

SciTinyML

Scientific Use of Machine Learning on Low Power Devices

Regional Workshop - Africa

Anomaly Detection and Post-Processing Hands-On Lab



Marcelo Rovai
Professor, UNIFEI - Brazil

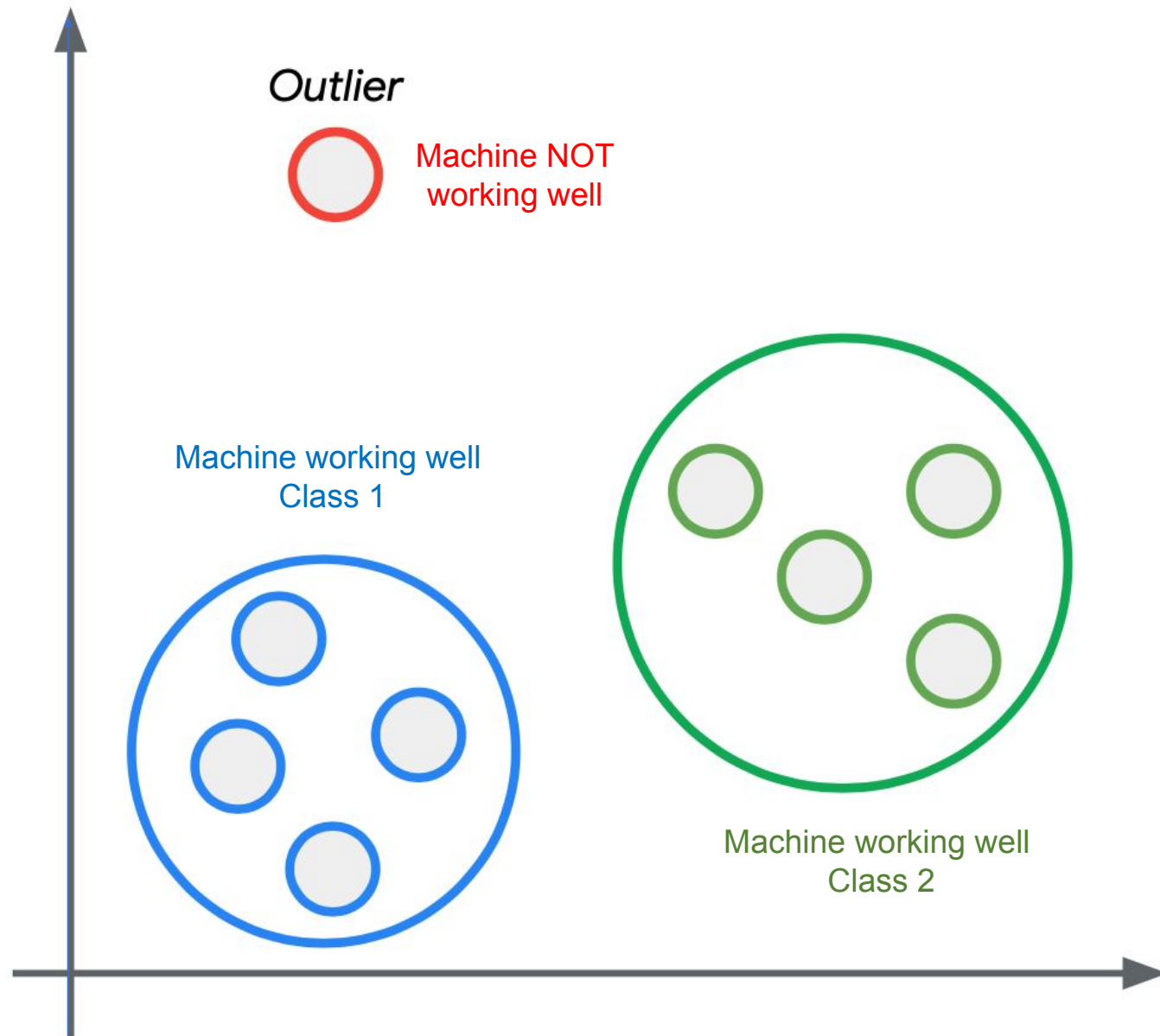
Shawn Himel
Senior DevRel Engineer, Edge Impulse

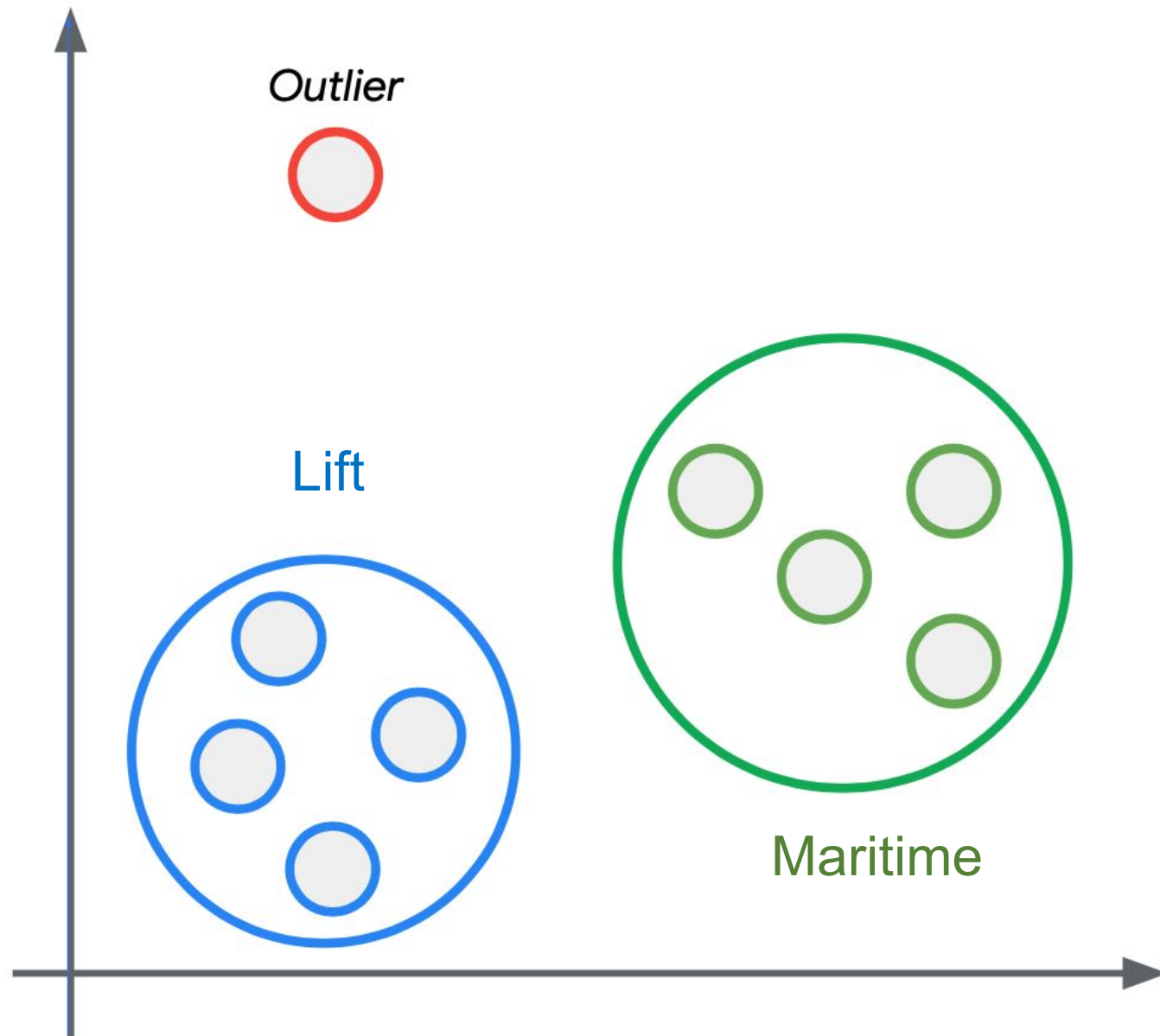


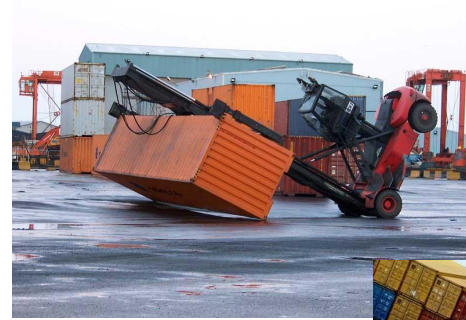
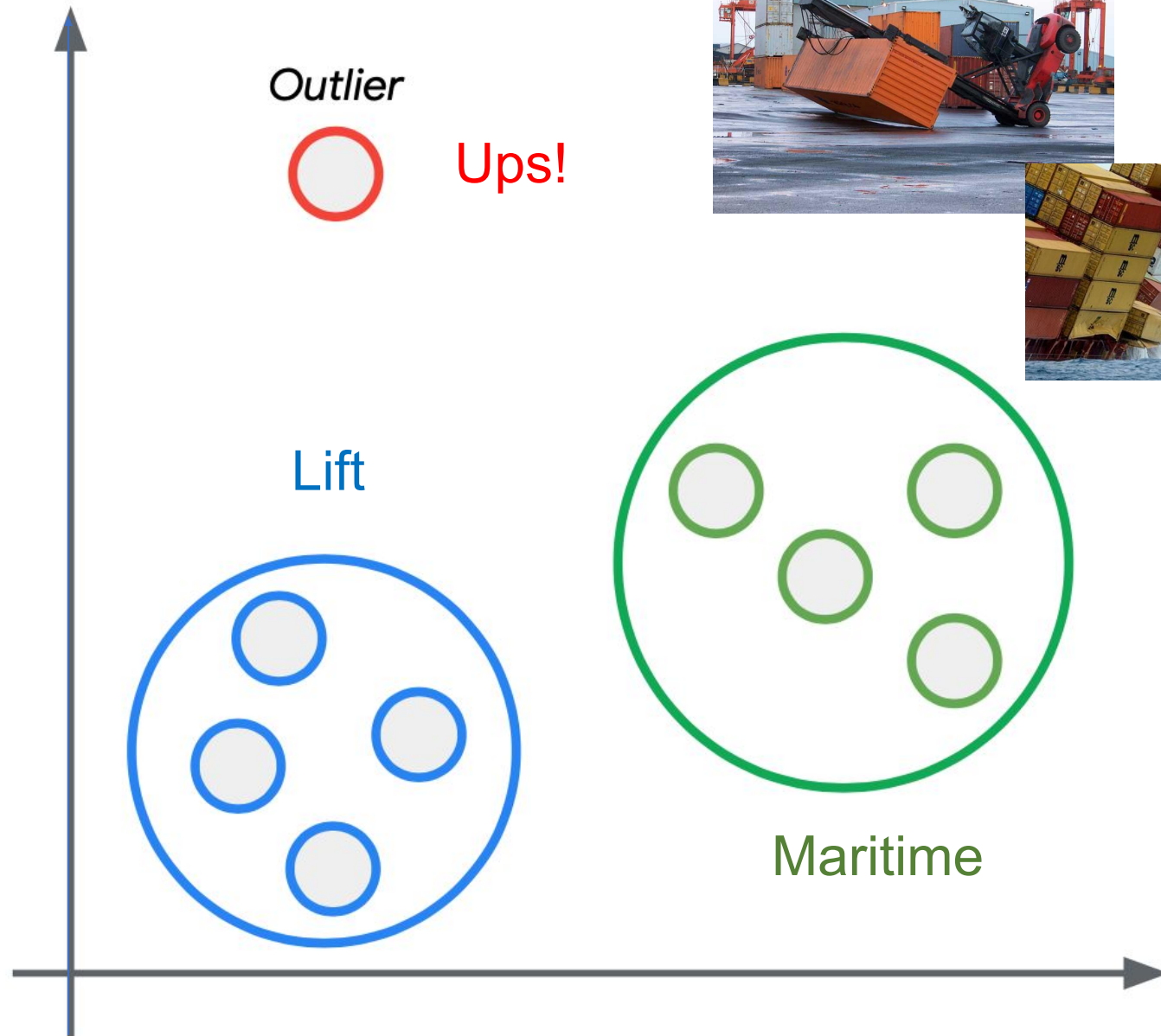
Anomaly Detection

What is Anomaly Detection?

In **data analysis**, **anomaly detection** is the **identification of rare** items, events or observations which **raise suspicions** because they **differing significantly** from the **majority of the data**.

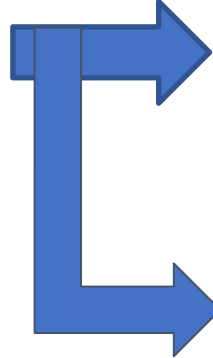








Spectral
Analysis



NN
Classifier

K-Means



Classes

- Lift
- Terrestrial
- Maritime
- Idle

- Anomaly

CREATE IMPULSE (IEST101 - NANO MOTION CLASSIFICATION)

MJRoBot (Marcelo Roval)

An impulse takes raw data, uses signal processing to extract features, and then uses a learning block to classify new data.

Time series data

Axes
accX, accY, accZ

Window size

Window increase

Frequency (Hz)
100

Zero-pad data

Spectral Analysis

Classification (Keras)

Output features

4 (idle, lift, maritime, terrestrial)

Save Impulse

Add a learning block

Some learning blocks have been hidden based on the data in your project.

DESCRIPTION	AUTHOR	RECOMMENDED	
Classification (Keras) Learns patterns from data, and can apply these to new data. Great for categorizing movement or recognizing audio.	EdgeImpulse Inc.	★	Add
Anomaly Detection (K-means) Find outliers in new data. Good for recognizing unknown states, and to complement classifiers.	EdgeImpulse Inc.	★	Add
Regression (Keras) Learns patterns from data, and can apply these to new data. Great for predicting numeric continuous values.	EdgeImpulse Inc.		Add

Cancel

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CREATE IMPULSE (IEST101 - NANO MOTION CLASSIFICATION)

MJRoBot (Marcelo Rovai)

An impulse takes raw data, uses signal processing to extract features, and then uses a learning block to classify new data.

Time series data

Axes
accX, accY, accZ

Window size
2000 ms.

Window increase
80 ms.

Frequency (Hz)
100

Zero-pad data

Spectral Analysis

Name
Spectral features

Input axes
 accX
 accY
 accZ

Add a processing block

Classification (Keras)

Name
NN Classifier

Input features
 Spectral features

Output features
4 (idle, lift, maritime, terrestrial)

Output features

5 (idle, lift, maritime, terrestrial, Anomaly score)

Save Impulse

Anomaly Detection (K-means)

Name
Anomaly detection

Input features
 Spectral features

Output features
1 (Anomaly score)

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

- EDGE IMPULSE
- Dashboard
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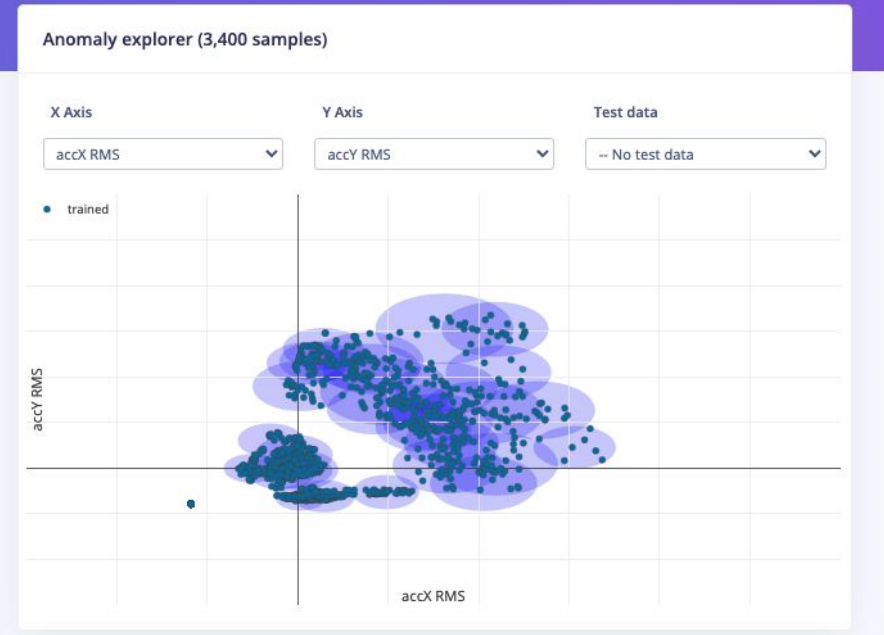
Anomaly detection settings

Cluster count: 32

Axes Select all axes

<input checked="" type="checkbox"/> accX RMS ★	<input type="checkbox"/> accY Spectral Power 0.1 - 0.5
<input type="checkbox"/> accX Peak 1 Freq	<input type="checkbox"/> accY Spectral Power 0.5 - 1.0
<input type="checkbox"/> accX Peak 1 Height	<input type="checkbox"/> accY Spectral Power 1.0 - 2.0
<input type="checkbox"/> accX Peak 2 Freq	<input type="checkbox"/> accY Spectral Power 2.0 - 5.0
<input type="checkbox"/> accX Peak 2 Height	<input checked="" type="checkbox"/> accZ RMS ★
<input type="checkbox"/> accX Peak 3 Freq	<input type="checkbox"/> accZ Peak 1 Freq
<input type="checkbox"/> accX Peak 3 Height	<input type="checkbox"/> accZ Peak 1 Height
<input type="checkbox"/> accX Spectral Power 0.1 - 0.5	<input type="checkbox"/> accZ Peak 2 Freq
<input type="checkbox"/> accX Spectral Power 0.5 - 1.0	<input type="checkbox"/> accZ Peak 2 Height
<input type="checkbox"/> accX Spectral Power 1.0 - 2.0	<input type="checkbox"/> accZ Peak 3 Freq
<input type="checkbox"/> accX Spectral Power 2.0 - 5.0	<input type="checkbox"/> accZ Peak 3 Height
<input checked="" type="checkbox"/> accY RMS ★	<input type="checkbox"/> accZ Spectral Power 0.1 - 0.5
<input type="checkbox"/> accY Peak 1 Freq	<input type="checkbox"/> accZ Spectral Power 0.5 - 1.0
<input type="checkbox"/> accY Peak 1 Height	<input type="checkbox"/> accZ Spectral Power 1.0 - 2.0
<input type="checkbox"/> accY Peak 2 Freq	<input type="checkbox"/> accZ Spectral Power 2.0 - 5.0
<input type="checkbox"/> accY Peak 2 Height	
<input type="checkbox"/> accY Peak 3 Freq	
<input type="checkbox"/> accY Peak 3 Height	

Start training

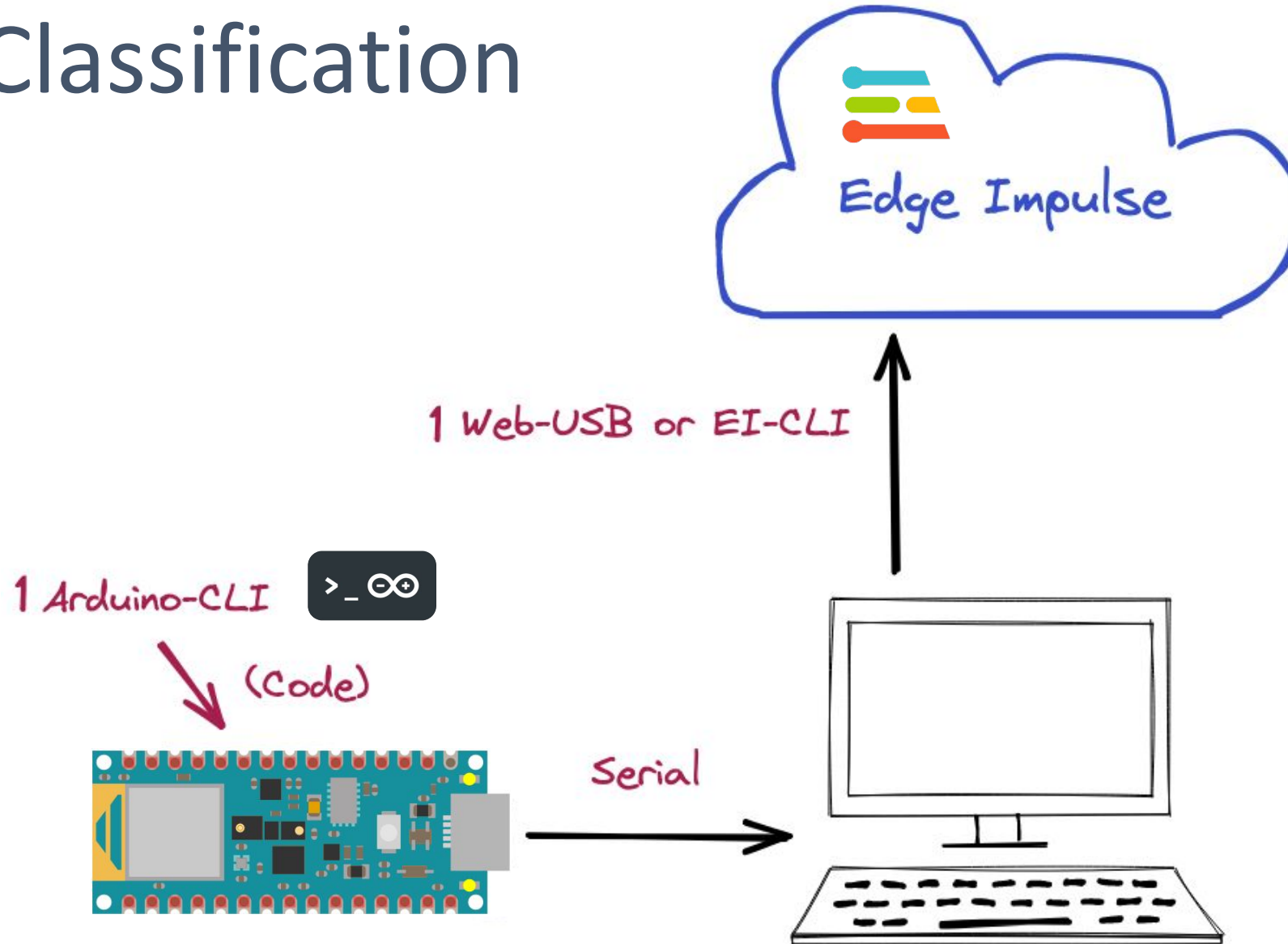


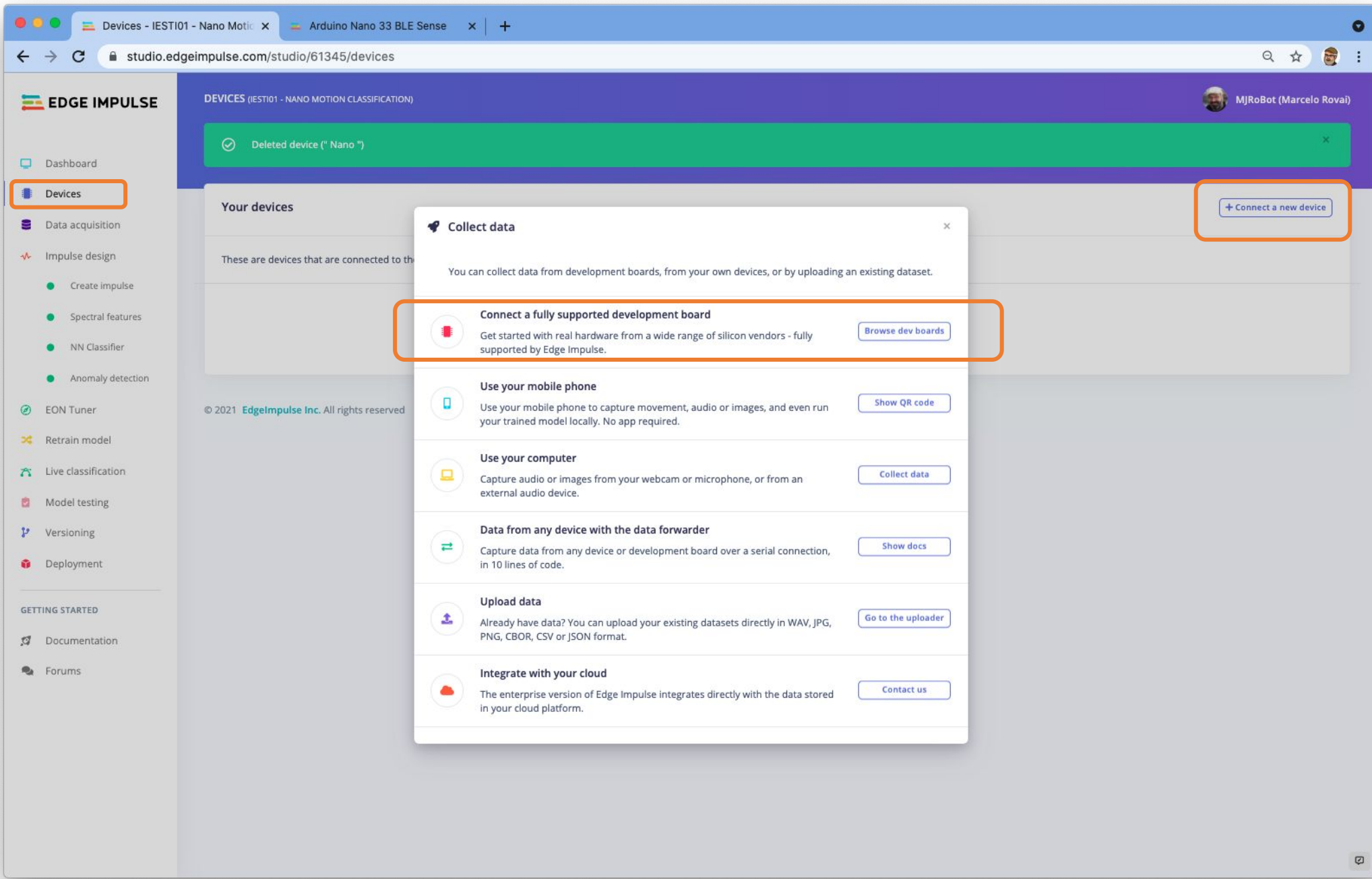
Training output

```
0.6082163453102112, 0.25316372513771057], 'max_error': 0.34954408210594134}, {'center': [-0.5115050673484802, -0.004735563416033983, 0.709574282169342], 'max_error': 0.2947459724666345}, {'center': [2.031501531600952, 1.2126123905181885, 1.129497766494751], 'max_error': 0.6769873962564943}, {'center': [1.391443133354187, 0.9029868841171265, 0.8108663558959961], 'max_error': 0.5210900944982784}, {'center': [0.035471659153699875, 1.796299695968628, 1.2969461679458618], 'max_error': 0.5249936584588187}, {'center': [0.10634401440620422, 2.2963626384735107, 0.7528809985052185], 'max_error': 0.44105256183930464}, {'center': [1.6457377672195435, 1.7475732564926147, 1.4299843311309814], 'max_error': 0.5520137297917197}, {'center': [2.219975709915161, 2.0978941917419434, 0.7476416230201721], 'max_error': 0.5746162180430946}, {'center': [0.032550420612096786, -0.03719609975814819, 1.598340256690979], 'max_error': 0.4070282568799601}, {'center': [0.2832728922367096, 2.612391710281372, 1.1812870502471924], 'max_error': 0.43737044666248764}, {'center': [1.6214791536331177, 3.0532443523406982, 1.385027527809143], 'max_error': 0.7516882902121250}, {'center': [0.974450409412384, 1.6822280883789062, 1.557731032371521], 'max_error': 0.7167072825903013}, {'center': [3.062652111053467, 0.4566035866737366, 0.4609105587005615], 'max_error': 0.4446181809668133}]
```

Job completed

Live Classification





Deleted device (" Nano ")

Dashboard

Devices

Data acquisition

Impulse design

- Create impulse
- Spectral features
- NN Classifier
- Anomaly detection

EON Tuner

Retrain model

Live classification

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GETTING STARTED

Documentation

Forums

Your devices

These are devices that are connected to the

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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](#)

+ Connect a new device

Devices - IESTI01 - Nano Moti... x Arduino Nano 33 BLE Sense x +


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

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
- Nordic Semi nRF9160 DK
- Nordic Semi Thingy:91
- SiLabs Thunderboard Sense 2
- Sony's Spresense
- Syntiant TinyML Board
- TI CC1352P Launchpad
- Arduino Portenta H7 + Vision shield (preview)
- Raspberry Pi 4
- NVIDIA Jetson Nano
- Mobile phone
- Porting guide



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

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:

```
edge-impulse-daemon
```

This will start a wizard which will ask you to log in, and choose an Edge Impulse project. If you want to switch projects run the command with `--clean` .


Alternatively, recent versions of Google Chrome and Microsoft Edge can collect data directly from your development board, without the need for the Edge Impulse CLI. See [this blog post](#) for more information.

4. Verifying that the device is connected

That's all! Your device is now connected to Edge Impulse. To verify this, go to [your Edge Impulse project](#), and click **Devices**. The device will be listed here.

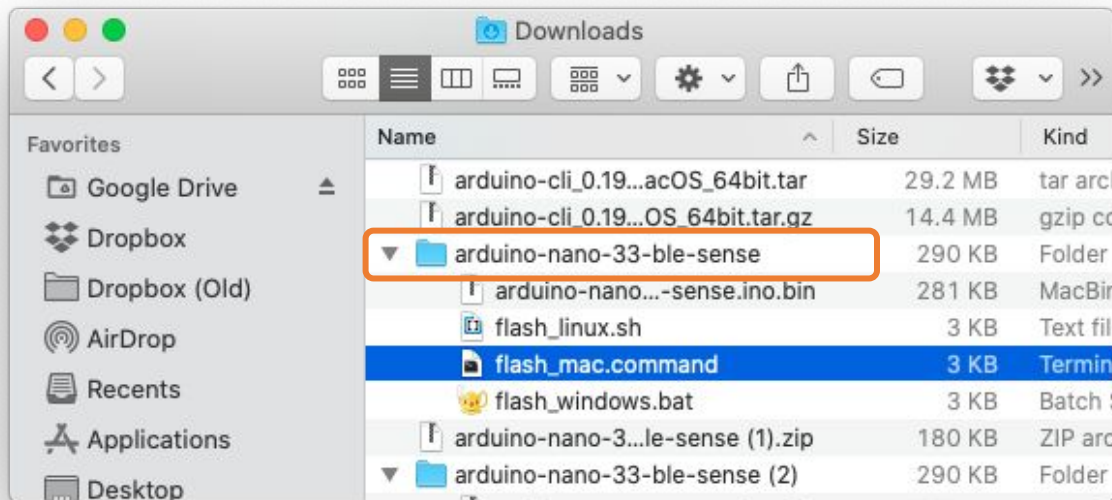
Your devices + Connect a new device

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	REM...	LAST SEEN
 Jan's Nano 33 BLE Sense	51:05:F2:F4:3D:C1	ARDUINO_NANO3...	Built-in accelerometer...	●	Today, 18:40:09

<https://cdn.edgeimpulse.com/firmware/arduino-nano-33-ble-sense.zip>

arduino-nano-33....zip Show All ×



```
mjrovai — flash_mac.command — 80x43
Last login: Thu Nov 11 14:24:32 on ttys000
You have new mail.
/Users/mjrovai/Downloads/arduino-nano-33-ble-sense/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-3
3-ble-sense/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 10.982 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.
Deleting expired sessions...none found.

[Process completed]
```

studio.edgeimpulse.com wants to connect to a serial port

- cu.Bluetooth-Incoming-Port
- cu.MALS
- cu.RovaisAirPods-Wirelessi
- cu.SOC
- Arduino Nano 33 BLE (cu.usbmodem145101) - Paired**

Cancel Connect

TRAIN / TEST SPLIT
80% / 20%

Record new data
Connect using WebUSB

No devices connected to the remote management API.

RAW DATA
Click on a sample to load...

ADDED	LENGTH	
Nov 09 2021, 15:06:09	1m 20s	
Nov 09 2021, 14:57:35	10s	
Nov 09 2021, 14:57:13	10s	
Nov 09 2021, 14:56:48	10s	
Nov 09 2021, 14:56:31	10s	
Nov 09 2021, 14:55:55	10s	
Nov 09 2021, 14:55:36	10s	
Nov 09 2021, 14:55:19	10s	
Nov 09 2021, 14:55:00	10s	
Nov 09 2021, 14:41:45	10s	
Nov 09 2021, 14:41:26	10s	
Nov 09 2021, 14:41:06	10s	

maritime.json.2jvi5bit maritime Nov 09 2021, 14:56:48 10s

maritime.json.2jvi4q7J maritime Nov 09 2021, 14:56:31 10s

maritime.json.2jvi3nhg maritime Nov 09 2021, 14:55:55 10s

maritime.json.2jvi354j maritime Nov 09 2021, 14:55:36 10s

maritime.json.2jvi2rj maritime Nov 09 2021, 14:55:19 10s

maritime.json.2jvi21ls maritime Nov 09 2021, 14:55:00 10s

lift.json.2jvh9pe3 lift Nov 09 2021, 14:41:45 10s

lift.json.2jvh96uh lift Nov 09 2021, 14:41:26 10s

lift.json.2jvh8j6q lift Nov 09 2021, 14:41:06 10s

ei-iesti01---nano....zip Show All

Alternative option with Edge Impulse CLI

```
mjrovai — node /usr/local/bin/edge-impulse-daemon --clean — 80x45
Last login: Mon Nov 15 17:22:34 on ttys001
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-daemon --clean ]
Edge Impulse serial daemon v1.13.16
[? What is your user name or e-mail address (edgeimpulse.com)? rovai@mjrobot.org ]
[? What is your password? [hidden] ]
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, trying to read config...
[SER] Clearing configuration
[SER] Clearing configuration OK
[SER] Retrieved configuration
[SER] Device is running AT command version 1.6.0

? 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) / IESTI01 - Motion Classification Test
MJRoBot (Marcelo Rovai) / ICTP_Mosquito_Sound_Classification
MJRoBot (Marcelo Rovai) / Mosquito Wingbeat Sound 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
(Hove up and down to reveal more choices)
```

```
mjrovai — node /usr/local/bin/edge-impulse-daemon --clean — 80x39
Last login: Mon Nov 15 17:22:34 on ttys001
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-daemon --clean ]
Edge Impulse serial daemon v1.13.16
[? What is your user name or e-mail address (edgeimpulse.com)? rovai@mjrobot.org ]
[? What is your password? [hidden] ]
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, trying to read config...
[SER] Clearing configuration
[SER] Clearing configuration OK
[SER] Retrieved configuration
[SER] Device is running AT command version 1.6.0

? To which project do you want to connect this device? MJRoBot (Marcelo Rovai) /
  IESTI01 - Nano Motion Classification
Setting upload host in device... OK
Configuring remote management settings... OK
Configuring API key in device... OK
Configuring HMAC key in device... OK
[SER] Device is not connected to remote management API, will use daemon
[WS ] Connecting to wss://remote-mgmt.edgeimpulse.com
[WS ] Connected to wss://remote-mgmt.edgeimpulse.com
[? What name do you want to give this device? nano ]
[WS ] Device "nano" is now connected to project "IESTI01 - Nano Motion Classific
ation"
[WS ] Go to https://studio.edgeimpulse.com/studio/61345/acquisition/training to
build your machine learning model!
```


Devices - IESTI01 - Nano Moti... x +

studio.edgeimpulse.com/studio/61345/devices

EDGE IMPULSE



DEVICES (IESTI01 - NANO MOTION CLASSIFICATION)

MJRoBot (Marcelo Roval)

Deleted device ("Nano")


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 ...	LAST SEEN
 36:17:55:F9:70:F7	36:17:55:F9:70:F7	ARDUINO_NANO33BLE	Built-in accelerometer, Built-in micro...		Today, 17:45:37

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Collect data



Device 36:17:55:F9:70:F7 is now connected

[Get started!](#)

Dashboard

Devices

Data acquisition

Impulse design

- Create impulse
- Spectral features
- NN Classifier
- Anomaly detection

EON Tuner

Retrain model

Live classification

Model testing

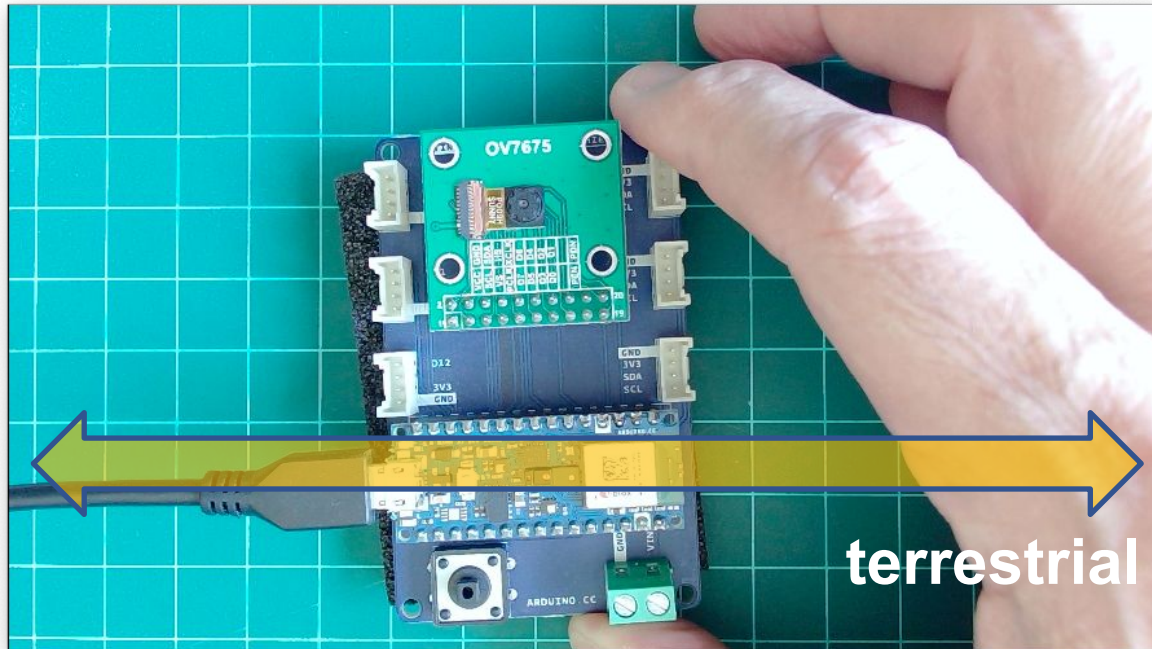
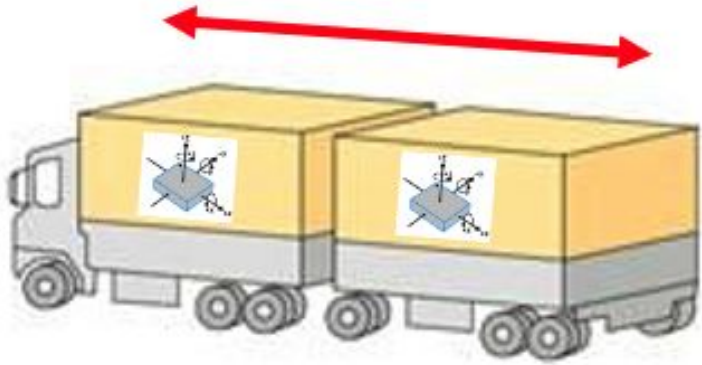
Versioning

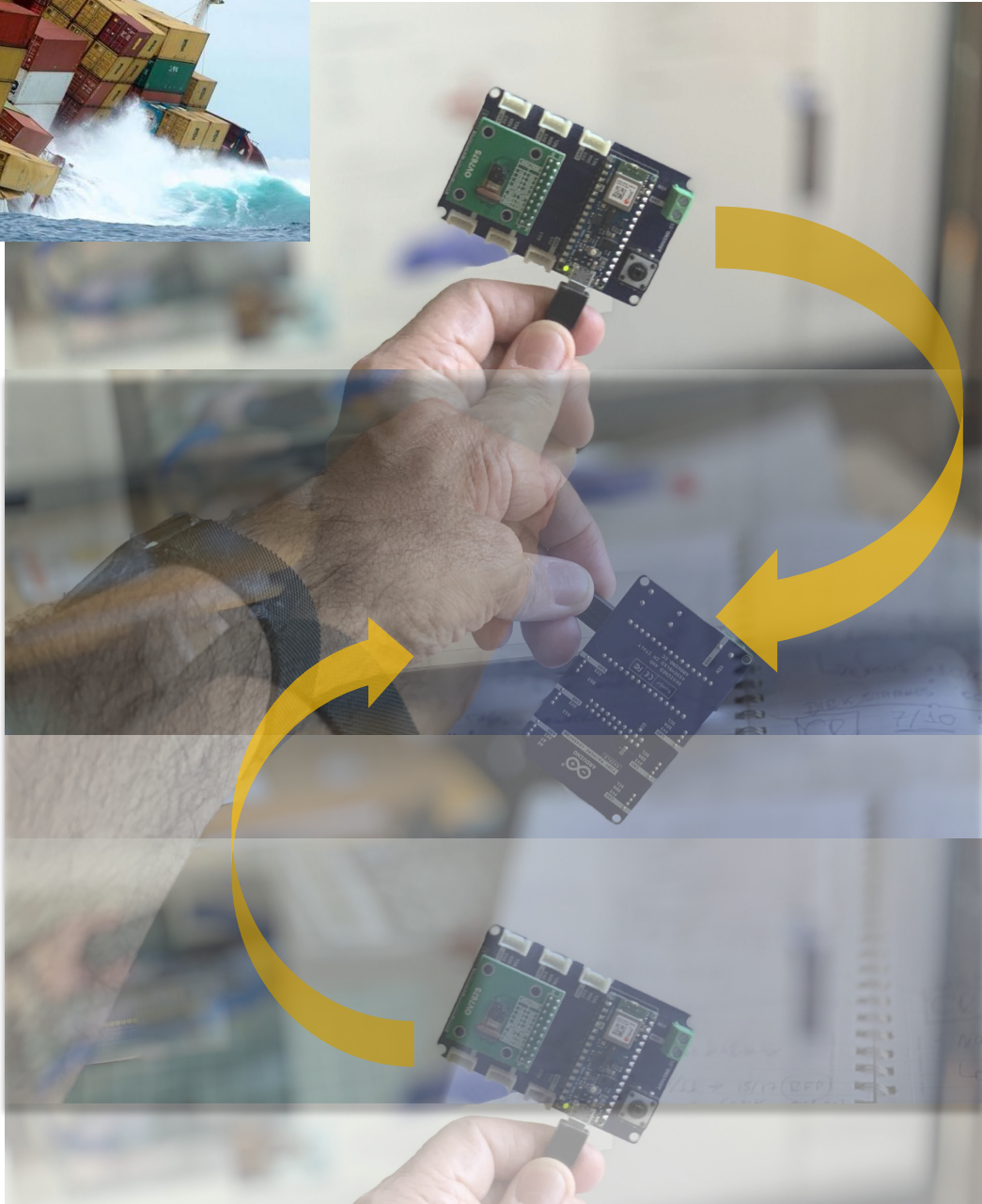
Deployment

GETTING STARTED

- Documentation
- Forums

Test: terrestrial





Classification result

Summary

Name

Expected outcome

CATEGORY	COUNT
idle	0
lift	0
maritime	7
terrestrial	0
uncertain	0
anomaly	94

Anomaly explorer (3,501 samples)

X Axis

Y Axis

- trained
- classified
- classification 0

accY RMS



accX RMS

Distance from closest cluster

accX RMS: 0.2653, accY RMS: 1.3105, accZ RMS: 0.8946

Send

Starting inferencing in 2 seconds...

Sampling...

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

idle: 0.00000

lift: 0.00000

maritime: 0.99609

terrestrial: 0.00000

anomaly score: 0.620

Starting inferencing in 2 seconds...

Sampling...

Predictions (DSP: 20 ms., Classification: 0 ms., Anomaly: 2 ms.):

idle: 0.00000

lift: 0.00000

maritime: 0.99609

terrestrial: 0.00000

anomaly score: 1.470

Autoscroll Show timestamp

Both NL & CR

115200 baud

Clear output

Pos-processing

Turn on/off LEDS

- Idle : ==> All OFF
- lift: ==> **Green ON**
- maritime: ==> **Red ON**
- terrestrial: ==> **Blue ON**
- Anomaly ==> **LED_BUILTIN ON**

```
motion_classification_nano_ble33_sense_accelerometer | Arduino 1.8.16
motion_classification_nano_ble33_sense_accelerometer $
36 void setup()
37 {
38     Serial.begin(115200);
39     while (!Serial);
40
41     Serial.println("IESTI01 - Nano Motion Classification - Inferencing Test");
42
43     pinMode(LED_BUILTIN, OUTPUT);
44     pinMode(LEDR, OUTPUT);
45     pinMode(LEDG, OUTPUT);
46     pinMode(LEDB, OUTPUT);
47
48     // Ensure the LED is off by default.
49     digitalWrite(LED_BUILTIN, LOW);
50     digitalWrite(LEDR, HIGH);
51     digitalWrite(LEDG, HIGH);
52     digitalWrite(LEDB, HIGH);
53
54     if (!IMU.begin()) {
55         ei_printf("Failed to initialize IMU!\r\n");
56     }
57     else {
58         ei_printf("IMU initialized\r\n");
59     }
60
61     if (EI_CLASSIFIER_RAW_SAMPLES_PER_FRAME != 3) {
62         ei_printf("ERR: EI_CLASSIFIER_RAW_SAMPLES_PER_FRAME should be equal to 3 (t
63         return;
64     }
65 }
66
Done Saving.
[=====] 100% (39/39 pages)
Done in 6.193 seconds
reset()
```

```
motion_classification_nano_ble33_sense_accelerometer | Arduino 1.8.16
motion_classification_nano_ble33_sense_accelerometer $
66
67 void turn_off_leds(){
68     digitalWrite(LEDR, HIGH);
69     digitalWrite(LEDG, HIGH);
70     digitalWrite(LEDB, HIGH);
71 }
72 /*
73
74
75
76
77
78
79
80 void turn_on_leds(int pred_index) {
81     switch (pred_index)
82     {
83         case 0: // Idle: [0] ==> All OFF
84             turn_off_leds();
85             break;
86
87         case 1: // lift: [1] ==> Green ON
88             turn_off_leds();
89             digitalWrite(LEDG, LOW);
90             break;
91
92         case 2: // maritime: [2] ==> Red ON
93             turn_off_leds();
94             digitalWrite(LEDR, LOW);
95             break;
96
97         case 3: //terrestrial:[3] ==> Blue ON
98             turn_off_leds();
99             digitalWrite(LEDB, LOW);
100            break;
101    }
102
Done Saving.
[=====] 100% (39/39 pages)
Done in 6.193 seconds
reset()
```

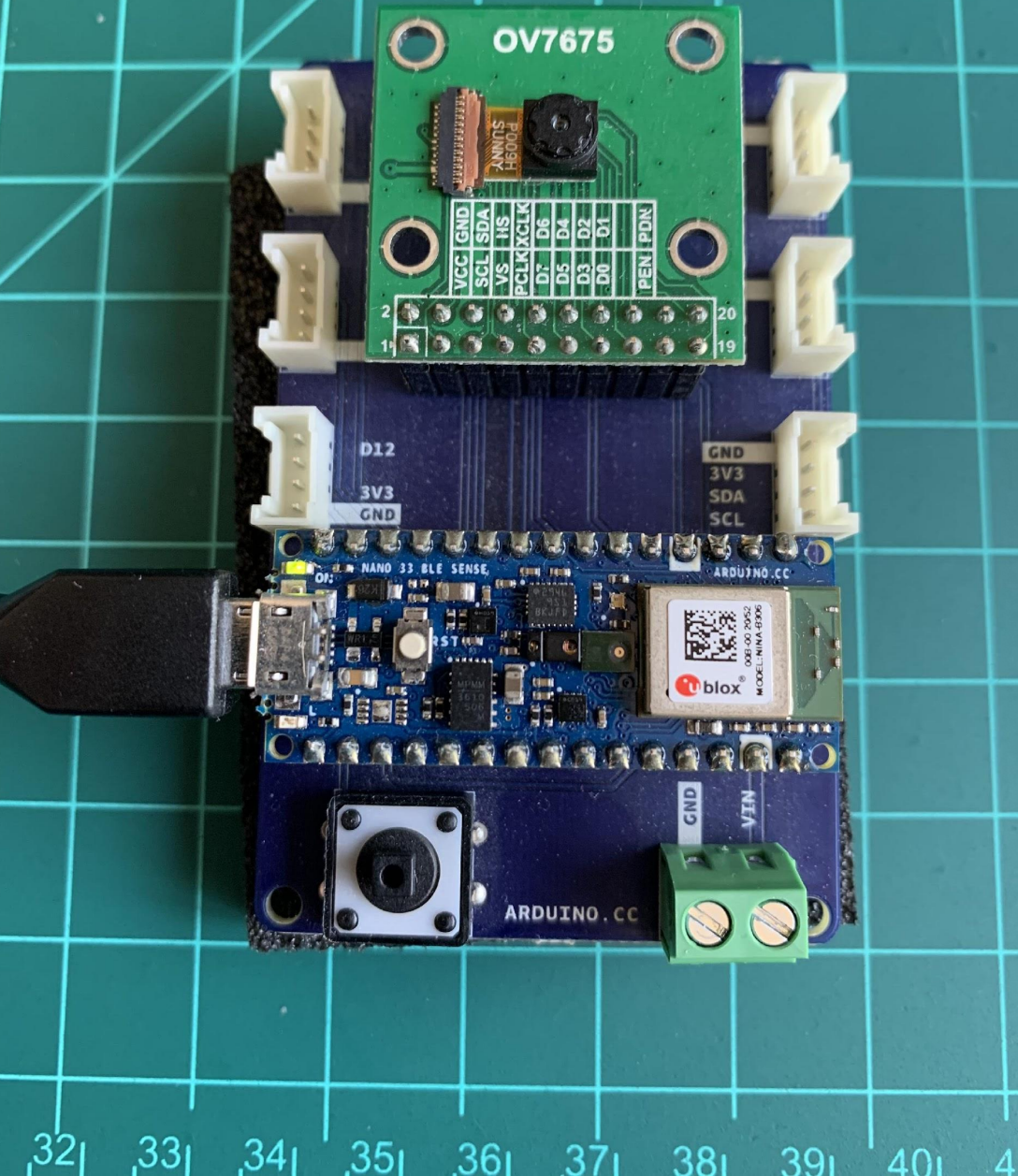
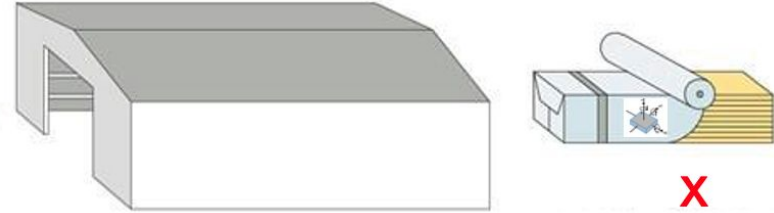
```
motion_classification_nano_ble33_sense_accelerometer | Arduino 1.8.16
motion_classification_nano_ble33_sense_accelerometer 5
159 // Run the classifier
160 ei_impulse_result_t result = { 0 };
161 err = run_classifier(&signal, &result, debug_nn);
162 if (err != EI_IMPULSE_OK) {
163     ei_printf("ERR: Failed to run classifier (%d)\n", err);
164     return;
165 }
166
167 // print the predictions
168 ei_printf("Predictions ");
169 ei_printf("(DSP: %d ms., Classification: %d ms., Anomaly: %d ms.)",
170     result.timing.dsp, result.timing.classification, result.timing.anomaly);
171 ei_printf(": \n");
172
173 int pred_index = 0;
174 float pred_value = result.classification[0].value;
175
176 for (size_t ix = 0; ix < EI_CLASSIFIER_LABEL_COUNT; ix++) {
177     ei_printf("  %s: %.5f\n", result.classification[ix].label, result.classif
178     if (result.classification[ix].value > pred_value){
179         pred_index = ix;
180         pred_value = result.classification[ix].value;
181     }
182 }
183 ei_printf(" Prediction: %s with probability %.2f\n", result.classification[pre
184     turn_on_leds (pred_index);
185
186 #if EI_CLASSIFIER_HAS_ANOMALY == 1
187     ei_printf("  anomaly score: %.3f\n", result.anomaly);
188     if (result.anomaly > 0.5)
189         digitalWrite(LED_BUILTIN, HIGH);
190     else
191         digitalWrite(LED_BUILTIN, LOW);
192 #endif
193 }
```

Done uploading.

```
writeBuffer(scr_addr=0x34, dst_addr=0x25000, size=0x1000)
[===== ] 94% (37/39 pages)write(addr=0x34,size=0x1000)
writeBuffer(scr_addr=0x34, dst_addr=0x25000, size=0x1000)
[===== ] 97% (38/39 pages)write(addr=0x34 size=0x1000)
```

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

label: idle

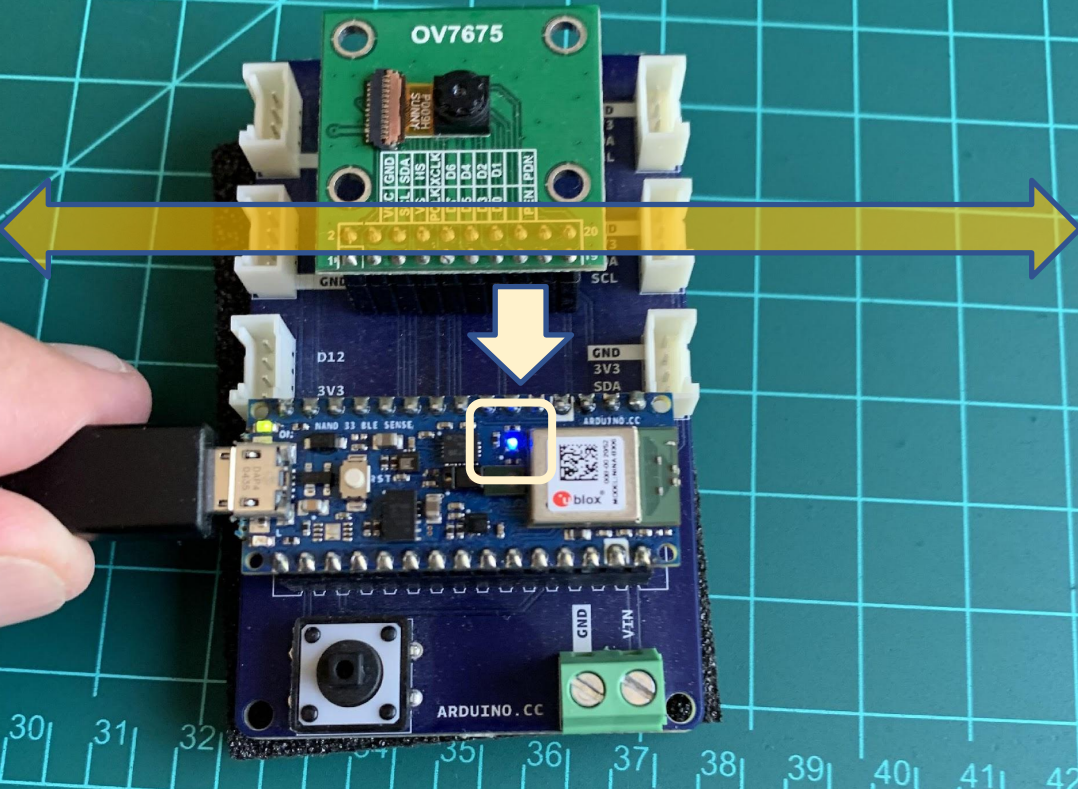
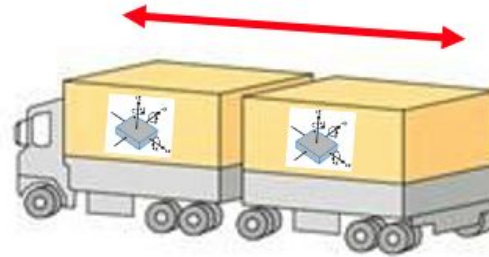


```
/dev/cu.usbmodem145101
IESTI01 - Nano Motion Classification - Inferencing Test
IMU initialized

Starting inferencing in 2 seconds...
Sampling...
Predictions (DSP: 20 ms., Classification: 0 ms., Anomaly: 2 ms.):
  idle: 0.99219
  lift: 0.00391
  maritime: 0.00391
  terrestrial: 0.00000
Prediction: idle with probability 0.99
  anomaly score: 0.001

Starting inferencing in 2 seconds...
Sampling...
Predictions (DSP: 20 ms., Classification: 1 ms., Anomaly: 1 ms.):
  idle: 0.99219
  lift: 0.00391
  maritime: 0.00391
  terrestrial: 0.00000
Prediction: idle with probability 0.99
  anomaly score: -0.001
```

label: terrestrial

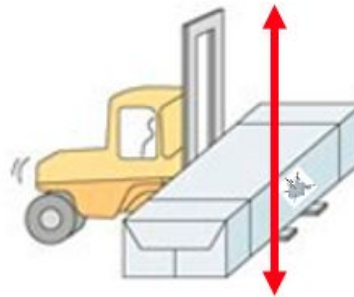


```
/dev/cu.usbmodem145101
Starting inferencing in 2 seconds...
Sampling...
Predictions (DSP: 20 ms., Classification: 1 ms., Anomaly: 1 ms.):
  idle: 0.00000
  lift: 0.00000
  maritime: 0.00000
  terrestrial: 0.99609
Prediction: terrestrial with probability 1.00
anomaly score: -0.190

Starting inferencing in 2 seconds...
Sampling...
Predictions (DSP: 20 ms., Classification: 0 ms., Anomaly: 2 ms.):
  idle: 0.00000
  lift: 0.00000
  maritime: 0.00000
  terrestrial: 0.99609
Prediction: terrestrial with probability 1.00
anomaly score: -0.096
```

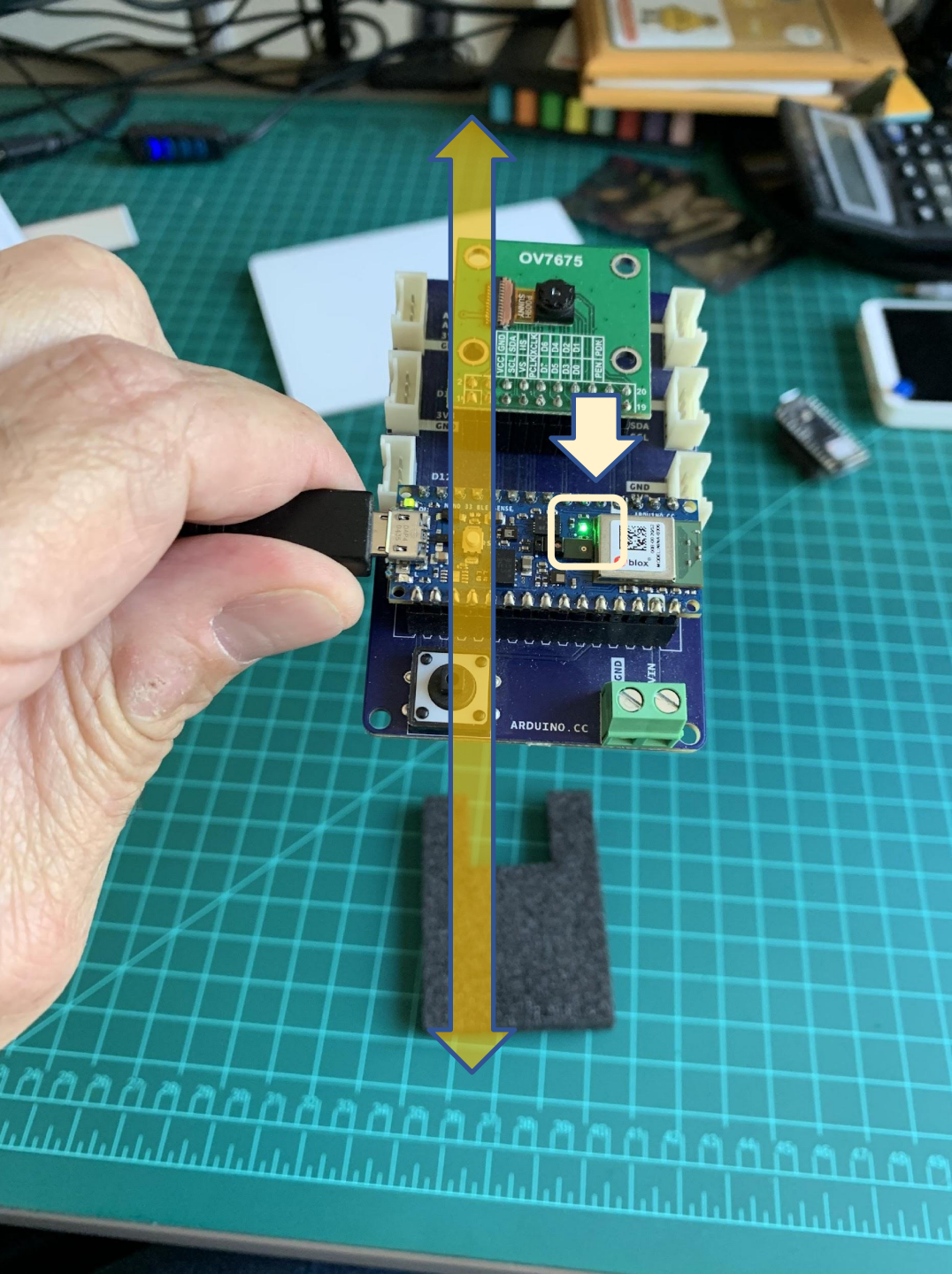
Autoscroll Show timestamp Both NL & CR 115200 baud Clear output

label: lift

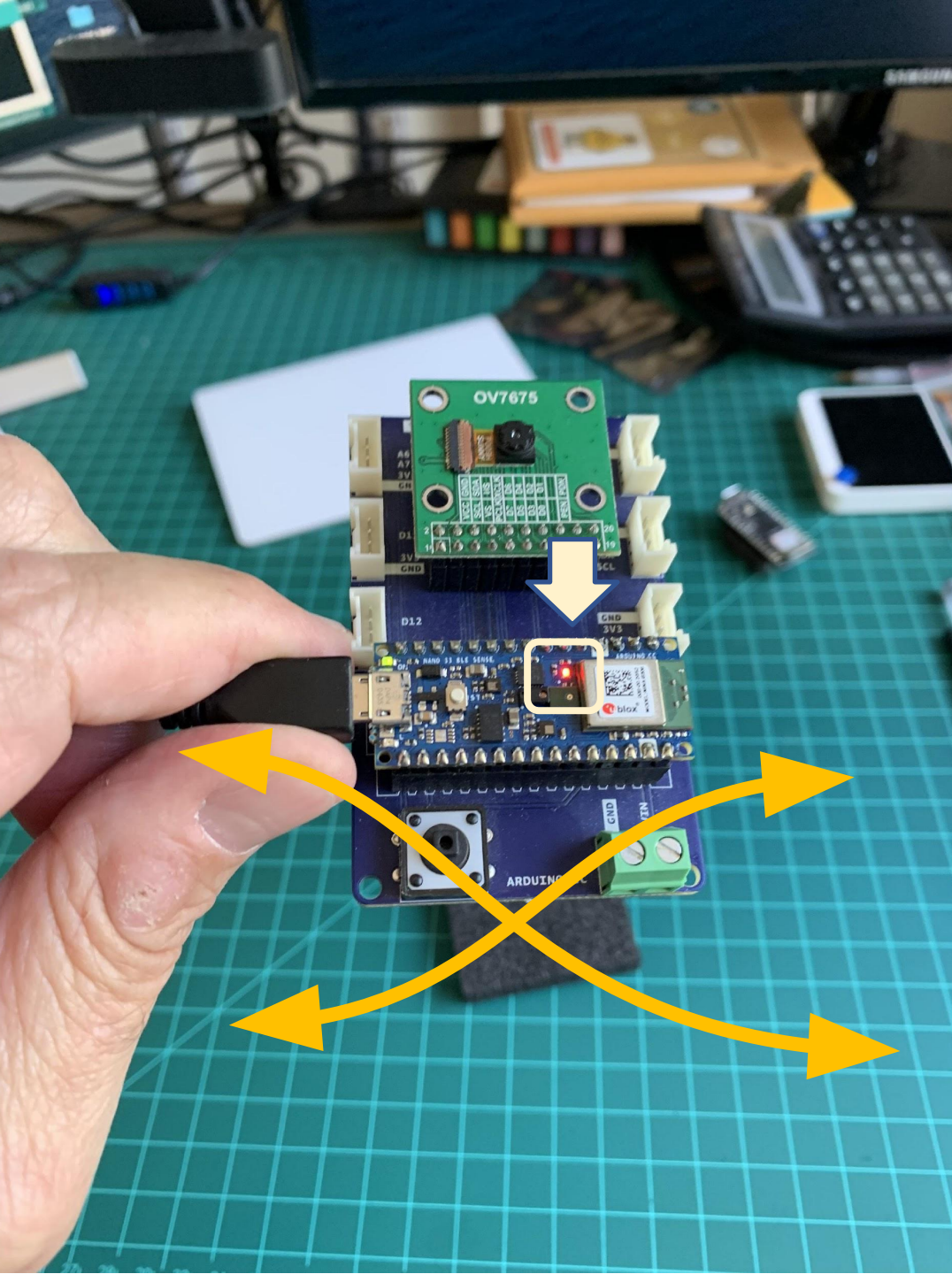
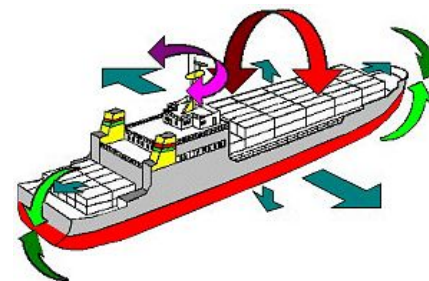


```
/dev/cu.usbmodem145101
Starting inferencing in 2 seconds...
Sampling...
Predictions (DSP: 20 ms., Classification: 0 ms., Anomaly: 2 ms.):
idle: 0.00000
lift: 0.99609
maritime: 0.00000
terrestrial: 0.00000
Prediction: lift with probability 1.00
anomaly score: 0.047
Starting inferencing in 2 seconds...
Sampling...
Predictions (DSP: 20 ms., Classification: 1 ms., Anomaly: 1 ms.):
idle: 0.76172
lift: 0.12500
maritime: 0.10547
terrestrial: 0.00781
Prediction: idle with probability 0.76
anomaly score: 0.874
```

Autoscroll Show timestamp Both NL & CR 115200 baud Clear output



label: maritime



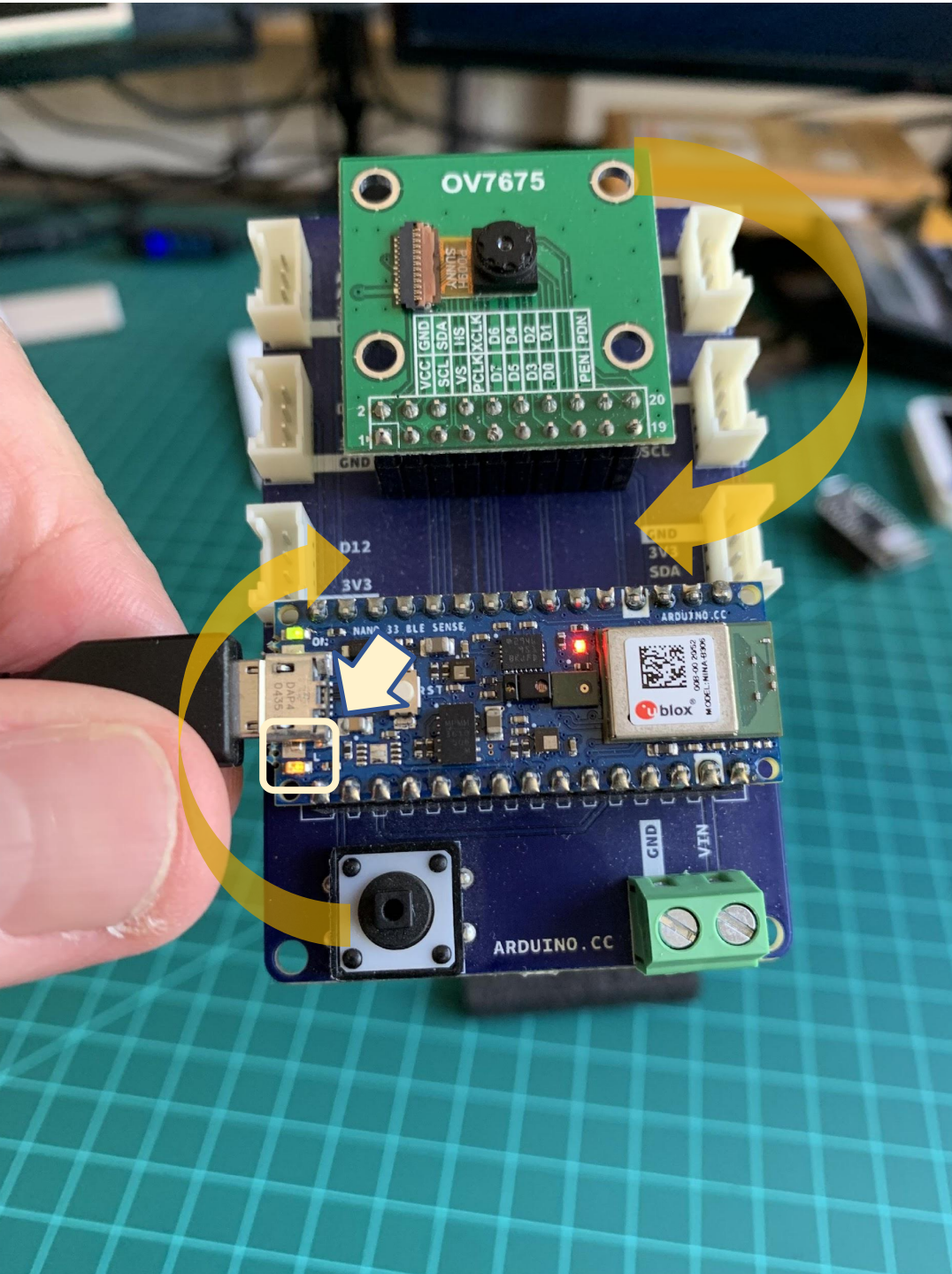
```
/dev/cu.usbmodem145101
Send

Starting inferencing in 2 seconds...
Sampling...
Predictions (DSP: 20 ms., Classification: 0 ms., Anomaly: 2 ms.):
  idle: 0.00391
  lift: 0.29297
  maritime: 0.40625
  terrestrial: 0.29297
Prediction: maritime with probability 0.41
anomaly score: 0.431

Starting inferencing in 2 seconds...
Sampling...
Predictions (DSP: 20 ms., Classification: 0 ms., Anomaly: 1 ms.):
  idle: 0.95312
  lift: 0.03516
  maritime: 0.00781
  terrestrial: 0.00391
Prediction: idle with probability 0.95
anomaly score: 0.247

 Autoscroll  Show timestamp
Both NL & CR 115200 baud Clear output
```

label: anomaly



```
/dev/cu.usbmodem145101
Send

Starting inferencing in 2 seconds...
Sampling...
Predictions (DSP: 20 ms., Classification: 1 ms., Anomaly: 1 ms.):
  idle: 0.00781
  lift: 0.12109
  maritime: 0.87109
  terrestrial: 0.00000
Prediction: maritime with probability 0.87
  anomaly score: 0.902

Starting inferencing in 2 seconds...
Sampling...
Predictions (DSP: 20 ms., Classification: 1 ms., Anomaly: 1 ms.):
  idle: 0.89453
  lift: 0.08984
  maritime: 0.01172
  terrestrial: 0.00781
Prediction: idle with probability 0.89
  anomaly score: 0.248

 Autoscroll  Show timestamp
Both NL & CR 115200 baud Clear output
```

Thanks

