

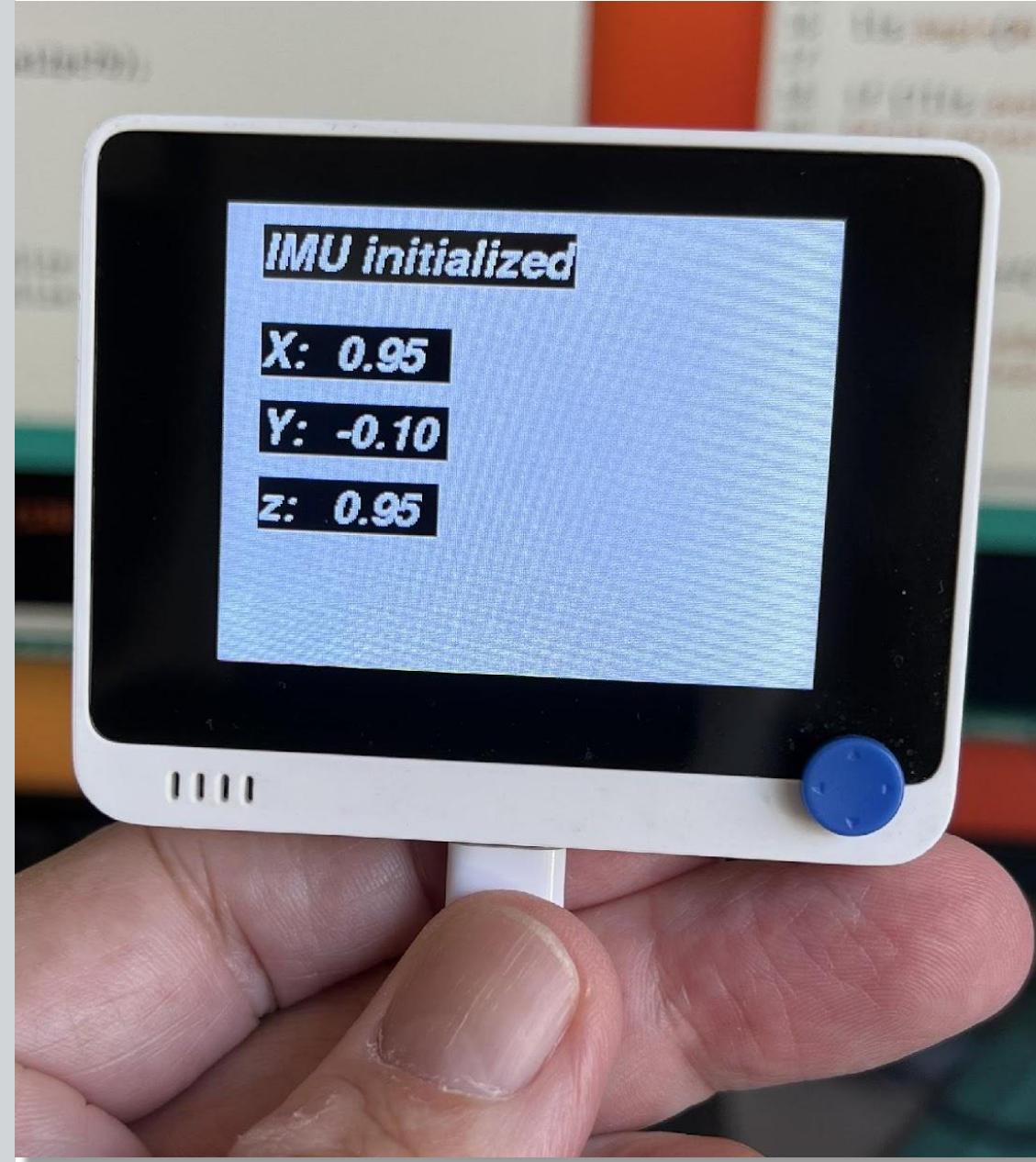
# IESTI01 – TinyML

## Embedded Machine Learning

17.b Wio Terminal Overview –  
Installation, Test & EI  
connexion



Prof. Marcelo Rovai  
UNIFEI



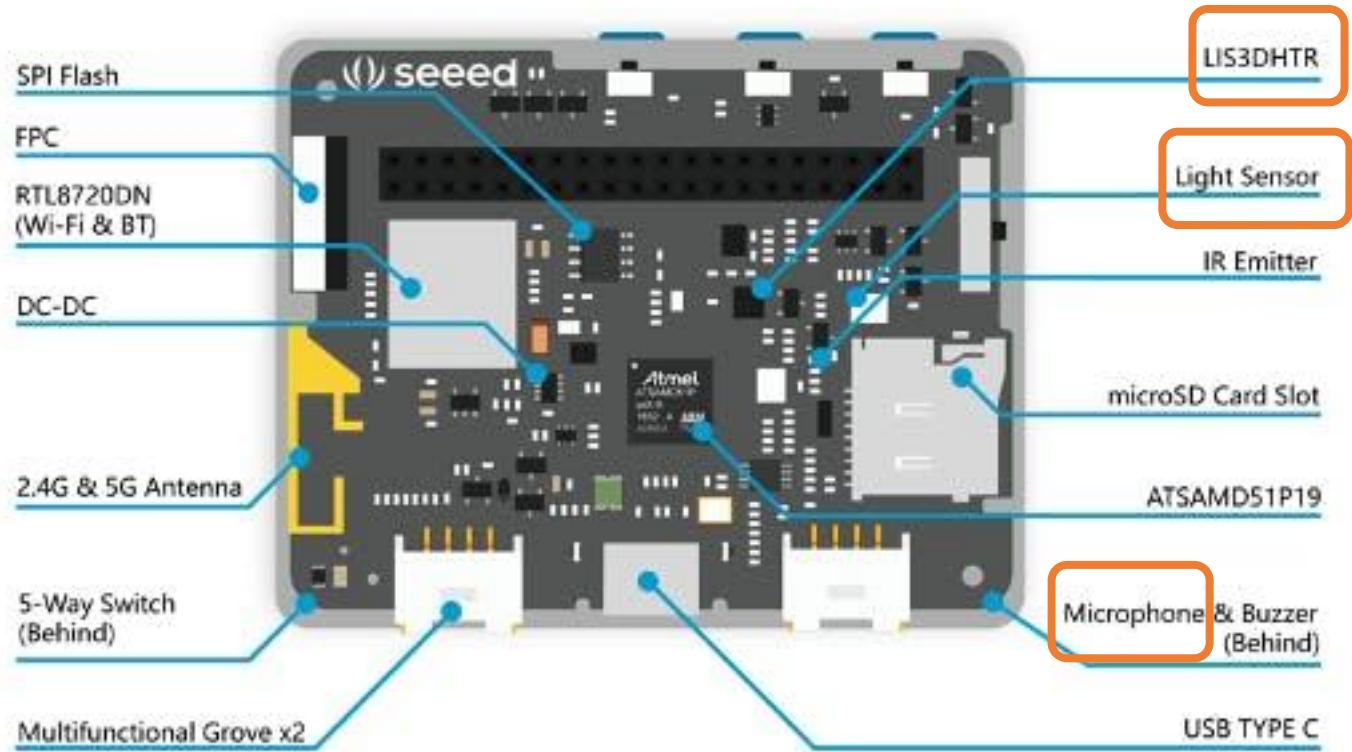
# The Wio Terminal

# The Wio Terminal

The [Wio Terminal](#) uses an ATSAMD51P19 microcontroller with **ARM Cortex-M4F** running at **120MHz** (boost up to 200MHz), **4MB of external flash memory**, and **192KB of RAM**.

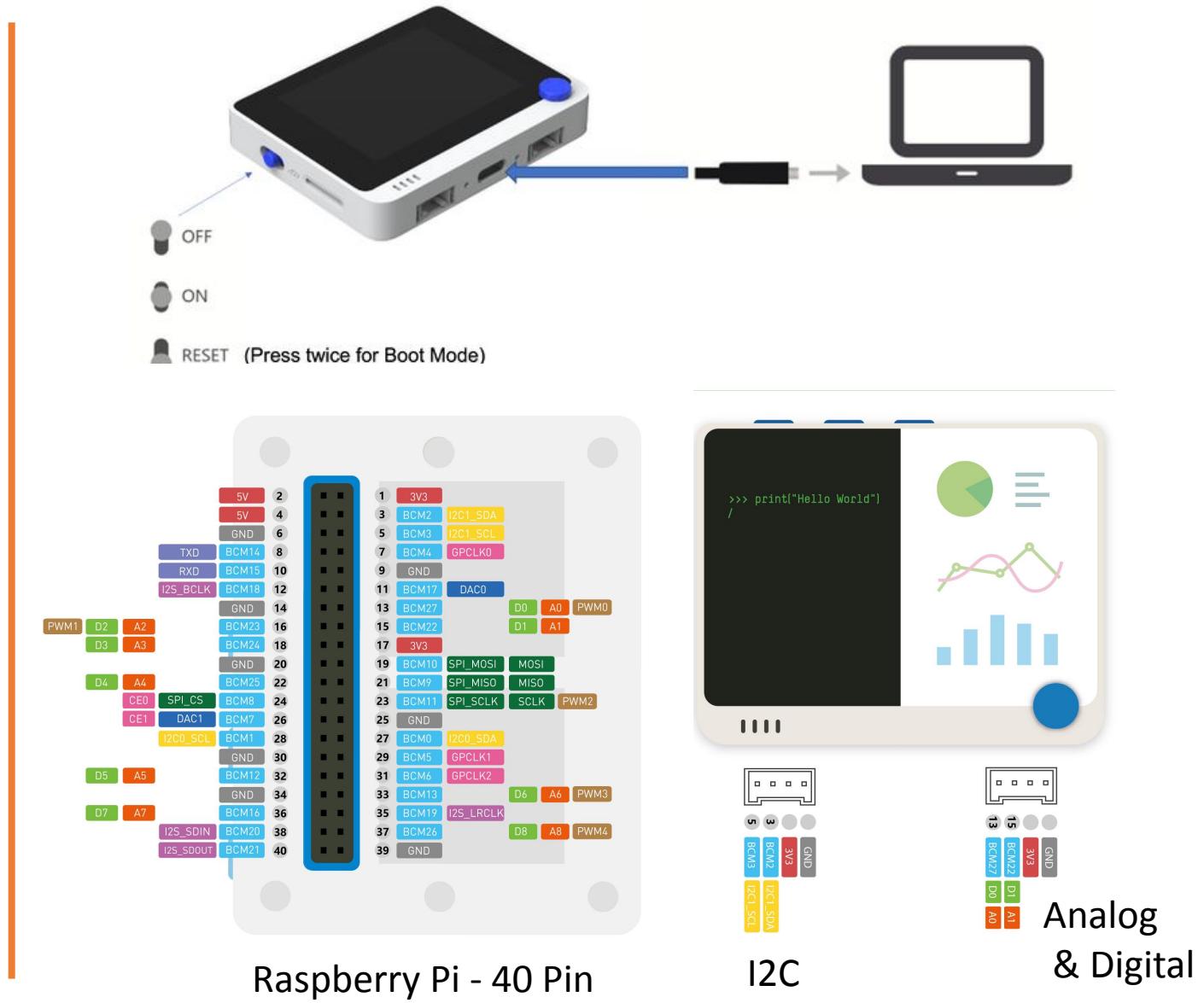
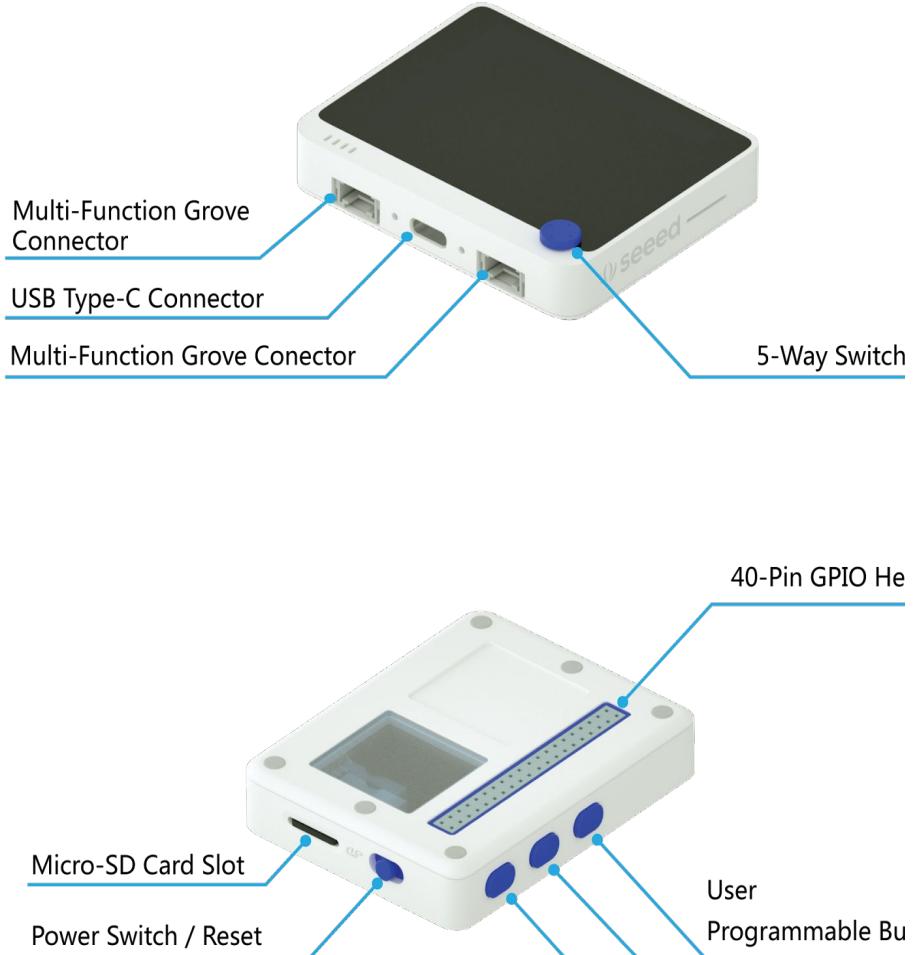
Wireless connectivity with Realtek RTL8720DN support. It is compatible with Arduino and MicroPython. It supports **Bluetooth and Wi-Fi**. There is a 2.4-inch LCD screen on Wio Terminal, an onboard **Accelerometer (LIS3DHTR)**, a **microphone**, a **buzzer**, a **microSD card slot**, a **light sensor**, and an **IR emitter** (IR 940nm).

It has two multi-functional Grove connectors (**I2C and Dig/Analog GPIOs**) and Raspberry Pi-compatible 40-pin GPIO pins for additional add-on support.



<https://wiki.seeedstudio.com/Wio-Terminal-Getting-Started/>

# The Wio Terminal – Hardware installation / Expansion

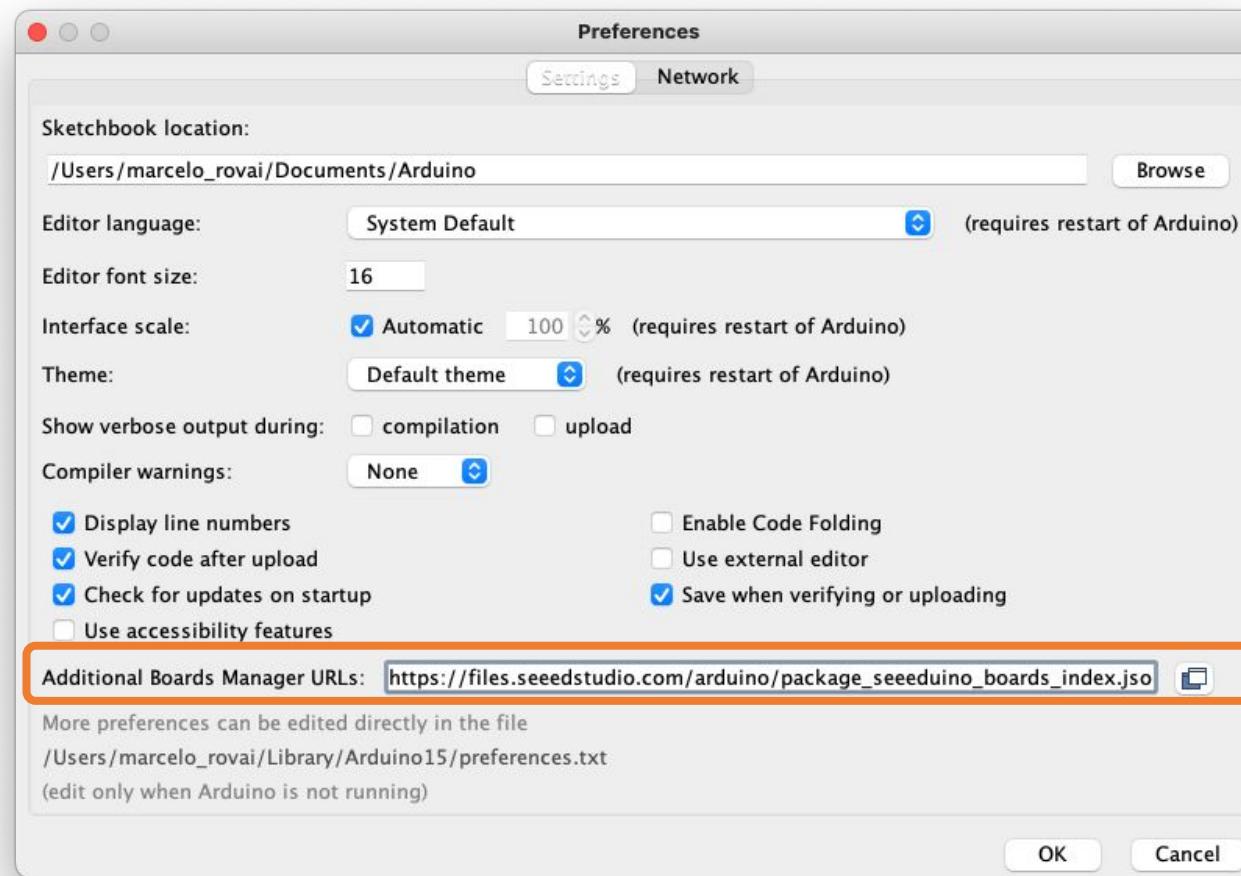


# Installing Wio Terminal – Arduino IDE

Open the Arduino IDE, and click on:

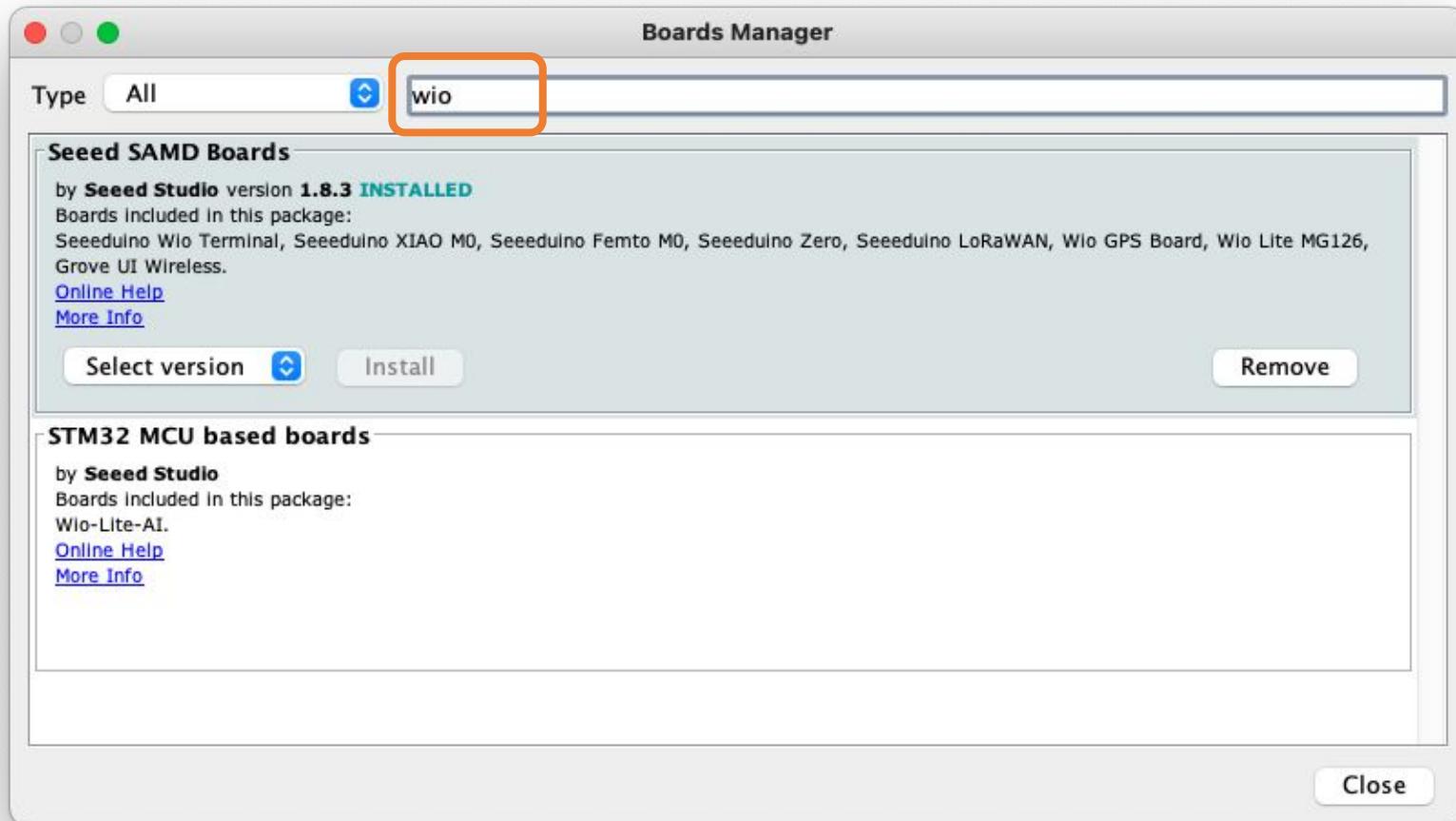
**File > Preferences**, and copy the below URL to **Additional Boards Manager URLs**:

**[https://files.seeedstudio.com/arduino/package\\_seeeduino\\_boards\\_index.json](https://files.seeedstudio.com/arduino/package_seeeduino_boards_index.json)**

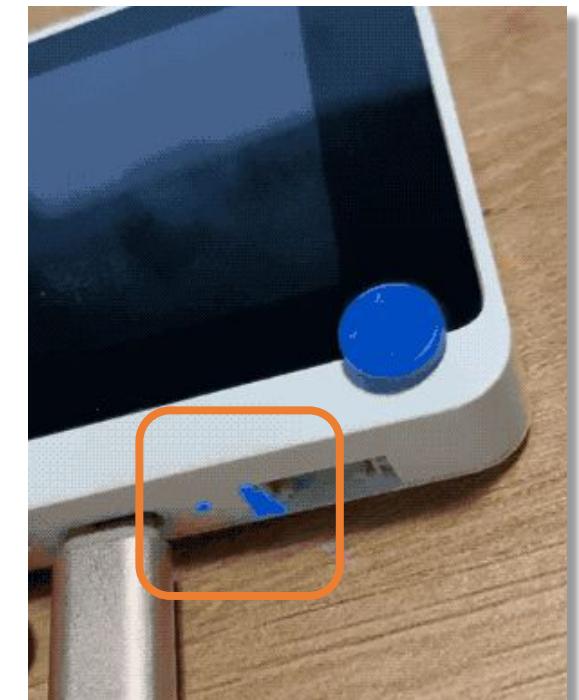
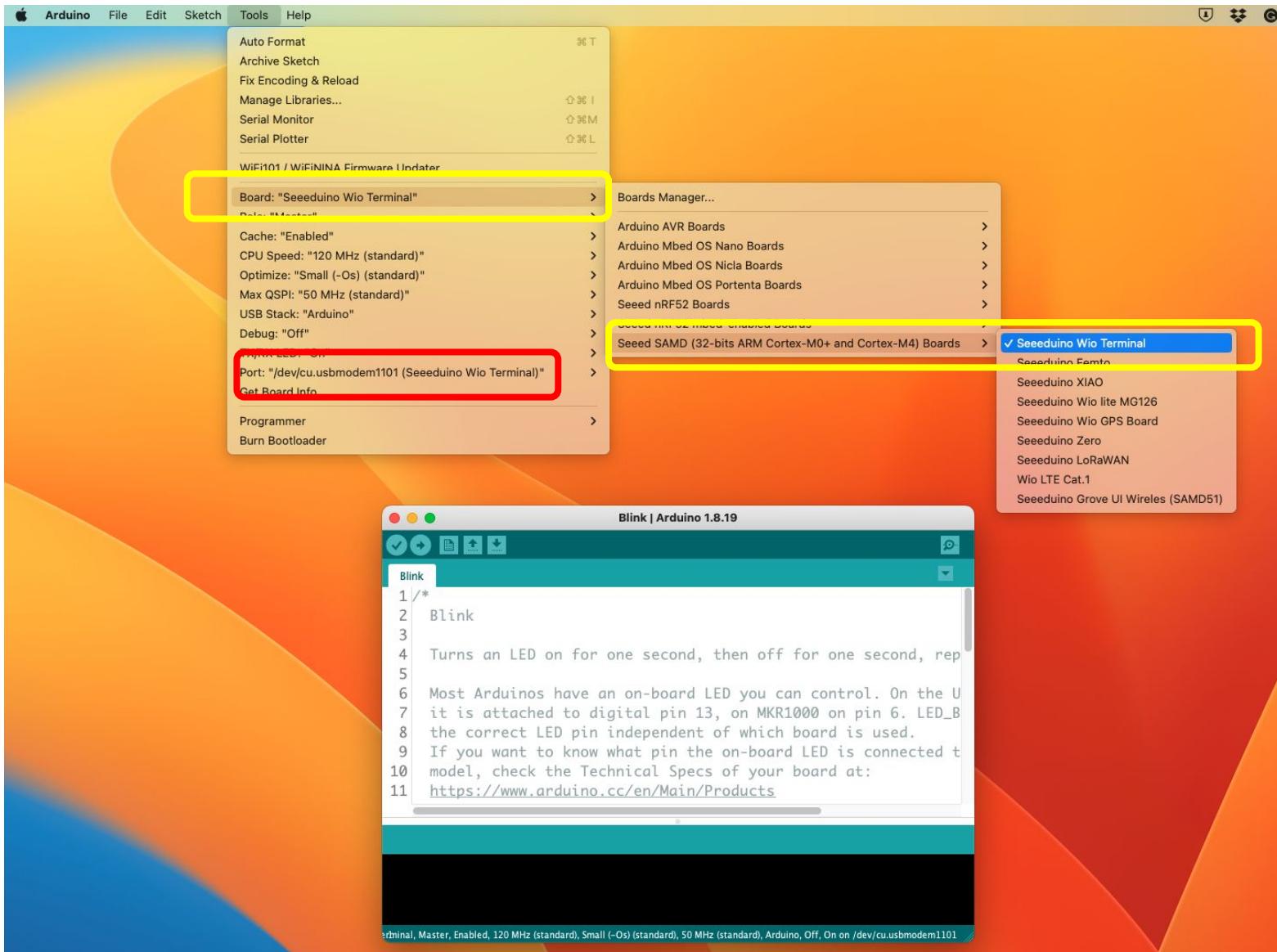


Click **Tools > Board > Board Manager** and Search **Wio Terminal** in the Boards Manager.

Install the last available version.



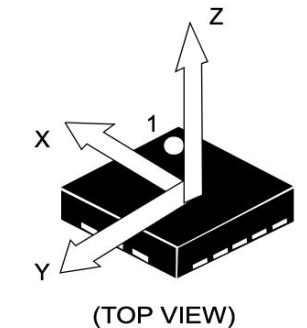
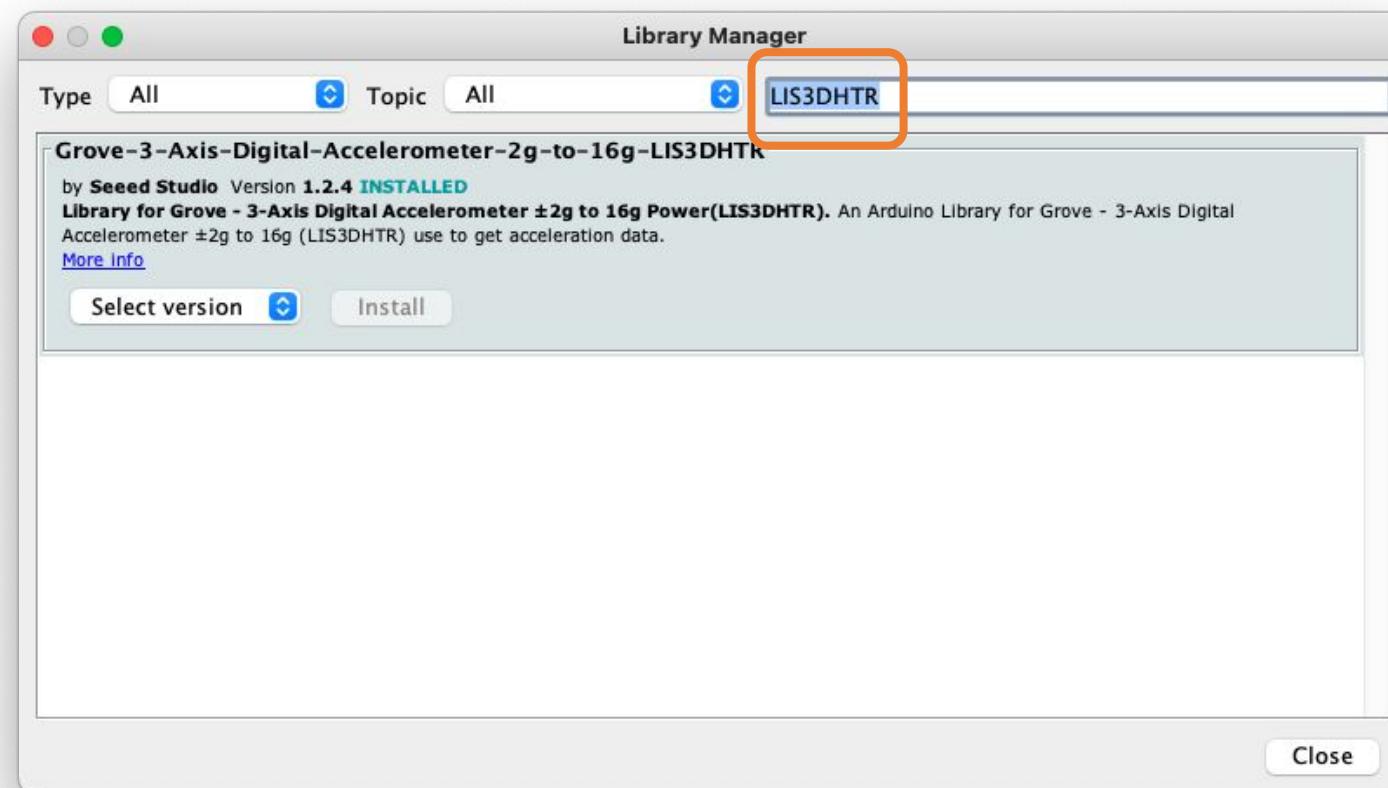
Select your **board** and **port**. Load the **Blink** sketch and run it.



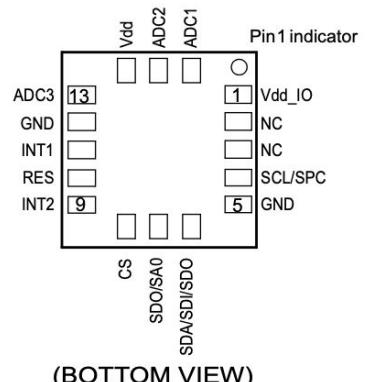
# Installing the 3-Axis Accelerometer (LIS3DHTR)

Click **Tools > Manage Libraries ..** and Search in the Libraries Manager.

Install the last available version.



DIRECTION OF THE  
DETECTABLE  
ACCELERATIONS



<https://www.mouser.cl/datasheet/2/389/cd00274221-1797088.pdf>

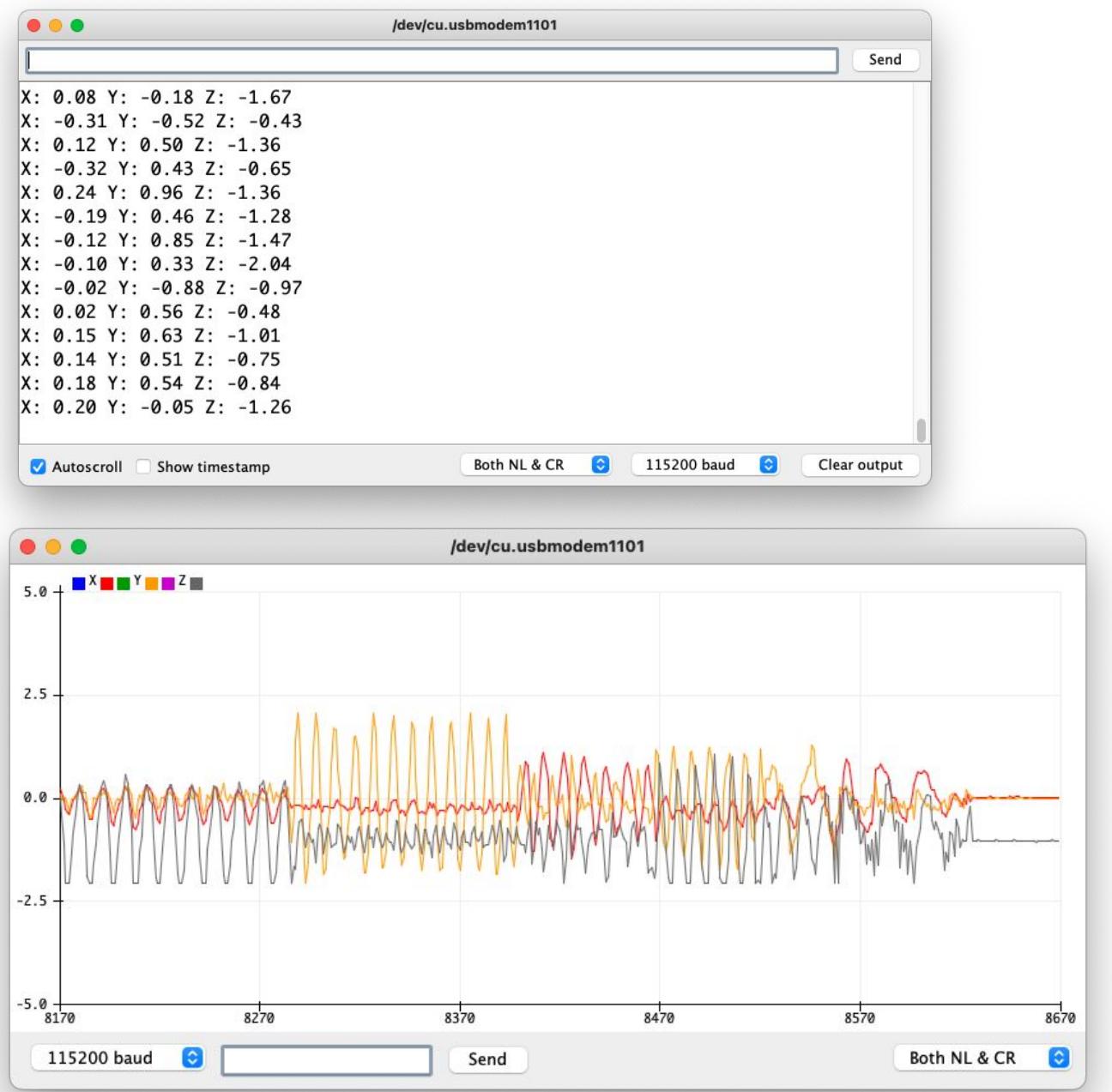
Acc\_LIS3DHTR\_test | Arduino 1.8.19

```

Acc_LIS3DHTR_test
1 #include "LIS3DHTR.h"
2 LIS3DHTR<TwoWire> lis;
3
4 void setup() {
5   Serial.begin(115200);
6   lis.begin(Wire1);
7
8   if (!lis) {
9     Serial.println("ERROR");
10    while(1);
11  }
12 lis.setOutputDataRate(LIS3DHTR_DATARATE_50HZ); //Data output rate
13 lis.setFullScaleRange(LIS3DHTR_RANGE_2G); //Scale range set to 2g
14 }
15
16 void loop() {
17   float x_values, y_values, z_values;
18   x_values = lis.getAccelerationX();
19   y_values = lis.getAccelerationY();
20   z_values = lis.getAccelerationZ();
21
22   Serial.print("X: "); Serial.print(x_values);
23   Serial.print(" Y: "); Serial.print(y_values);
24   Serial.print(" Z: "); Serial.print(z_values);
25   Serial.println();
26   delay(50);
27 }
28

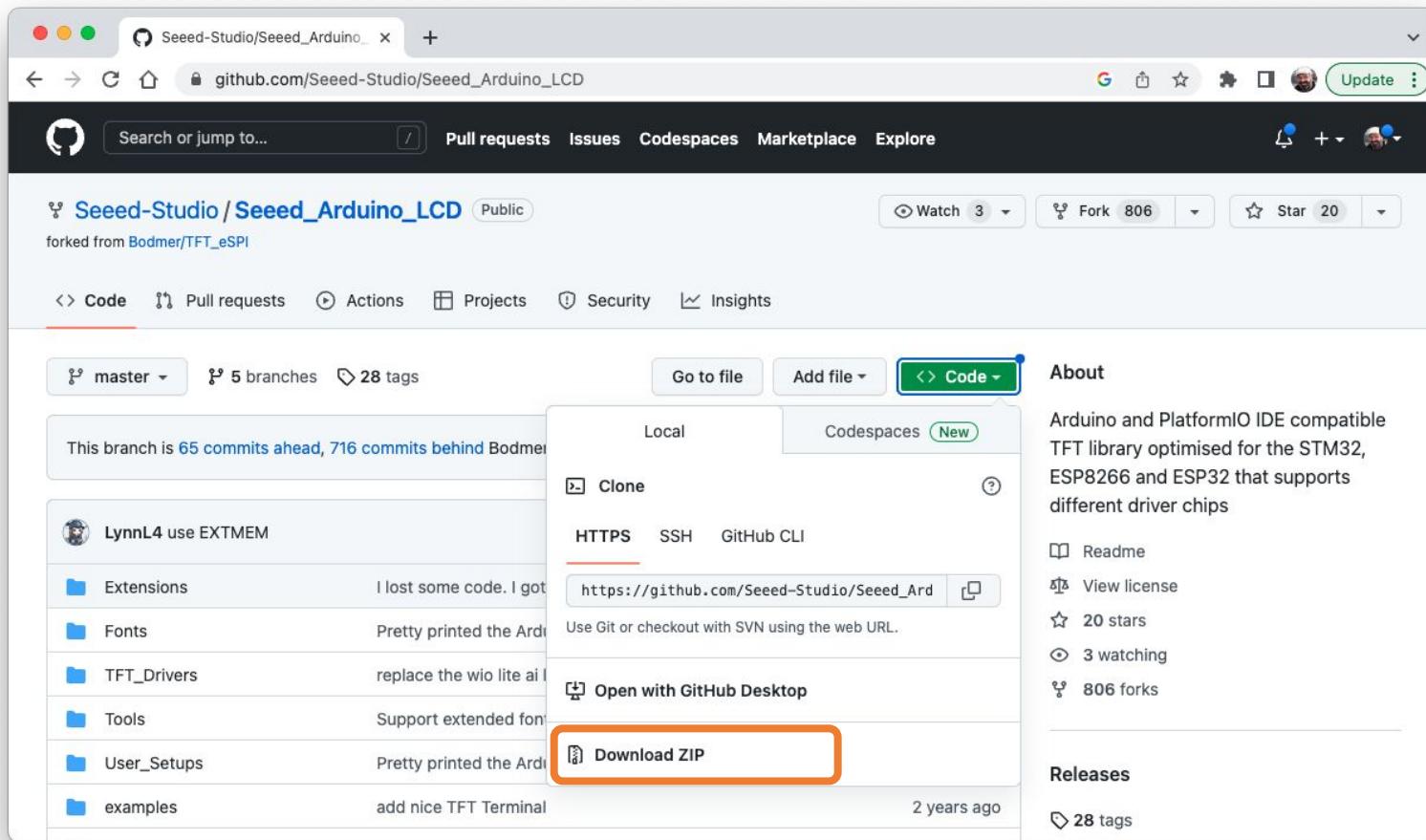
```

Done uploading.  
done in 0.495 seconds  
Verify 38372 bytes of flash  
[=====] 100% (75/75 pages)  
Verify successful  
Done in 0.096 seconds



# Installing the TFT LCD Library

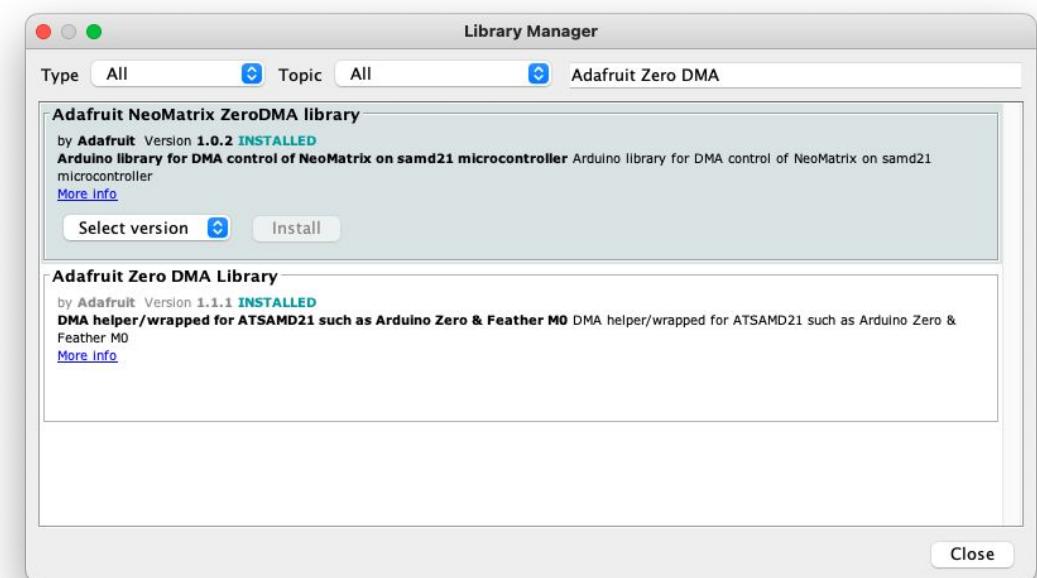
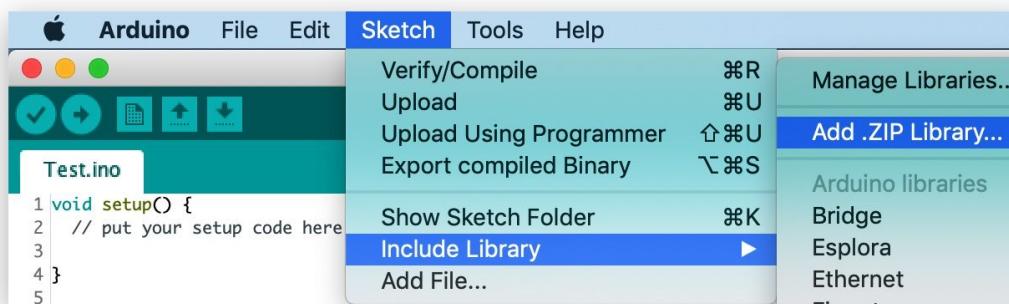
- Go to the URL: [https://github.com/Seeed-Studio/Seeed\\_Arduino\\_LCD](https://github.com/Seeed-Studio/Seeed_Arduino_LCD)
- Download the entire repo in your drive as .ZIP



# Installing the TFT LCD Library

- Open the Arduino IDE, and click sketch  
-> Include Library -> Add .ZIP Library,  
and choose the Seeed\_Arduino\_LCD file  
that you've have just downloaded.
- Click Tools > Manage Libraries .. >  
and Search in the Libraries Manager.

Install the last available version.



# Using the TFT Display

```
Acc_LIS3DHTR_LCD_test | Arduino 1.8.19
```

```
Acc_LIS3DHTR_LCD_test §
2 * Wio Terminal Setup
3 * IMU test and Display on TFT
4 * @MJRovai 23Feb23
5 */
6
7 #include "LIS3DHTR.h"
8 #include "TFT_eSPI.h"
9 LIS3DHTR<TwoWire> lis;
10 TFT_eSPI tft;
11
12 void setup() {
13   Serial.begin(115200);
14
15   // Initiate LCD
16   tft.begin();
17   tft.setRotation(3);
18   tft.fillScreen(TFT_WHITE);
19   tft.setFreeFont(&FreeSansBoldOblique12pt7b);
20
21   // Initiate Accelerometer
22   lis.begin(Wire1);
23
24   if (!lis.available()) {
25     Serial.println("Failed to initialize IMU!");
26     tft.drawString("Failed to initialize IMU!", 20, 10);
27     while (1);
28   }
29   else {
30     Serial.println("IMU initialized");
31     tft.drawString("IMU initialized", 20, 10);
32   }
33
34   //Setting output data rage to 100Hz, can be set up tp 5kHz
35   lis.setOutputDataRate(LIS3DHTR_DATARATE_100HZ);
36   //Scale range set to 16g, select from 2,4,8,16g
37   lis.setFullScaleRange(LIS3DHTR_RANGE_16G);
38 }
```

Done uploading.

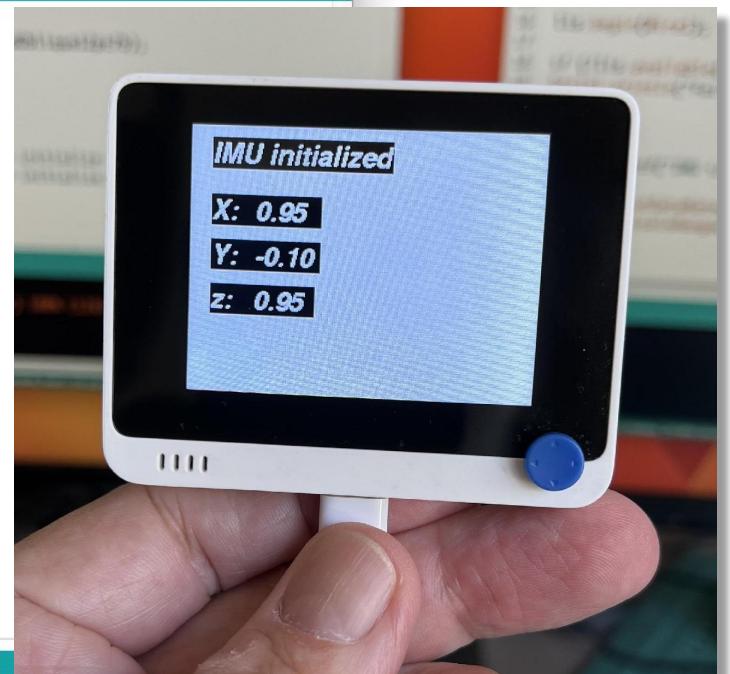
Verify 65376 bytes of flash  
[=====] 100% (128/128 pages)  
Verify successful

```
Acc_LIS3DHTR_LCD_test | Arduino 1.8.19
```

```
Acc_LIS3DHTR_LCD_test §
40 void loop() {
41   float x_values, y_values, z_values;
42   x_values = lis.getAccelerationX();
43   y_values = lis.getAccelerationY();
44   z_values = lis.getAccelerationZ();
45
46   Serial.print("X: "); Serial.print(x_values);
47   Serial.print(" Y: "); Serial.print(y_values);
48   Serial.print(" Z: "); Serial.print(z_values);
49   Serial.println();
50
51   tft.drawString("X: ", 20, 60);
52   tft.drawString(String(x_values), 60, 60);
53   tft.drawString("Y: ", 20, 100);
54   tft.drawString(String(y_values), 60, 100);
55   tft.drawString("z: ", 20, 140);
56   tft.drawString(String(z_values), 60, 140);
57   delay(100);
58   //tft.fillScreen(TFT_WHITE);
59 }
60
```

Done uploading.

Verify 65376 bytes of flash  
[=====] 100% (128/128 pages)  
Verify successful



Set up connection between Wio Terminal  
and Edge Impulse

Login - Edge Impulse

studio.edgeimpulse.com/login

EDGE IMPULSE

Log in

rovai@mjrobot.org

.....

Forgot your password?

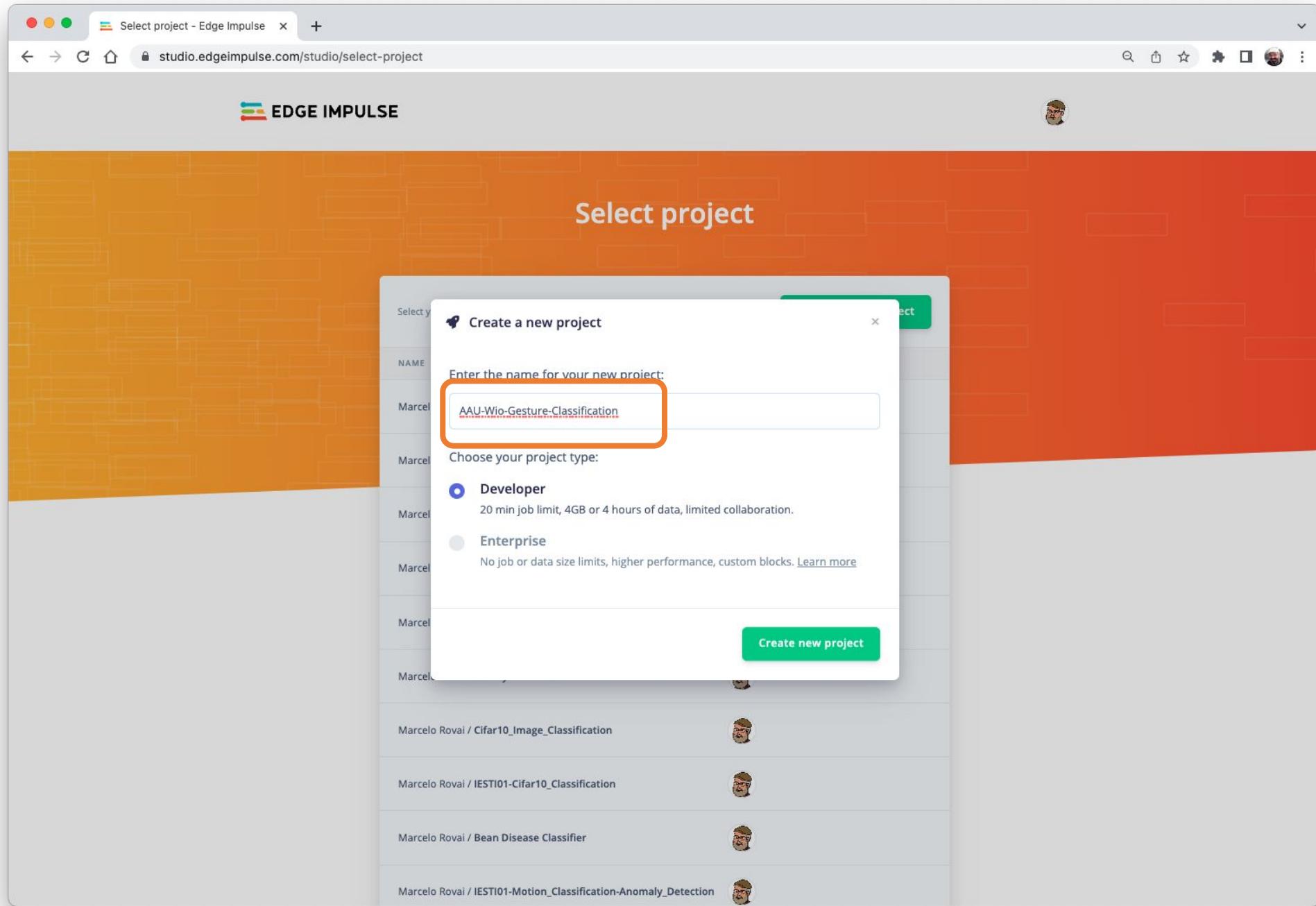
**Log in**

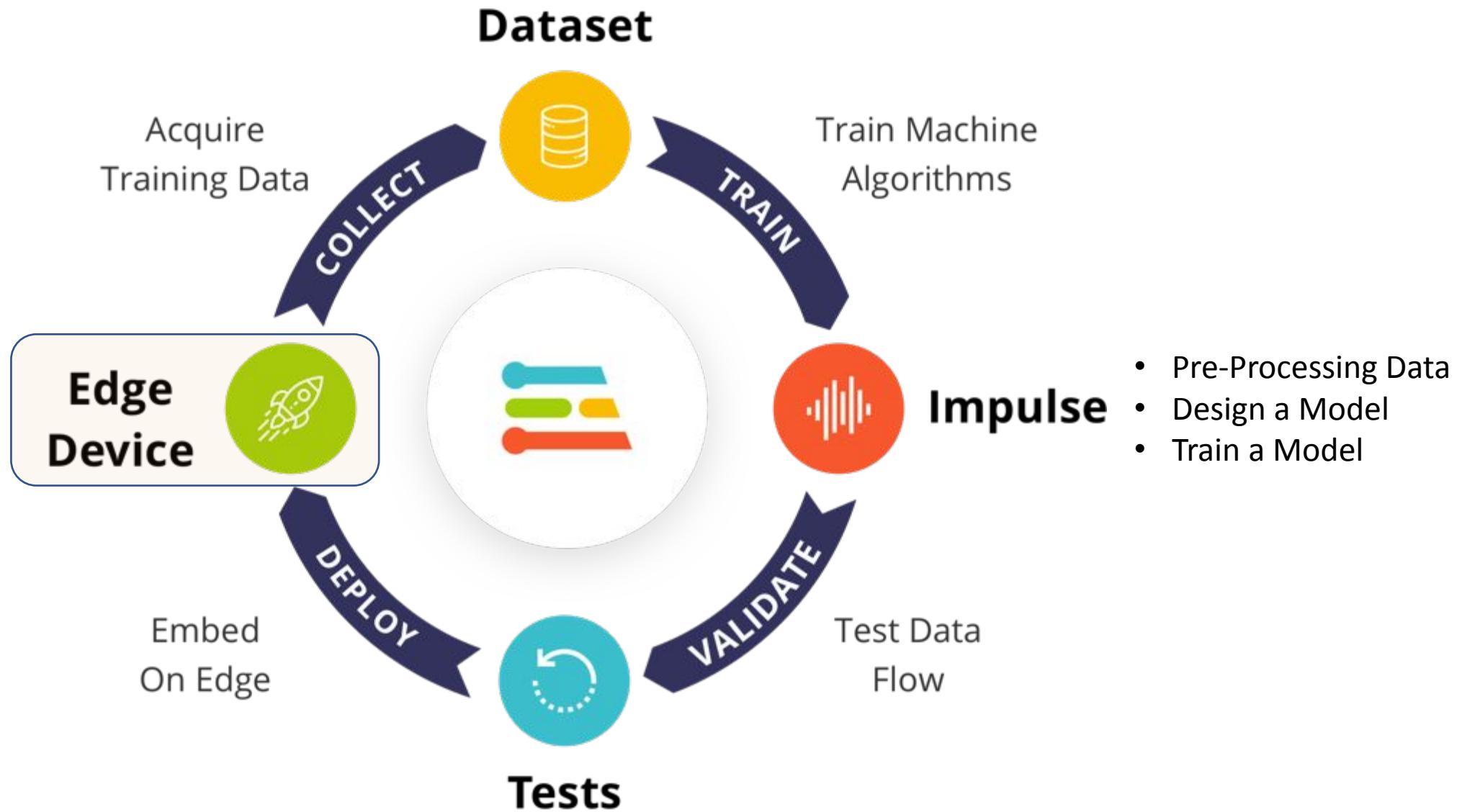
Don't have an account? [Sign up](#)



**Start building embedded machine learning models today.**

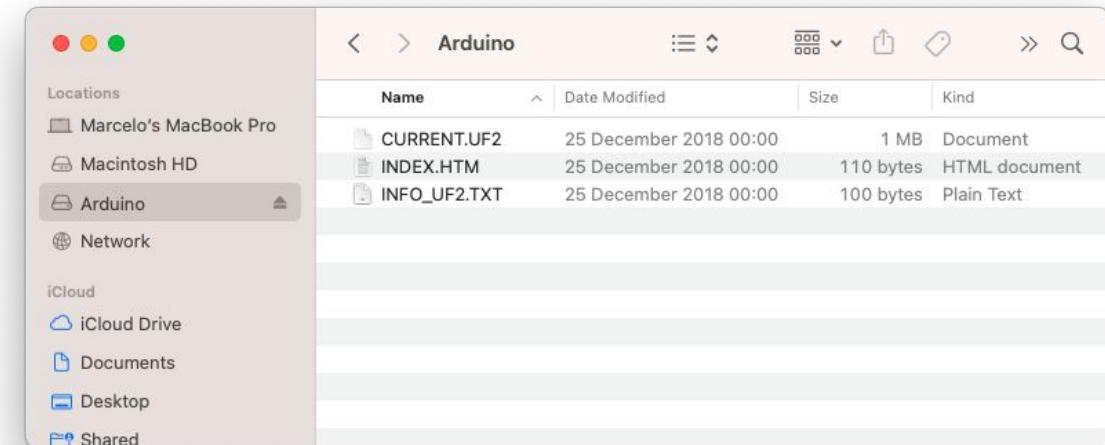
© 2022 EdgeImpulse Inc. All rights reserved





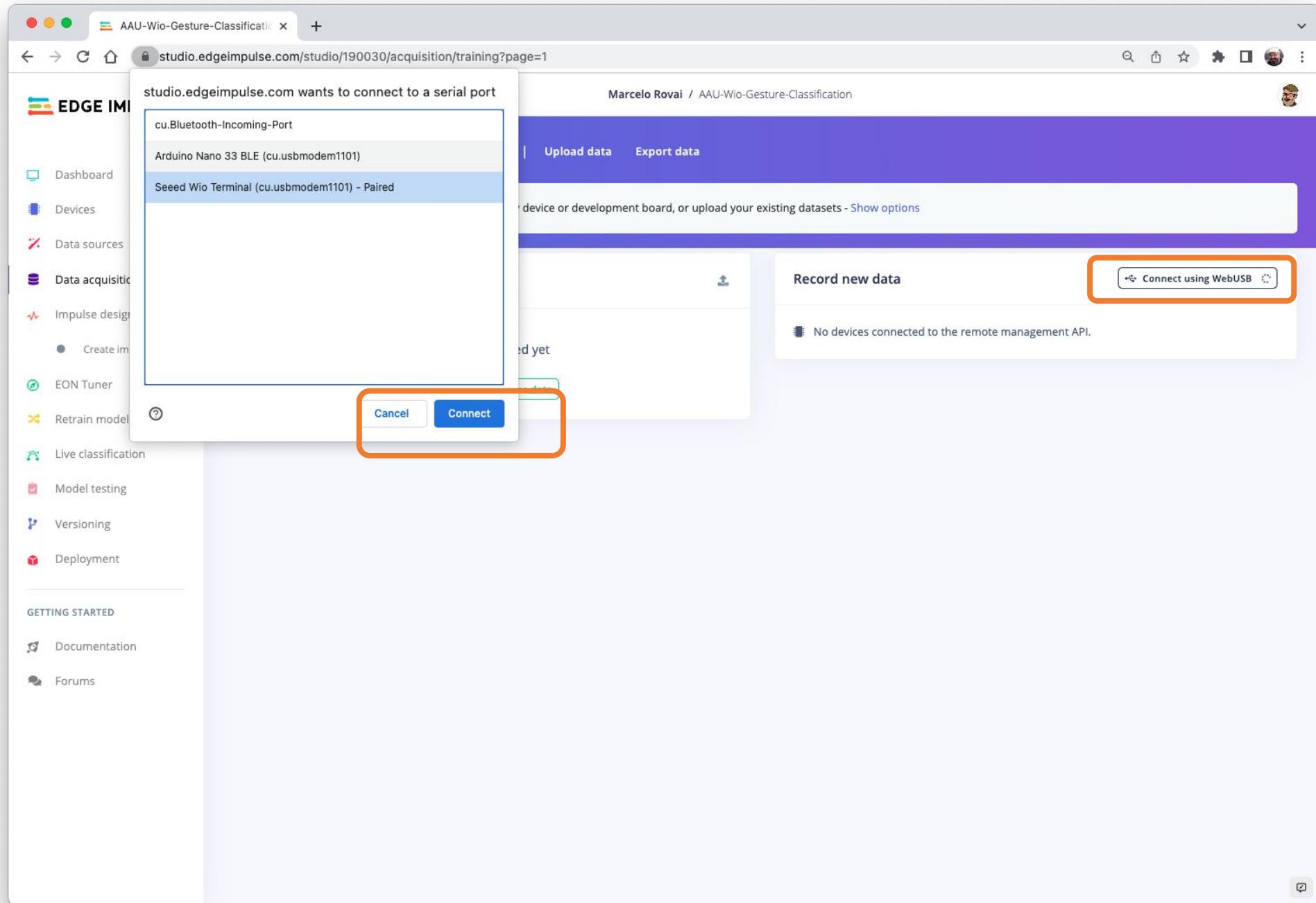
# Firmware installation

1. Connect Wio Terminal to your computer.
2. Entering the bootloader mode by sliding the power switch twice quickly.
3. An external drive named Arduino should appear in your PC.
4. Drag the the downloaded [Edge Impulse uf2 firmware files](#) to the Arduino drive. Now, Edge Impulse is loaded on Seeeduino Wio Terminal!



A screenshot of a GitHub release page for the 'wio-terminal-ei' repository. The page shows the '1.4.0' release. The release notes mention added built-in microphone support and internal light sensor support. The 'Assets' section lists three files: 'wio-terminal-ei-1.4.0.uf2' (highlighted with a red box), 'Source code (zip)', and 'Source code (tar.gz)'. The 'wio-terminal-ei-1.4.0.uf2' file is 239 KB in size.

# Built-in Sensor's Test



AAU-Wio-Gesture-Classificatio x +

studio.edgeimpulse.com/studio/190030/devices

Marcelo Rovai / AAU-Wio-Gesture-Classification

EDGE IMPULSE

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	REMOT...	LAST SEEN
23:D1:FF:14:17:05	23:D1:FF:14:17:05	SEEED_WIO_TERMINAL	Built-in accelerometer, Built-i...	●	Today, 17:12:18

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Dashboard

Devices

Data sources

Data acquisition

Impulse design

Create impulse

EON Tuner

Retrain model

Live classification

Model testing

Versioning

Deployment

GETTING STARTED

Documentation

Forums

The screenshot shows the Edge Impulse Studio interface on a web browser. The URL is [studio.edgeimpulse.com/studio/190030/acquisition/training?page=1](https://studio.edgeimpulse.com/studio/190030/acquisition/training?page=1). The top navigation bar includes tabs for "Training data" (which is selected), "Test data", "Data explorer", "Upload data", and "Export data". A notification bar at the top says, "Did you know? You can capture data from any device or development board, or upload your existing datasets - [Show options](#)". The left sidebar contains a list of features: Dashboard, Devices, Data sources, Data acquisition (selected), Impulse design, Create impulse, EON Tuner, Retrain model, Live classification, Model testing, Versioning, Deployment, GETTING STARTED, Documentation, and Forums.

The main area is divided into two sections: "Collected data" (left) and "Record new data" (right). The "Collected data" section displays a message: "No data collected yet" and a button labeled "Let's collect some data". The "Record new data" section has fields for "Device" (set to 23:D1:FF:14:17:05), "Label" (set to "lateral"), and "Sample length (ms.)" (set to 10000). Below these, a dropdown menu lists various sensors: "Built-in accelerometer" (selected, highlighted with an orange border), "Built-in microphone", "Built-in light sensor", "External multichannel gas(Grove-multichannel gas v2)", "External temperature&humidity&pressure sensor(Grove-BME280)", "External pressure sensor(Grove-DPS310)", "External distance sensor(Grove-TFmini)", "External 6-axis accelerometer(Grove-BMI088)", "External ultrasonic sensor(Grove-ultrasonic sensor)", and "External CO2+Temp sensor(Grove-SCD30)". A "Start sampling" button is located to the right of the dropdown menu.

AAU-Wio-Gesture-Classifi: X +

studio.edgeimpulse.com/studio/190030/acquisition/training?page=1

EDGE IMPULSE

Training data Test data | Data explorer | Upload data Export data

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

DATA COLLECTED 10s TRAIN / TEST SPLIT 100% / 0% ▲

Collected data

SAMPLE NAME	LABEL	ADDED	LENGTH
lateral.3pq0n74t	lateral	Today, 17:12:17	10s

Record new data

Device ② 23:D1:FF:14:17:05

Label lateral Sample length (ms.) 10000

Sensor Built-in accelerometer Frequency 100Hz

Start sampling

RAW DATA lateral.3pq0n74t

accX accY accZ

AAU-Wio-Gesture-Classifi: X +

studio.edgeimpulse.com/studio/190030/acquisition/training?page=1

EDGE IMPULSE

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

DATA COLLECTED  
5s

TRAIN / TEST SPLIT  
100% / 0% ▲

Collected data

SAMPLE NAME	LABEL	ADDED	LENGTH
yes.3pq19fp5	yes	Today, 17:22:15	5s

Record new data

Device ⓘ  
23:D1:FF:14:17:05

Label Sample length (ms.)  
yes 5000

Sensor Frequency  
Built-in microphone 16000Hz

Start sampling

RAW DATA  
yes.3pq19fp5



0 520 1040 1560 2080 3120 3640 4160 4680

audio

▶ 0:05 / 0:05 ⏸ ⏴

24

AAU-Wio-Gesture-Classifi: X +

studio.edgeimpulse.com/studio/190030/acquisition/training?page=1

EDGE IMPULSE

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
rock.3pq1fjf	rock	Today, 17:25:36	5s
yes.3pq19fp5	yes	Today, 17:22:15	5s

Record new data

Device ⓘ  
23:D1:FF:14:17:05

Label      Sample length (ms.)

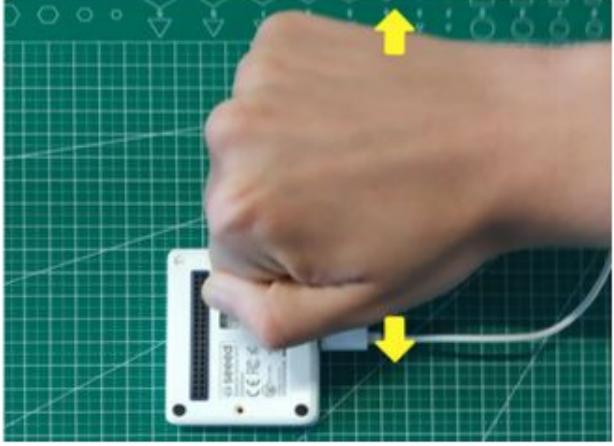
rock      5000

Sensor      Frequency

Built-in light sensor      62.5Hz

Start sampling

RAW DATA  
rock.3pq1fjf



Metadata

Metadata

25

# 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

I want to thank **Shawn Hymel** and **Edge Impulse**, **Pete Warden** and **Laurence Moroney** from Google, Professor **Vijay Janapa Reddi** and **Brian Plancher** from Harvard, and the rest of the **TinyMLEdu** team for preparing the excellent material on TinyML that is the basis of this course at UNIFEI.

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

Thanks



UNIFEI