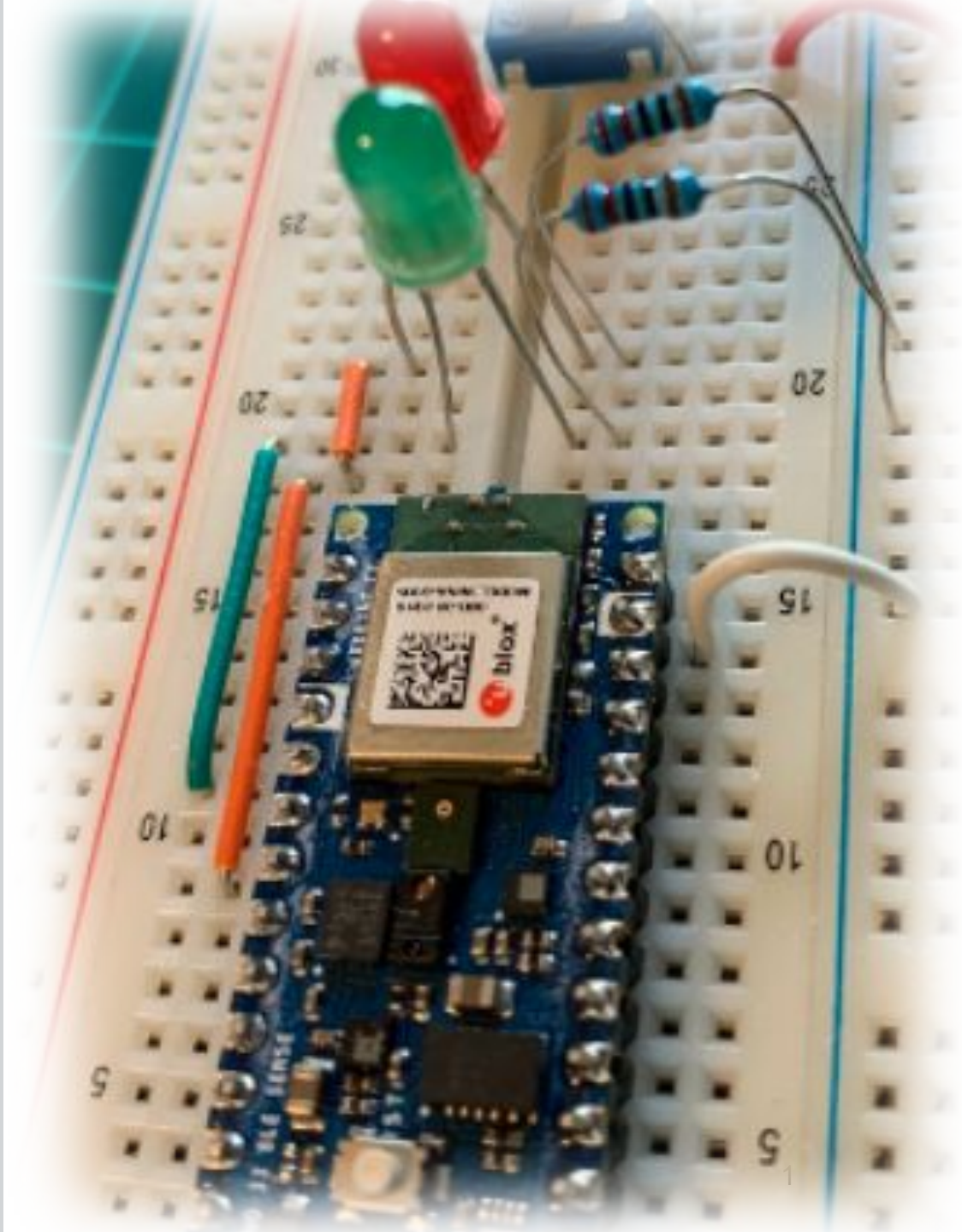
IESTI01 – TinyML

Embedded Machine Learning

17. TinyML Kit Overview - HW and SW installation & Test



Prof. Marcelo Rovai
UNIFEI

TinyML Kit Overview


ARDUINO
TINY MACHINE
LEARNING KIT
in partnership with:
edX
TensorFlow
OV7675

Nano 33 BLE Sense (+ USB cable)

Purpose

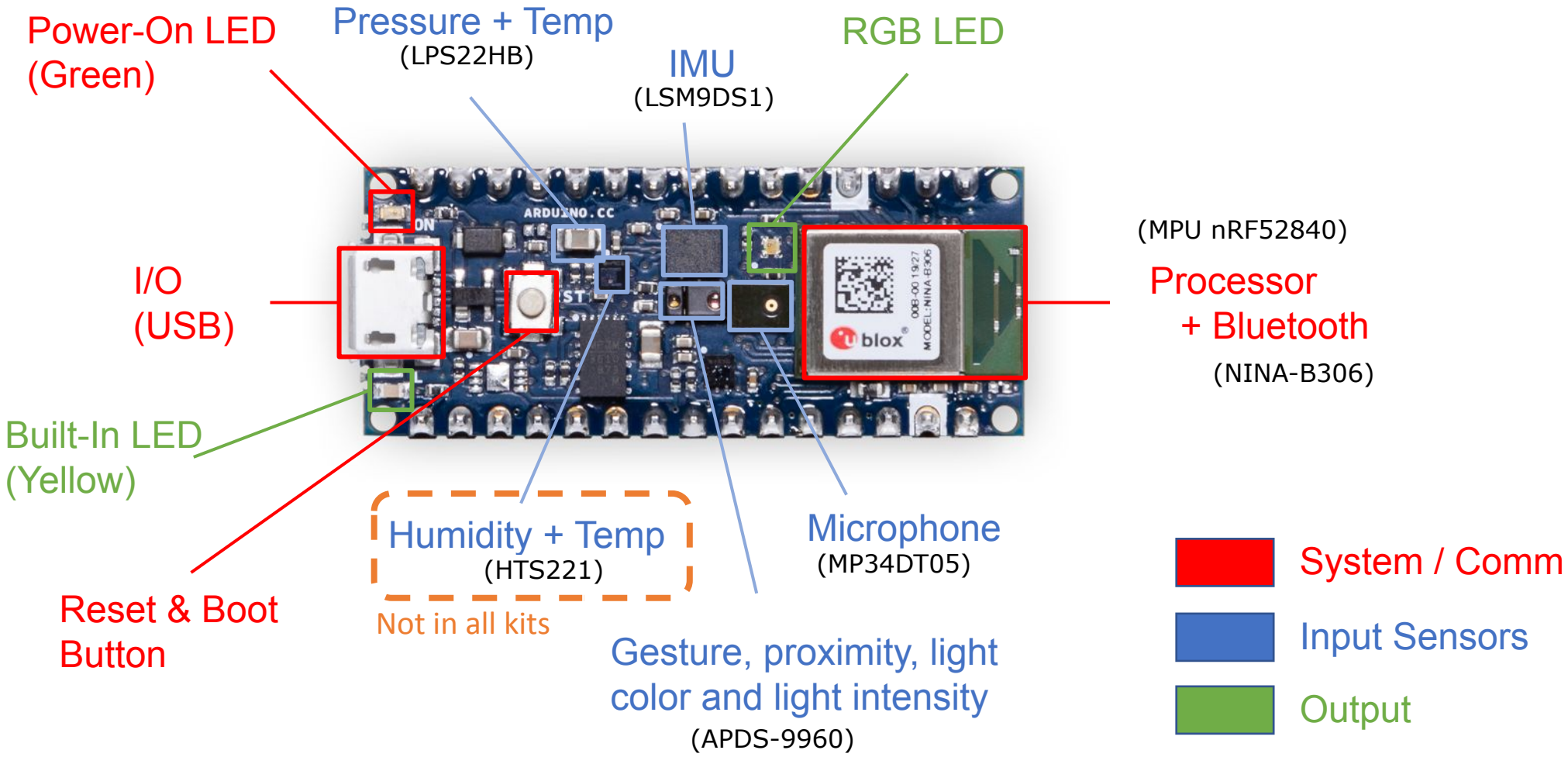
AI-enabled developmental **microcontroller board** with USB-A to microB cable

Specifications

- **MPU**: Nordic nRF52840 (ARM Cortex-M4 w/FPU): 3.3V, 64MHz, 1MB flash, 256 kB RAM
- **Sensors on board**: microphone, IMU (9 axis), color, light, proximity, barometric, temperature, ~~humidity~~*, gesture, and light intensity.
- BLE module covered by ArduinoBLE library
- RGB LEDs

* Not included in some packages. For projects you can use the external Grove - Temp&Humi&Barometer Sensor (BME280)

Nano 33 BLE Sense (Development board)



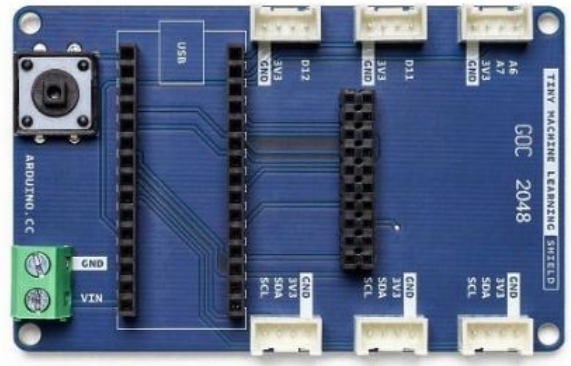
OV 7675 Camera Module

Purpose
Breakout PCB for ***tiny*** camera.

Specifications

- Low-cost, Low-voltage, **0.3 MP** CMOS VGA (can step down to **QVGA**, QQVGA) image sensor
- Serial Camera Control Bus (SCCB) + Camera Parallel Interface (CPI) / Digital Video Port (DVP) interface
- Breaks ribbon cable out to 2x10 pin array
- 1 or 5 fps (Frames per Second)

Tiny Machine Learning Shield



Purpose

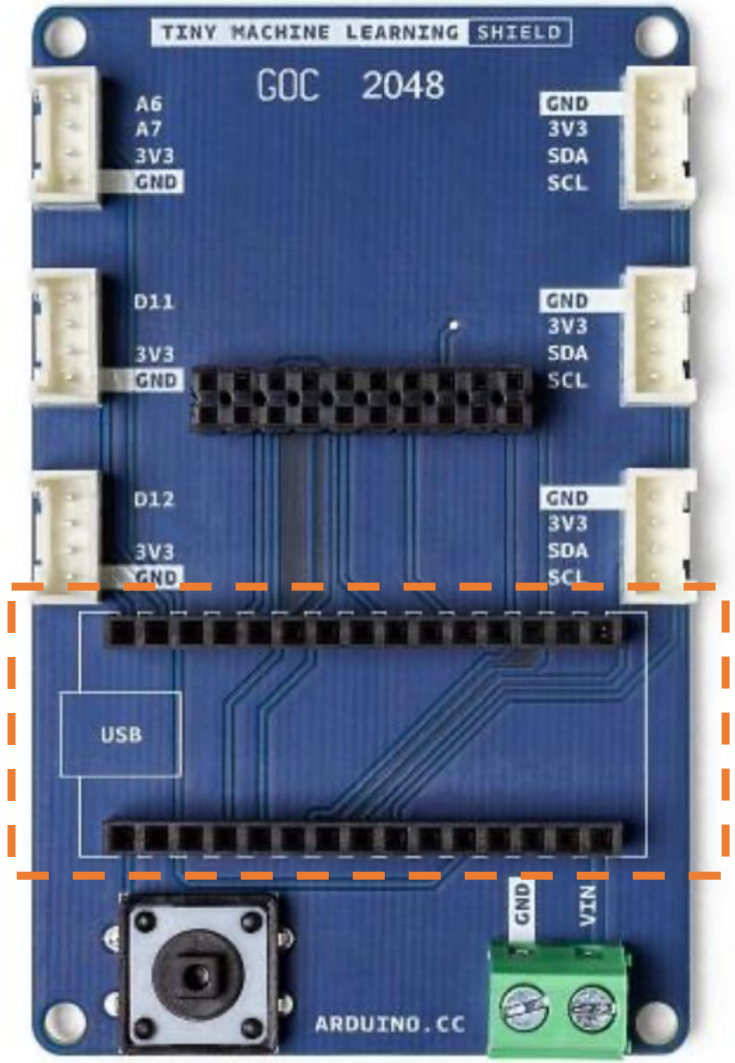
A daughter PCB designed to **breakout the I/O** from the Nano 33 BLE sense to permit easy, reliable **communication with** other local, **off-board elements**

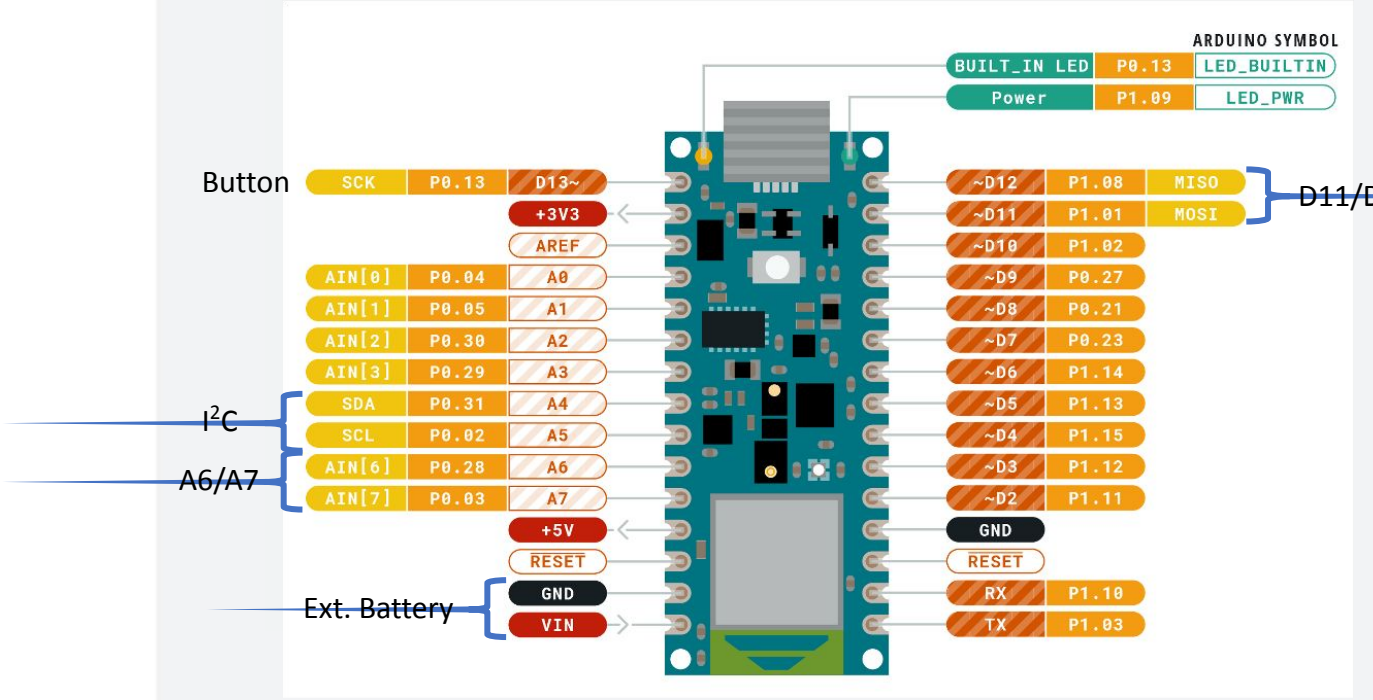
Specifications

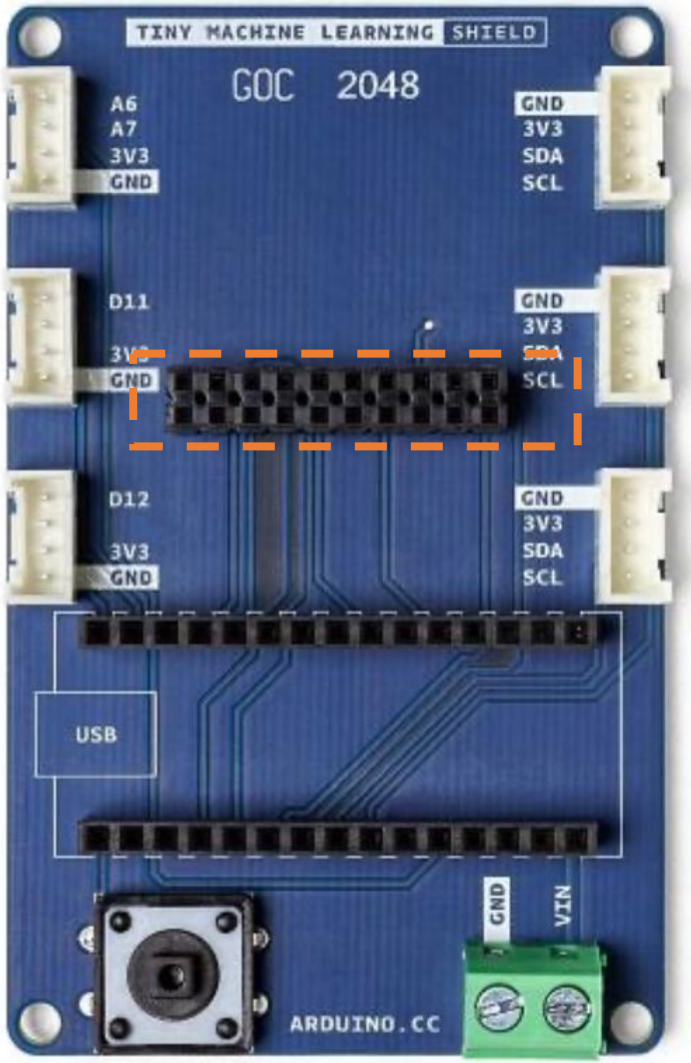
- Grove connectors (3.3V I2C and simple digital / analog - see pinouts)
- 2x10 pin array for OV7675 camera module
- Voltage input terminal block, accepts 4.5 to 21V (down regulated to 3.3V on Nano 33)

TinyML Shield

Two rows of 1x15 headers that you can slot the Nano 33 BLE sense into



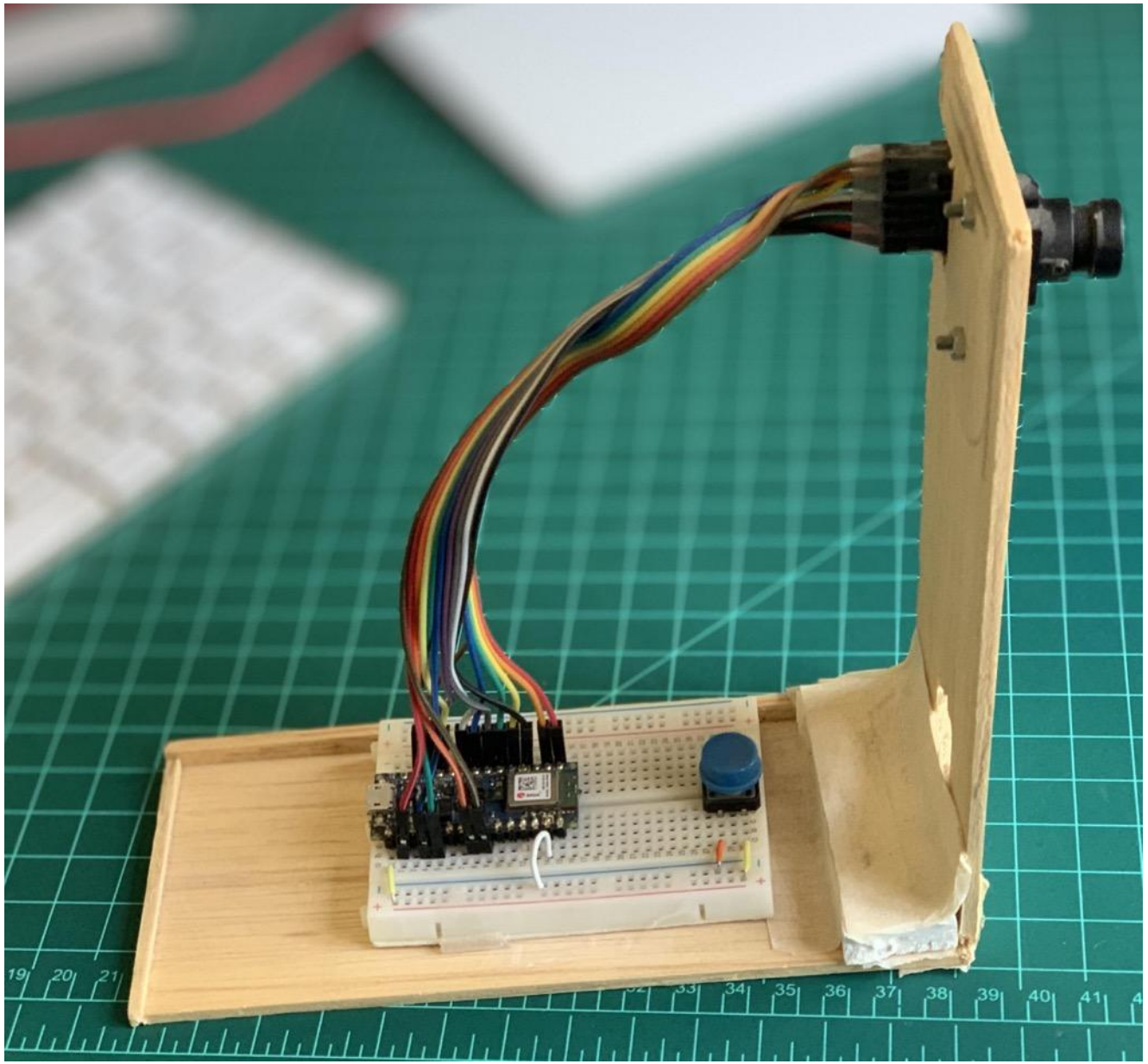




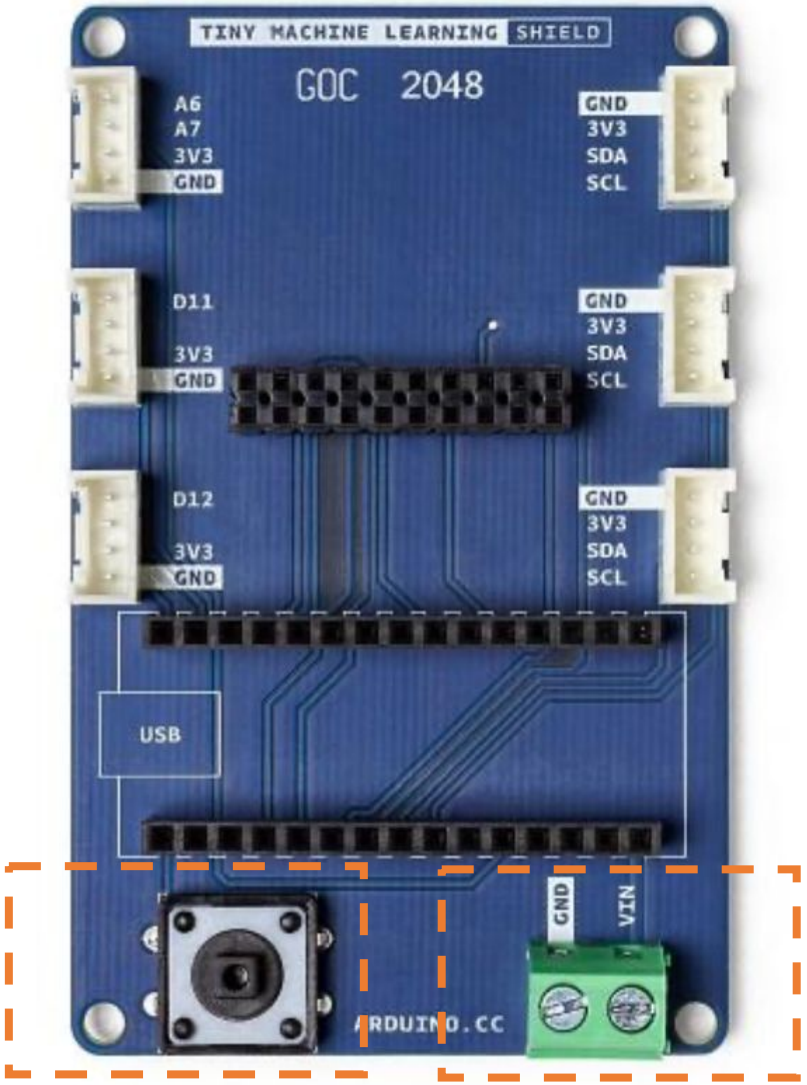
TinyML Shield

2x10 header that is intended to receive the corresponding pins of the OV7675 camera module

OV7670_VSYNC	8
OV7670_HREF	A1
OV7670_PLK	A0
OV7670_XCLK	9
OV7670_D0	10
OV7670_D1	1
OV7670_D2	0
OV7670_D3	2
OV7670_D4	3
OV7670_D5	5
OV7670_D6	6
OV7670_D7	4

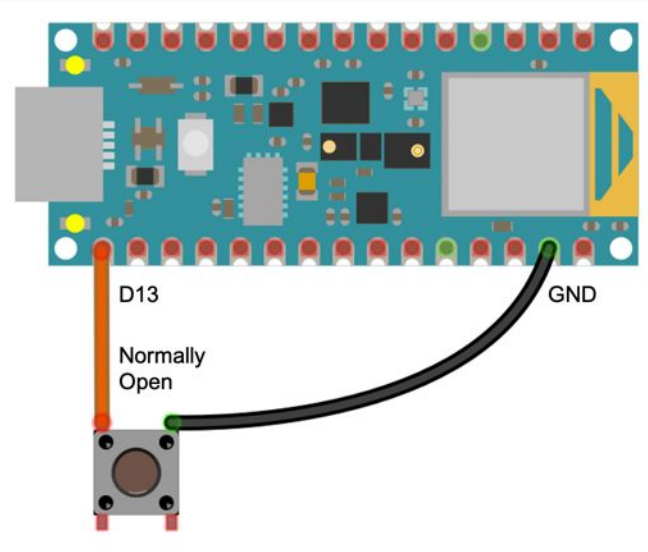



OV7675

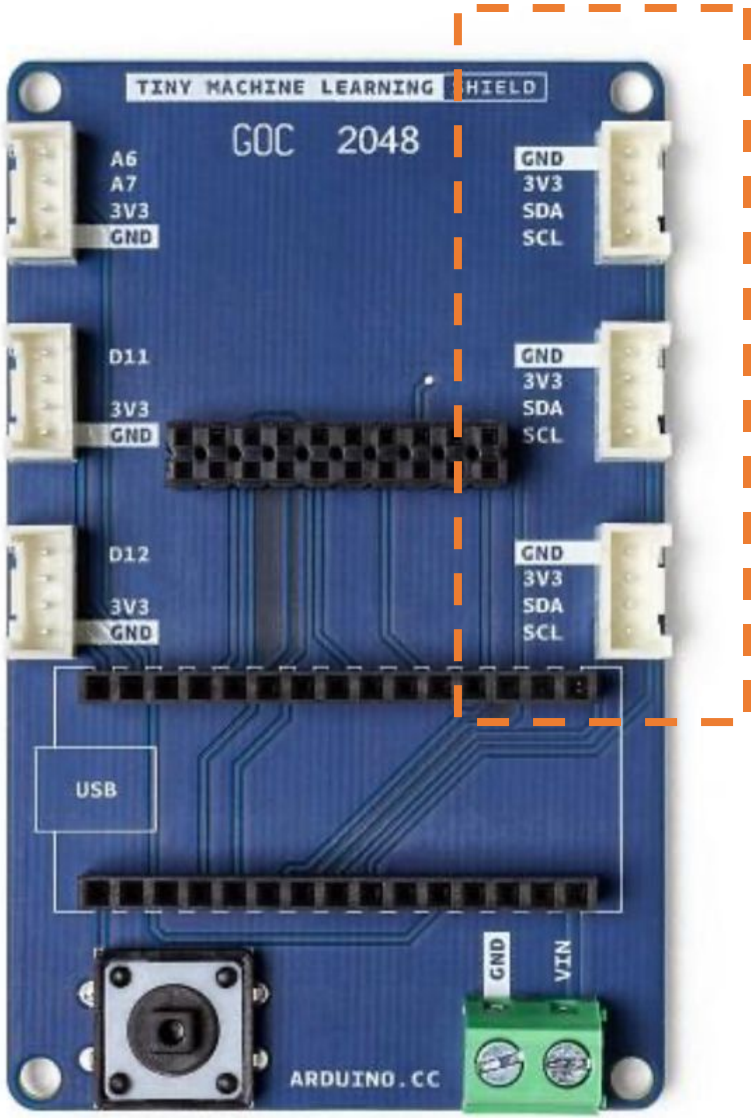


TinyML Shield

A easily programmable button on the left

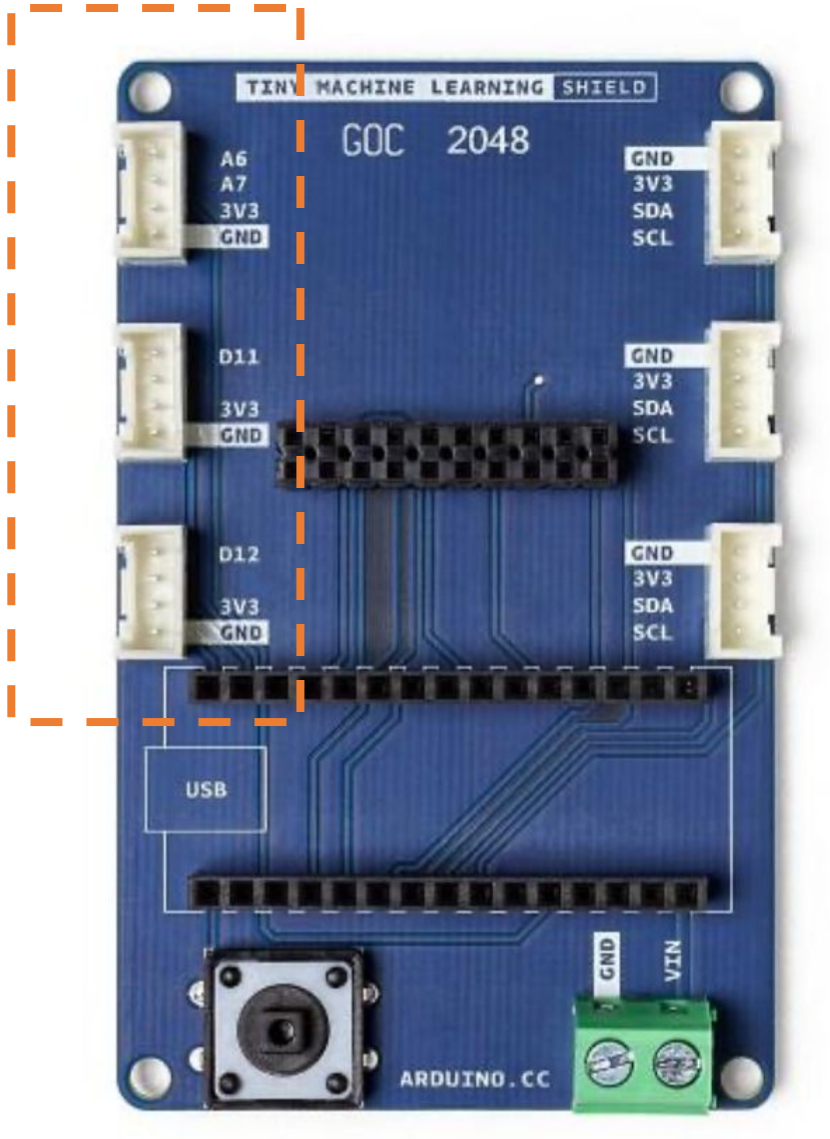


Screw-in terminal block for external (battery) power (4.5V to 21V)



TinyML Shield

Standard Grove connectors, to permit serial communication (I2C = power + data + clock) with modules (both sensors and actuators)



TinyML Shield

Grove connectors that break out analog and digital GPIO

Grove Connectors

Purpose

Facilitate **plug-and-play connections** to off-board modules to extend the possible scope of functionality to new **TinyML** applications

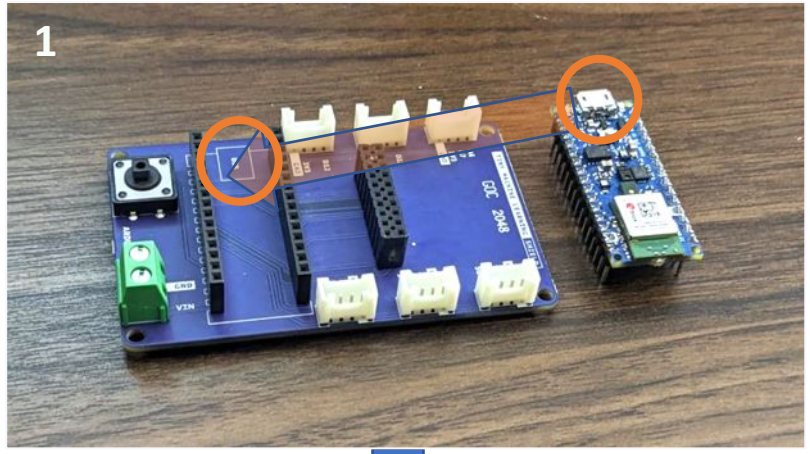
Specifications

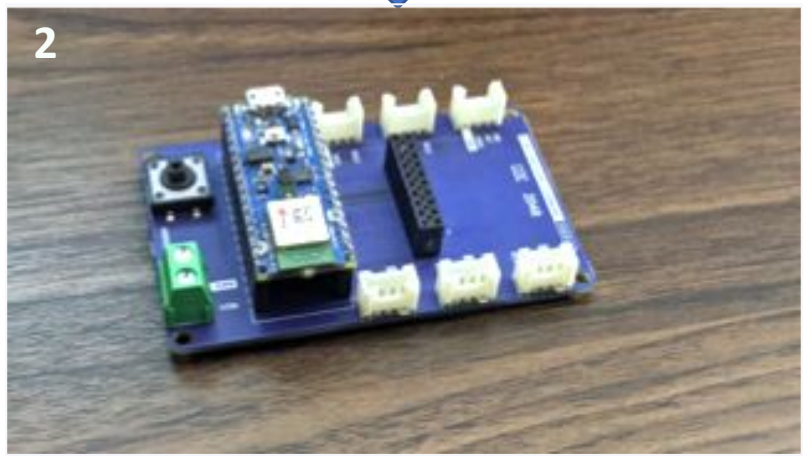
- Proprietary connection system from SeeedStudio, similar to JST PH-type connectors
- Large catalog of sensors, actuators available at seeedstudio.com
- Be sure to check the voltage requirements and pinout of any new Grove module for compatibility with this shield before purchasing or connecting said module

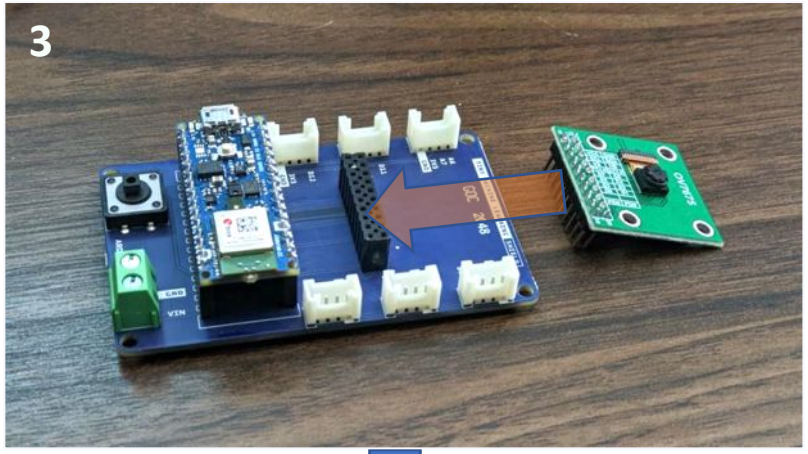
TinyML Kit Installation

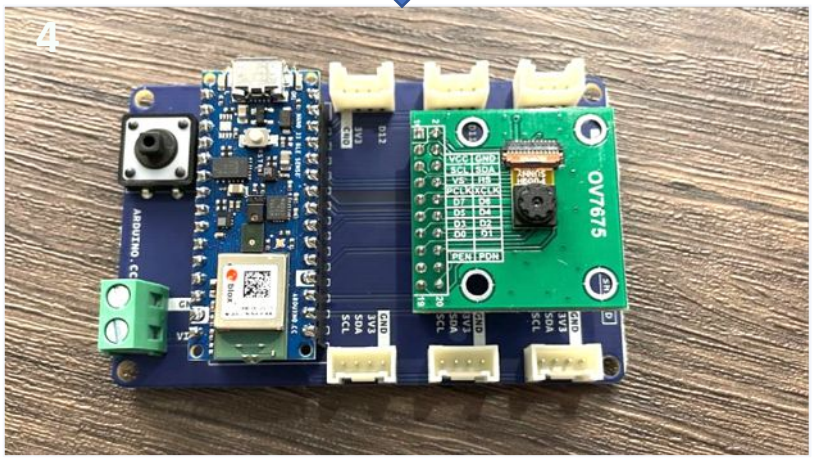
- Hardware Set-up
- Software Set-up

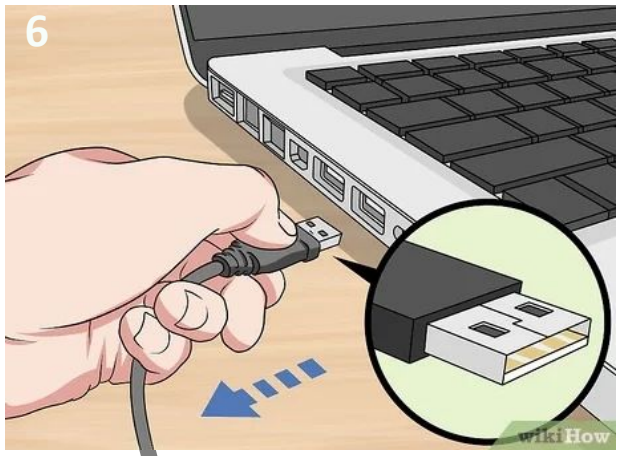
Installing the Hardware



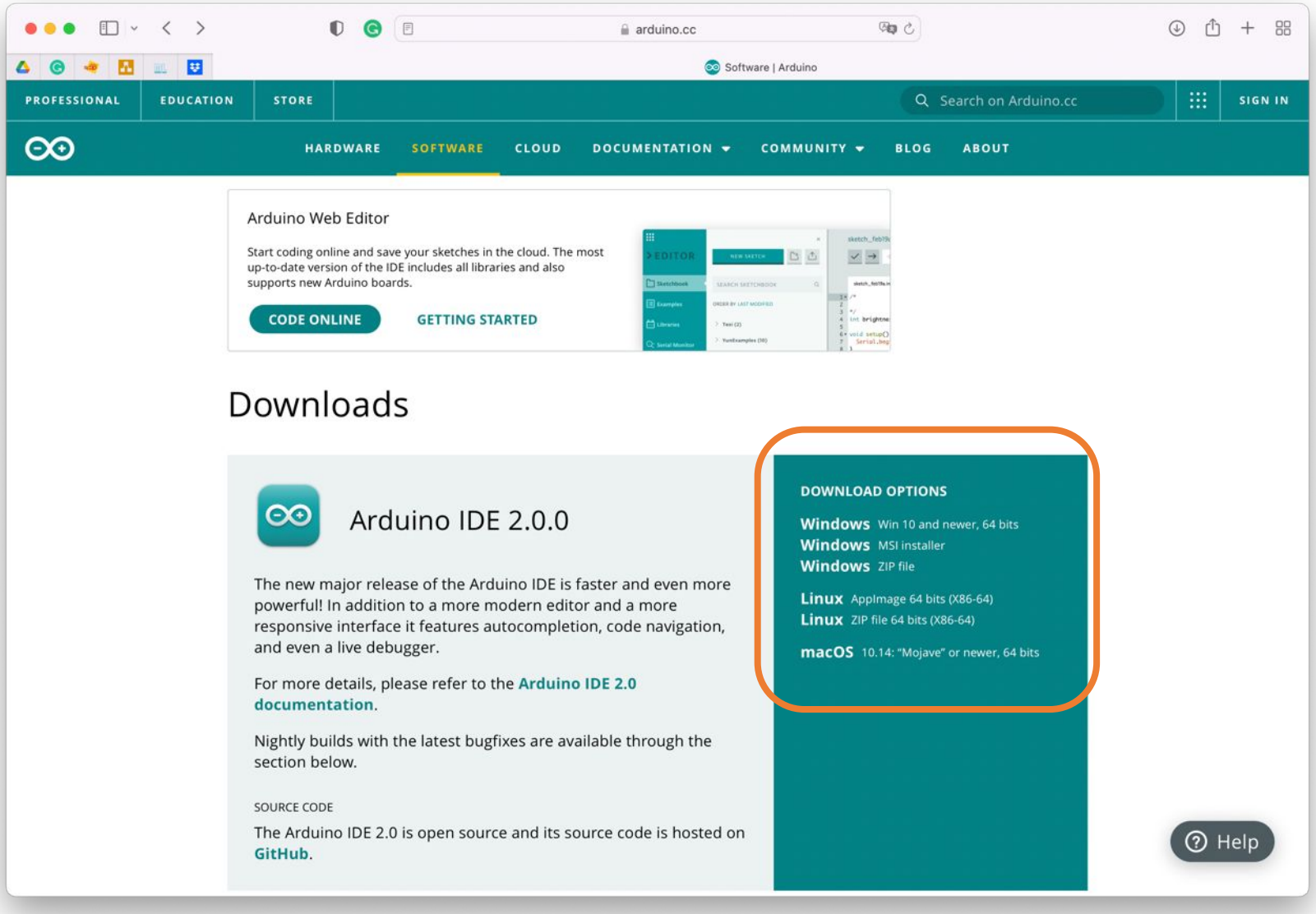




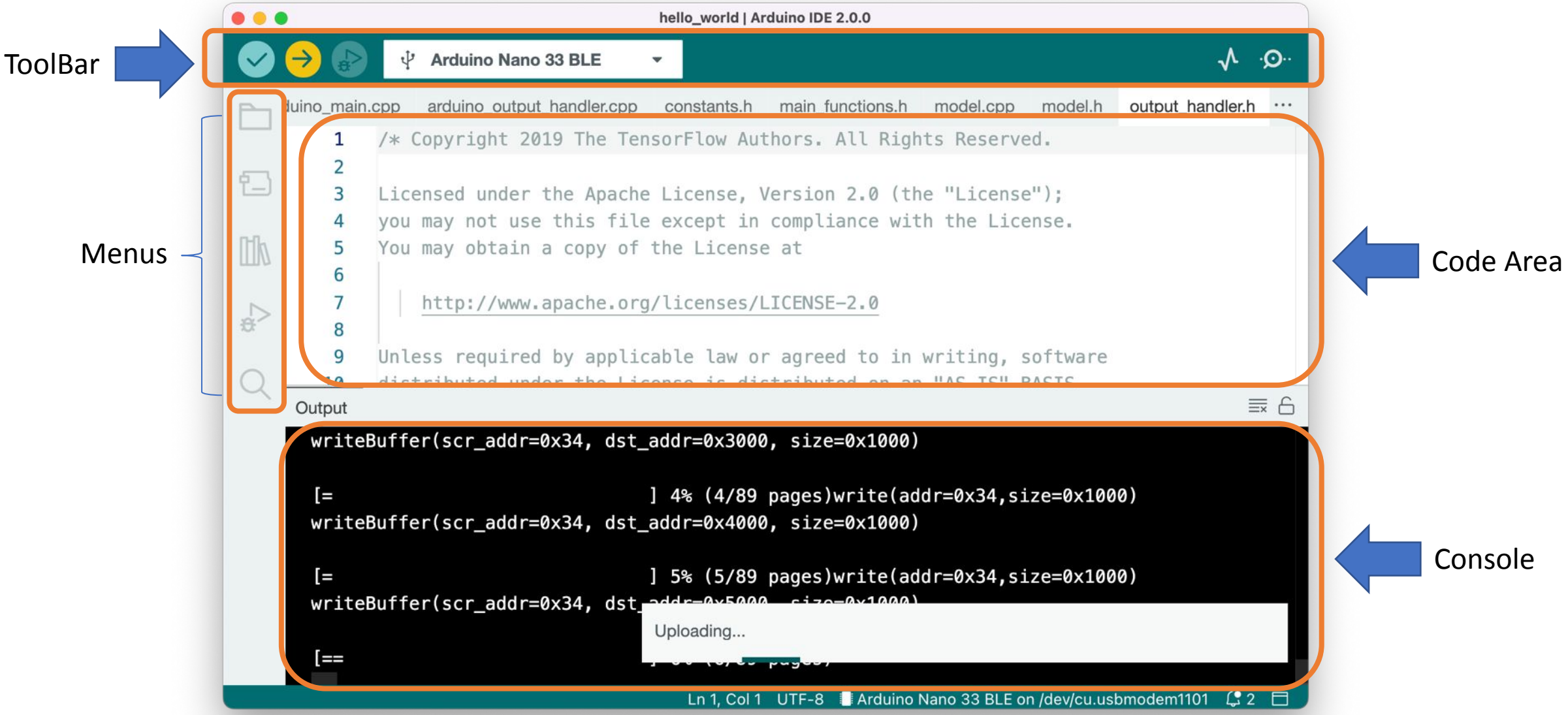




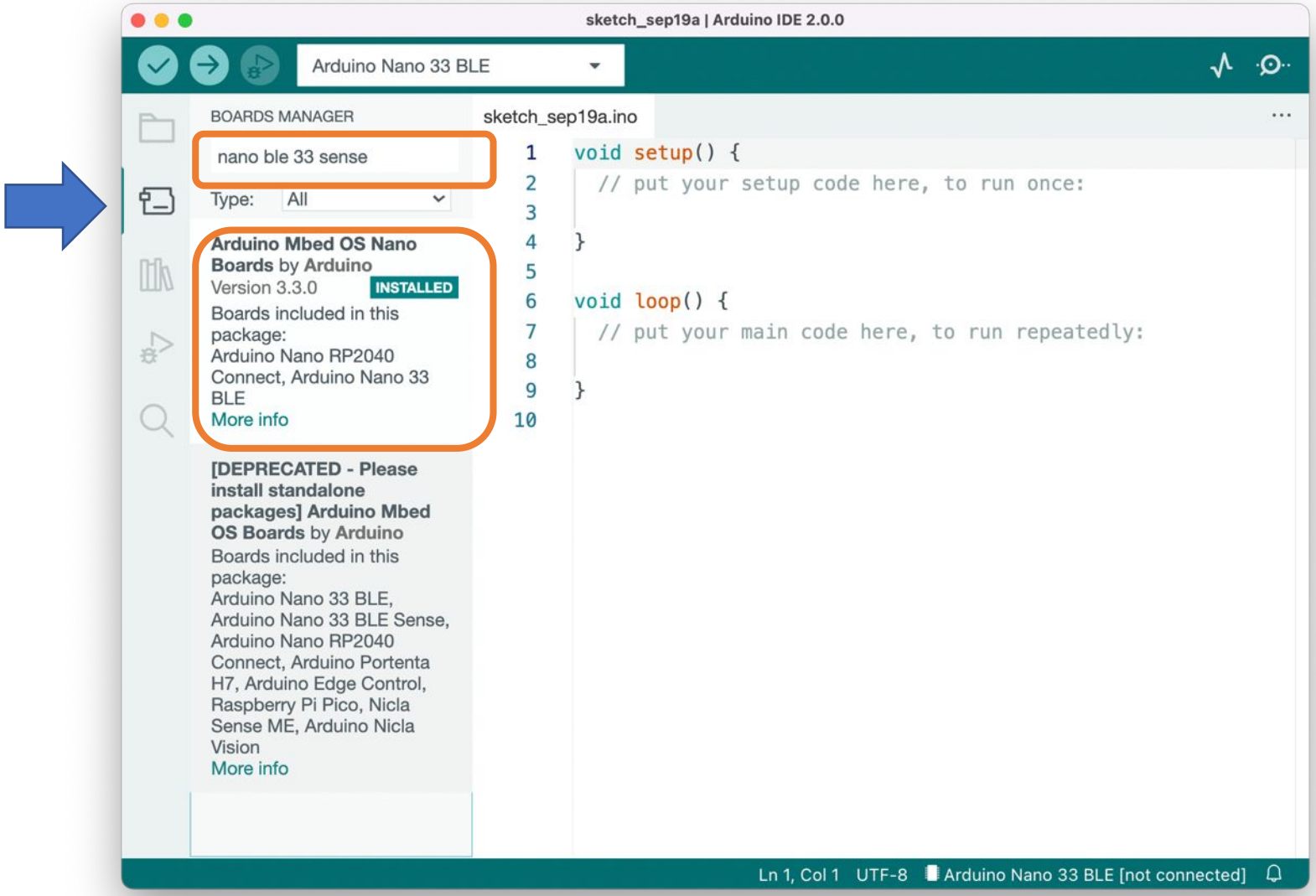
Installing the Arduino IDE 2.0



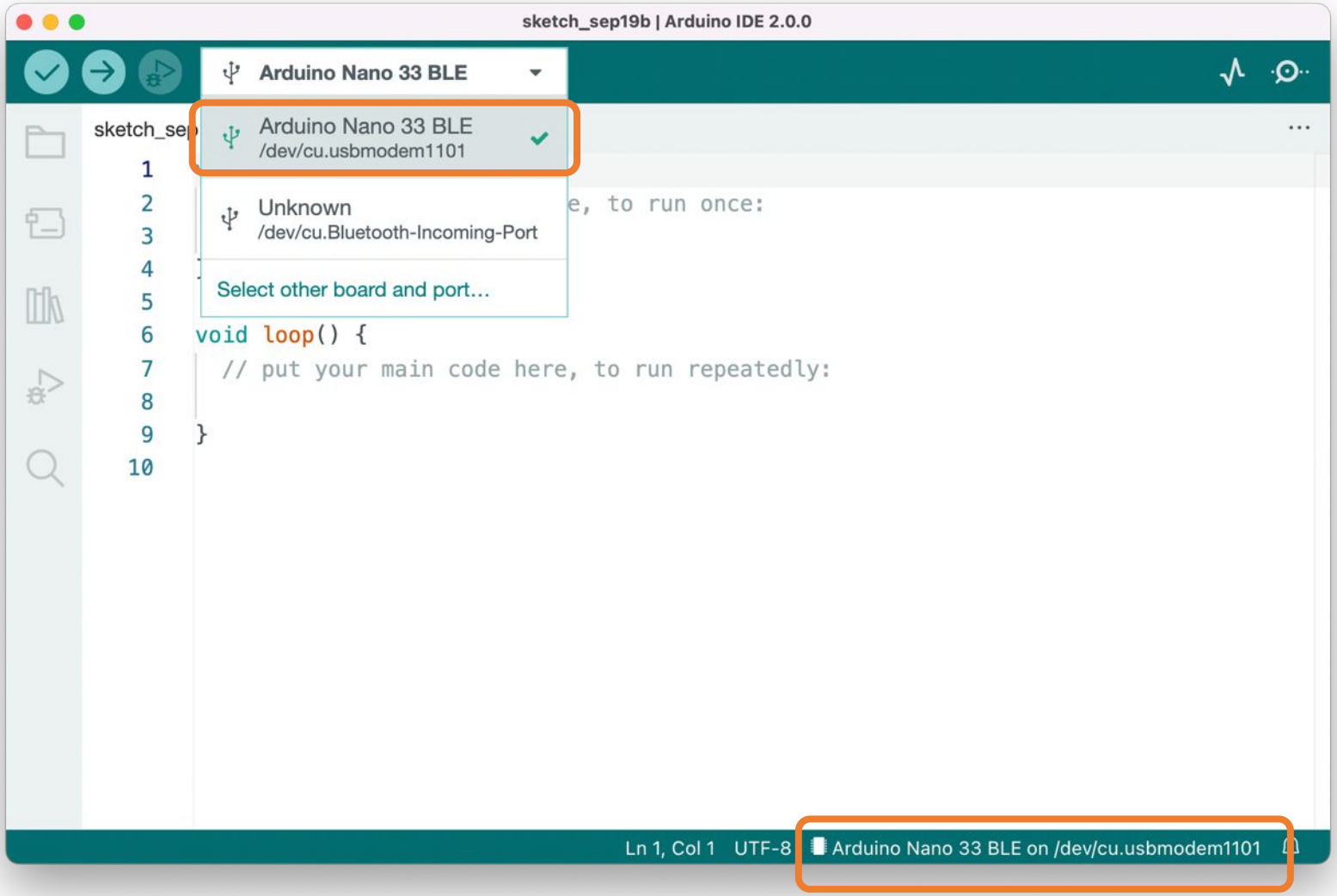
The Arduino IDE 2.0



Installing the Board Files



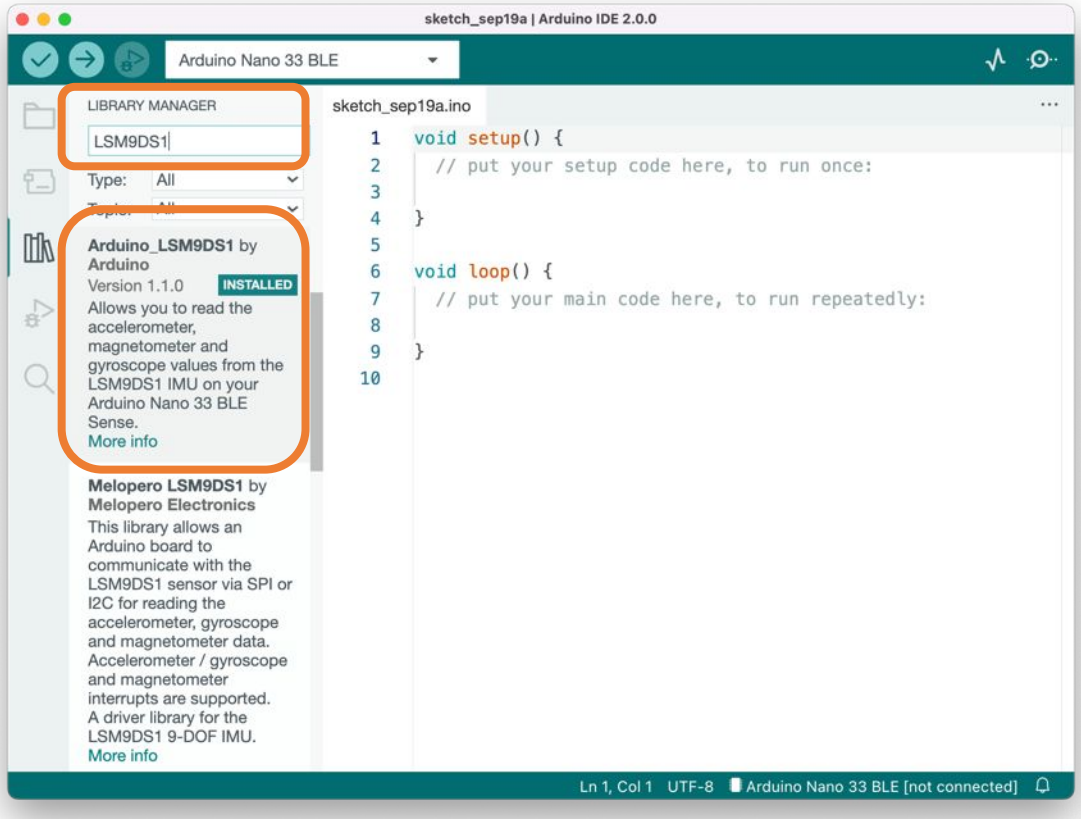
Select Board and Port

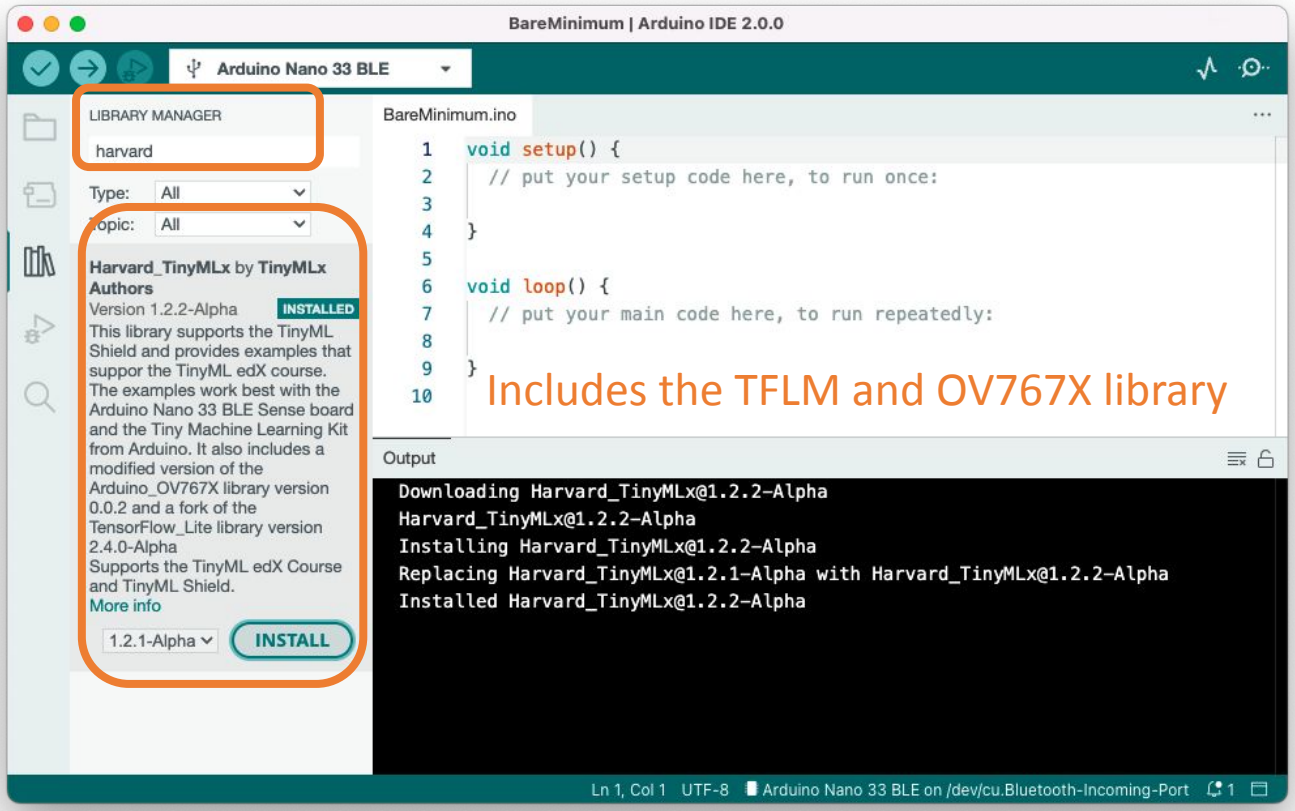


Installing Sensor and Auxilary Libraries

IMU library

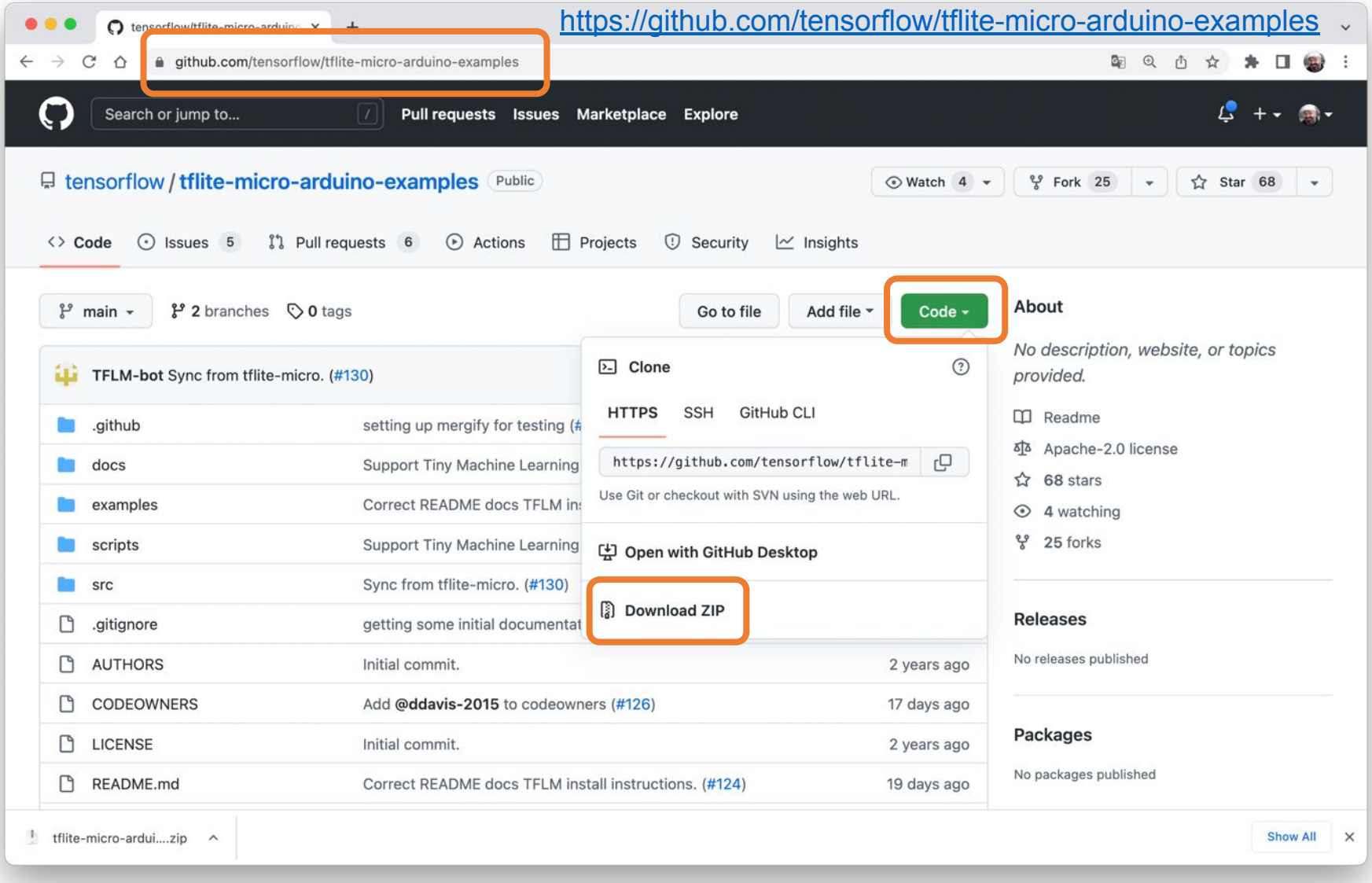
Shield, TFLM and Camera libraries





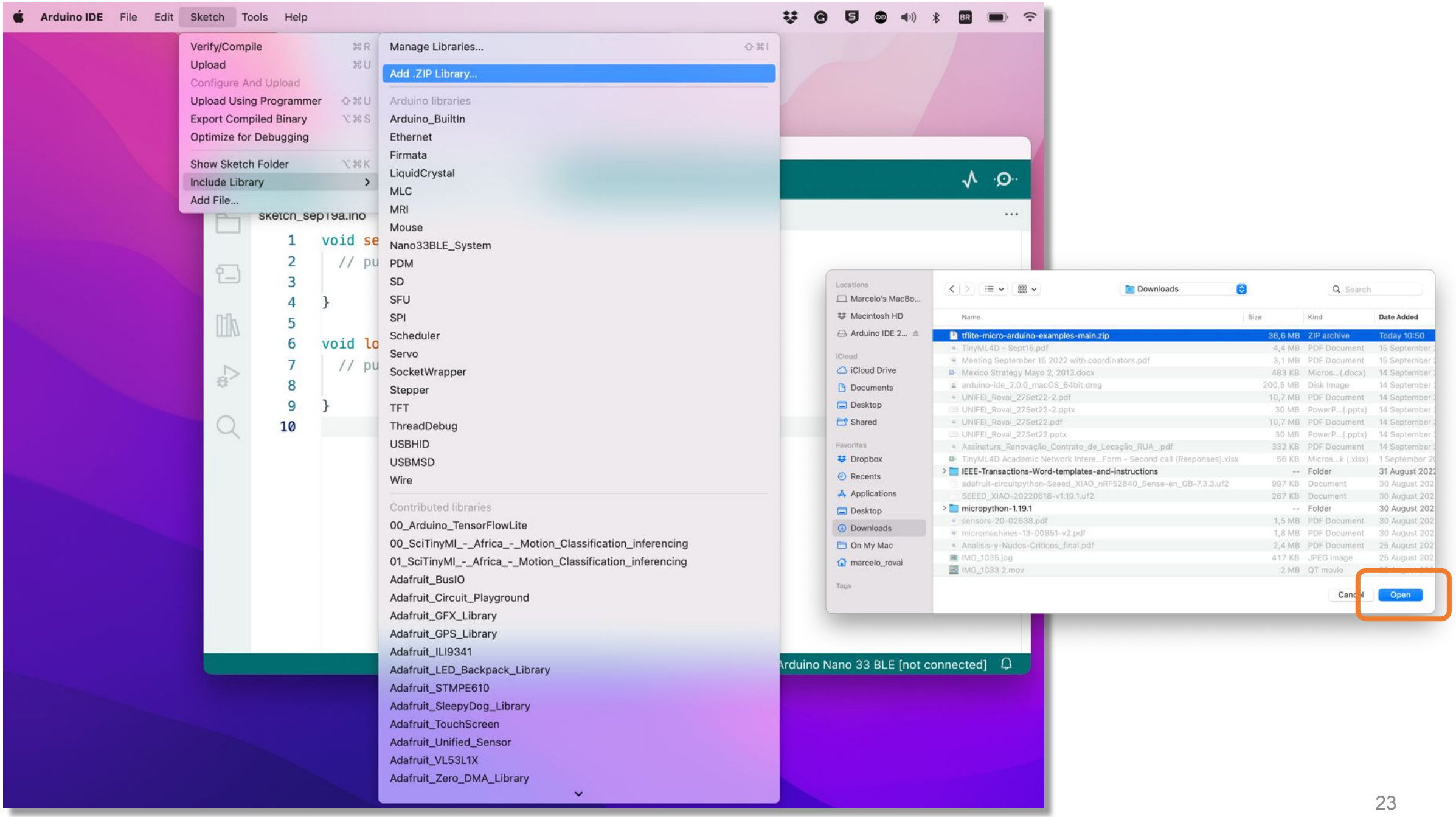
Installing Tensorflow Lite Micro (TFLM) Library (optional)

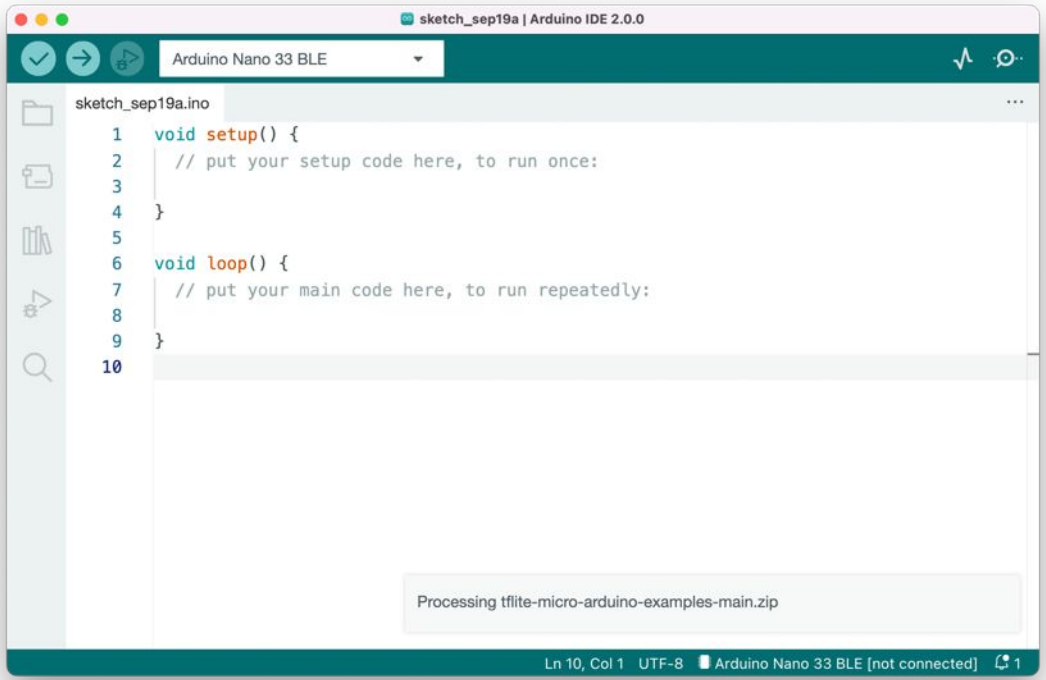
https://github.com/tensorflow/tflite-micro-arduino-examples

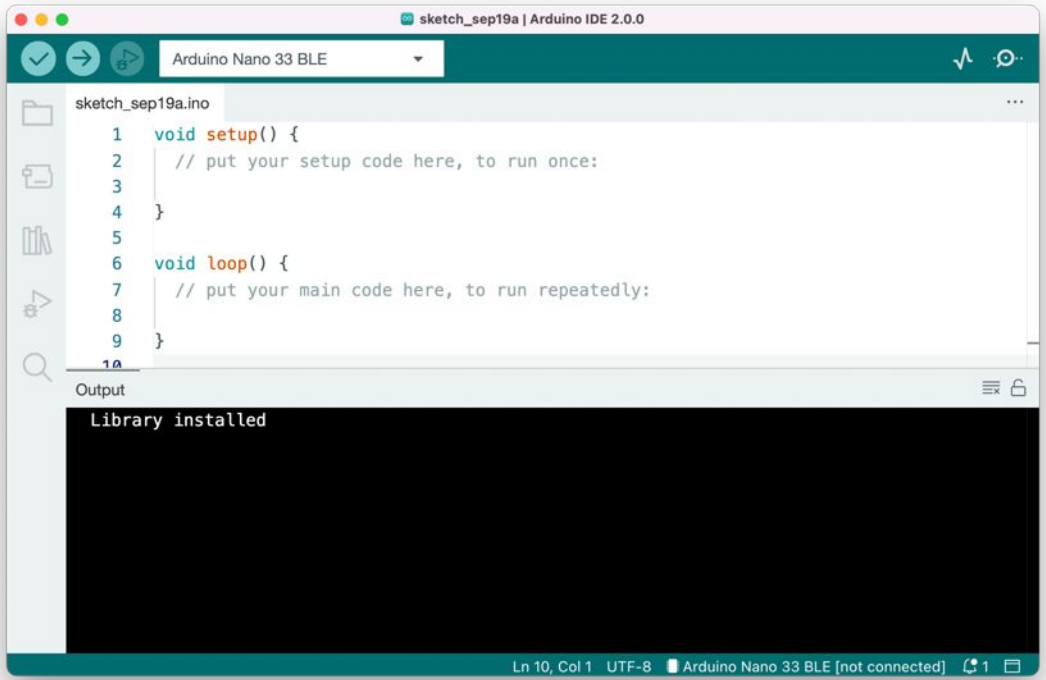


If you need install the TFLM library to be used stand alone

The TFLM library is not available directly on the Arduino IDE


Arduino IDE
File
Edit
Sketch
Tools
Help
Verify/Compile ⌘R
Upload ⌘U
Configure And Upload
Upload Using Programmer ⇧⌘U
Export Compiled Binary ⌥⌘S
Optimize for Debugging
Show Sketch Folder ⌥⌘K
Include Library
Add File...
Manage Libraries... ⇧⌘I
Add .ZIP Library...
Arduino libraries
Arduino_BuiltIn
Ethernet
Firmata
LiquidCrystal
MLC
MRI
Mouse
Nano33BLE_System
PDM
SD
SFU
SPI
Scheduler
Servo
SocketWrapper
Stepper
TFT
ThreadDebug
USBHID
USBMSD
Wire
Contributed libraries
00_Arduino_TensorFlowLite
00_SciTinyML_-_Africa_-_Motion_Classification_inferencing
01_SciTinyML_-_Africa_-_Motion_Classification_inferencing
Adafruit_BusIO
Adafruit_Circuit_Playground
Adafruit_GFX_Library
Adafruit_GPS_Library
Adafruit_ILI9341
Adafruit_LED_Backpack_Library
Adafruit_STMPE610
Adafruit_SleepyDog_Library
Adafruit_TouchScreen
Adafruit_Unified_Sensor
Adafruit_VL53L1X
Adafruit_Zero_DMA_Library
sketch_sep19a.ino
Downloads
Search
Name
Size
Kind
Date Added
tflite-micro-arduino-examples-main.zip
Cancel
Open
Arduino Nano 33 BLE [not connected]

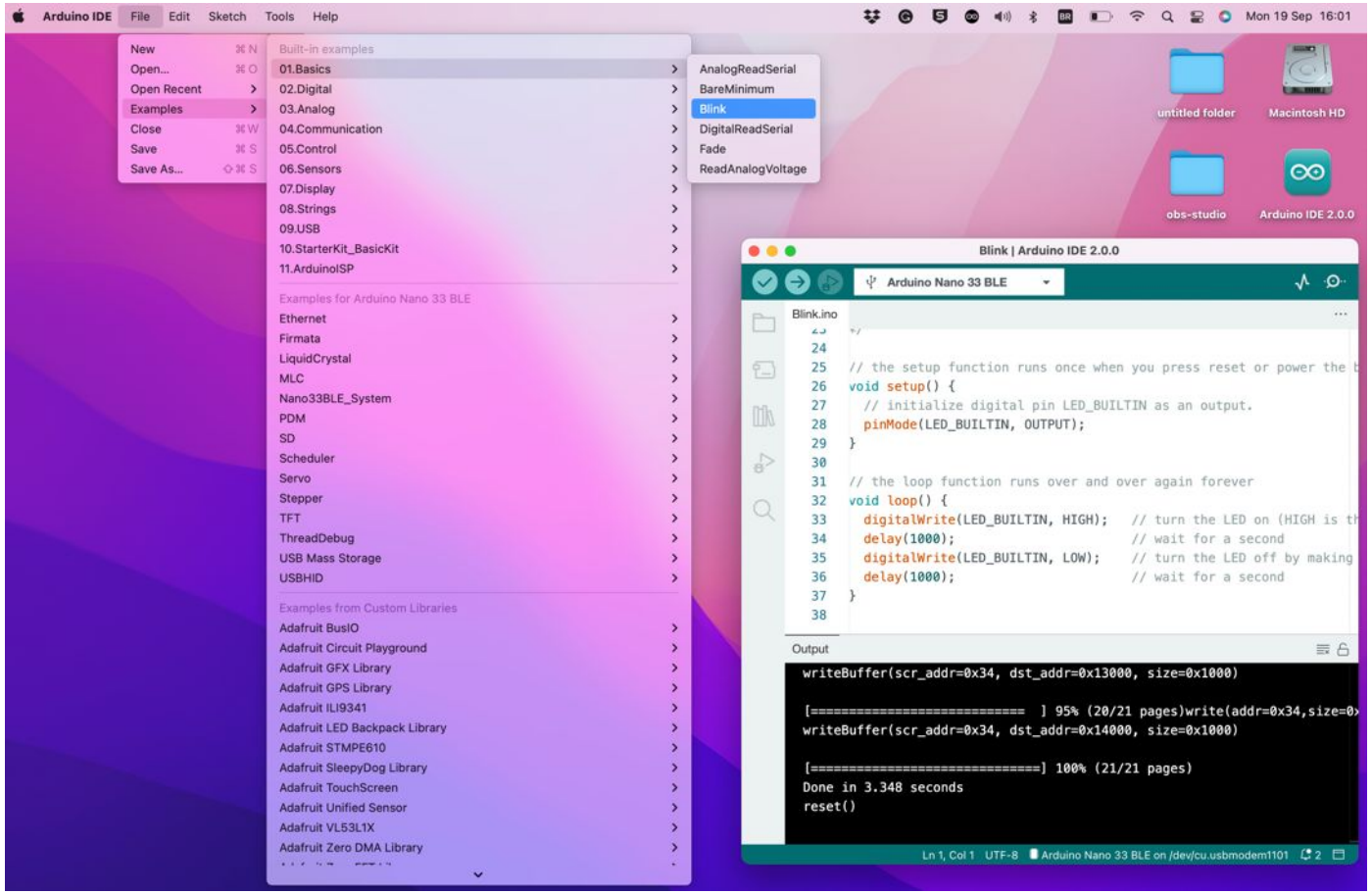

sketch_sep19a | Arduino IDE 2.0.0
Arduino Nano 33 BLE
sketch_sep19a.ino
1 void setup() {
2 // put your setup code here, to run once:
3
4 }
5
6 void loop() {
7 // put your main code here, to run repeatedly:
8
9 }
10
Processing tflite-micro-arduino-examples-main.zip
Ln 10, Col 1 UTF-8 Arduino Nano 33 BLE [not connected] 1

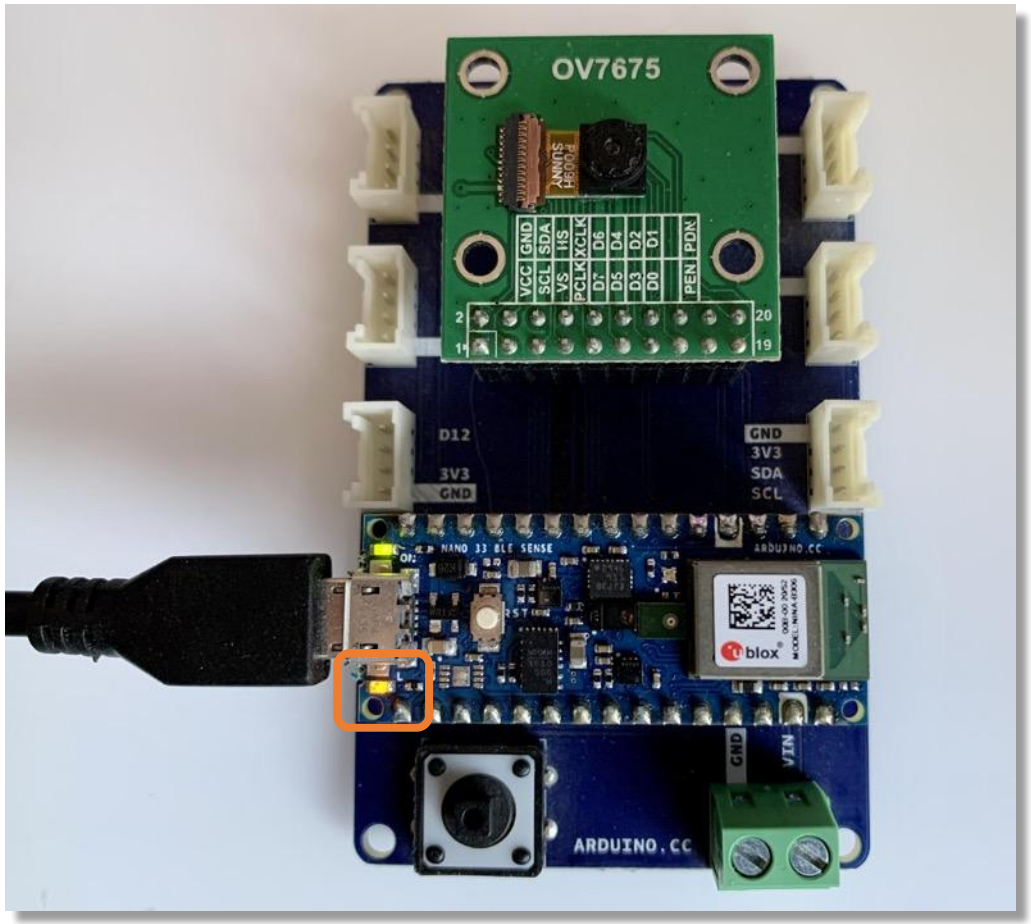

sketch_sep19a | Arduino IDE 2.0.0
Arduino Nano 33 BLE
sketch_sep19a.ino
1 void setup() {
2 // put your setup code here, to run once:
3
4 }
5
6 void loop() {
7 // put your main code here, to run repeatedly:
8
9 }
Output
Library installed
Ln 10, Col 1 UTF-8 Arduino Nano 33 BLE [not connected] 1

TinyML Kit Test

- MCU test (Blink)
- Sensors Test (IMU, MIC, CAMERA)

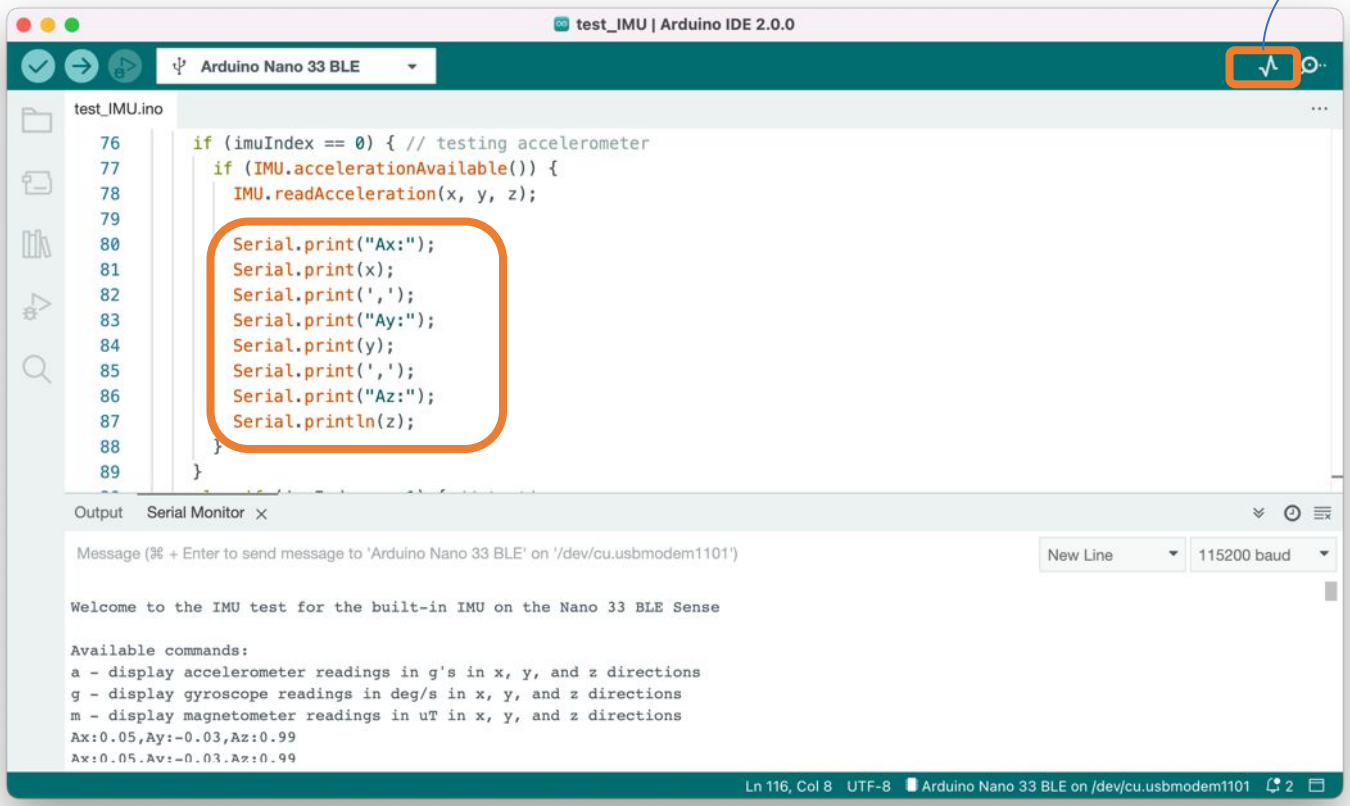
MCU installation test (Blink)



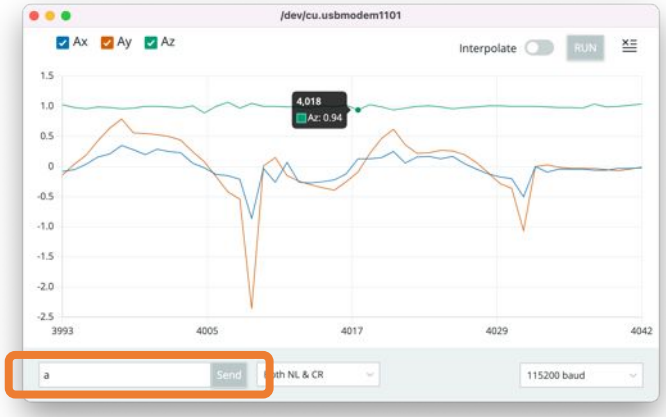


Testing IMU

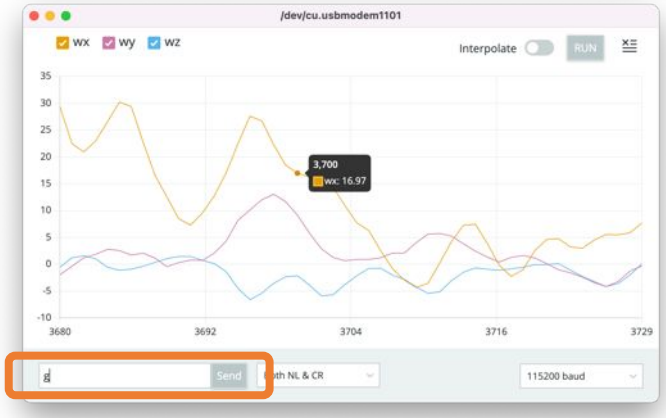
Arduino IDE Menu -> Files/Examples/Harvard_TinyMLx/test_IMU



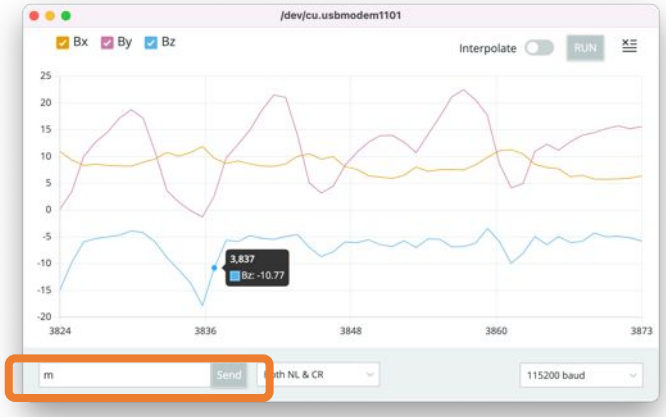
a ->



g ->



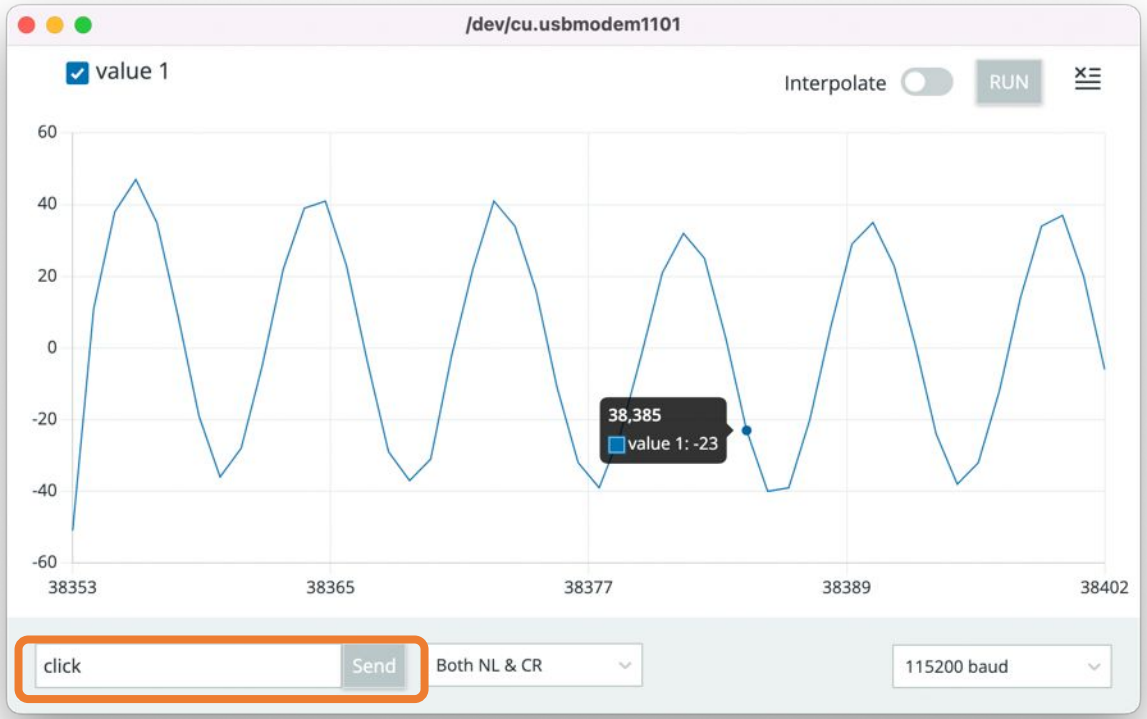
m ->



Note: To be shown simultaneously on Plotter, variables must be separated by coma (Change the sketch)

Testing Microphone

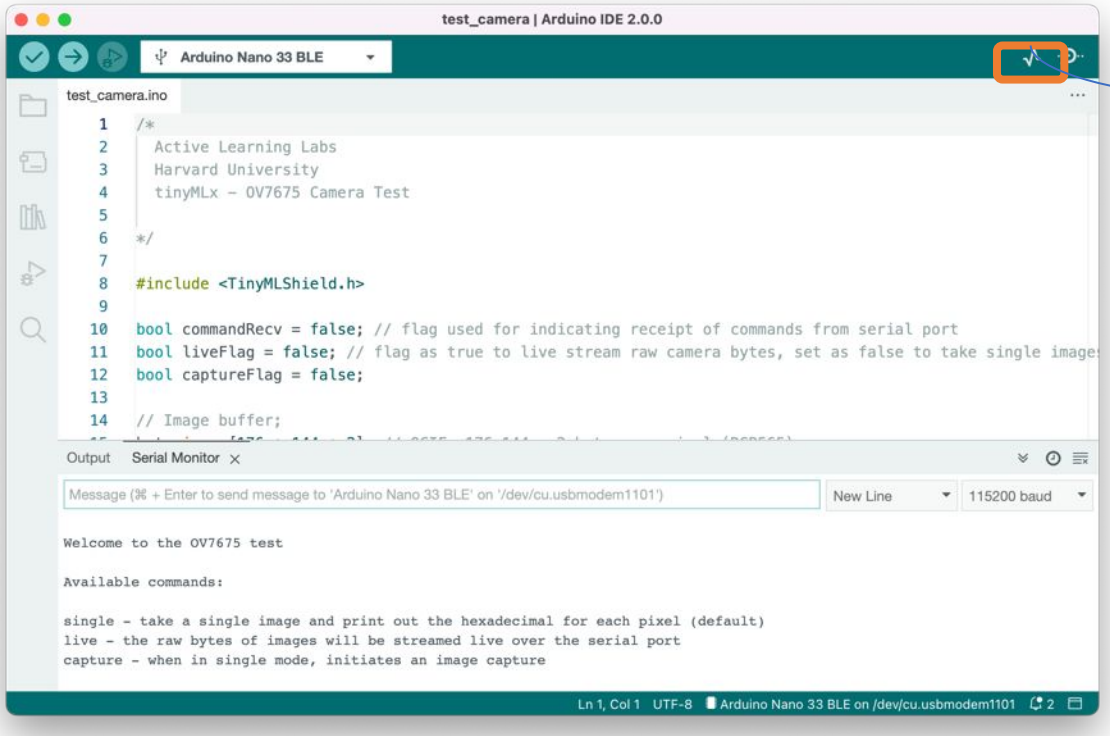
Arduino IDE Menu -> Files/Examples/Harvard_TinyMLx/test_microphone

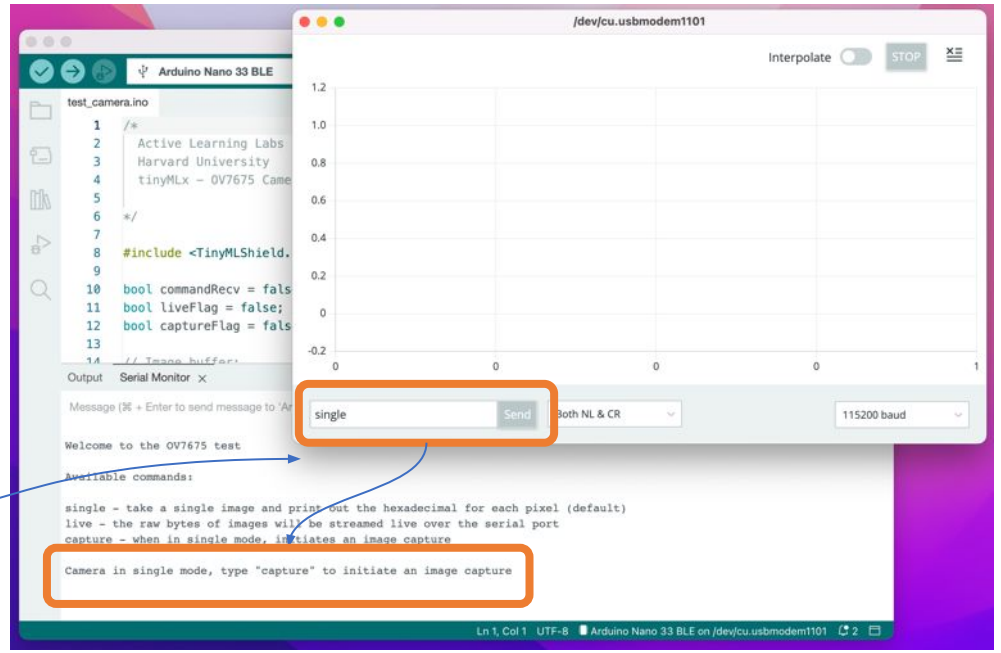


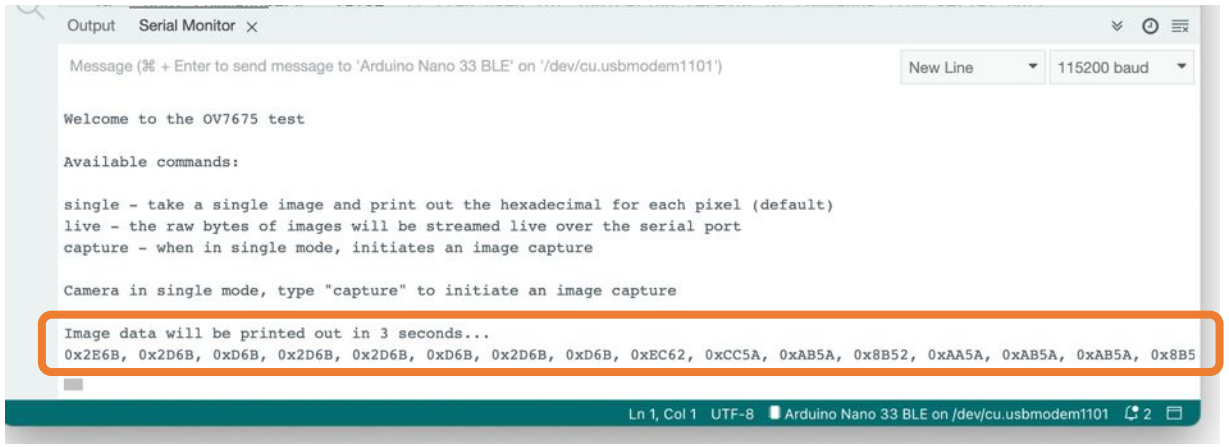
Note: Press the button on shield or send “click” as a command to start/stop sound record

Testing Camera

Arduino IDE Menu -> Files/Examples/Harvard_TinyMLx/test_camera







Note: Press the button on shield or send “capture” as a command to capture a image

Testing Camera

[OV7675 Image Viewer.ipynb]

Optional Tests (RGB LEDs)

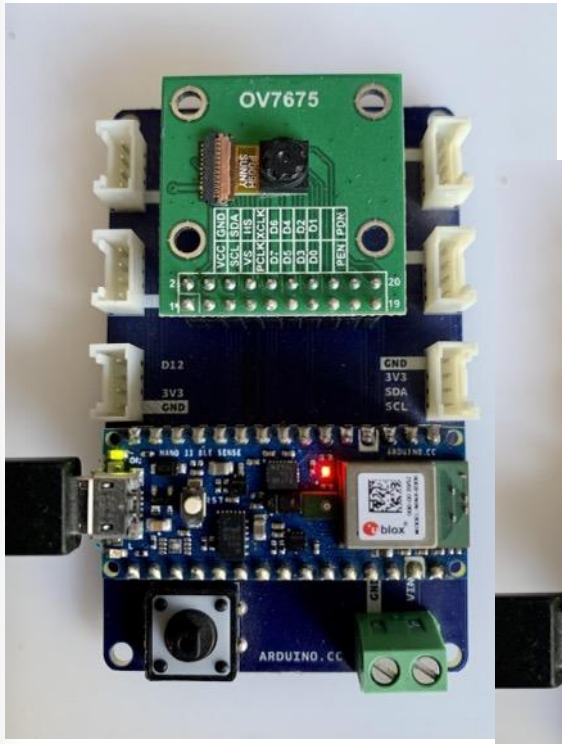
bilnk_RGB | Arduino IDE 2.0.0

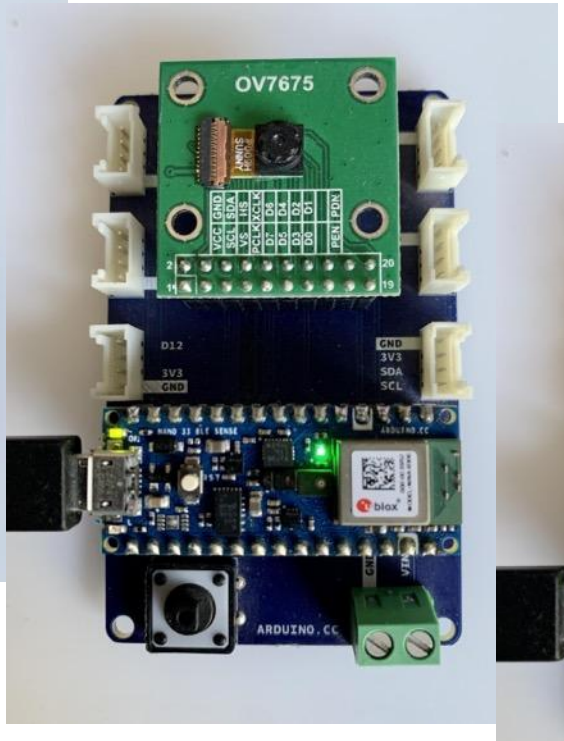
Arduino Nano 33 BLE

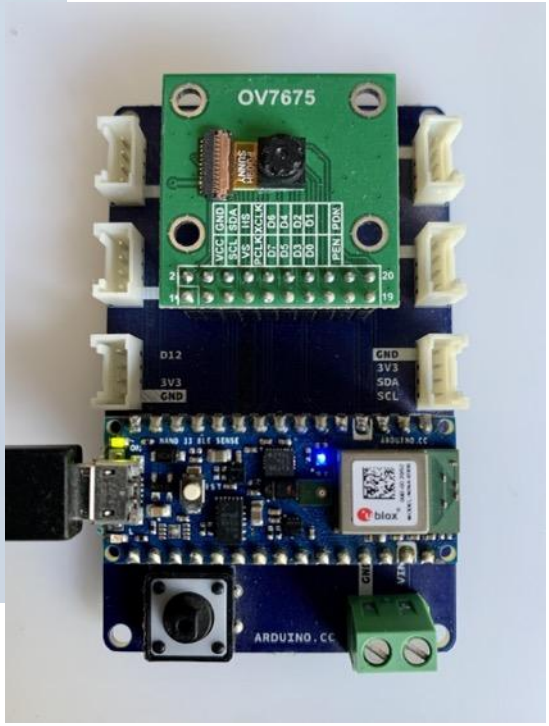
bilnk_RGB.ino

```ino
void setup() {

  // initialize serial.
  Serial.begin(115200);
  while (!Serial);
  Serial.println("Serial Started");

  // initialize digital pin LED_BUILTIN (13) as an output.
  pinMode(LED_BUILTIN, OUTPUT);

  // Pins for the built-in RGB LEDs on the Arduino Nano 33 BLE Sense
  pinMode(LEDR, OUTPUT);
  pinMode(LEDG, OUTPUT);
  pinMode(LEDB, OUTPUT);

  // Note: The RGB LEDs are ON when the pin is LOW and off when HIGH.
  digitalWrite(LEDR, HIGH);
  digitalWrite(LEDG, HIGH);
  digitalWrite(LEDB, HIGH);

  // turn the LED off by making the voltage LOW
  digitalWrite(LED_BUILTIN, LOW);

}

void loop() {
  digitalWrite(LEDR, LOW);
  Serial.println("LED RED ON");
  delay(1000);
  digitalWrite(LEDR, HIGH);
  Serial.println("LED RED OFF");
  delay(1000);

  digitalWrite(LEDG, LOW);
  Serial.println("LED GREEN ON");
  delay(1000);
  digitalWrite(LEDG, HIGH);
  Serial.println("LED GREEN OFF");
  delay(1000);

  digitalWrite(LEDB, LOW);
  Serial.println("LED GREEN ON");
  delay(1000);
  digitalWrite(LEDB, HIGH);
  Serial.println("LED GREEN OFF");
  delay(1000);

  digitalWrite(LED_BUILTIN, HIGH);
  Serial.println("LED ON");
  delay(1000);
  digitalWrite(LED_BUILTIN, LOW);
  Serial.println("LED OFF");
  delay(1000);
}
```

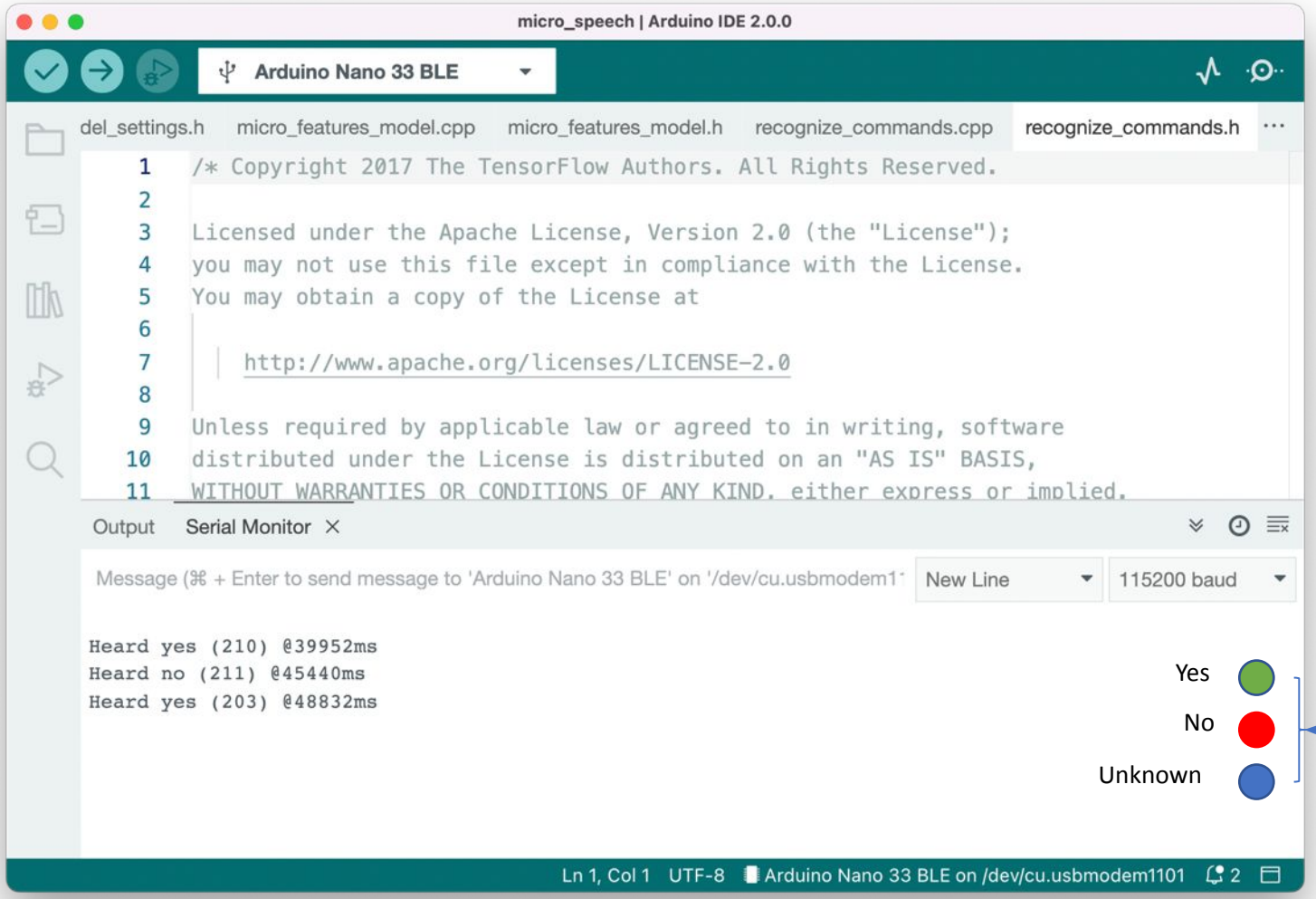
Ln 1, Col 1 UTF-8 Arduino Nano 33 BLE on /dev/cu.usbmodem1101





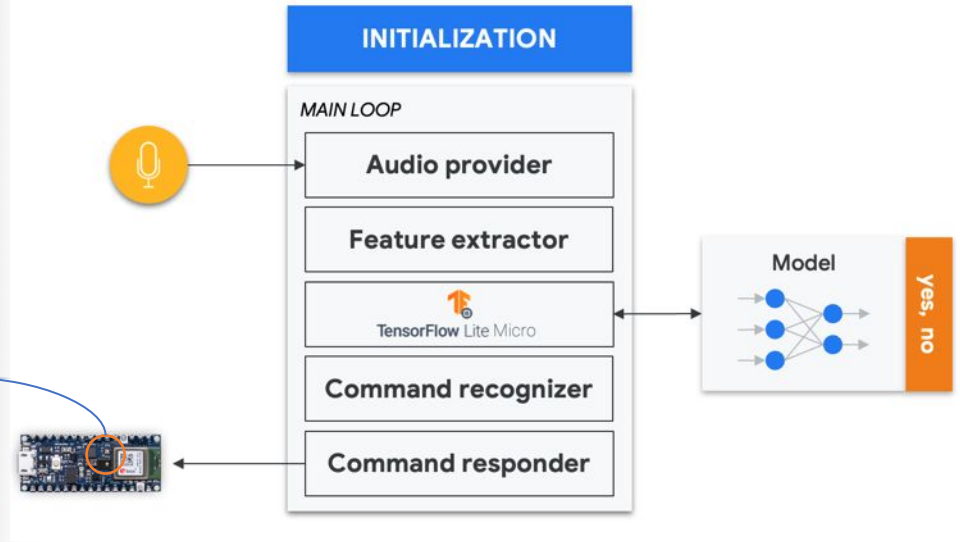


KeyWord Spotting (Optional)



You will find the code under:

File > Examples > Harvard_TinyMLx > micro_speech



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