

IESTI01 – TinyML

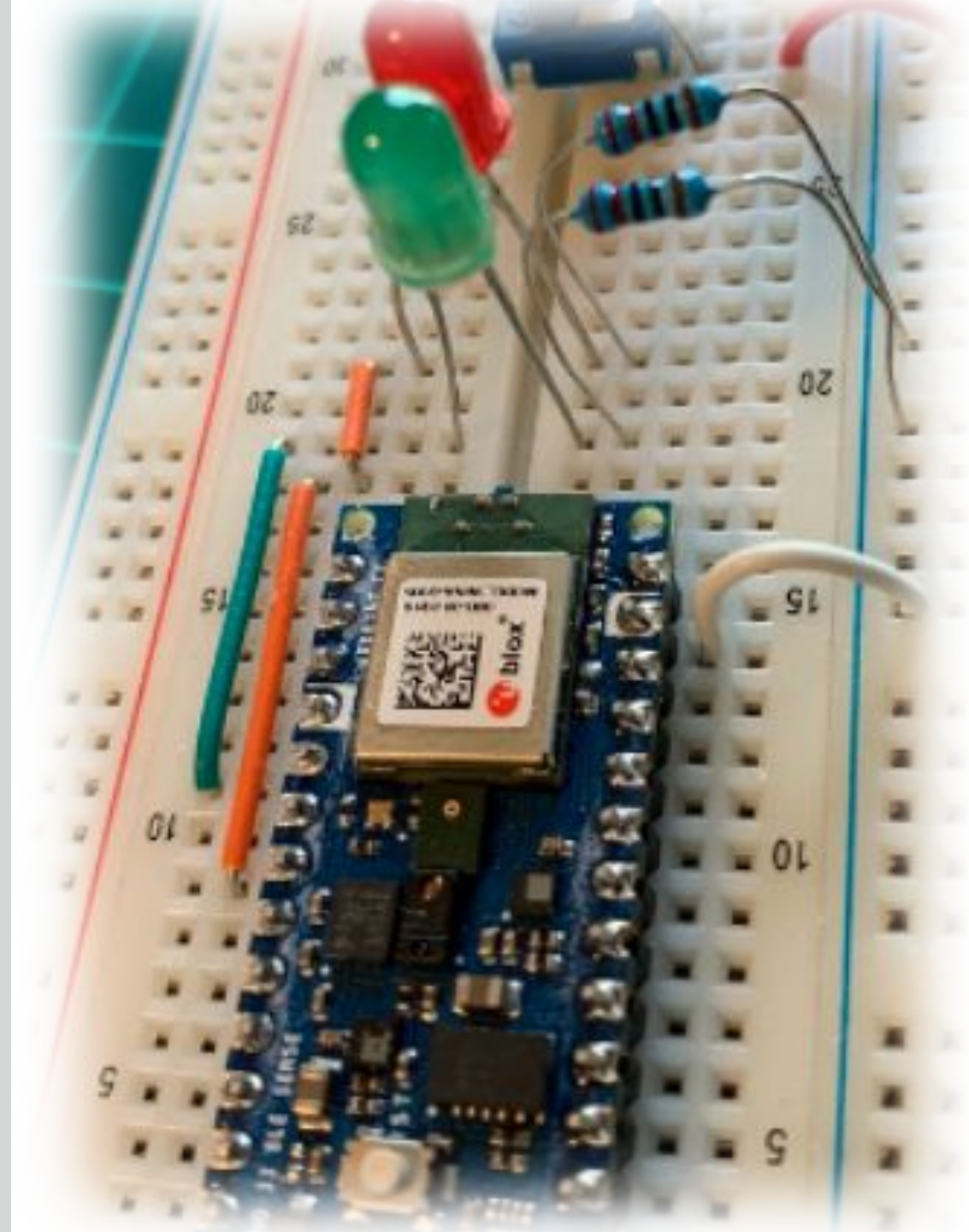
Embedded Machine Learning

20. Motion Classification using Arduino Nano-33 BLE Sense

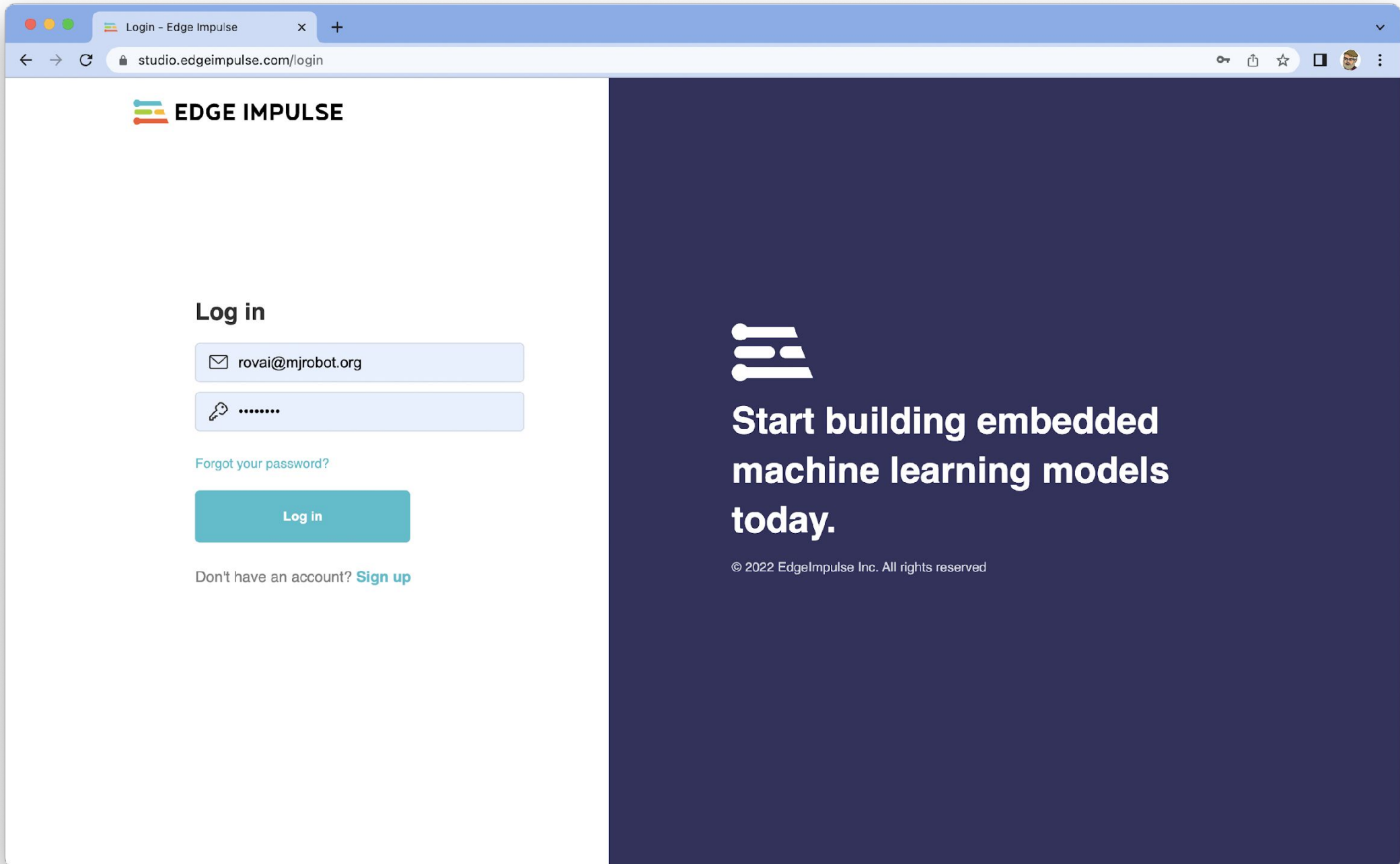


Prof. Marcelo Rovai

UNIFEI



Set up connection between **Arduino Nano**
and **Edge Impulse**



Log in

✉ rovai@mjrobot.org

🔑

[Forgot your password?](#)

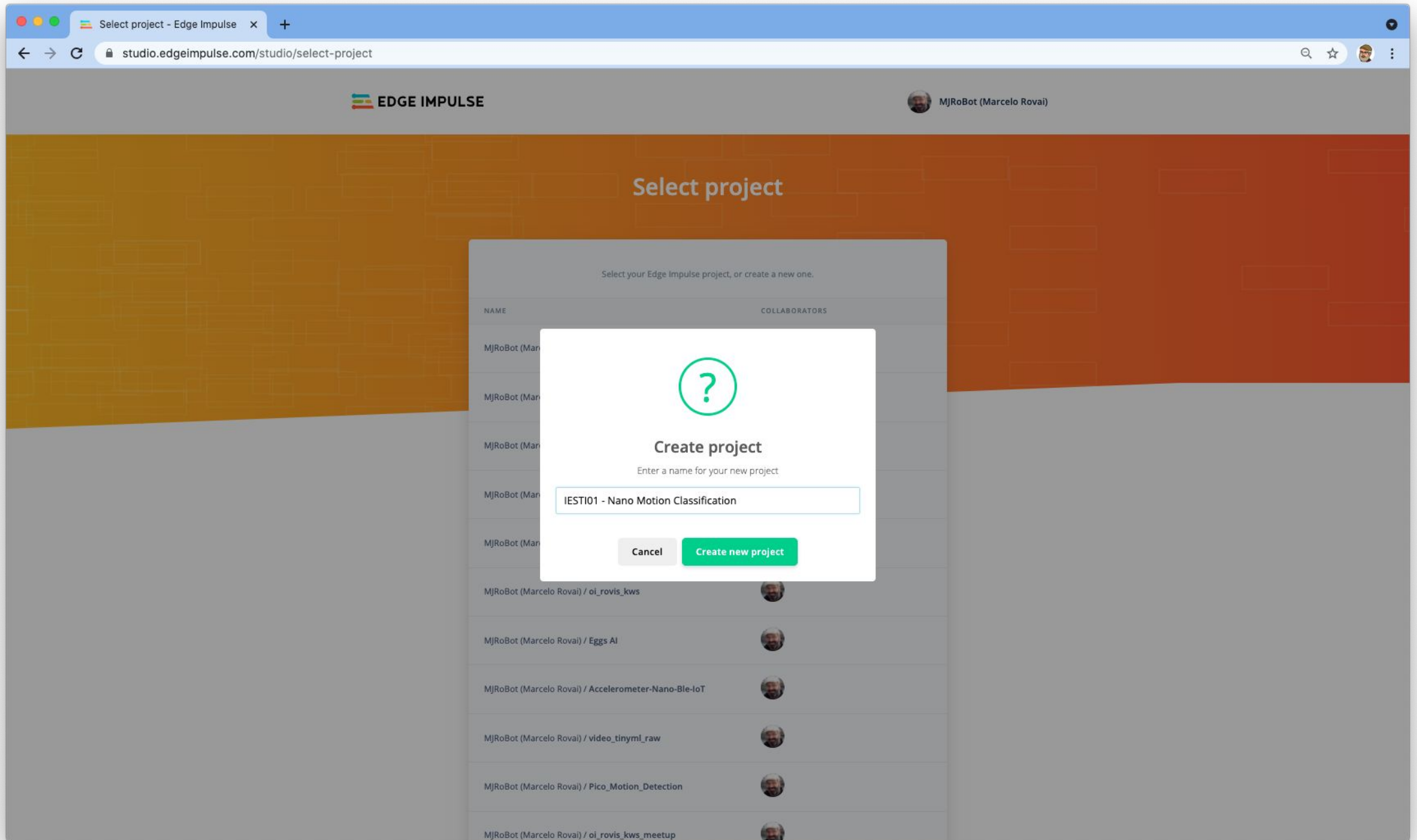
Log in

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Start building embedded
machine learning models
today.

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Select project

Select your Edge Impulse project, or create a new one.

NAME	COLLABORATORS
------	---------------

MJRoBot (Marcelo Rovai) / oi_rovis_kws	
--	---

MJRoBot (Marcelo Rovai) / Eggs AI	
-----------------------------------	---

MJRoBot (Marcelo Rovai) / Accelerometer-Nano-Ble-IoT	
--	---

MJRoBot (Marcelo Rovai) / video_tinyml_raw	
--	---

MJRoBot (Marcelo Rovai) / Pico_Motion_Detection	
---	---

MJRoBot (Marcelo Rovai) / oi_rovis_kws_meetup	
---	---

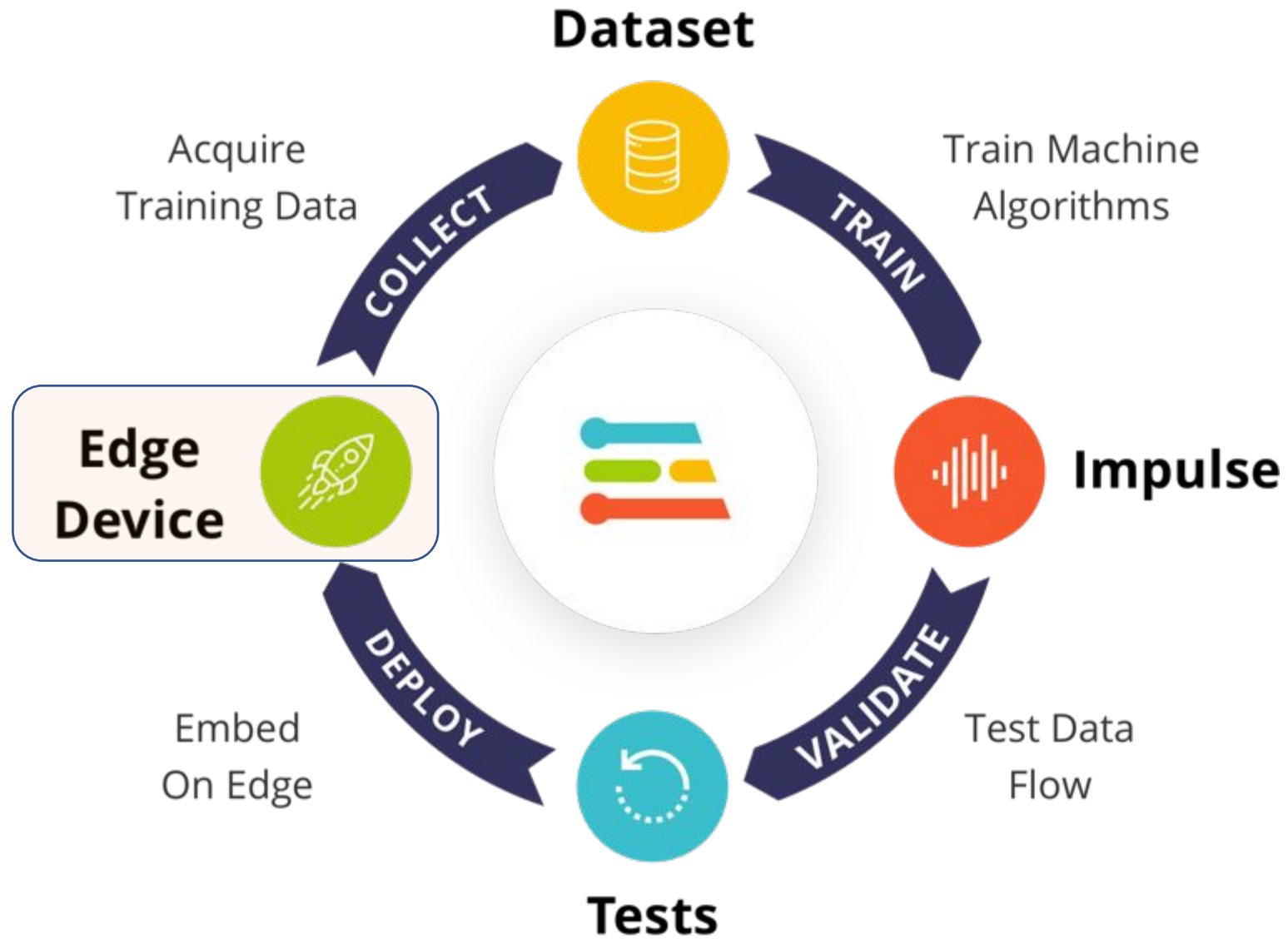


Create project

Enter a name for your new project

Cancel

Create new project



- Pre-Processing Data
- Design a Model
- Train a Model

Devices - IEST101 - Nano Moti... +

studio.edgeimpulse.com/studio/61345/devices

EDGE IMPULSE

DEVICES (IEST101 - NANO MOTION CLASSIFICATION)

MJRoBot (Marcelo Roval)

1 **2** **3**

Your devices

These are devices that are connected to the Edge Impulse remote management API, or have posted data to the ingestion SDK.

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Collect data

You can collect data from development boards, from your own devices, or by uploading an existing dataset.

- Connect a fully supported development board**
Get started with real hardware from a wide range of silicon vendors - fully supported by Edge Impulse.
Browse dev boards
- Use your mobile phone**
Use your mobile phone to capture movement, audio or images, and even run your trained model locally. No app required.
Show QR code
- Use your computer**
Capture audio or images from your webcam or microphone, or from an external audio device.
Collect data
- Data from any device with the data forwarder**
Capture data from any device or development board over a serial connection, in 10 lines of code.
Show docs
- Upload data**
Already have data? You can upload your existing datasets directly in WAV, JPG, PNG, CBOR, CSV or JSON format.
Go to the uploader
- Integrate with your cloud**
The enterprise version of Edge Impulse integrates directly with the data stored in your cloud platform.
Contact us

<https://docs.edgeimpulse.com/docs/fully-supported-development-boards>

Devices - IESTI01 - Nano Motio x

Overview - Edge Impulse Docu x

+

← → ↻

docs.edgeimpulse.com/docs/development-platforms/fully-supported-development-boards

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Officially supported MCU targets >

Officially supported CPU/GPU targets >

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Overview

There is a list of development boards that are fully supported by Edge Impulse. These boards come with a special firmware which enables data collection from all their sensors, allows you to build new ready-to-go binaries that include your trained impulse, and come with examples on integrating your impulse with your custom firmware. These boards are the perfect way to start building Machine Learning solutions on real embedded hardware.

Officially supported MCU targets

- **Arduino Nano 33 BLE Sense**
- Arduino Nicla Sense ME
- Arduino Portenta H7 + Vision Shield
- Espressif ESP32
- Himax WE-I Plus
- Nordic Semi nRF52840 DK
- Nordic Semi nRF5340 DK
- Nordic Semi nRF9160 DK
- Nordic Semi Thingy:91
- Open MV Cam H7 Plus
- Silicon Labs xG24 Dev Kit
- Silicon Labs Thunderboard Sense 2
- Sony's Spresense
- ST B-L475E-IOT01A
- Syntiant Tiny ML Board
- TI CC1352P Launchpad
- Raspberry Pi RP2040

El/Arduino CLI

Devices - SciTinyML-Motion-A X

Arduino Nano 33 BLE Sense - X

Arduino Nano 33 BLE Sense - X

+

▼

← → ↻ docs.edgeimpulse.com/docs/development-boards/arduino-nano-33-ble-sense 🔍 📄 ⚙️ 👤 ⋮

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ST B-L475E-IOT01A

Arduino Nano 33 BLE Sense

Arduino Portenta H7 + Vision Shield

Open MV Cam H7 Plus

Himax WE-I Plus

Nordic Semi nRF52840 DK

Nordic Semi nRF5340 DK

Nordic Semi nRF9160 DK

Nordic Semi Thingy:91

SiLabs Thunderboard Sense 2

Sony's Spresense

Syntiant Tiny ML Board

TI CC1352P Launchpad

Raspberry Pi 4

Raspberry Pi RP2040

NVIDIA Jetson Nano

Intel Based Macs

Linux x86_64

Mobile Phone

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Arduino Nano 33 BLE Sense

The Arduino Nano 33 BLE Sense is a tiny development board with a Cortex-M4 microcontroller, motion sensors, a microphone and BLE - and it's fully supported by Edge Impulse. You'll be able to sample raw data, build models, and deploy trained machine learning models directly from the studio. It's available for around 30 USD from [Arduino](#) and a wide range of distributors.

You can also use the [Arduino Tiny Machine Learning Kit](#) to run image classification models on the edge with the Arduino Nano and attached OV7675 camera module (or [connect the hardware together via jumper wire and a breadboard](#) if purchased separately).

The Edge Impulse firmware for this development board is open source and hosted on GitHub: [edgeimpulse/firmware-arduino-nano-33-ble-sense](#).



Arduino Nano 33 BLE Sense

Installing dependencies

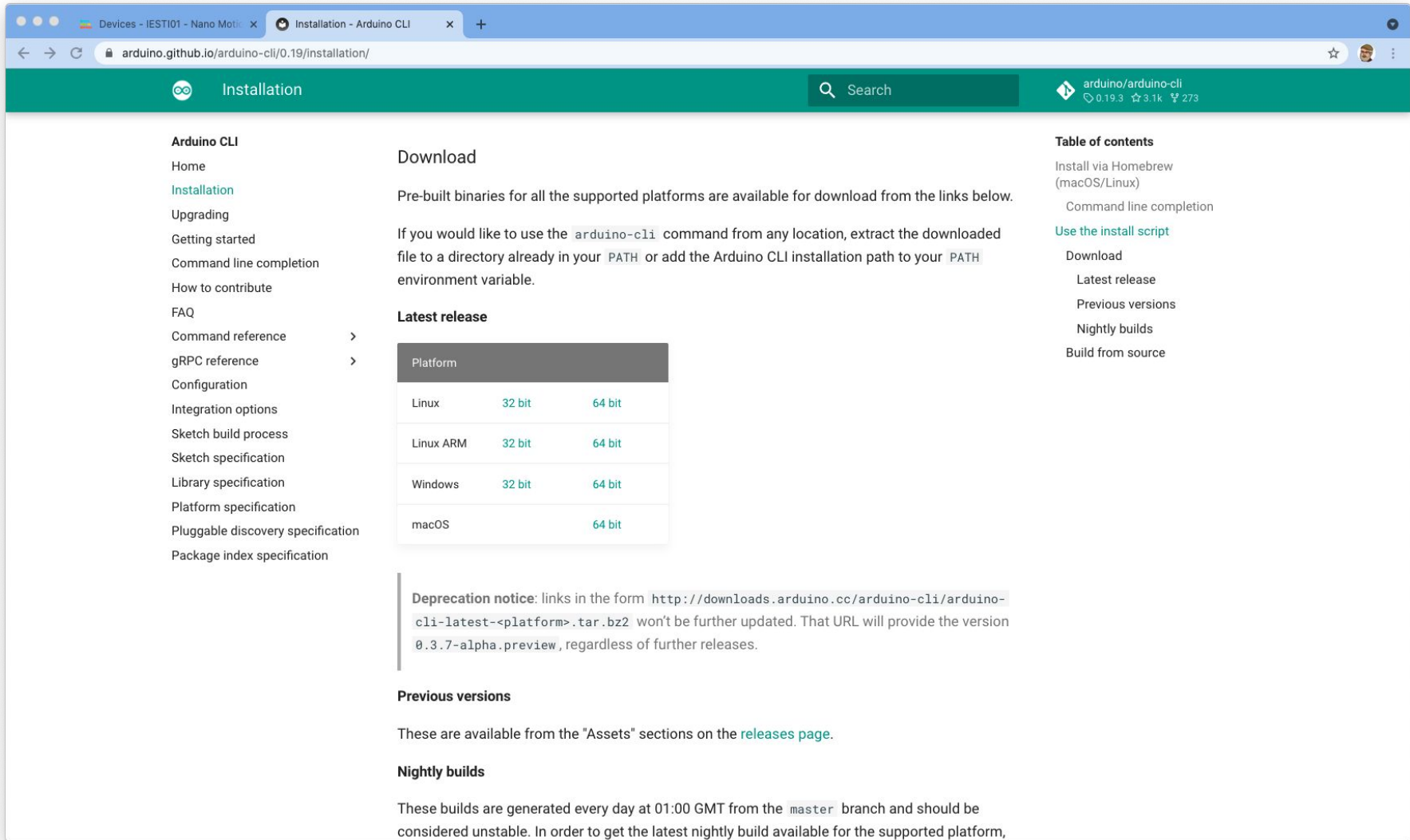
To set this device up in Edge Impulse, you will need to install the following software:

1. [Edge Impulse CLI](#).
2. [Arduino CLI](#).
 - Here's an [instruction video for Windows](#).
 - The [Arduino website](#) has instructions for macOS and Linux.

(Note that the **1. Edge Impulse CLI** is not necessary for Arduino Nano-33. We will use **WebUSB** instead)

Go to **2. Arduino CLI**

Arduino CLI



The screenshot shows the Arduino CLI installation page on GitHub. The page has a green header with the Arduino logo and the text "Installation". Below the header, there is a sidebar on the left with a list of links: Home, Installation (highlighted), Upgrading, Getting started, Command line completion, How to contribute, FAQ, Command reference, gRPC reference, Configuration, Integration options, Sketch build process, Sketch specification, Library specification, Platform specification, Pluggable discovery specification, and Package index specification. The main content area is titled "Download" and contains the following text: "Pre-built binaries for all the supported platforms are available for download from the links below. If you would like to use the `arduino-cli` command from any location, extract the downloaded file to a directory already in your `PATH` or add the Arduino CLI installation path to your `PATH` environment variable." Below this text is a table titled "Latest release" with the following data:

Platform	32 bit	64 bit
Linux	32 bit	64 bit
Linux ARM	32 bit	64 bit
Windows	32 bit	64 bit
macOS		64 bit

Below the table is a "Deprecation notice" stating: "links in the form `http://downloads.arduino.cc/arduino-cli/latest-<platform>.tar.bz2` won't be further updated. That URL will provide the version `0.3.7-alpha.preview`, regardless of further releases." Below the notice is a section titled "Previous versions" with the text: "These are available from the 'Assets' sections on the [releases page](#)." Below this is a section titled "Nightly builds" with the text: "These builds are generated every day at 01:00 GMT from the `master` branch and should be considered unstable. In order to get the latest nightly build available for the supported platform,"

On the right side of the page, there is a "Table of contents" section with the following links: "Install via Homebrew (macOS/Linux)", "Command line completion", "Use the install script", "Download", "Latest release", "Previous versions", "Nightly builds", and "Build from source".



See this video for Windows installation: <https://www.youtube.com/watch?v=1jMWsFER-Bc>

Arduino CLI Installation Summary

If you're on Windows:

- Unzip the .zip file to C:\Program Files\arduino-cli
- Open System Properties > Advanced > Environment Variables
- Path under "user variables" > Edit
- Add C:\Program Files\arduino-cli

If you're on macOS:

- I recommend using the curl method or homebrew shown on the installation page:
<https://arduino.github.io/arduino-cli/0.21/installation/>
- if you use the curl method, it likely installs arduino-cli to ~/bin. That might not be on your path. So, you might need to run: `export PATH=$PATH:~/bin`

Devices - SciTinyML-Motion-A x Arduino Nano 33 BLE Sense - x Installation - Arduino CLI x +

docs.edgeimpulse.com/docs/development-boards/arduino-nano-33-ble-sense

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Arduino Nano 33 BLE Sense

Arduino Portenta H7 + Vision Shield

Open MV Cam H7 Plus

Himax WE-I Plus

Nordic Semi nRF52840 DK

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Nordic Semi nRF9160 DK

Nordic Semi Thingy:91

SiLabs Thunderboard Sense 2

Sony's Spresense

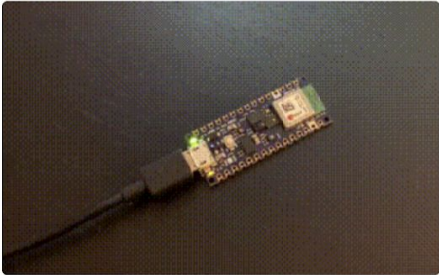
Syntiant Tiny ML Board

Powered By GitBook

1

1. Connect the development board to your computer

Use a micro-USB cable to connect the development board to your computer. Then press RESET twice to launch into the bootloader. The on-board LED should start pulsating to indicate this.



Press RESET twice quickly to launch the bootloader on the Arduino Nano 33 BLE Sense.

2

2. Update the firmware

The development board does not come with the right firmware yet. To update the firmware:

1. **Download the latest Edge Impulse firmware**, and unzip the file.
2. Open the flash script for your operating system (`flash_windows.bat`, `flash_mac.command` or `flash_linux.sh`) to flash the firmware.
3. Wait until flashing is complete, and press the RESET button once to launch the new firmware.

3. Setting keys

From a command prompt or terminal, run:

```
1 edge-impulse-daemon
```

3

Name

arduino-nano-33-ble-sense

flash_mac.command

flash_windows.bat

flash_linux.sh

arduino-nano-33-ble-sense.ino.bin

arduino-nano-33-ble-sense.zip

MacOS

```
mjrovai — flash_mac.command — 126x44

Last login: Tue Nov  9 12:15:56 on ttys002
You have new mail.
/Users/mjrovai/Downloads/arduino-nano-33-ble-sense\ \{(2)\}/flash_mac.command ; exit;

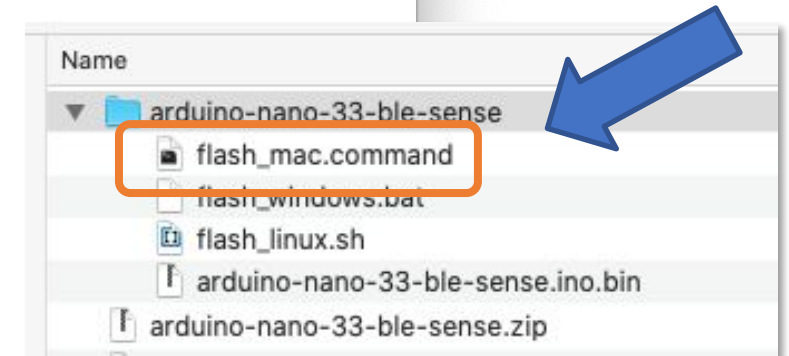
The default interactive shell is now zsh.
To update your account to use zsh, please run `chsh -s /bin/zsh`.
For more details, please visit https://support.apple.com/kb/HT208050.
(base) MacBook-Pro-de-Marcelo:~ mjrovai$ /Users/mjrovai/Downloads/arduino-nano-33-ble-sense\ \{(2)\}/flash_mac.command ; exit;
Finding Arduino Mbed core...
Finding Arduino Mbed OK
Finding Arduino Nano 33 BLE...
Finding Arduino Nano 33 BLE OK
Flashing board...
Device      : nRF52840-QIAA
Version     : Arduino Bootloader (SAM-BA extended) 2.0 [Arduino:IKXYZ]
Address     : 0x0
Pages       : 256
Page Size   : 4096 bytes
Total Size  : 1024KB
Planes      : 1
Lock Regions : 0
Locked      : none
Security    : false
Erase flash

Done in 0.001 seconds
Write 280848 bytes to flash (69 pages)
[=====] 100% (69/69 pages)
Done in 10.984 seconds

Flashed your Arduino Nano 33 BLE development board.
To set up your development with Edge Impulse, run 'edge-impulse-daemon'
To run your impulse on your development board, run 'edge-impulse-run-impulse'
logout
Saving session...
...copying shared history...
...saving history...truncating history files...
...completed.

[Process completed]
```

1. Press Nano-33 Reset button Twice
2. With Nano-33 LED Flashing:



3. Nano-33 LED Stop Flashing

Windows 10

```

C:\> Prompt de Comando

Microsoft Windows [versão 10.0.19041.1052]
(c) Microsoft Corporation. Todos os direitos reservados.

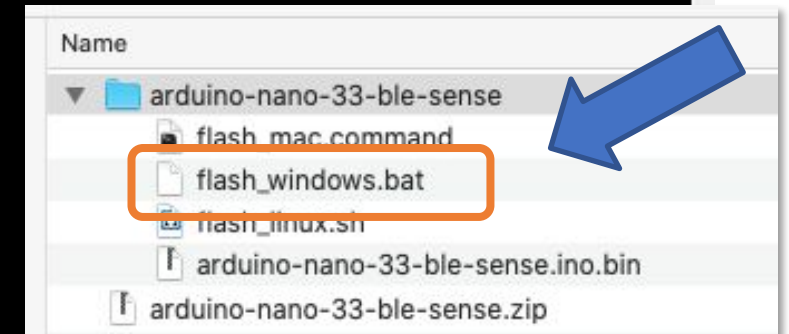
C:\Users\GUILH>arduino-cli
Arduino Command Line Interface (arduino-cli).

Usage:
  arduino-cli [command]

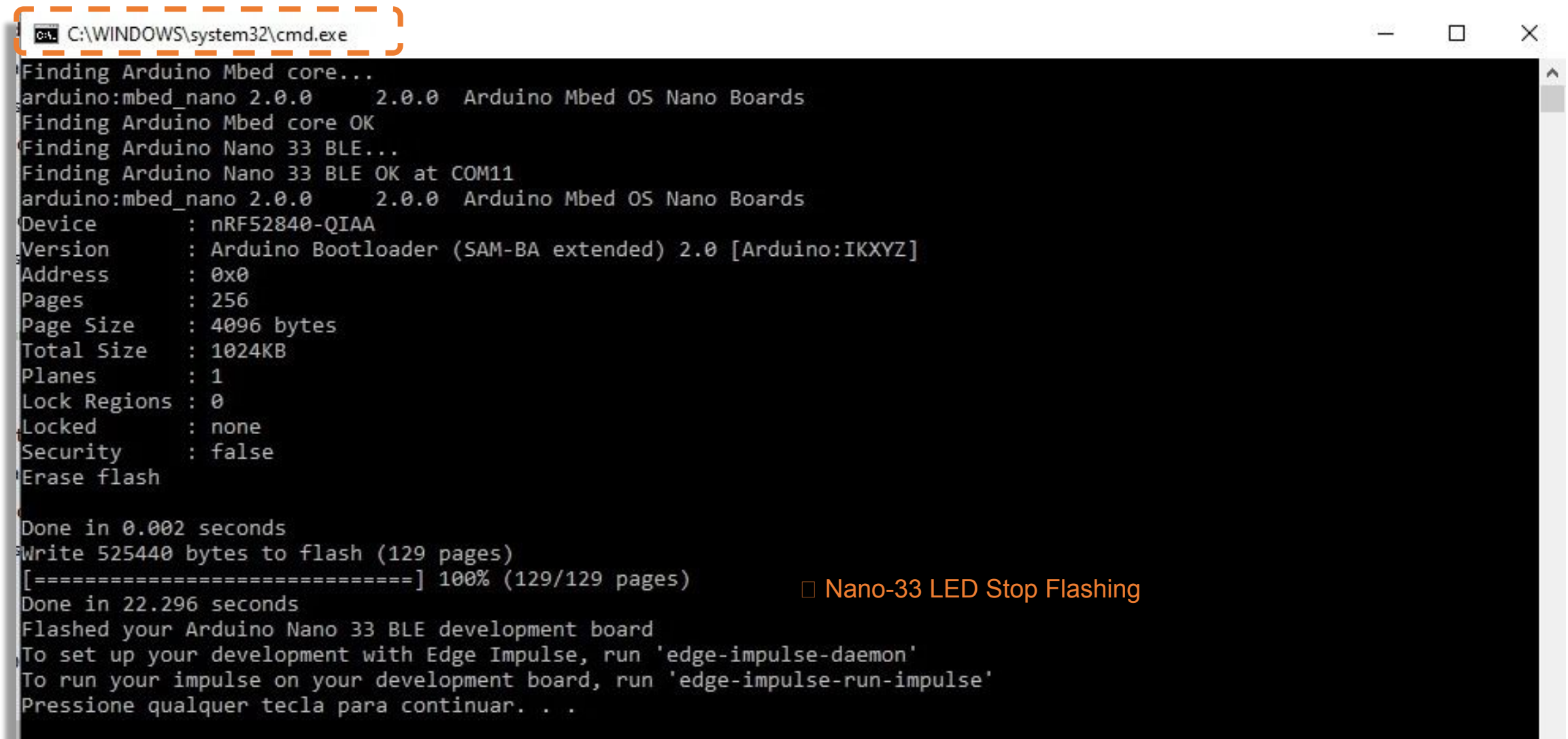
Examples:
  arduino-cli <command> [flags...]

Available Commands:
  board           Arduino board commands.
  burn-bootloader Upload the bootloader.
  cache           Arduino cache commands.
  compile         Compiles Arduino sketches.
  completion      Generates completion scripts
  config          Arduino configuration commands.
  core            Arduino core operations.
  daemon          Run as a daemon on port 50051
  debug           Debug Arduino sketches.
  help            Help about any command
  lib             Arduino commands about libraries.
  outdated        Lists cores and libraries that can be upgraded
  sketch          Arduino CLI sketch commands.
  update          Updates the index of cores and libraries
  upgrade         Upgrades installed cores and libraries.
  upload          Upload Arduino sketches.
  version         Shows version number of Arduino CLI.
```

1. Press Nano-33 Reset button Twice
2. With Nano-33 LED Flashing:



Windows 10



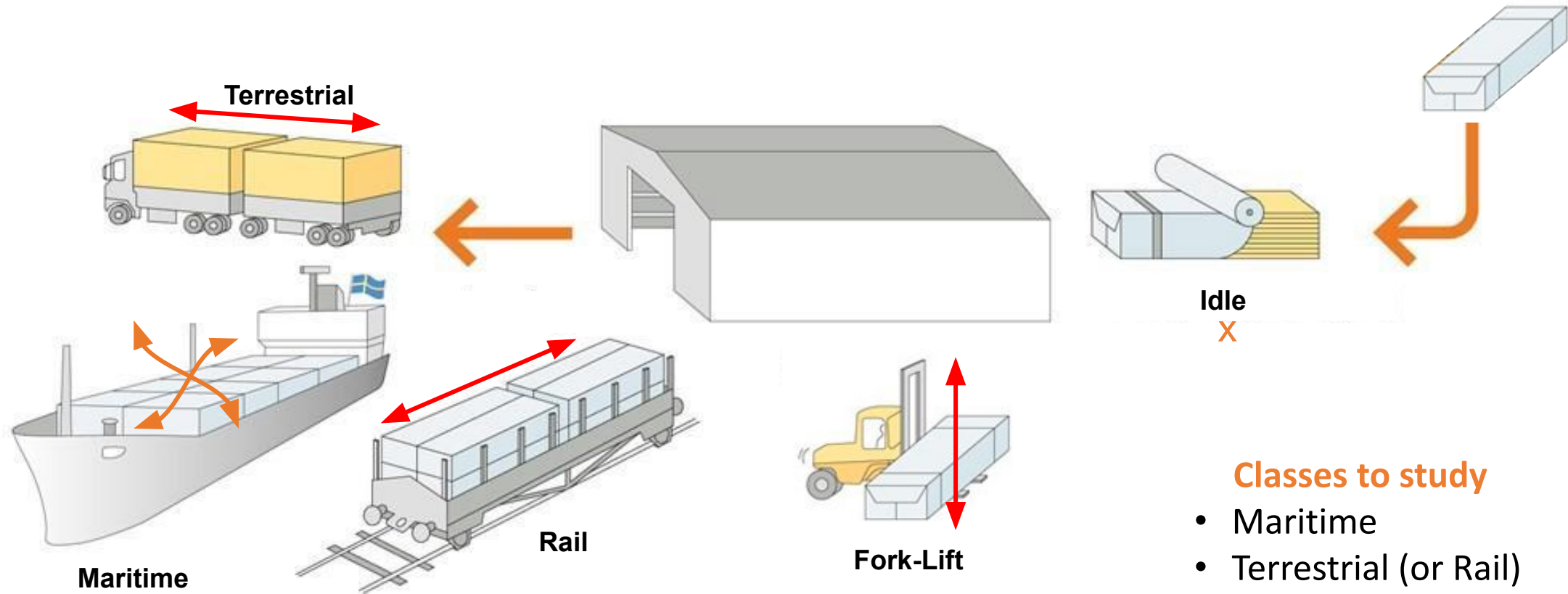
```
C:\WINDOWS\system32\cmd.exe
Finding Arduino Mbed core...
arduino:mbed_nano 2.0.0      2.0.0  Arduino Mbed OS Nano Boards
Finding Arduino Mbed core OK
Finding Arduino Nano 33 BLE...
Finding Arduino Nano 33 BLE OK at COM11
arduino:mbed_nano 2.0.0      2.0.0  Arduino Mbed OS Nano Boards
Device       : nRF52840-QIAA
Version      : Arduino Bootloader (SAM-BA extended) 2.0 [Arduino:IKXYZ]
Address      : 0x0
Pages        : 256
Page Size    : 4096 bytes
Total Size   : 1024KB
Planes       : 1
Lock Regions : 0
Locked       : none
Security     : false
Erase flash

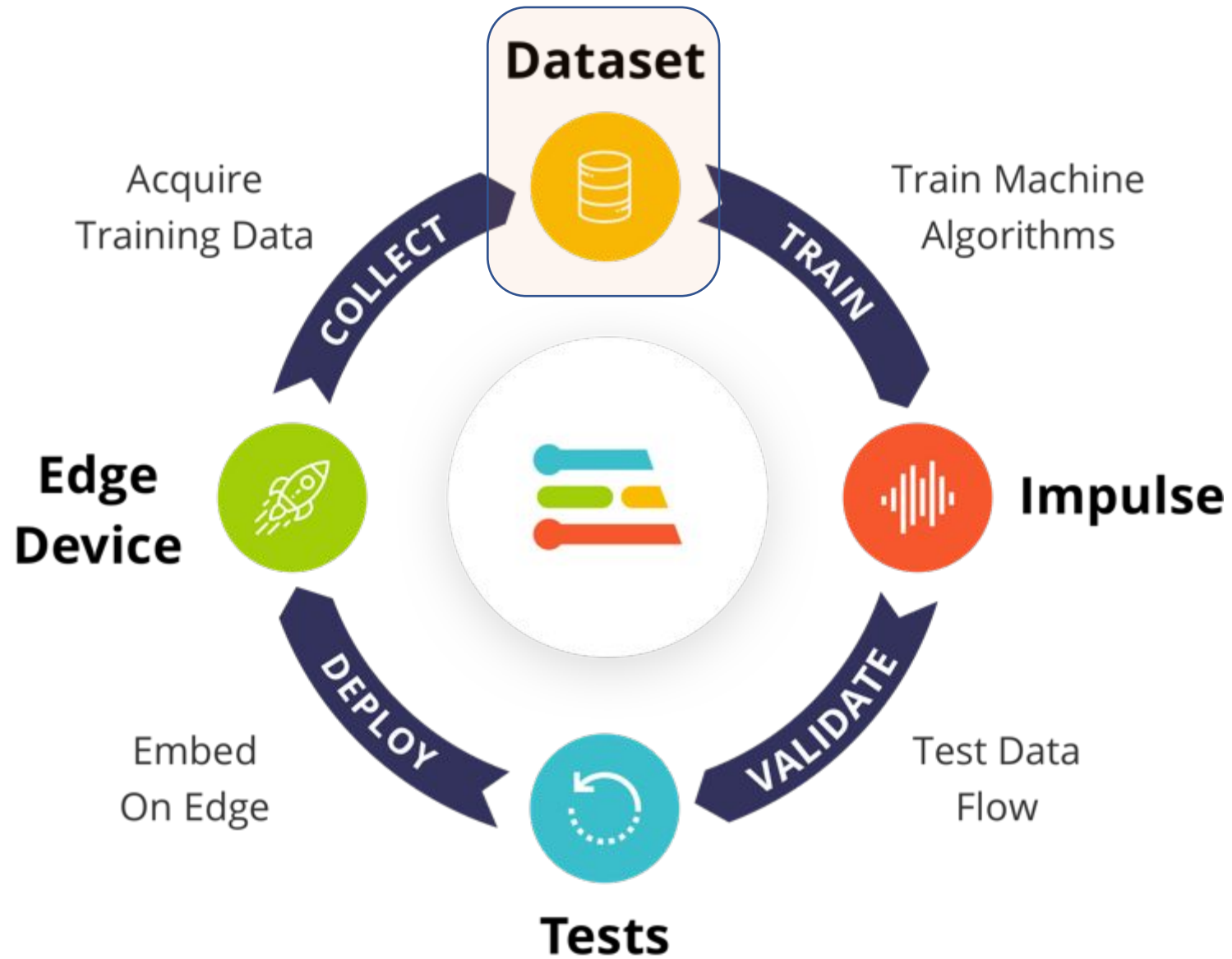
Done in 0.002 seconds
Write 525440 bytes to flash (129 pages)
[=====] 100% (129/129 pages)
Done in 22.296 seconds
Flashed your Arduino Nano 33 BLE development board
To set up your development with Edge Impulse, run 'edge-impulse-daemon'
To run your impulse on your development board, run 'edge-impulse-run-impulse'
Pressione qualquer tecla para continuar. . .
```

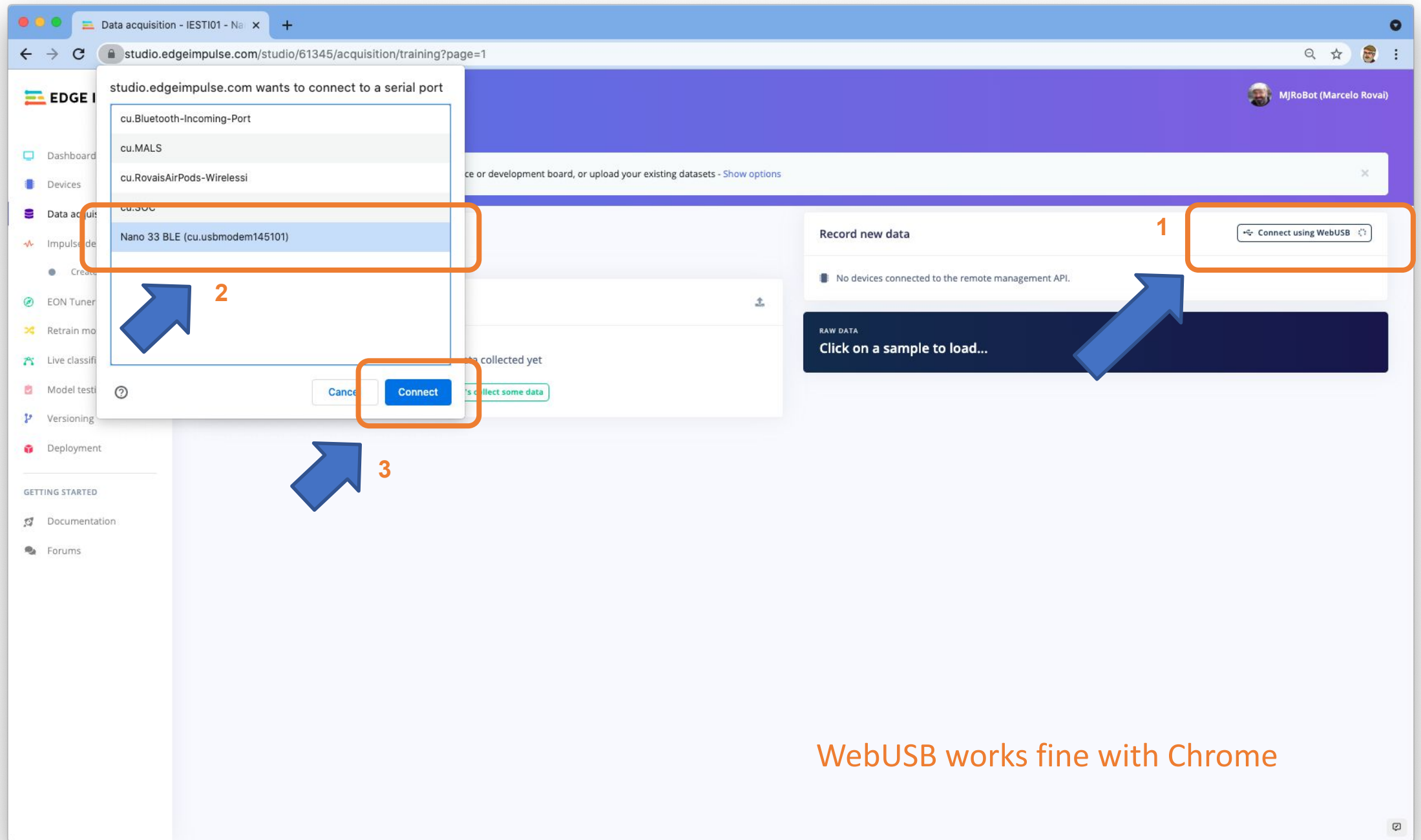
□ Nano-33 LED Stop Flashing

Hands-on lab for motion classification

Case Study: Mechanical Stresses in Transport







WebUSB works fine with Chrome

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Training data

Test data

Did you know? You can capture data from any device or development board, or upload your existing datasets - [Show options](#)

DATA COLLECTED

-

Collected data

No data collected yet

Let's collect some data

Record new data

Device

36:17:55:F9:70:F7

Label

terrestrial

Sample length (ms.)

10000

Sensor

Built-in accelerometer

Frequency

100Hz

Start sampling

RAW DATA

Click on a sample to load...

Devices - IEST101 - Nano Motion Classification

studio.edgeimpulse.com/studio/61345/devices

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MJRoBot (Marcelo Roval)

Your devices

+ Connect a new device

These are devices that are connected to the Edge Impulse remote management API, or have posted data to the ingestion SDK.

NAME	ID	TYPE	SENSORS	REMOTE M...	LAST SEEN
 36:17:55:F9:70:F7	36:17:55:F9:70:F7	ARDUINO_NANO33BLE	Built-in accelerometer, Built-in microph...		Today, 12:26:49

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Test data

Did you know? You can capture data from any device or development board, or upload your existing datasets - [Show options](#)

DATA COLLECTED

10s

TRAIN / TEST SPLIT

100% / 0%

Collected data

SAMPLE NAME	LABEL	ADDED	LENGTH
terrestrial.json.2jvbimlk	terrestrial	Today, 13:01:46	10s

Record new data

Connect using WebUSB

Device

Nano

Label

terrestrial

Sample length (ms.)

10000

Sensor

Sensor with 3 axes (accX, accY, accZ)

Frequency

100Hz

Start sampling

RAW DATA

terrestrial.json.2jvbimlk

20

15

10

5

0

-5

-10

-15

-20

0

1040

2080

3120

4160

5200

6240

7280

8320

9360

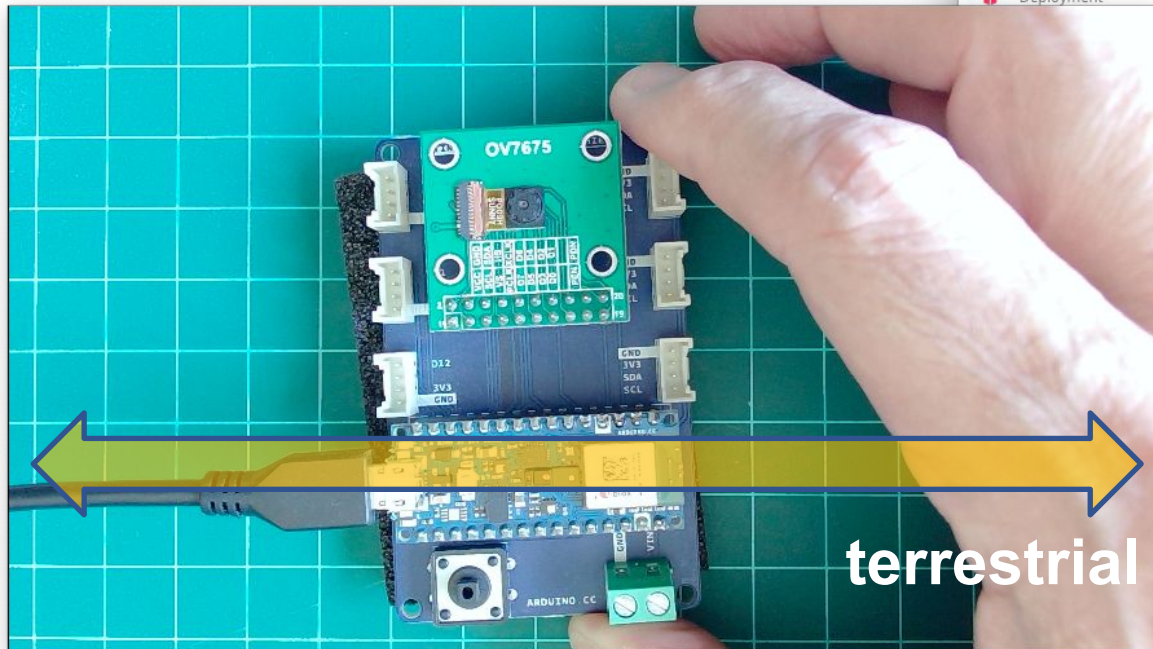
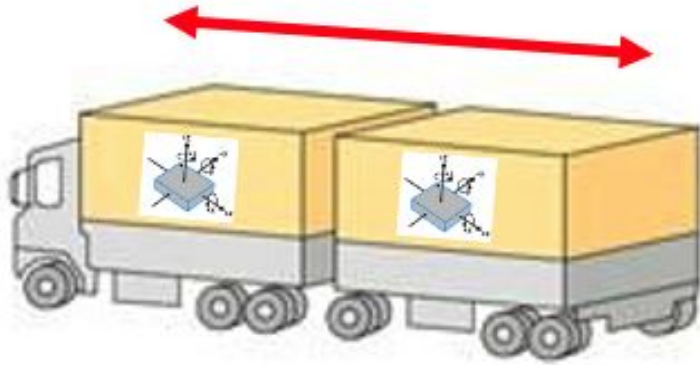
accX

accY

accZ

https://studio.edgeimpulse.com/studio/61345/acquisition/training?page=1#

Label: terrestrial



EDGE IMPULSE

DATA ACQUISITION (IESTI01 - NANO MOTION CLASSIFICATION)

Training data Test data

Did you know? You can capture data from any device or development board, or upload your existing datasets - [Show options](#)

DATA COLLECTED 1m 40s

TRAIN / TEST SPLIT 100% / 0%

Record new data [Connect using WebUSB](#)

Device Nano

Label terrestrial Sample length (ms.) 10000

Sensor Sensor with 3 axes (accX, accY, accZ) Frequency 100Hz

Start sampling

Collected data

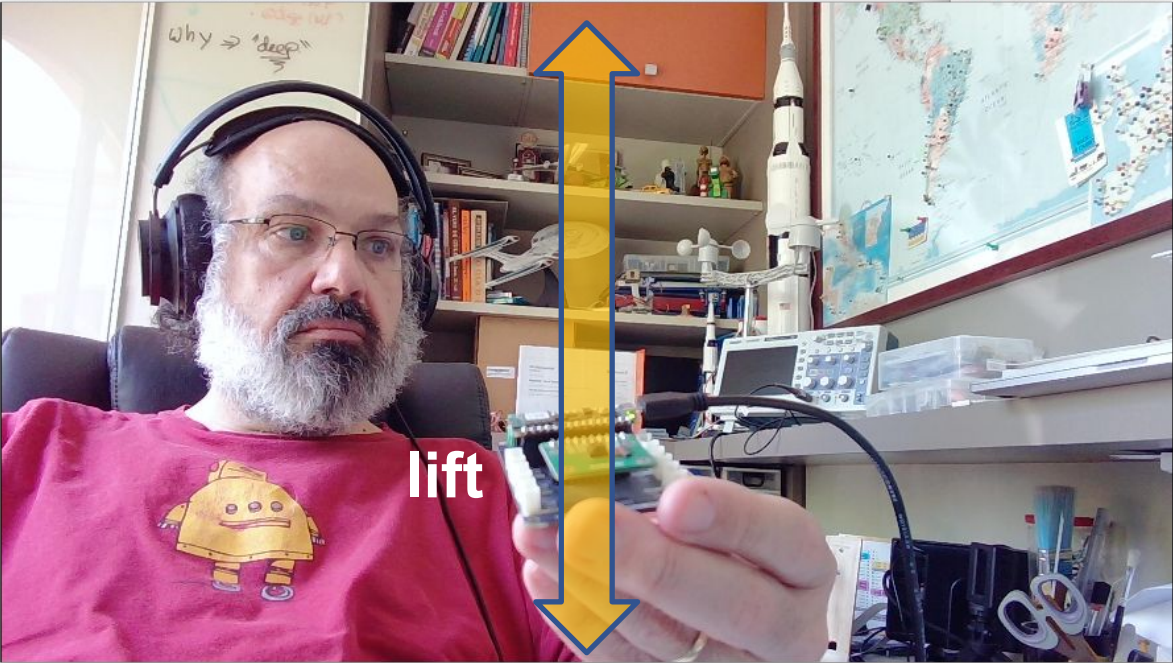
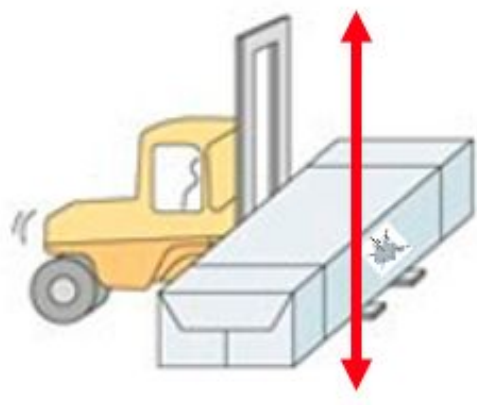
SAMPLE NAME	LABEL	ADDED	LENGTH
terrestrial.json.2jv...	terrestrial	Today, 14:26:56	10s
terrestrial.json.2jv...	terrestrial	Today, 14:26:29	10s
terrestrial.json.2jv...	terrestrial	Today, 14:26:06	10s
terrestrial.json.2jv...	terrestrial	Today, 14:25:48	10s
terrestrial.json.2jv...	terrestrial	Today, 14:25:29	10s
terrestrial.json.2jv...	terrestrial	Today, 14:25:04	10s
terrestrial.json.2jv...	terrestrial	Today, 14:24:45	10s
terrestrial.json.2jv...	terrestrial	Today, 14:24:21	10s
terrestrial.json.2jv...	terrestrial	Today, 14:17:45	10s
terrestrial.json.2jv...	terrestrial	Today, 13:01:46	10s

RAW DATA

terrestrial.json.2jvgelce

accX accY accZ

Label: LIFT



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Training dataTest data

Did you know? You can capture data from any device or development board, or upload your existing datasets - Show options

DATA COLLECTED
3m 20s

TRAIN / TEST SPLIT
100% / 0%

Collected data

SAMPLE NAME	LABEL	ADDED	LENGTH
lift.json.2jvhabt7	lift	Today, 14:42:04	10s
lift.json.2jvh9pe3	lift	Today, 14:41:45	10s
lift.json.2jvh96uh	lift	Today, 14:41:26	10s
lift.json.2jvh8j6q	lift	Today, 14:41:06	10s
lift.json.2jvh80rg	lift	Today, 14:40:47	10s
lift.json.2jvh7g2v	lift	Today, 14:40:30	10s
lift.json.2jvh6uqu	lift	Today, 14:40:12	10s
lift.json.2jvh6c6a	lift	Today, 14:39:53	10s
lift.json.2jvh5qbe	lift	Today, 14:39:35	10s
lift.json.2jvh55hs	lift	Today, 14:39:14	10s
terrestrial.json.2jv...	terrestrial	Today, 14:26:56	10s
terrestrial.json.2jv...	terrestrial	Today, 14:26:29	10s

Record new data

Connect using WebUSB

Device
Nano

Label
lift

Sample length (ms.)
10000

Sensor
Sensor with 3 axes (accX, accY, accZ)

Frequency
100Hz

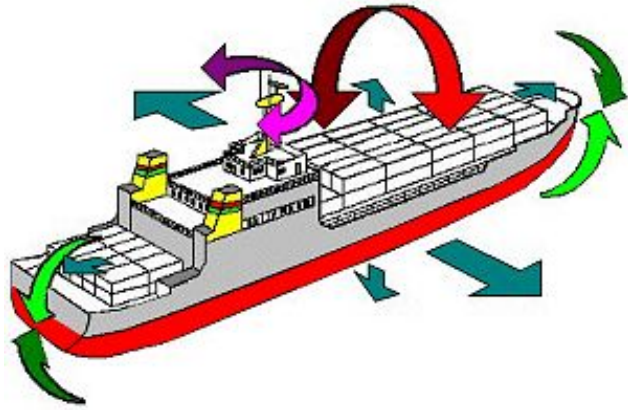
Start sampling

RAW DATA

lift.json.2jvhabt7

accXaccYaccZ

Label: maritime



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DATA ACQUISITION (IESTI01 - NANO MOTION CLASSIFICATION)

Training data Test data

Did you know? You can capture data from any device or development board, or upload your existing datasets - Show options

DATA COLLECTED 5m 0s

TRAIN / TEST SPLIT 100% / 0%

Record new data [Connect using WebUSB](#)

Device Nano

Label maritime

Sample length (ms.) 10000

Sensor Sensor with 3 axes (accX, accY, accZ)

Frequency 100Hz

Start sampling

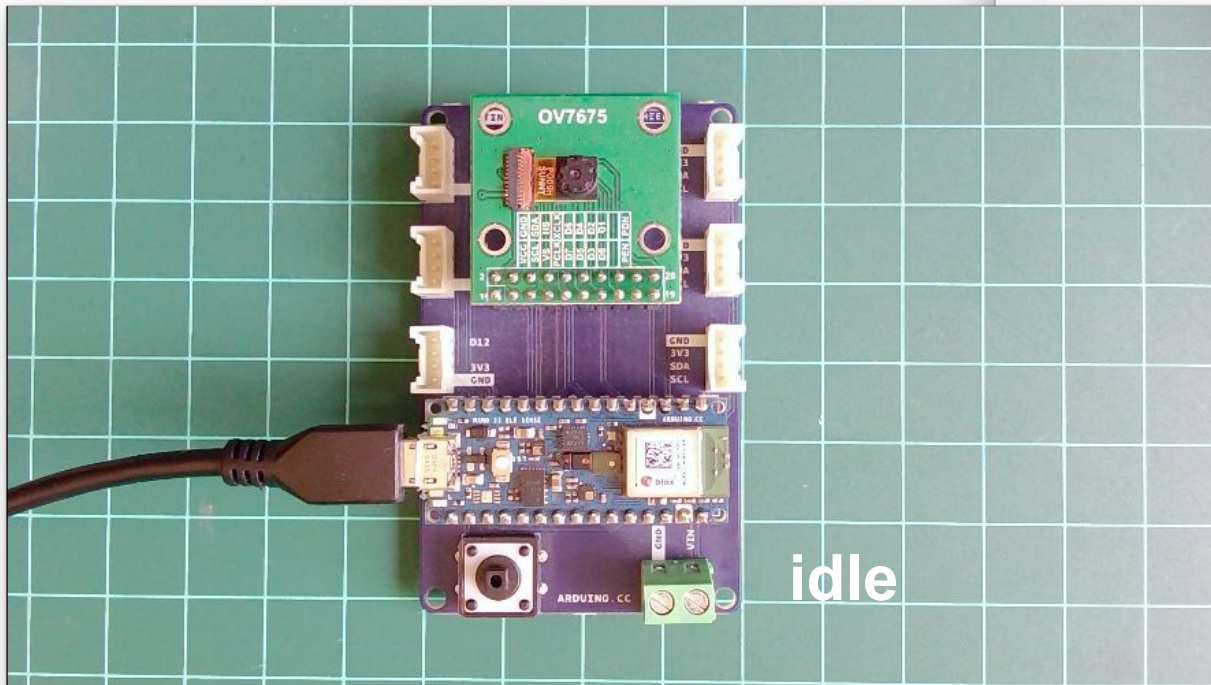
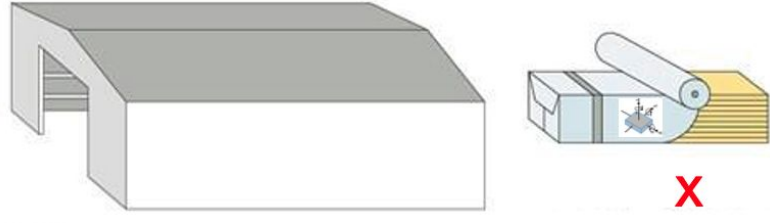
Collected data

SAMPLE NAME	LABEL	ADDED	LENGTH
maritime.json.2jvi6...	maritime	Today, 14:57:35	10s
maritime.json.2jvi6...	maritime	Today, 14:57:13	10s
maritime.json.2jvi5...	maritime	Today, 14:56:48	10s
maritime.json.2jvi4...	maritime	Today, 14:56:31	10s
maritime.json.2jvi4...	maritime	Today, 14:56:13	10s
maritime.json.2jvi3...	maritime	Today, 14:55:55	10s
maritime.json.2jvi3...	maritime	Today, 14:55:36	10s
maritime.json.2jvi2...	maritime	Today, 14:55:19	10s
maritime.json.2jvi2...	maritime	Today, 14:55:00	10s
maritime.json.2jvi1...	maritime	Today, 14:54:42	10s
lift.json.2jvhbt7	lift	Today, 14:42:04	10s
lift.json.2jvh9pe3	lift	Today, 14:41:45	10s

RAW DATA maritime.json.2jvi6p3r

accX accY accZ

Label: idle



EDGE IMPULSE

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DATA ACQUISITION (IESTI01 - NANO MOTION CLASSIFICATION)

Training data Test data

Did you know? You can capture data from any device or development board, or upload your existing datasets - [Show options](#)

DATA COLLECTED 6m 40s

TRAIN / TEST SPLIT 100% / 0%

Record new data [Connect using WebUSB](#)

Device Nano

Label idle Sample length (ms.) 100000

Sensor Sensor with 3 axes (accX, accY, accZ) Frequency 100Hz

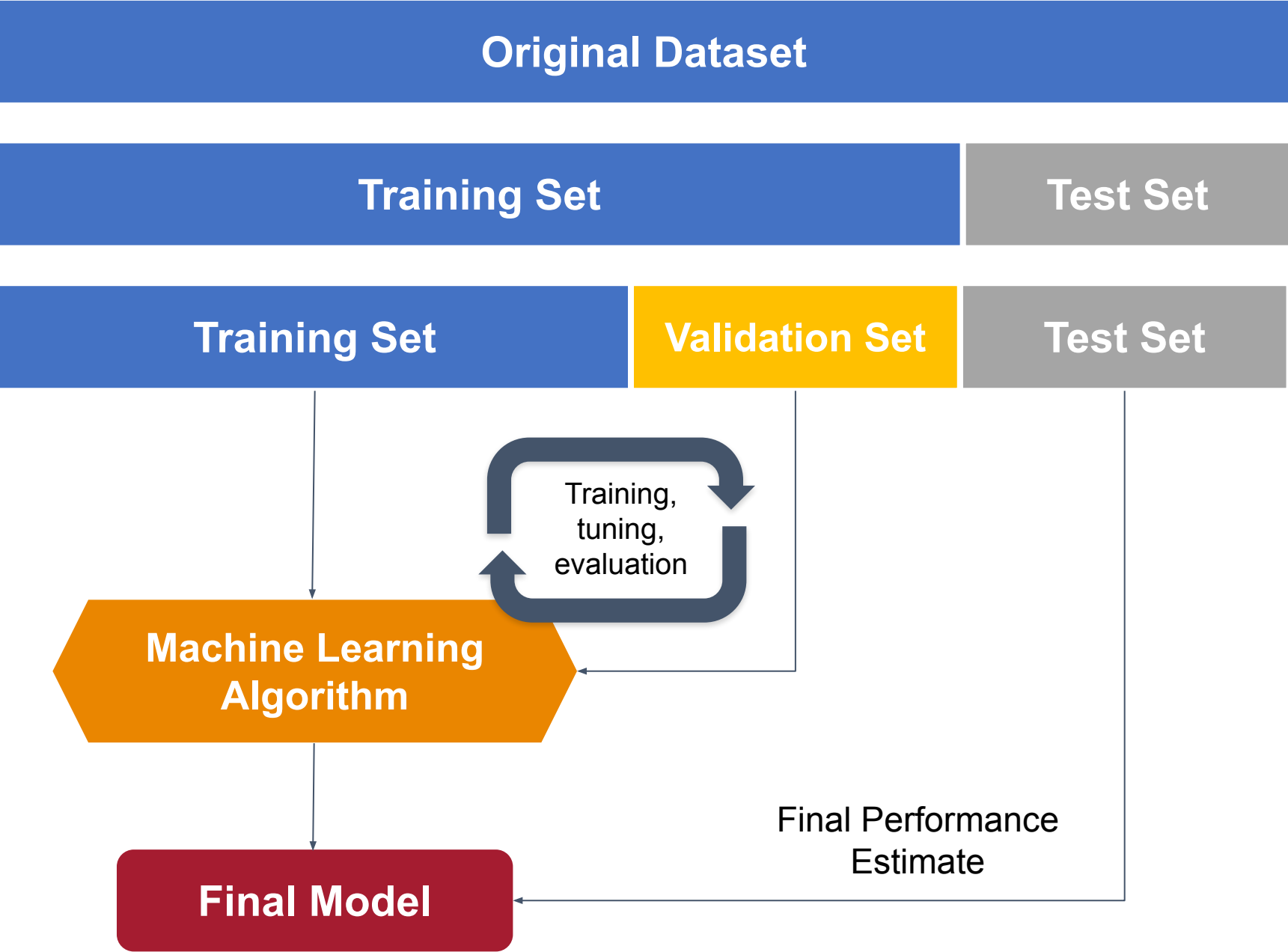
Start sampling

Collected data

SAMPLE NAME	LABEL	ADDED	LENGTH
idle.json.2jvimf14	idle	Today, 15:06:09	1m 40s
maritime.json.2jvi6...	maritime	Today, 14:57:35	10s
maritime.json.2jvi6...	maritime	Today, 14:57:13	10s
maritime.json.2jvi5...	maritime	Today, 14:56:48	10s
maritime.json.2jvi4...	maritime	Today, 14:56:31	10s
maritime.json.2jvi4...	maritime	Today, 14:56:13	10s
maritime.json.2jvi3...	maritime	Today, 14:55:55	10s
maritime.json.2jvi3...	maritime	Today, 14:55:36	10s
maritime.json.2jvi2...	maritime	Today, 14:55:19	10s
maritime.json.2jvi2...	maritime	Today, 14:55:00	10s
maritime.json.2jvi1...	maritime	Today, 14:54:42	10s
lift.json.2jvhabt7	lift	Today, 14:42:04	10s

RAW DATA idle.json.2jvimf14

accX accY accZ



Dashboard - IESTI01 - Nano M x +

studio.edgeimpulse.com/studio/61345

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Download block output

No downloads available yet

Performance settings

Use GPU for training ☐

Parallel DSP jobs

Job limit in minutes

DSP file size limit (MB)

Administrative zone

☐ Show Linux deploy options ?

Save experiments

Danger zone

Perform train / test split

Delete this project

Delete all data in this project

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Dashboard - IESTI01 - Nano M x +

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Download block output

No downloads available yet

Performance settings

Use GPU for training ☐

Parallel DSP jobs

Job limit in minutes

DSP file size limit (MB)

Administrative zone

☐ Show Linux deploy options ?

Save experiments

Danger zone

Performing split...

Delete this project

Delete all data in this project

Project info

Project ID 61345

Labeling method One label per da

Latency calculations Cortex-M4F 80M

Perform train / test split

Are you sure you want to rebalance your dataset? This splits all your data automatically between the training and testing set, and resets the categories for all data. This is irrevocable!

Cancel **Yes, perform the train / test split**

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Edge Impulse Studio interface for Data Acquisition - Testing. The interface shows a sidebar with navigation options: Dashboard, Devices, Data acquisition (highlighted), Impulse design, Create impulse, EON Tuner, Retrain model, Live classification, Model testing, Versioning, and Deployment. The main content area displays the 'DATA ACQUISITION - TESTING' page, which includes a 'Training data' tab and a 'Test data' tab. A notification banner states: 'Did you know? You can capture data from any device or development board, or upload your existing datasets - Show options'. The 'DATA COLLECTED' section shows 40s of data. The 'TRAIN / TEST SPLIT' section shows 90% / 10% split. The 'Record new data' section includes a 'Device' dropdown (Nano), a 'Label' input (idle), a 'Sample length (ms.)' input (100000), a 'Sensor' dropdown (Sensor with 3 axes (accX, accY, accZ)), and a 'Frequency' dropdown (100Hz). A 'Start sampling' button is present. The 'Collected data' table lists samples with columns: SAMPLE NAME, LABEL, ADDED, and LENGTH.

SAMPLE NAME	LABEL	ADDED	LENGTH
maritime.json.2jvi4...	maritime	Today, 14:56:13	10s
maritime.json.2jvi1...	maritime	Today, 14:54:42	10s
lift.json.2jvh6uqu	lift	Today, 14:40:12	10s
terrestrial.json.2jv...	terrestrial	Today, 13:01:46	10s

RAW DATA
Click on a sample to load...

If automatic split is not good, proceed with manual split

EDGE IMPULSE

DATA ACQUISITION - TESTING (IEE... ON CLASSIFICATION)

Training data Test data

Did you know? You can capture data from any device or development board, or upload your existing datasets - Show options

DATA COLLECTED 1m 20s

TRAIN / TEST SPLIT 80% / 20%

Record new data

Device Nano

Label idle

Sample length (ms.) 20000

Sensor Sensor with 3 axes (accX, accY, accZ)

Frequency 100Hz

Start sampling

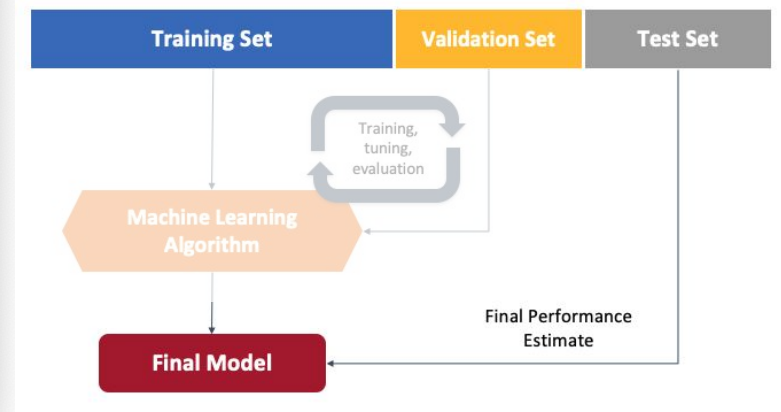
Collected data

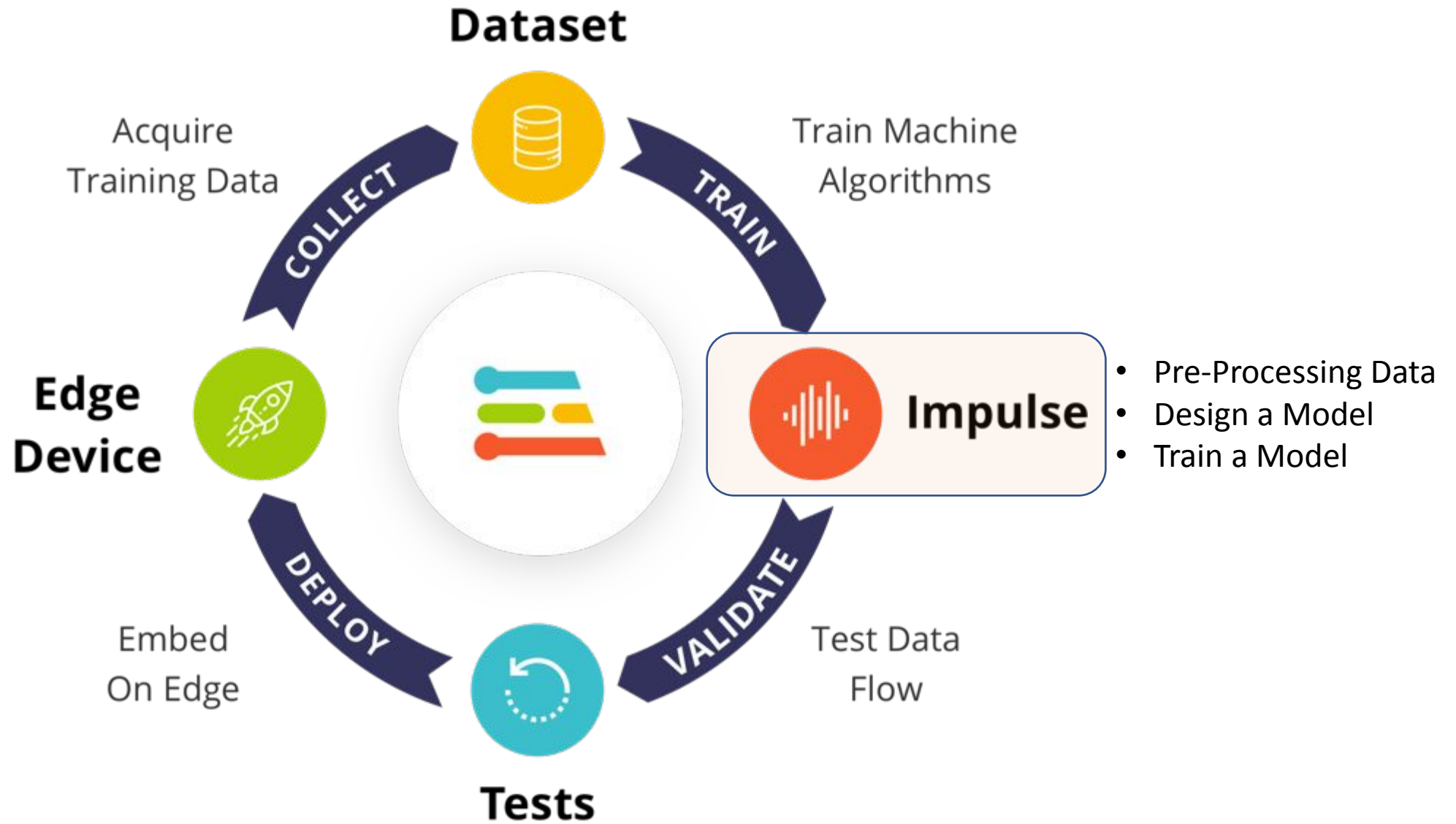
SAMPLE NAME	LABEL	ADDED	LENGTH
terrestrial.json.2jv...	terrestrial	Today, 15:23:49	10s
lift.json.2jvhbt7	lift	Today, 15:23:38	10s
idle.json.2jvjlvon	idle	Today, 15:23:22	20s
maritime.json.2jvi4...	maritime	Today, 14:56:13	10s
maritime.json.2jvi1...	maritime	Today, 14:54:42	10s
lift.json.2jvh6uqu	lift	Today, 14:40:12	10s
terrestrial.json.2jv...	terrestrial	Today, 13:01:46	10s

RAW DATA

Click on a sample to load...

Dataset is balanced (has representative samples from all classes) and split 80%/20%





Time series data

accX, accY, accZ

Window size2000 ms.

Window increase80 ms.

Frequency (Hz)62.5

Zero-pad data

Spectral Analysis

Spectral Analysis

accXaccYaccZ

Neural Network (Keras)

Neural Network (Keras)

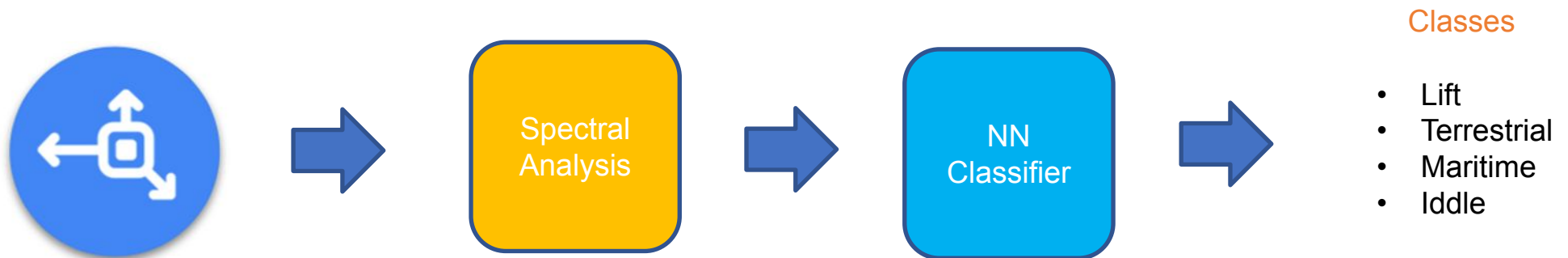
Spectral Analysis

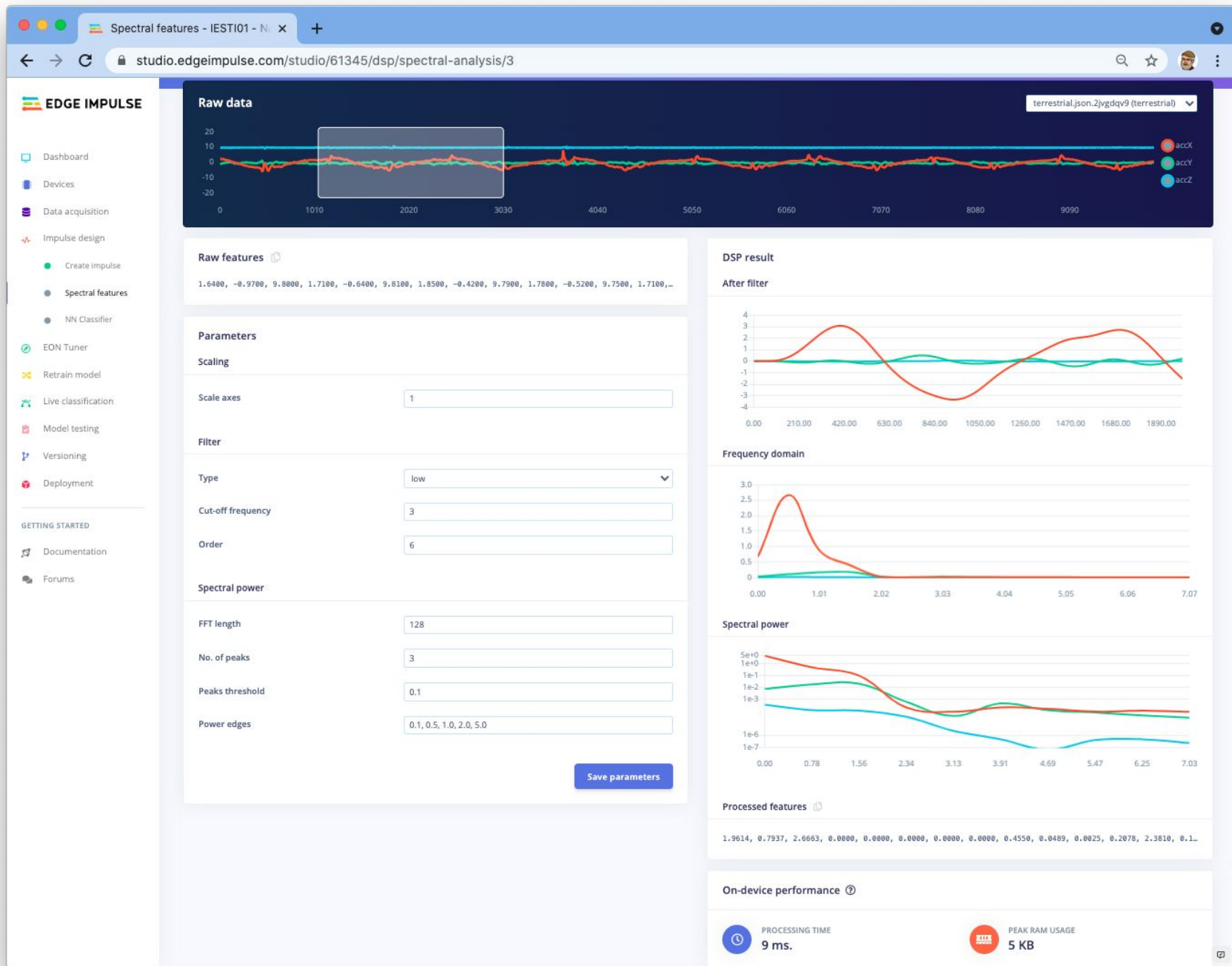
4 (idle, lift, maritime, terrestrial)

Output features

4 (idle, lift, maritime, terrestrial)

Save Impulse





Raw data

terrestrial.json.2jvgdv9 (terrestrial)

accX

accY

accZ

20
10
0
-10
-20

0 1010 2020 3030 4040 5050 6060 7070 8080 9090

Raw features

1.6400, -0.9700, 9.8000, 1.7100, -0.6400, 9.8100, 1.8500, -0.4200, 9.7900, 1.7800, -0.5200, 9.7500, 1.7100,...

Parameters

Scaling

Scale axes

1

Filter

Type

low

Cut-off frequency

3

Order

6

Spectral power

FFT length

128

No. of peaks

3

Peaks threshold

0.1

Power edges

0.1, 0.5, 1.0, 2.0, 5.0

Save parameters

DSP result

After filter

4
3
2
1
0
-1
-2
-3
-4

0.00 210.00 420.00 630.00 840.00 1050.00 1260.00 1470.00 1680.00 1890.00

Frequency domain

3.0
2.5
2.0
1.5
1.0
0.5
0

0.00 1.01 2.02 3.03 4.04 5.05 6.06 7.07

Spectral power

5e+0
1e+0
1e-1
1e-2
1e-3
1e-6
1e-7

0.00 0.78 1.56 2.34 3.13 3.91 4.69 5.47 6.25 7.03

Processed features

1.9614, 0.7937, 2.6663, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.4550, 0.0489, 0.0025, 0.2078, 2.3810, 0.1...

On-device performance

PROCESSING TIME

9 ms.

PEAK RAM USAGE

5 KB

Neural Network settings

Training settings

Number of training cycles ?

30

Learning rate ?

0.0005

Neural network architecture

Input layer (33 features)

Dense layer (20 neurons)

Dense layer (10 neurons)

Add an extra layer

Output layer (4 classes)

Start training

Model

Model version: ? Quantized (int8) ▼

Last training performance (validation set)

ACCURACY
99.9%

LOSS
0.01

Confusion matrix (validation set)

	IDLE	LIFT	MARITIME	TERRESTRIAL
IDLE	100%	0%	0%	0%
LIFT	0%	99.4%	0.6%	0%
MARITIME	0%	0%	100%	0%
TERRESTRIAL	0%	0%	0%	100%
F1 SCORE	1.00	1.00	1.00	1.00

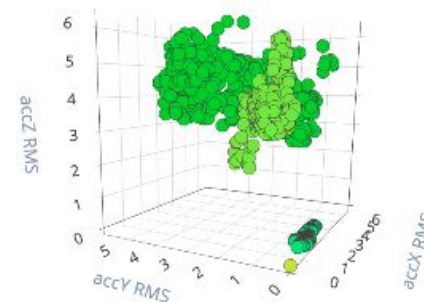
Feature explorer (full training set) ?

accX RMS ▼

accY RMS ▼

accZ RMS ▼

- idle - correct
- lift - correct
- maritime - correct
- terrestrial - correct
- lift - incorrect

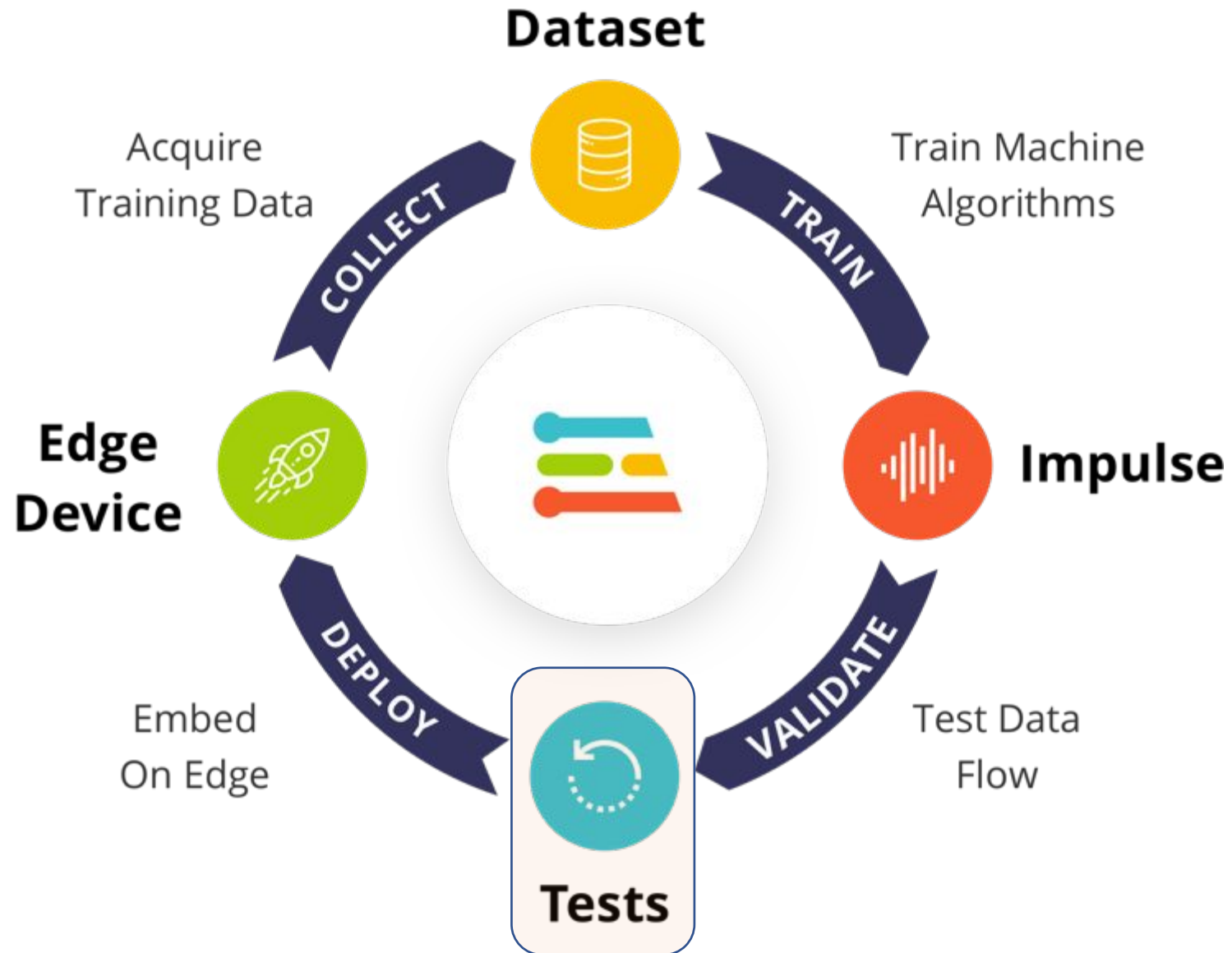


On-device performance ?

INFERRING TIME
1 ms.

PEAK RAM USAGE
1.7K

FLASH USAGE
19.0K



- Pre-Processing Data
- Design a Model
- Train a Model

Model testing - IESTI01 - Nano

studio.edgeimpulse.com/studio/61345/validation

EDGE IMPULSE

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- Create impulse
- Spectral features
- NN Classifier

EON Tuner

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Test data

Classify all

Set the 'expected outcome' for each sample to the desired outcome to automatically score the impulse.

SAMPLE NAME	EXPECTED OUTCOME	LENGTH	ACCURACY	RESULT
terrestrial.json.2...	terrestrial	10s	100%	101 terrestrial
lift.json.2jvhbt7	lift	10s	100%	101 lift
idle.json.2jvjlvon	idle	20s	100%	226 idle
maritime.json.2j...	maritime	10s	100%	101 maritime
maritime.json.2j...	maritime	10s	100%	101 maritime
lift.json.2jvh6uqu	lift	10s	100%	101 lift
terrestrial.json.2...	terrestrial	10s	100%	101 terrestrial

Model testing output

Classifying data for NN Classifier...

Copying features from processing blocks...

Copying features from DSP block...

Copying features from DSP block OK

Copying features from processing blocks OK

Classifying data for float32 model...

Scheduling job in cluster...

Job started

Classifying data for NN Classifier OK

Job completed

Model testing results

%

ACCURACY

100.00%

	IDLE	LIFT	MARITIME	TERRESTRIAL	UNCERTAIN
IDLE	100%	0%	0%	0%	0%
LIFT	0%	100%	0%	0%	0%
MARITIME	0%	0%	100%	0%	0%
TERRESTRIAL	0%	0%	0%	100%	0%
F1 SCORE	1.00	1.00	1.00	1.00	

Feature explorer

accX RMS

accY RMS

accZ RMS

idle - correct

lift - correct

maritime - correct

terrestrial - correct

3D scatter plot showing accuracy (accX RMS, accY RMS, accZ RMS) for different classes (idle, lift, maritime, terrestrial) and their correctness status (correct).

Training Set

Validation Set

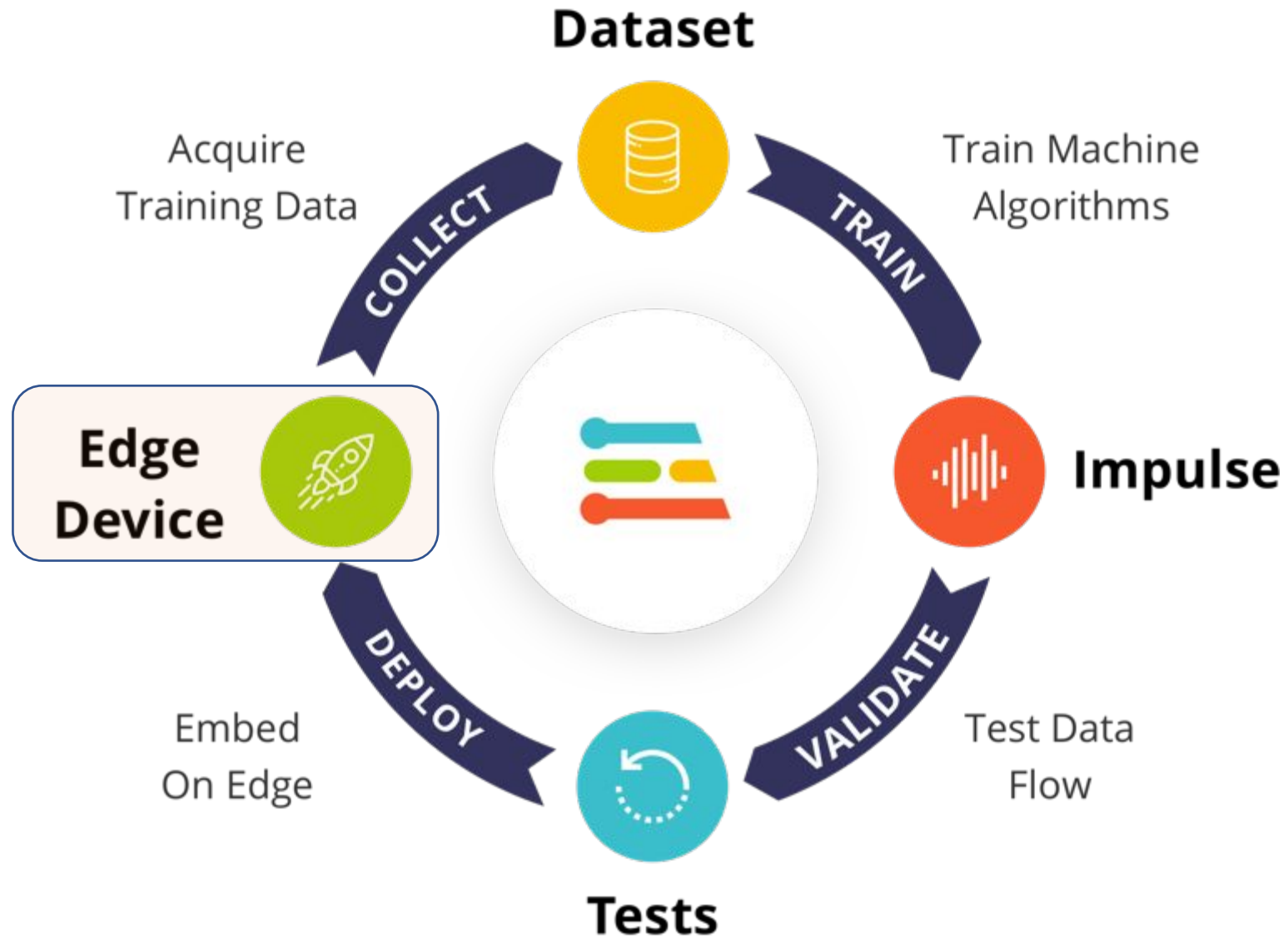
Test Set

Machine Learning Algorithm

Final Model

Training, tuning, evaluation

Final Performance Estimate



- Pre-Processing Data
- Design a Model
- Train a Model

Deployment - IESTI01 - Nano

studio.edgeimpulse.com/studio/61345/deployment

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DEPLOYMENT (IESTI01 - NANO MOTION CLASSIFICATION)

MJRoBot (Marcelo Rovai)

Deploy your impulse

You can deploy your impulse to any device. This makes the model run without an internet connection, minimizes latency, and runs with minimal power consumption. [Read more.](#)

Create library

Turn your impulse into optimized source code that you can run on any device.

C++ library

Arduino library

Cube.MX CMSIS-PACK

WebAssembly

TensorRT library

Build firmware

Or get a ready-to-go binary for your development board that includes your impulse.

ST IoT Discovery Kit

Arduino Nano 33 BLE Sense

Eta Compute ECM3532 AI Sensor

SilLabs Thunderboard Sense 2

Himax WE-I Plus

Nordic nRF52840 DK + IKS02A1

Nordic nRF5340 DK + IKS02A1

Nordic nRF9160 DK + IKS02A1

Nordic Thingy:91

Build output

Creating job... OK (ID: 1646786)

Writing templates...
Writing templates OK

Copying Edge Impulse SDK...
Copying Edge Impulse SDK OK

Compiling EON model...
Compiling EON model OK

Removing clutter and updating headers...
Removing clutter and updating headers OK

Creating archive...
Job started
Creating archive OK

Job completed

ei-iesti01---nano....zip

Show All

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SilLabs Thunderboard Sense 2

Himax WE-I Plus

Nordic nRF52840 DK + IKS02A1

Nordic nRF5340 DK + IKS02A1

Nordic nRF9160 DK + IKS02A1

Nordic Thingy:91

Sony's Spresense

Select optimizations (optional)

Model optimizations can increase on-device inference performance. Choose from recommended choices for your target. Click on a choice to learn more.

Enable EON™ Compiler

Same accuracy, up to 50% less RAM usage

Available optimizations for NN Classifier

Quantized (int8) ★

Currently selected

This optimization is recommended for best performance.

Unoptimized (float32)

Click to select

RAM USAGE

1.8K

FLASH USAGE

21.3K

LATENCY

1 ms

ACCURACY

100%

CONFUSION MATRIX

100	0	0	0	0	0
0	100	0	0	0	0
0	0	100	0	0	0
0	0	0	100	0	0

Estimate for Cortex-M4F 80MHz

Build

Build output

Creating job... OK (ID: 1646786)

Writing templates...
Writing templates OK

Copying Edge Impulse SDK...
Copying Edge Impulse SDK OK

Compiling EON model...
Compiling EON model OK

Removing clutter and updating headers...
Removing clutter and updating headers OK

Creating archive...
Creating archive OK

ei-iesti01---nano....zip

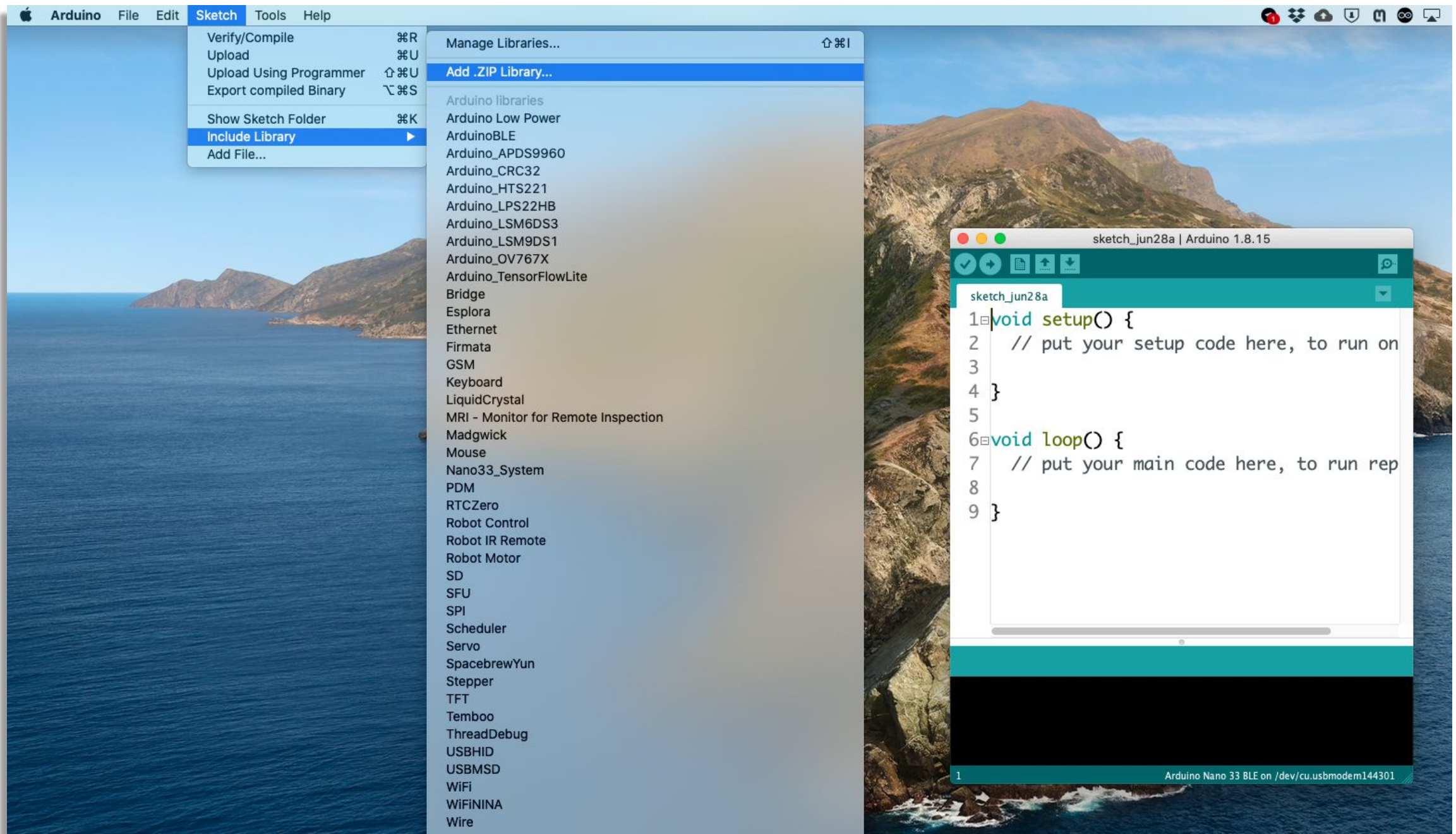
Show All

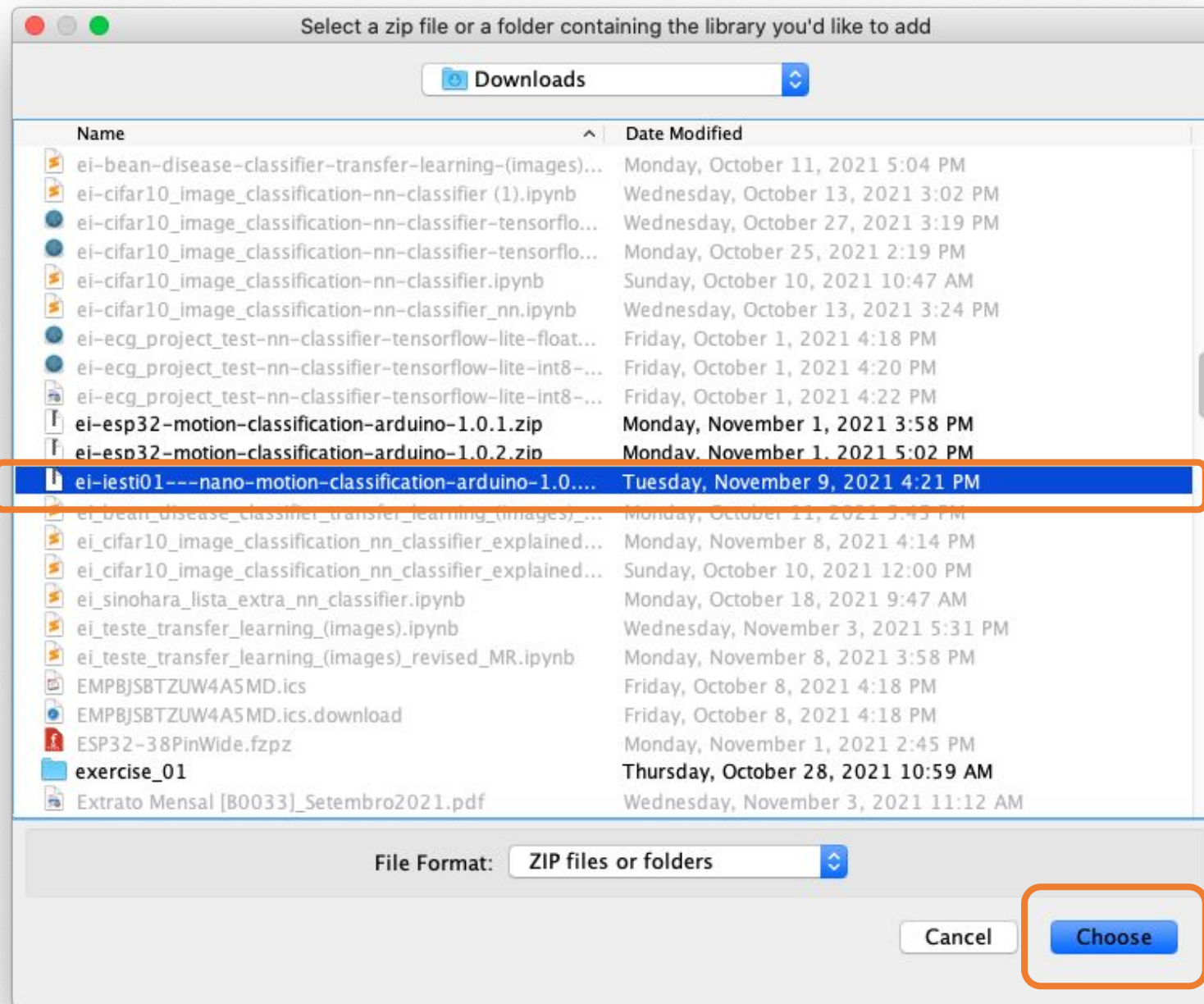
✓

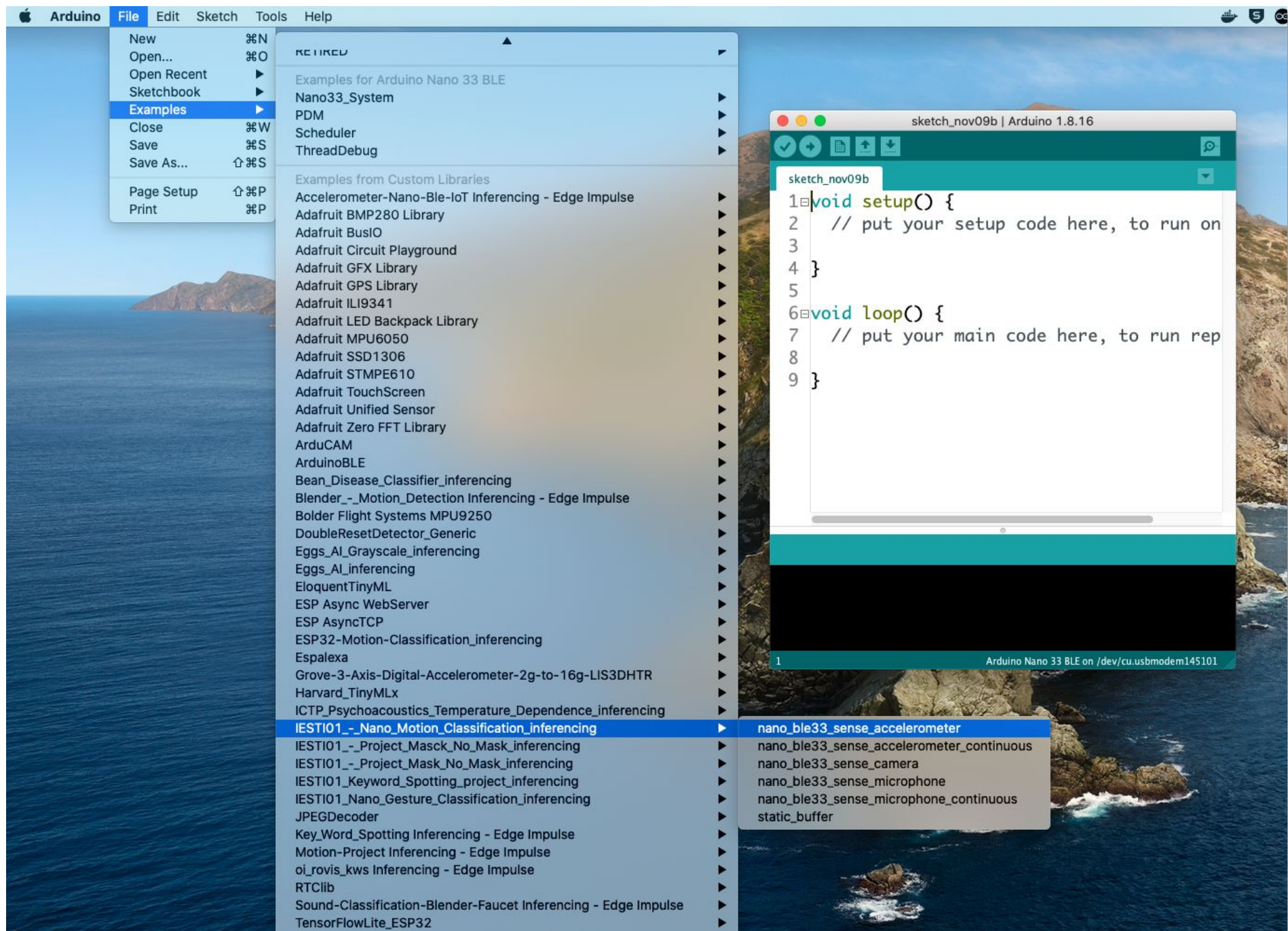
Built Arduino library

Add this library through the Arduino IDE via:
Sketch > Include Library > Add .ZIP Library...

Examples can then be found under:
File > Examples > IESTI01_-_Nano_Motion_Classification_inferencing







Model Inference

Arduino File Edit Sketch Tools Help

/dev/cu.usbmodem145101

Send

Sampling...

Predictions (DSP: 20 ms., Classification: 0 ms., Anomaly: 0 ms.):

idle: 0.00000

lift: 0.00000

maritime: 0.00000

terrestrial: 0.99609

Starting inferencing in 2 seconds...

Sampling...

Predictions (DSP: 20 ms., Classification: 1 ms., Anomaly: 0 ms.):

idle: 0.00000

lift: 0.00000

maritime: 0.00000

terrestrial: 0.99609

Starting inferencing in 2 seconds...

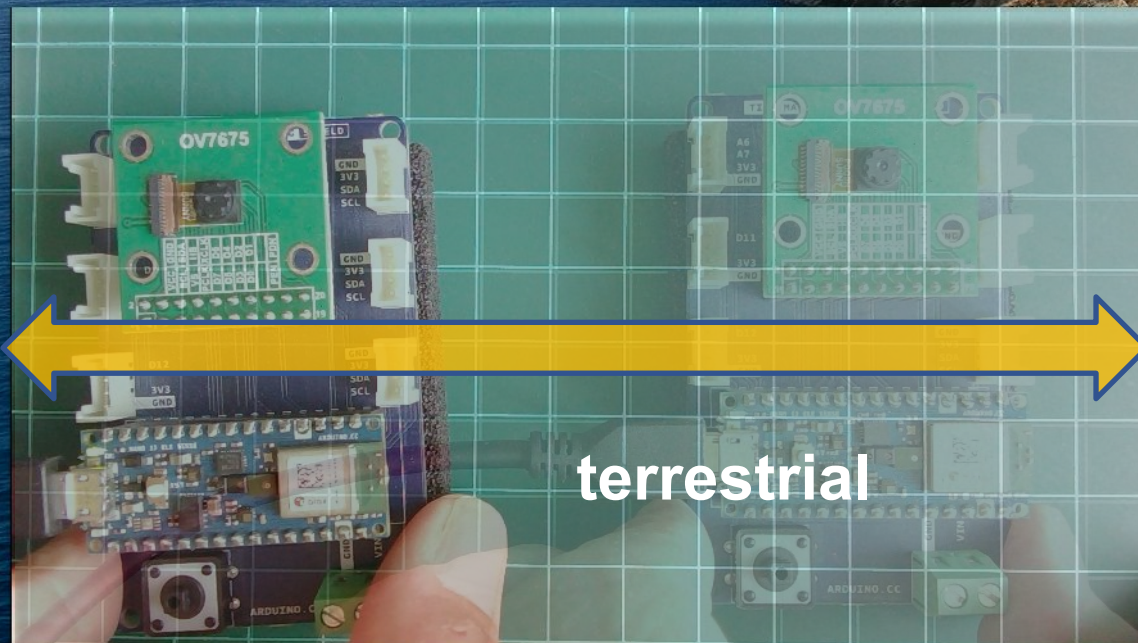
☒ Autoscroll ☐ Show timestamp

Both NL & CR 115200 baud Clear output

nano_ble33_sense_accelerometer | Arduino 1.8.16

nano_ble33_sense_accelerometer

```
1/* Edge Impulse Arduino examples
2 * Copyright (c) 2021 EdgeImpulse Inc.
3 *
4 * Permission is hereby granted, free of charge, to any person obtaining a copy
5 * of this software and associated documentation files (the "Software"), to use,
6 * in the Software without restriction, including without limitation the rights
7 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
8 * copies of the Software, and to permit persons to whom the Software is
9 * furnished to do so, subject to the following conditions:
10 *
11 * The above copyright notice and this permission notice shall be included in
12 * all copies or substantial portions of the Software.
13 *
14 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS OR
15 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
16 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL THE
17 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
18 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING FROM
19 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN
20 * THE SOFTWARE.
21 */
22
23 /* Includes -----
24 #include <IESTI01_-_Nano_Motion_Classification_inferencing.h>
25 #include <Arduino_LSM9DS1.h>
26
27 /* Constant defines -----
28 #define CONVERT_G_TO_MS2 9.80665f
29
30 /* Private variables -----
31 static bool debug_nn = false; // Set this to true to see e.g. features generated
32
33 Done in 6.027 seconds
34 reset()
35
36 Arduino Nano 33 BLE on /dev/cu.usbmodem145101
```



/dev/cu.usbmodem145101

Send

```

Predictions (DSP: 29 ms., Classification: 0 ms., Anomaly: 0 ms.): terrestrial [ 0, 0, 0, 10, 0, 0,
Predictions (DSP: 29 ms., Classification: 0 ms., Anomaly: 0 ms.): terrestrial [ 0, 0, 0, 10, 0, 0,
Predictions (DSP: 29 ms., Classification: 0 ms., Anomaly: 0 ms.): terrestrial [ 0, 0, 0, 10, 0, 0,
Predictions (DSP: 29 ms., Classification: 0 ms., Anomaly: 0 ms.): terrestrial [ 0, 0, 0, 10, 0, 0,
Predictions (DSP: 29 ms., Classification: 0 ms., Anomaly: 0 ms.): terrestrial [ 0, 0, 0, 10, 0, 0,
Predictions (DSP: 29 ms., Classification: 0 ms., Anomaly: 0 ms.): terrestrial [ 0, 0, 0, 10, 0, 0,
Predictions (DSP: 29 ms., Classification: 0 ms., Anomaly: 0 ms.): terrestrial [ 0, 0, 0, 10, 0, 0,
Predictions (DSP: 29 ms., Classification: 0 ms., Anomaly: 0 ms.): terrestrial [ 0, 0, 0, 10, 0, 0,
Predictions (DSP: 27 ms., Classification: 0 ms., Anomaly: 0 ms.): terrestrial [ 0, 0, 0, 10, 0, 0,
Predictions (DSP: 27 ms., Classification: 0 ms., Anomaly: 0 ms.): terrestrial [ 0, 0, 0, 10, 0, 0,
Predictions (DSP: 27 ms., Classification: 0 ms., Anomaly: 0 ms.): terrestrial [ 0, 0, 0, 10, 0, 0,
Predictions (DSP: 29 ms., Classification: 0 ms., Anomaly: 0 ms.): terrestrial [ 0, 0, 0, 10, 0, 0,
Predictions (DSP: 29 ms., Classification: 0 ms., Anomaly: 0 ms.): terrestrial [ 0, 0, 0, 10, 0, 0,

```

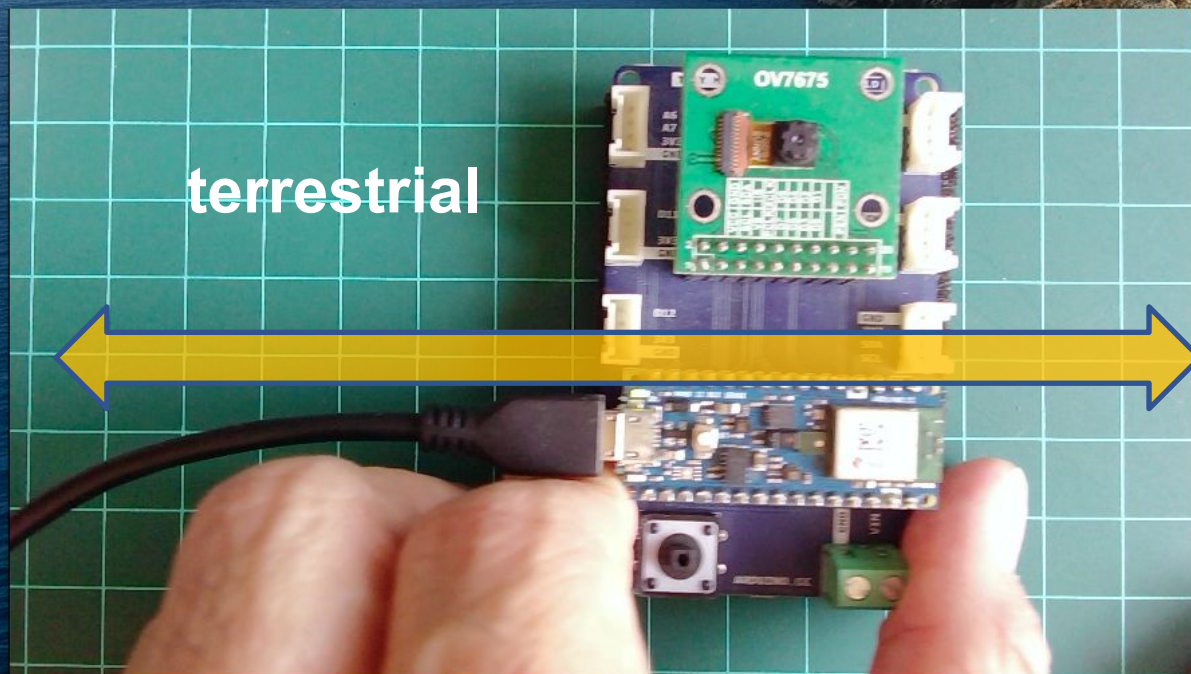
☒ Autoscroll
 ☐ Show timestamp

Both NL & CR

115200 baud

Clear output

terrestrial



nano_ble33_sense_accelerometer_continuous | Arduino 1.8.16

nano_ble33_sense_accelerometer_continuous

```

22
23 /* Includes -----
24 #include <IESTI01_-_Nano_Motion_Classification_inferencing.h>
25 #include <Arduino_LSM9DS1.h>
26
27 /* Constant defines -----
28 #define CONVERT_G_TO_MS2    9.80665f
29
30 /* Private variables -----
31 static bool debug_nn = false; // Set this to true to see e.g. features
32 static uint32_t run_inference_every_ms = 200;
33 static rtos::Thread inference_thread(osPriorityLow);
34 static float buffer[EI_CLASSIFIER_DSP_INPUT_FRAME_SIZE] = { 0 };
35 static float inference_buffer[EI_CLASSIFIER_DSP_INPUT_FRAME_SIZE];
36
37 /* Forward declaration */
38 void run_inference_background();
39
40 /**
41  * @brief    Arduino setup function
42  */
43 void setup()
44 {
45     // put your setup code here, to run once:
46     Serial.begin(115200);
47     Serial.println("Edge Impulse Inferencing Demo");
48
49     if (!IMU.begin()) {
50         ei_printf("Failed to initialize IMU!\r\n");
51     }
52     else {
53         ei_printf("IMU initialized\r\n");
54     }
55 }

```

Done uploading.

 Done in 6.034 seconds
 reset()

TinyML motion classification uses
on Real Life

Cow Monitoring

Using the Internet of Things for Agricultural Monitoring

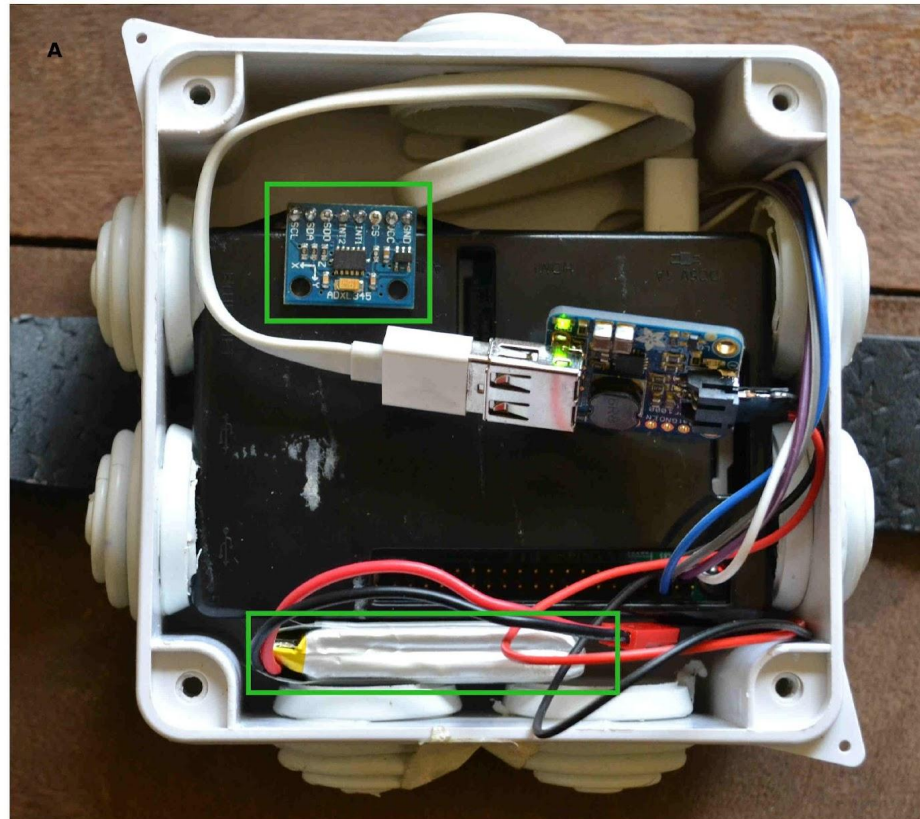
“We aim to deploy a variety of sensors for agricultural monitoring. One of the projects involves using **accelerometer sensors** to monitor activity levels in dairy cows with a view to determining when the cows are on heat or when they are sick.”



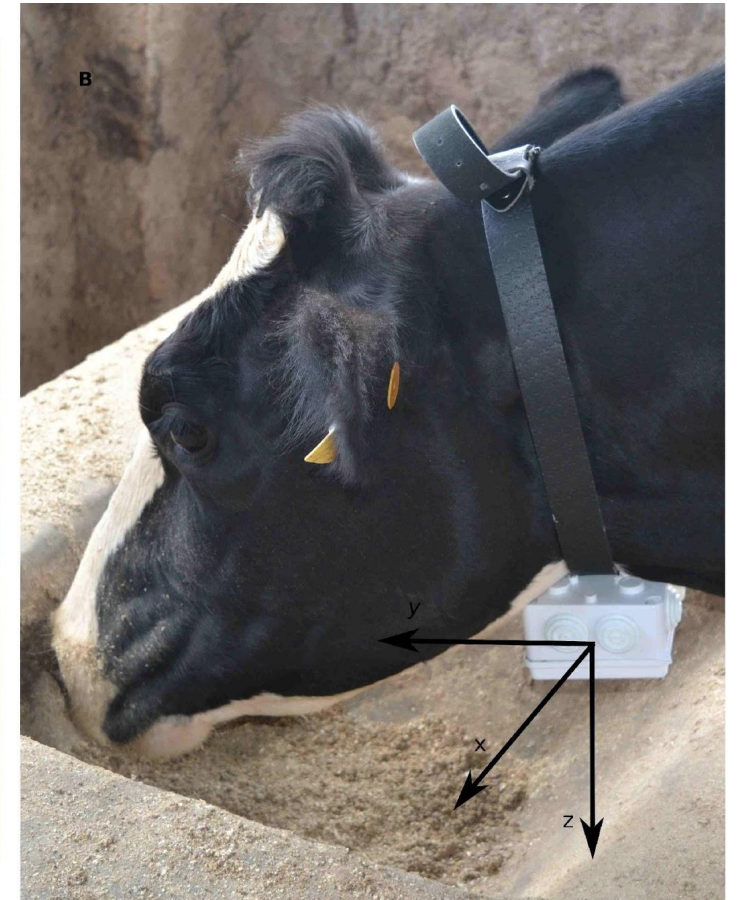
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Senior Lecturer
Department of Electrical and Electronic Engineering
Dedan Kimathi University of Technology
Nyeri Kenya
Email: ciira.maina@dkut.ac.ke

Kenia



<https://sites.google.com/site/cwamainadekut/research>



Predict and classify common Elephant behavior



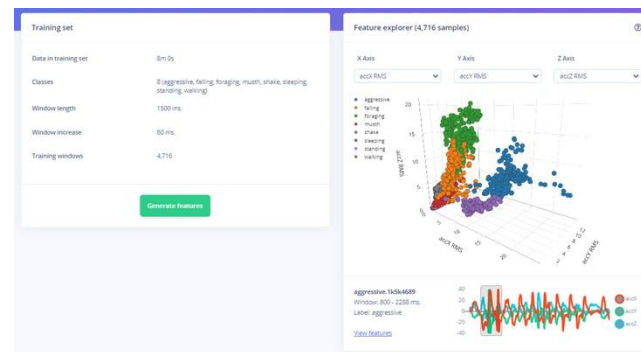
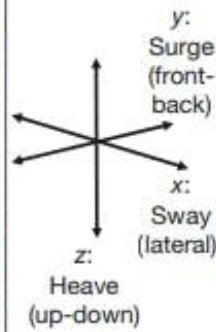
Aggressive



Standing



Sleeping



https://www.hackster.io/dhruvsheth_/eletect-tinyml-and-iot-based-smart-wildlife-tracker-c03e5a#toc-accelerometer-data-models-4

Addendum:

Using Edge Impulse CLI

DOCUMENTATION

[Getting Started](#)[API and SDK references](#)[What is embedded ML, anyway?](#)[Frequently asked questions](#)

DEVELOPMENT BOARDS

[Overview](#)[ST B-L475E-IOT01A](#)[Arduino Nano 33 BLE Sense](#)[Eta Compute ECM3532 AI Sensor](#)[Eta Compute ECM3532 AI Vision](#)[OpenMV Cam H7 Plus](#)[Himax WE-I Plus](#)[Nordic Semi nRF52840 DK](#)[Nordic Semi nRF5340 DK](#)[SiLabs Thunderboard Sense 2](#)[Sony's Spresense](#)[Arduino Portenta H7 + Vision shield \(preview\)](#)[Raspberry Pi 4](#)[NVIDIA Jetson Nano](#)[Mobile phone](#)[Porting guide](#)

COMMUNITY BOARDS

[Seeed Wio Terminal](#)[Agora Product Development Kit](#)

EDGE IMPULSE FOR LINUX

Installation

Edge Impulse CLI optional Installation

This Edge Impulse CLI is used to control local devices, act as a proxy to synchronise data for devices that don't have an internet connection, and to upload and convert local files. The CLI consists of seven tools:

- [edge-impulse-daemon](#) - configures devices over serial, and acts as a proxy for devices that do not have an IP connection.
- [edge-impulse-uploader](#) - allows uploading and signing local files.
- [edge-impulse-data-forwarder](#) - a very easy way to collect data from any device over a serial connection, and forward the data to Edge Impulse.
- [edge-impulse-run-impulse](#) - show the impulse running on your device.
- [edge-impulse-blocks](#) - create organizational transformation blocks.
- [eta-flash-tool](#) - to flash the Eta Compute ECM3532 AI Sensor.
- [himax-flash-tool](#) - to flash the Himax WE-I Plus.

Connect to devices without the CLI? Recent versions of Google Chrome and Microsoft Edge can connect directly to fully-supported development boards, without the CLI. See [this blog post](#) for more information.

Installation - macOS and Windows

1. Install [Python 3](#) on your host computer.
2. Install [Node.js](#) v14 or higher on your host computer.
 - For Windows users, install the **Additional Node.js tools** when prompted. You may skip this setup if you have Visual Studio 2015 or more.
3. Install the CLI tools via:

```
npm install -g edge-impulse-cli --force
```

You should now have the tools available in your PATH.

Installation - Linux/Ubuntu and Raspbian OS



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Installation - Linux/Ubuntu and Raspbian OS

Alternative Data Capture using EI CLI:

`$ edge-impulse-data-forwarder`

```
Capture_Ardu33_Sense_IMU_Acc | Arduino 1.8.16
Capture_Ardu33_Sense_IMU_Acc
1 #include <Arduino_LSM9DS1.h>
2
3 #define CONVERT_G_TO_MS2 9.80665f
4 #define FREQUENCY_HZ 100
5 #define INTERVAL_MS (1000 / (FREQUENCY_HZ + 1))
6
7 void setup() {
8   Serial.begin(9600);
9   while (!Serial);
10  Serial.println("Started");
11
12  if (!IMU.begin()) {
13    Serial.println("Failed to initialize IMU!");
14    while (1);
15  }
16 }
17
18 void loop() {
19   static unsigned long last_interval_ms = 0;
20   float x, y, z;
21
22   if (millis() > last_interval_ms + INTERVAL_MS) {
23     last_interval_ms = millis();
24
25     IMU.readAcceleration(x, y, z);
26
27     Serial.print(x * CONVERT_G_TO_MS2);
28     Serial.print(',');
29     Serial.print(y * CONVERT_G_TO_MS2);
30     Serial.print(',');
31     Serial.println(z * CONVERT_G_TO_MS2);
32   }
33 }
```

```
mjrovai — node /usr/local/bin/edge-impulse-data-forwarder — 72x42
Last login: Thu Nov 4 19:04:50 on ttys000
You have new mail.

The default interactive shell is now zsh.
To update your account to use zsh, please run `chsh -s /bin/zsh`.
For more details, please visit https://support.apple.com/kb/HT208050.
(base) MacBook-Pro-de-Marcelo:~ mjrovai$ edge-impulse-data-forwarder
Edge impulse data forwarder v1.15.16
Endpoints:
  Websocket: wss://remote-mgmt.edgeimpulse.com
  API: https://studio.edgeimpulse.com/v1
  Ingestion: https://ingestion.edgeimpulse.com

[SER] Connecting to /dev/tty.usbmodem145101
[SER] Serial is connected (4A:5A:36:17:55:F9:70:F7)
[WS ] Connecting to wss://remote-mgmt.edgeimpulse.com
[WS ] Connected to wss://remote-mgmt.edgeimpulse.com

? To which project do you want to connect this device?
MJRoBot (Marcelo Rovai) / IESTI01 - Covid-19: Detection by Cough
MJRoBot (Marcelo Rovai) / TinyML Kit Camera test
MJRoBot (Marcelo Rovai) / Harvard - Person Detection
MJRoBot (Marcelo Rovai) / Wio - Gesture Recognition
MJRoBot (Marcelo Rovai) / Cifar10_Image_Classification
MJRoBot (Marcelo Rovai) / Bean Disease Classifier
MJRoBot (Marcelo Rovai) / SciTinyML-Motion-Anomaly-Project
MJRoBot (Marcelo Rovai) / 1-Hands-On-SciTinyML-Motion-Project
MJRoBot (Marcelo Rovai) / ESP32-Motion-Classification
MJRoBot (Marcelo Rovai) / ESP32_KWS_Project
MJRoBot (Marcelo Rovai) / IESTI01 - Nano Motion Classification
MJRoBot (Marcelo Rovai) / Motion-Project
MJRoBot (Marcelo Rovai) / Blender - Motion Detection
MJRoBot (Marcelo Rovai) / Key_Word_Spotting
MJRoBot (Marcelo Rovai) / Oi_Rovis_Key_Word_Spotting
MJRoBot (Marcelo Rovai) / Sound-Classification-Blender-Faucet
MJRoBot (Marcelo Rovai) / oi_rovis_kws
MJRoBot (Marcelo Rovai) / Eggs AI
MJRoBot (Marcelo Rovai) / Accelerometer-Nano-Ble-IoT
MJRoBot (Marcelo Rovai) / video_tinyml_raw
(Move up and down to reveal more choices)
```

```
(base) MacBook-Pro-de-Marcelo:~ mjrovai$  
(base) MacBook-Pro-de-Marcelo:~ mjrovai$  
(base) MacBook-Pro-de-Marcelo:~ mjrovai$ edge-impulse-data-forwarder  
[Edge Impulse data forwarder v1.13.16  
[Endpoints:  
[  Websocket: wss://remote-mgmt.edgeimpulse.com  
    API:      https://studio.edgeimpulse.com/v1  
    Ingestion: https://ingestion.edgeimpulse.com  
  
[SER] Connecting to /dev/tty.usbmodem145101  
[SER] Serial is connected (4A:5A:36:17:55:F9:70:F7)  
[WS ] Connecting to wss://remote-mgmt.edgeimpulse.com  
[WS ] Connected to wss://remote-mgmt.edgeimpulse.com  
  
? To which project do you want to connect this device? MJRoBot (Marcelo  
Rovai) / IESTI01 - Nano Motion Classification  
[SER] Detecting data frequency...  
[SER] Detected data frequency: 100Hz  
? 3 sensor axes detected (example values: [-0.13, -0.34, 9.81]). What do y  
ou want to call them? Separate the names with ',': accX, accY, accZ  
? What name do you want to give this device? Nano  
[WS ] Device "Nano" is now connected to project "IESTI01 - Nano Motion Classification"  
[[WS ] Go to https://studio.edgeimpulse.com/studio/61345/acquisition/training to build your machine learning model!  
[]
```

Devices - IEST101 - Nano Motion Classification

studio.edgeimpulse.com/studio/61345/devices

EDGE IMPULSE

Dashboard

Devices

Data acquisition

Impulse design

Create impulse

EON Tuner

Retrain model

Live classification

Model testing

Versioning

Deployment

GETTING STARTED

Documentation

Forums

DEVICES (IEST101 - NANO MOTION CLASSIFICATION)

MJRoBot (Marcelo Roval)

Your devices

+ Connect a new device

These are devices that are connected to the Edge Impulse remote management API, or have posted data to the ingestion SDK.

NAME	ID	TYPE	SENSORS	REMOTE M...	LAST SEEN	
 Nano	4A:5A:36:17:55:F9:70:F7	DATA_FORWARDER	Sensor with 3 axes (accX, accY, accZ)		Today, 12:42:15	
 36:17:55:F9:70:F7	36:17:55:F9:70:F7	ARDUINO_NANO33BLE	Built-in accelerometer, Built-in microph...		Today, 12:26:49	

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Reading Material

Main references

- [Harvard School of Engineering and Applied Sciences - CS249r: Tiny Machine Learning](#)
- [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](#)
- Fundamentals textbook: [“Deep Learning with Python” by François Chollet](#)
- Applications & Deploy textbook: [“TinyML” by Pete Warden, Daniel Situnayake](#)
- Deploy textbook [“TinyML Cookbook” by Gian Marco Iodice](#)

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Thanks



UNIFEI