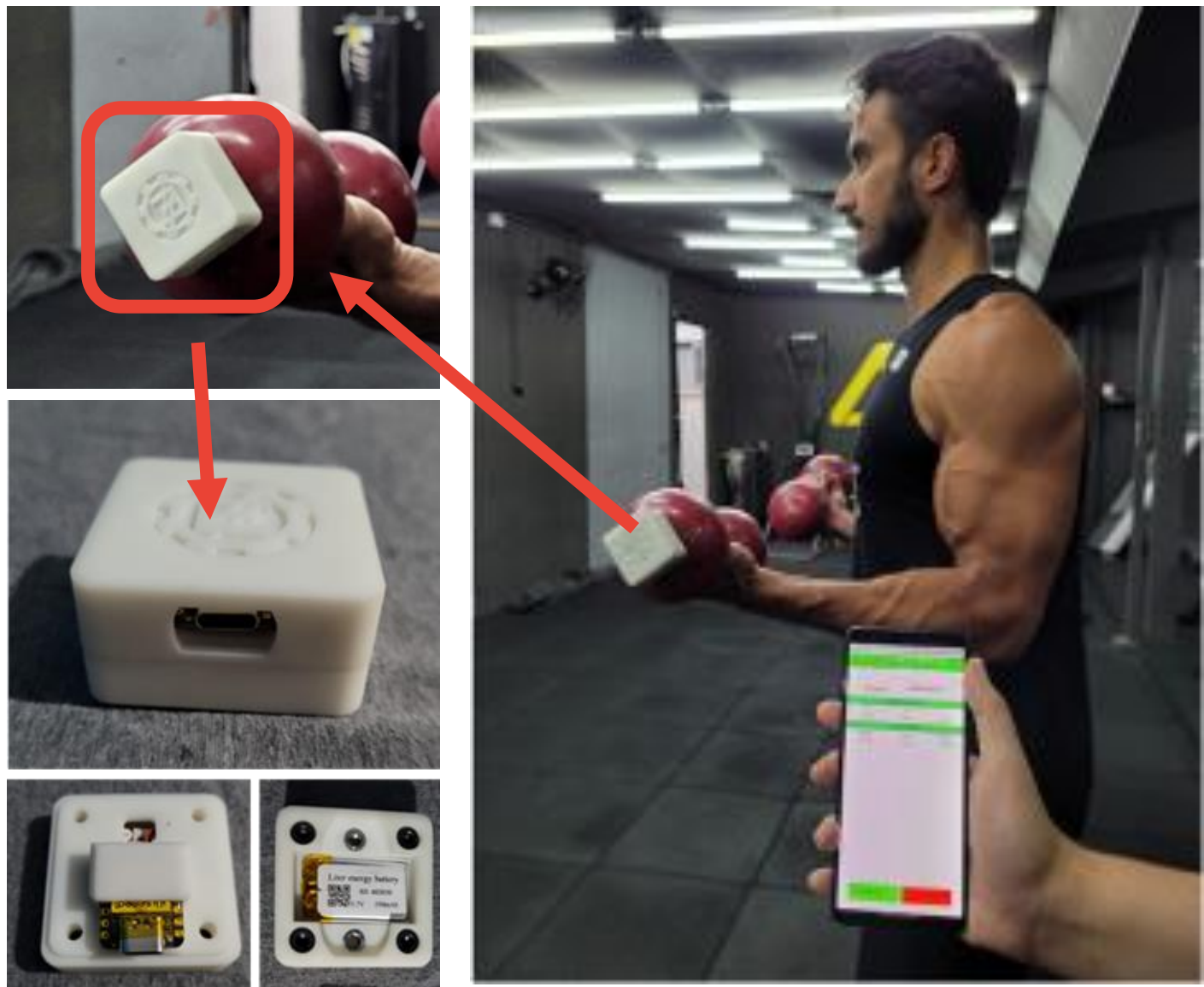
Mateus F. Delangélica e
Renato M. Neto, UNIFEI

Bionic Hand Voice Commands



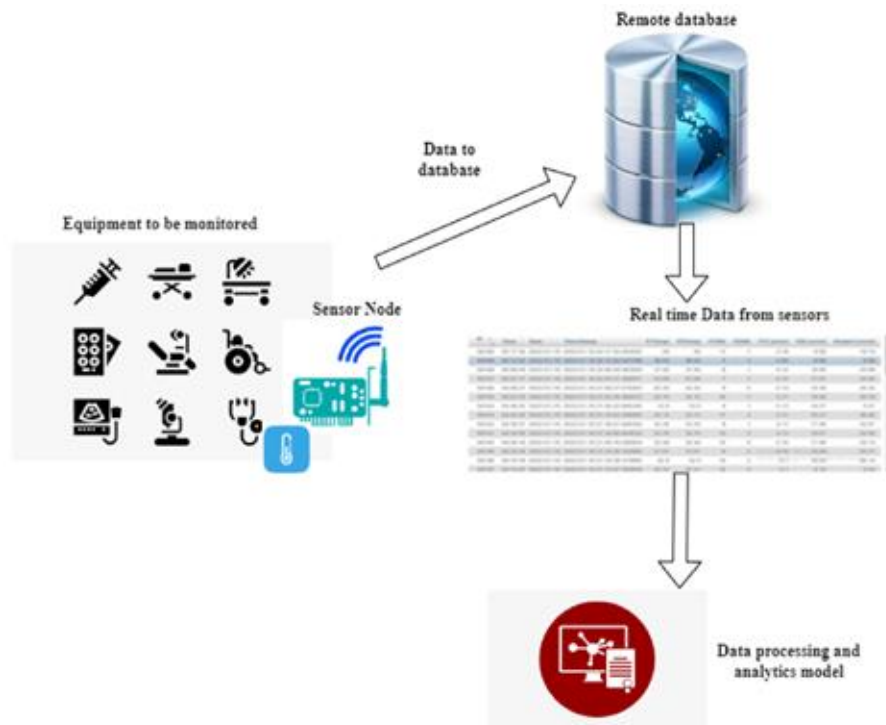
<https://www.hackster.io/ex-machina/bionic-hand-voice-commands-module-w-edge-impulse-arduino-aa97e3>

Personal Trainer



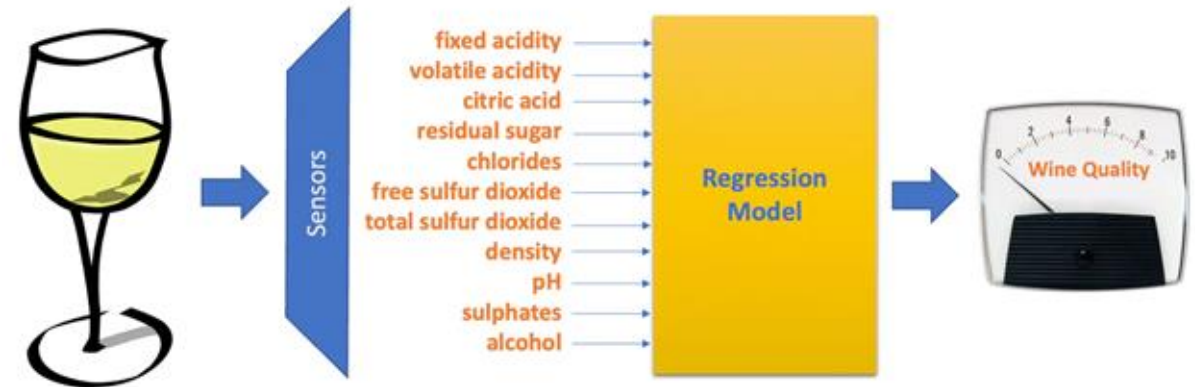
Ricardo Magno C. Junior
Luiz Fernando Kikuchi
UNIFEI

Regression on TinyML



[On-Device IoT-Based Predictive Maintenance Analytics Model: Comparing TinyLSTM and TinyModel from Edge Impulse](#)

Sensor fusion



[TinyML Made Easy: Exploring Regression - White Wine Quality](#)

Real-World Applications

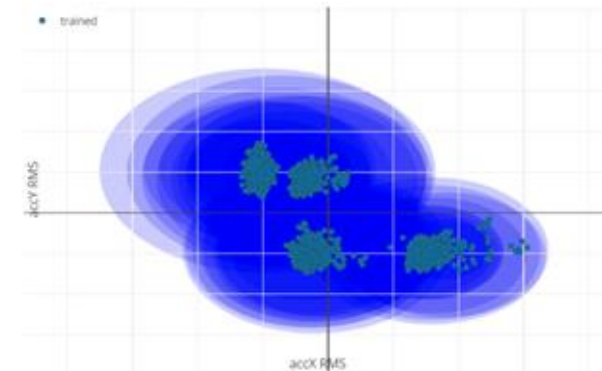
Agriculture

Healthcare

Industry

Environment

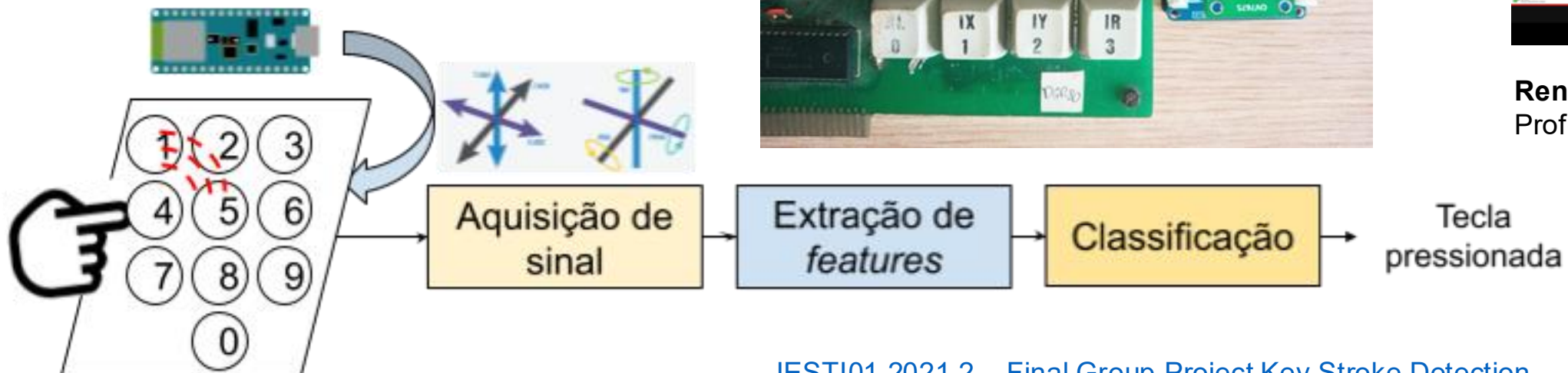
Industrial – Anomaly Detection



Keystroke **Sound** Detection



Renam Castro
Professor IFESP



Reinforcement on TinyML



Deep Reinforcement Learning for Autonomous Source Seeking on a Nano Drone

Bardienus P. Duisterhof^{1,3} Srivatsan Krishnan¹ Jonathan J. Cruz¹ Colby R. Banbury¹ William Fu¹

Aleksandra Faust² Guido C. H. E. de Croon³ Vijay Janapa Reddi^{1,4}

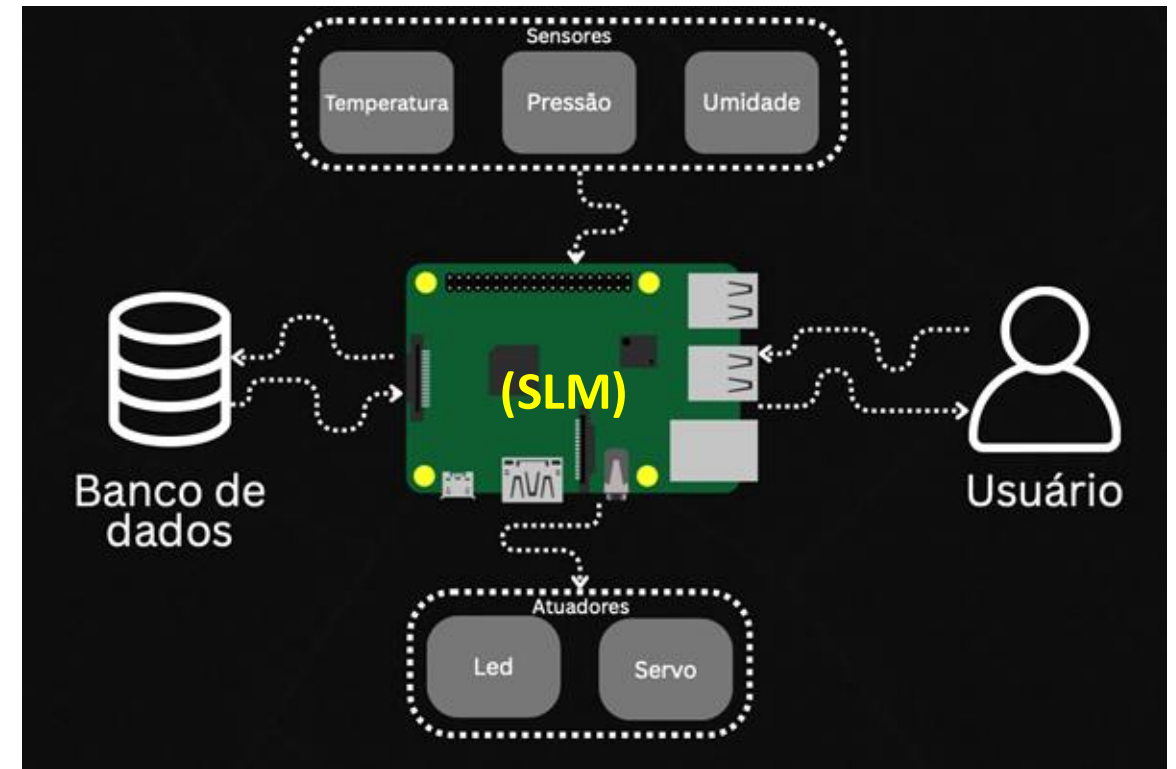
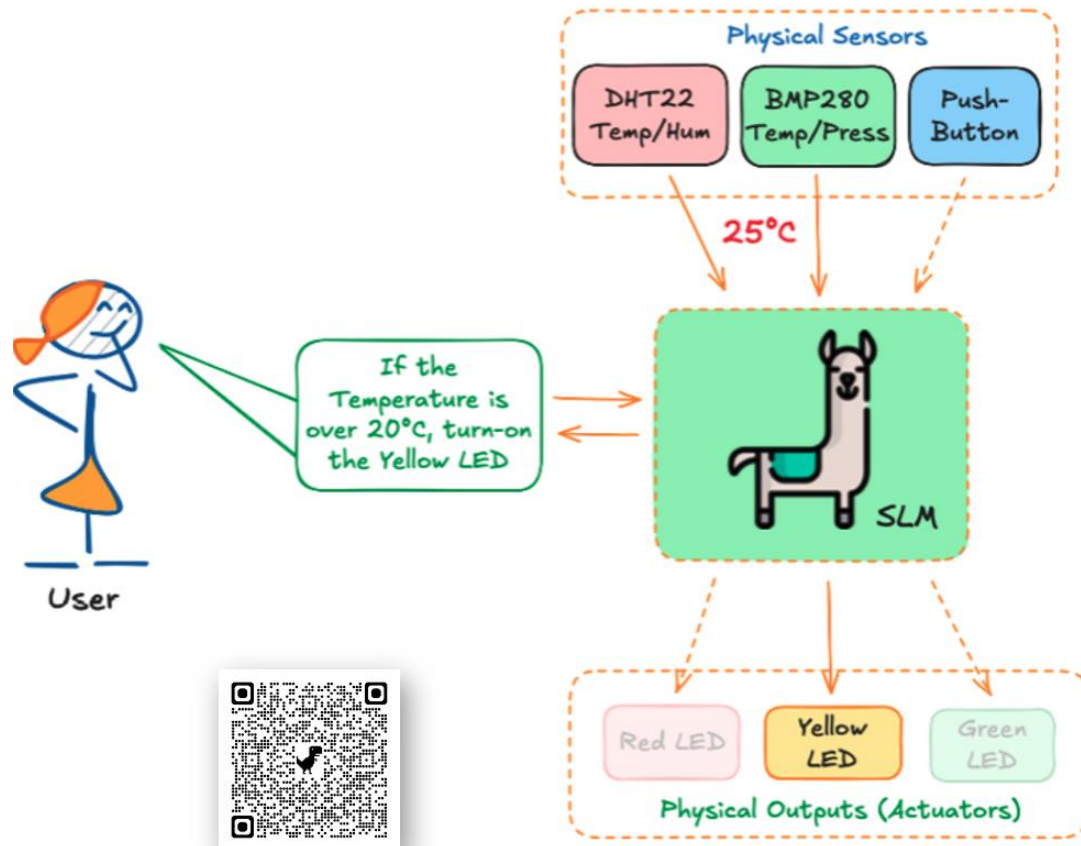
¹Harvard University, ²Robotics at Google, ³Delft University of Technology, ⁴The University of Texas at Austin



<https://arxiv.org/abs/1909.11236>

<https://youtu.be/wmVKbX7MOnU>

Intelligent Control

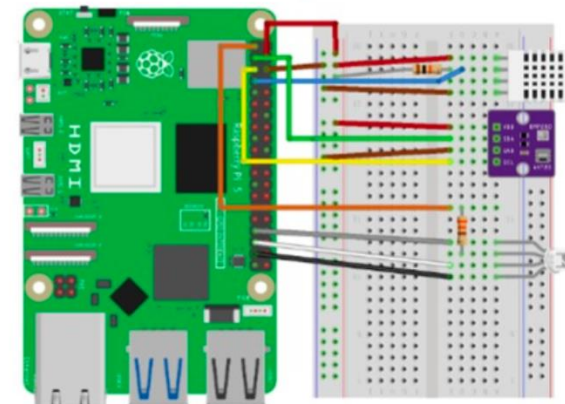
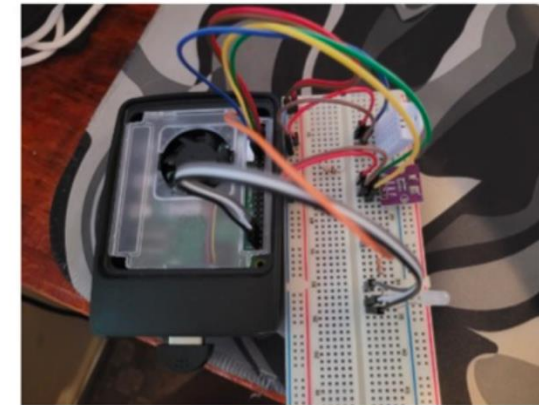
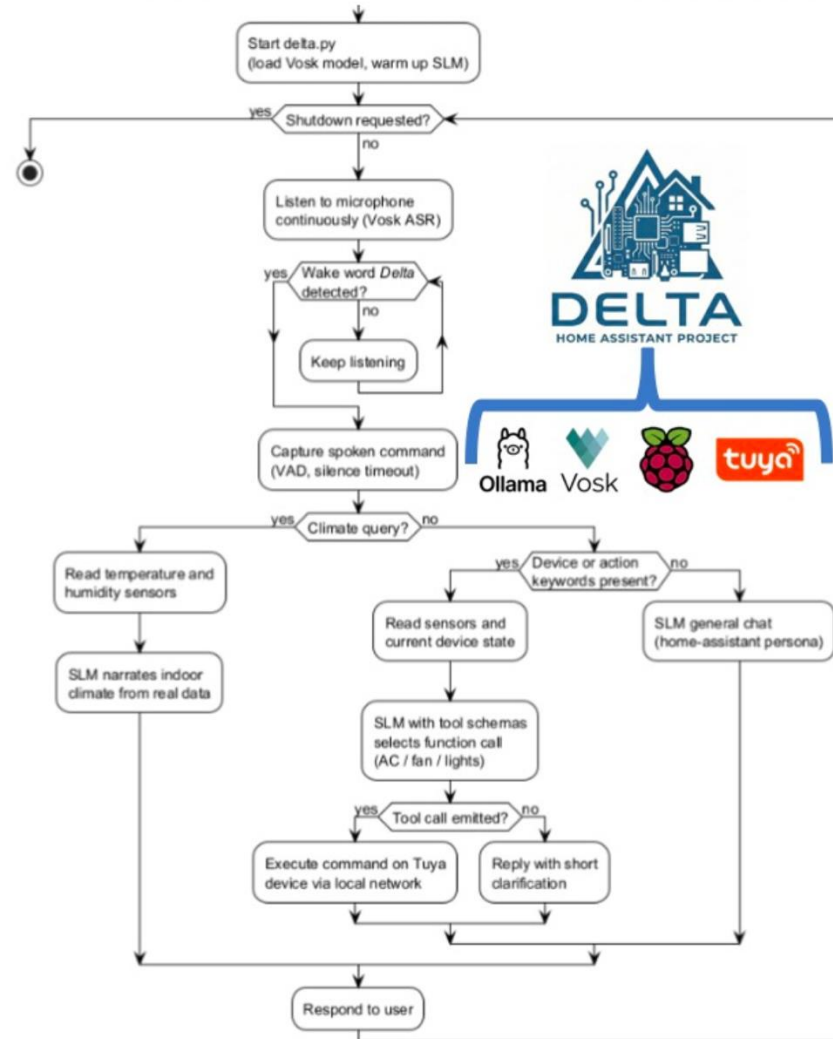


João Pedro Fonseca
UNIFEI Grad Student (IESTI)

Matheus Souza
UNIFEI Grad Student (IMC)



DELTA: Home Automation with SLMs



Ricardo Magno C. Junior
UNIFEI

Real-World Applications

Agriculture

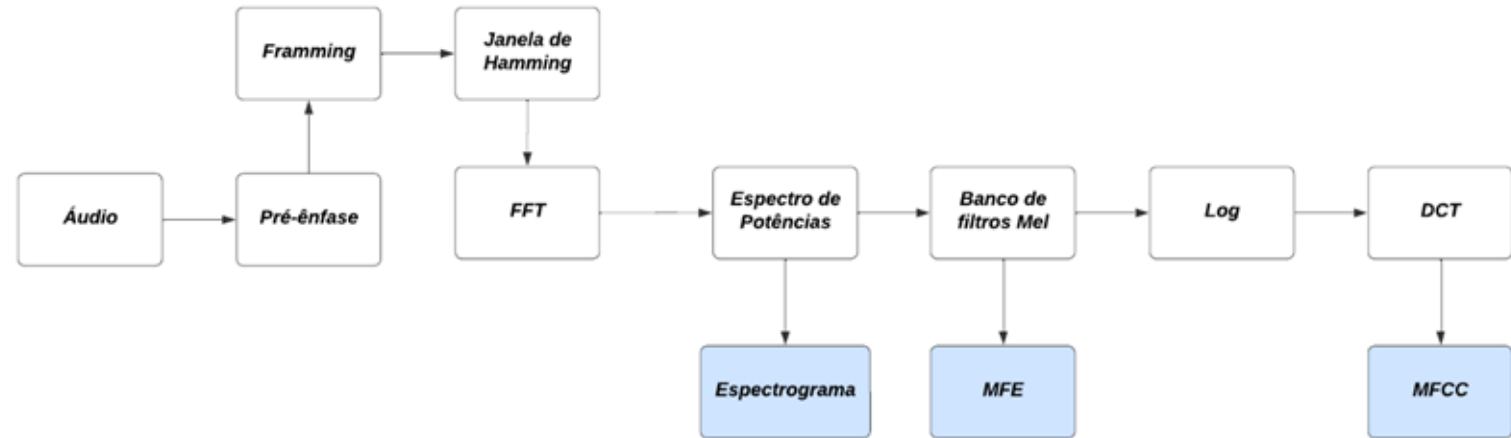
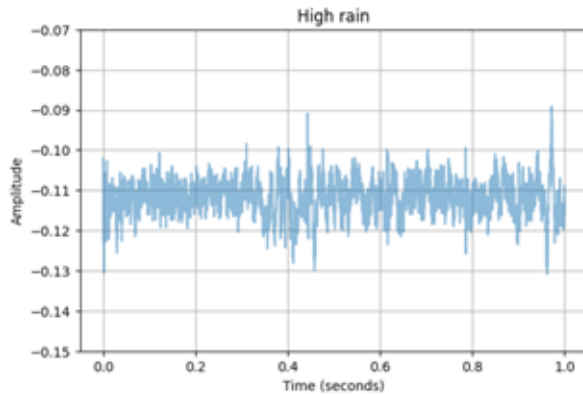
Healthcare

Industry

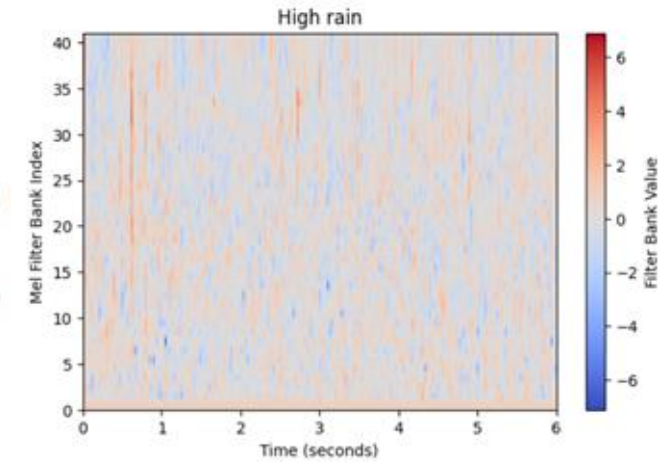
Environment



Measure rainfall using sound detection



```
Edge Impulse standalone inferencing
run_classifier returned: 0
Timing: DSP 630 ms, inference 47 ms,
Predictions:
  HighRain: 0.99609
  LowRain: 0.00000
  MediumRain: 0.00000
  NoRain: 0.00000
```



TinyML/EdgeAI/GenAI Education

IESTI01 TinyML

TinyML Kit



XIAOML Kit



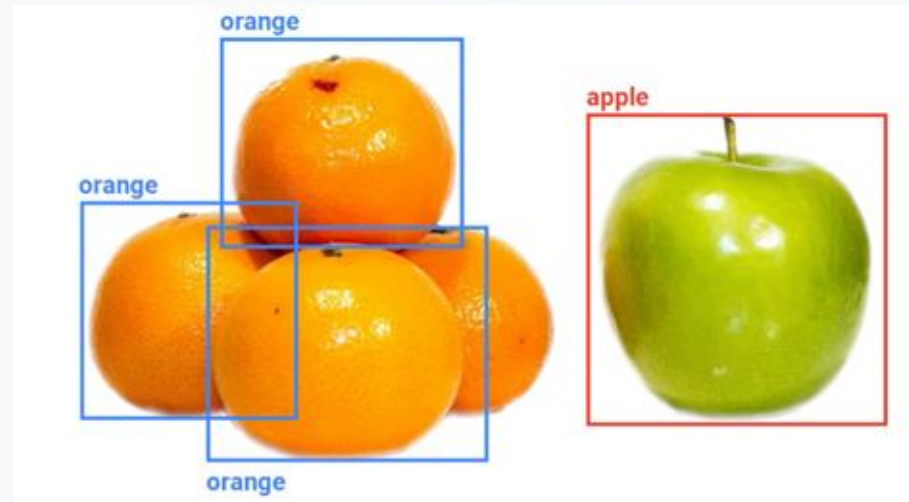
Hands-on Activities

Speech



Okay, Google.

Vision



IMU



+



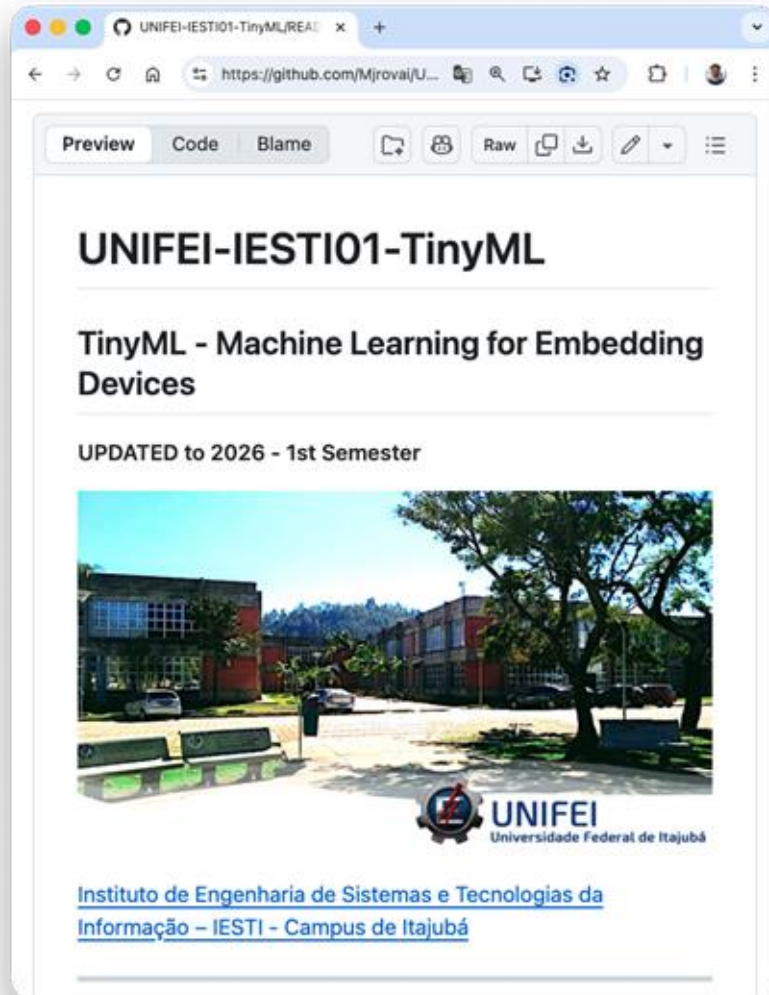
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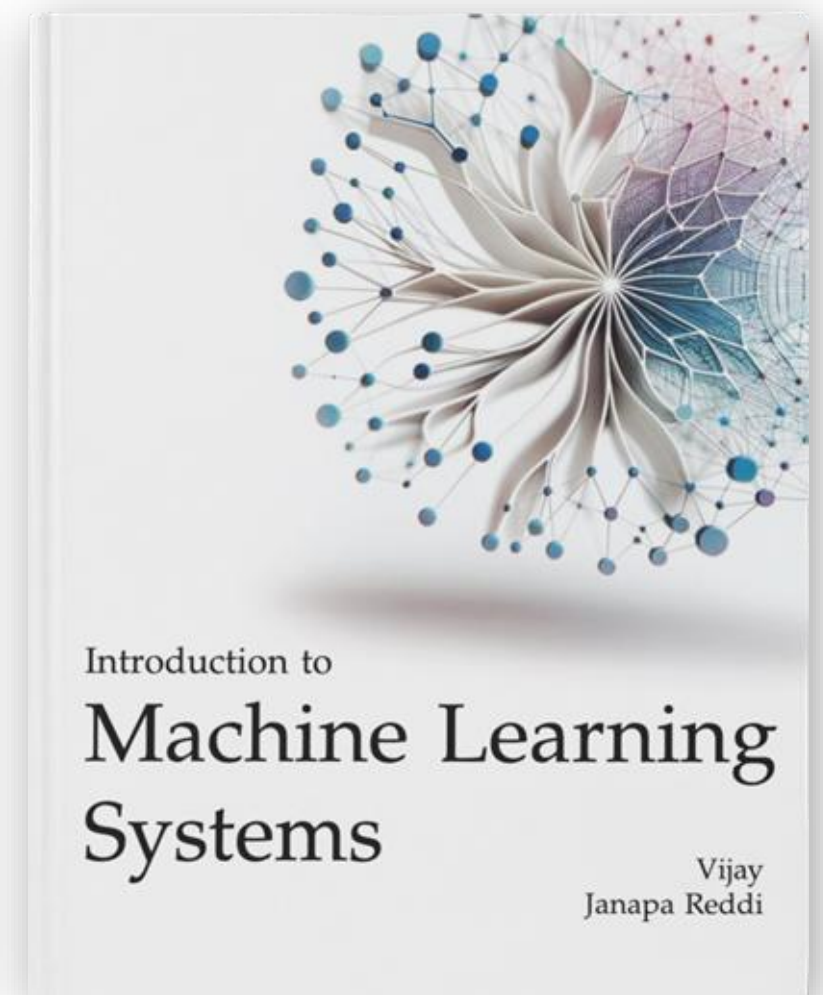
Additional Reading Support



[IESTI01 - Repo](#)



[XIAOML Kit Labs](#)

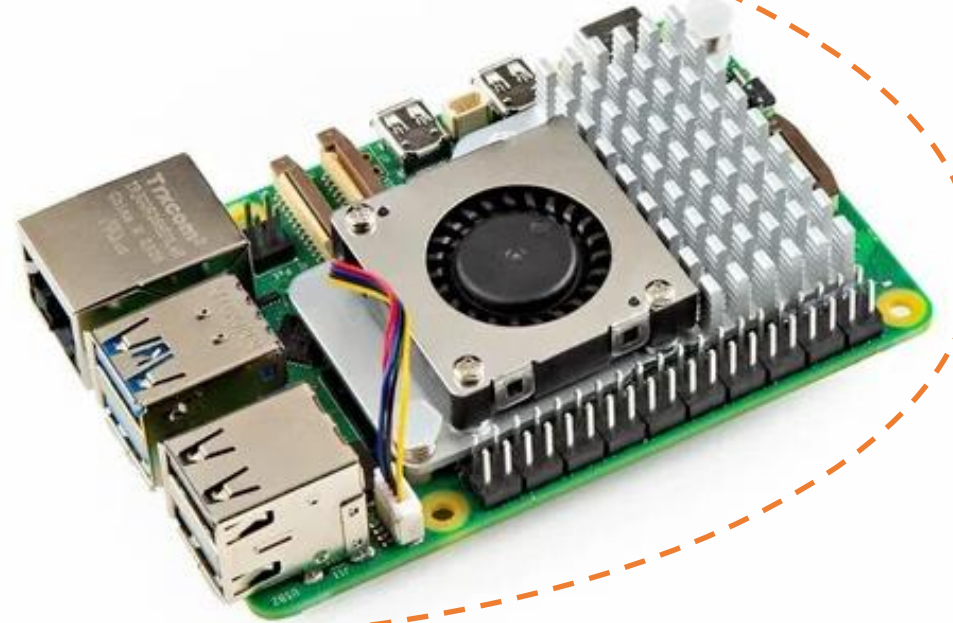
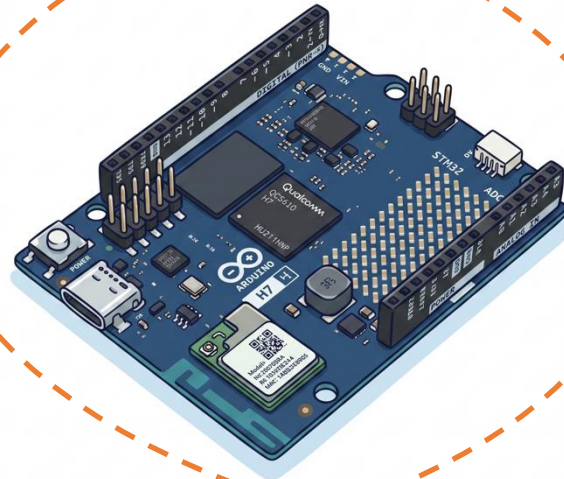


[MLSys Book](#)

IEST105 Edge AI Engineering

Part 1: Fixed Function AI (Reactive)

Part 2: Generative AI (Proactive)

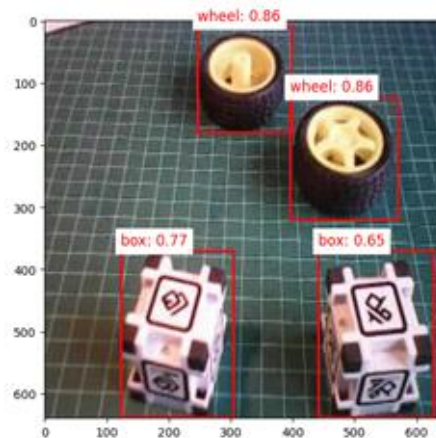
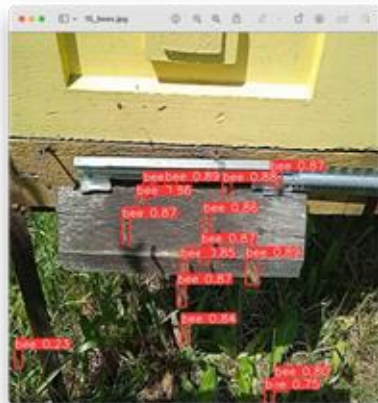


Raspberry Pi Zero W2

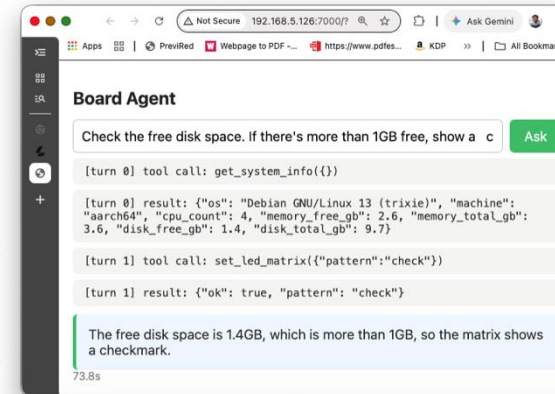
Arduino UNO Q

Raspberry Pi 5

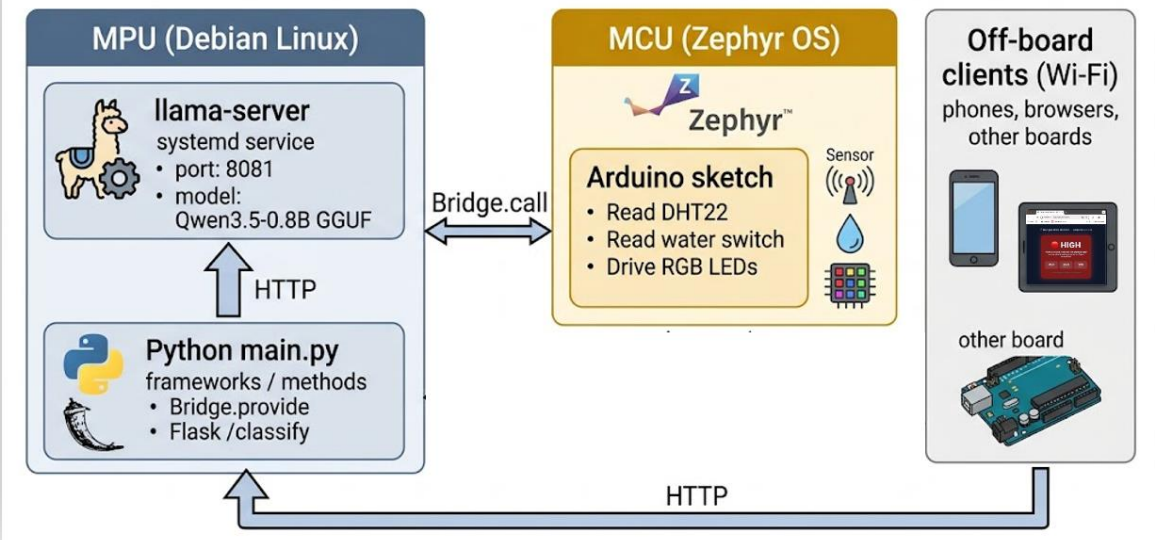
Part 1: Fixed Function AI (Reactive)



Part 2: Generative AI (Proactive)



SYSTEM ARCHITECTURE: ARDUINO UNO Q QWEN AI CLASSIFIER



Additional Reading Support

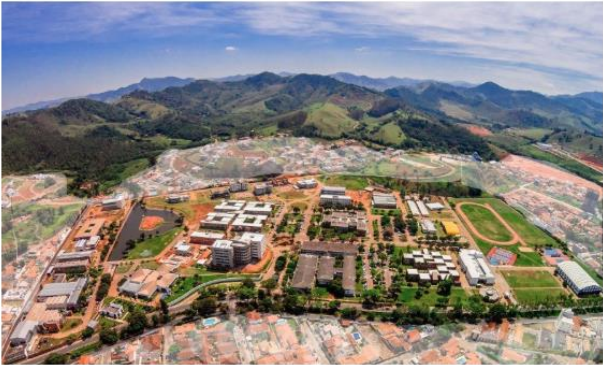
mjrovai.github.io/UNIFEI...

UNIFEI-UESTI05-EDGE_AI

UESTI05 - EDGE AI

Edge Machine Learning Systems Engineering

UPDATED to 2026 - 2nd Semester



Federal University of Itajubá – UNIFEI – Campus de Itajubá, MG Brasil

Material

- Materials will be uploaded to this repo every week.
 - Slides, Notebooks, Code, and Docs in English
 - Videos in Portuguese

GenAI at the Edge

Running Small Language Models with Arduino UNO Q and llama.cpp

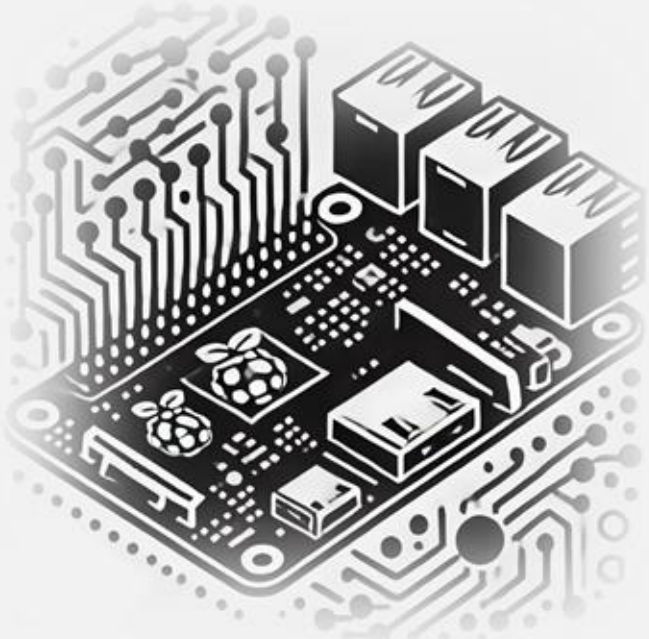


UNIFEI

Marcelo Rovai
2026

Edge AI Engineering

Hands-On with the Raspberry Pi



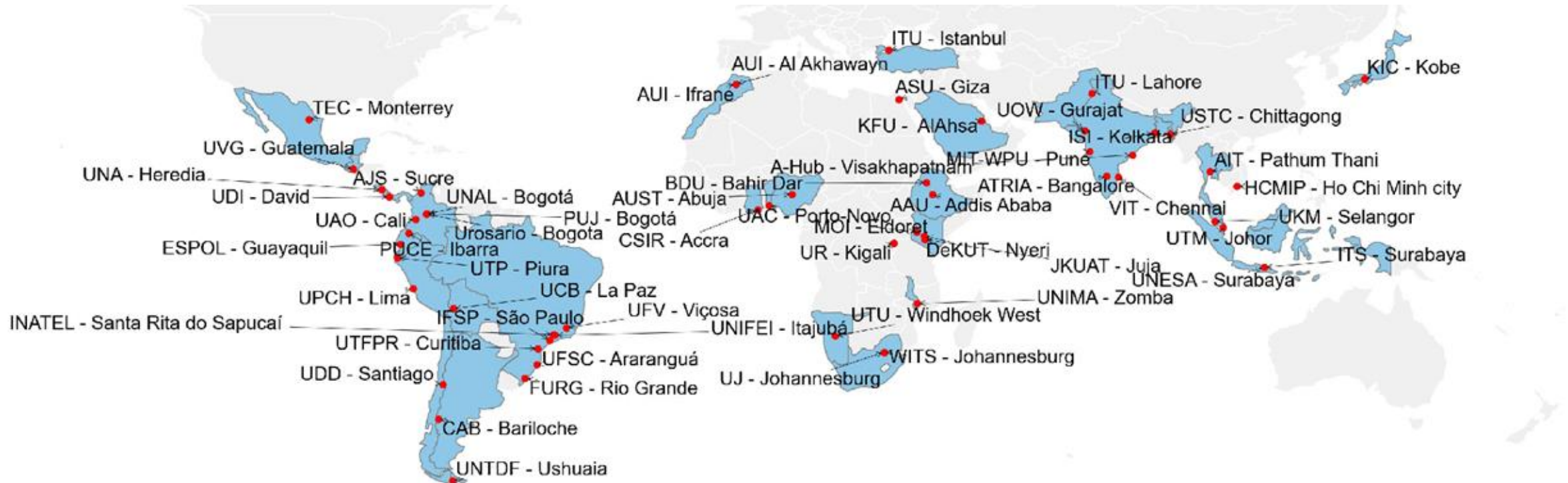
UNIFEI

Marcelo Rovai
Professor Honoris Causa

AIEng4D Academic Network

Real Projects. Real Impact.

Students & researchers solving local problems with global tools



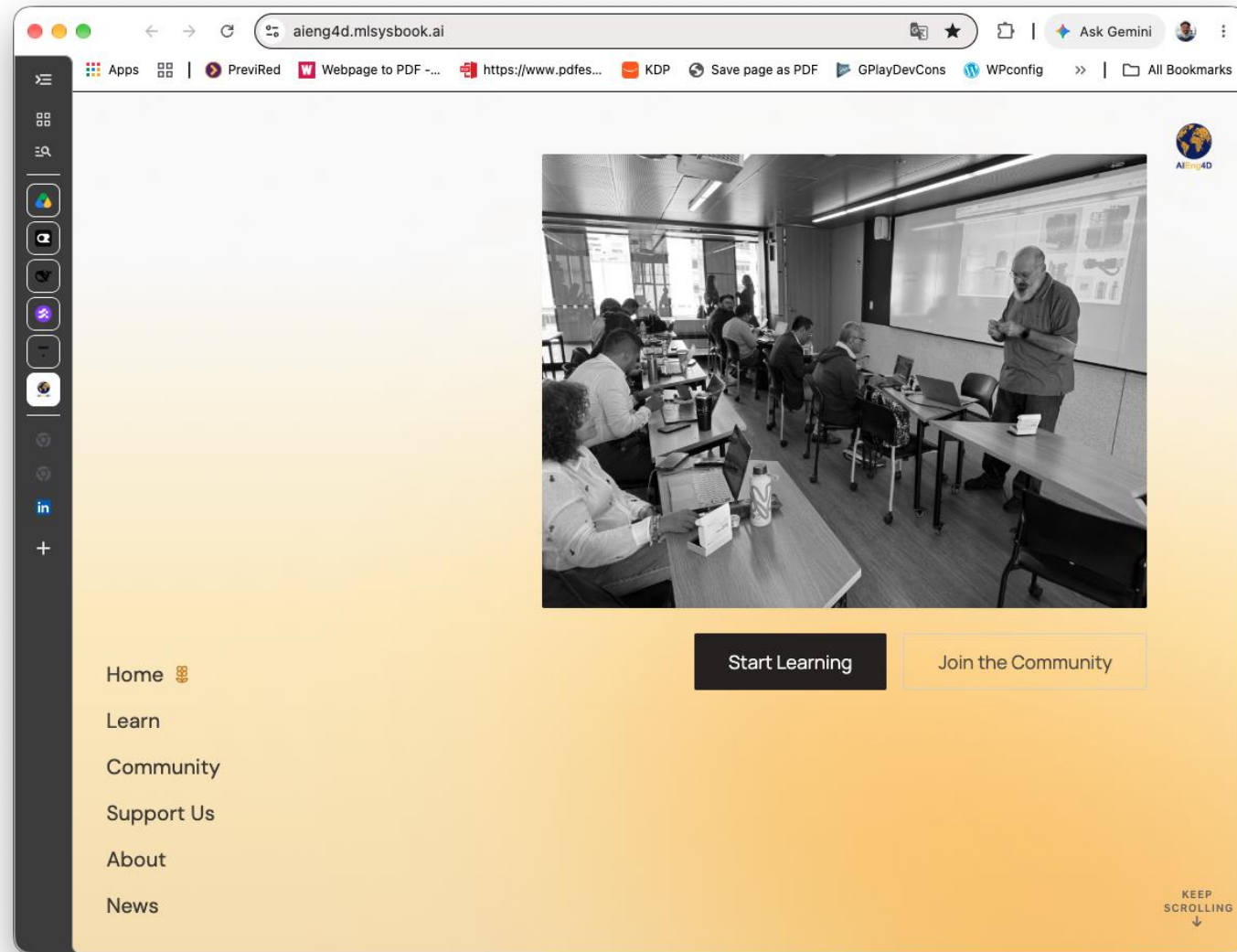
Harvard John A. Paulson
School of Engineering
and Applied Sciences



EDGE
IMPULSE



EDGEAI
FOUNDATION

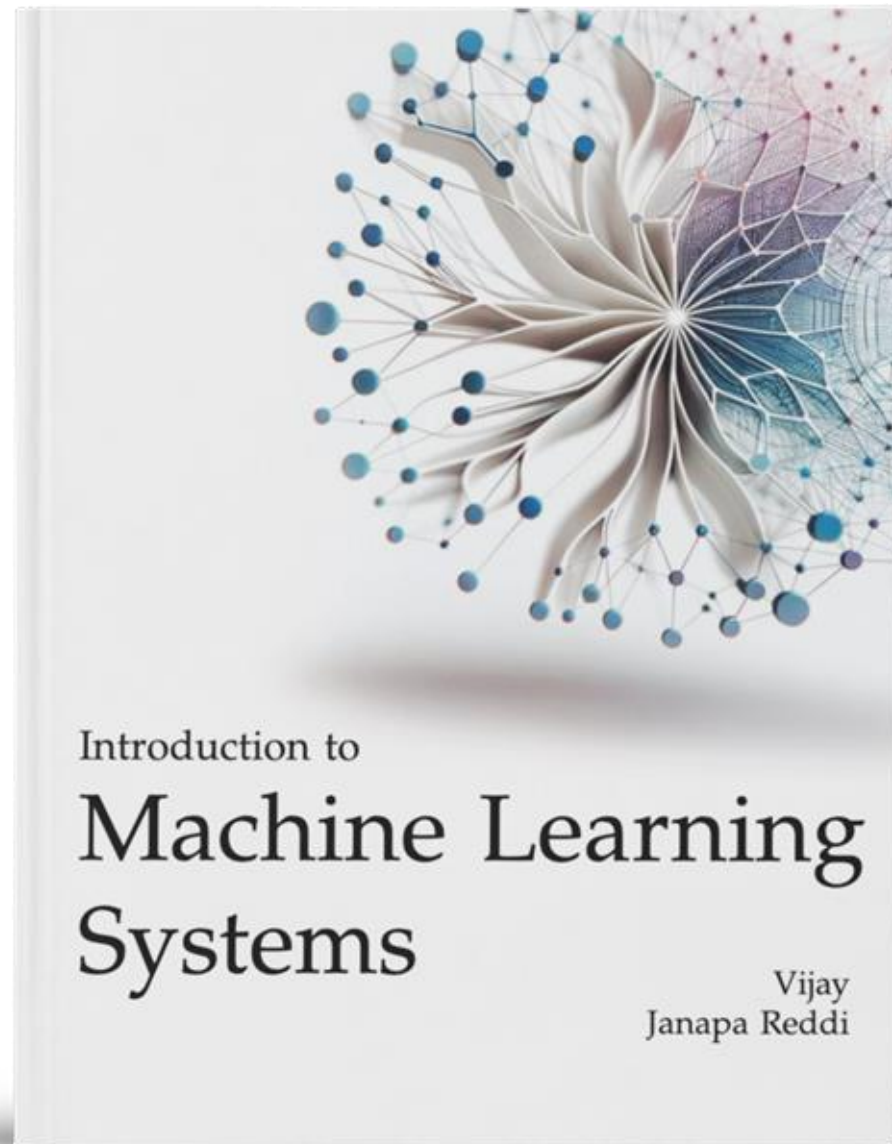


AIEng4D

AI Engineering
for Global Impact



<https://mlsysbook.ai/kits/>



Nicla Vision
Cortex-M4/M7



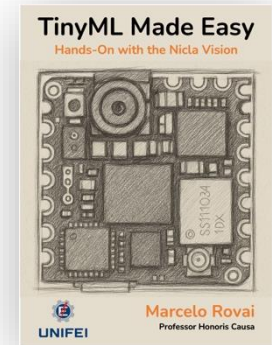
XIAO ML Kit
Xtensa LX7



Grove Vision AI V2
Cortex-M55/U55



Raspberry Pi
Cortex-A53/A76



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

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

ICTP

Description:
TinyML enables machine learning technologies to perform on-device analysis of sensor data at extremely low power. This allows for new scientific applications to be developed on an extremely low cost and of large scale.

Topics:
• All general concepts
• Scientific Applications of ML
• Introduction to TinyML
• Experimental TinyML applications

How to apply:
Please apply by 15 October 2021. Successful candidates are encouraged to apply.

Registration:
There is no registration fee.

Deadline:
8 October 2021

Speakers:
• Prof. Stefano Corbelli, INFN
• Dr. Andrea Cossentino, INFN
• Dr. Andrea Cossentino, INFN
• Dr. Andrea Cossentino, INFN

Directors:
• Prof. Stefano Corbelli, INFN
• Dr. Andrea Cossentino, INFN
• Dr. Andrea Cossentino, INFN

Organiser:
• Dr. Andrea Cossentino, INFN

Further information:
https://www.ictp.academy.org/2021/10/18-22oct21

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

25-29 April 2022
Online

ICTP

Description:
TinyML is a subset of Machine Learning focused on developing models that can be executed on small, real-time, low-power, and low-cost embedded devices. This allows for new scientific applications to be developed on an extremely low cost and of large scale.

Topics:
• All general concepts
• Scientific Applications of ML
• Introduction to TinyML
• Experimental TinyML applications

How to apply:
Please apply by 15 April 2022. Successful candidates are encouraged to apply.

Registration:
There is no registration fee.

Deadline:
15 April 2022

Speakers:
• Prof. Stefano Corbelli, INFN
• Dr. Andrea Cossentino, INFN
• Dr. Andrea Cossentino, INFN
• Dr. Andrea Cossentino, INFN

Directors:
• Prof. Stefano Corbelli, INFN
• Dr. Andrea Cossentino, INFN
• Dr. Andrea Cossentino, INFN

Organiser:
• Dr. Andrea Cossentino, INFN

Further information:
https://www.ictp.academy.org/2022/04/25-29apr22

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

6-10 June 2022
Online

ICTP

Description:
TinyML is a subset of Machine Learning focused on developing models that can be executed on small, real-time, low-power, and low-cost embedded devices. This allows for new scientific applications to be developed on an extremely low cost and of large scale.

Topics:
• All general concepts
• Scientific Applications of ML
• Introduction to TinyML
• Experimental TinyML applications

How to apply:
Please apply by 15 June 2022. Successful candidates are encouraged to apply.

Registration:
There is no registration fee.

Deadline:
22 May 2022

Speakers:
• Prof. Stefano Corbelli, INFN
• Dr. Andrea Cossentino, INFN
• Dr. Andrea Cossentino, INFN
• Dr. Andrea Cossentino, INFN

Directors:
• Prof. Stefano Corbelli, INFN
• Dr. Andrea Cossentino, INFN
• Dr. Andrea Cossentino, INFN

Organiser:
• Dr. Andrea Cossentino, INFN

Further information:
https://www.ictp.academy.org/2022/06/06-10jun22

Latin American Regional Workshop on SciTinyML: Scientific Use of Machine Learning on Low-Power Devices

13-18 July 2022
An ICTP Virtual Meeting
Trieste, Italy

ICTP

Description:
TinyML is a subset of Machine Learning focused on developing models that can be executed on small, real-time, low-power, and low-cost embedded devices. This allows for new scientific applications to be developed on an extremely low cost and of large scale.

Topics:
• All general concepts
• Scientific Applications of ML
• Introduction to TinyML
• Experimental TinyML applications

How to apply:
Please apply by 15 July 2022. Successful candidates are encouraged to apply.

Registration:
There is no registration fee.

Deadline:
29 June 2022

Speakers:
• Prof. Stefano Corbelli, INFN
• Dr. Andrea Cossentino, INFN
• Dr. Andrea Cossentino, INFN
• Dr. Andrea Cossentino, INFN

Directors:
• Prof. Stefano Corbelli, INFN
• Dr. Andrea Cossentino, INFN
• Dr. Andrea Cossentino, INFN

Organiser:
• Dr. Andrea Cossentino, INFN

Further information:
https://www.ictp.academy.org/2022/07/13-18jul22

Workshop on Scientific Use of Machine Learning on Low-Power Devices: Applications and Advanced Topics

17-21 April 2023
An ICTP Virtual Meeting
Trieste, Italy

ICTP

Description:
TinyML is a subset of Machine Learning focused on developing models that can be executed on small, real-time, low-power, and low-cost embedded devices. This allows for new scientific applications to be developed on an extremely low cost and of large scale.

Topics:
• All general concepts
• Scientific Applications of ML
• Introduction to TinyML
• Experimental TinyML applications

How to apply:
Please apply by 15 April 2023. Successful candidates are encouraged to apply.

Registration:
There is no registration fee.

Deadline:
7 April 2023

Speakers:
• Prof. Stefano Corbelli, INFN
• Dr. Andrea Cossentino, INFN
• Dr. Andrea Cossentino, INFN
• Dr. Andrea Cossentino, INFN

Directors:
• Prof. Stefano Corbelli, INFN
• Dr. Andrea Cossentino, INFN
• Dr. Andrea Cossentino, INFN

Organiser:
• Dr. Andrea Cossentino, INFN

Further information:
https://www.ictp.academy.org/2023/04/17-21apr23

ICTP-UNU Workshop on TinyML for Sustainable Development

AN ICTP 60th ANNIVERSARY SATELLITE EVENT

ICTP

Description:
TinyML is a new technology that allows machine learning models to run on low-cost, low-power microcontrollers. This technology has a significant role to play in achieving the Sustainable Development Goals (SDGs) and in facilitating scientific research in areas such as environmental monitoring and the physics of complex systems.

Topics:
• All general concepts
• Scientific Applications of ML
• Introduction to TinyML
• Experimental TinyML applications

How to apply:
Please apply by 15 March 2024. Successful candidates are encouraged to apply.

Registration:
There is no registration fee.

Deadline:
15 March 2024

Speakers:
• Prof. Stefano Corbelli, INFN
• Dr. Andrea Cossentino, INFN
• Dr. Andrea Cossentino, INFN
• Dr. Andrea Cossentino, INFN

Directors:
• Prof. Stefano Corbelli, INFN
• Dr. Andrea Cossentino, INFN
• Dr. Andrea Cossentino, INFN

Organiser:
• Dr. Andrea Cossentino, INFN

Further information:
https://www.ictp.academy.org/2024/03/15mar24

Workshop on Machine Learning on Low-Power Devices: Applications and Advanced Topics

6-10 May 2024
Online

ICTP

Description:
TinyML is a new technology that allows machine learning models to run on low-cost, low-power microcontrollers. This technology has a significant role to play in achieving the Sustainable Development Goals (SDGs) and in facilitating scientific research in areas such as environmental monitoring and the physics of complex systems.

Topics:
• All general concepts
• Scientific Applications of ML
• Introduction to TinyML
• Experimental TinyML applications

How to apply:
Please apply by 15 May 2024. Successful candidates are encouraged to apply.

Registration:
There is no registration fee.

Deadline:
15 May 2024

Speakers:
• Prof. Stefano Corbelli, INFN
• Dr. Andrea Cossentino, INFN
• Dr. Andrea Cossentino, INFN
• Dr. Andrea Cossentino, INFN

Directors:
• Prof. Stefano Corbelli, INFN
• Dr. Andrea Cossentino, INFN
• Dr. Andrea Cossentino, INFN

Organiser:
• Dr. Andrea Cossentino, INFN

Further information:
https://www.ictp.academy.org/2024/05/06-10may24

Workshop on TinyML for Sustainable Development

23-28 July 2024
Zomba, Malawi

ICTP

Description:
TinyML is a new technology that allows machine learning models to run on low-cost, low-power microcontrollers. This technology has a significant role to play in achieving the Sustainable Development Goals (SDGs) and in facilitating scientific research in areas such as environmental monitoring and the physics of complex systems.

Topics:
• All general concepts
• Scientific Applications of ML
• Introduction to TinyML
• Experimental TinyML applications

How to apply:
Please apply by 15 July 2024. Successful candidates are encouraged to apply.

Registration:
There is no registration fee.

Deadline:
15 July 2024

Speakers:
• Prof. Stefano Corbelli, INFN
• Dr. Andrea Cossentino, INFN
• Dr. Andrea Cossentino, INFN
• Dr. Andrea Cossentino, INFN

Directors:
• Prof. Stefano Corbelli, INFN
• Dr. Andrea Cossentino, INFN
• Dr. Andrea Cossentino, INFN

Organiser:
• Dr. Andrea Cossentino, INFN

Further information:
https://www.ictp.academy.org/2024/07/23-28jul24

Workshop on TinyML for Sustainable Development

31 March - 4 April 2025
Zomba, Malawi

ICTP

Description:
TinyML is a new technology that allows machine learning models to run on low-cost, low-power microcontrollers. This technology has a significant role to play in achieving the Sustainable Development Goals (SDGs) and in facilitating scientific research in areas such as environmental monitoring and the physics of complex systems.

Topics:
• All general concepts
• Scientific Applications of ML
• Introduction to TinyML
• Experimental TinyML applications

How to apply:
Please apply by 15 March 2025. Successful candidates are encouraged to apply.

Registration:
There is no registration fee.

Deadline:
15 March 2025

Speakers:
• Prof. Stefano Corbelli, INFN
• Dr. Andrea Cossentino, INFN
• Dr. Andrea Cossentino, INFN
• Dr. Andrea Cossentino, INFN

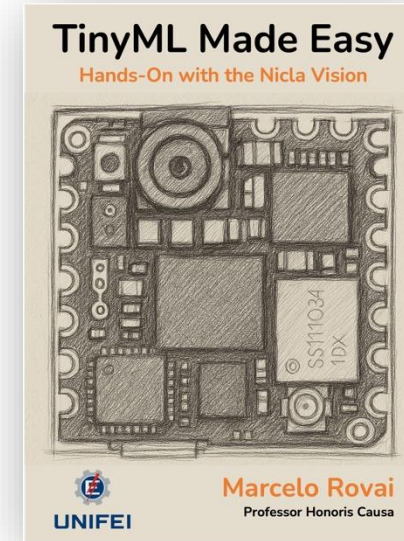
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• Dr. Andrea Cossentino, INFN

Organiser:
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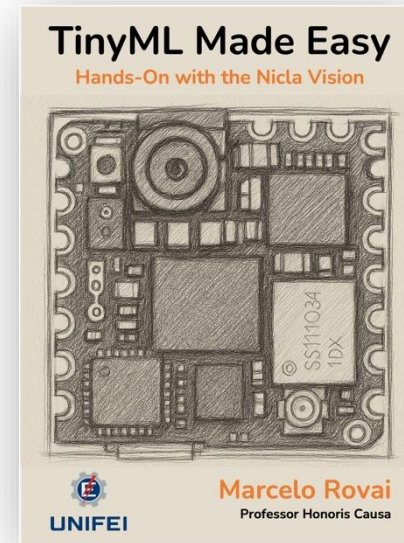
Further information:
https://www.ictp.academy.org/2025/03/31mar25

More
than 2000
people
trained!

Brazil 2024



Malawi 2025



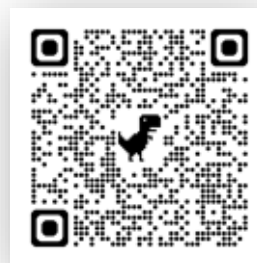




CUTTING AI DOWN TO SIZE



A \$14 chip
incorporating tinyML
AI models.
Actual size shown.



<https://www.science.org/content/article/what-s-tinyml-global-south-s-alternative-power-hungry-pricey-ai>

Questions?

Prof. Marcelo J. Rovai

rovai@unifei.edu.br

UNIFEI - Federal University of Itajuba, Brazil

TinyML4D - Academic Network Co-Chair

EdgeAIP - Academia-Industry Partnership Co-Chair





Universidad
Pontificia
Bolivariana

Vigilada Mineducación



#SinLímites

II CONGRESO INTERNACIONAL DE INGENIERÍA 2026