Leveraging any Microcontrollers & Data Collection at Edge Impulse Studio

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“Edge AI is a truly complete technology. As a topic, it makes use of knowledge from everything from the physical properties of semiconductor electronics all the way up to the engineering of high-level architectures that span devices and the cloud. It demands expertise in the most cutting-edge approaches to artificial intelligence and machine learning along with the most venerable skills of bare-metal embedded software engineering. It makes use of the entire history of computer science and electrical engineering, laid out end to end.”

Situnayake, Daniel; Plunkett, Jenny

*AI at the Edge* (pp. 215-216)
O'Reilly Media
Marcelo Rovai was born in São Paulo and holds a Master’s degree in Data Science from the Universidad del Desarrollo (UDD) in Chile and an MBA from IBMEC (INSPER) in Brazil. He graduated in 1982 as an Engineer from UNIFEI, Federal University of Itajubá, with a specialization from Escola Politécnica de Engenharia of São Paulo University (USP), both institutions located in Brazil.

Rovai has experience as a teacher, engineer, and executive in several technology companies such as CDT/ETEP, AVIBRAS Aeroespacial, SID Informática, ATT-GIS, NCR, DELL, COMPAQ (HP), and more recently at IGT as a VP and a Senior Advisor for Latin America.

Marcelo Rovai publishes articles about electronics on websites such as MJRoBot.org, Hackster.io, Instructables.com, and Medium.com. Furthermore, he is a volunteer Professor at the UNIFEI in Brazil and a lecturer at several Congresses and Universities on IoT and TinyML. He is an active member and a Co-Chair of the TinyML4D group, an initiative to bring TinyML education to developing countries.
Hardware
## Hardware

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<tbody>
<tr>
<td></td>
<td>Dual-core Arm Cortex-M0+</td>
<td>Arm Cortex-M4F</td>
<td>Xtensa LX6 Dual Core</td>
<td>Arm Cortex-M4F (BLE)</td>
<td>Dual Core Arm Cortex M7/M4</td>
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<td>1MB</td>
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<td>BLE</td>
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<td>Yes (Sense)</td>
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<td></td>
<td>2MB / 8MB</td>
<td>256KB / 8MB</td>
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<td>2MB</td>
<td>BLE/WiFi</td>
<td>No</td>
<td>Yes (Nicla)</td>
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<tr>
<td>Radio</td>
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<td></td>
<td></td>
<td>BLE</td>
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<td>BLE / WiFi (ESP32S3)</td>
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<td>Sensors</td>
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<td>Yes</td>
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<td>Yes (Sense)</td>
<td>Yes</td>
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<td>Yes (Nicla)</td>
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<td>Bat. Power Manag.</td>
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- Programmable LED
- Boot Selection Button
- 2 MByte Quad-SPI Flash
- 0.1″ Spacing Pads  
  Breadboard friendly
- SMT Friendly  
  Castellated Edges
- USB Micro B  
  Power & Data
- Built-in 12-bit Temperature Sensor
- RP2040 MCU Silicon
  - Dual-Core
  - 32-bit ARM Cortex M0+
  - 264 KByte SRAM
  - Clock @48MHz, Max at 133MHz
  - USB 1.1 Host and Device
RP2040 MCU Board, with LCD, accelerometer, and gyroscope Sensor

1. USB Type-C connector
   USB 1.1 with device and host support

2. ETA6096
   High efficiency Lithium battery recharge manager

3. Battery Header
   MX1.25 header, for 3.7V Lithium battery, allows recharging the battery and powering the board at the same time

4. QMI8659C
   IMU, includes a 3-axis gyroscope and a 3-axis accelerometer

5. 1.27mm pitch headers
   Adapting all GPIO and Debug pins

6. W25Q16JVUXIQ
   2MB NOR-Flash

7. RP2040
   Dual-core processor, up to 133MHz operating frequency

8. RESET Button

9. BOOT Button
   press it when resetting to enter download mode

https://www.waveshare.com/rp2040-lcd-1.28.htm
TinyML under the hood: Spectral Analysis

MJRorBot (Marcelo Rovai)
EI Studio Data Ingestion
Alternative methods
Officially supported MCU

Arduino, Wio Terminal

Supported MCU

XIAOs, ESPs

Not supported MCU

WiFi

Edge Impulse

Serial

Studio Uploader

.json

.wav

.csv

.jpg
1. SmartPhone

![Diagram showing a smartphone connected to Edge Impulse via WiFi]
1. **Data Ingestion using Smart Phone**
1. Data Capture and Model Training

*Connected as phone_12rkzyb0*

You can collect data from this device from the **Data Acquisition** page in the Edge Impulse studio.

- Collecting images?
- Collecting audio?
- Collecting motion?

---

Permission required

Give access to the camera

---

Enter a label

mug

---

Split automatically (80/20)

- Training
- Testing

---

Capture
1. Off-Line Inference
2. Web-USB (Arduino CLI)

Issue: Limited MCU and sensors
2. **Data Ingestion using Arduino-Cli + Web-USB (or EI-CLI)**
Arduino Nano 33 BLE Sense Rev2

- **IMU** - LSM9DS1 - 9 axis ➔ BMI270 – 6 axis + BMM150 - 3 axis
- **Temperature and humidity sensor** - HTS221 ➔ HS3003
- **Microphone** - MP34DT05 ➔ MP34DT06JTR.

https://docs.arduino.cc/resources/datasheets/ABX00069-datasheet.pdf
2. Web-USB (.uf2)

Issue: Limited MCU and sensors
2. (.uf2) Firmware installation

1. Connect Wio Terminal to your computer.
2. Entering the bootloader mode by sliding the power switch twice quickly.
3. An external drive named Arduino should appear in your PC.
4. Drag the downloaded **Edge Impulse uf2 firmware files** to the Arduino drive. Now, Edge Impulse is loaded on Seeeduino Wio Terminal!
3. Data-Forward
3. Data-Forward

1. Edge Impulse

2. Web-USB or EI-CLI

3. EI-CLI + Data-Forward

2. Arduino-CLI

3. Arduino-IDE

TinyML Made Easy: Anomaly Detection & Motion Classification
MJRobst (Marcelo Roval)
2. **Data Ingestion using EI-Cli + Data Forward**

```bash
$ edge-impulse-data-forwarder --clean
```
4. Uploading Data
4. **Data Ingestion using Upload existing Data**

(CBOR, JSON, CSV), or as WAV, JPG or PNG files.
4. Uploading .wav data
4. Uploading .jpg data

https://github.com/YoongiKim/CIFAR-10-images
5. (.CSV) PLX-DAQ (Windows)
5. (.CSV) PLX-DAQ (Windows)
5. Data Ingestion using PLX-DAQ (Windows) => Final Format: .csv

https://www.youtube.com/watch?v=BwbnNleZCZo
5. (.CSV) PySerial
5. Data Ingestion using Python (PySerial) => Final Format: .csv
6. (.csv) by Bluetooth
6. (.csv) by Bluetooth
6. (.csv) by Bluetooth
7. (.json)
7. Raw Uploader (.json files)

**Image Classification: Raw Uploader**

Run this notebook to convert images to a single row of raw, normalized values (between 0 and 1) and upload them to Edge Impulse as raw samples. Note that pixel values will be normalized to be between 0 and 1.

Create a folder named "dataset" in the /content directory and upload your images there. The images should be divided into their respective classes, where each class has its own folder with the name of the class. For example:

```
/content
    |--- dataset
    |     |--- background
    |     |--- capacitor
    |     |--- diode
    |     |--- led
    |     |--- resistor
```

Author: EdgeImpulse, Inc.
Date: June 6, 2021
License: Apache-2.0
Data Ingestion

Summary

1. Edge Impulse

2. Web-USB or EI-CLI

3. EI-CLI + Data-Forward

2. Firmware (.uf2)

2. Arduino-CLI

3. Arduino-IDE

4. DATA (.wav)

5. PLX-DAQ

6. (Code)
To learn more …

- IESTI01 TinyML - Machine Learning for Embedding Devices (Videos: Pt)
- WALC 22 – Applied AI - TinyML (Videos in Spanish)
- Professional Certificate in Tiny Machine Learning (TinyML) – edX/Harvard
- Introduction to Embedded Machine Learning - Coursera/Edge Impulse
- Computer Vision with Embedded Machine Learning - Coursera/Edge Impulse
- "Deep Learning with Python" book by François Chollet
- "TinyML" book by Pete Warden, Daniel Situnayake
- "TinyML Cookbook" by Gian Marco Iodice
- "AI at the Edge" book by Daniel Situnayake, Jenny Plunkett

On the TinyML4D website, You can find lots of educational materials on TinyML. They are all free and open-source for educational uses – we ask that if you use the material, please cite them! TinyML4D is an initiative to make TinyML education available to everyone globally.
Thanks