AIoT PROJECT

PLAY DINSOR

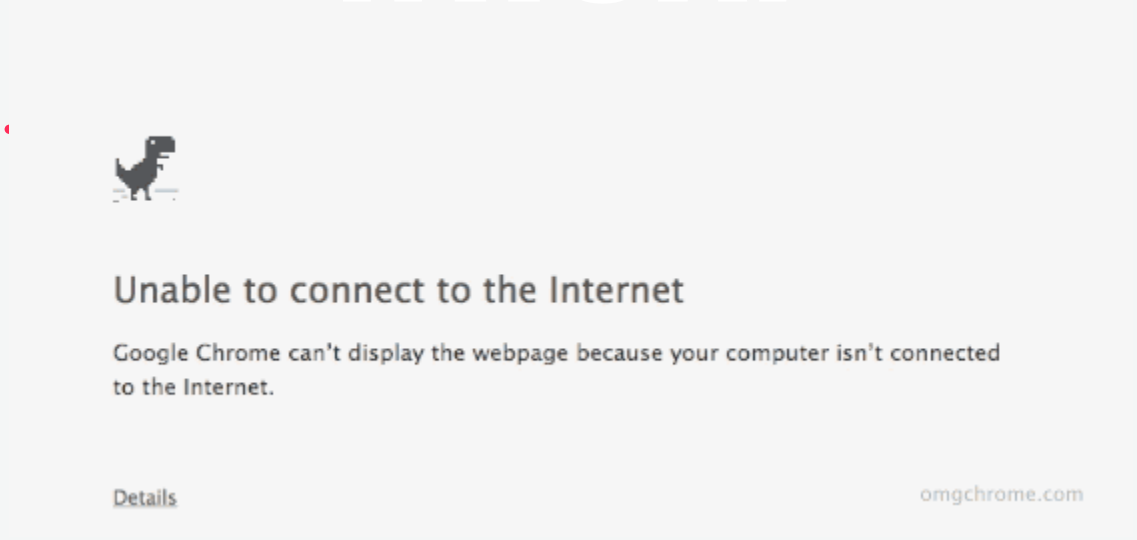
PRESENTATION

TEACHER: NGUYEN DUC HOANG HA
TA: DO THI THANH HA
COURSE: AN INTRODUCTION TO SMART DEVICE PROGRAMMING

INTRODUCE MYSELF

Full Name: Hoang Huu Minh An
ID: 20127102
Class: 20TGMT
Major: Knowledge Engineering

WHOA!



Learn how to play Chrome's dino game physically using Edge Impulse and ESP-32

01

INTRODUCTION
PLAY DINSOR

02

HARDWARE &
SOFTWARE

03

HOW IT WORK ?
HOW TO BUILD?

04

BUILD MODEL
HANDLE IT

05

TRAINING &
TESTING

06

DELOYMENT &
CONNECT BLE?

07

DELOY

08

SUMMARY

LET'S START PRESENTATION!

01

INTRODUCTION
PLAY DINSOR

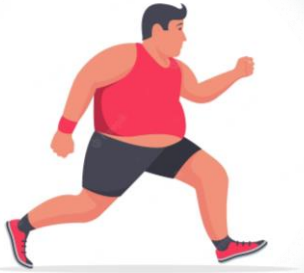
01. IDEARS
02. QUESTION
03. APPROACH

01. IDEARS

The average person between the ages of 16 and 65 sits for around *8h per day*, a number that got increasingly larger

As we all know, long-term inactivity causes many diseases, including obesity, back pain, stress, etc.

So, I believe it's time for us to get some exercise.



01. MY IDEARS

I attempted to utilize a mobile app that assisted with performing physical activities without the use of equipment, but it quickly became boring and I gave up.

why don't we do something fun and burn calories at the same time

- ❑ Connect to Computer
- ❑ Open Dino chrome://dino/
- ❑ Jump

02. QUESTION

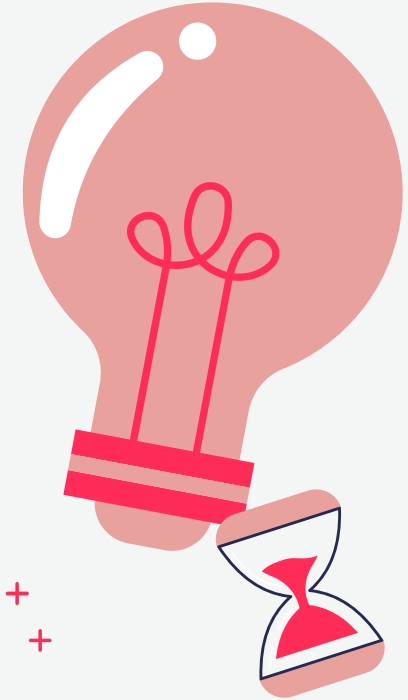
HOW TO MAKE IT WORKING ?

HOW TO DETECT MOTION JUMP ?

HOW TO BUILD ONE MODEL ?

- INPUT ?
- OUTPUT ?

03. APPROACH



Machine learning and algorithms: Using machine learning and artificial intelligence algorithms, you can build predictive models

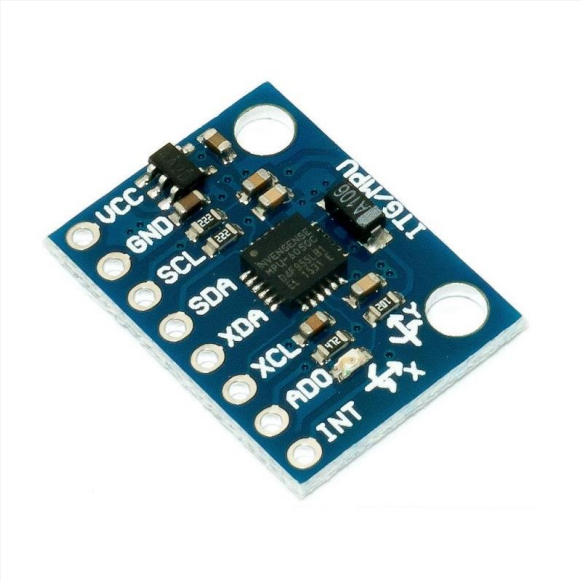
Data Analytics: AIoT enables the collection and analysis of large amounts of data from connected devices. Using algorithms and artificial intelligence models, you can find patterns, trends, and useful information from this data to make smart decisions.

02

HARDWARE & SOFTWARE

What we need ?

HARDWARE



GY-521 6DOF IMU MPU6050 – Hshop.vn

GY-521 6DOF IMU MPU6050 sensor is used to measure 6 parameters: 3-axis Angle (Gyro), 3-axis accelerometer (Accelerometer)

- Use voltage: 3~5VDC
- Communication voltage: 3~5VDC
- Communication standard: I2C
- Gyroscopes value in the range: +/- 250 500 1000 2000 degree/sec
- Acceleration values in the range: +/- 2g, +/- 4g, +/- 8g, +/- 16g
- Gold-plated circuit board, automatic welding components by best quality machine.

HARDWARE

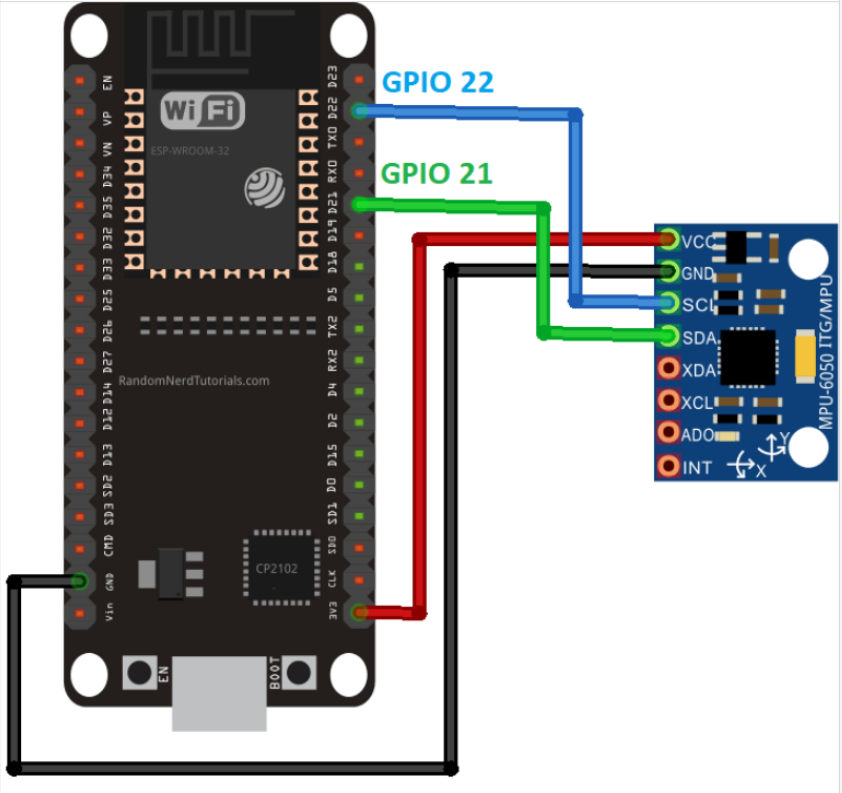
Wifi BLE ESP32 NodeMCU-32S CH340 Ai-Thinker

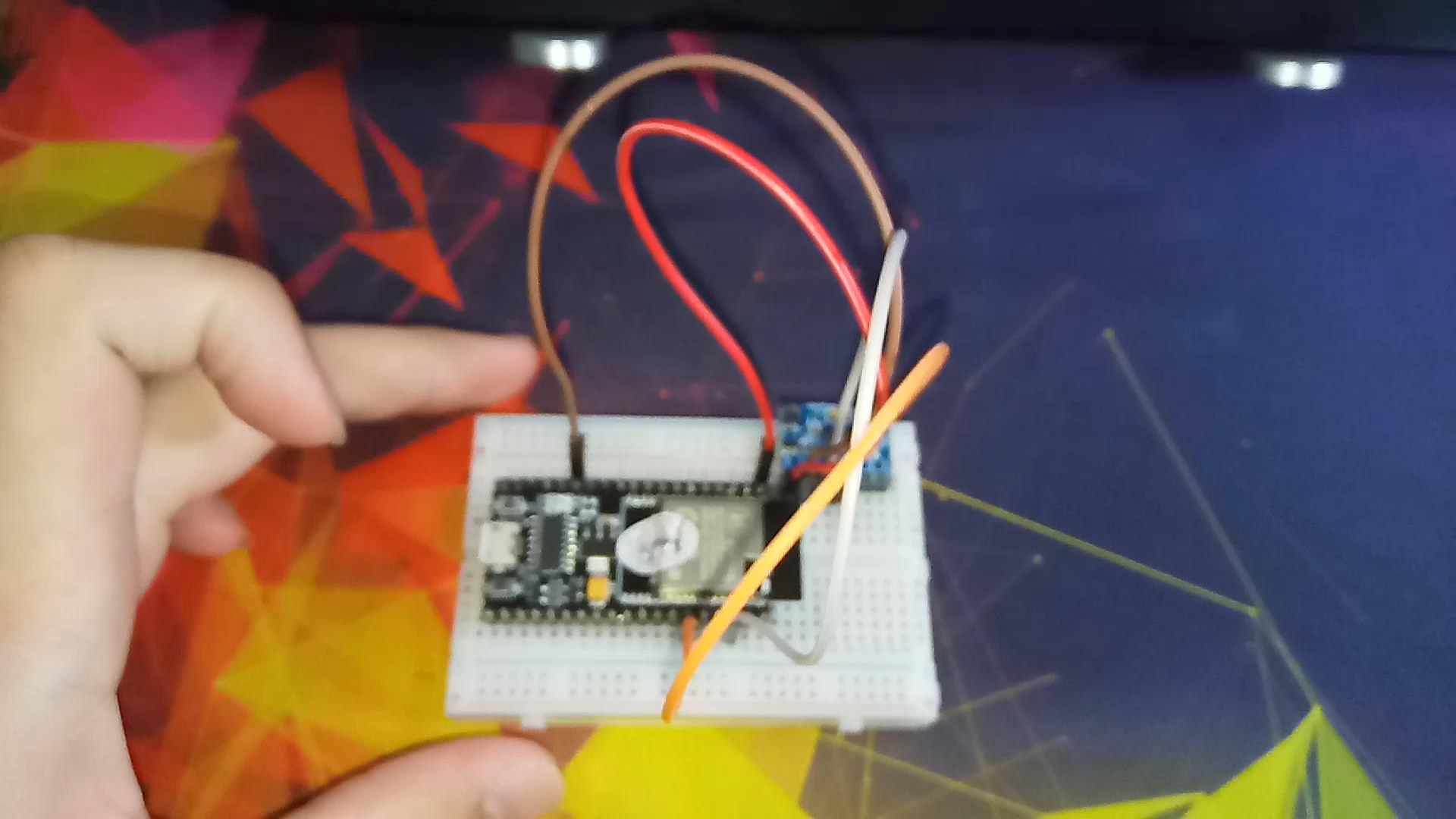
- Producer: Ai-Thinker
- Hub Module: Ai-Thinker ESP32-S
- SPI Flash: 32Mbits
- Frequency Range: 2400~2483.5Mhz
- Bluetooth: BLE 4.2 BR/EDR
- Wifi: 802.11 b/g/n/e/i
- Support Interface: UART/SPI/SDIO/I2C/PWM/I2S/IR/ADC/DAC
- Power used: 5VDC from Micro USB port.
- Built-in charger and UART CH340 .
- communication circuit Standard 38 pins 2.54mm, full output of ESP32 module.
- Integrated LED Status, push button IO0 (BOOT) and ENABLE. Dimensions: 25.4 x 48.3mm

Kit RF thu phát Wifi BLE ESP32 NodeMCU-32S CH340 Ai-Thinker – Hshop.vn

HARDWARE

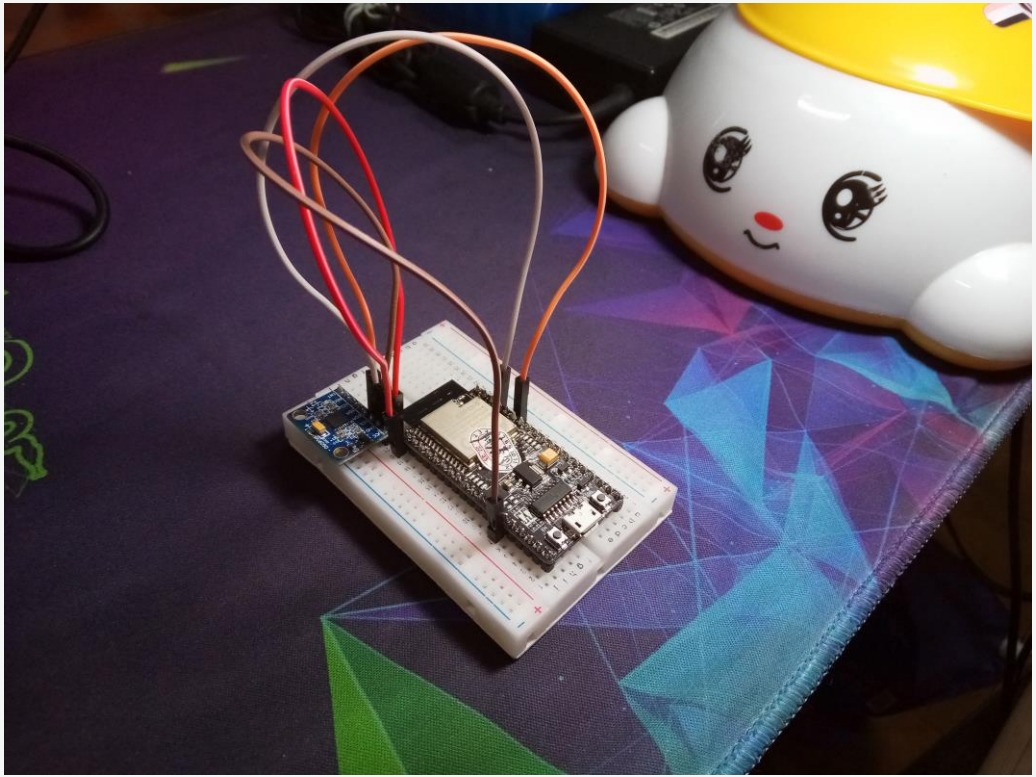
MPU6050 connection with Esp32





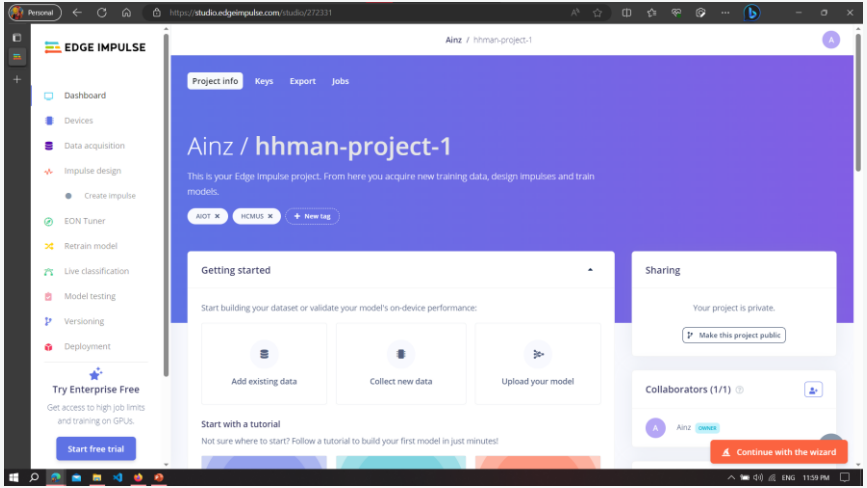
HARDWARE

MPU6050 connection with Esp32

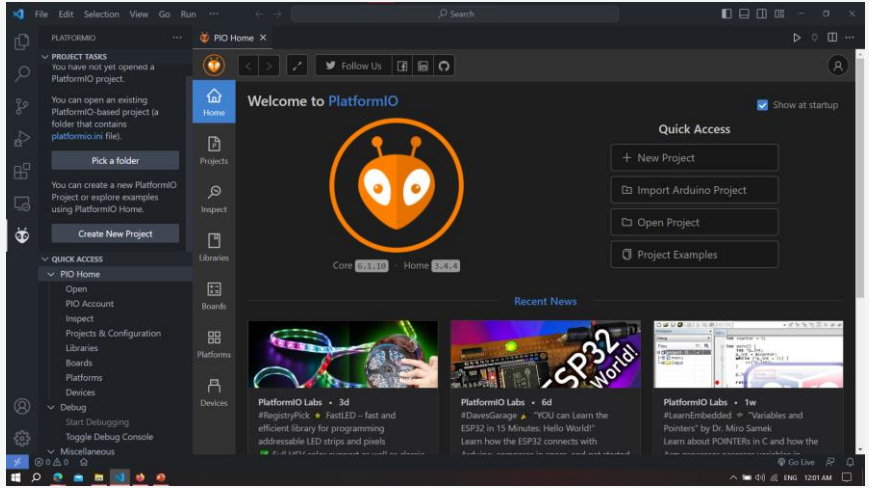


SOFTWARE

EDGE IMPULSE



PLATFORMIO.ORG



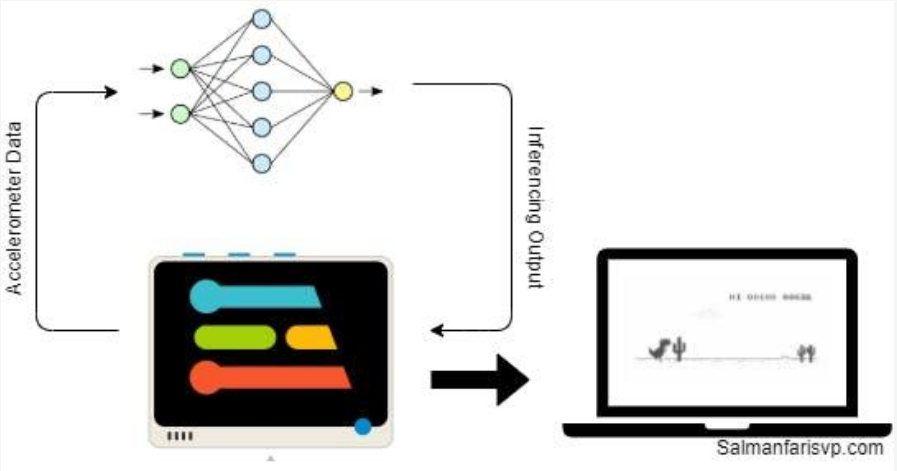
HOW IT WORK ?
HOW TO BUILD ONE ?

you need it

03

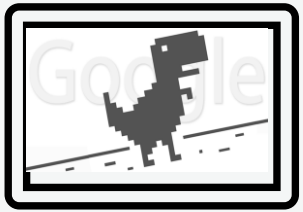
HOW IT WORK ?

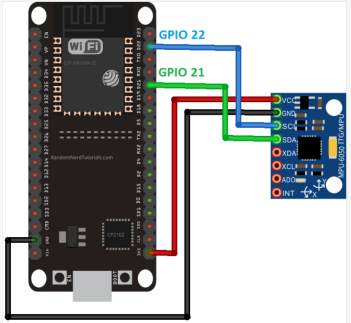
When the user jumps, a system (Esp32+MPCU6050) is attached to the user's body or held by the user. User actions will be detected based on the accelerometer. EdgeImplulse analyzes the data from the accelerometer and decides whether the user will act normally or jump. If it's a Jump activity the system will simulate keystrokes send to the computer.

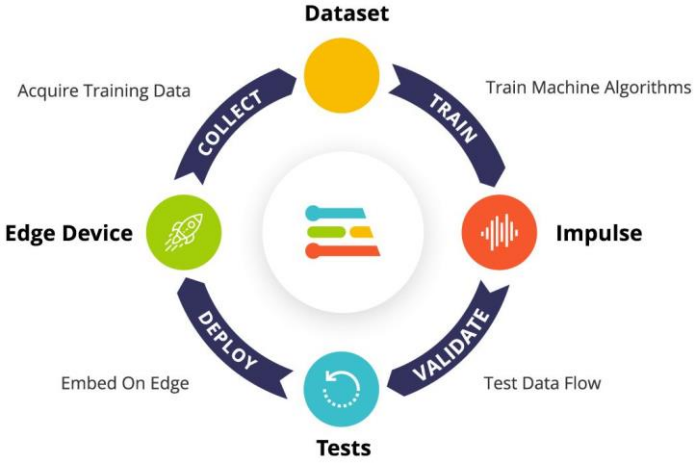


HOW TO BUILD ?

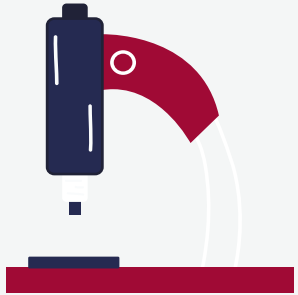
The project is a combination of machine learning and embedded electronics







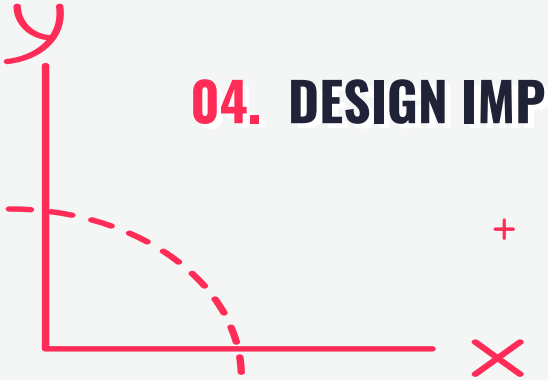
04



BUILD MODEL
HANDLE IT

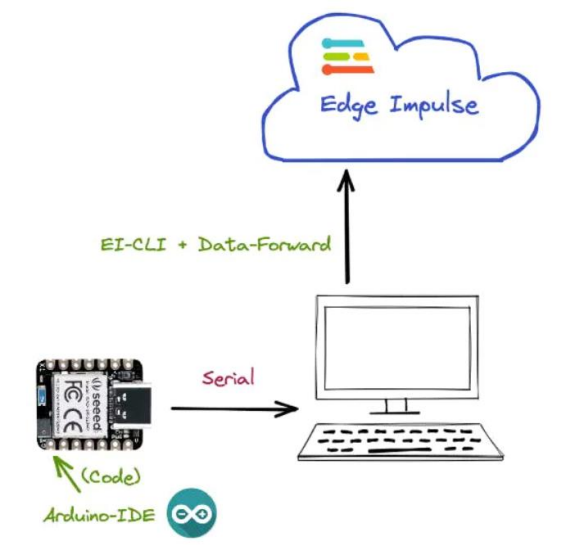
Prepare

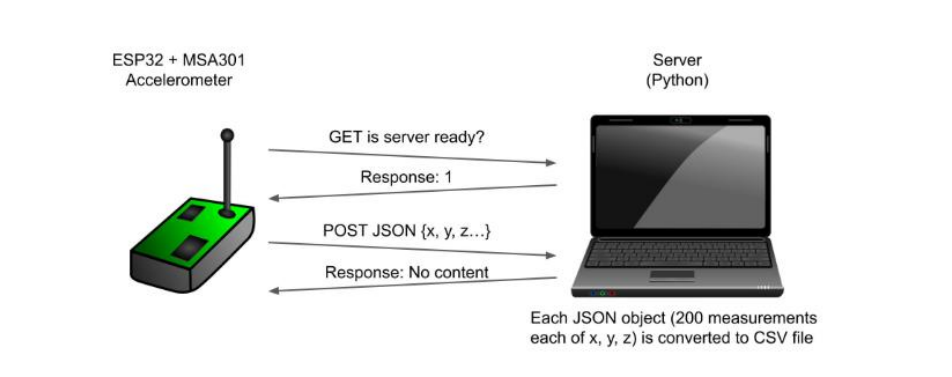
01. CONNECT DEVICE TO EDGE IMPULSE
02. DATA COLLECTION
03. DATA PRE-PROCESSING
04. DESIGN IMPULSE



01. CONNECT DEVICE TO EDGE IMPULSE

For data collection, we should first connect our device to the Edge Impulse Studio, which will also be used for data pre-processing, model training, testing, and deployment.





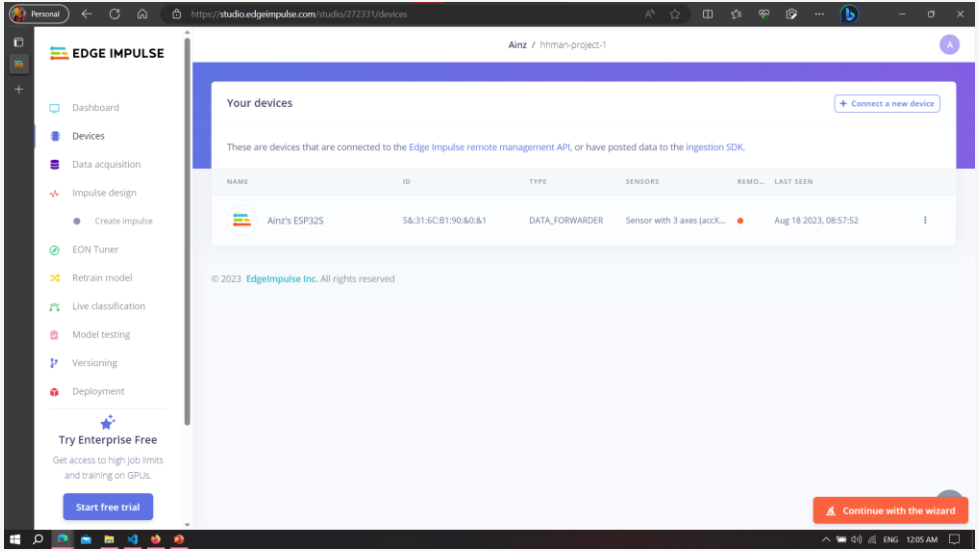
Installation - Edge Impulse Documentation

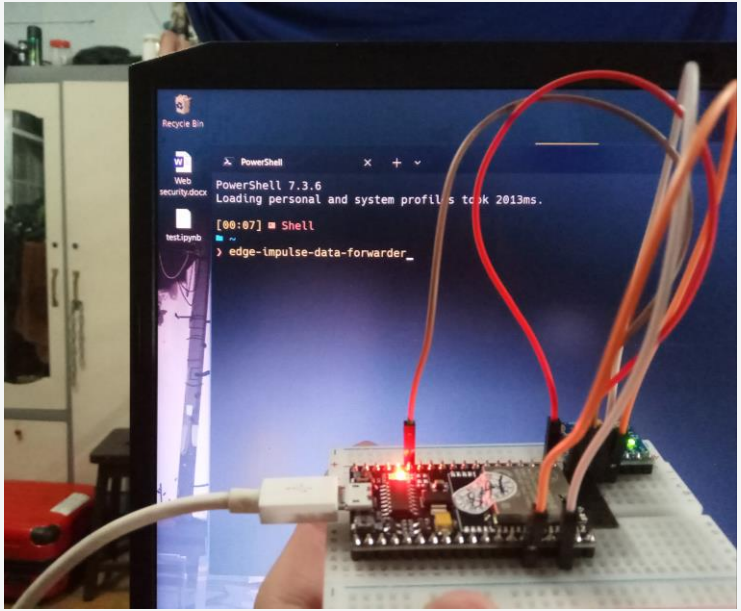
Data forwarder - Edge Impulse Documentation

tinyml-example/esp32-accel-post· GitHub

tinyml-example/http-accel-server.py GitHub

01. CONNECT DEVICE TO EDGE IMPULSE



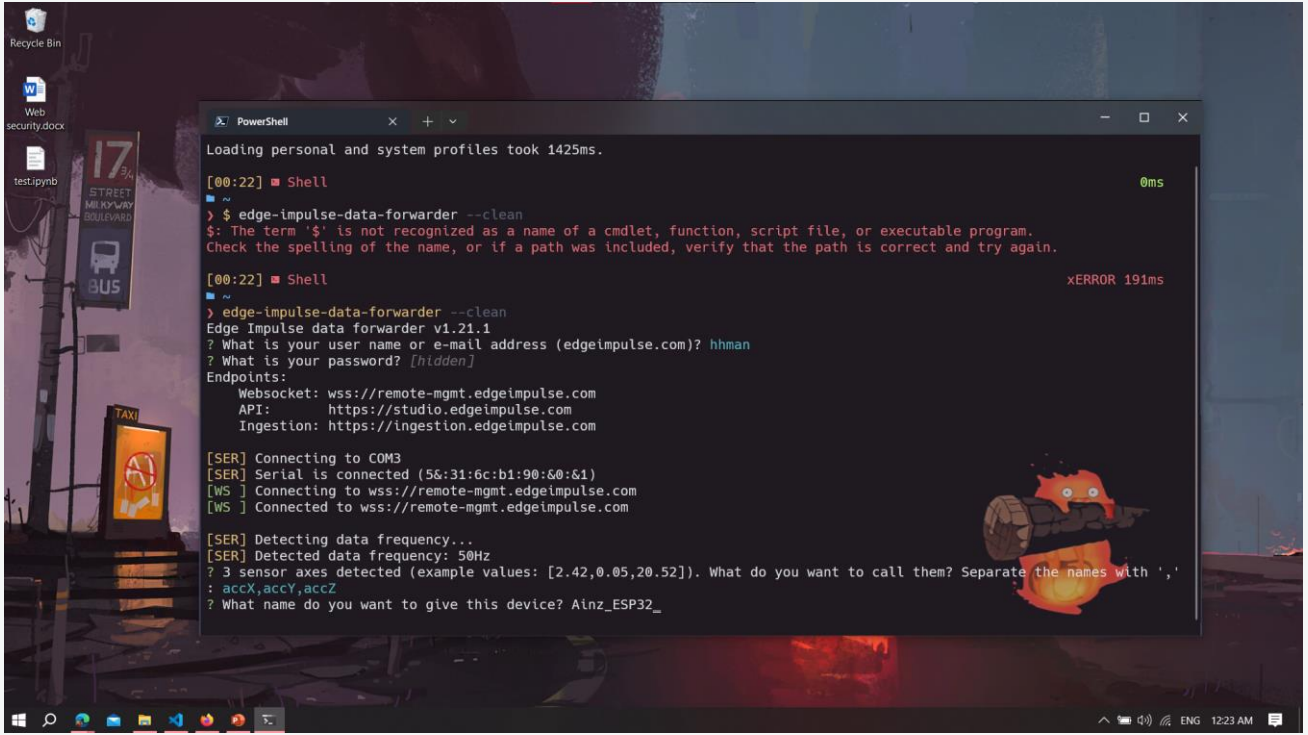


01. CONNECT DEVICE TO EDGE IMPULSE

$ edge-impulse-data-forwarder

Set Name of device

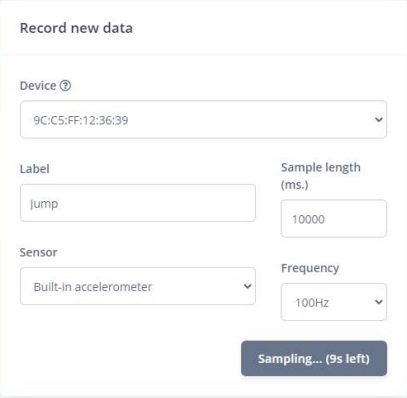
Set 3 sensor axes



Installation - Edge Impulse Documentation

Data forwarder - Edge Impulse Documentation

02. DATA COLLECTION



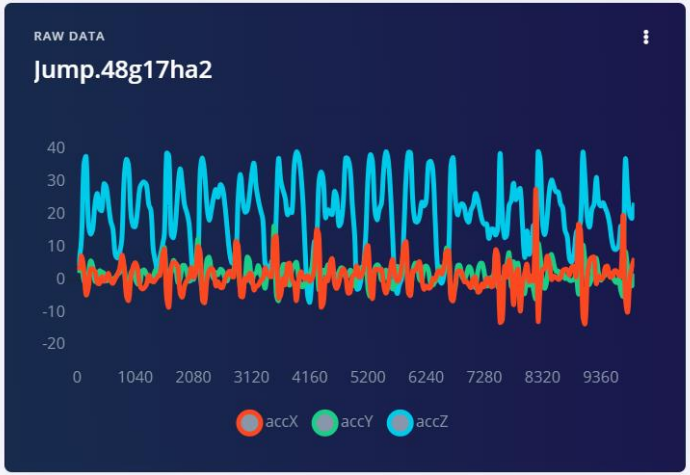
Motion Classification:

- Jump
- Idle

We should capture data from all two body state Classes.

More data is better, and try to equalize all the datasets otherwise model will underfit or overfit

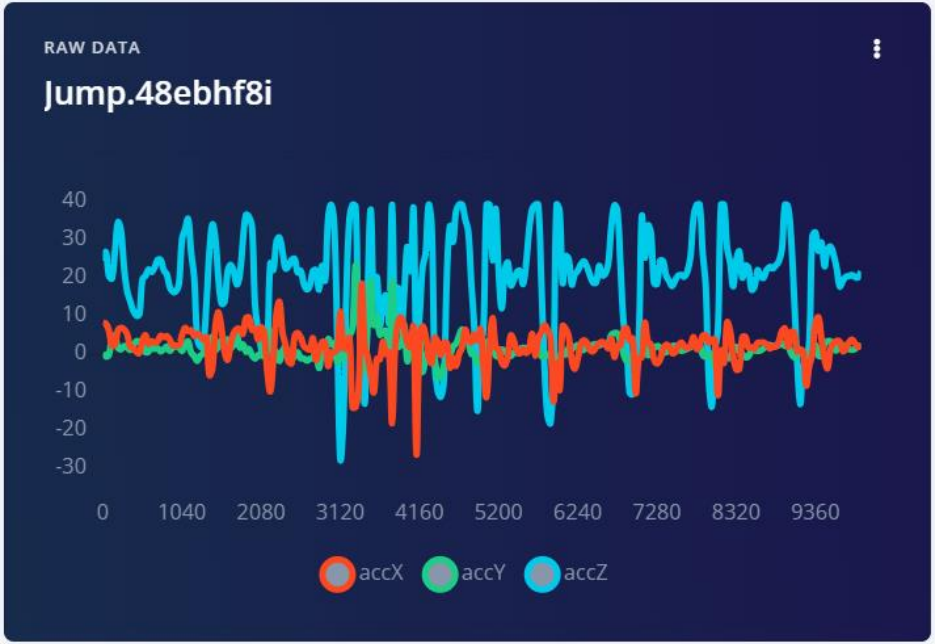
Jump

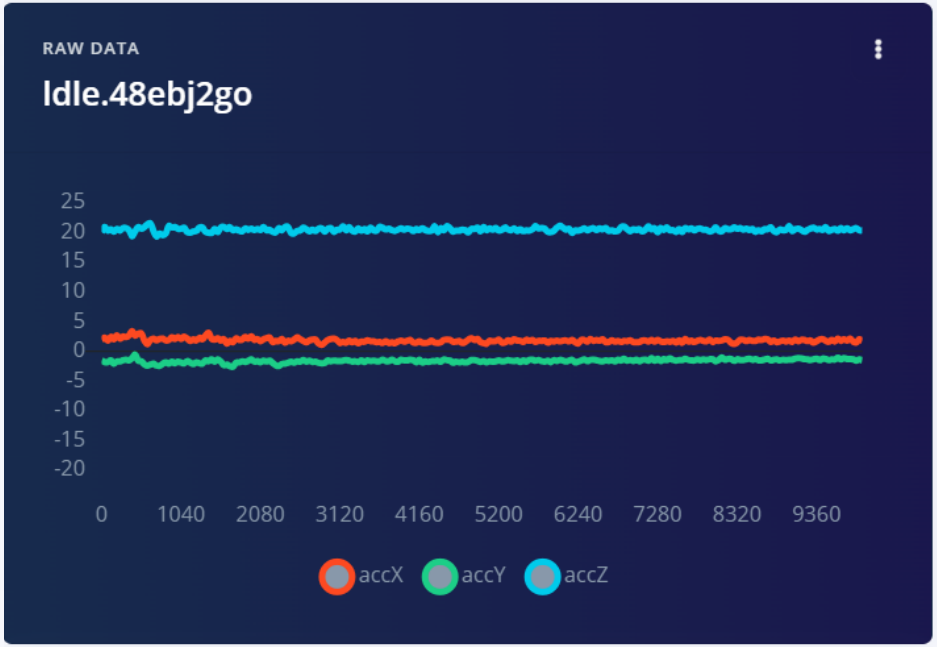


(raw data) of 10 seconds

02. DATA COLLECTION

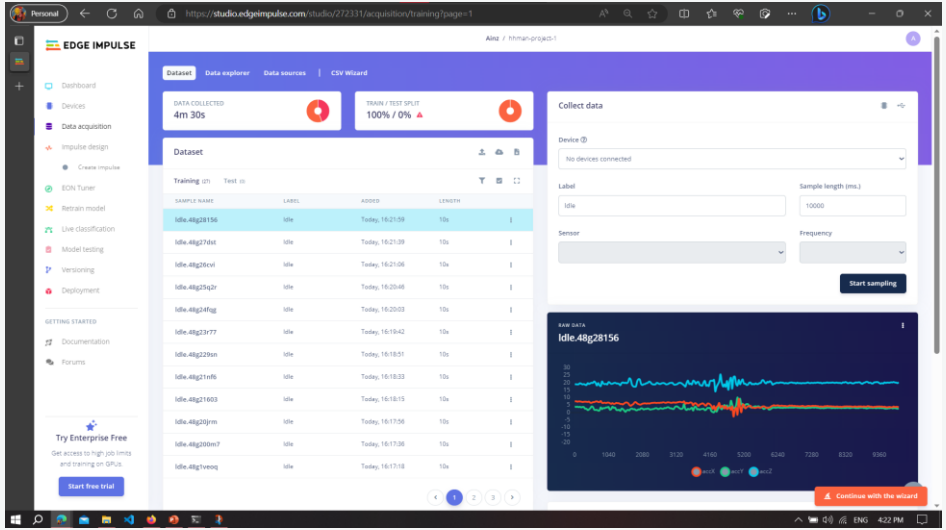
(raw data) of 10 seconds



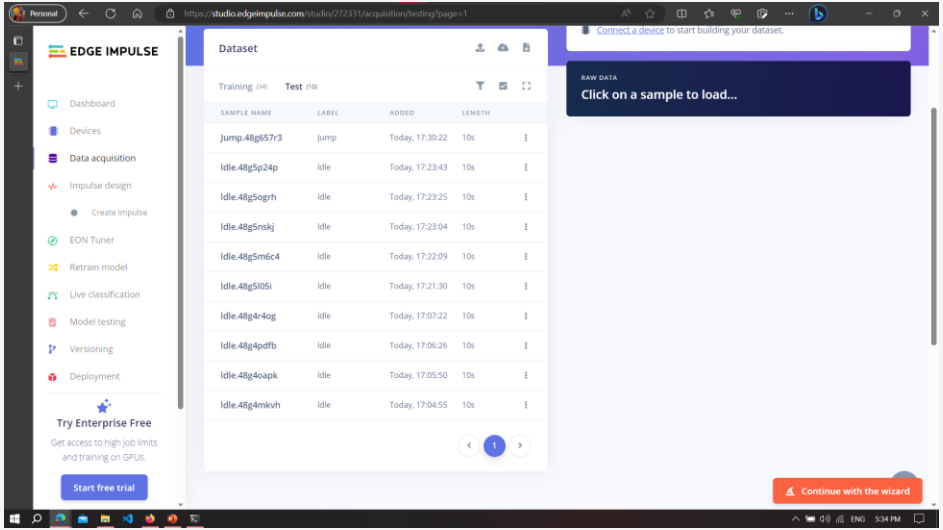


- Jump
- Idle

02. DATA COLLECTION



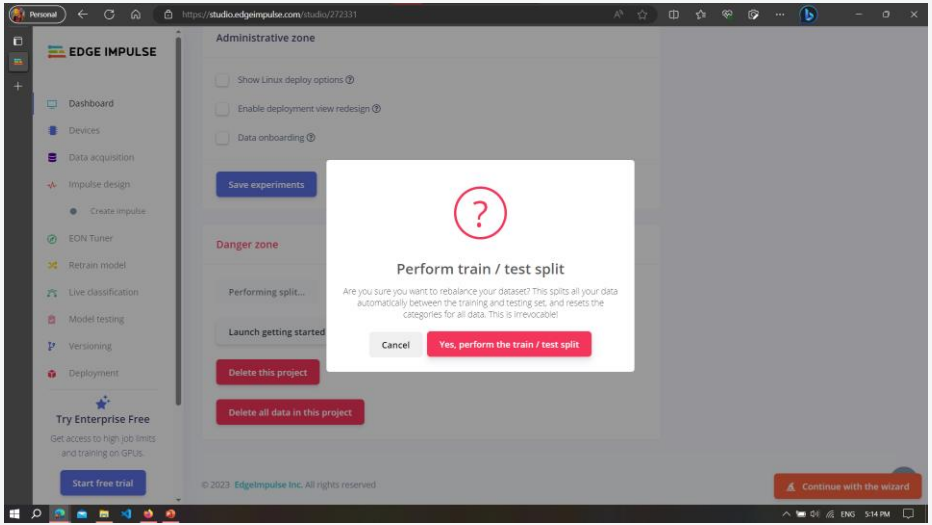
Training data

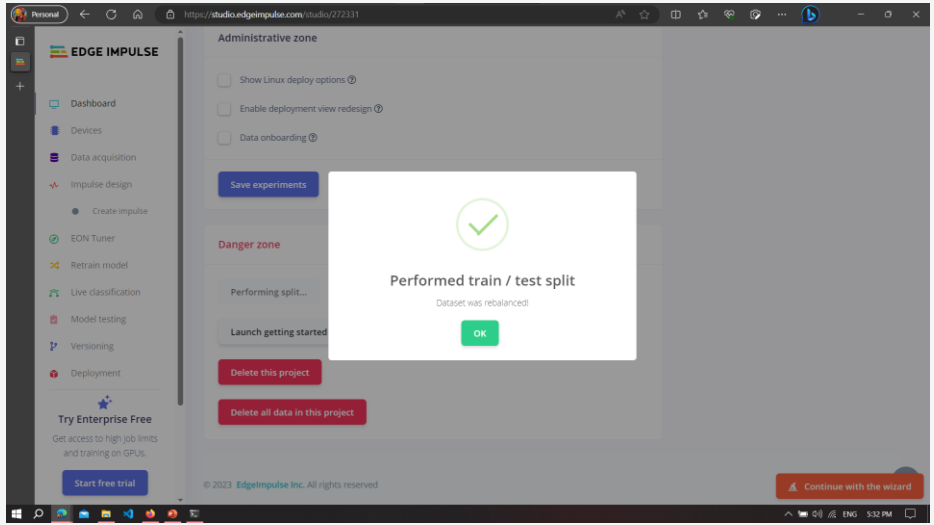


Testing data

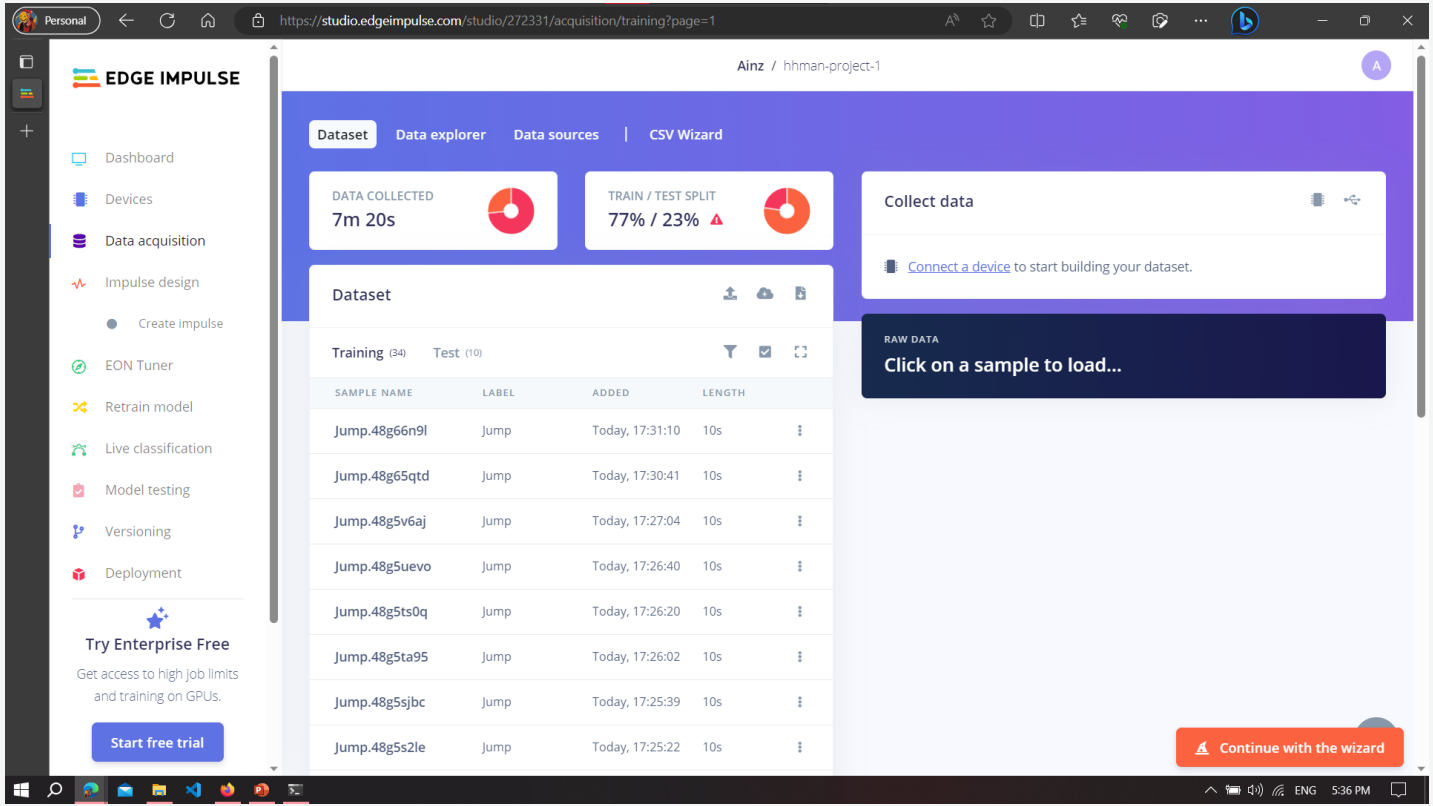
02. DATA COLLECTION

rebalance data





02. DATA COLLECTION

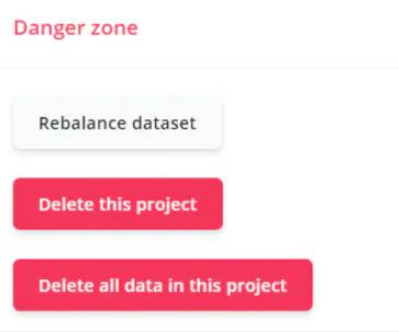


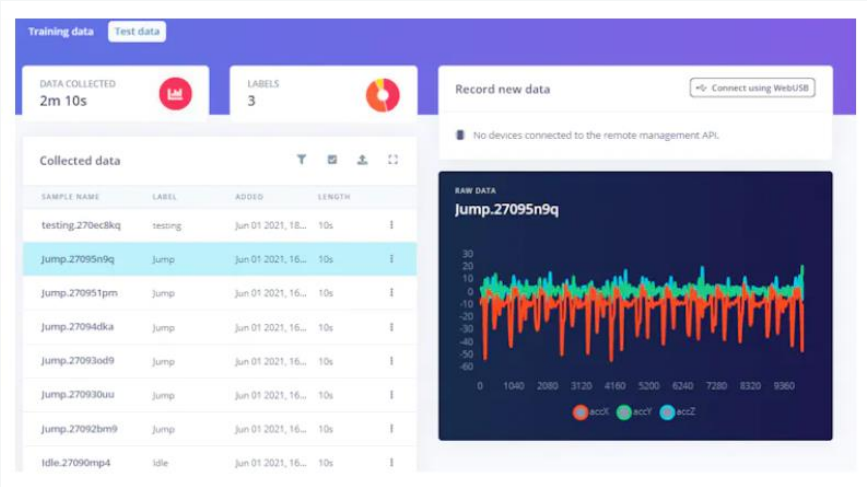
02. DATA COLLECTION

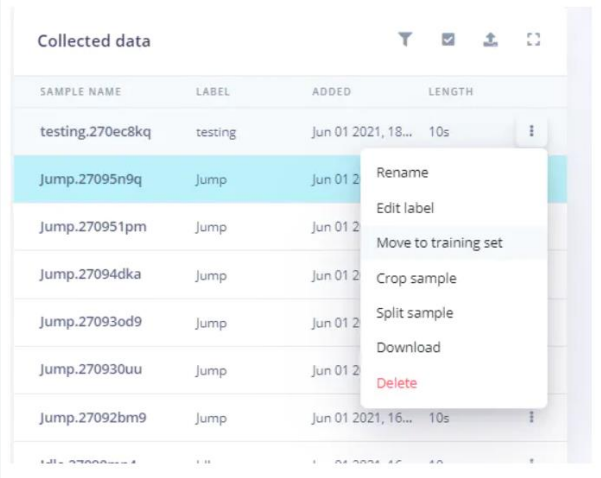
In order to build a better ML model we need to provide quality data and to test the quality of the model we need scale

Training Set: You can extract features and train to fit a model and so on.

Testing Set: Measure the model accuracy by predicting the data set





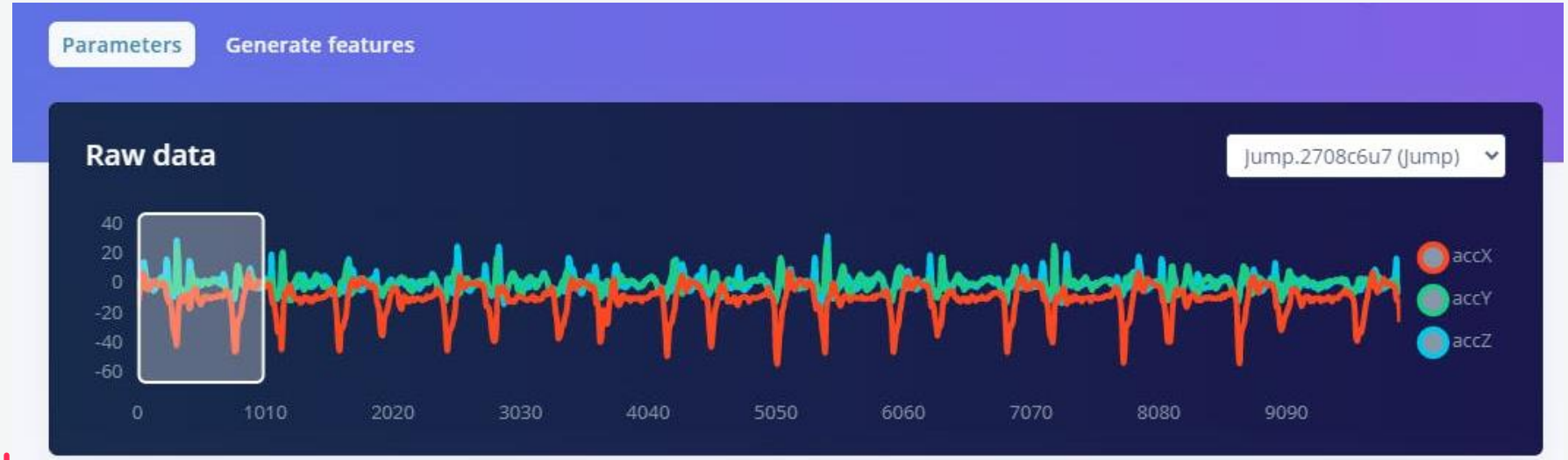


you can see the Test data

if it's not balanced, you can move each dataset manually

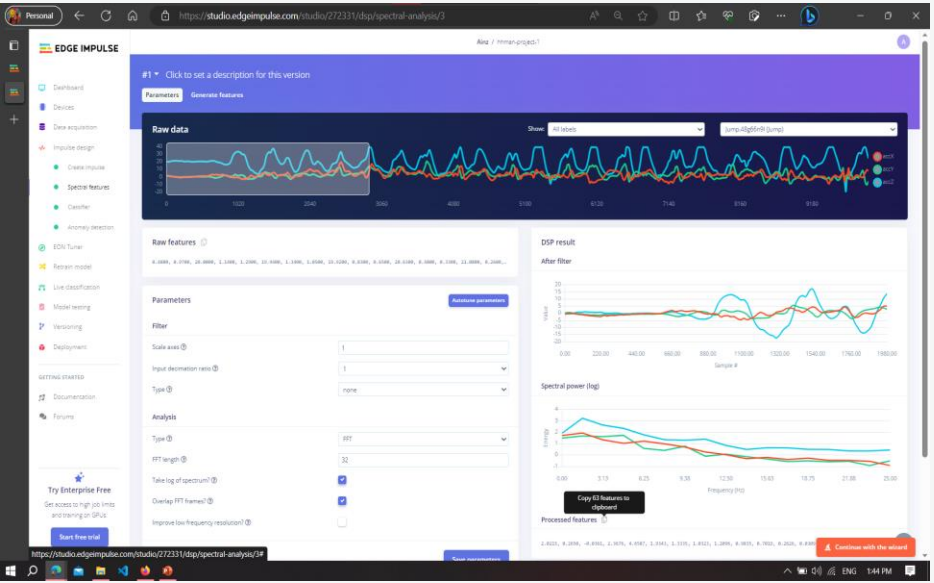
03. DATA PRE-PROCESSING

The raw data type captured by the accelerometer is a "time series" and should be converted to "tabular data". We can do this conversion using a sliding window over the sample data.
Using Spectral Analysis as a processing block, Since it's great for analyzing repetitive motion, such as data from accelerometers.

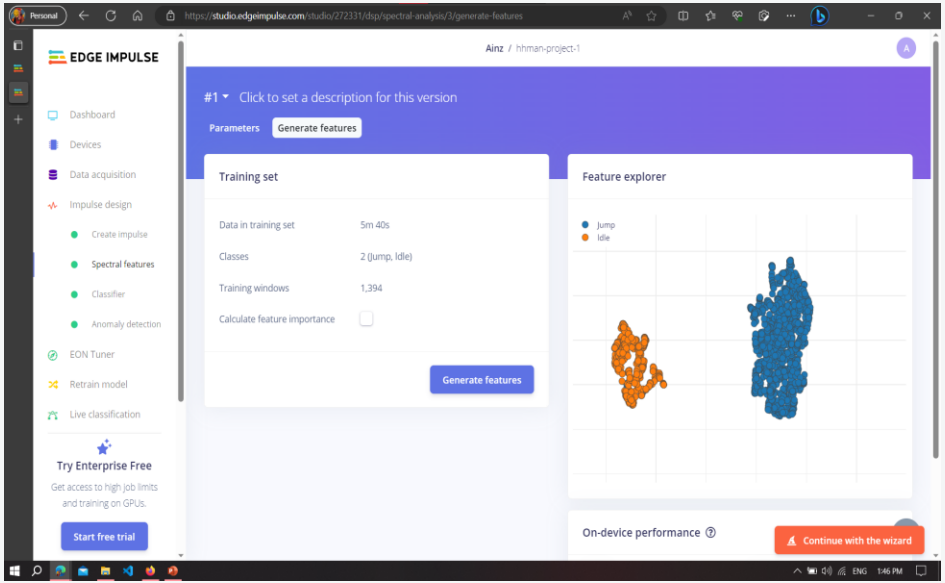


03. DATA PRE-PROCESSING

Spectral features



Generate features

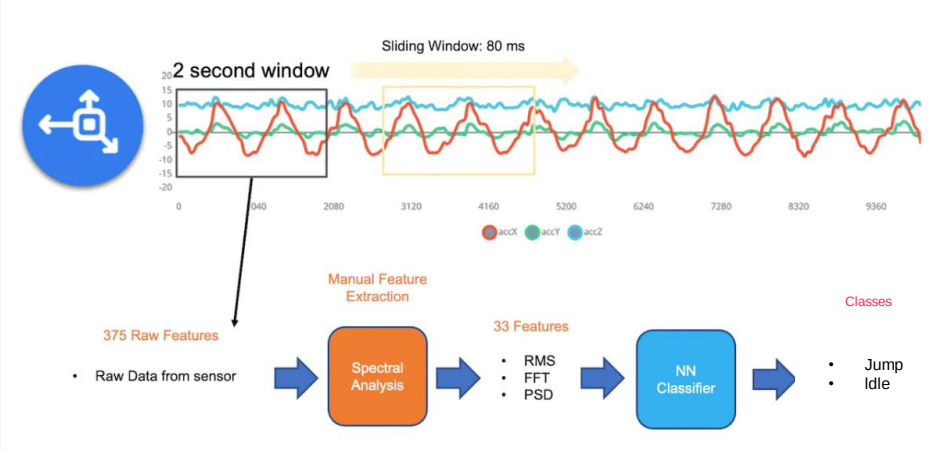


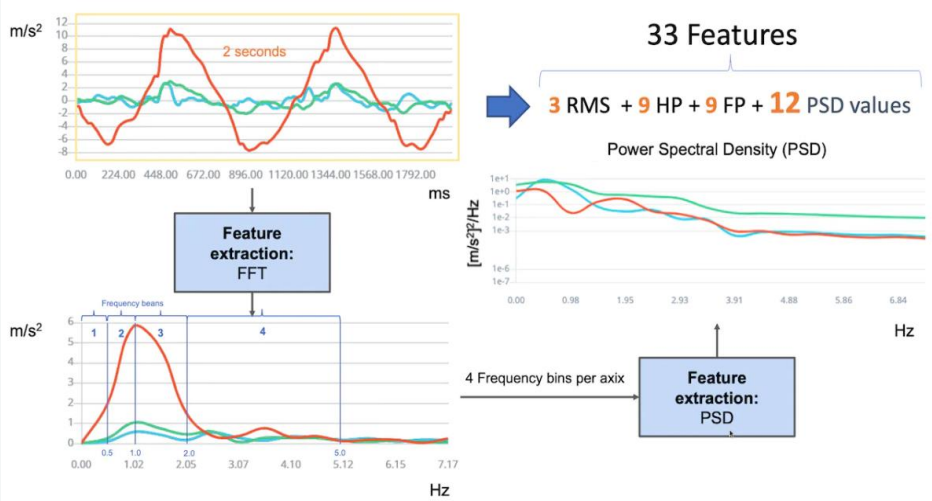
03. DATA PRE-PROCESSING

This block extracts the RMS, frequency (FFT), and power characteristics (PSD) of a signal over time, resulting in a tabular dataset of 33 features (11 per each axe),

Pattern recognition, noise detection and reduction, and important information extraction

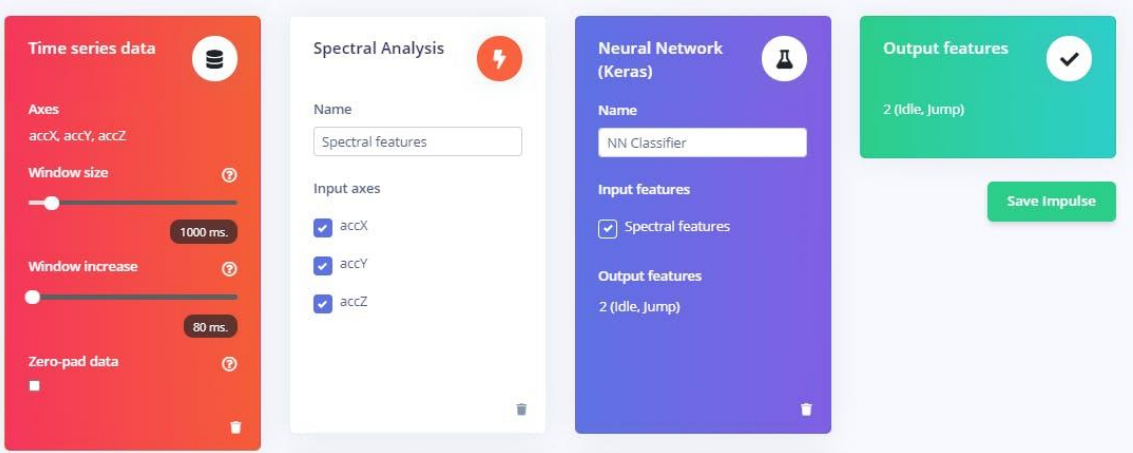
Those 33 features will be the Input Tensor of a Neural Network Classifier.

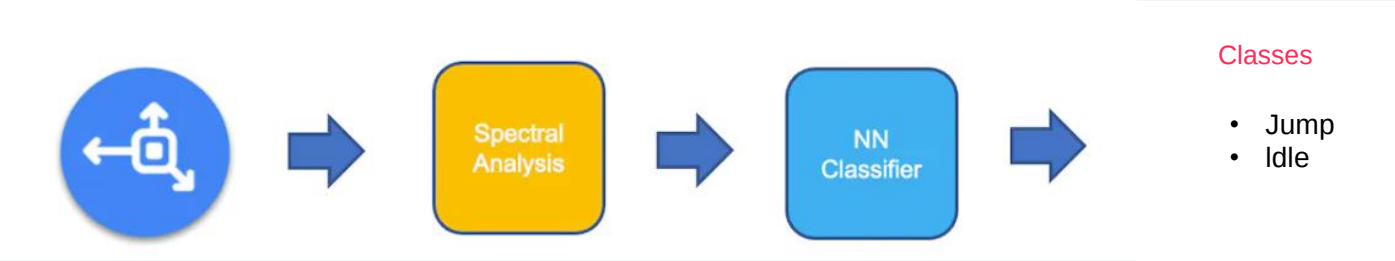




04. DESIGN IMPULSE

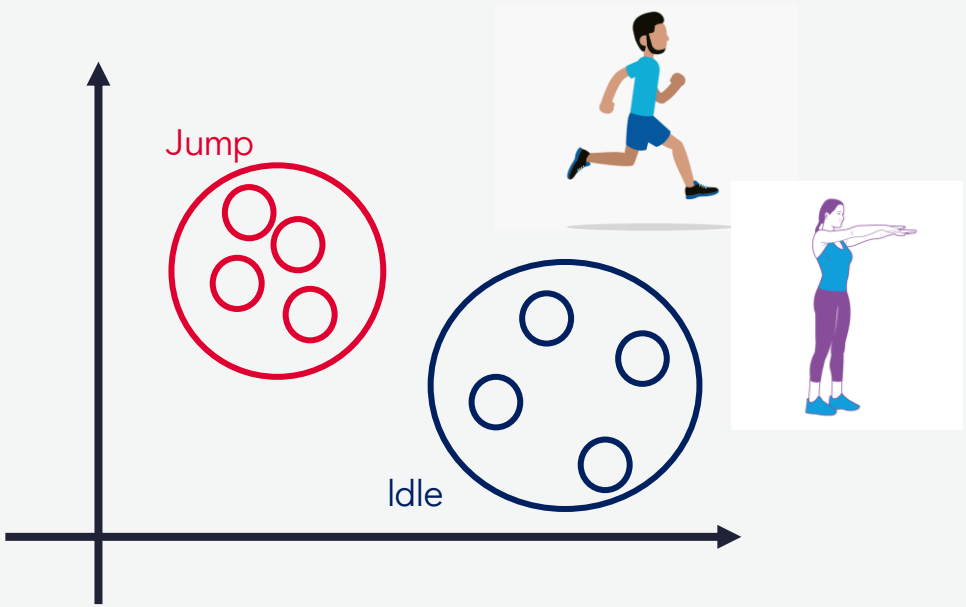
An impulse takes raw data, uses signal processing to extract features, and then uses a learning block to classify new data.





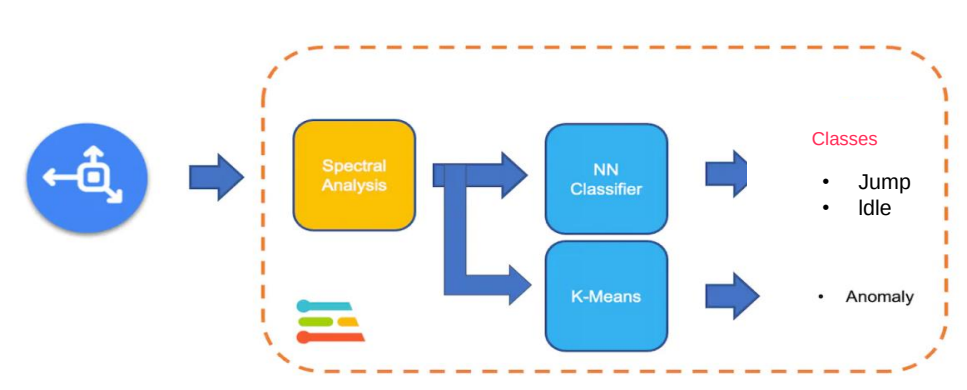
04. DESIGN IMPUSE

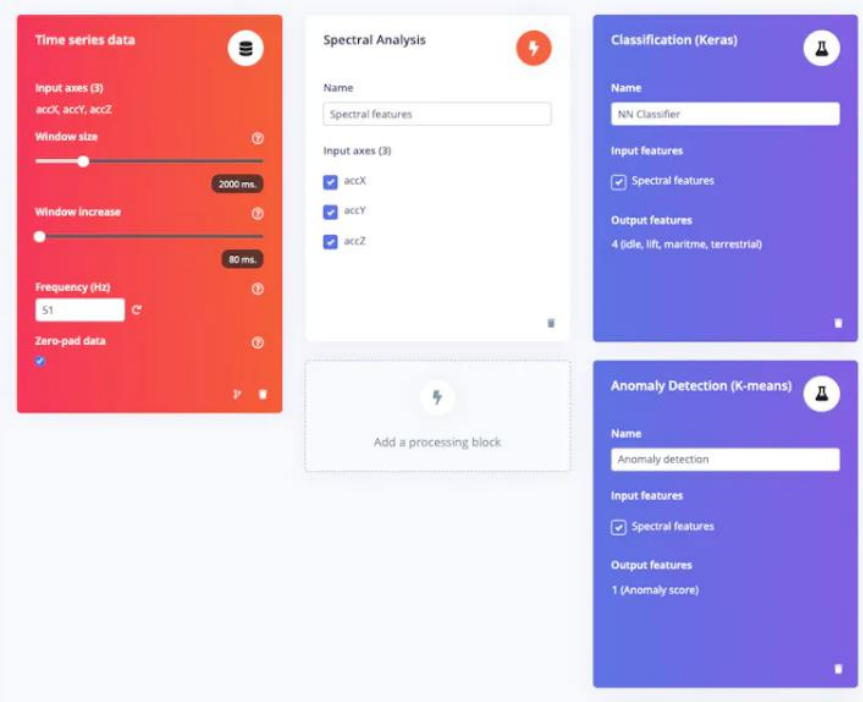
we can also take advantage of a second model, the K-means, that can be used for Anomaly Detection. If we imagine that we could have our known classes as clusters, any sample that could not fit on that could be an outlier, an anomaly.



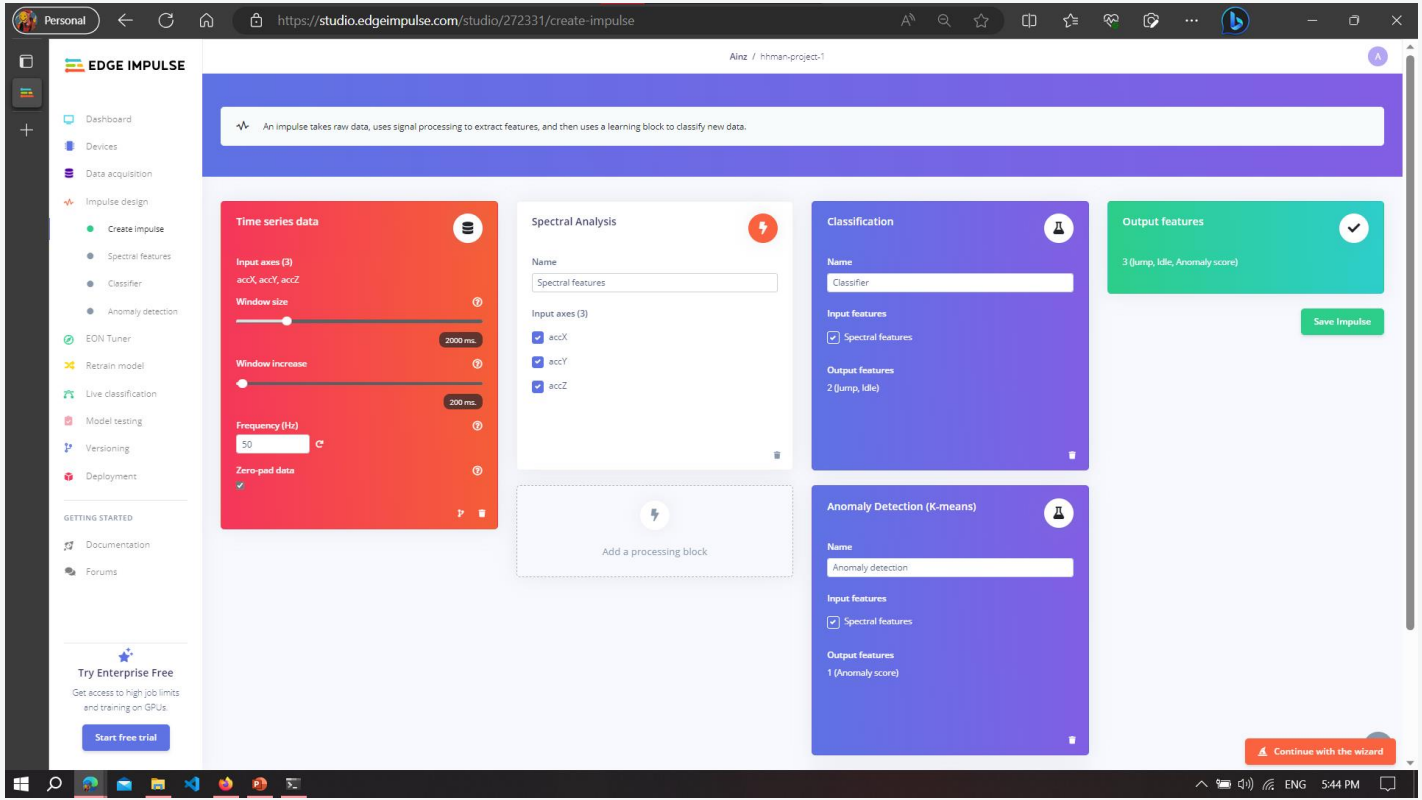
04. DESIGN IMPULSE

we can use the same input tensor that goes to the NN Classifier as the input of a K-means model





04. DESIGN IMPULSE

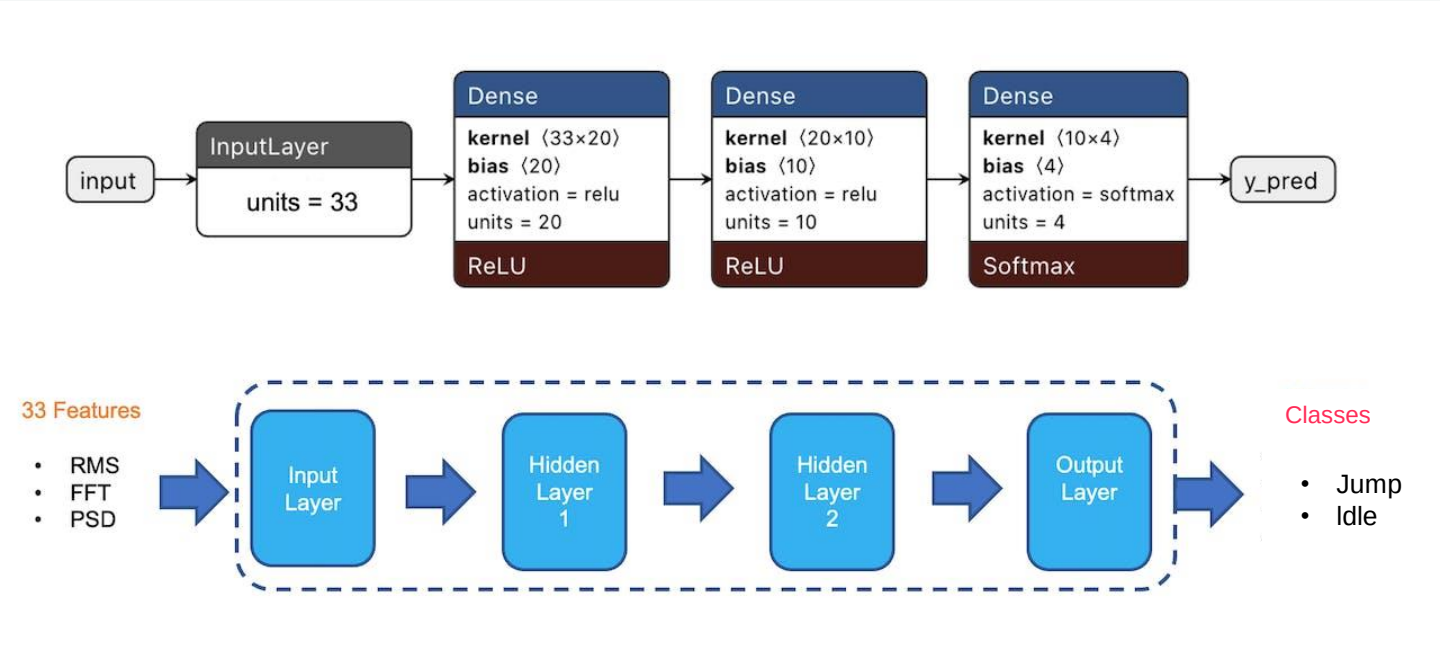


05

TRAINING & TESTING

01. TRAINING

model has four layers, as shown below



01. TRAINING

Classifier

https://studio.edgeimpulse.com/studio/272331/learning/keras/7

EDGE IMPULSE

Ainz / hhman-project-1

#1 Click to set a description for this version

Target: Cortex-M4F 80MHz

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

GETTING STARTED

- Documentation
- Forums

Try Enterprise Free

Get access to high job limits and training on GPUs.

Start free trial

Neural Network settings

Training settings

Number of training cycles: 30

Learning rate: 0.0005

Advanced training settings

Validation set size: 20 %

Split train/validation set on metadata key:

Auto-balance dataset: ☐

Profile int8 model: ☑

Neural network architecture

- Input layer (63 features)
- Dense layer (20 neurons)
- Dense layer (10 neurons)
- Add an extra layer
- Output layer (2 classes)

Start training

Training output

CPU

(0)

Model

Model version: Quantized (int8)

Last training performance (validation set)

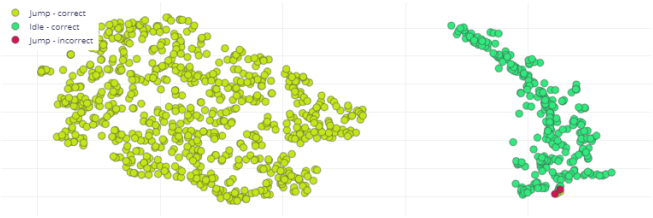
ACCURACY 100.0%

LOSS 0.00

Confusion matrix (validation set)

	JUMP	IDLE
JUMP	100%	0%
IDLE	0%	100%
F1 SCORE	1.00	1.00

Data explorer (full training set)



On-device performance

INFERENCING TIME 1 ms.

PEAK RAM USAGE 1.3K

FLASH USAGE 15.1K

Continue with the wizard

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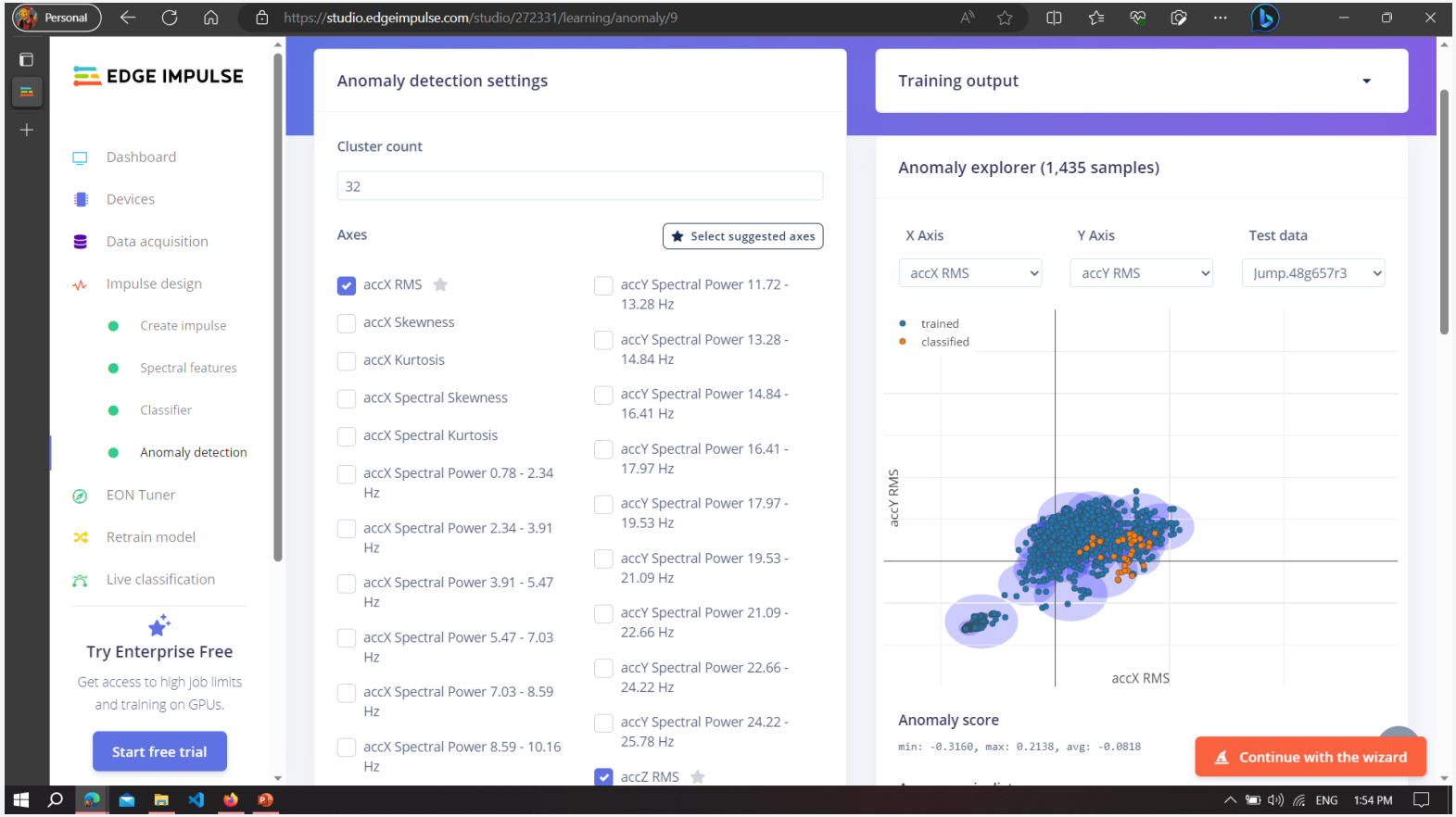
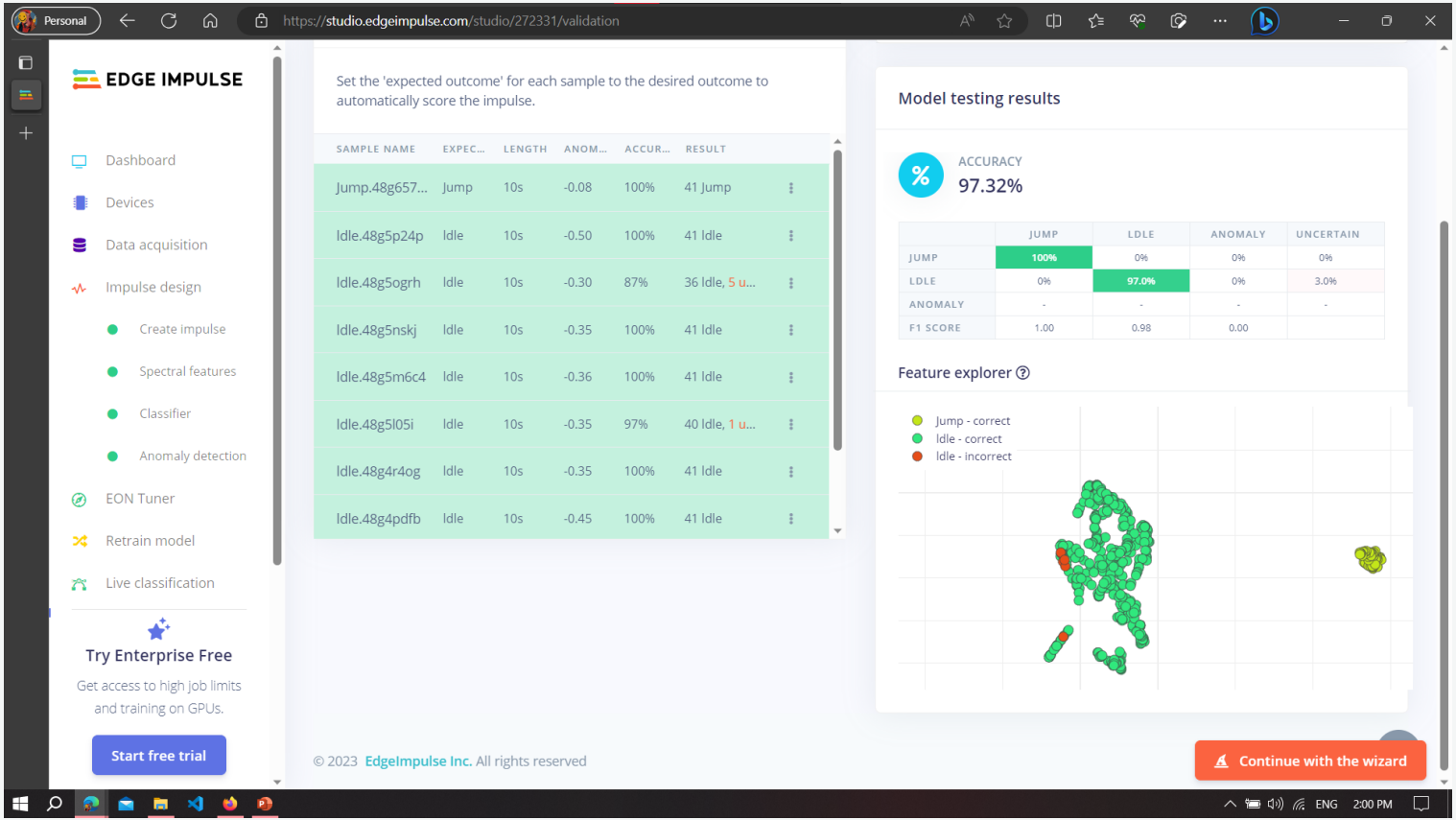
ENG 1:51 PM

01. TRAINING

Anomaly Detection



02. TESTING


Personal
https://studio.edgeimpulse.com/studio/272331/validation
EDGE IMPULSE
Dashboard
Devices
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Try Enterprise Free
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Set the 'expected outcome' for each sample to the desired outcome to automatically score the impulse.
SAMPLE NAME EXPEC... LENGTH ANOM... ACCUR... RESULT
Jump.48g657... Jump 10s -0.08 100% 41 Jump
Idle.48g5p24p Idle 10s -0.50 100% 41 Idle
Idle.48g5ogrh Idle 10s -0.30 87% 36 Idle, 5 u...
Idle.48g5nskj Idle 10s -0.35 100% 41 Idle
Idle.48g5m6c4 Idle 10s -0.36 100% 41 Idle
Idle.48g5l05i Idle 10s -0.35 97% 40 Idle, 1 u...
Idle.48g4r4og Idle 10s -0.35 100% 41 Idle
Idle.48g4pdfb Idle 10s -0.45 100% 41 Idle
Model testing results
ACCURACY
97.32%
JUMP LDLE ANOMALY UNCERTAIN
JUMP 100% 0% 0% 0%
LDLE 0% 97.0% 0% 3.0%
ANOMALY - - - -
F1 SCORE 1.00 0.98 0.00
Feature explorer
Jump - correct
Idle - correct
Idle - incorrect
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Continue with the wizard
ENG 2:00 PM

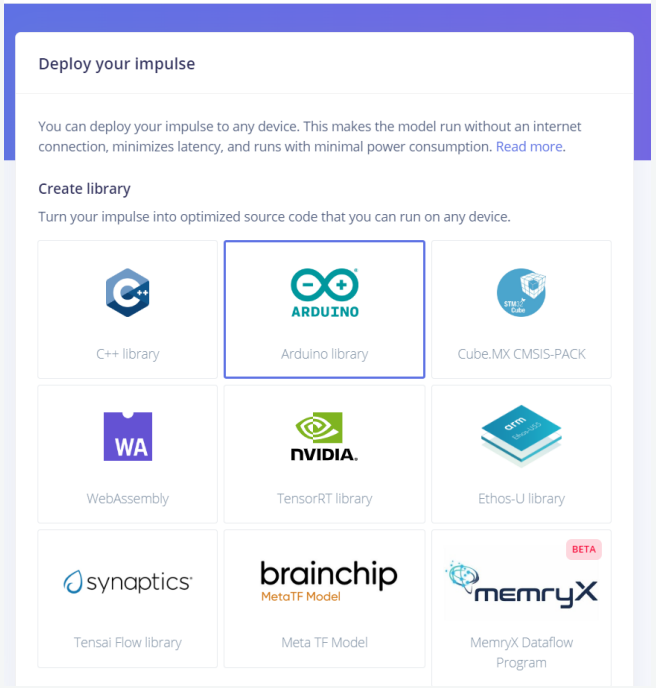
DELOYMENT CONNECT BLE?

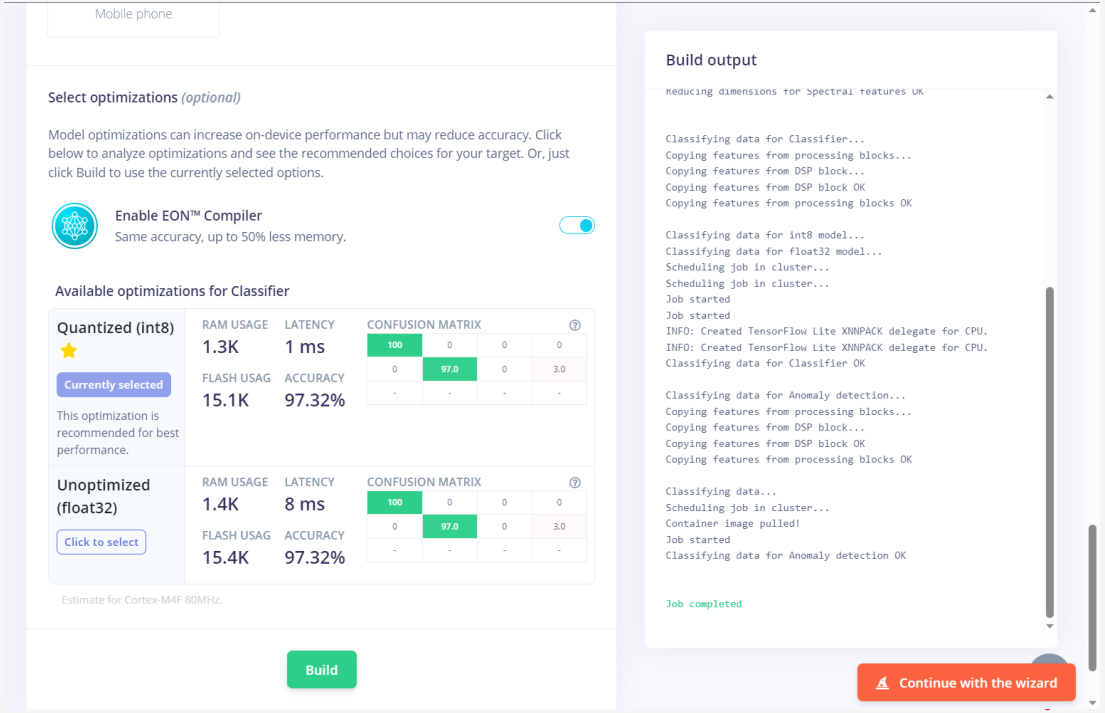
you need it

06

01. DELOYMENT

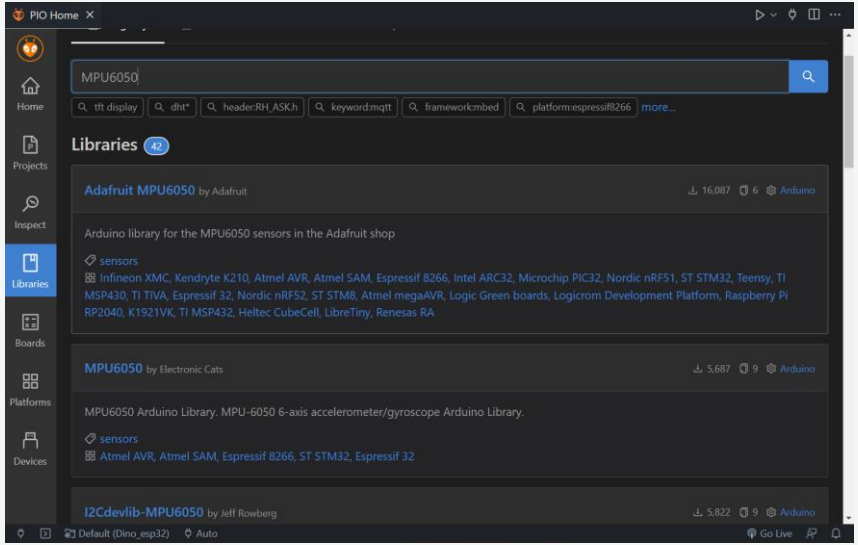
The Studio will package all the needed libraries, preprocessing functions, and trained models, downloading them to your computer. You should select the option Arduino Library and at the bottom, select Quantized (Int8) and Build

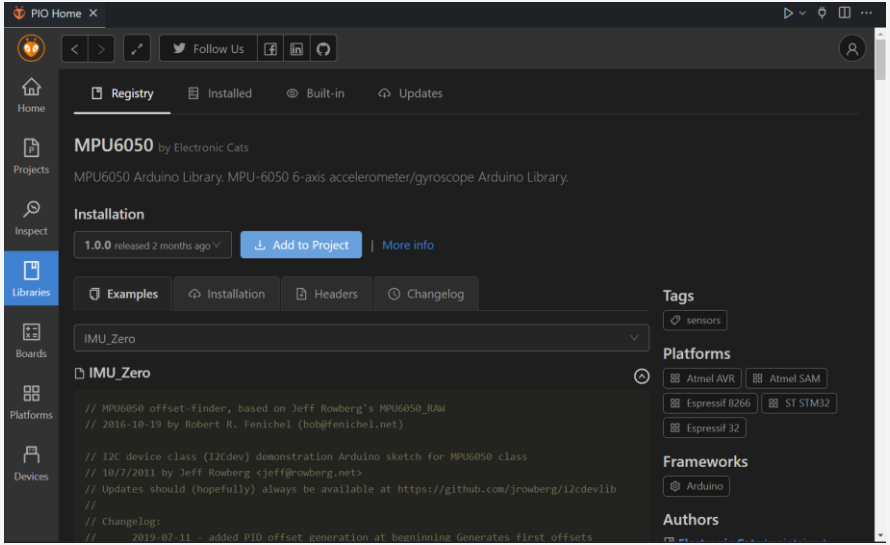




02. DELOYMENT

Librarires > Search MPU6050 > Select MPU6050 by Electronic Cats > Add to Project

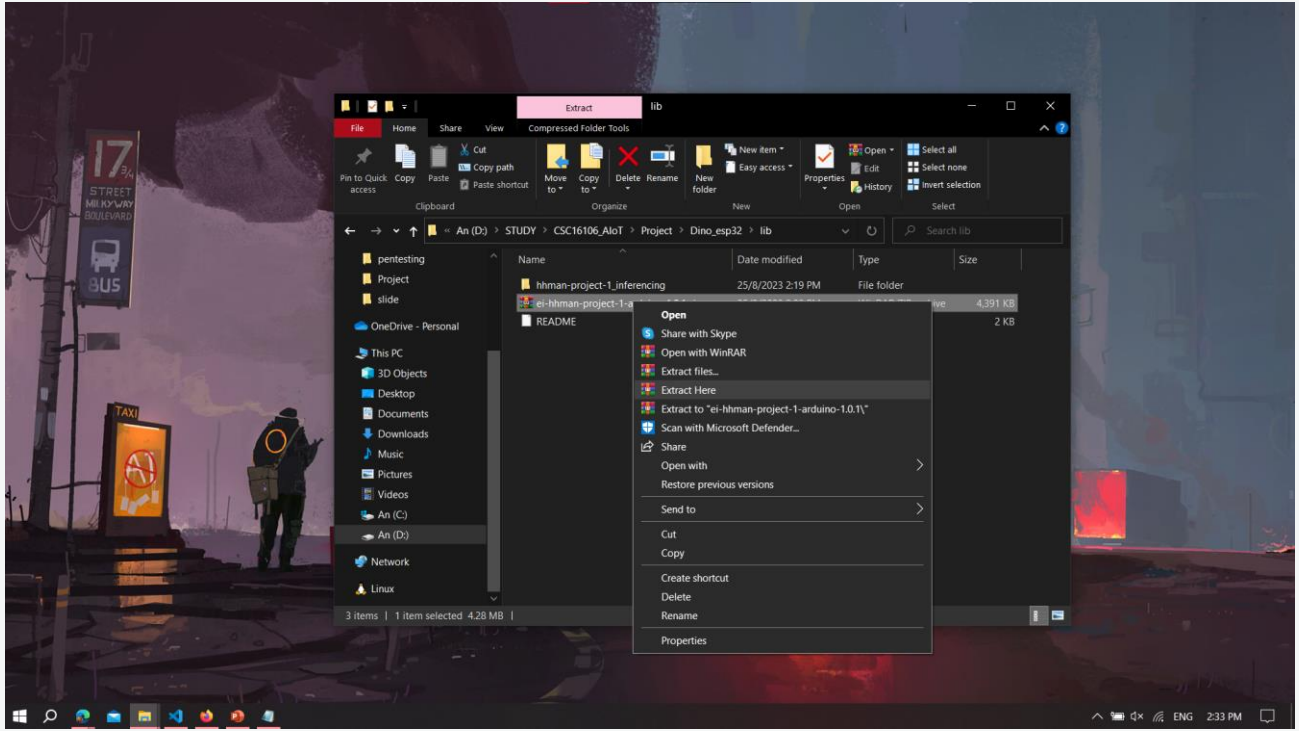


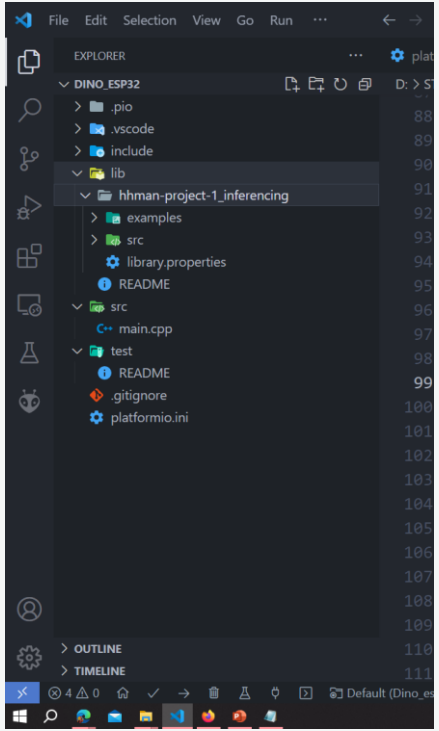


/IMU/MPU6050/Acc-Data-Acquisition(github.com)

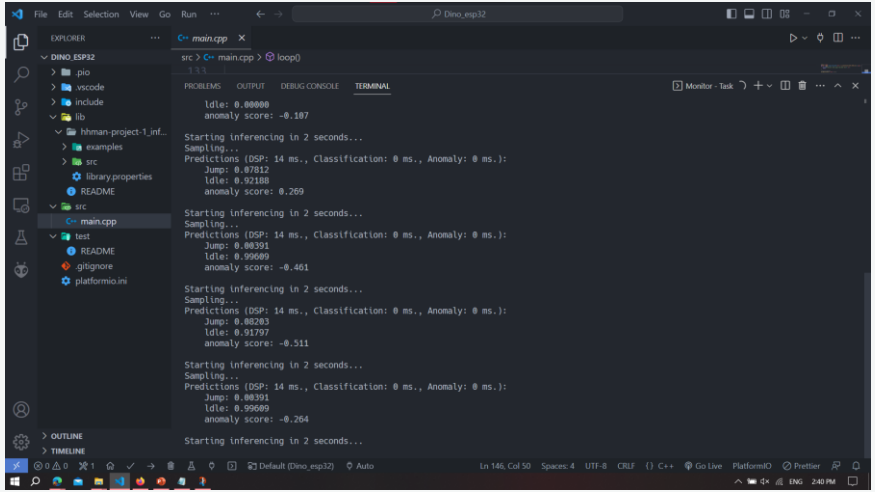
02. DELOYMENT

Unzip, add folder into lib





02. DELOYMENT




```
Starting inferencing in 2 seconds...
Sampling...
Predictions (DSP: 14 ms., Classification: 0 ms., Anomaly: 0 ms.):
    Jump: 0.99609
    ldle: 0.00000
    anomaly score: -0.107

Starting inferencing in 2 seconds...
Sampling...
Predictions (DSP: 14 ms., Classification: 0 ms., Anomaly: 0 ms.):
    Jump: 0.07812
    ldle: 0.92188
    anomaly score: 0.269
```

```
Starting inferencing in 2 seconds...
Sampling...
Predictions (DSP: 14 ms., Classification: 0 ms., Anomaly: 0 ms.):
    Jump: 0.00391
    ldle: 0.99609
    anomaly score: -0.264

Starting inferencing in 2 seconds...
Sampling...
Predictions (DSP: 14 ms., Classification: 0 ms., Anomaly: 0 ms.):
    Jump: 0.00000
    ldle: 0.99609
    anomaly score: -0.226
```

07

DEMO :<

What we need ?

08

SUMMARY

01. COMMENTS

Advantage

- Heathy
- Fun with hommie
- Simple easy to use
- Machine learning model is not overfitting

Disadvantage

- Simple classification data
- The rest of the device is simple
- Signal processing is still slow

In the future

- Collect data and improve the model
- complete a device

02. CONCLUSION

The ESP32 is a giant tiny device! It is powerful, not expensive, low power, and suitable for use on the most common embedded machine learning applications. Even though Edge Impulse, we realized it could be easily connected with the Studio.

Regarding the IMU, this project used the low-cost MPU6050 but could also use other IMUs, for example, the LCM20600 (6-axis), which is part of the Seeed Grove - IMU 9DOF (lcm20600+AK09918).

Project that combines fitness with the game "Dinsor" has the potential to bring health benefits, motivation and entertainment to players

REFERENCES

- Gesture Classification with Esp32 and TinyML - Hackster.io
- Play Chrome's Dino Game Physically 🦕 - Hackster.io
- Exploring Machine Learning with the new XIAO ESP32S3 - Hackster.io
- tinyML Talks: Unleashing the Power of the New XIAO ESP32S3 Sense: Tackling Anomaly Detection... – YouTube
- Edge AI Anomaly Detection Part 1: Data Collection | Digi-Key Electronics - YouTube

THANKS A LOT!

Do you have any questions?

20127102@student.hcmus.edu.vn