SciTinyML

Scientific Use of Machine Learning on Low Power Devices

Regional Workshop - Africa

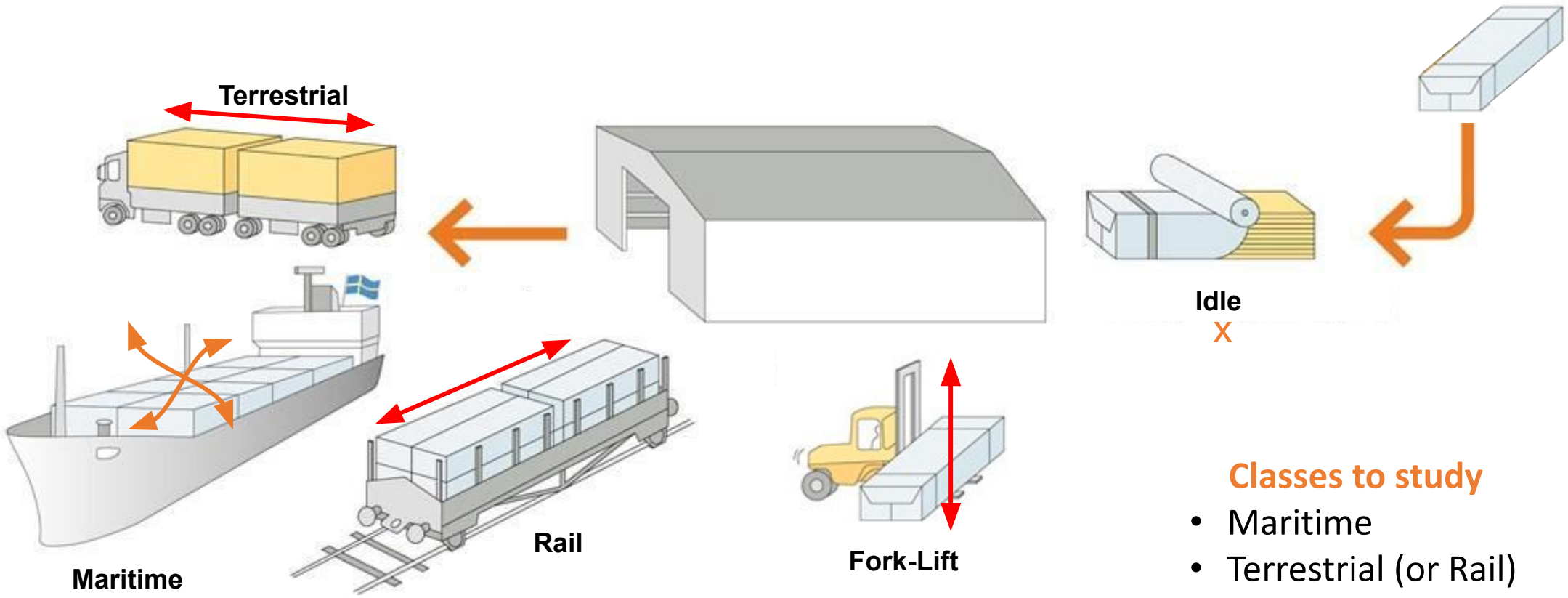
Hands-on Lab with Edge Impulse
Motion Classification

Marcelo Rovai
Professor, UNIFEI - Brazil

Shawn Himel
Senior DevRel Engineer, Edge Impulse

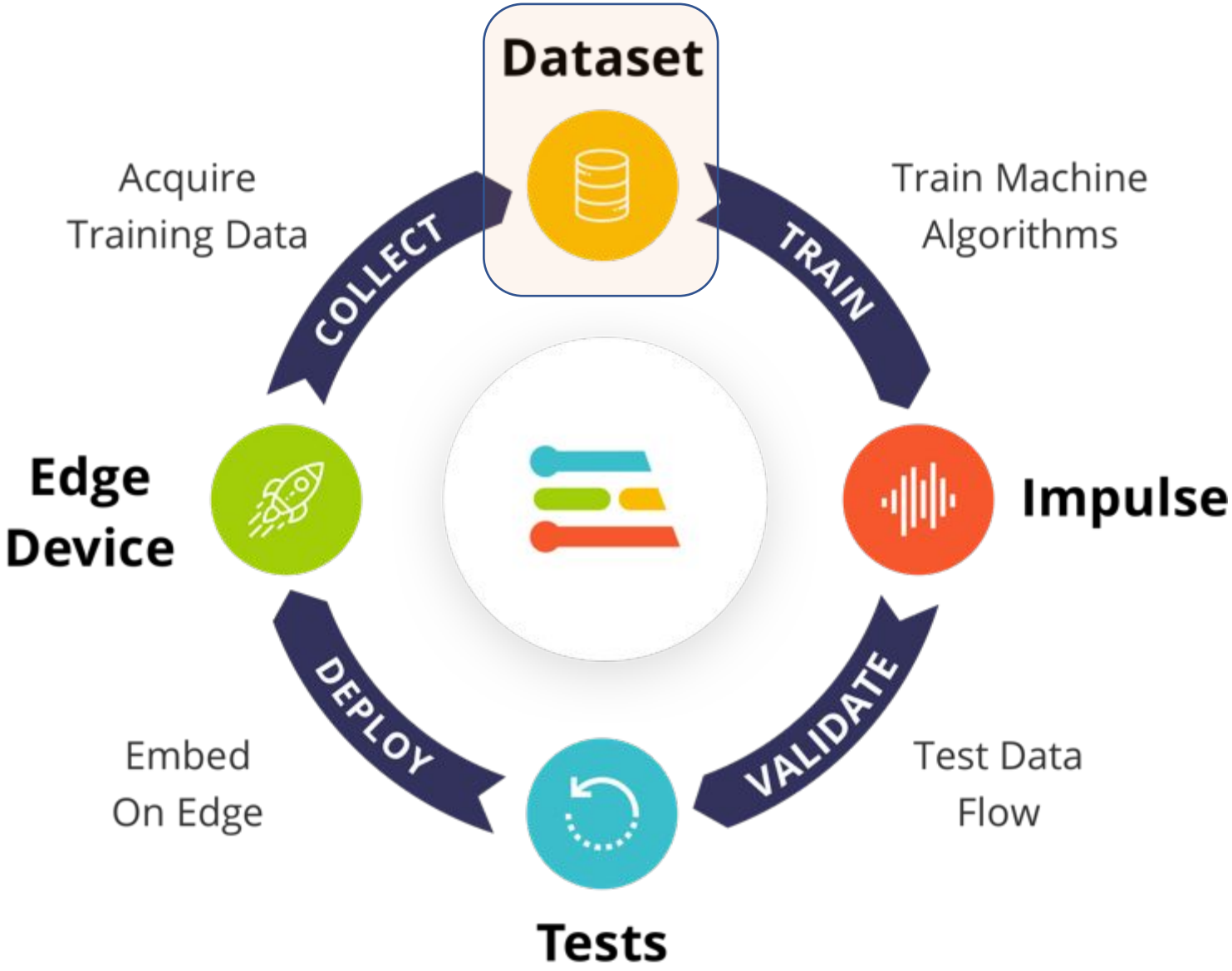
Hands-on lab for motion classification

Case Study: Mechanical Stresses in Transport

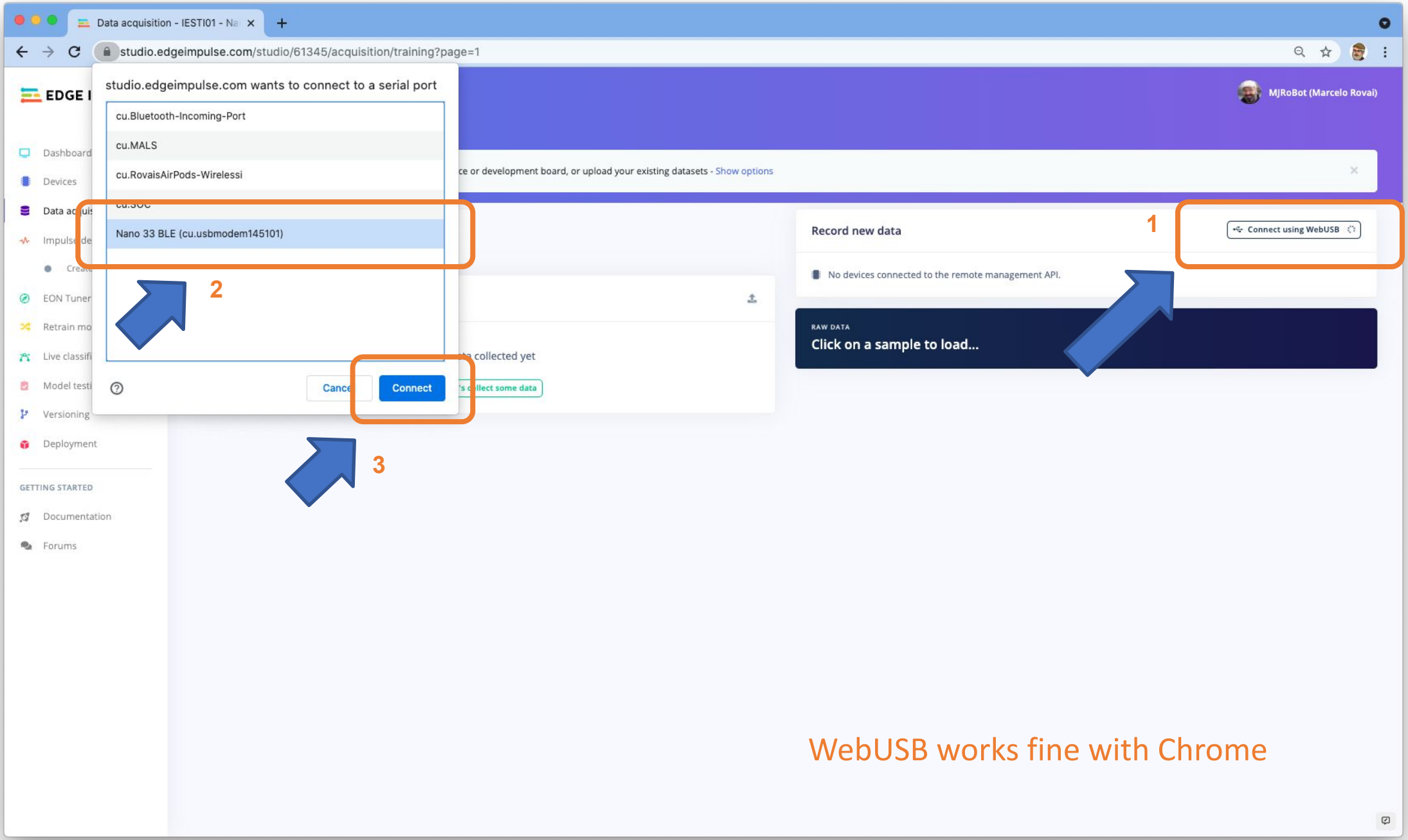


Classes to study

- Maritime
- Terrestrial (or Rail)
- Lift
- Idle



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


Data acquisition - IESTI01 - Na
studio.edgeimpulse.com/studio/61345/acquisition/training?page=1
studio.edgeimpulse.com wants to connect to a serial port
cu.Bluetooth-Incoming-Port
cu.MALS
cu.RovaisAirPods-Wirelessi
Nano 33 BLE (cu.usbmodem145101)
Cancel
Connect
2
3
1
MJRoBot (Marcelo Rovai)
Dashboard
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EON Tuner
Retrain mo
Live classifi
Model testi
Versioning
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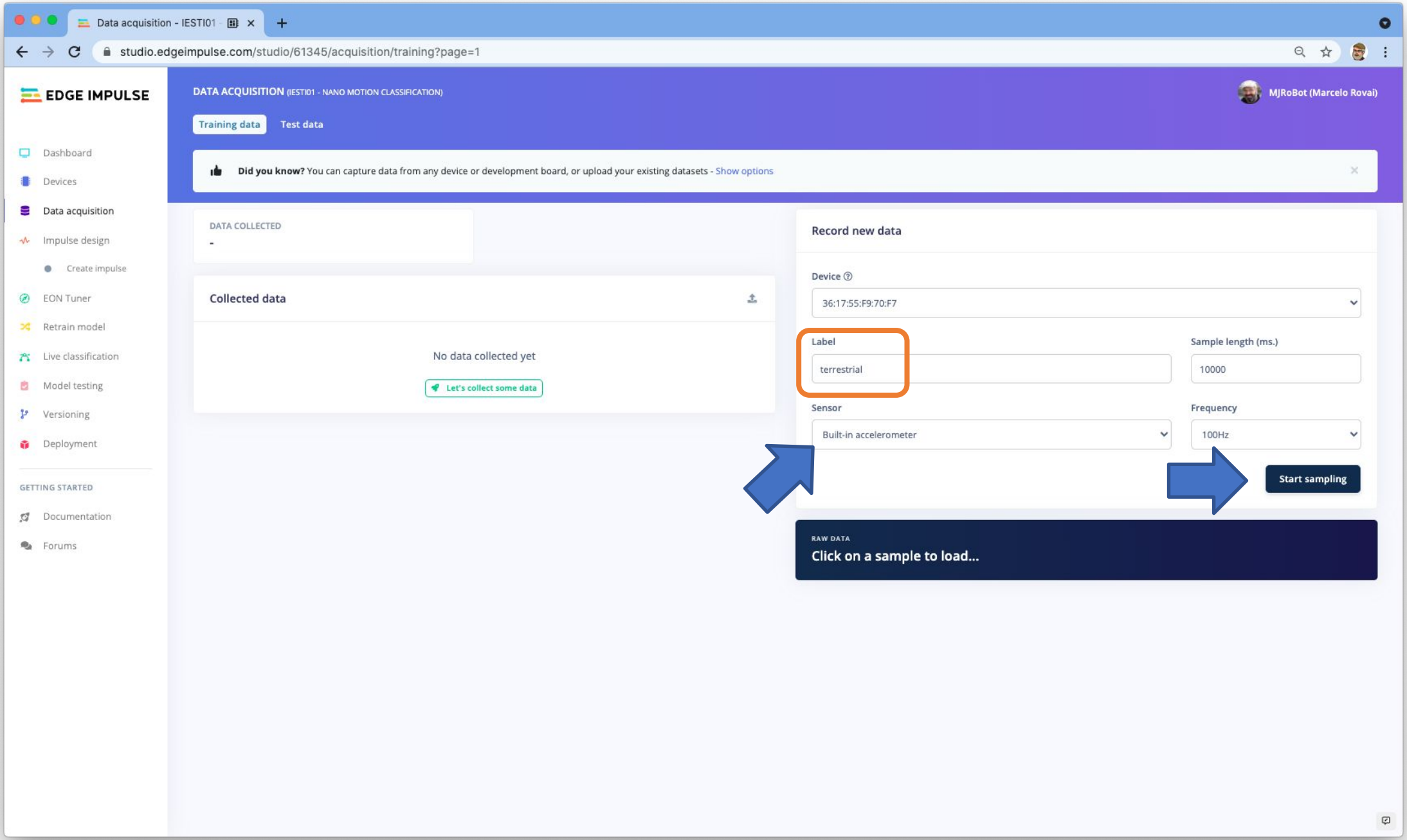
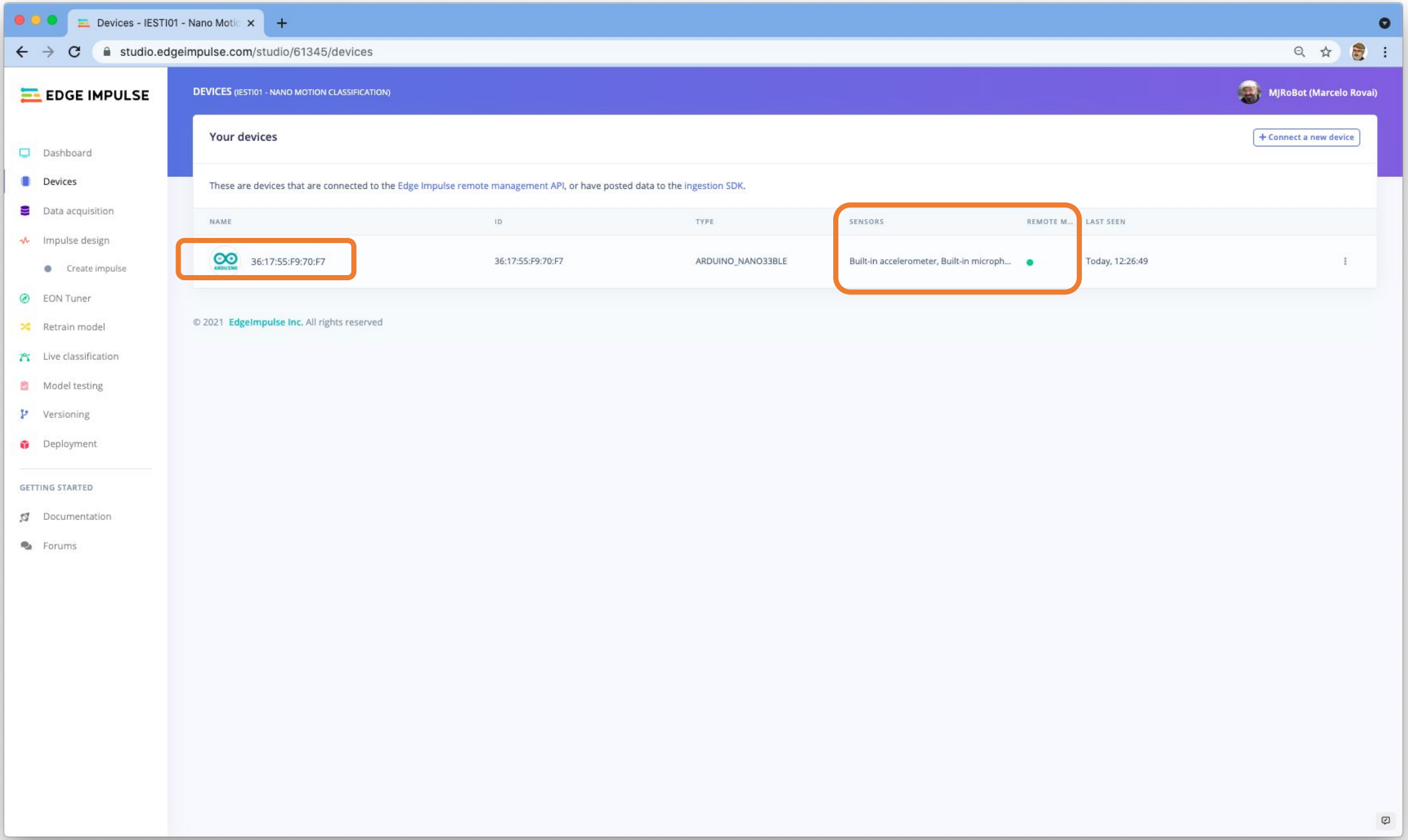
ce or development board, or upload your existing datasets - Show options
Record new data
Connect using WebUSB
No devices connected to the remote management API.
RAW DATA
Click on a sample to load...
collected yet
WebUSB works fine with Chrome


Data acquisition - IESTI01
studio.edgeimpulse.com/studio/61345/acquisition/training?page=1
EDGE IMPULSE
DATA ACQUISITION (IESTI01 - NANO MOTION CLASSIFICATION)
MJRoBot (Marcelo Rovai)
Training data
Test data
Did you know? You can capture data from any device or development board, or upload your existing datasets - Show options
Dashboard
Devices
Data acquisition
Impulse design
Create impulse
EON Tuner
Retrain model
Live classification
Model testing
Versioning
Deployment
GETTING STARTED
Documentation
Forums
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 - IESTI01 - Nano Motic
studio.edgeimpulse.com/studio/61345/devices
EDGE IMPULSE
DEVICES (IESTI01 - NANO MOTION CLASSIFICATION)
MJRoBot (Marcelo Rovai)
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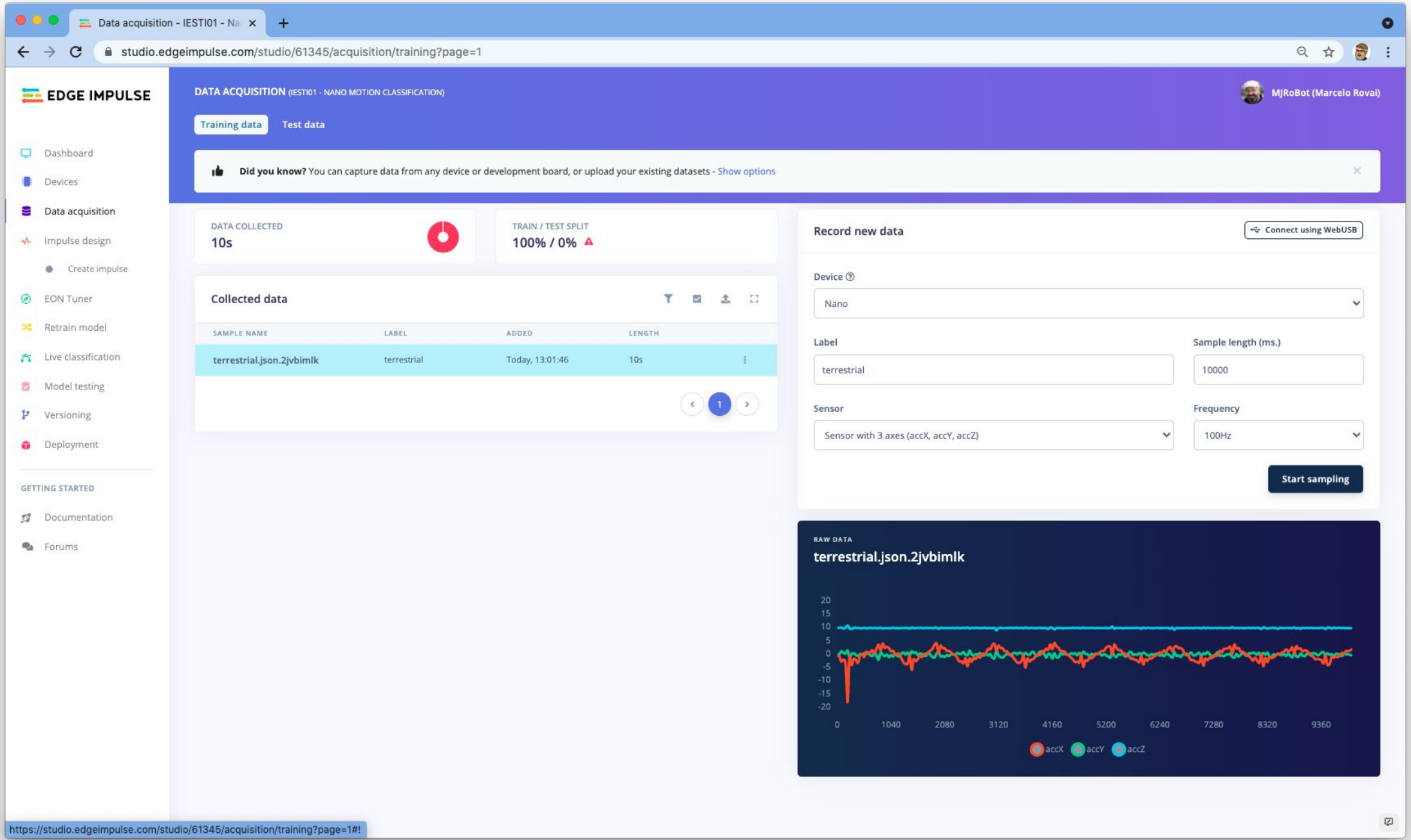
Your devices
+ Connect a new device
These are devices that are connected to the Edge Impulse remote management API, or have posted data to the ingestion SDK.
NAME
ID
TYPE
SENSORS
REMOTE M...
LAST SEEN
36:17:55:F9:70:F7
36:17:55:F9:70:F7
ARDUINO_NANO33BLE
Built-in accelerometer, Built-in microph...
Today, 12:26:49
© 2021 EdgeImpulse Inc. All rights reserved


Data acquisition - IESTI01 - Na
studio.edgeimpulse.com/studio/61345/acquisition/training?page=1
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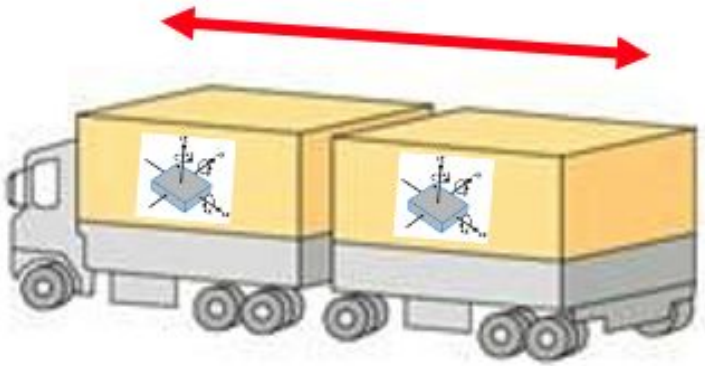
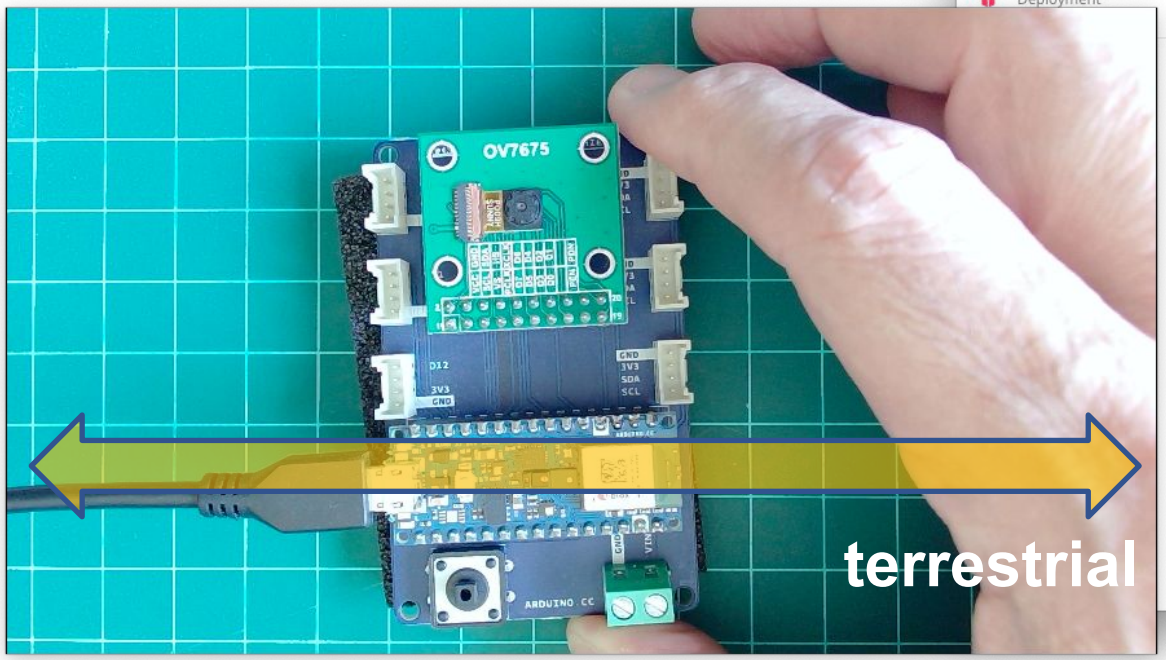
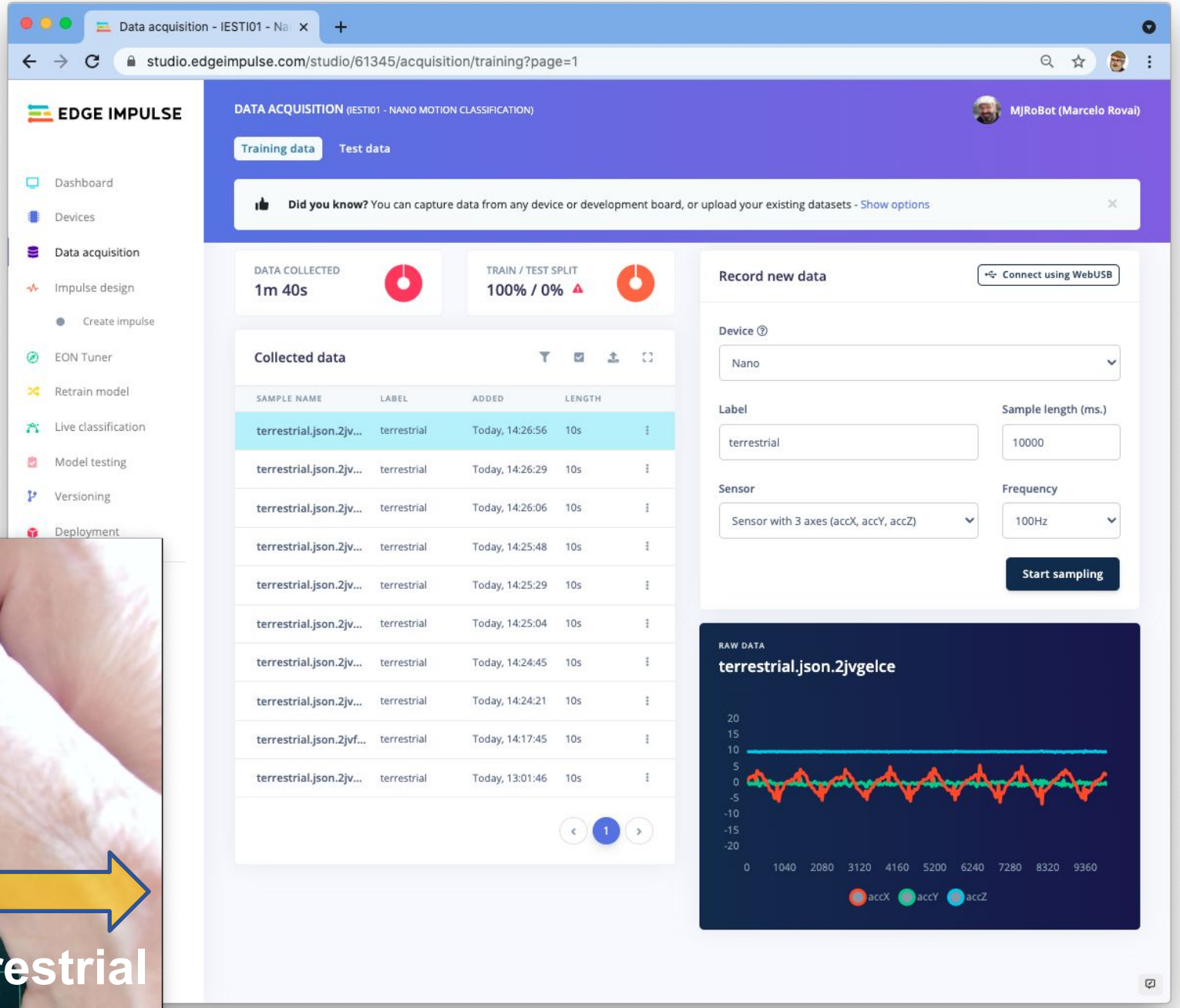
Did you know? You can capture data from any device or development board, or upload your existing datasets - Show options
DATA COLLECTED
10s
TRAIN / TEST SPLIT
100% / 0%
Collected data
SAMPLE NAME
LABEL
ADDED
LENGTH
terrestrial.json.2jvbimlk
terrestrial
Today, 13:01:46
10s
Record new data
Connect using 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#!

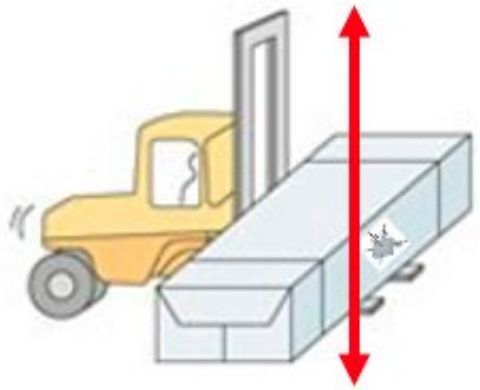
Label: terrestrial

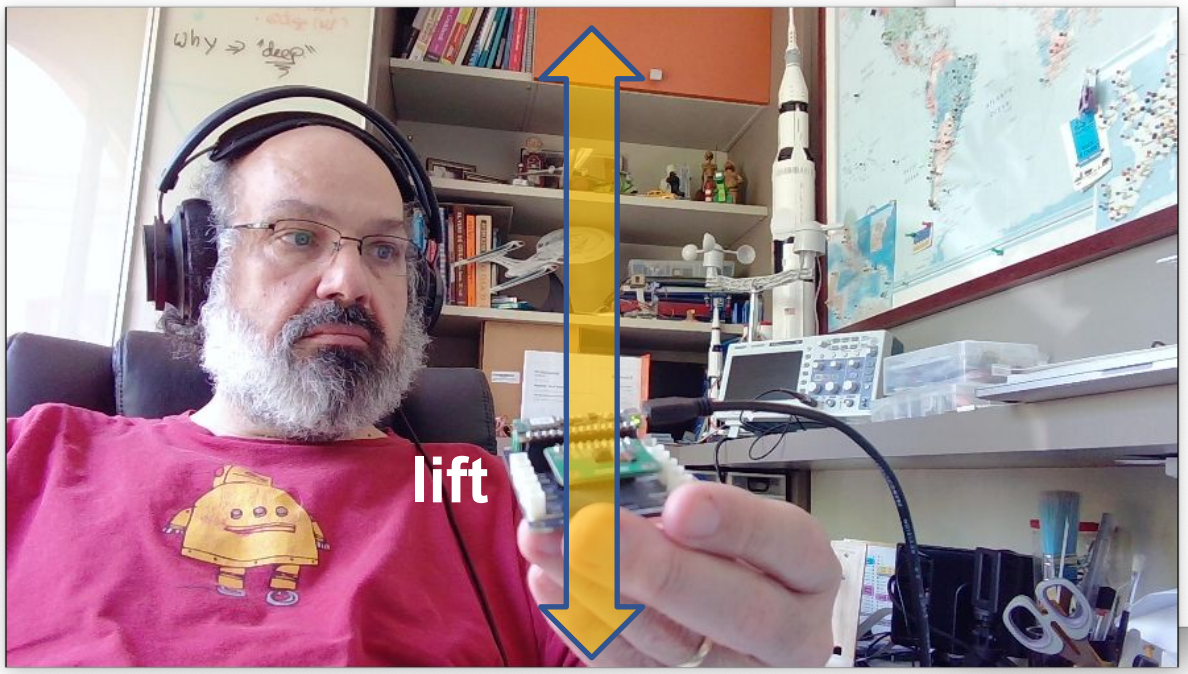


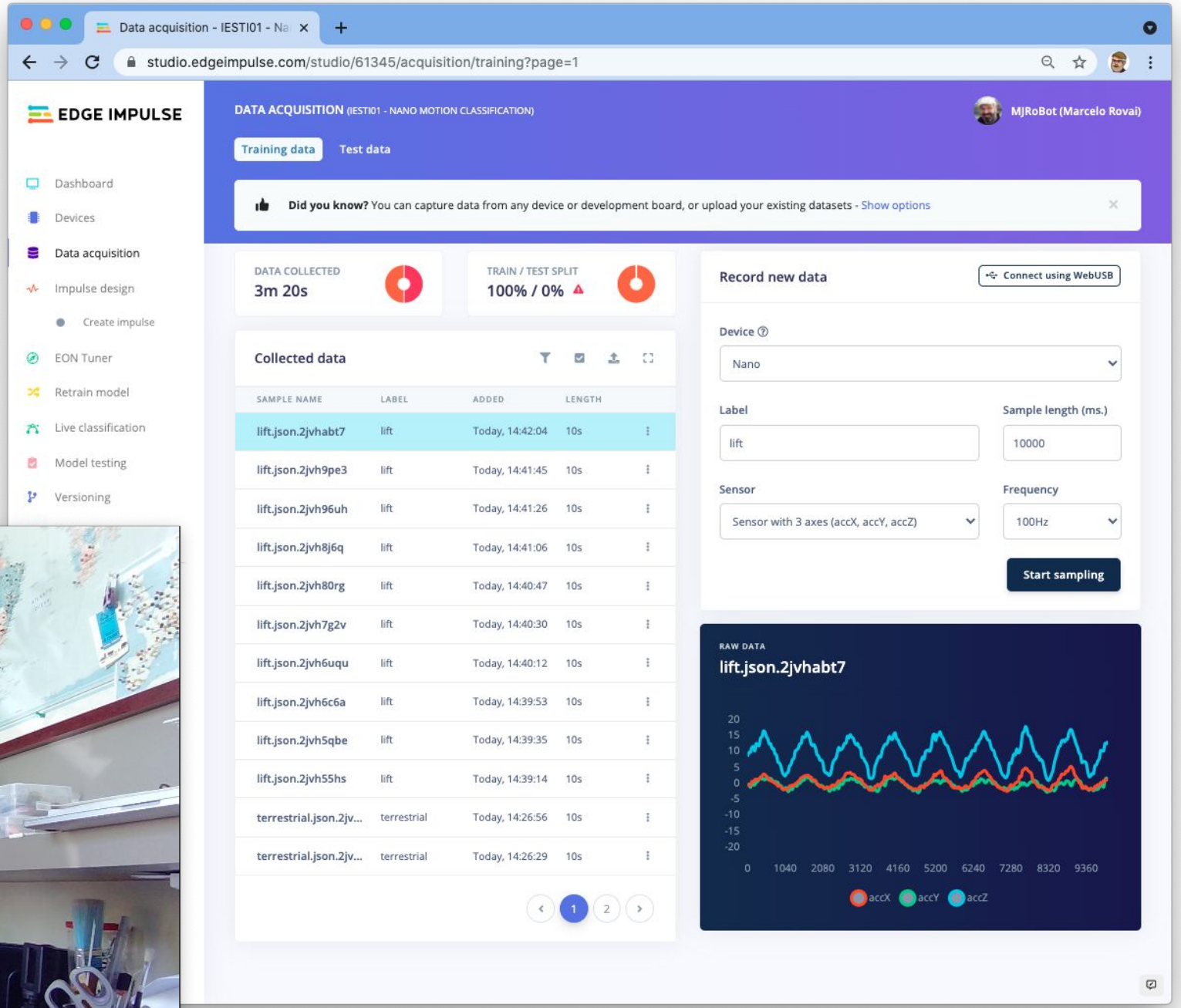




Label: LIFT




lift


Data acquisition - IESTI01 - Na
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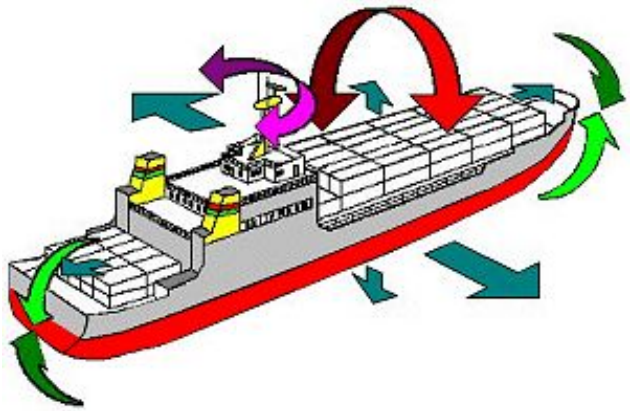
DATA ACQUISITION (IESTI01 - NANO MOTION CLASSIFICATION)
MJRoBot (Marcelo Rovai)
Training data
Test data
Did you know? You can capture data from any device or development board, or upload your existing datasets - Show options
DATA COLLECTED
3m 20s
TRAIN / TEST SPLIT
100% / 0%
Collected data
SAMPLE NAME
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
accX
accY
accZ

Label: maritime



Data acquisition - IESTI01 - Na

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

EDGE IMPULSE

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DATA ACQUISITION (IESTI01 - NANO MOTION CLASSIFICATION)

MJRoBot (Marcelo Rovai)

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%

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.2jvhabt7	lift	Today, 14:42:04	10s
lift.json.2jvh9pe3	lift	Today, 14:41:45	10s

1 2 3

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

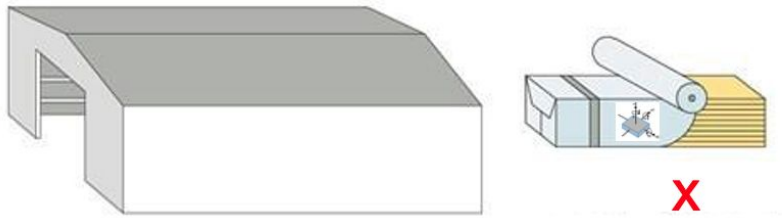
RAW DATA
maritime.json.2jvi6p3r

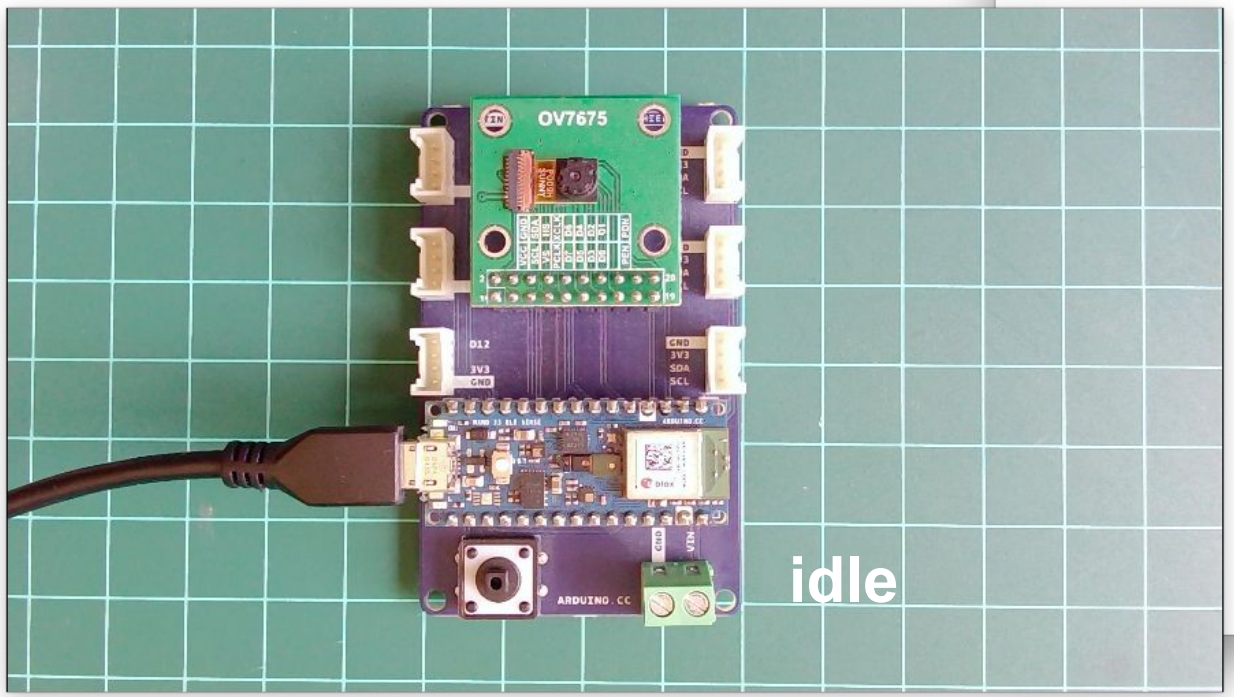
25 20 15 10 5 0 -5 -10 -15 -20

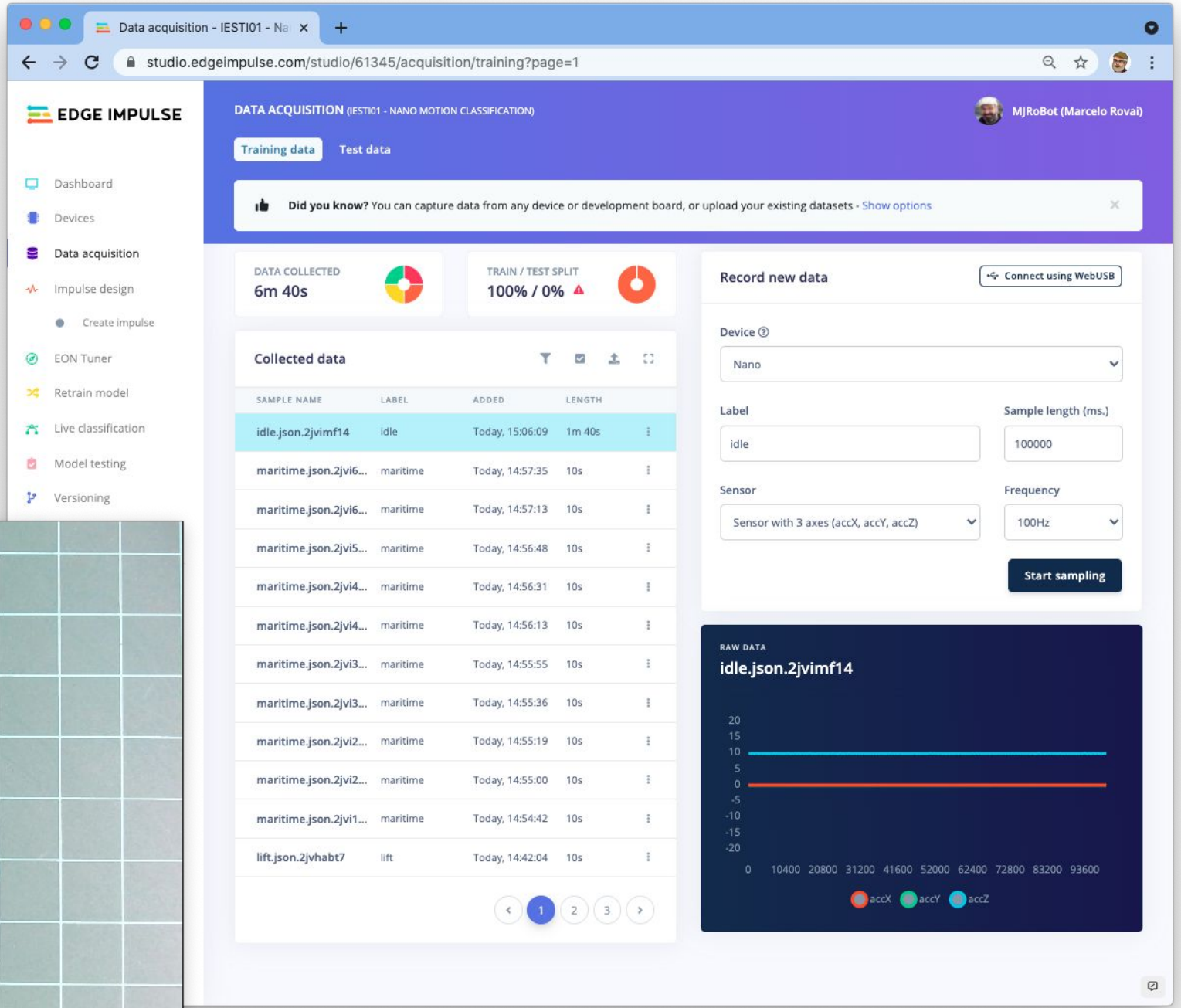
0 1040 2080 3120 4160 5200 6240 7280 8320 9360

accX accY accZ

Label: idle


X


OV7675
idle


Data acquisition - IESTI01 - Na
studio.edgeimpulse.com/studio/61345/acquisition/training?page=1
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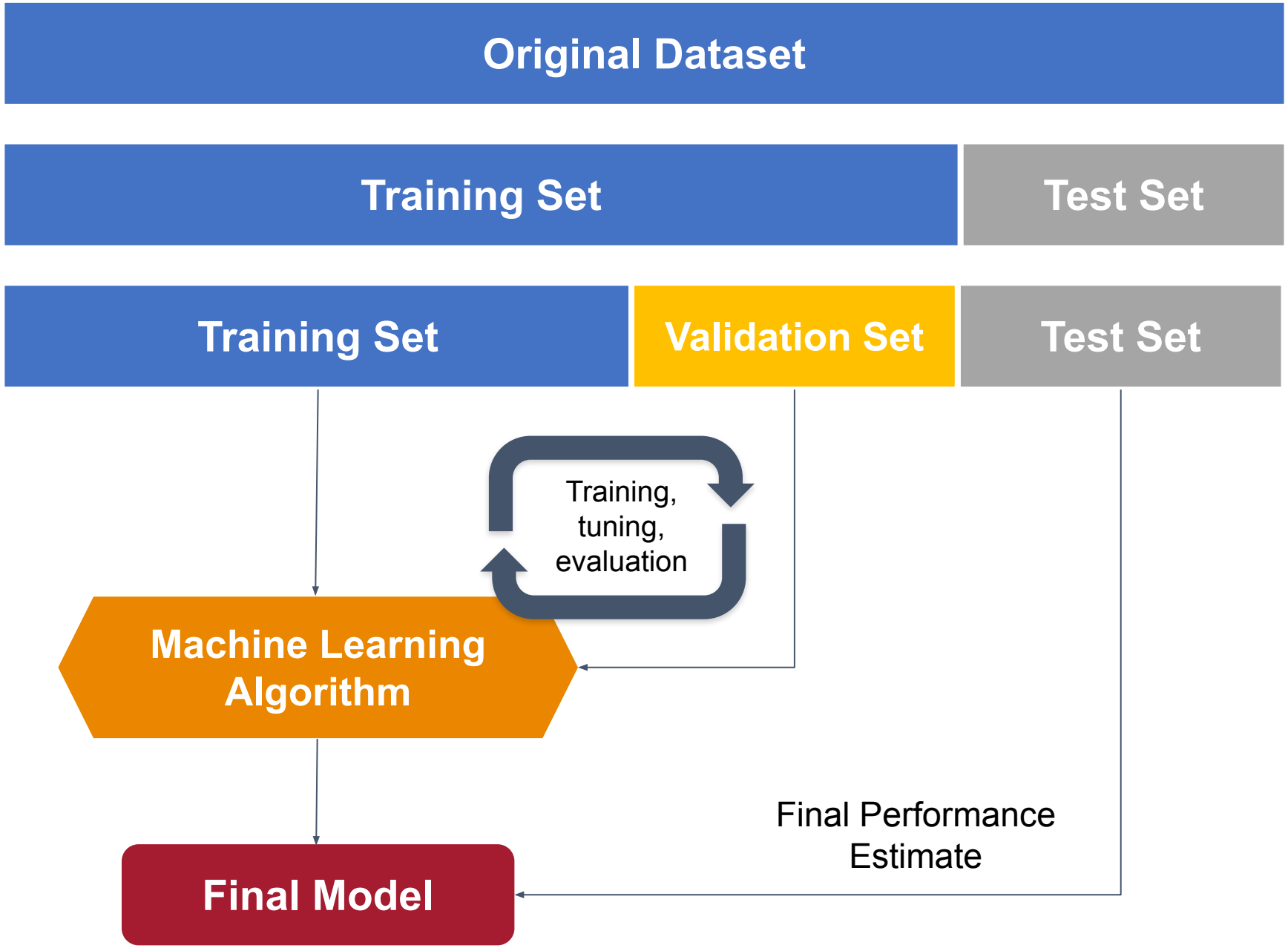
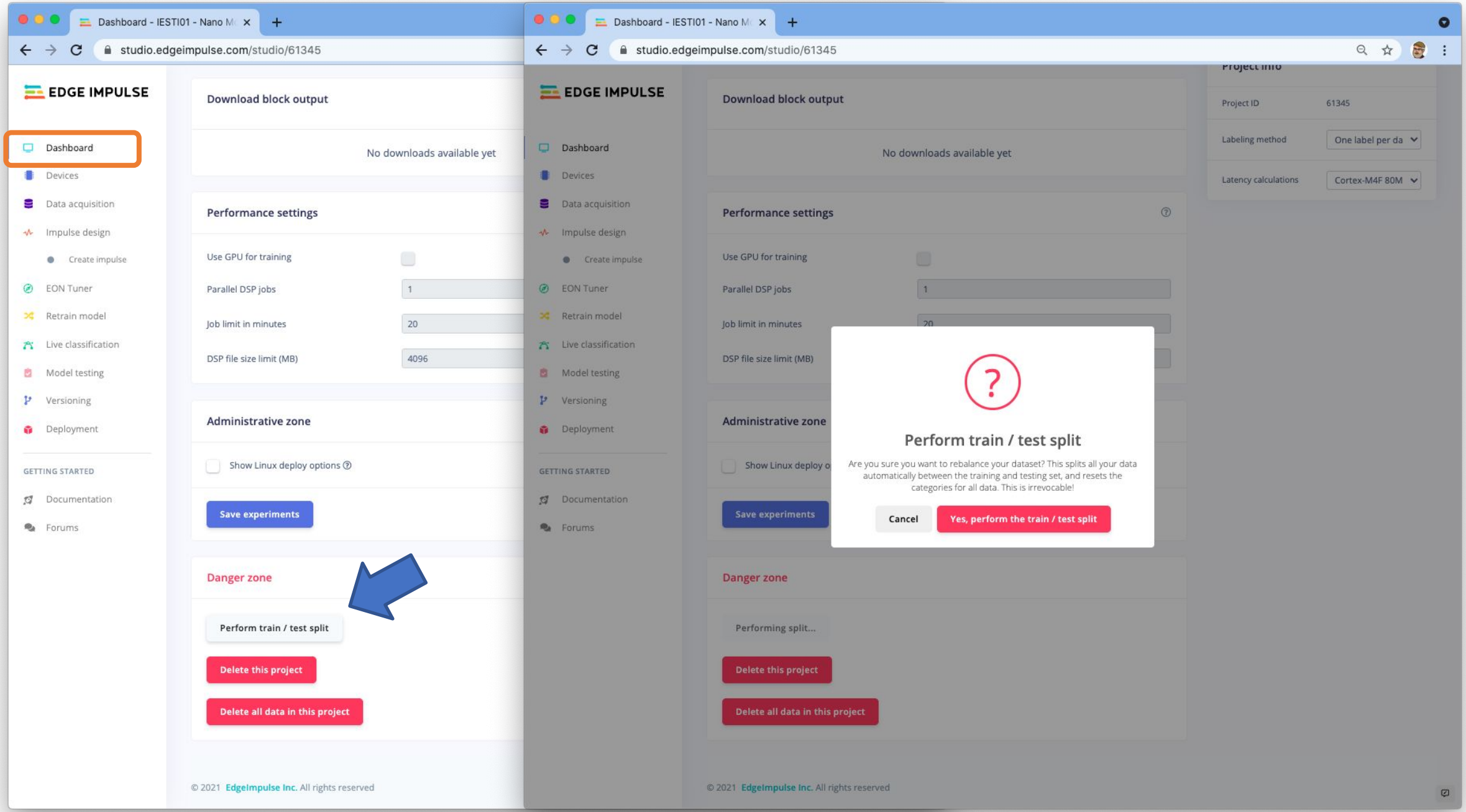
MJRoBot (Marcelo Rovai)
Training data
Test data
Did you know? You can capture data from any device or development board, or upload your existing datasets - Show options
DATA COLLECTED
6m 40s
TRAIN / TEST SPLIT
100% / 0%
Collected data
SAMPLE NAME
LABEL
ADDED
LENGTH
idle.json.2jvimf14 idle Today, 15:06:09 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
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
RAW DATA
idle.json.2jvimf14
20
15
10
5
0
-5
-10
-15
-20
0
10400
20800
31200
41600
52000
62400
72800
83200
93600
accX
accY
accZ


Original Dataset
Training Set
Test Set
Training Set
Validation Set
Test Set
Training,
tuning,
evaluation
Machine Learning
Algorithm
Final Performance
Estimate
Final Model


Dashboard - IESTI01 - Nano M
studio.edgeimpulse.com/studio/61345
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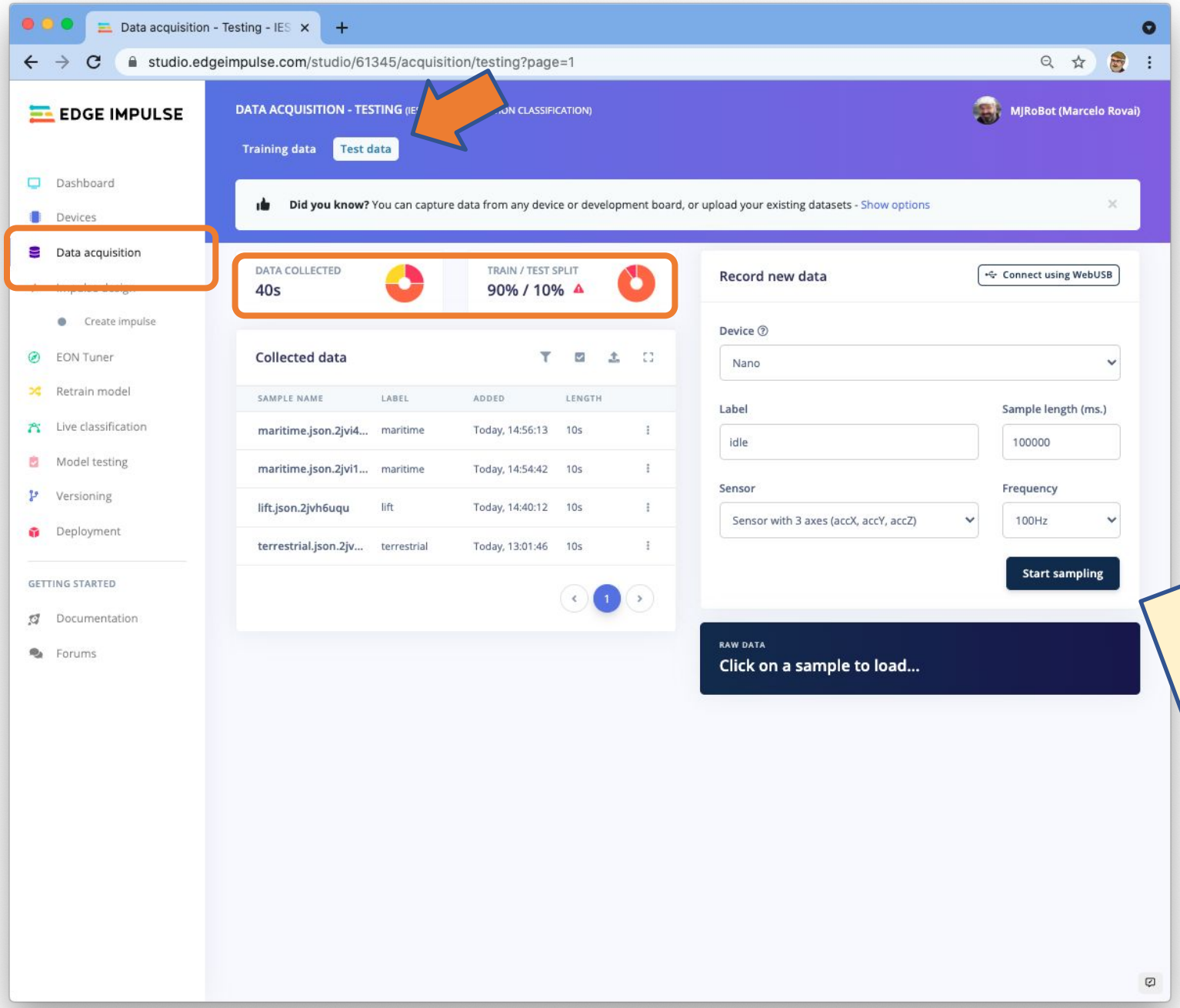
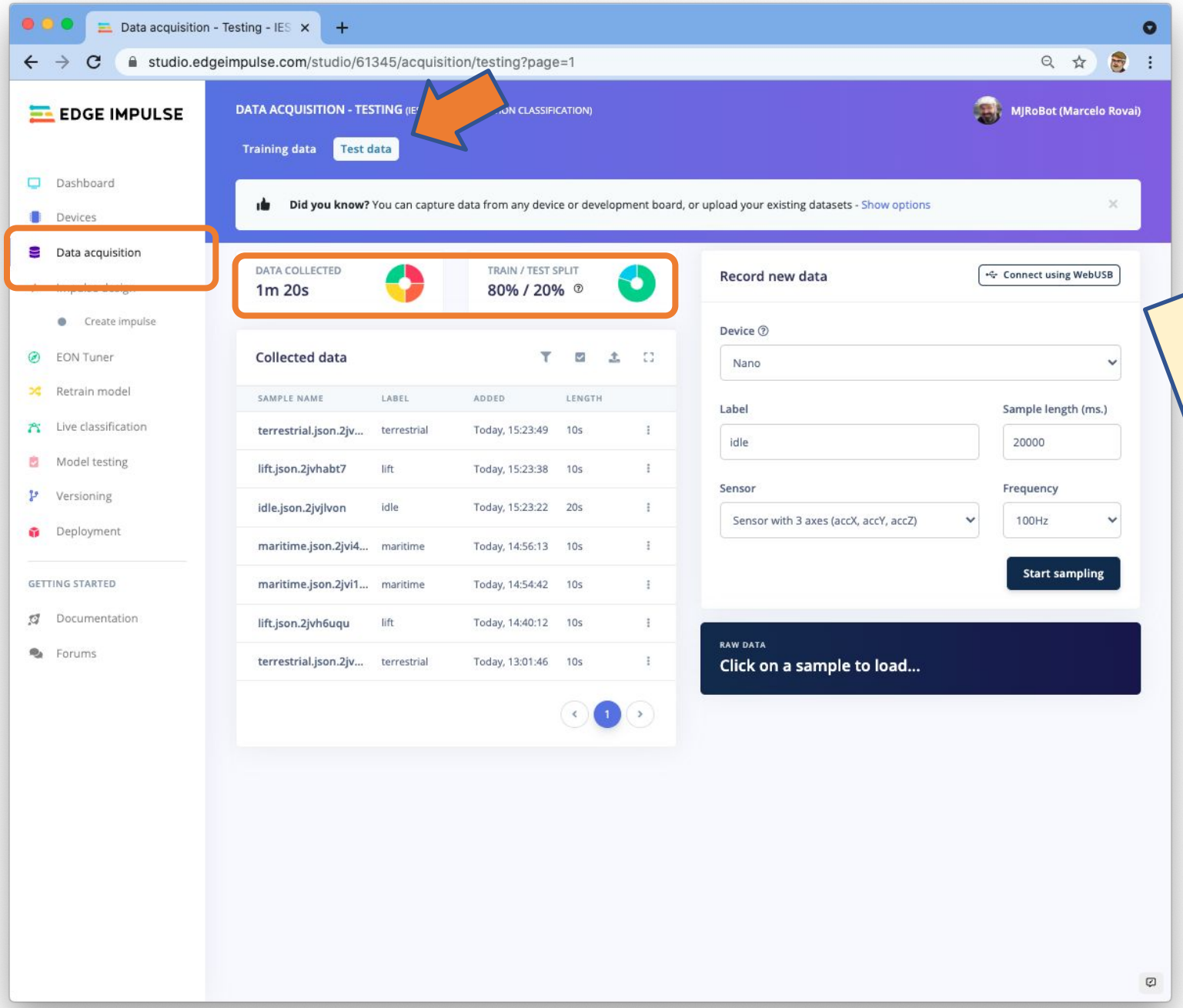
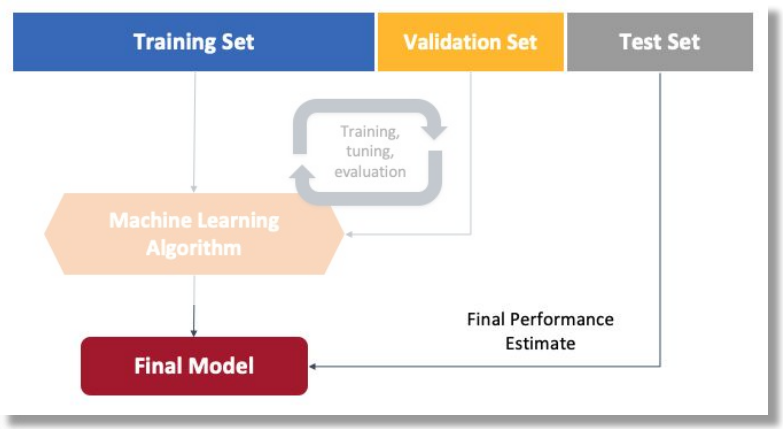
Download block output
No downloads available yet
Performance settings
Use GPU for training
Parallel DSP jobs
1
Job limit in minutes
20
DSP file size limit (MB)
4096
Administrative zone
Show Linux deploy options
Save experiments
Danger zone
Perform train / test split
Delete this project
Delete all data in this project
© 2021 EdgeImpulse Inc. All rights reserved
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
Performing split...

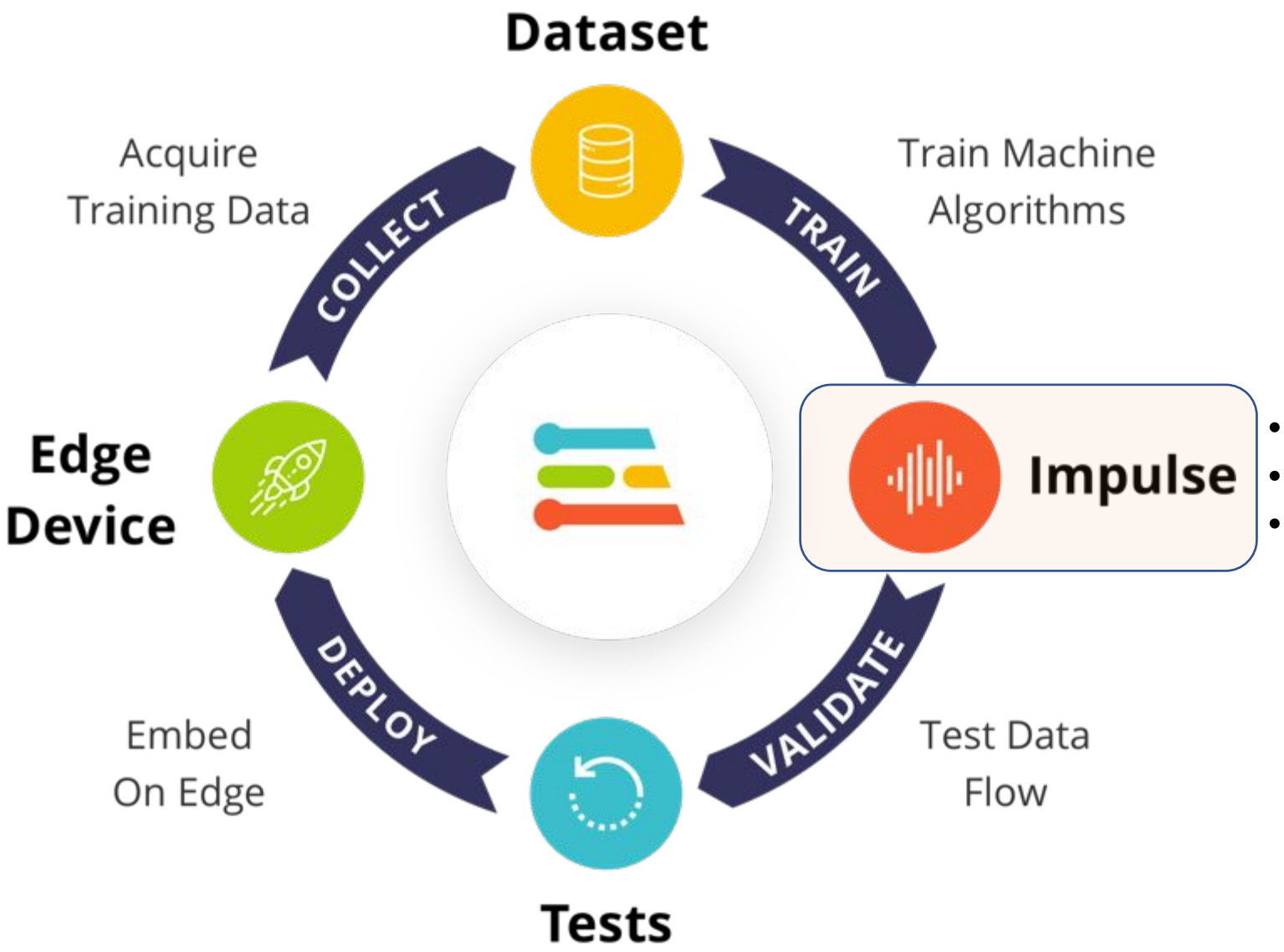


If automatic split is not good, proceed with manual split

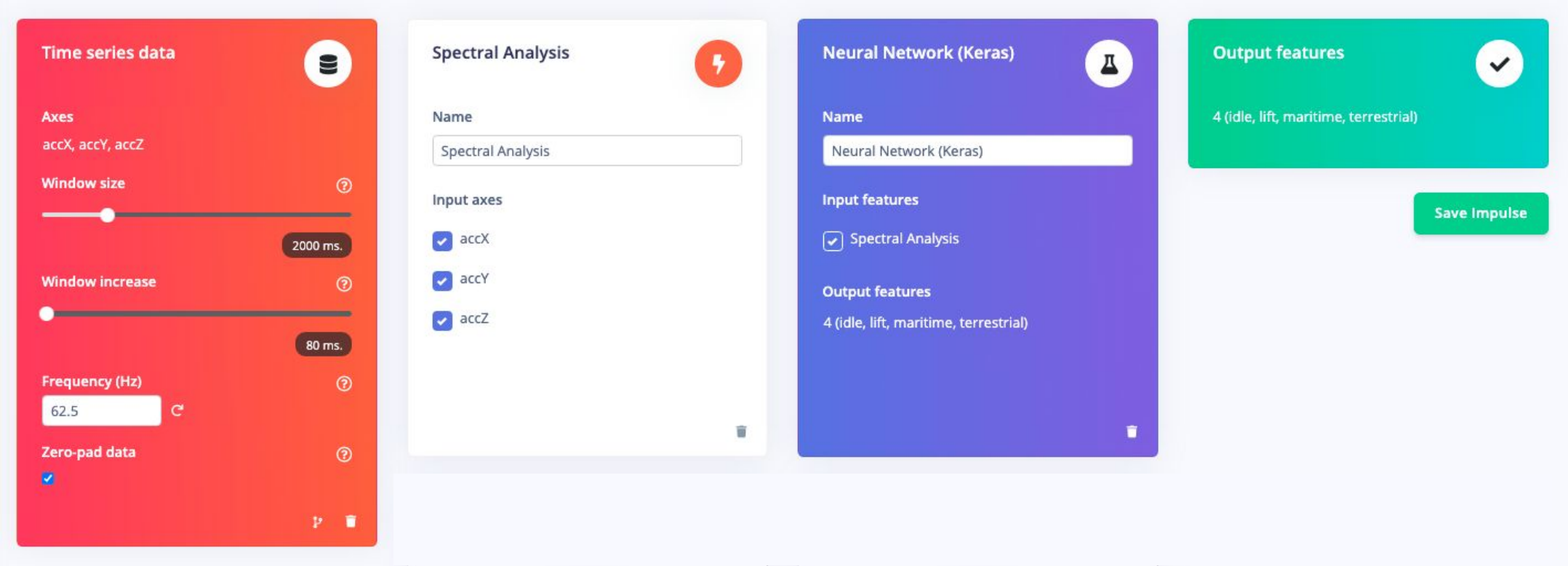


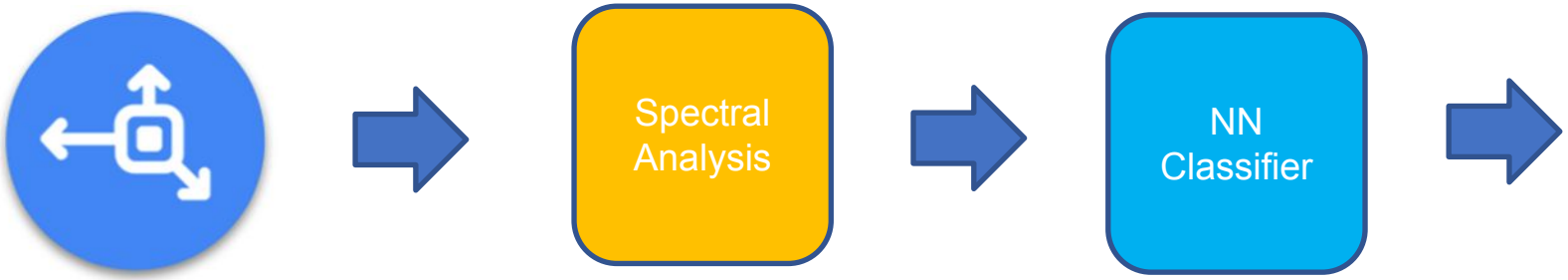
Dataset is balanced (has representative samples from all classes) and split 80%/20%





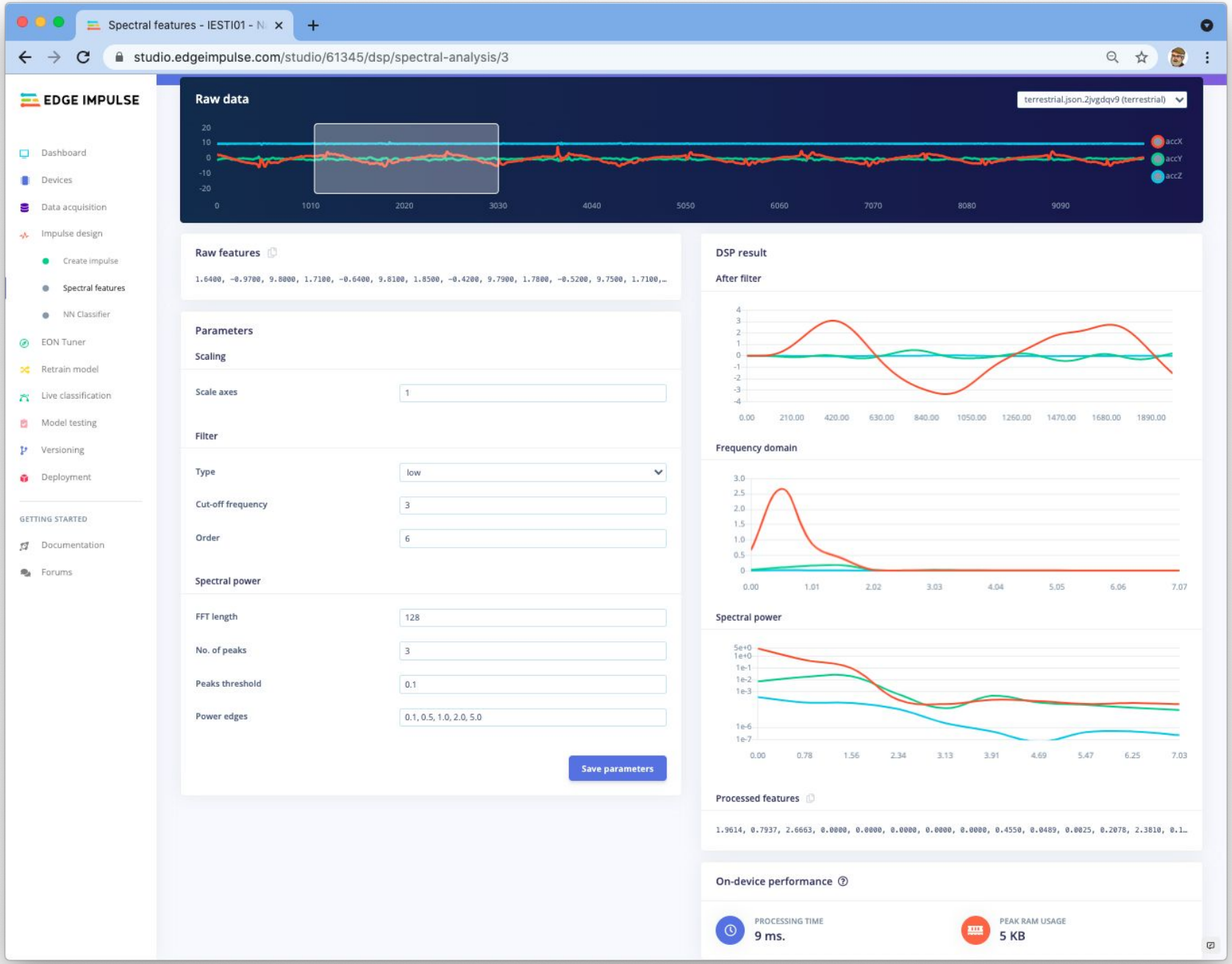
- Pre-Processing Data
- Design a Model
- Train a Model





Classes

- Lift
- Terrestrial
- Maritime
- Iddle


Spectral features - IESTI01 - N
studio.edgeimpulse.com/studio/61345/dsp/spectral-analysis/3
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Raw data
terrestrial.json.2jvgdqv9 (terrestrial)
accX
accY
accZ
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
Frequency domain
Spectral power
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

Spectral features - IESTI01 - N

studio.edgeimpulse.com/studio/61345/dsp/spectral-analysis/3/generate-features

EDGE IMPULSE

- Dashboard
- Devices
- Data acquisition
- Impulse design
  - Create impulse
  - Spectral features
  - NN Classifier
- EON Tuner
- Retrain model
- Live classification
- Model testing
- Versioning
- Deployment

GETTING STARTED

- Documentation
- Forums

SPECTRAL FEATURES (IESTI01 - NANO MOTION CLASSIFICATION)

MJRoBot (Marcelo Rovai)

#1 Click to set a description for this version

Parameters | Generate features

Training set

Data in training set	5m 20s
Classes	4 (idle, lift, maritime, terrestrial)
Window length	2000 ms.
Window increase	80 ms.
Training windows	3,400

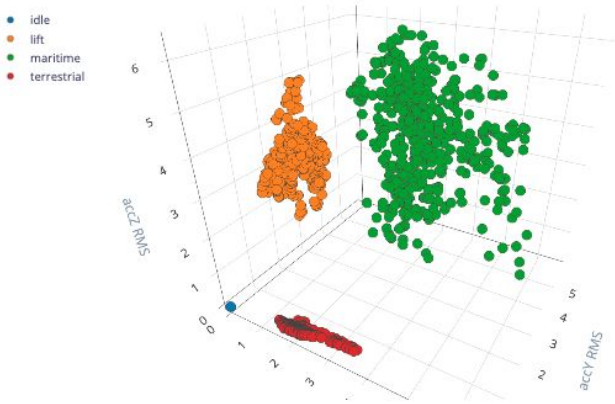
Generate features

Feature generation output

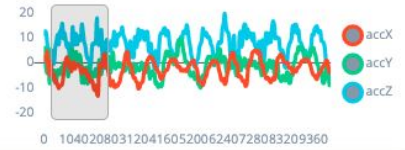
```
Job started
Creating windows from 25 files...
[ 0/25] Creating windows from files...
[ 1/25] Creating windows from files...
[25/25] Creating windows from files...
Created 3400 windows: idle: 976, lift: 808, maritime: 808, terrestrial: 808

Creating features
[   1/3400] Creating features...
[ 898/3400] Creating features...
[1798/3400] Creating features...
[2704/3400] Creating features...
[3400/3400] Creating features...
Created features

Job completed
```

Feature explorer (3,400 samples)

X Axis: accX RMS | Y Axis: accY RMS | Z Axis: accZ RMS



maritime.json.2jvi4q7j
Window: 240 - 2240 ms.
Label: maritime
View sample
View features



On-device performance

PROCESSING TIME	PEAK RAM USAGE
9 ms.	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

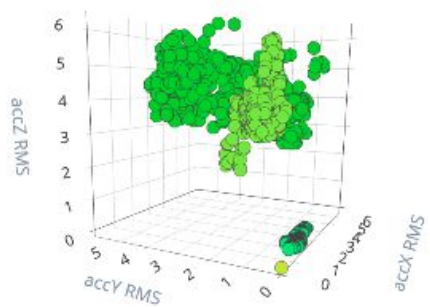
Confusion matrix (validation set)

	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

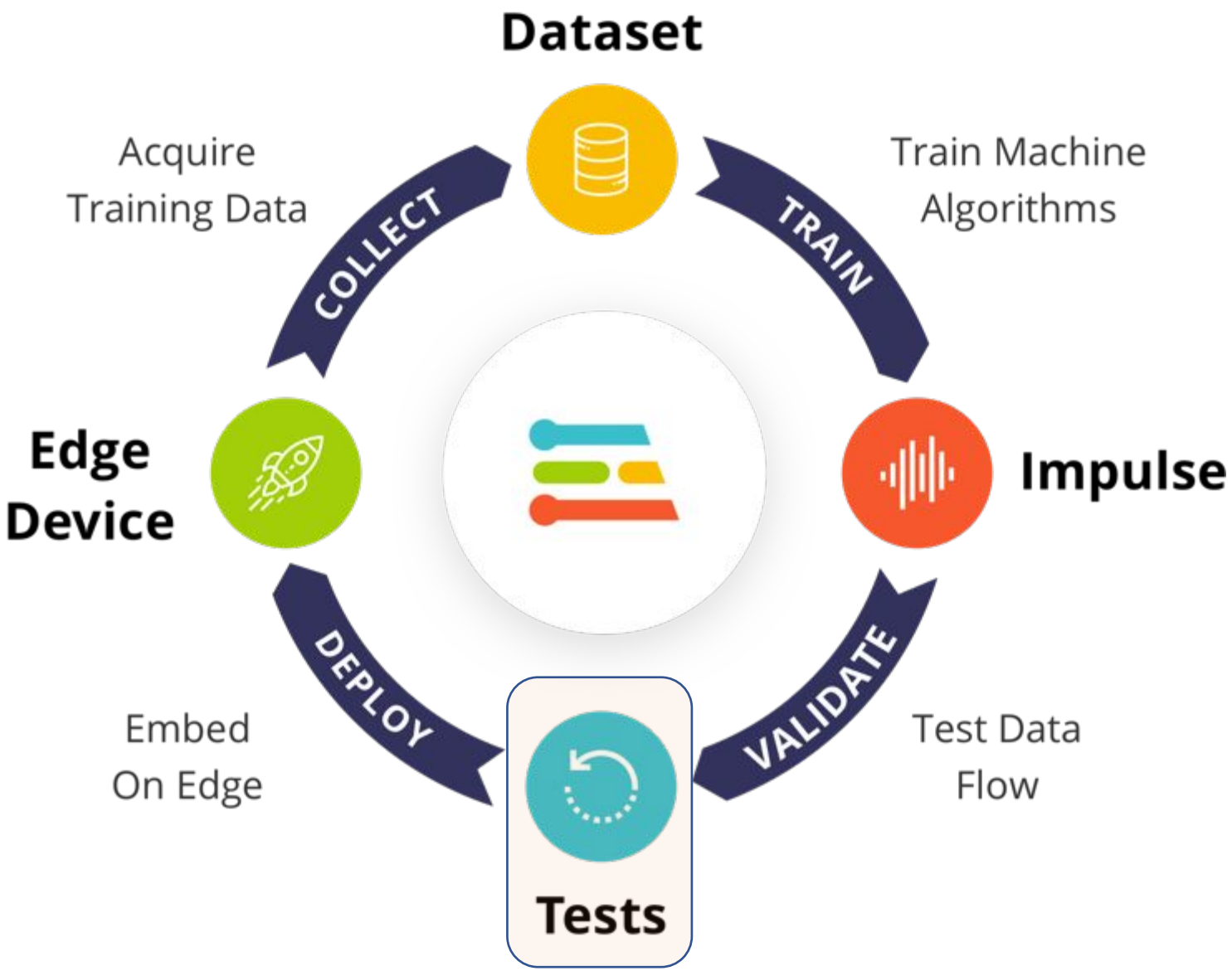


On-device performance

INFERENCING 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

- Dashboard
- Devices
- Data acquisition
- Impulse design
  - Create impulse
  - Spectral features
  - NN Classifier
- EON Tuner
- Retrain model
- Live classification
- Model testing
- Versioning
- Deployment

GETTING STARTED

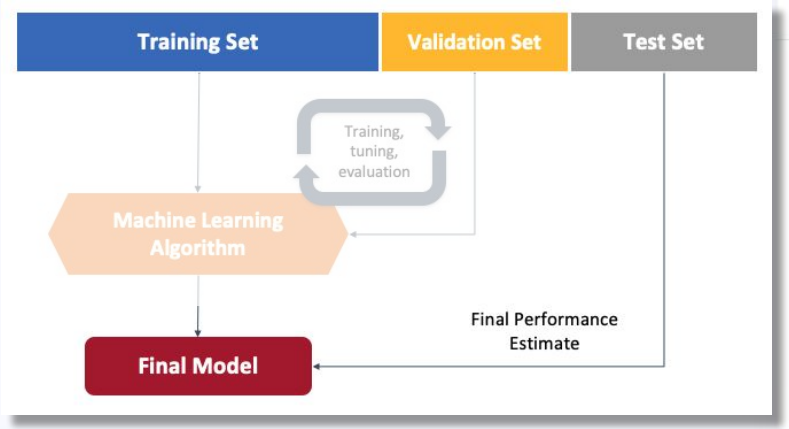
- Documentation
- Forums

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.2jvhabt7	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

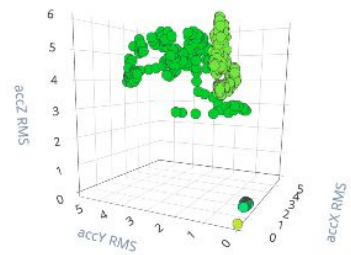
ACCURACY
100.00%

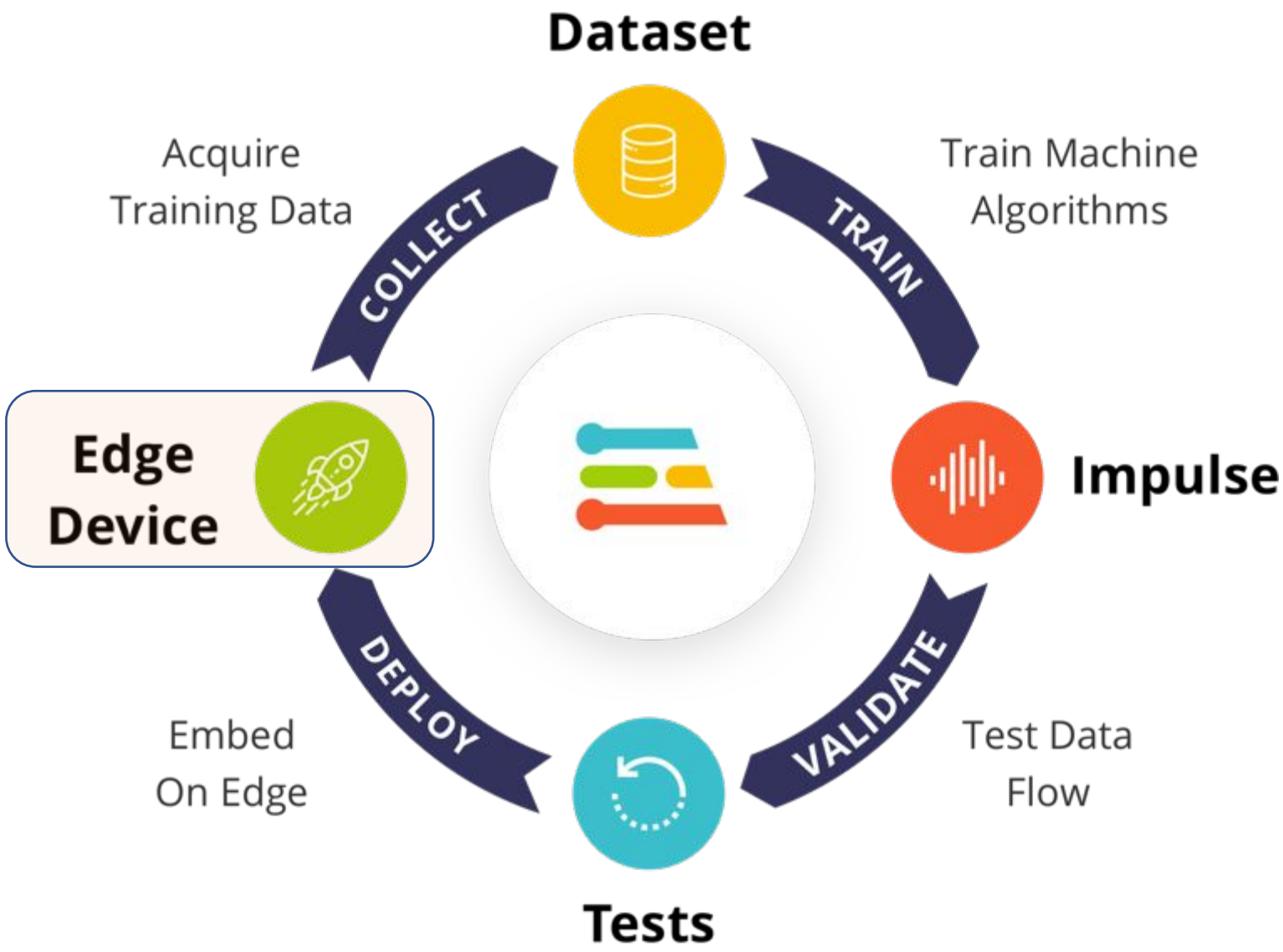
	IDLE	LIFT	MARITIME	TERRESTRIAL	UNCERTAIN
IDLE	100%	0%	0%	0%	0%
LIFT	0%	100%	0%	0%	0%
MARITIME	0%	0%	100%	0%	0%
TERRESTRIAL	0%	0%	0%	100%	0%
F1 SCORE	1.00	1.00	1.00	1.00	

Feature explorer

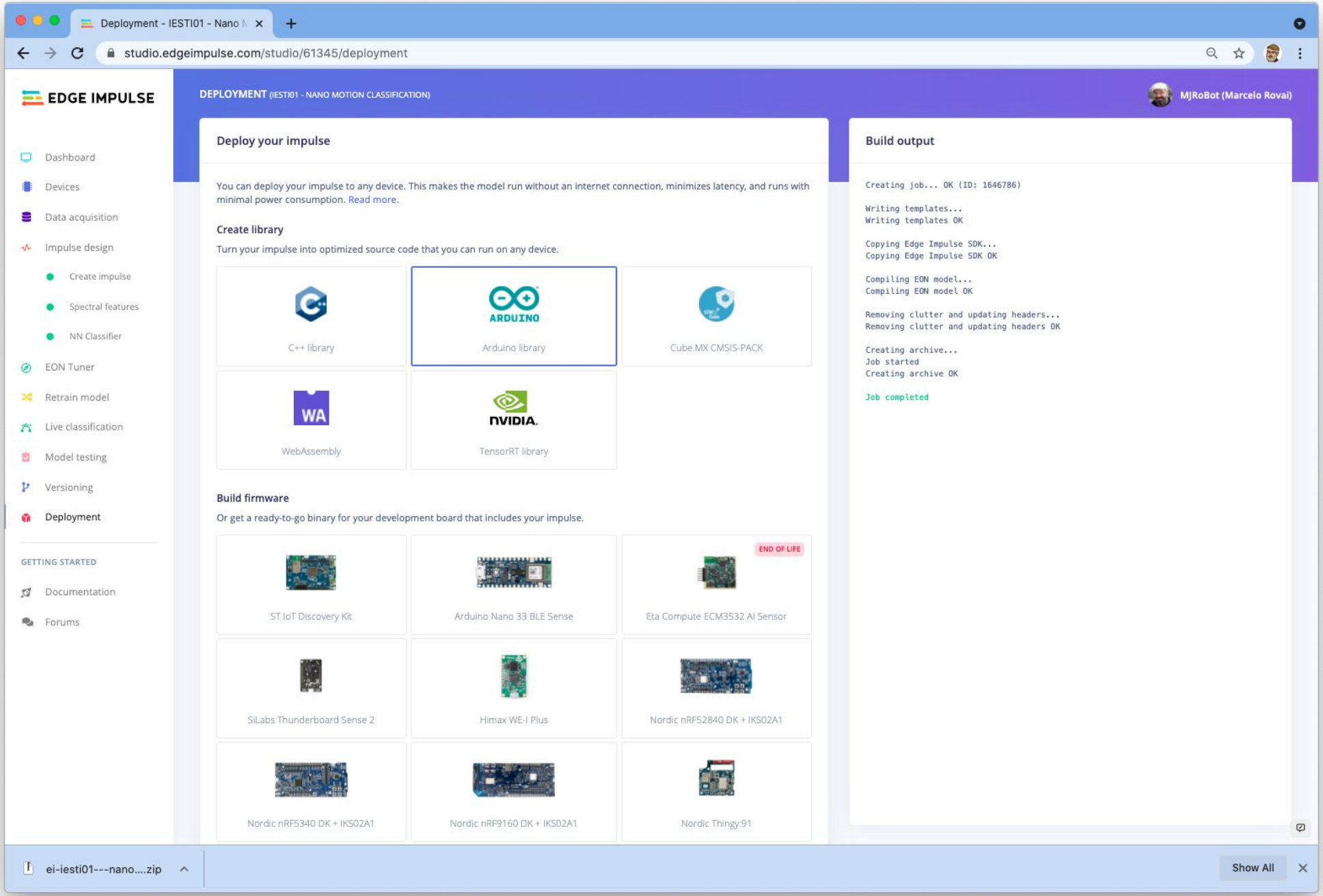
accX RMS | accY RMS | accZ RMS

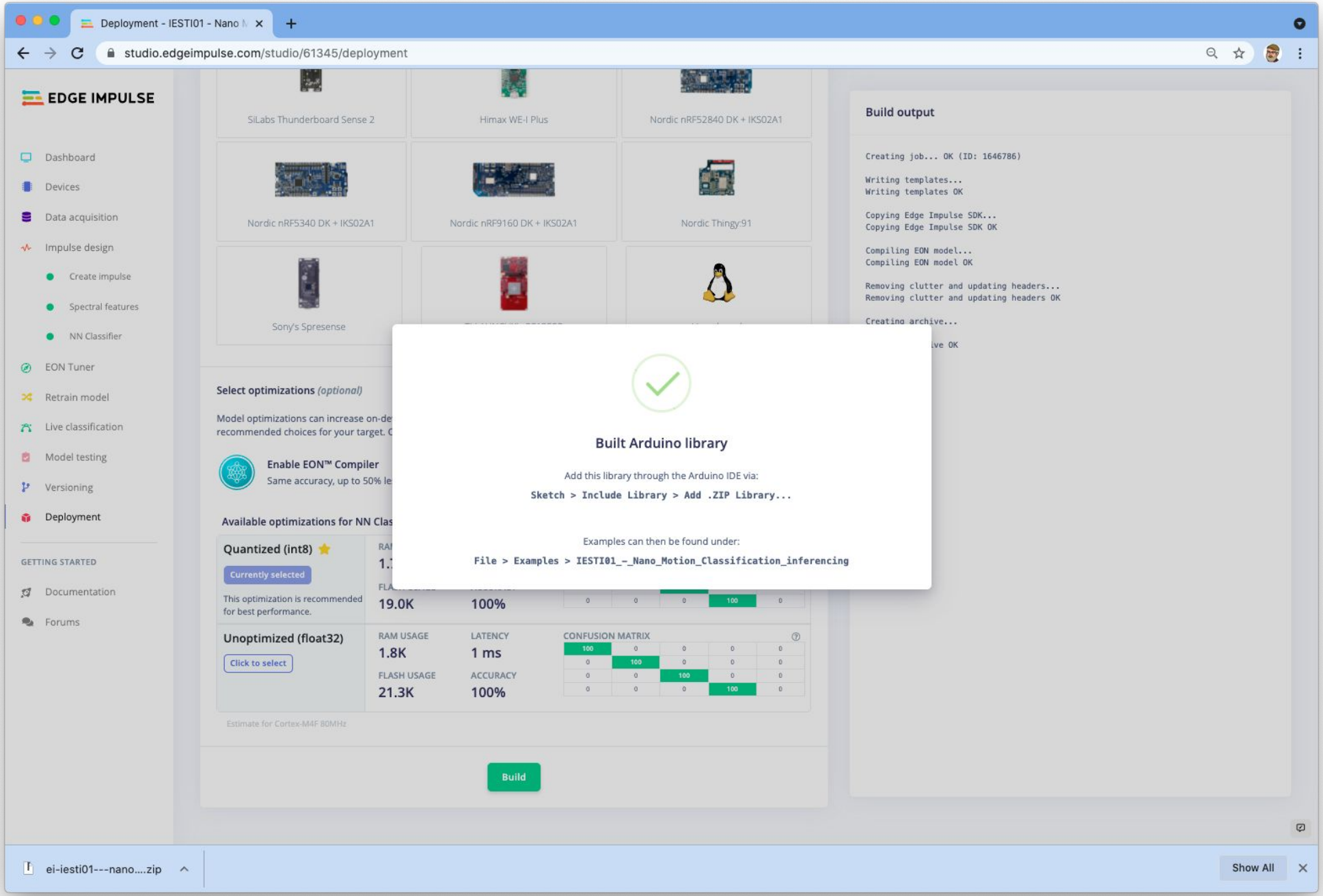
- idle - correct
- lift - correct
- maritime - correct
- terrestrial - correct





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


Deployment - IESTI01 - Nano
studio.edgeimpulse.com/studio/61345/deployment
EDGE IMPULSE
DEPLOYMENT (IESTI01 - NANO MOTION CLASSIFICATION)
MJRoBot (Marcelo Rovai)
Dashboard
Devices
Data acquisition
Impulse design
Create impulse
Spectral features
NN Classifier
EON Tuner
Retrain model
Live classification
Model testing
Versioning
Deployment
GETTING STARTED
Documentation
Forums
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
END OF LIFE
Eta Compute ECM3532 AI Sensor
SiLabs 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


Deployment - IESTI01 - Nano
studio.edgeimpulse.com/studio/61345/deployment
EDGE IMPULSE
Dashboard
Devices
Data acquisition
Impulse design
Create impulse
Spectral features
NN Classifier
EON Tuner
Retrain model
Live classification
Model testing
Versioning
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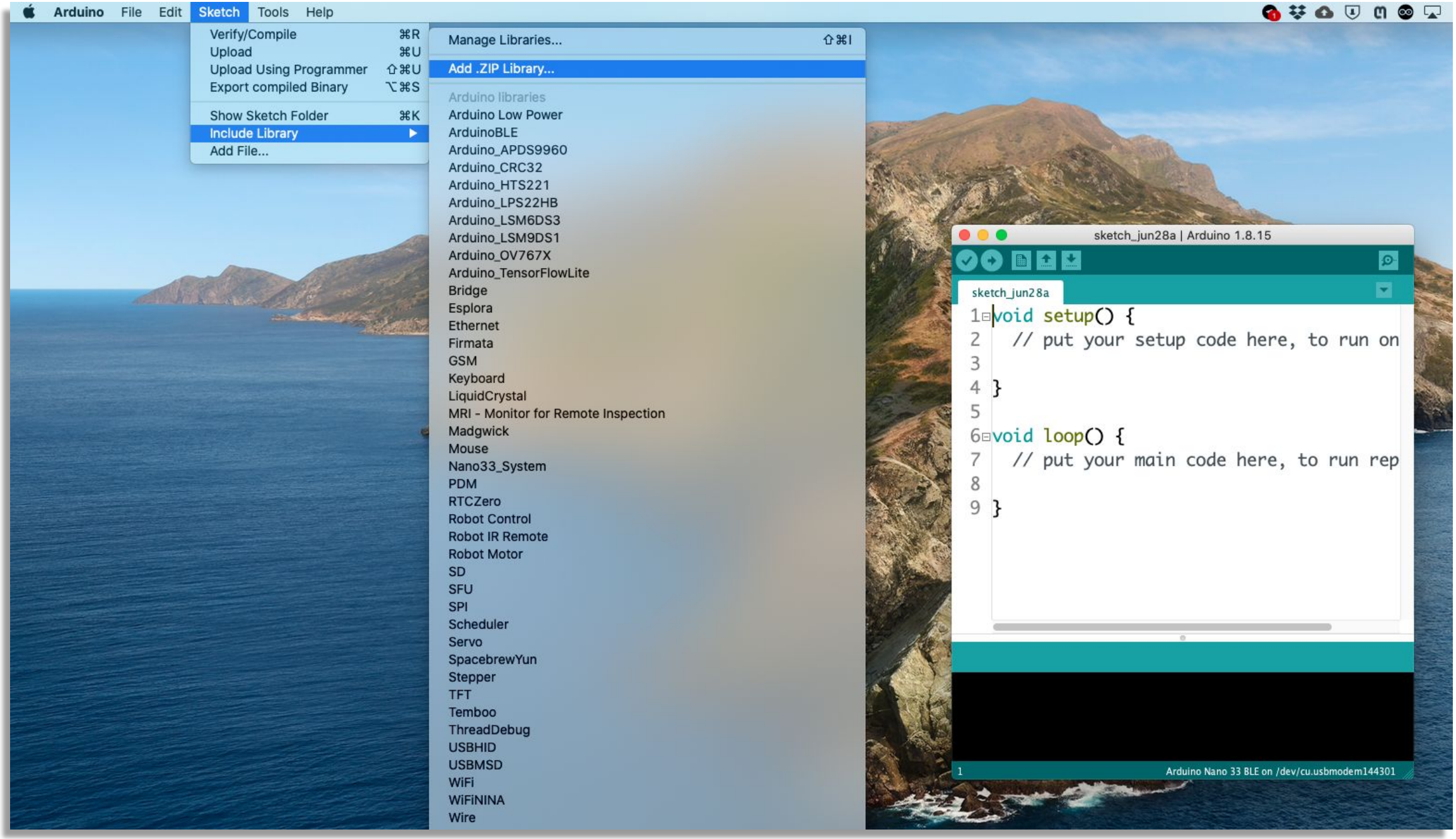
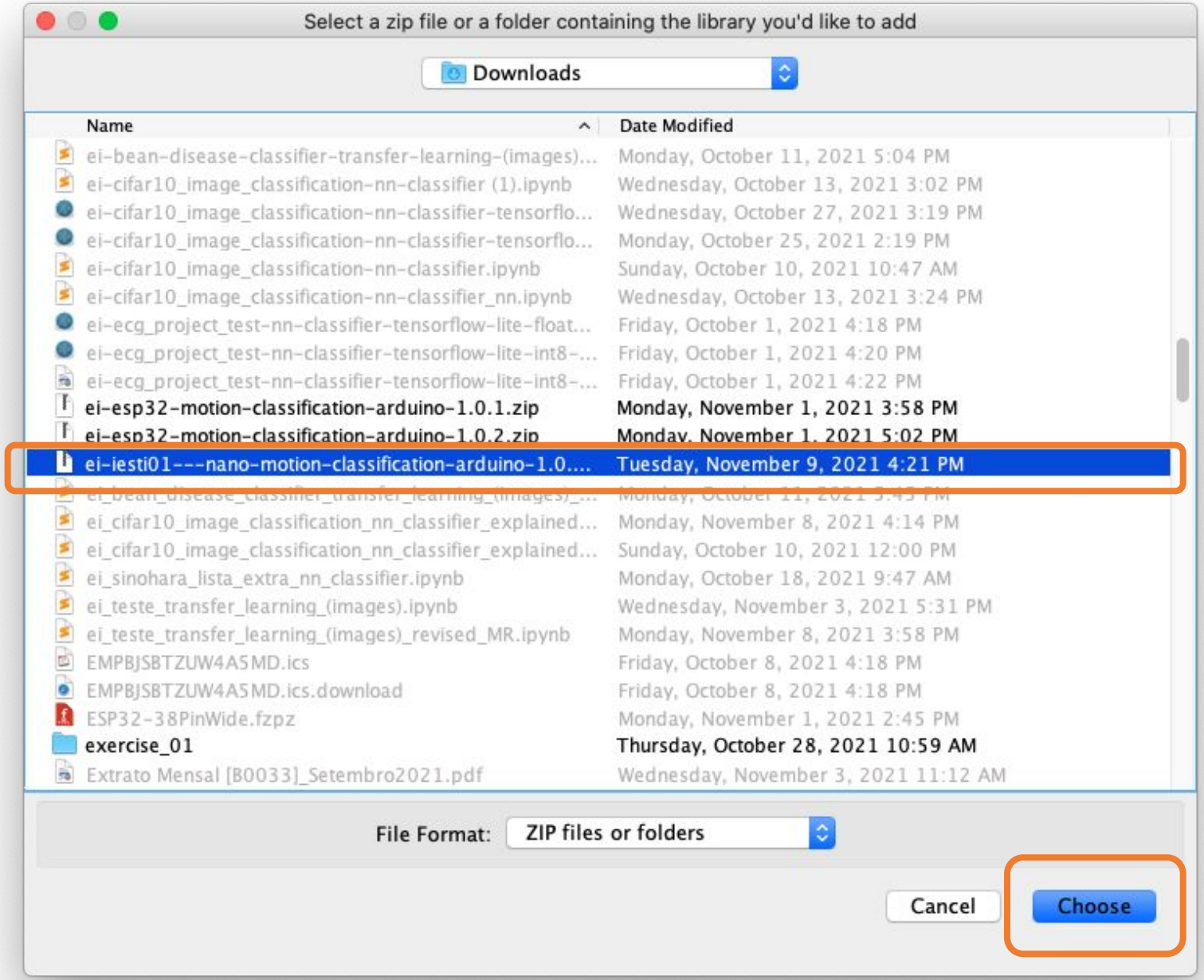
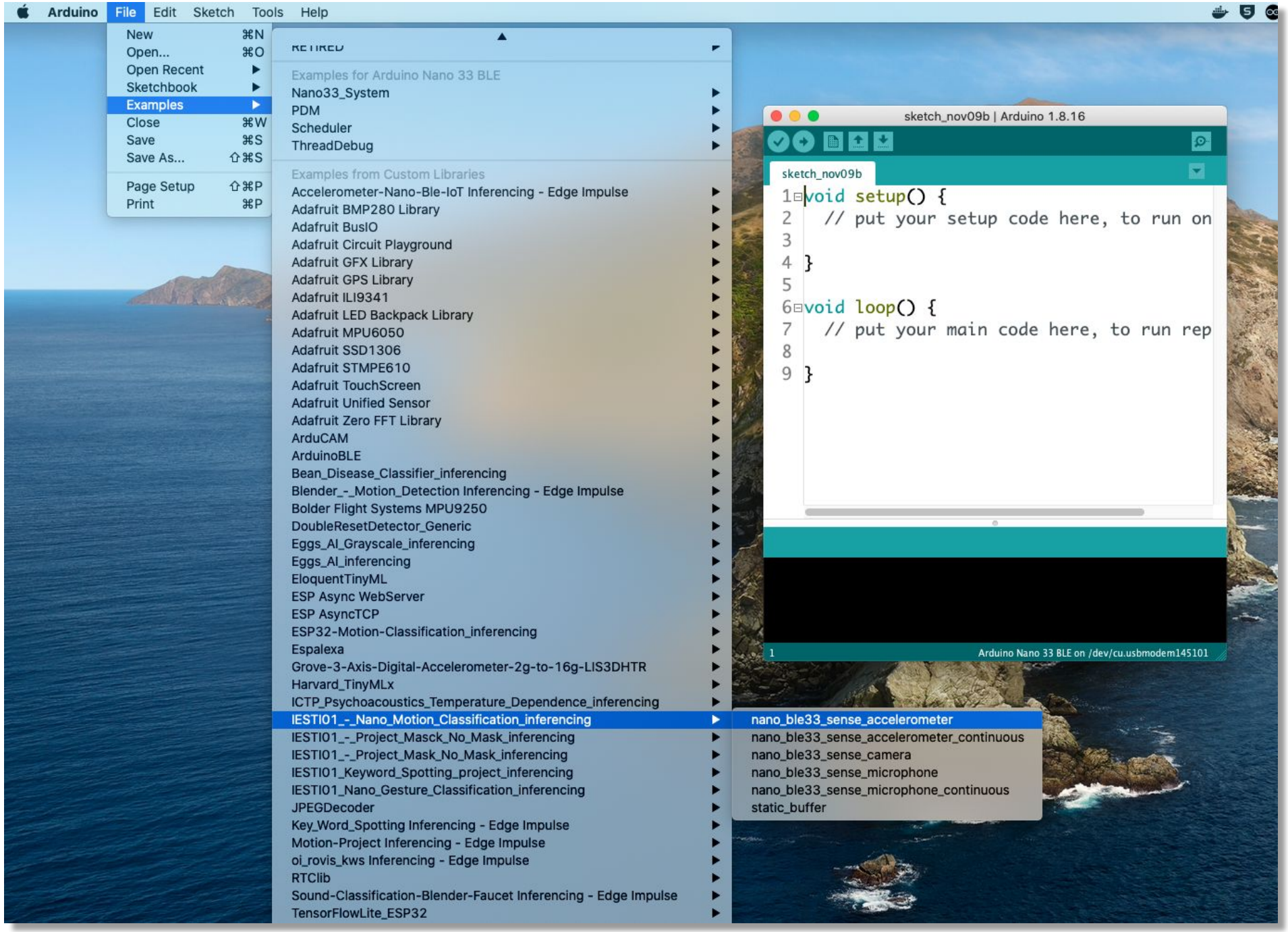
Documentation
Forums
SiLabs Thunderboard Sense 2
Himax WE-I Plus
Nordic nRF52840 DK + IKS02A1
Nordic nRF5340 DK + IKS02A1
Nordic nRF9160 DK + IKS02A1
Nordic Thingy:91
Sony's Spresense
Select optimizations (optional)
Enable EON™ Compiler
Available optimizations for NN Clas
Quantized (int8)
Currently selected
This optimization is recommended for best performance.
RAM USAGE
1.7
FLASH USAGE
19.0K
ACCURACY
100%
CONFUSION MATRIX
Unoptimized (float32)
Click to select
RAM USAGE
1.8K
LATENCY
1 ms
FLASH USAGE
21.3K
ACCURACY
100%
Estimate for Cortex-M4F 80MHz
Build
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
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...
ei-iesti01---nano....zip
Show All


Arduino File Edit Sketch Tools Help
Verify/Compile ⌘R
Upload ⌘U
Upload Using Programmer ⇧⌘U
Export compiled Binary ⌥⌘S
Show Sketch Folder ⌘K
Include Library
Add File...
Manage Libraries... ⇧⌘I
Add .ZIP Library...
Arduino libraries
Arduino Low Power
ArduinoBLE
Arduino_APDS9960
Arduino_CRC32
Arduino_HTS221
Arduino_LPS22HB
Arduino_LSM6DS3
Arduino_LSM9DS1
Arduino_OV767X
Arduino_TensorFlowLite
Bridge
Esplora
Ethernet
Firmata
GSM
Keyboard
LiquidCrystal
MRI - Monitor for Remote Inspection
Madgwick
Mouse
Nano33_System
PDM
RTCZero
Robot Control
Robot IR Remote
Robot Motor
SD
SFU
SPI
Scheduler
Servo
SpacebrewYun
Stepper
TFT
Temboo
ThreadDebug
USBHID
USBMSD
WiFi
WiFiNINA
Wire
sketch_jun28a | Arduino 1.8.15
sketch_jun28a
1 void setup() {
2 // put your setup code here, to run on
3
4 }
5
6 void loop() {
7 // put your main code here, to run rep
8
9 }
1
Arduino Nano 33 BLE on /dev/cu.usbmodem144301


Select a zip file or a folder containing the library you'd like to add
Downloads
Name
Date Modified
ei-bean-disease-classifier-transfer-learning-(images)... Monday, October 11, 2021 5:04 PM
ei-cifar10_image_classification-nn-classifier (1).ipynb Wednesday, October 13, 2021 3:02 PM
ei-cifar10_image_classification-nn-classifier-tensorflo... Wednesday, October 27, 2021 3:19 PM
ei-cifar10_image_classification-nn-classifier-tensorflo... Monday, October 25, 2021 2:19 PM
ei-cifar10_image_classification-nn-classifier.ipynb Sunday, October 10, 2021 10:47 AM
ei-cifar10_image_classification-nn-classifier_nn.ipynb Wednesday, October 13, 2021 3:24 PM
ei-ecg_project_test-nn-classifier-tensorflow-lite-float... Friday, October 1, 2021 4:18 PM
ei-ecg_project_test-nn-classifier-tensorflow-lite-int8-... Friday, October 1, 2021 4:20 PM
ei-ecg_project_test-nn-classifier-tensorflow-lite-int8-... Friday, October 1, 2021 4:22 PM
ei-esp32-motion-classification-arduino-1.0.1.zip Monday, November 1, 2021 3:58 PM
ei-esp32-motion-classification-arduino-1.0.2.zip Monday, November 1, 2021 5:02 PM
ei-iesti01---nano-motion-classification-arduino-1.0.... Tuesday, November 9, 2021 4:21 PM
ei_cifar10_image_classification_nn_classifier_explained... Monday, November 8, 2021 4:14 PM
ei_cifar10_image_classification_nn_classifier_explained... Sunday, October 10, 2021 12:00 PM
ei_sinohara_lista_extra_nn_classifier.ipynb Monday, October 18, 2021 9:47 AM
ei_teste_transfer_learning_(images).ipynb Wednesday, November 3, 2021 5:31 PM
ei_teste_transfer_learning_(images)_revised_MR.ipynb Monday, November 8, 2021 3:58 PM
EMPBJSBTZUW4A5MD.ics Friday, October 8, 2021 4:18 PM
EMPBJSBTZUW4A5MD.ics.download Friday, October 8, 2021 4:18 PM
ESP32-38PinWide.fzpz Monday, November 1, 2021 2:45 PM
exercise_01 Thursday, October 28, 2021 10:59 AM
Extrato Mensal [B0033]_Setembro2021.pdf Wednesday, November 3, 2021 11:12 AM
File Format:
ZIP files or folders
Cancel
Choose


Arduino
File
Edit
Sketch
Tools
Help
New ⌘N
Open... ⌘O
Open Recent
Sketchbook
Examples
Close ⌘W
Save ⌘S
Save As... ⇧⌘S
Page Setup ⇧⌘P
Print ⌘P
RETIRED
Examples for Arduino Nano 33 BLE
Nano33_System
PDM
Scheduler
ThreadDebug
Examples from Custom Libraries
Accelerometer-Nano-Ble-IoT Inferencing - Edge Impulse
Adafruit BMP280 Library
Adafruit BusIO
Adafruit Circuit Playground
Adafruit GFX Library
Adafruit GPS Library
Adafruit ILI9341
Adafruit LED Backpack Library
Adafruit MPU6050
Adafruit SSD1306
Adafruit STMPE610
Adafruit TouchScreen
Adafruit Unified Sensor
Adafruit Zero FFT Library
ArduCAM
ArduinoBLE
Bean_Disease_Classifier_inferencing
Blender_-_Motion_Detection Inferencing - Edge Impulse
Bolder Flight Systems MPU9250
DoubleResetDetector_Generic
Eggs_AI_Grayscale_inferencing
Eggs_AI_inferencing
EloquentTinyML
ESP Async WebServer
ESP AsyncTCP
ESP32-Motion-Classification_inferencing
Espalexa
Grove-3-Axis-Digital-Accelerometer-2g-to-16g-LIS3DHTR
Harvard_TinyMLx
ICTP_Psychoacoustics_Temperature_Dependence_inferencing
IESTI01_-_Nano_Motion_Classification_inferencing
IESTI01_-_Project_Masck_No_Mask_inferencing
IESTI01_-_Project_Mask_No_Mask_inferencing
IESTI01_Keyword_Spotting_project_inferencing
IESTI01_Nano_Gesture_Classification_inferencing
JPEGDecoder
Key_Word_Spotting Inferencing - Edge Impulse
Motion-Project Inferencing - Edge Impulse
oi_rovis_kws Inferencing - Edge Impulse
RTClib
Sound-Classification-Blender-Faucet Inferencing - Edge Impulse
TensorFlowLite_ESP32
nano_ble33_sense_accelerometer
nano_ble33_sense_accelerometer_continuous
nano_ble33_sense_camera
nano_ble33_sense_microphone
nano_ble33_sense_microphone_continuous
static_buffer
sketch_nov09b | Arduino 1.8.16
sketch_nov09b
1 void setup() {
2 // put your setup code here, to run on
3
4 }
5
6 void loop() {
7 // put your main code here, to run rep
8
9 }
1
Arduino Nano 33 BLE on /dev/cu.usbmodem145101

Model Inference

Arduino File Edit Sketch Tools Help

/dev/cu.usbmodem145101

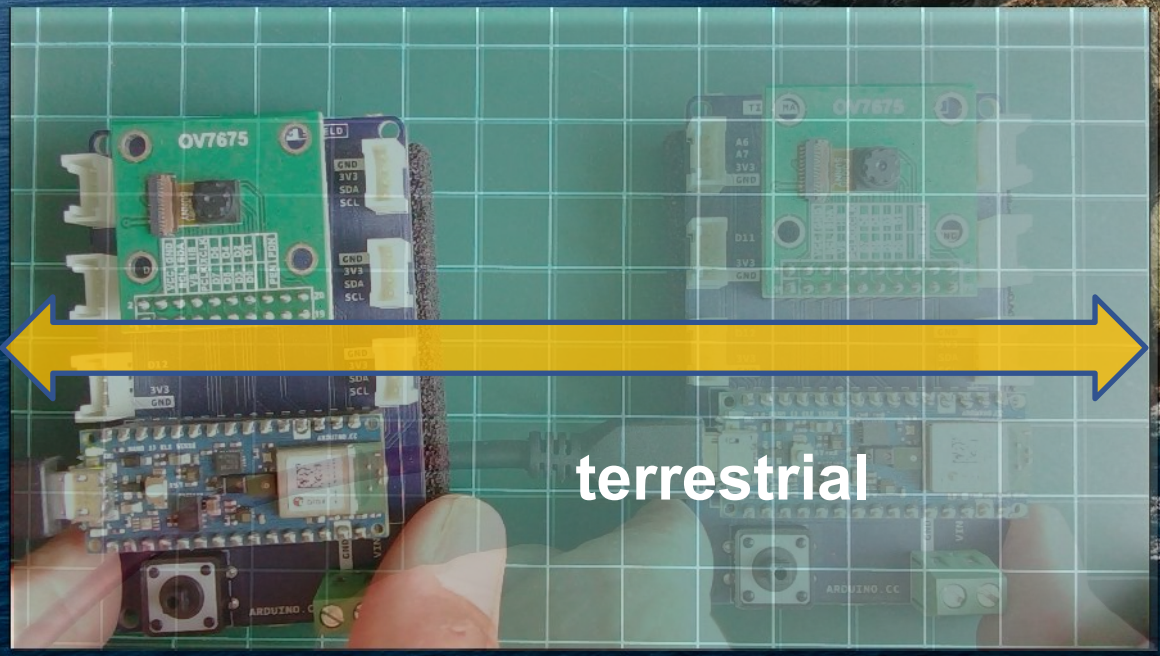
Send

```
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

```
/* Edge Impulse Arduino examples
 * Copyright (c) 2021 EdgeImpulse Inc.
 *
 * Permission is hereby granted, free of charge, to any person obtaining a cop
 * of this software and associated documentation files (the "Software"), to de
 * in the Software without restriction, including without limitation the right
 * to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
 * copies of the Software, and to permit persons to whom the Software is
 * furnished to do so, subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included in
 * all copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
 * FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL THE
 * AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
 * LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING FRO
 * OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN T
 * SOFTWARE.
 */

/* Includes ---------------------------------------------------------------- *
#include <IESTI01_-_Nano_Motion_Classification_inferencing.h>
#include <Arduino_LSM9DS1.h>

/* Constant defines -------------------------------------------------------- *
#define CONVERT_G_TO_MS2    9.80665f

/* Private variables ------------------------------------------------------- *
static bool debug_nn = false; // Set this to true to see e.g. features generat
```

```
Done in 6.027 seconds
reset()
```

15 Arduino Nano 33 BLE on /dev/cu.usbmodem145101

Quick Camera Camera Edit Window Help

/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: 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: 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

nano_ble33_sense_accelerometer_continuous | Arduino 1.8.16

nano_ble33_sense_accelerometer_continuous

```
/* Includes ---------------------------------------------------------------
#include <IESTI01_-_Nano_Motion_Classification_inferencing.h>
#include <Arduino_LSM9DS1.h>

/* Constant defines -------------------------------------------------------
#define CONVERT_G_TO_MS2    9.80665f

/* Private variables ------------------------------------------------------
static bool debug_nn = false; // Set this to true to see e.g. features
static uint32_t run_inference_every_ms = 200;
static rtos::Thread inference_thread(osPriorityLow);
static float buffer[EI_CLASSIFIER_DSP_INPUT_FRAME_SIZE] = { 0 };
static float inference_buffer[EI_CLASSIFIER_DSP_INPUT_FRAME_SIZE];

/* Forward declaration */
void run_inference_background();

/**
* @brief      Arduino setup function
*/
void setup()
{
    // put your setup code here, to run once:
    Serial.begin(115200);
    Serial.println("Edge Impulse Inferencing Demo");

    if (!IMU.begin()) {
        ei_printf("Failed to initialize IMU!\r\n");
    }
    else {
        ei_printf("IMU initialized\r\n");
    }
```

Done uploading.

```
Done in 6.034 seconds
reset()
```

40 Arduino Nano 33 BLE on /dev/cu.usbmodem145101

TinyML motion classification uses on Real Life

Cow Monitoring

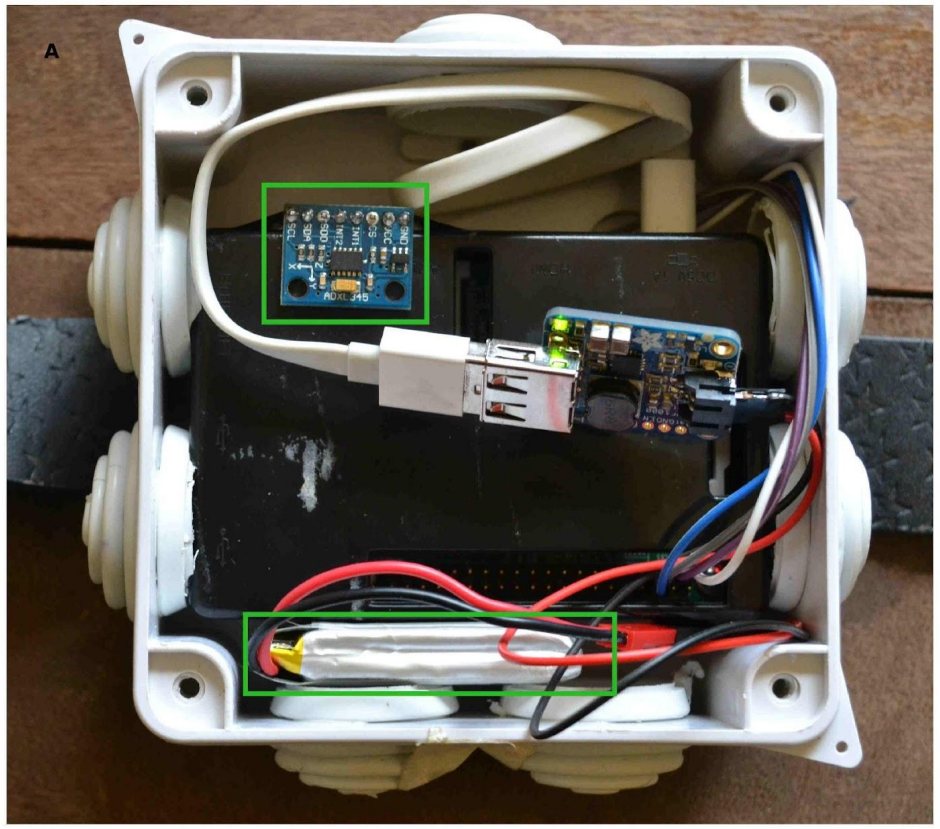
Using the Internet of Things for Agricultural Monitoring

"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."

Ciira wa Maina, Ph.D.

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

Kenia



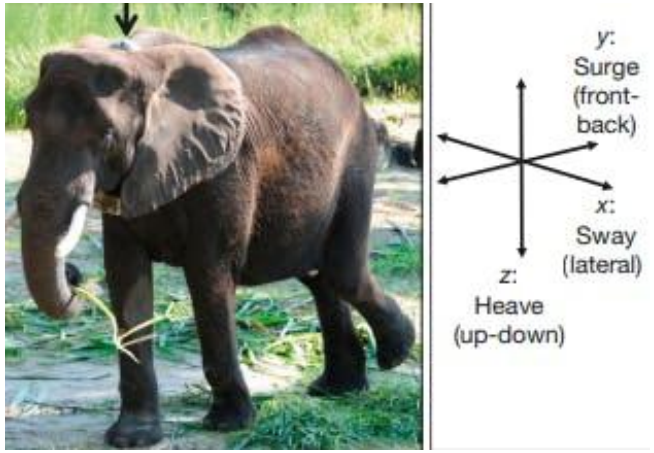
https://sites.google.com/site/cwamainadekut/research

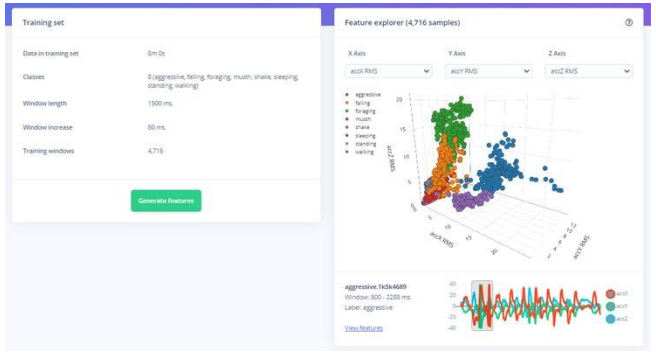
Predict and classify common Elephant behavior

Aggressive

Standing

Sleeping





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

Thanks