

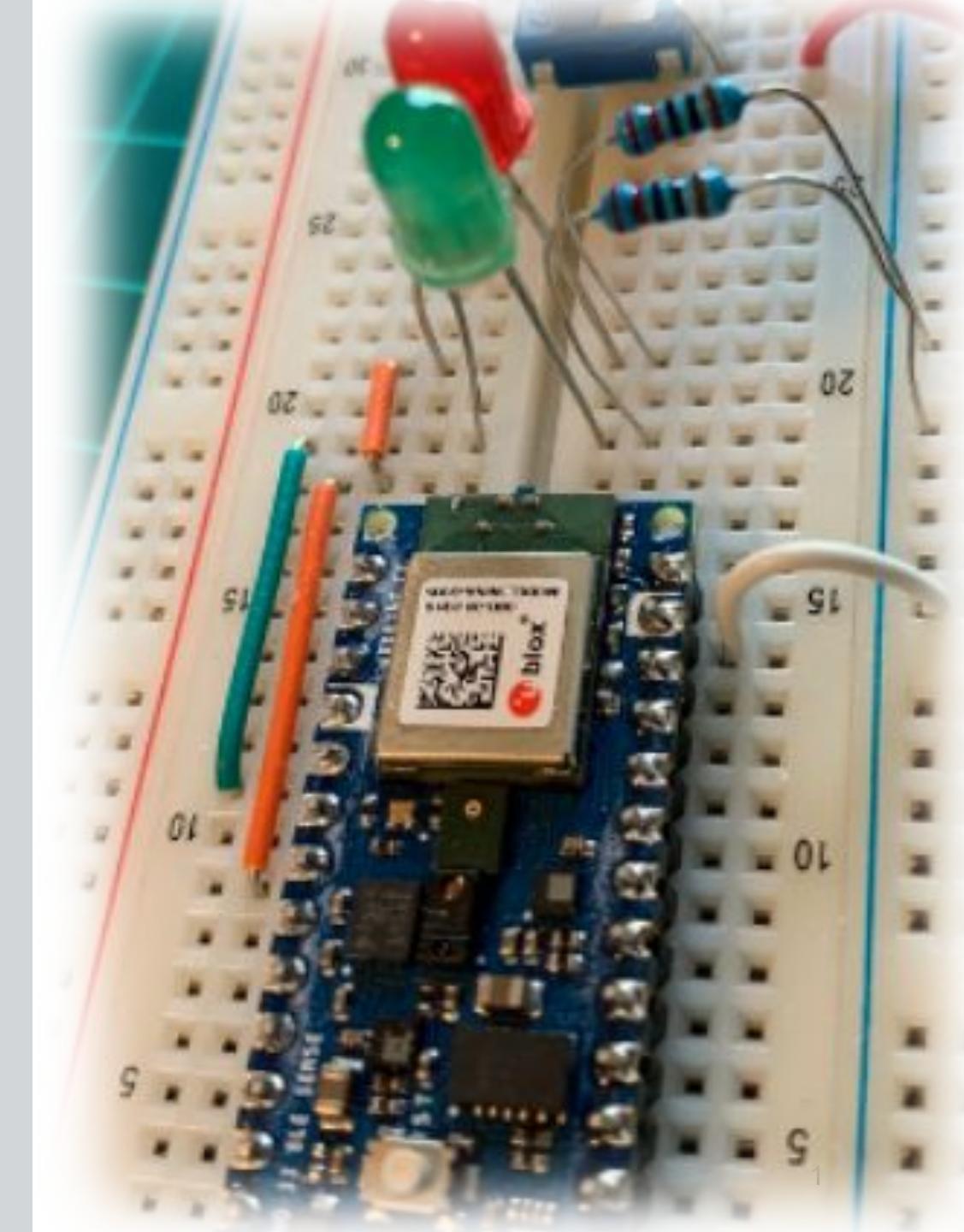
IESTI01 – TinyML

Embedded Machine Learning

27. Collecting Data with Edge Impulse Studio



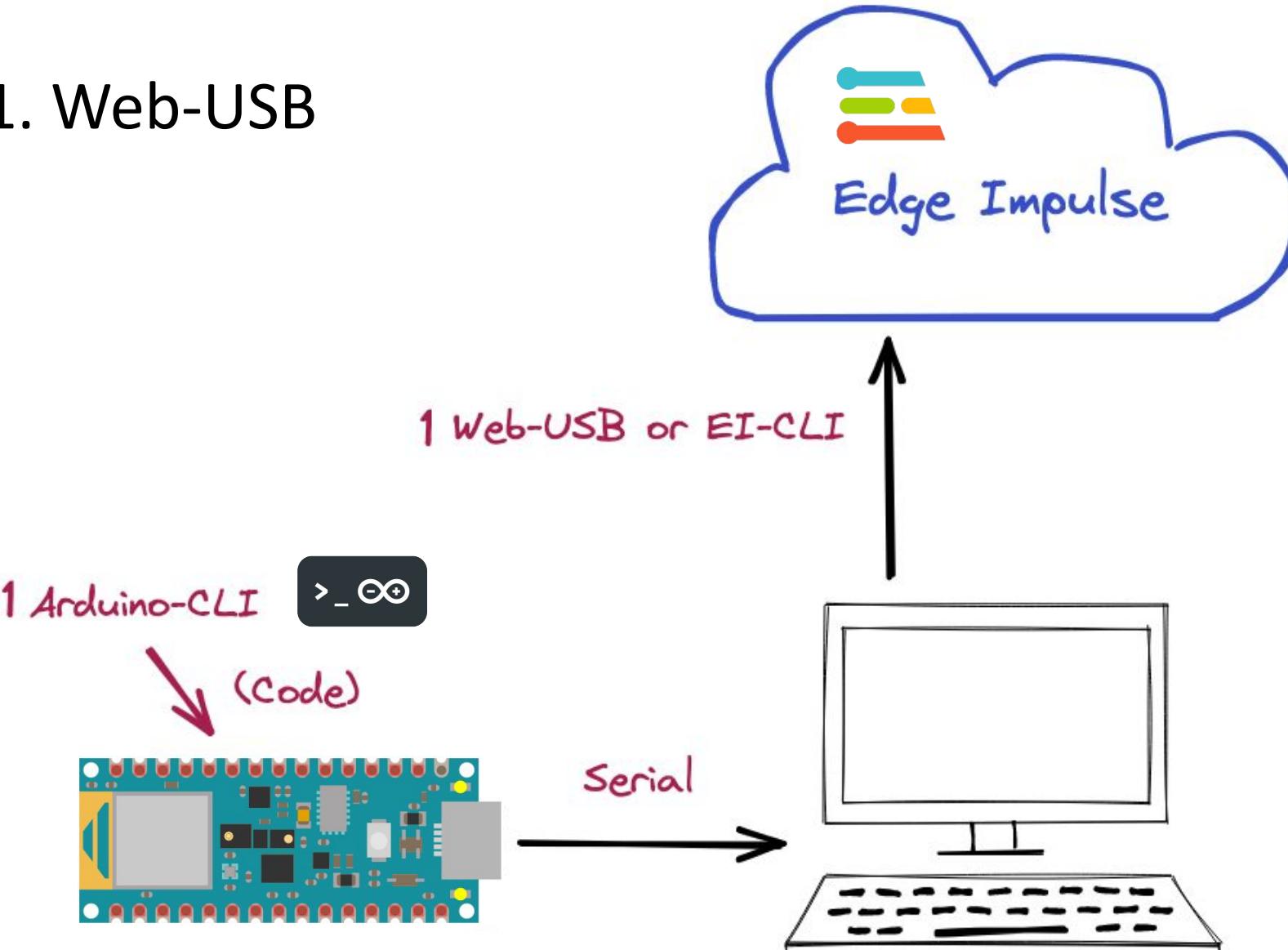
Prof. Marcelo Rovai
UNIFEI



Sensor Data – EI Studio Ingestion

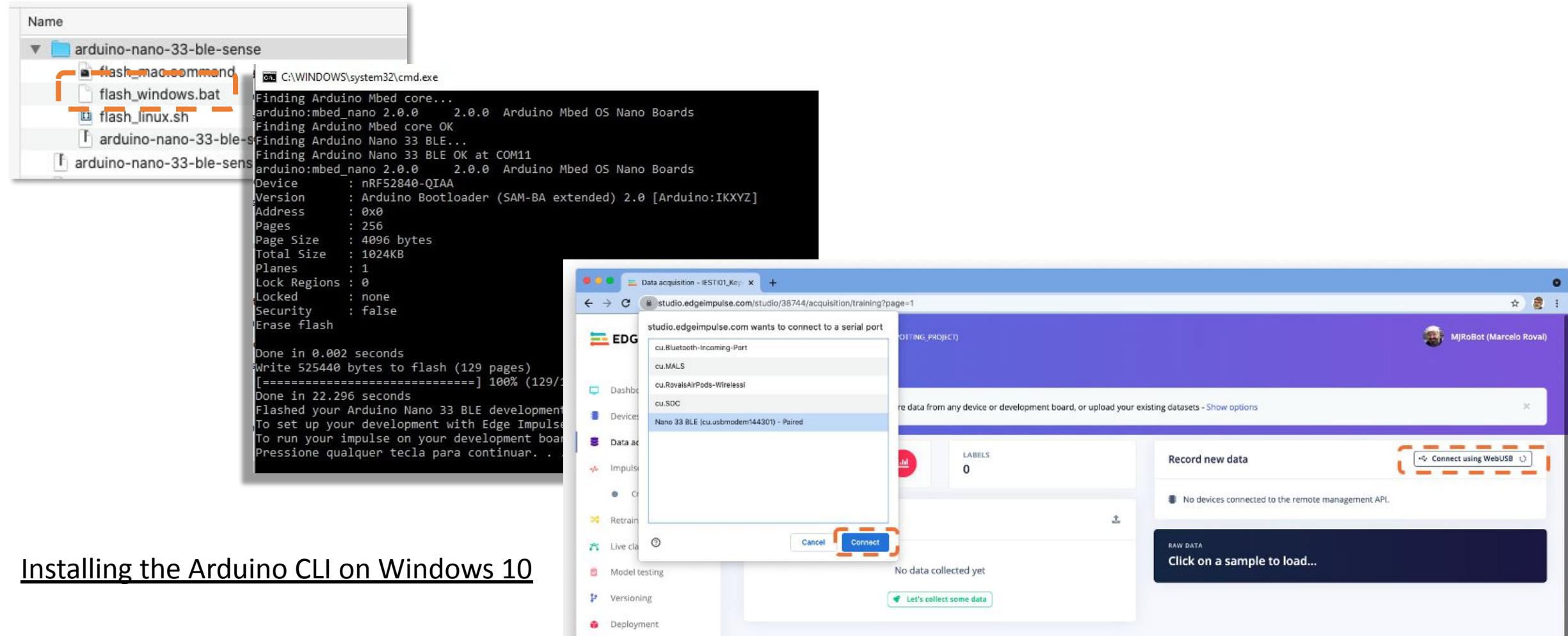
Alternative methods

1. Web-USB



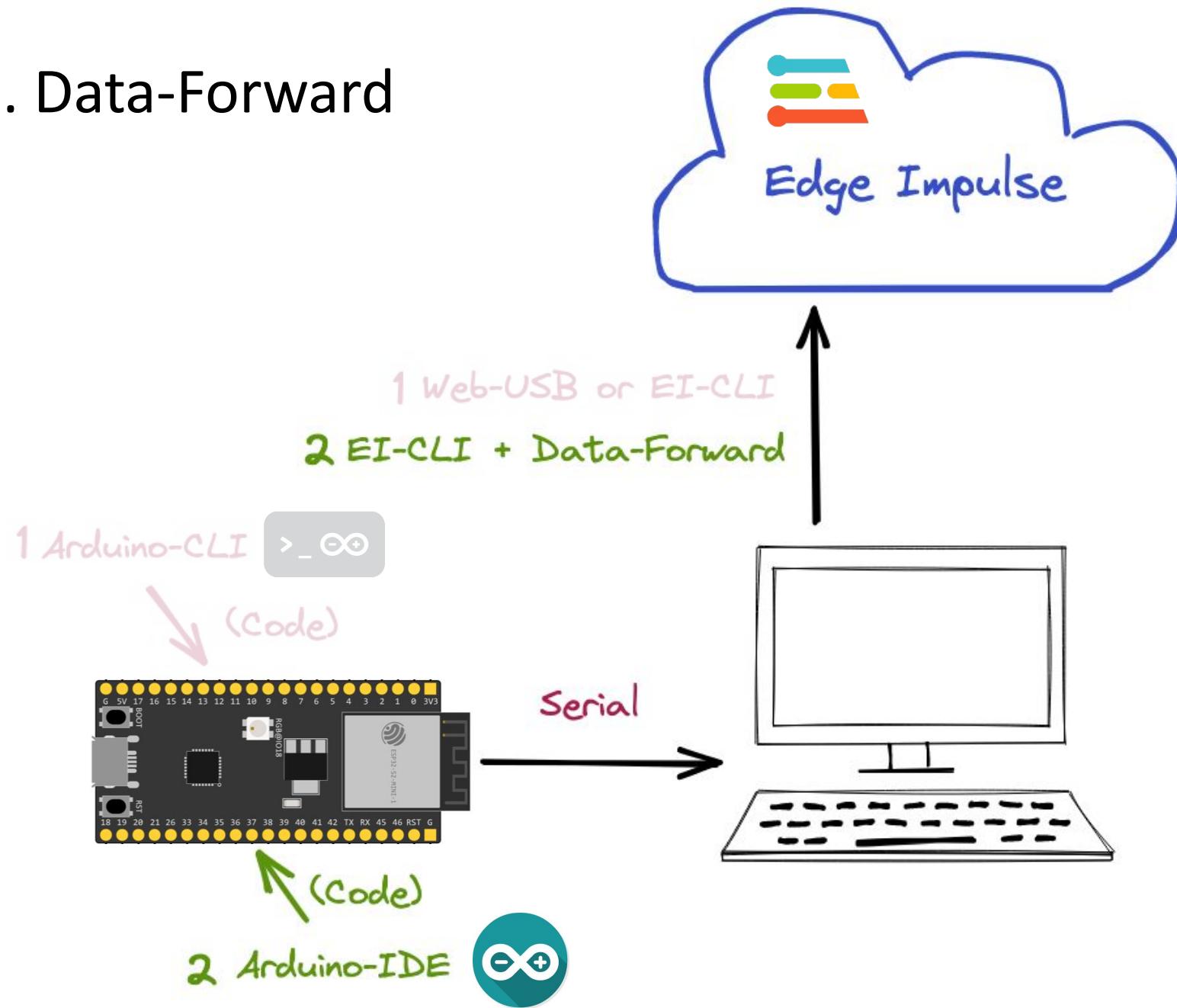
Issue: Limited MCU and sensors

1. Data Ingestion using Arduino-Cli + Web-USB (or EI-CLI)



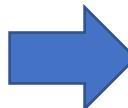
Installing the Arduino CLI on Windows 10

2. Data-Forward



2. Data Ingestion using El-Cli + Data Forward

```
Capture_Ardub33_Sense_IMU_Acc
1 #include <Arduino_LSM9DS1.h>
2
3 #define CONVERT_G_TO_MS2 9.80665f
4 #define FREQUENCY_HZ 50
5 #define INTERVAL_MS (1000 / (FREQUENCY_HZ + 1))
6
7 void setup() {
8     Serial.begin(115200);
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 }
```



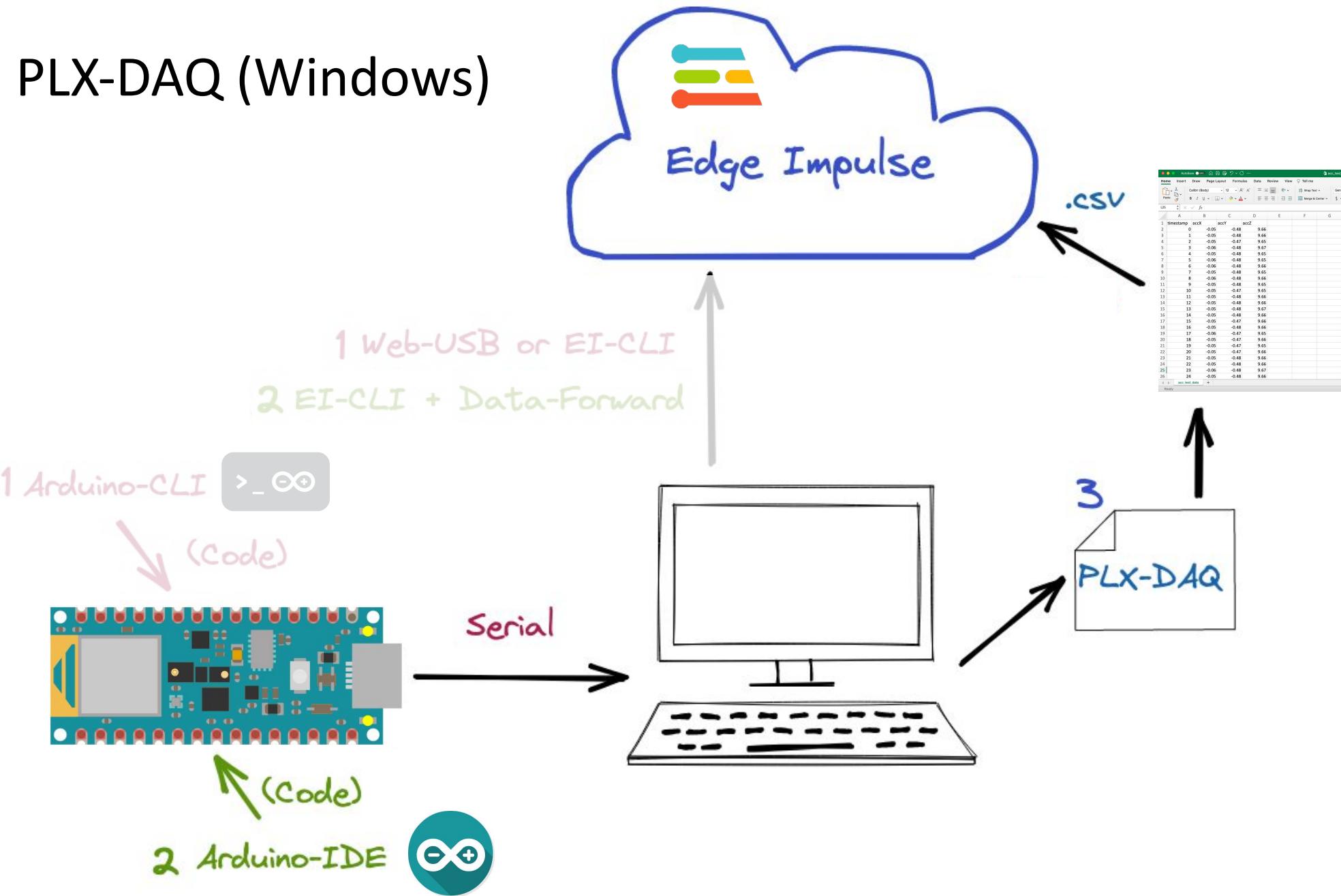
```
$ edge-impulse-data-forwarder --clean
```

```
mjrovai — bash — 80x41
(base) MacBook-Pro-de-Marcelo:~ mjrovai$ edge-impulse-data-forwarder --clean
Edge Impulse data forwarder v1.12.2
[?] 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.usbmodem144301
[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

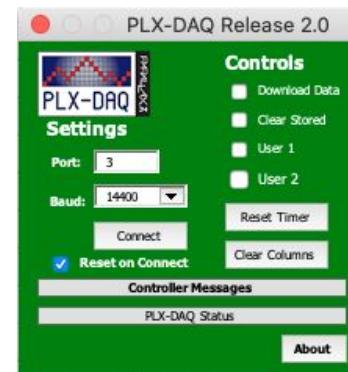
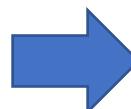
? To which project do you want to connect this device? MJRoBot (Marcelo Rovai) / IESTI01_Input_Data_Test
[SER] Detecting data frequency...
[SER] Detected data frequency: 51Hz
[?] 3 sensor axes detected (example values: [-0.08,-0.34,9.82]). What do you want to call them? Separate the names with ',': accX, accY, accZ
? What name do you want to give this device? nano
[WS ] Device "nano" is now connected to project "IESTI01_Input_Data_Test"
[WS ] Go to https://studio.edgeimpulse.com/studio/39877/acquisition/training to build your machine learning model!
[WS ] Incoming sampling request (
  path: '/api/training/data',
  label: 'left-right',
  length: 10000,
  interval: 19.607843137254903,
  hmacKey: '6ee929b90e563aa74517f505a3ecb9c8',
  sensor: 'Sensor with 3 axes (accX, accY, accZ)'
```

3. PLX-DAQ (Windows)



3. Data Ingestion using PLX-DAQ (Windows) => Final Format: .csv

```
Capture_Ard33_Sense_IMU_Acc
1 #include <Arduino_LSM9DS1.h>
2
3 #define CONVERT_G_TO_MS2 9.80665f
4 #define FREQUENCY_HZ 50
5 #define INTERVAL_MS (1000 / (FREQUENCY_HZ + 1))
6
7 void setup() {
8     Serial.begin(115200);
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 }
```



	A	B	C	D	E	F	G
1	timestamp	accX	accY	accZ			
2		0	-0.05	-0.48	9.66		
3		1	-0.05	-0.48	9.66		
4		2	-0.05	-0.47	9.65		
5		3	-0.06	-0.48	9.67		
6		4	-0.05	-0.48	9.65		
7		5	-0.06	-0.48	9.65		
8		6	-0.06	-0.48	9.66		
9		7	-0.05	-0.48	9.65		
10		8	-0.06	-0.48	9.66		
11		9	-0.05	-0.48	9.65		
12		10	-0.05	-0.47	9.65		
13		11	-0.05	-0.48	9.66		
14		12	-0.05	-0.48	9.66		
15		13	-0.05	-0.48	9.67		
16		14	-0.05	-0.48	9.66		
17		15	-0.05	-0.47	9.66		
18		16	-0.05	-0.48	9.66		
19		17	-0.06	-0.47	9.65		
20		18	-0.05	-0.47	9.66		
21		19	-0.05	-0.47	9.65		
22		20	-0.05	-0.47	9.66		
23		21	-0.05	-0.48	9.66		
24		22	-0.05	-0.48	9.66		
25		23	-0.06	-0.48	9.67		
26		24	-0.05	-0.48	9.66		

3. Data Ingestion using PLX-DAQ (Windows) => Final Format: .csv

The screenshot shows the Arduino IDE interface. The top menu bar includes 'Arquivo', 'Editar', 'Sketch', 'Ferramentas', and 'Ajuda'. The title bar says 'IMU_excel | Arduino 1.8.15'. The code editor contains the following sketch:

```
#include <Arduino_LSM9DS1.h>
#define CONVERT_G_TO_MS2 9.80665f
#define FREQUENCY_HZ 50
#define INTERVAL_MS (1000/ (FREQUENCY_HZ + 1))

void setup() {
  Serial.begin(9600);
  while (!Serial)
  {
    // do nothing
  }
  //limpa todos os dados do sheet incluindo os labels
  Serial.println("CLEARSHHEET");
  Serial.println("CLEARDATA");
  //delay para dar o tempo suficiente para excluir os labels originais a fim de substitui-los
  delay(300);
  //escrevendo os nomes das colunas da planilha. É sempre necessário escrever o nome LABEL com o objetivo de sinalizar de que se quer nomear as colunas.
  //Após isso, basta colocar os nomes das colunas, sempre separando-as por vírgulas.
  //O nome "timestamp" para representar o horário pelo qual foram adicionados os dados é escolhido pensando na possibilidade de subir esses dados no EdgetImpulse.
}

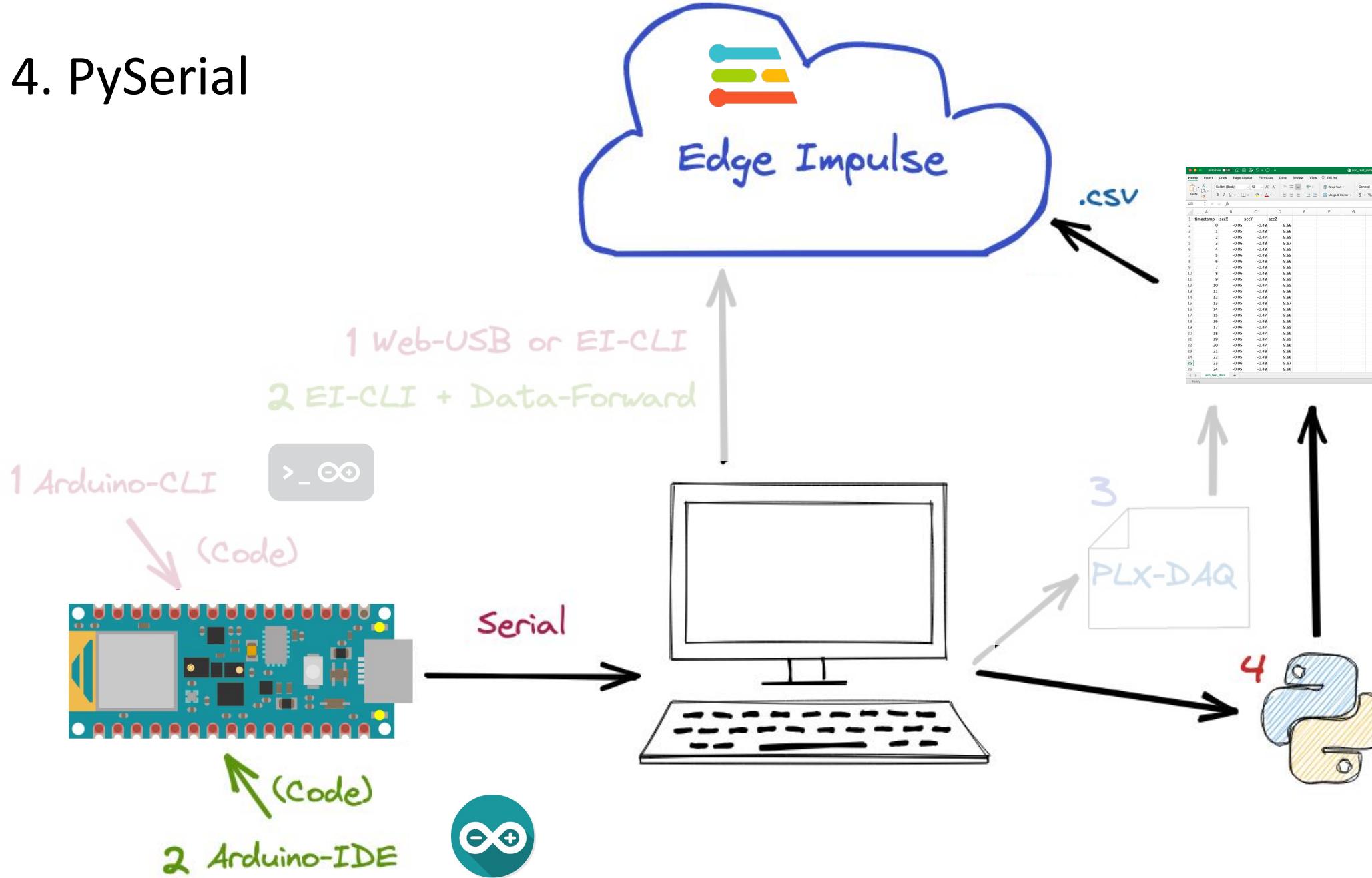
Carregado:
writeBuffer(scr_addr=0x34, dst_addr=0x14000, size=0x1000)
[=====] 87% (21/24 pages) write(addr=0x34, size=0x1000)
writeBuffer(scr_addr=0x34, dst_addr=0x15000, size=0x1000)
[=====] 91% (22/24 pages) write(addr=0x34, size=0x1000)
writeBuffer(scr_addr=0x34, dst_addr=0x16000, size=0x1000)
[=====] 95% (23/24 pages) write(addr=0x34, size=0x1000)
writeBuffer(scr_addr=0x34, dst_addr=0x17000, size=0x1000)
[=====] 100% (24/24 pages)
Done in 3.995 seconds
reset()

48
```

The Serial Monitor window shows the progress of writing data to memory, indicating completion at 100% (24/24 pages) in 3.995 seconds. The status bar at the bottom right shows 'Arduino Nano 33 BLE em COM10', '10°C Pred. limpo', '02:35', and the date '14/07/2021'.

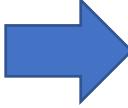
<https://www.youtube.com/watch?v=BwbmNle2CZo>

4. PySerial



4. Data Ingestion using Python (PySerial) => Final Format: .csv

```
Capture_Ardub33_Sense_IMU_Acc
1 #include <Arduino_LSM9DS1.h>
2
3 #define CONVERT_G_TO_MS2    9.80665f
4 #define FREQUENCY_HZ        50
5 #define INTERVAL_MS          (1000 / (FREQUENCY_HZ + 1))
6
7 void setup() {
8     Serial.begin(115200);
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 }
```

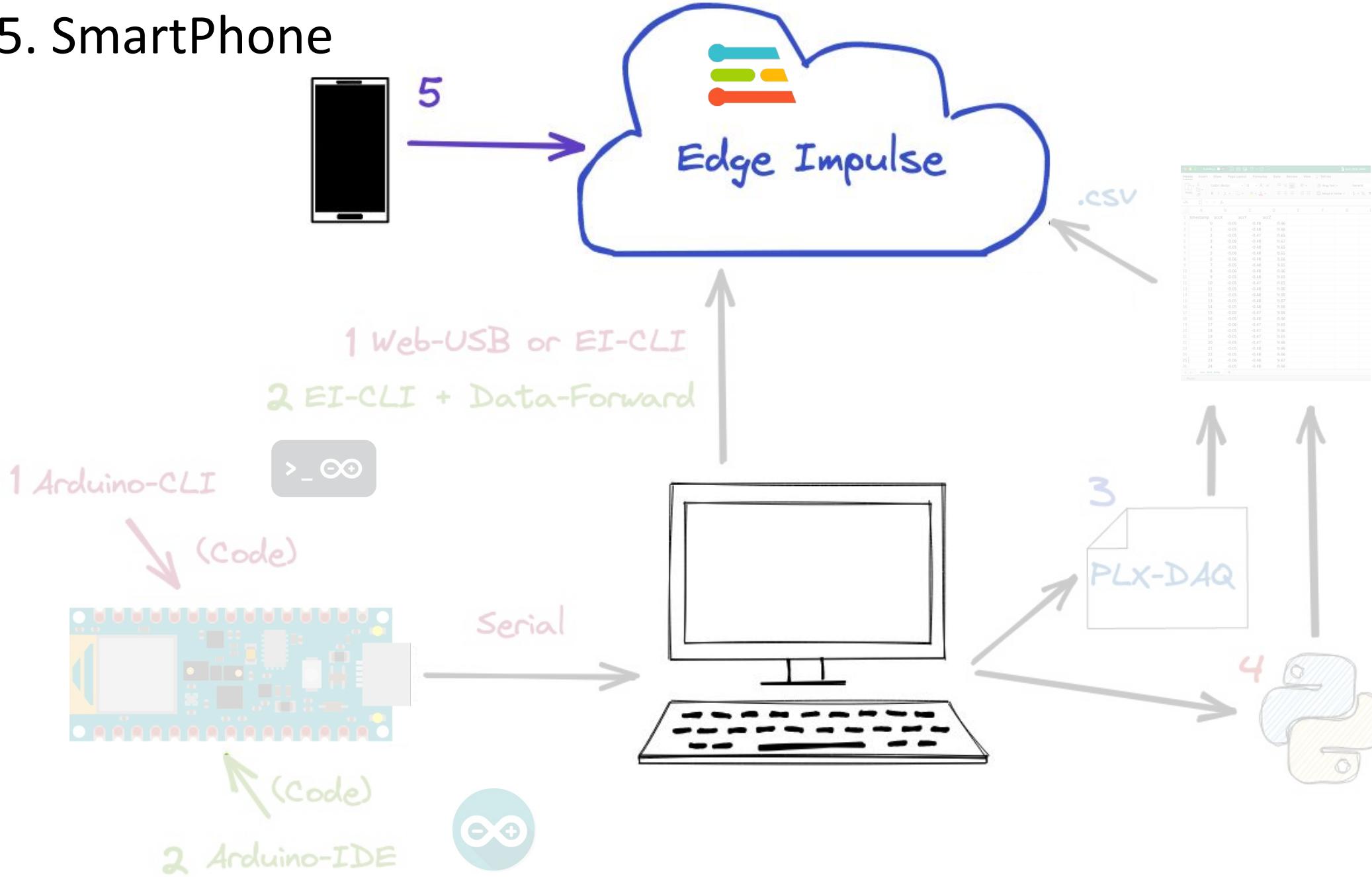


```
1 # Sensor data Logger (CSV)
2 # by Marcelo Rovai @ 13July21
3
4 import serial
5
6 arduino_port = '/dev/tty.usbmodem144301'
7 baud_rate = 115200
8 ser = serial.Serial(port=arduino_port, baudrate=baud_rate)
9
10 fileName = "acc_test_data.csv" # name of the CSV file generated
11
12 first_line = 'timestamp,accX,accY,accZ'
13 file = open(fileName, "w")
14 file.write(first_line + "\n") # write data with a newline
15 file.close()
16
17 Freq_hz = 50
18 num_seconds = 10 # number of seconds collecting data
19 samples = num_seconds * Freq_hz # number of samples to collect
20
21 sample = 0
22 while sample <= samples:
23     getData = str(ser.readline())
24     data = getData[2:][:-5]
25     print(data)
26
27     file = open(fileName, "a")
28     file.write(str(sample) + "," + data + "\n")
29     sample = sample+1
30 print("Data collection complete!")
31 file.close()
```



	A	B	C	D	E	F	G
1	timestamp	accX	accY	accZ			
2	0	-0.05	-0.48	9.66			
3	1	-0.05	-0.48	9.66			
4	2	-0.05	-0.47	9.65			
5	3	-0.06	-0.48	9.67			
6	4	-0.05	-0.48	9.65			
7	5	-0.06	-0.48	9.65			
8	6	-0.06	-0.48	9.66			
9	7	-0.05	-0.48	9.65			
10	8	-0.06	-0.48	9.66			
11	9	-0.05	-0.48	9.65			
12	10	-0.05	-0.47	9.65			
13	11	-0.05	-0.48	9.66			
14	12	-0.05	-0.48	9.66			
15	13	-0.05	-0.48	9.67			
16	14	-0.05	-0.48	9.66			
17	15	-0.05	-0.47	9.66			
18	16	-0.05	-0.48	9.66			
19	17	-0.06	-0.47	9.65			
20	18	-0.05	-0.47	9.66			
21	19	-0.05	-0.47	9.65			
22	20	-0.05	-0.47	9.66			
23	21	-0.05	-0.48	9.66			
24	22	-0.05	-0.48	9.66			
25	23	-0.06	-0.48	9.67			
26	24	-0.05	-0.48	9.66			

5. SmartPhone



5. Data Ingestion using Smart Phone

The screenshot shows the Edge Impulse Studio interface on a web browser. The URL in the address bar is `studio.edgeimpulse.com`. The main title of the project is "MJRoBot (Marcelo Rovai) / IESTI01 - Gesture Classification". The left sidebar contains a navigation menu with the following items:

- EDGE IMPULSE
- Dashboard
- Devices
- Data acquisition
- Impulse design
- Create impulse
- Retrain model
- Live classification
- Model testing
- Versioning
- Deployment

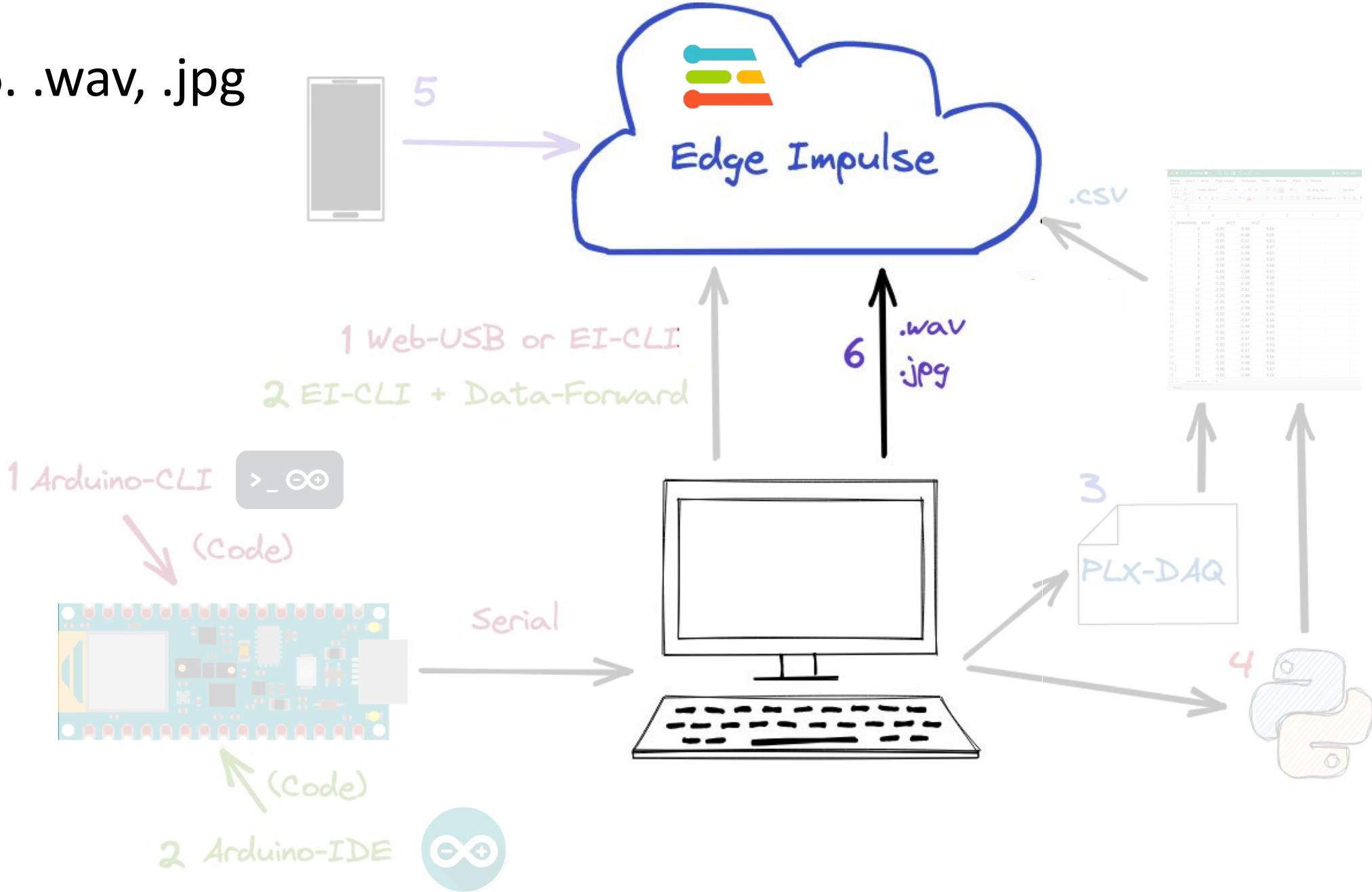
Below this, under "GETTING STARTED", are links for Documentation and Forums.

The central area displays a "Collect data" modal window. The title of the modal is "Creating your first impulse (0)". It contains three sections: "Acquire data", "Design an impulse", and "Deploy".

- Acquire data:** Text: "You can collect data from any smartphone. From your smartphone go to [this URL](#), or scan the QR code below." Below this is a large QR code.
- Design an impulse:** Text: "Teach the model to interpret new data. Use this to categorize new readings." Sub-sections include "GETTING STARTED: CONTINUOUS", "GETTING STARTED: RESPONDING", and "GETTING STARTED: ADDING".
- Deploy:** Text: "Package the complete impulse up, from signal processing code to trained model, and deploy it on your device. This ensures that the impulse runs with low latency and without requiring a network connection." Sub-sections include "DEPLOY YOUR MODEL".

On the right side of the screen, there is a "Sharing" section which says "Your project is private." and a "Make this project public" button. Below that is a "Summary" section showing "DEVICES CONNECTED: 0" and "DATA COLLECTED: -". The "Collaborators" section lists "MjRoBot (Marcelo Rovai) OWNER". At the bottom is a "Project info" section.

6. .wav, .jpg



6. Data Ingestion using Upload existing Data

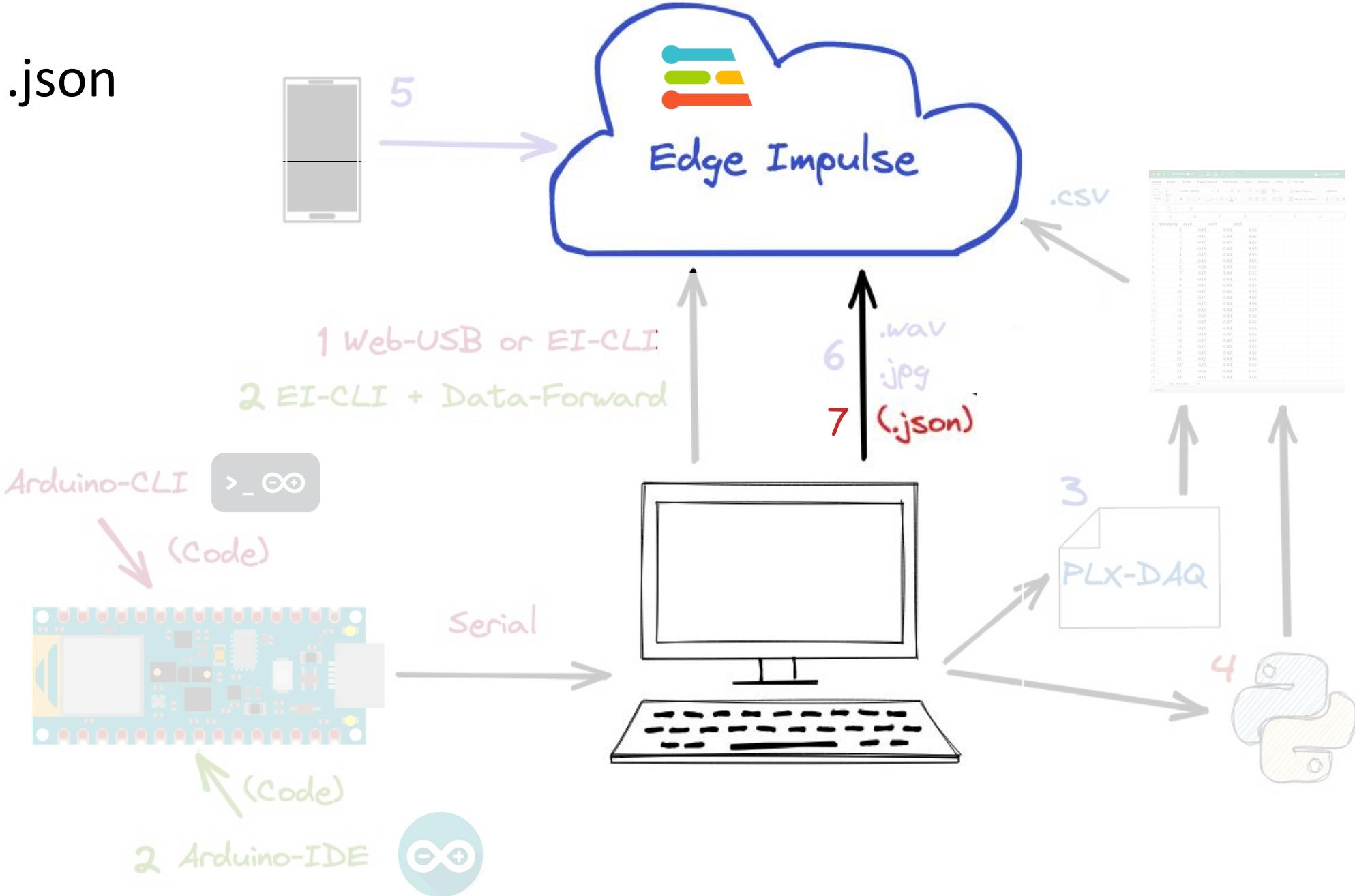
The screenshot illustrates the DataRobot interface for data ingestion. On the left, the 'LABELS' panel shows 5 labels. The main interface features a central 'Upload existing data' button. Below it, a tree view displays a folder structure: 'data' containing 'cool' and 'hot' subfolders, with numerous wav files listed under each. A blue arrow points from the 'hot' folder to the 'Upload existing data' dialog. This dialog is titled 'UPLOAD DATA (ICTP_PSYCHOACOUSTICS_TEMPERATURE_DEPENDENCE)' and contains the following fields:

- Upload existing data:** A text area with instructions: "You can upload existing data to your project in the Data Acquisition Format (CBOR, JSON, CSV), or as WAV, JPG or PNG files."
- Select files:** A 'Choose Files' button with the placeholder "No file chosen".
- Upload into category:** A radio button group where "Training" is selected.
- Label:** A radio button group where "Enter label:" is selected, with the input field containing "hot".

At the bottom of the dialog is a green 'Begin upload' button. To the right, the 'Upload output' panel shows the progress of uploading 14 files, listing each file name followed by 'OK'. The status message at the bottom right indicates "Done. Files uploaded successful: 14. Files that failed to upload: 0." and "Job completed".

(CBOR, JSON, CSV), or as WAV, JPG or PNG files.

7. .json



7. Raw Uploader (.json files)

Image Classification: Raw Uploader

 Open in Colab

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

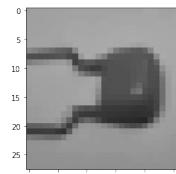
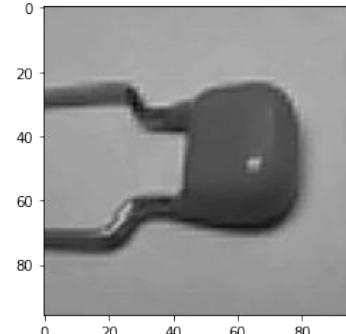
Create a folder named "dataset" in the /content directory and upload your images there. The images should be divided into their respective classes, where each class has its own folder with the name of the class. For example:

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

Author: EdgImpulse, Inc.

Date: June 6, 2021

License: [Apache-2.0](#)



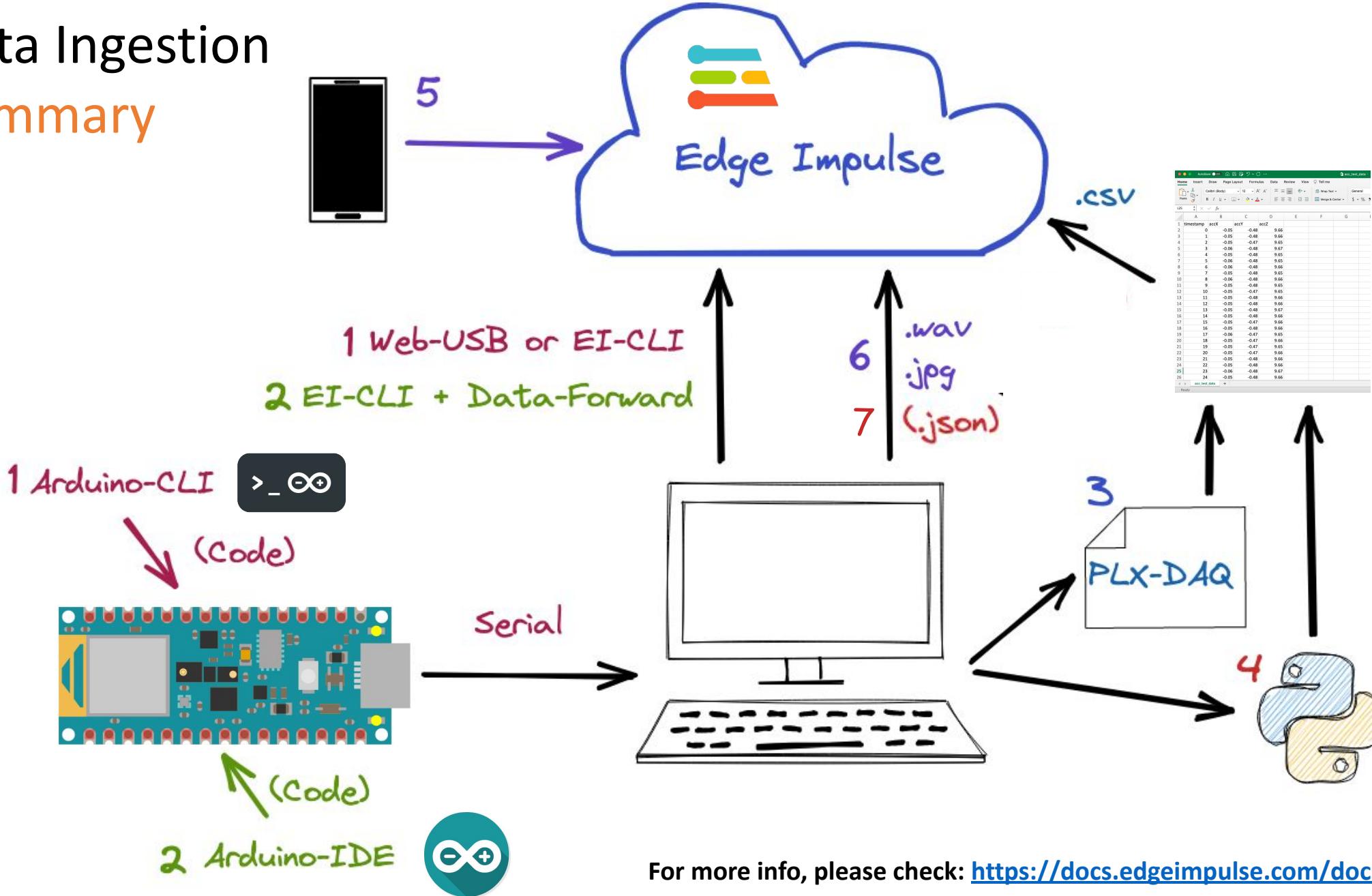
.json



EDGE IMPULSE
(Training as DNN)

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

Data Ingestion Summary



Temperature Dependence Psychoacoustics

Simple TinyML Proof-of-concept



<https://www.hackster.io/mjrobot/listening-temperature-with-tinyml-7e1325>



Audio Engineering Society

Convention e-Brief 473

Presented at the 145th Convention
2018 October 17 – 20, New York, NY, USA

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Why can you hear a difference between pouring hot and cold water? An investigation of temperature dependence in psychoacoustics.

He Peng¹ and Joshua D. Reiss²

¹Tianjin University

²Queen Mary University of London

Correspondence should be addressed to He Peng, Joshua Reiss (hepeng2018@hotmail.com, joshua.reiss@qmul.ac.uk)

[http://www.eecs.qmul.ac.uk/~josh/
documents/2018/19737.pdf](http://www.eecs.qmul.ac.uk/~josh/documents/2018/19737.pdf)

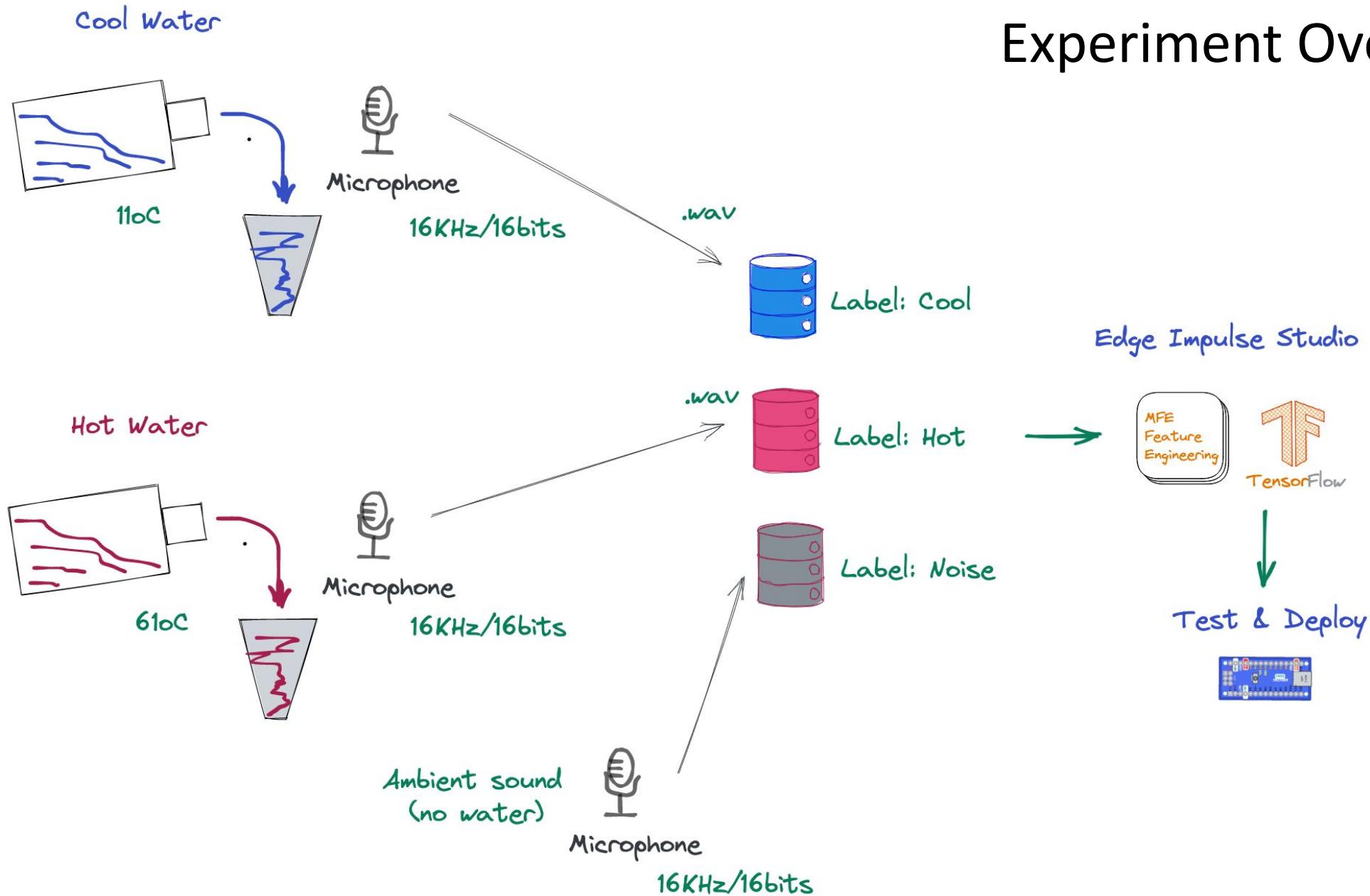


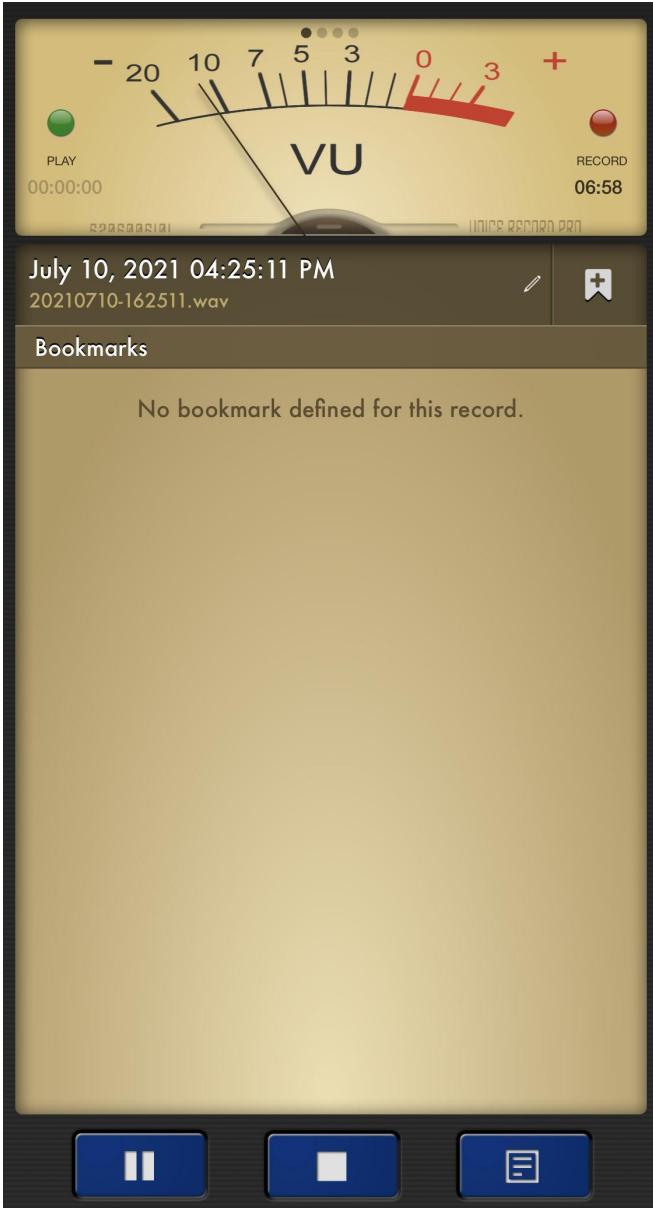
You Can Hear The Difference Between Hot and Cold W...

Tom Scott

[\(min: 0.17 => min 2:37\)](https://www.youtube.com/watch?v=Ri_4dDvcZeM)

Experiment Overview





Voice Recorder

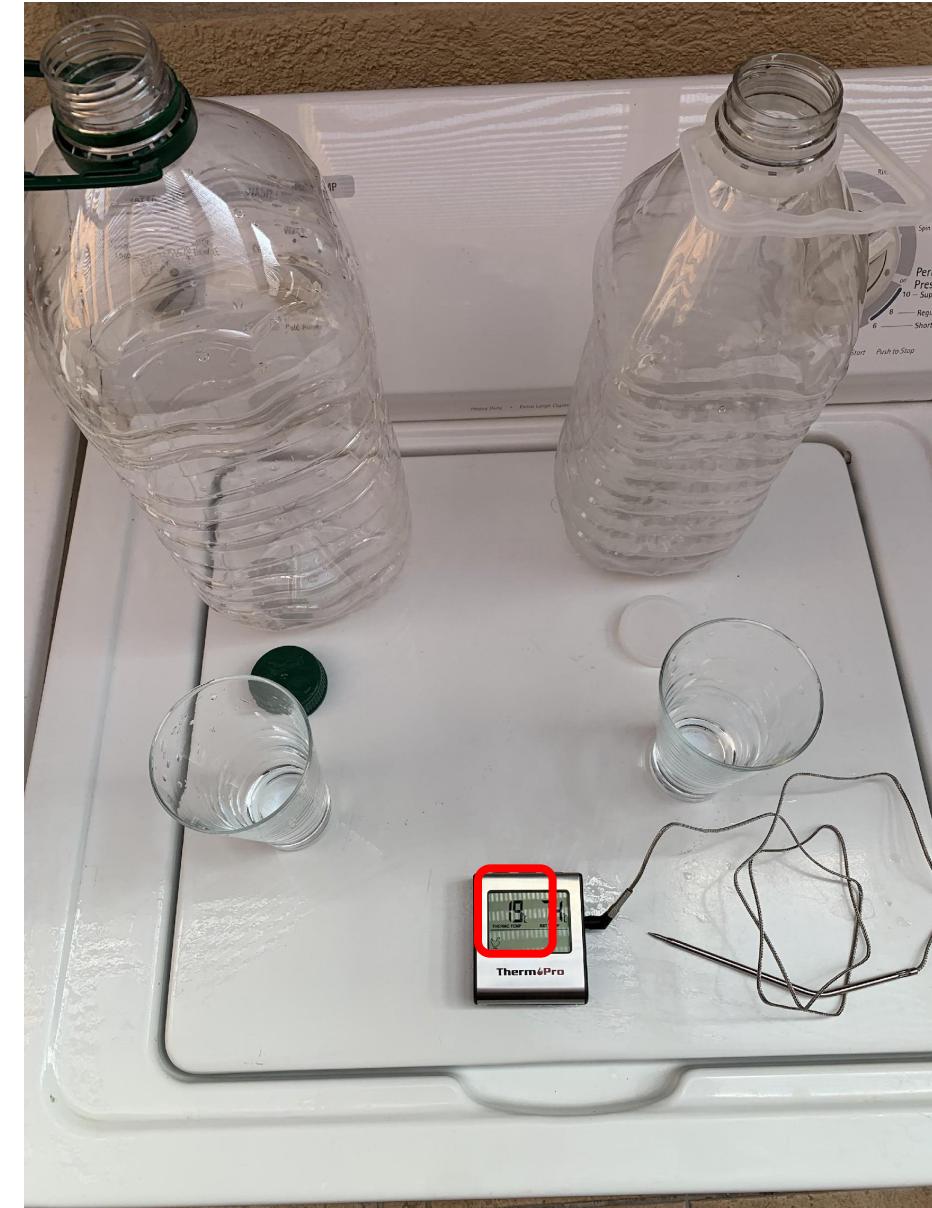


Sample Sound:

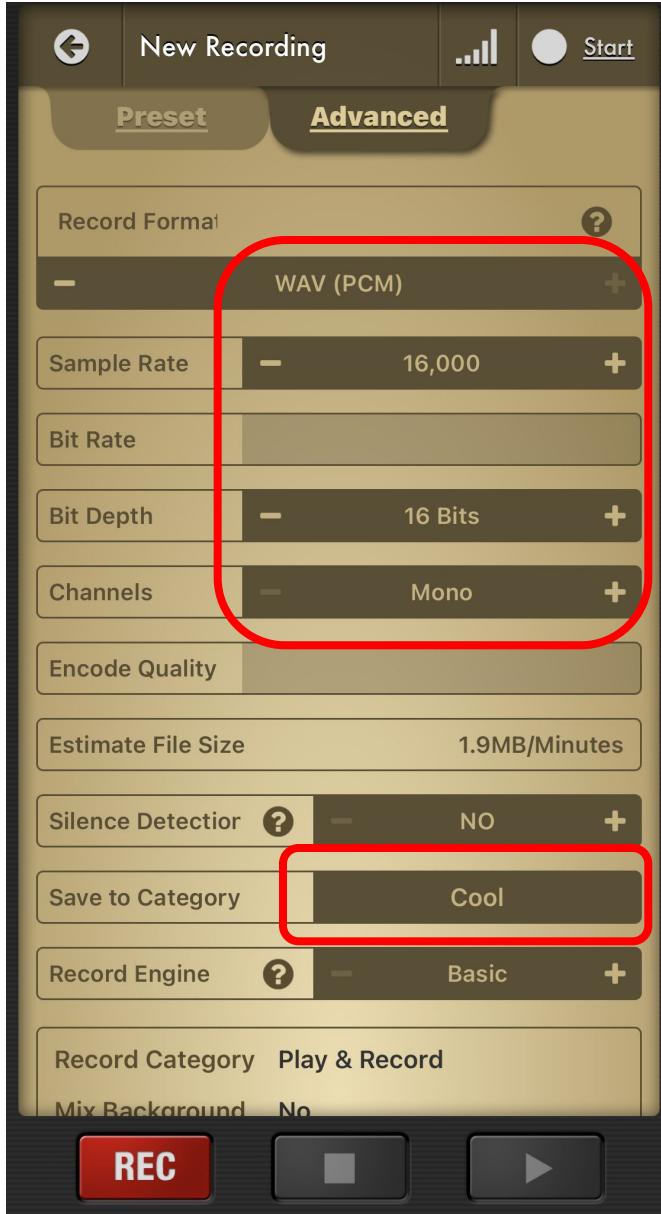
- 16KHz
- PCM – 16bits
- Mono

Classes:

- Hot
- Cool
- Noise



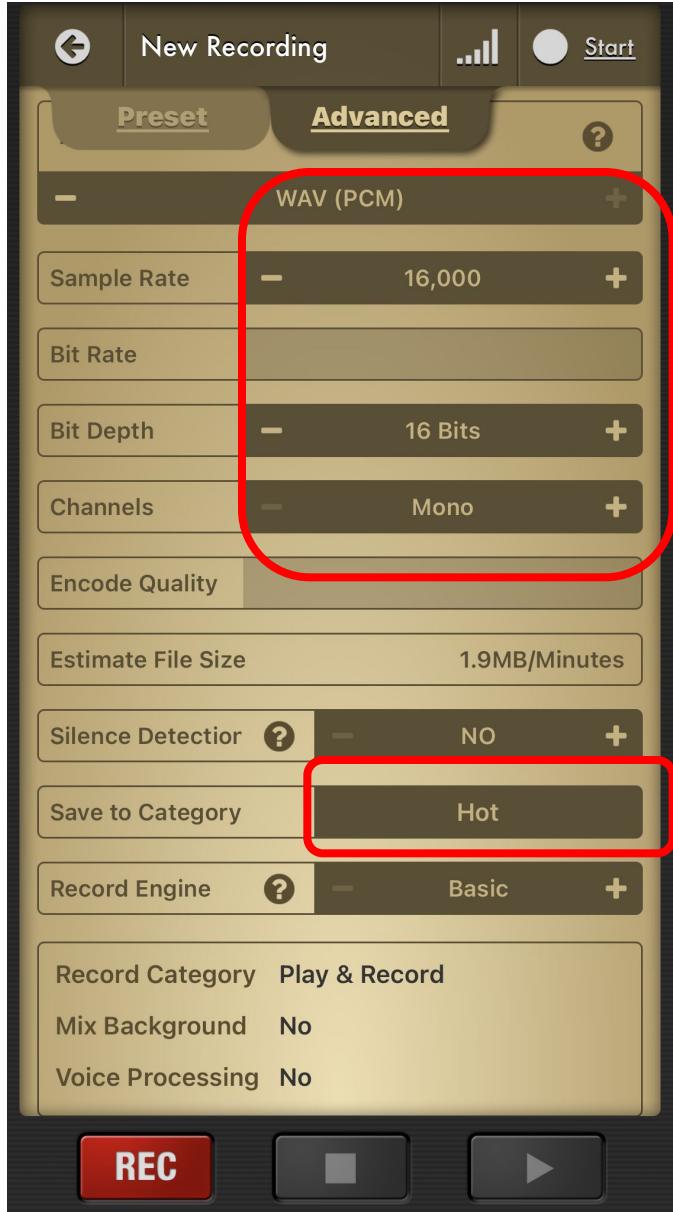
Ambient Temperature: 19°C



Class: Cool



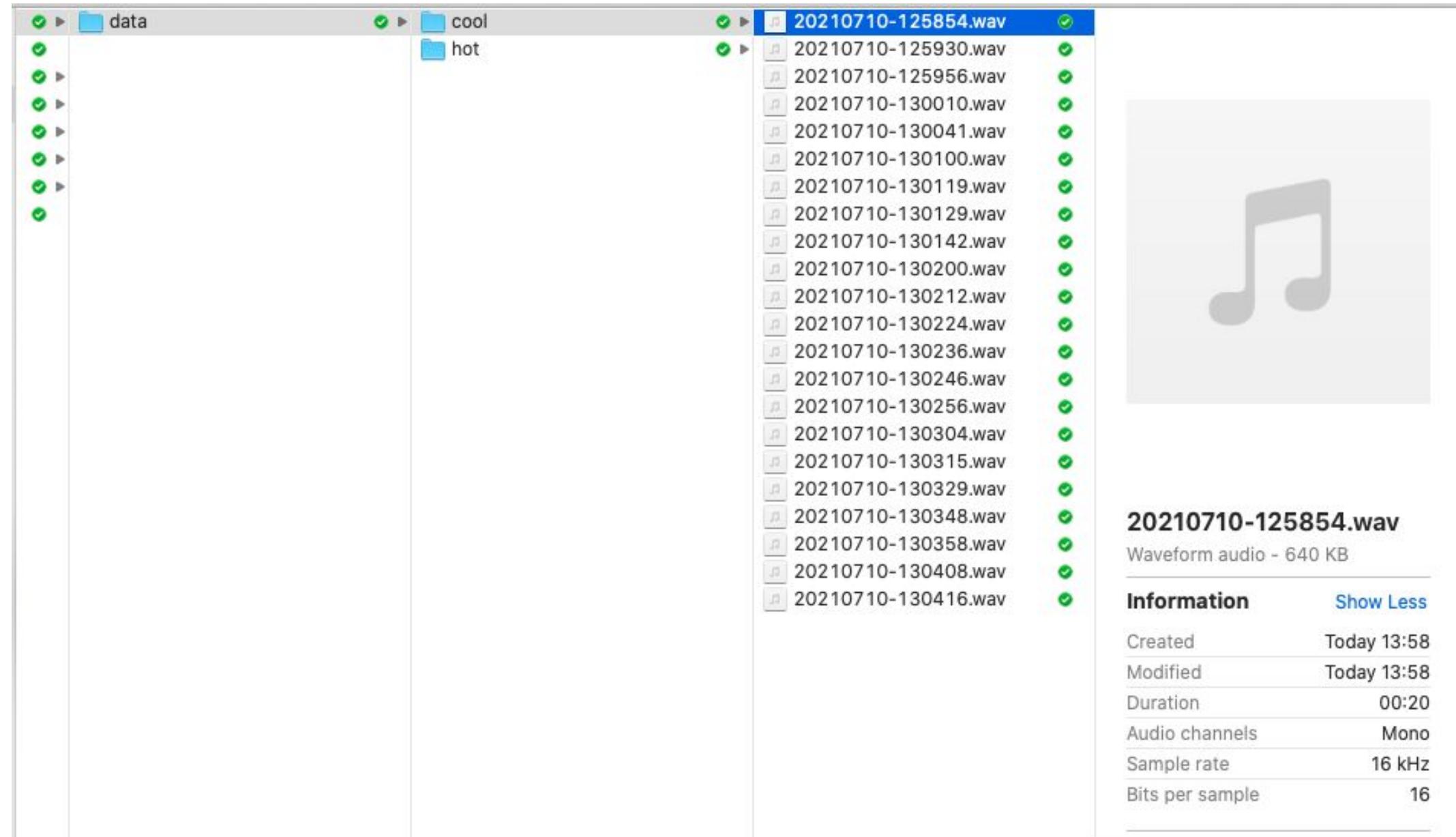
Cool Water Temperature: 11°C



Class: Hot



Hot Water Temperature: 61°C



The screenshot shows a file explorer window with three main directories: 'data', 'cool', and 'hot'. The 'cool' directory is expanded, revealing a list of 24 wav files, each with a green checkmark icon. The file '20210710-125854.wav' is selected and highlighted in blue. To the right of the file list, there is a detailed view of the selected file, including its name, file type, and a table of information.

20210710-125854.wav
Waveform audio - 640 KB

Information	Show Less
Created	Today 13:58
Modified	Today 13:58
Duration	00:20
Audio channels	Mono
Sample rate	16 kHz
Bits per sample	16

Data captured using app Voice Recorder and uploaded to Computer



Upload existing data

You can upload existing data to your project in the [Data Acquisition Format](#) (CBOR, JSON, CSV), or as WAV, JPG or PNG files.

Select files

No file chosen

Upload into category

- Automatically split between training and testing ?
- Training
- Testing

Label

- Infer from filename ?
- Enter label:

hot

Upload output

Uploading 14 files...

```
[ 1/14] Uploading 20210710-130535.wav OK
[ 2/14] Uploading 20210710-130603.wav OK
[ 3/14] Uploading 20210710-130544.wav OK
[ 4/14] Uploading 20210710-130553.wav OK
[ 5/14] Uploading 20210710-130738.wav OK
[ 6/14] Uploading 20210710-130718.wav OK
[ 7/14] Uploading 20210710-130649.wav OK
[ 8/14] Uploading 20210710-130700.wav OK
[ 9/14] Uploading 20210710-130630.wav OK
[10/14] Uploading 20210710-130621.wav OK
[11/14] Uploading 20210710-130709.wav OK
[12/14] Uploading 20210710-130611.wav OK
[13/14] Uploading 20210710-130728.wav OK
[14/14] Uploading 20210710-130639.wav OK
```

Done. Files uploaded successful: 14. Files that failed to upload: 0.

Job completed

Raw Data uploaded to Edge Impulse Studio as .wav

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

DATA COLLECTED

2m 49s



LABEL

2



Collected data

SAMPLE NAME	LABEL	ADDED	LENGTH
20210710-130621.wav.2a5e0...	hot	Today, 14:02:55	4s
20210710-130630.wav.2a5e0...	hot	Today, 14:02:54	3s
20210710-130700.wav.2a5e0...	hot	Today, 14:02:52	4s
20210710-130649.wav.2a5e0...	hot	Today, 14:02:52	5s
20210710-130718.wav.2a5e0...	hot	Today, 14:02:52	5s
20210710-130738.wav.2a5e0...	hot	Today, 14:02:51	5s
20210710-130553.wav.2a5e0...	hot	Today, 14:02:51	4s
20210710-130544.wav.2a5e0...	hot	Today, 14:02:51	4s
20210710-130603.wav.2a5e0...	hot	Today, 14:02:51	3s
20210710-130535.wav.2a5e0...	hot	Today, 14:02:48	5s
20210710-130416.wav.2a5dv...	cool	Today, 14:02:12	4s
20210710-130408.wav.2a5dv...	cool	Today, 14:02:11	4s

Record new data

⬅ Connect using WebUSB

 No devices connected to the remote management API.



Raw Data cleaned as split in 1 second samples

Split sample '20210710-130621.wav.2a5e0r33'

x

[+ Add Segment](#)[Remove segment](#)

is.):

1000

[Apply](#)

0

379

758

1138

1517

1896

2276

2655

3035

3414

audio

0:01 / 0:01

[Cancel](#)

Raw Data cleaned as split in 1 second samples

 Shift samples [Split](#)



⚡ 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
audio

Window size 1000 ms.

Window increase 500 ms.

Zero-pad data

Audio (MFE)

Name

Input axes audio

Neural Network (Keras)

Name

Input features MFE

Output features
3 (cool, hot, noise)

Output features

3 (cool, hot, noise)

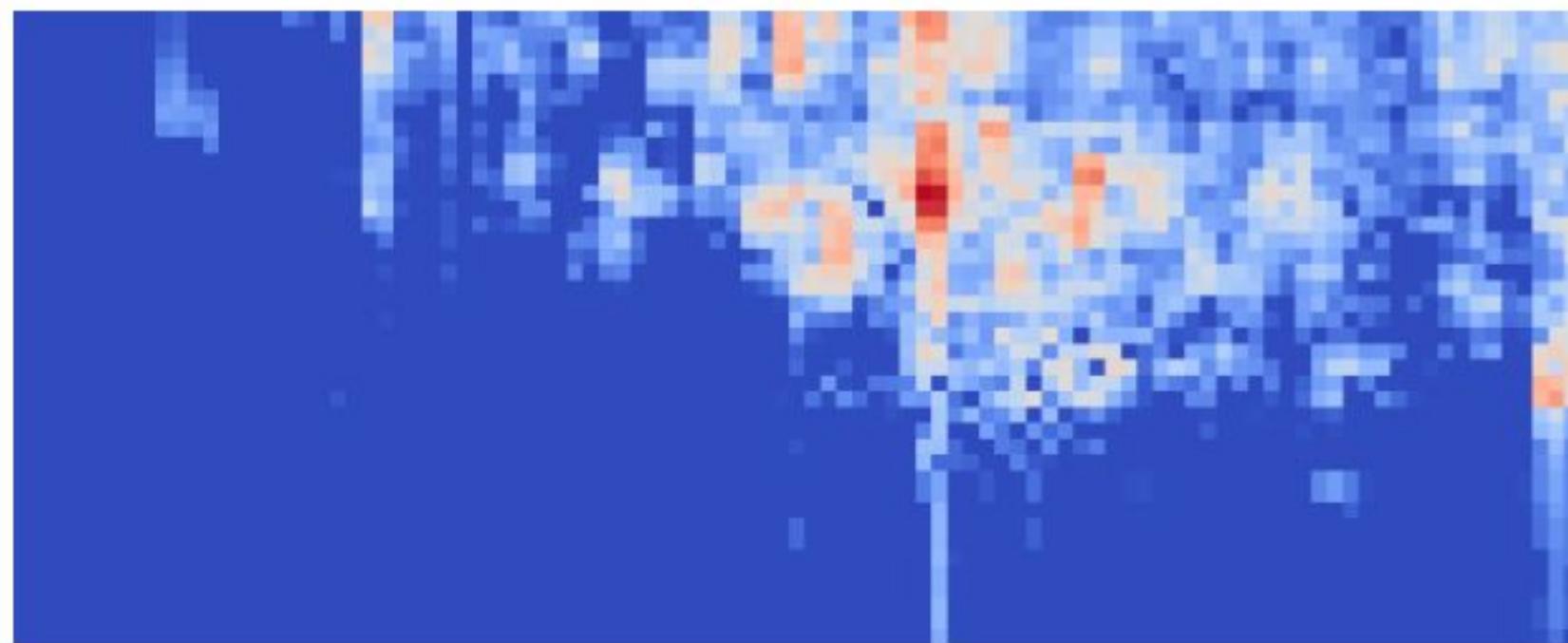
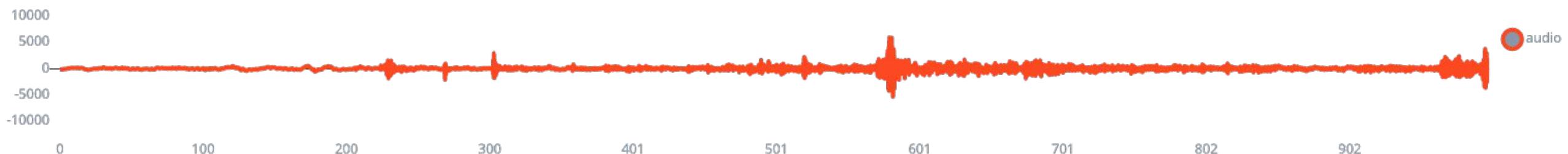
Save Impulse

Add a processing block

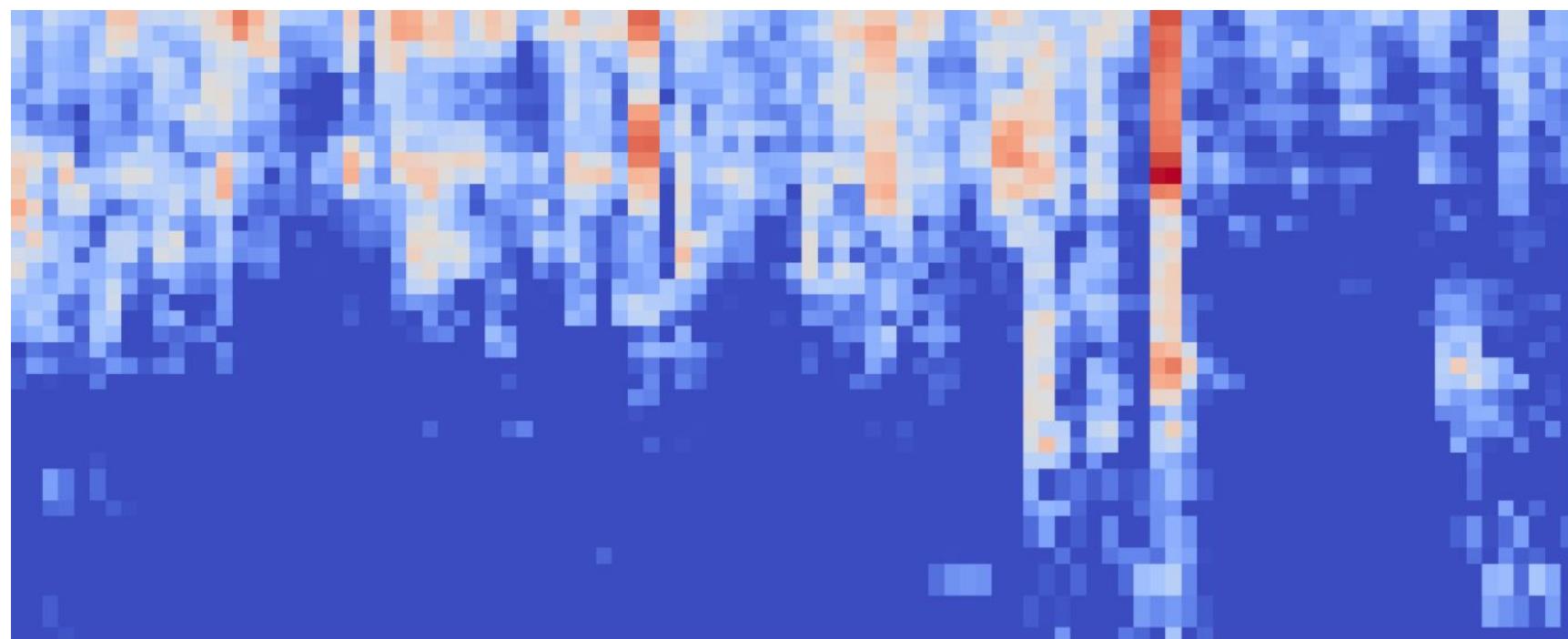
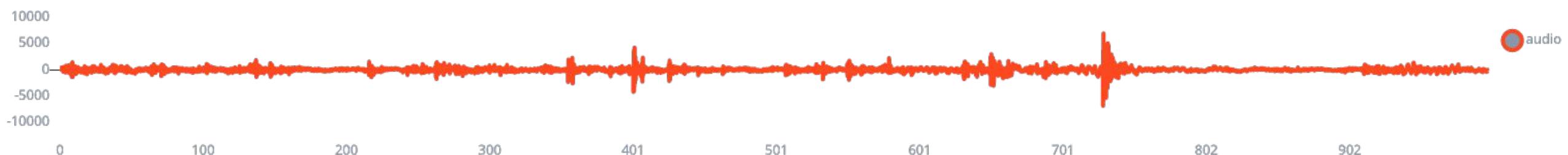
Add a learning block

Audio (MFE)
Extracts a spectrogram from audio signals using **Mel-filterbank energy features**, great for non-voice audio.

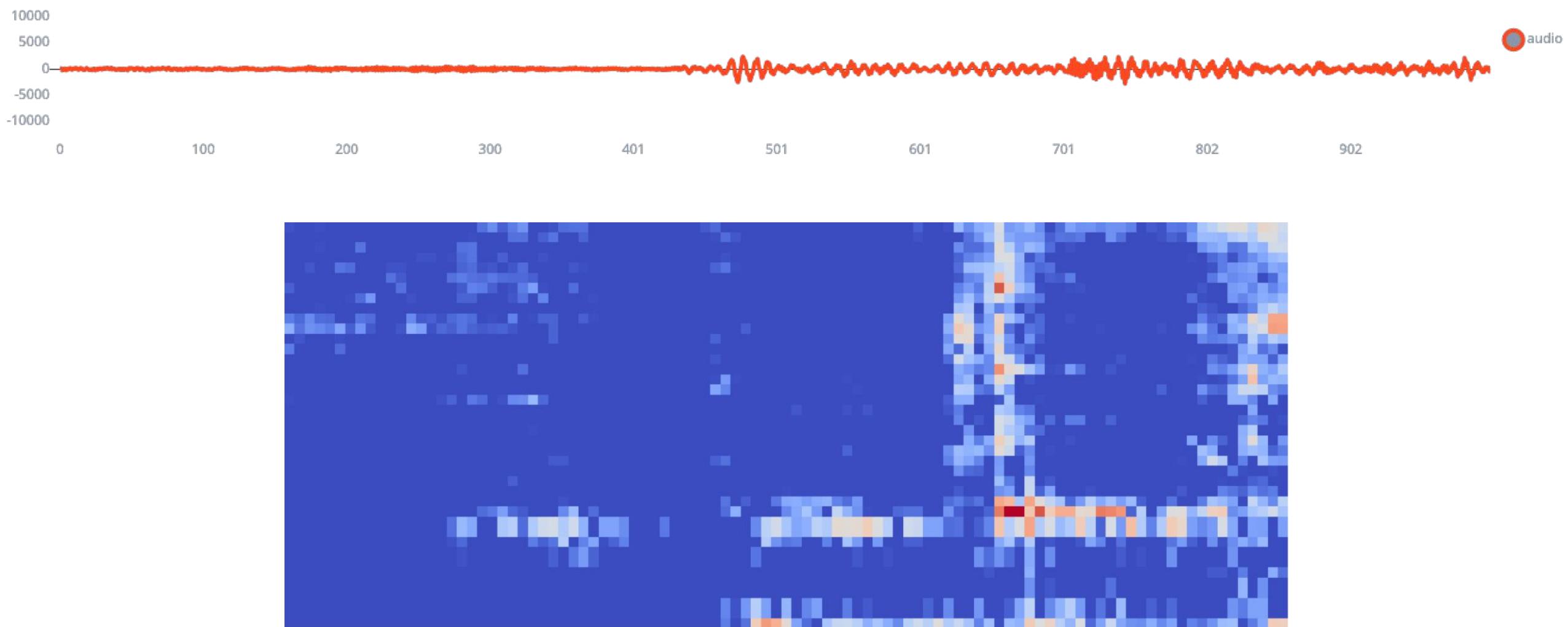
Cool Water 1 second sample



Hot Water 1 second sample



Noise 1 second sample



Parameters Generate features

Training set

Data in training set	2m 35s
Classes	3 (cool, hot, nois
Window length	1000 ms.
Window increase	500 ms.
Training windows	155

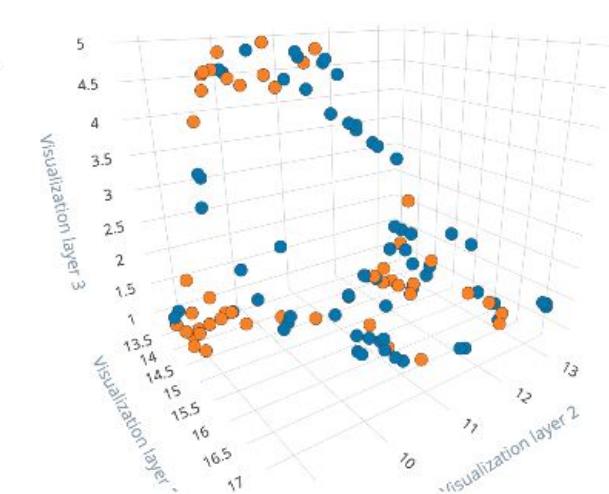
Generate feature

Feature explorer (155 samples)

?

Y Axis

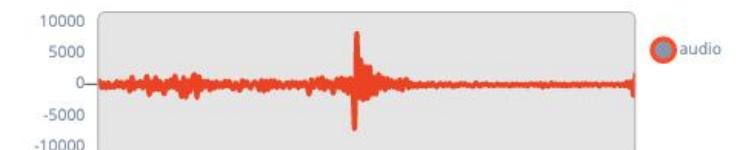
Z Axis



20210710-125930.wav.2a5dy05j.s2

Label: coc

[View sample](#)



On-device performance ⓘ

PROCESSING TIME
250 ms.

PEAK RAM USAGE
25 KB

#1 ▾ Click to set a description for this version

Neural Network settings

Training settings

Number of training cycles

Learning rate

Minimum confidence rating

Audio training options

Data augmentation

Neural network architecture

Architecture presets 1D Convolutional (Default) 2D Convolutional

Input layer (3,960 features)

Reshape layer (40 columns)

1D conv / pool layer (8 neurons, 3 kernel size, 1 layer)

Dropout (rate 0.25)

1D conv / pool layer (16 neurons, 3 kernel size, 1 layer)

Dropout (rate 0.25)

Flatten layer

Add an extra layer

Output layer (3 features)

Training output

Model

Model version:

Last training performance (validation set)

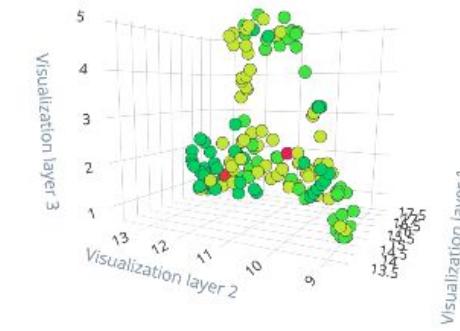
 ACCURACY	93.5%	 LOSS	0.13
--	--------------	--	-------------

Confusion matrix (validation set)

	COOL	HOT	NOISE
COOL	92.9%	7.1%	0%
HOT	16.7%	83.3%	0%
NOISE	0%	0%	100%
F1 SCORE	0.93	0.83	1.00

Feature explorer (full training set)

- cool - correct
- hot - correct
- noise - correct
- cool - incorrect
- hot - incorrect



On-device performance

 INFERENCING TIME	17 ms.
 PEAK RAM USAGE	10.9K
 FLASH USAGE	31.4K



This lists all test data. You can manage this data through [Data acquisition](#).

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	...
20210710-130728.wav	hot	1s	100%	1 hot	...
20210710-130639.wav	hot	1s	100%	1 hot	...
20210710-130553.wav	hot	1s	100%	1 hot	...
20210710-130535.wav	hot	1s	100%	1 hot	...
20210710-130535.wav	hot	1s	100%	1 hot	...
20210710-130224.wav	cool	1s	0%	1 noise	...
20210710-130304.wav	cool	1s	100%	1 cool	...
20210710-130236.wav	cool	1s	100%	1 cool	...
20210710-130256.wav	cool	1s	100%	1 cool	...
20210710-130224.wav	cool	1s	100%	1 cool	...
20210710-130142.wav	cool	1s	0%	1 noise	...
20210710-130100.wav	noise	1s	100%	1 noise	...
20210710-130041.wav	noise	1s	100%	1 noise	...
20210710-125854.wav	noise	1s	100%	1 noise	...
20210710-125854.wav	noise	1s	100%	1 noise	...

Model testing output

Model testing results

ACCURACY

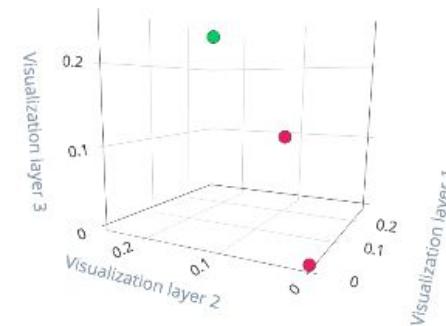
86.67%

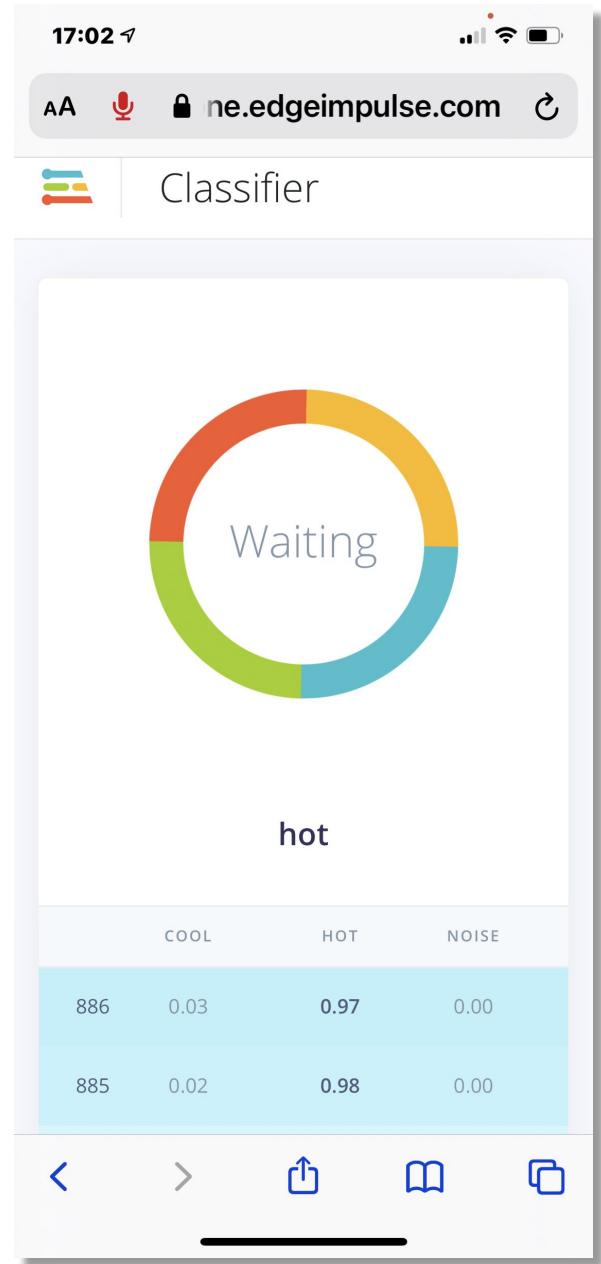
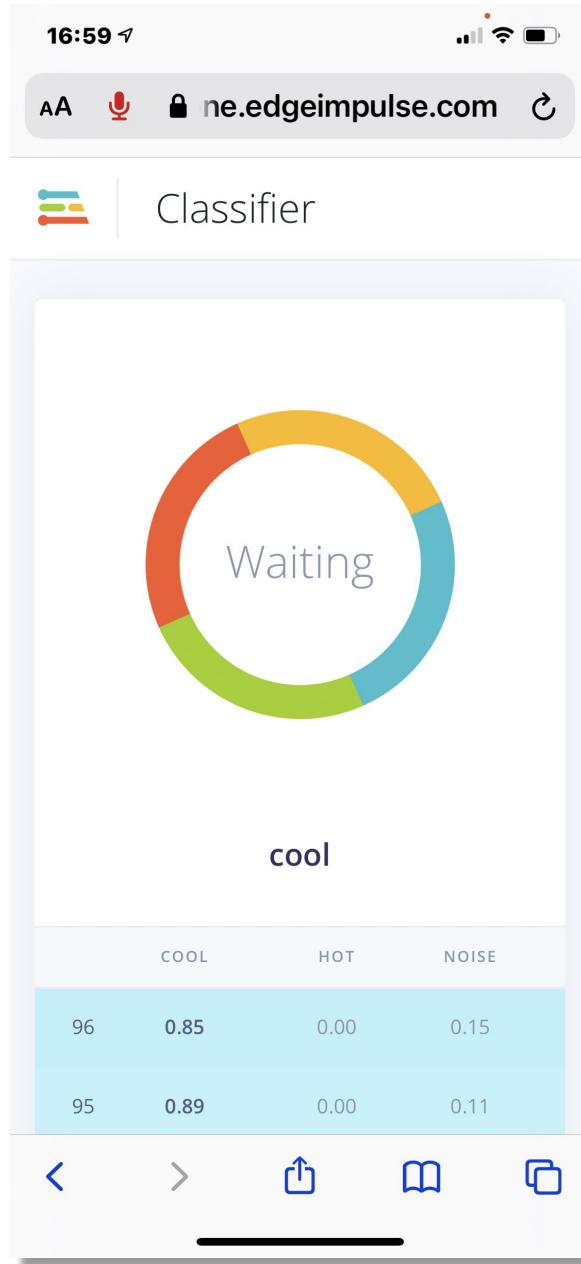
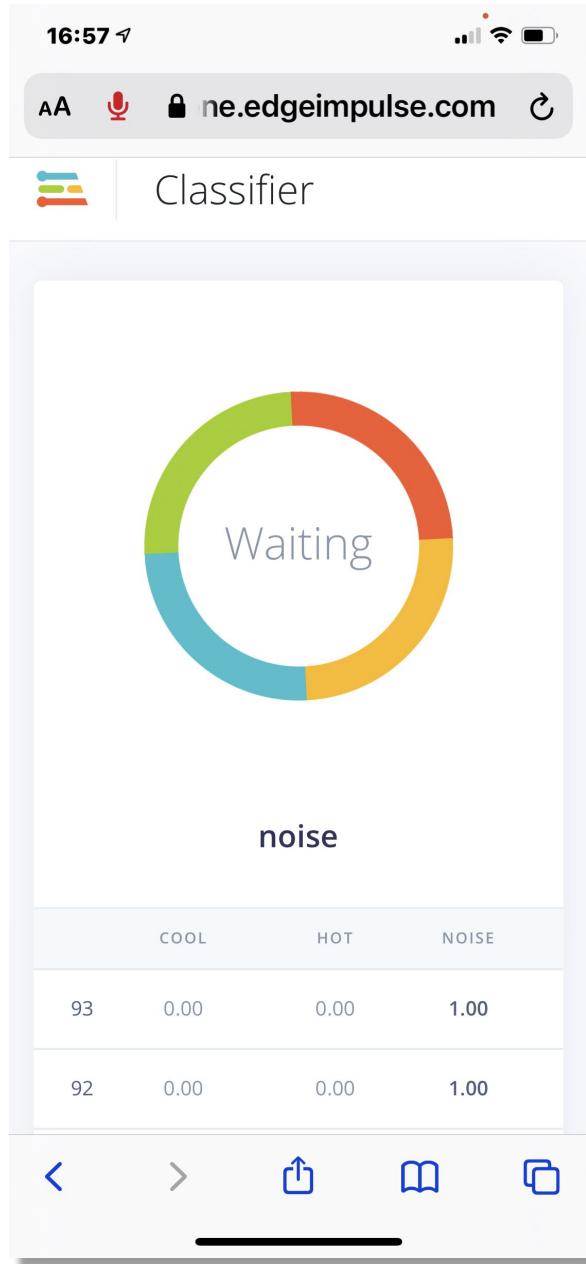


	COOL	HOT	NOISE	UNCERTAIN
COOL	66.7%	0%	33.3%	0%
HOT	0%	100%	0%	0%
NOISE	0%	0%	100%	0%

Feature explorer

- cool - correct
- hot - correct
- noise - correct
- cool - incorrect





Live Classifier (Off line) using iphone

Select optimizations (optional)

Model optimizations can increase on-device performance but may reduce accuracy. Click below to analyze optimizations and see the recommended choices for your target. Or, just click Build to use the currently selected options.



Enable EON™ Compiler

Same accuracy, up to 50% less memory. Open source.



Available optimizations for NN Classifier

Quantized (int8)	RAM USAGE	LATENCY	CONFUSION MATRIX			
	10.9K	17 ms	66.7	0	33.3	0
Currently selected	FLASH USAGE	ACCURACY	0	100	0	0
	31.4K	86.67%	0	0	100	0
Unoptimized (float32)	RAM USAGE	LATENCY	CONFUSION MATRIX			
	33.9K	78 ms	66.7	0	33.3	0
Click to select	FLASH USAGE	ACCURACY	0	100	0	0
	38.0K	86.67%	0	0	100	0

Estimate for Cortex-M4F 80MHz (ST IoT Discovery Kit)

Arduino File Edit Sketch Tools Help

nano_ble33_sense_microphone_continuous_LED | Arduino 1.8.15

/dev/cu.usbmodem144301

ICTP - PSYCOACOUSTICS TEMPERATURE Project

Inferencing settings:

- Interval: 0.06 ms.
- Frame size: 16000
- Sample length: 1000 ms.
- No. of classes: 3

Predictions (DSP: 126 ms., Classification: 21 ms., Anomaly: 0 ms.):

:
 PREDICTION: ==> noise with probability 1.00
 :
 Predictions (DSP: 126 ms., Classification: 21 ms., Anomaly: 0 ms.):
 :
 PREDICTION: ==> noise with probability 1.00
 :
 Predictions (DSP: 126 ms., Classification: 20 ms., Anomaly: 0 ms.):
 :
 PREDICTION: ==> noise with probability 1.00

Autoscroll Show timestamp Both NL & CR 115200 baud Clear output

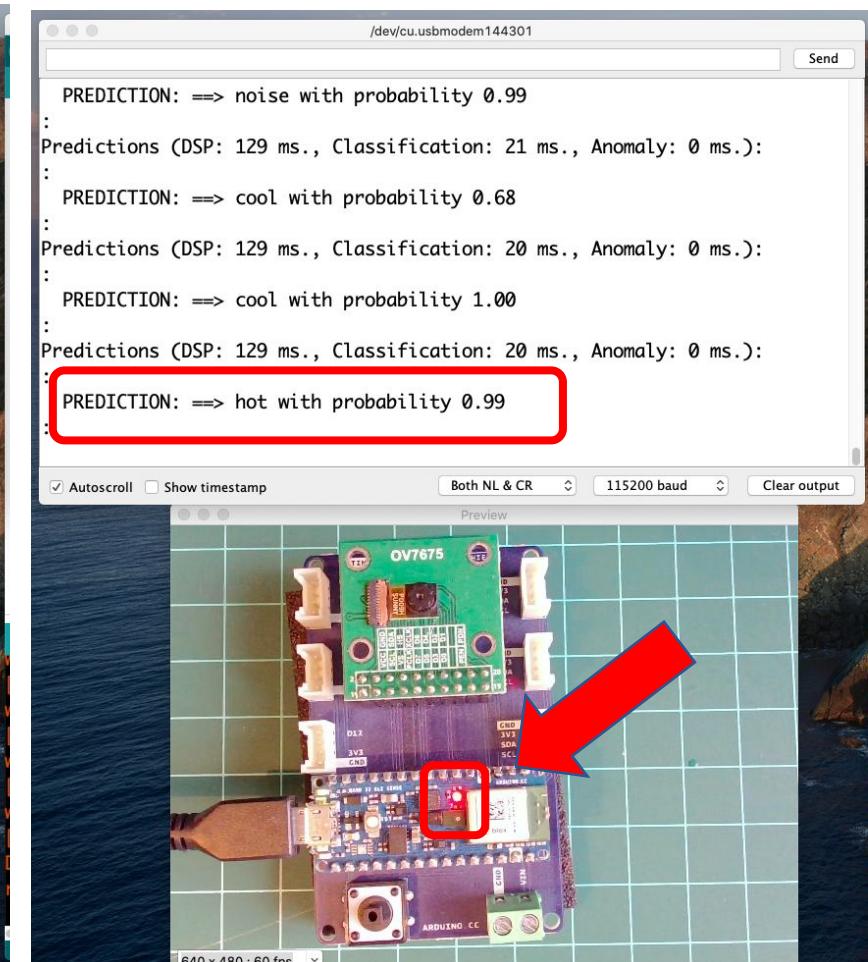
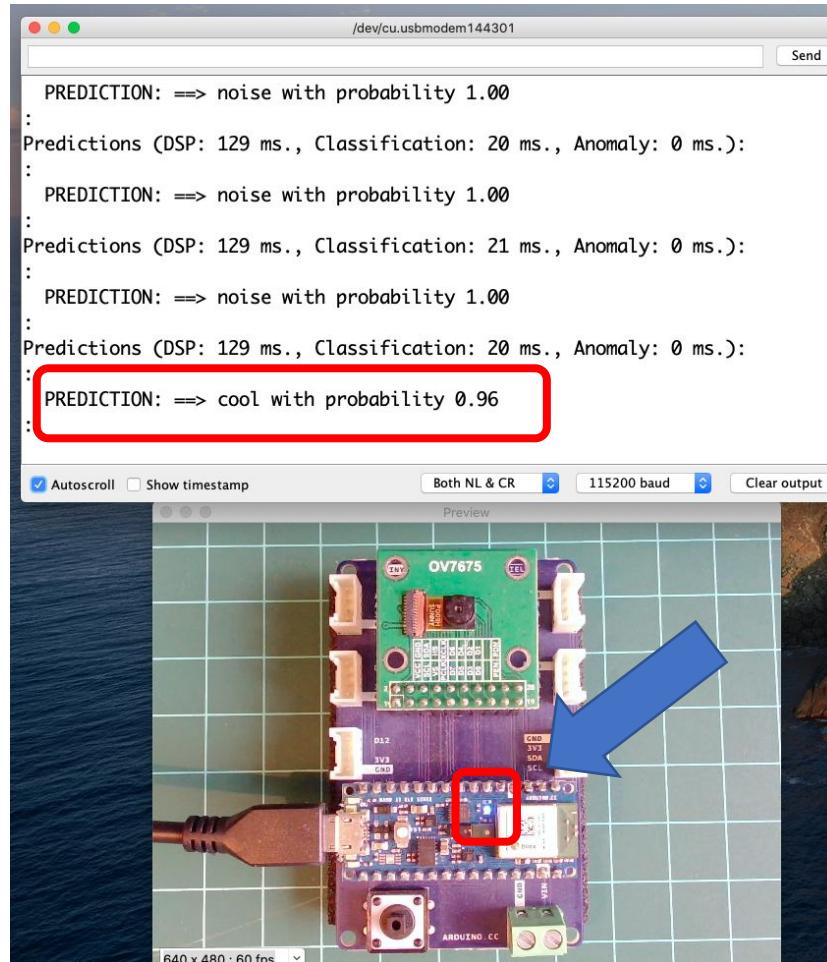
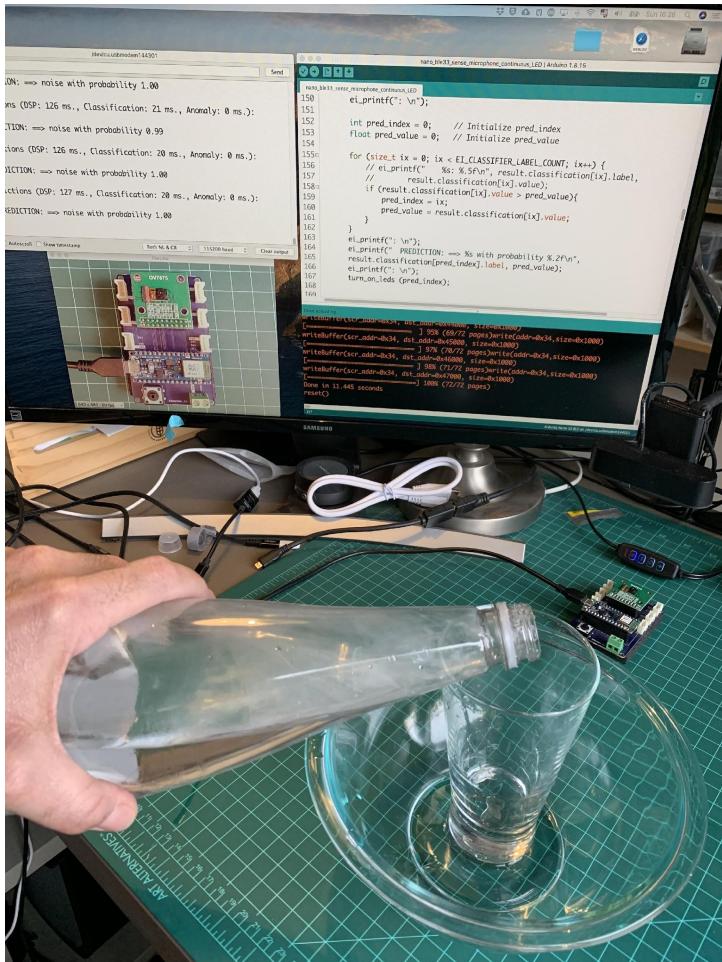
Preview

640 x 480 : 60 fps

88 */***
 89 * @brief Special Postprocess function for RGB LEDs
 90 */
 91
 92 **void** turn_off_leds(){
 93 digitalWrite(LED_R, HIGH);
 94 digitalWrite(LED_G, HIGH);
 95 digitalWrite(LED_B, HIGH);
 96 }
 97
 98 */**
 99 * cool: [0] ==> Blue ON
 100 * hot: [1] ==> Red ON
 101 * noise: [2] ==> ALL OFF
 102 */
 103
 104 **void** turn_on_leds(**int** pred_index) {
 105 **switch** (pred_index)
 106 {
 107 **case** 0:
 108 turn_off_leds();
 109 digitalWrite(LED_B, LOW);
 110 **break**;
 111
 112 **case** 1:
 113 turn_off_leds();
 114 digitalWrite(LED_R, LOW);
 115 **break**;
 116
 117 **case** 2:
 118 turn_off_leds();
 119 **break**;
 120 }
 121 }
 122

Done uploading.
 writeBuffer(scr_addr=0x34, dst_addr=0x44000, size=0x1000)
 [=====] 95% (69/72 pages) write(addr=0x34, size=0x1000)
 writeBuffer(scr_addr=0x34, dst_addr=0x45000, size=0x1000)
 [=====] 97% (70/72 pages) write(addr=0x34, size=0x1000)

Arduino Nano 33 BLE on /dev/cu.usbmodem144301



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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The IESTI01 course is part of the [TinyML4D](#), an initiative to make TinyML education available to everyone globally.

Thanks



UNIFEI