

SciTinyML

Scientific Use of Machine Learning on Low Power Devices

Regional Workshops

TinyML Kit Overview - HW and SW Installation & Test



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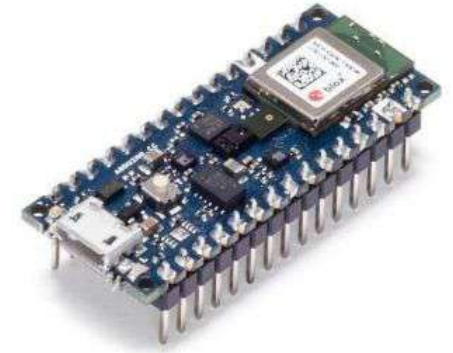
UNIFEI - Federal University of Itajubá, Brazil



TinyML Kit Overview



Nano 33 BLE Sense (+ USB cable)



Purpose

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

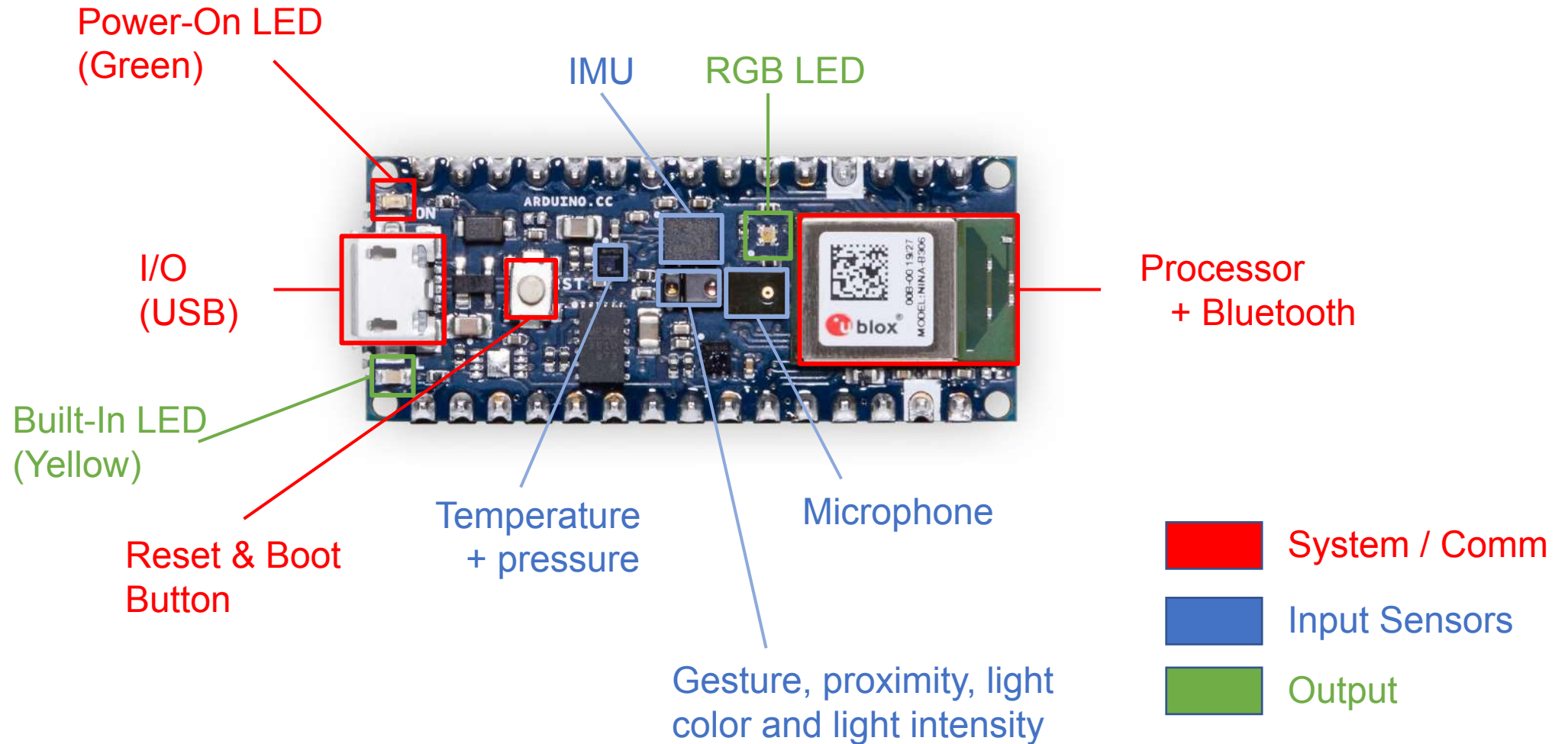
Specifications

- **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 the package.** For projects we will use the external Grove - Temp&Humi&Barometer Sensor (BME280)

Nano 33 BLE Sense (Development board)



OV 7675 Camera Module



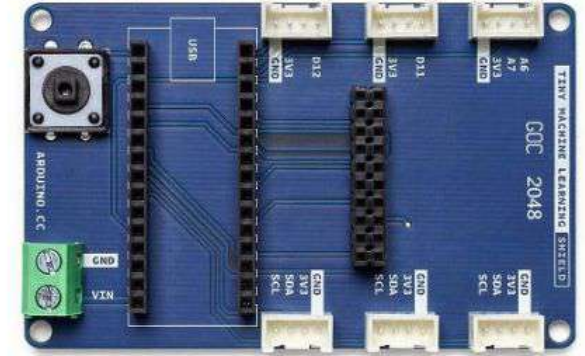
Purpose

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

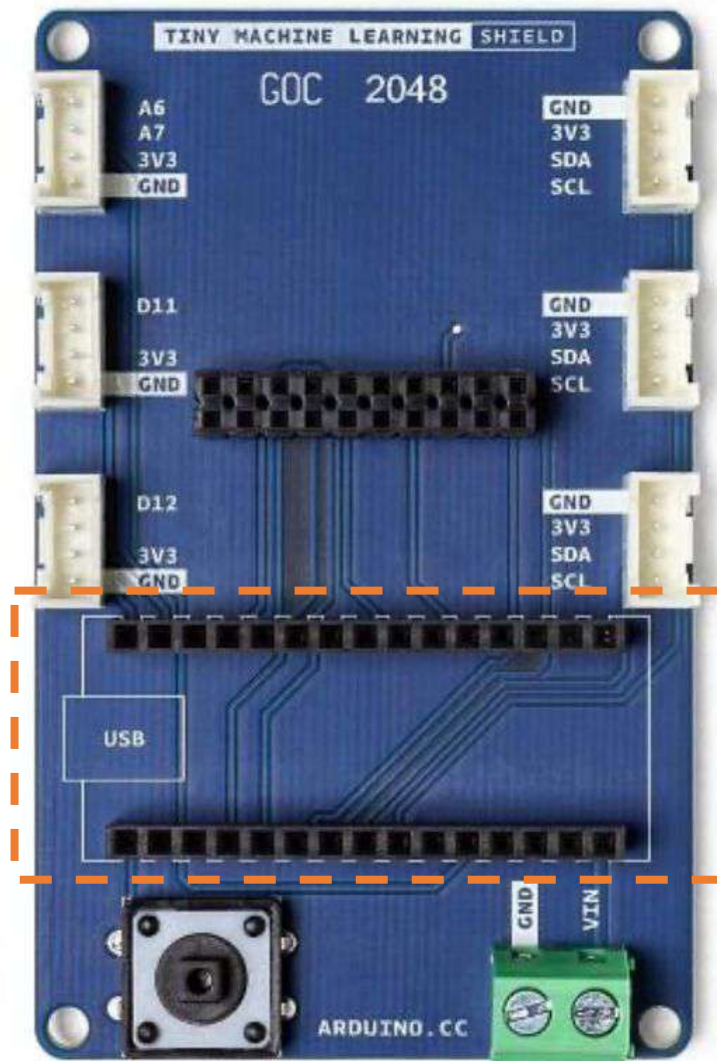


Purpose

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**

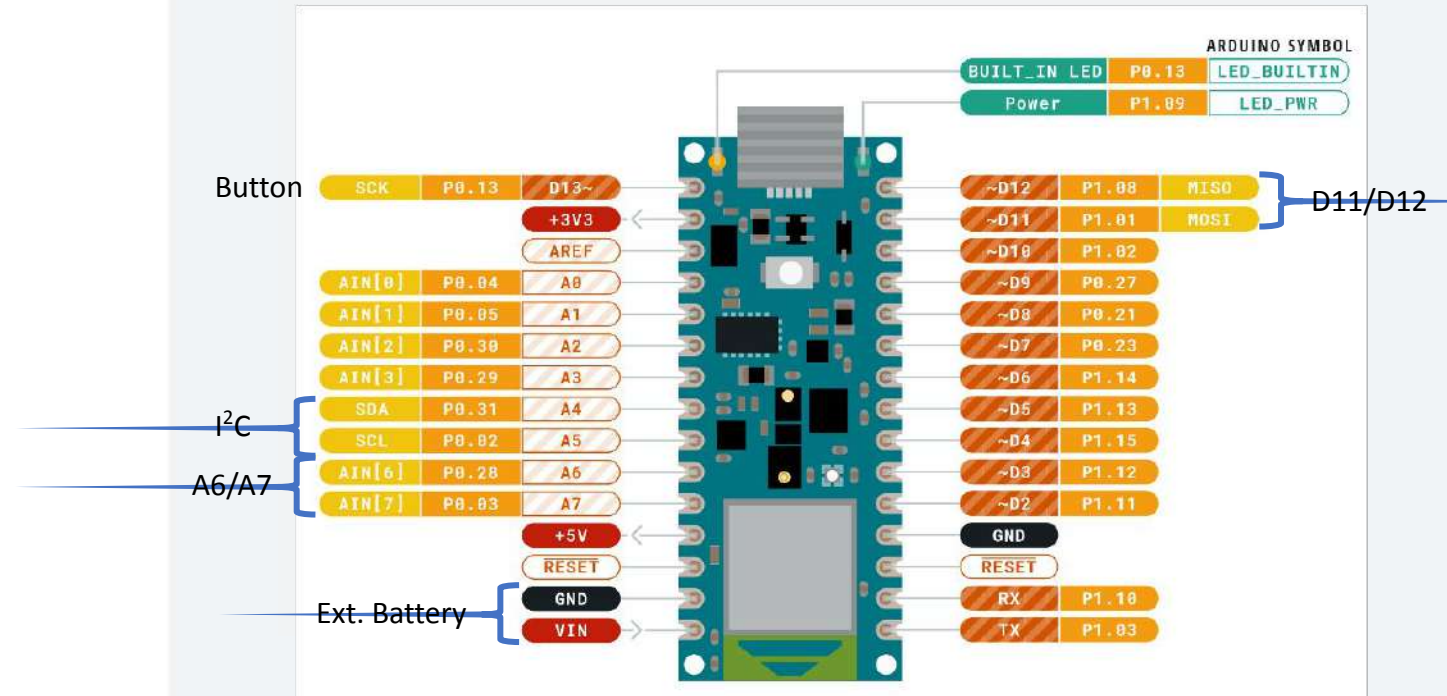
Specifications

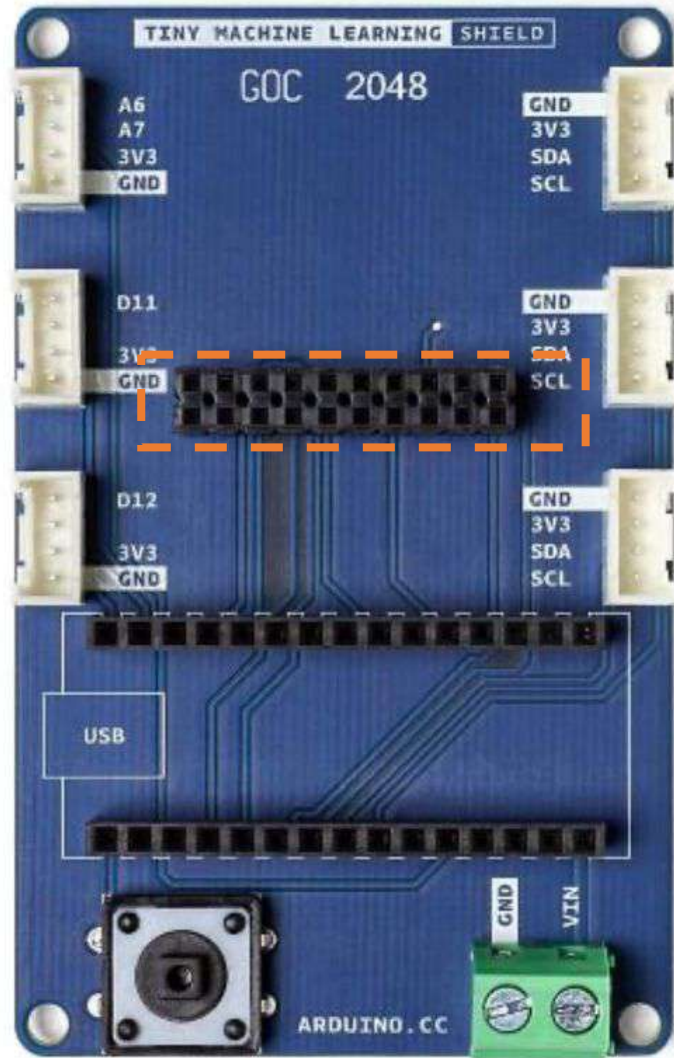
- Grove connectors (3.3V I2C and simple digital / analog - see pinouts)
- 2x10 pin array for OV7675 camera module
- Voltage input terminal block, accepts 4.5 to 21V (down regulated to 3.3V on Nano 33)



TinyML Shield

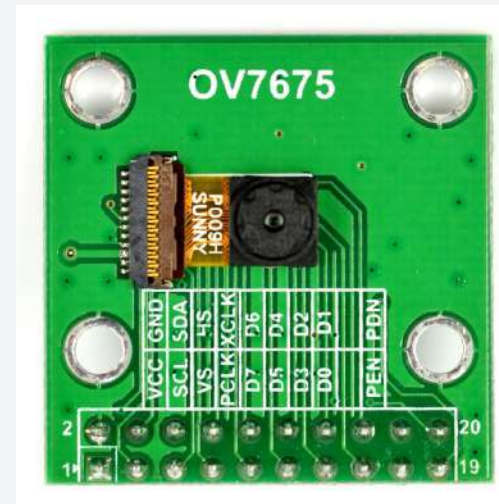
Two rows of 1x15 headers
that you can slot the Nano
33 BLE sense into



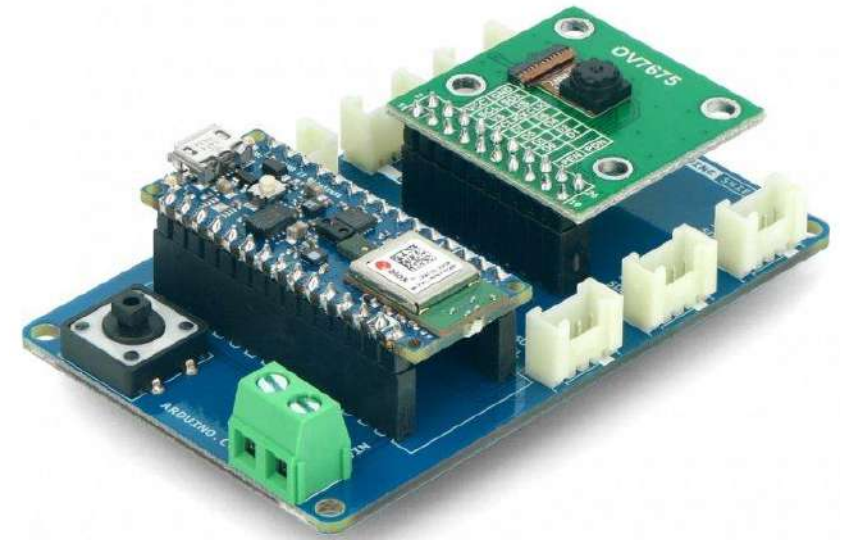
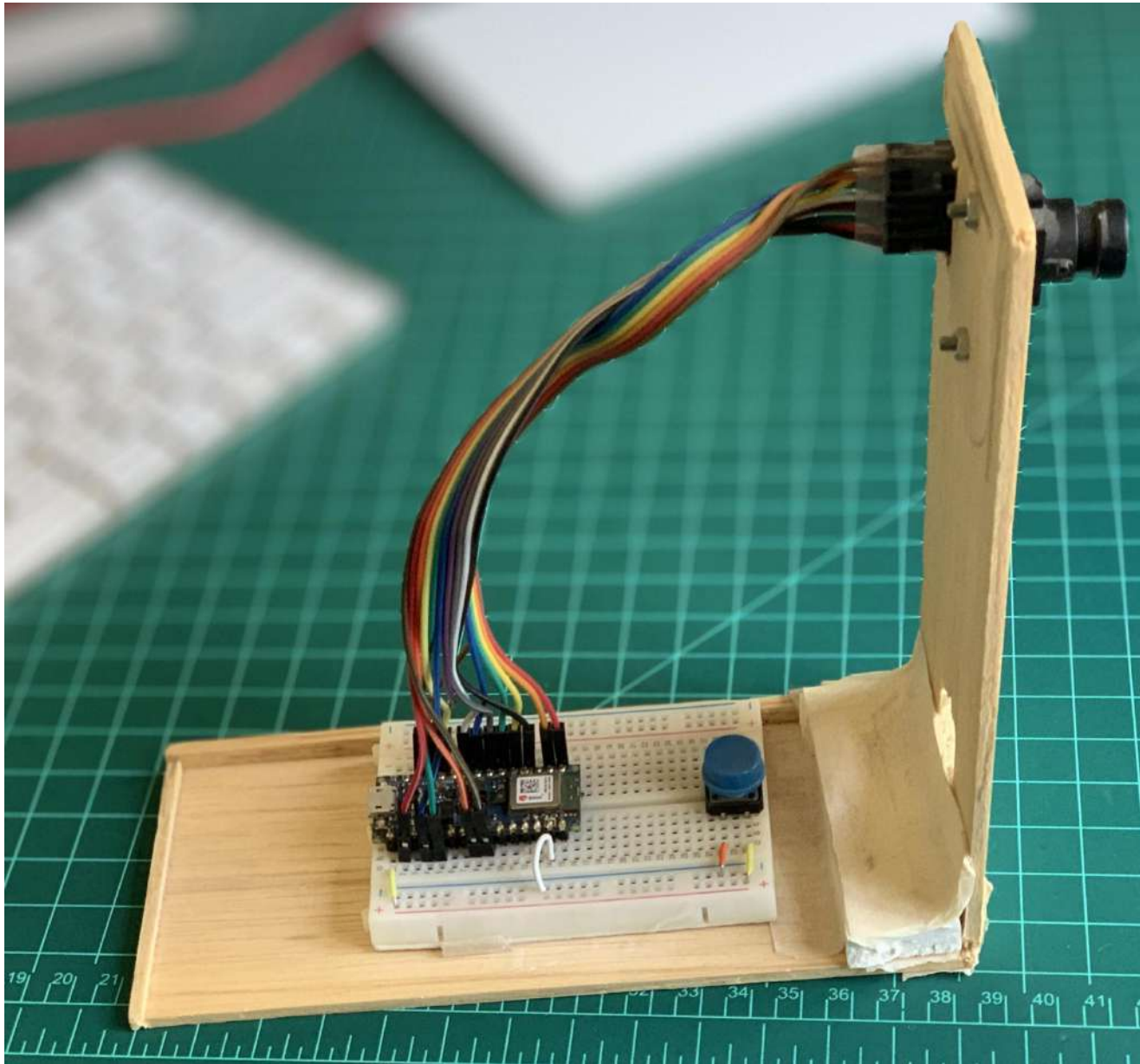


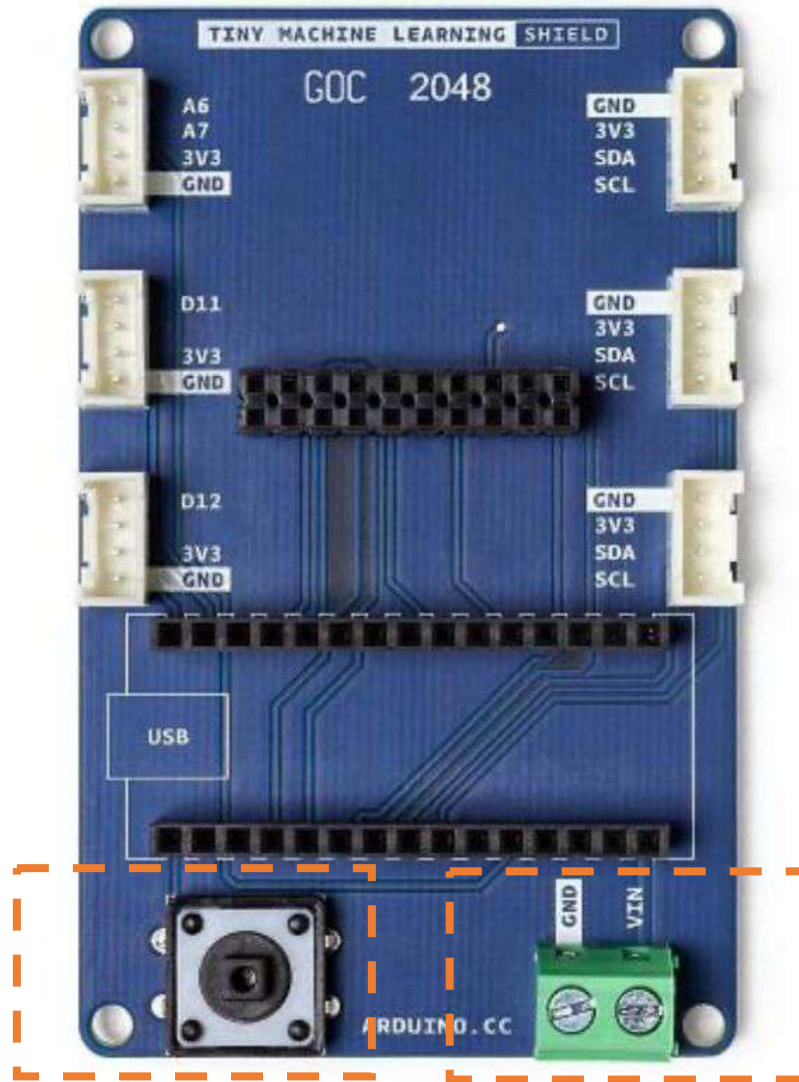
TinyML Shield

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



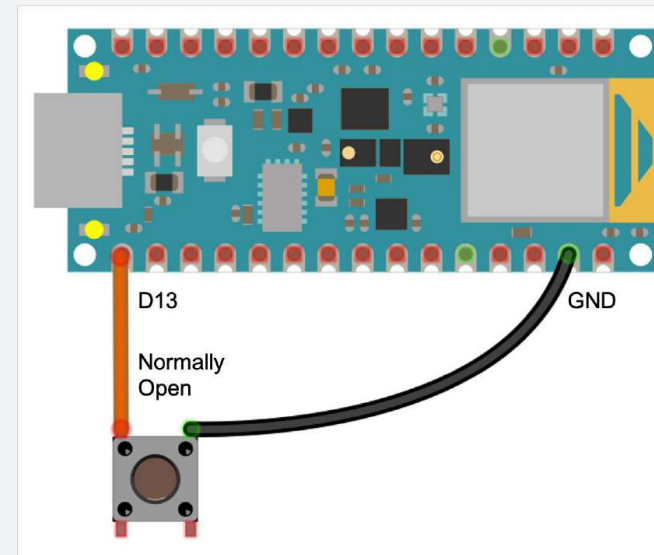
OV7670_VSYNC	8
OV7670_HREF	A1
OV7670_PLK	A0
OV7670_XCLK	9
OV7670_D0	10
OV7670_D1	1
OV7670_D2	0
OV7670_D3	2
OV7670_D4	3
OV7670_D5	5
OV7670_D6	6
OV7670_D7	4



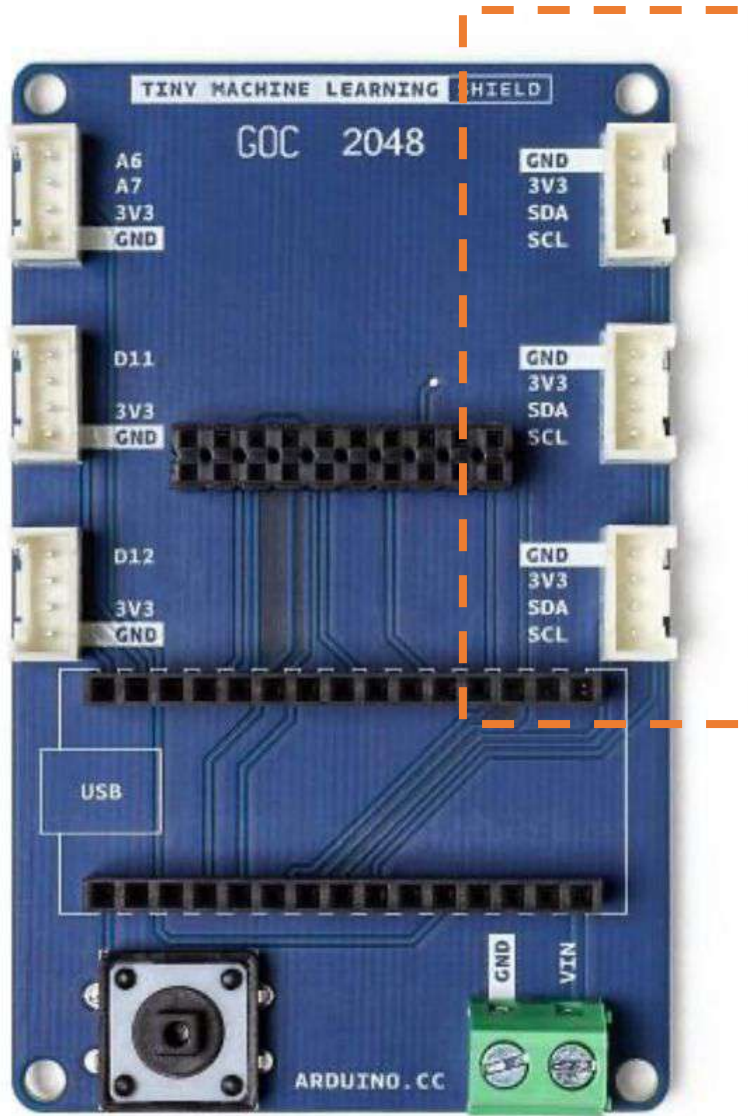


TinyML Shield

A easily programmable
button on the left

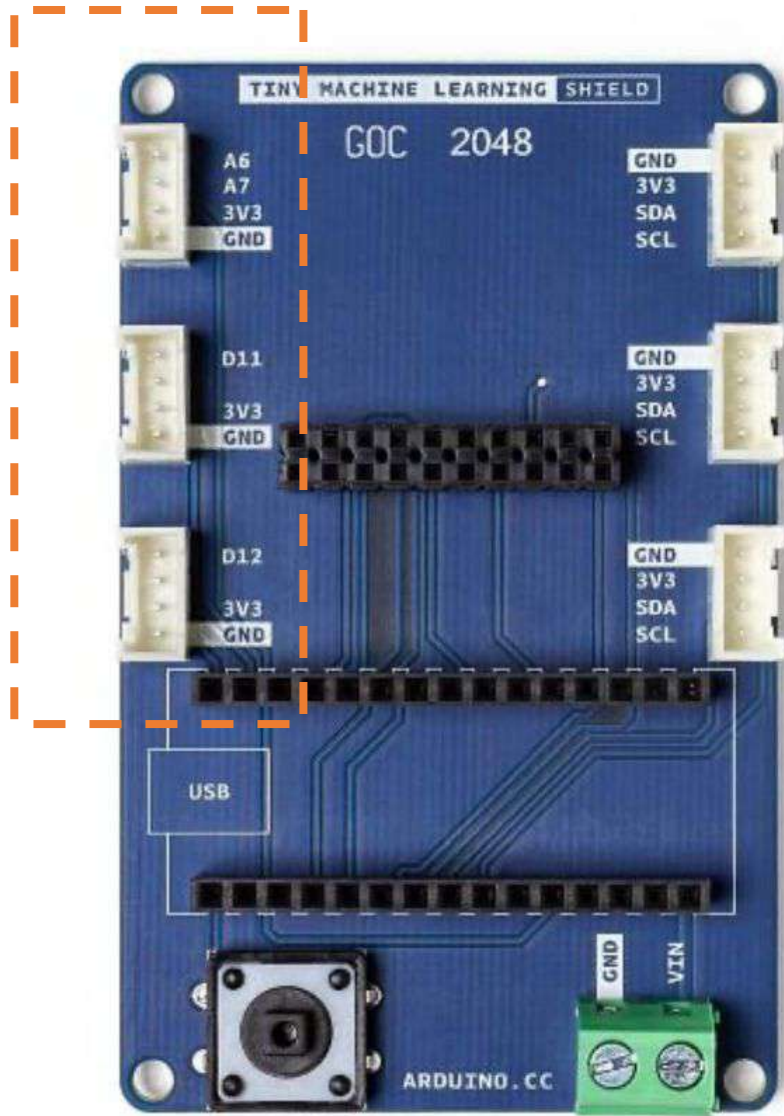


Screw-in terminal block for
external (battery) power (4.5V to 21V)



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

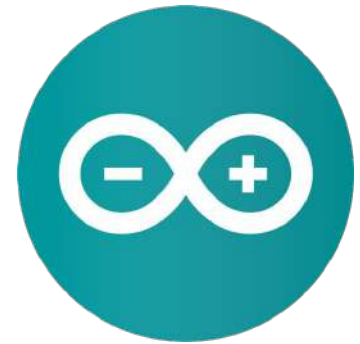
Facilitate **plug-and-play connections** to off-board modules to extend the possible scope of functionality to new **TinyML** applications

Specifications

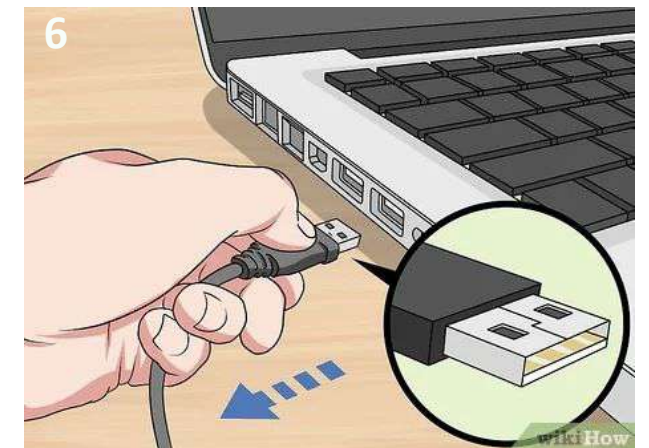
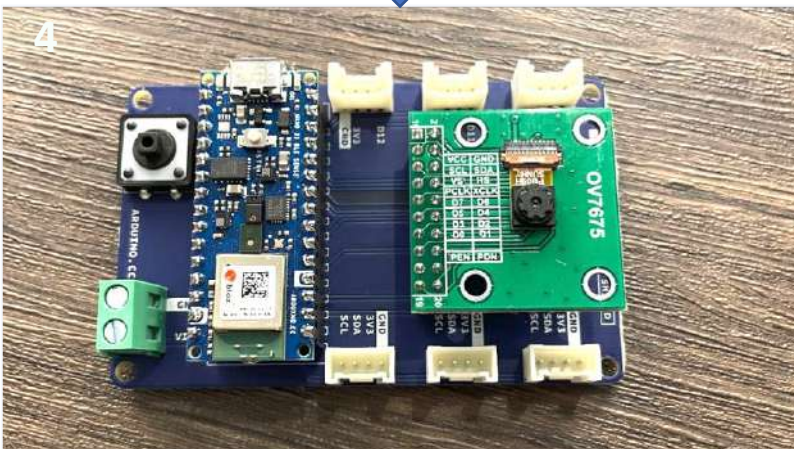
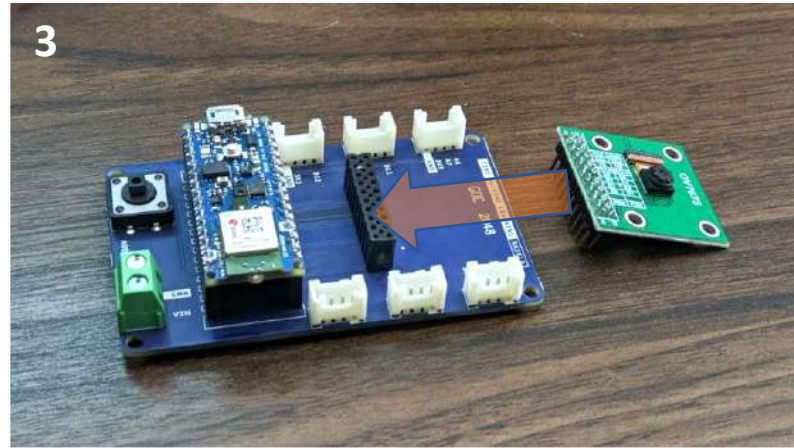
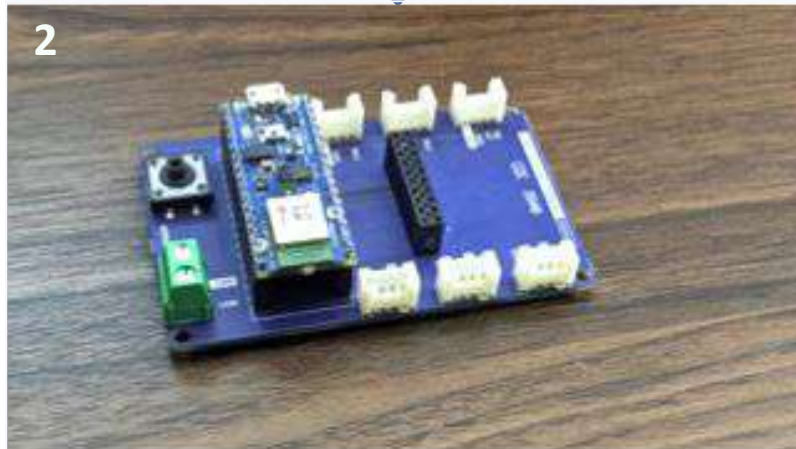
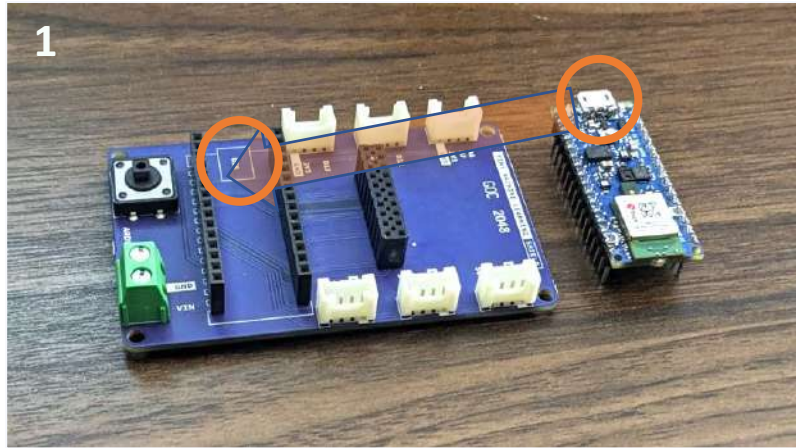
- Proprietary connection system from SeeedStudio, similar to JST PH-type connectors
- Large catalog of sensors, actuators available at [seeedstudio.com](https://www.seeedstudio.com)
- Be sure to check the voltage requirements and pinout of any new Grove module for compatibility with this shield before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

TinyML Kit Installation

- Hardware Set-up
- Software Set-up



Installing the Hardware



Installing the Arduino IDE

The screenshot shows the Arduino Software website. The top navigation bar includes links for PROFESSIONAL, EDUCATION, STORE, and a search bar. Below the navigation bar, there's a language switcher set to English. The main content area features a section for the Arduino Web Editor with a 'CODE ONLINE' button. Below this, the 'Downloads' section is highlighted, showing the Arduino IDE 1.8.19 download options. The download options are listed in a teal box with a white border, which is highlighted by an orange rounded rectangle. The options include Windows (Win 7 and newer), Windows app (Win 8.1 or 10), Linux (32 bits, 64 bits, ARM 32 bits, ARM 64 bits), and Mac OS X (10.10 or newer). A 'Get' button is visible next to the Windows app option. Below the download options, there are links for 'Release notes' and 'Checksums (sha512)'. A 'Help' button is located at the bottom right of the download options box.

Software | Arduino

arduino.cc/en/software

PROFESSIONAL EDUCATION STORE

SEARCH on Arduino.cc

SIGN IN

HARDWARE SOFTWARE CLOUD DOCUMENTATION COMMUNITY BLOG ABOUT

This page is available in another language. Switch to: English

Arduino Web Editor

Start coding online and save your sketches in the cloud. The most up-to-date version of the IDE includes all libraries and also supports new Arduino boards.

CODE ONLINE GETTING STARTED

Downloads

Arduino IDE 1.8.19

The open-source Arduino Software (IDE) makes it easy to write code and upload it to the board. This software can be used with any Arduino board.

Refer to the [Getting Started](#) page for installation instructions.

SOURCE CODE

Active development of the Arduino software is [hosted by GitHub](#). See the instructions for [building the code](#). Latest release source code archives are available [here](#). The archives are PGP-signed so they can be verified using [this](#) gpg key.

DOWNLOAD OPTIONS

Windows Win 7 and newer
Windows ZIP file

Windows app Win 8.1 or 10 [Get](#)

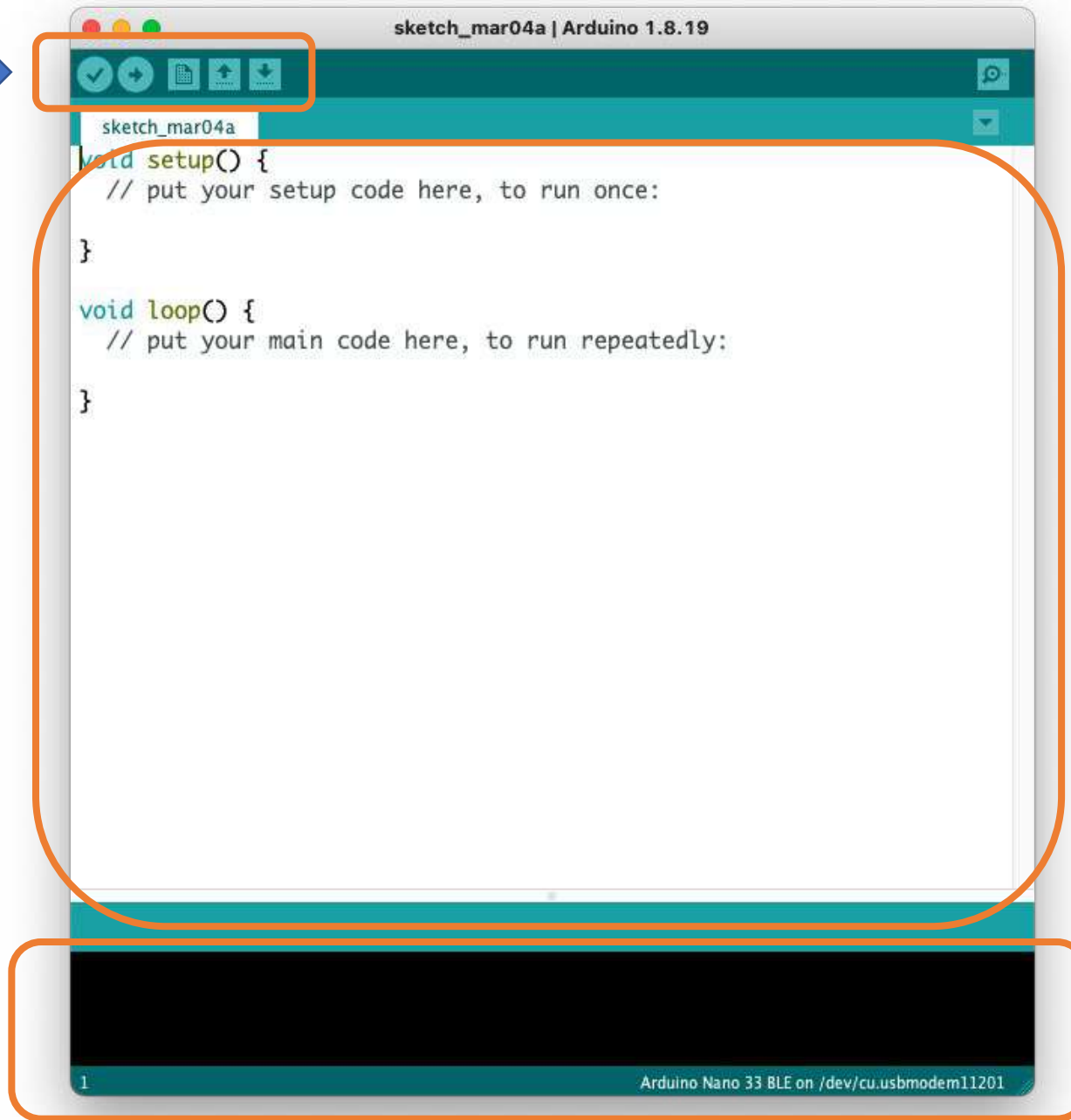
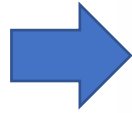
Linux 32 bits
Linux 64 bits
Linux ARM 32 bits
Linux ARM 64 bits

Mac OS X 10.10 or newer

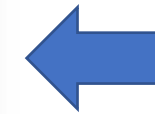
[Release notes](#)
[Checksums \(sha512\)](#)

[Help](#)

Menus
and
ToolBar



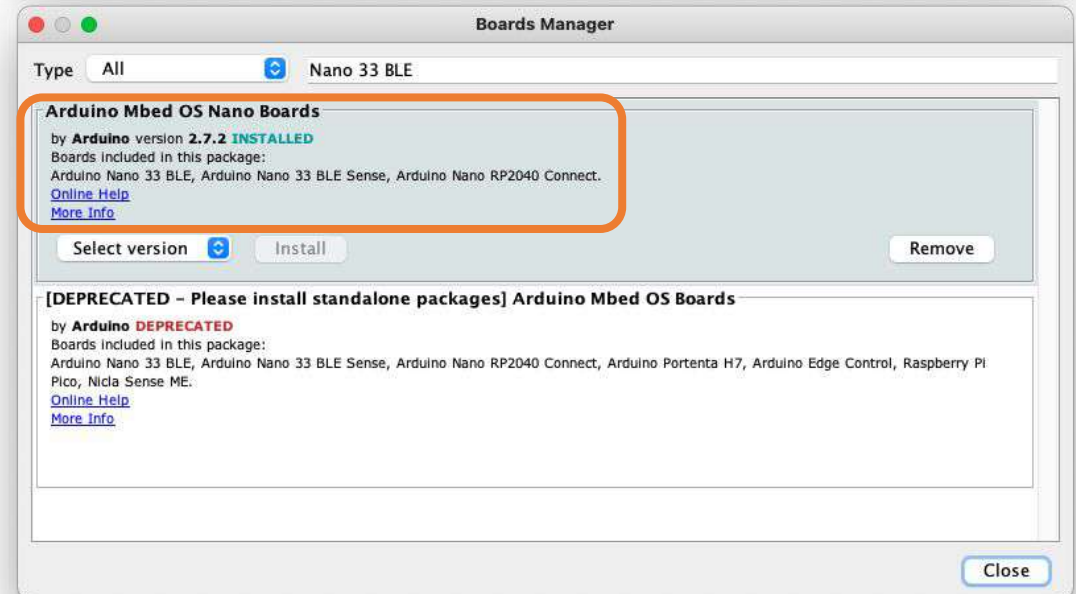
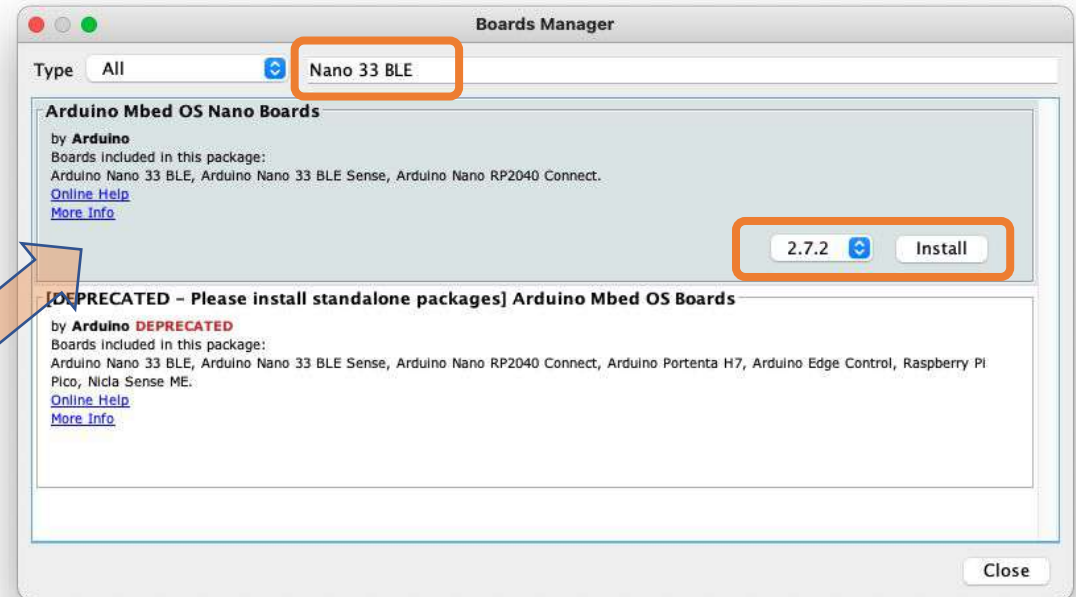
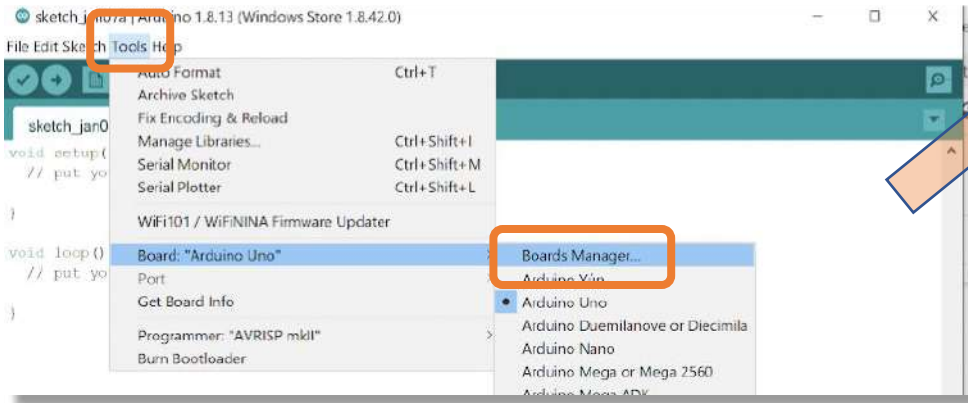
Code Area



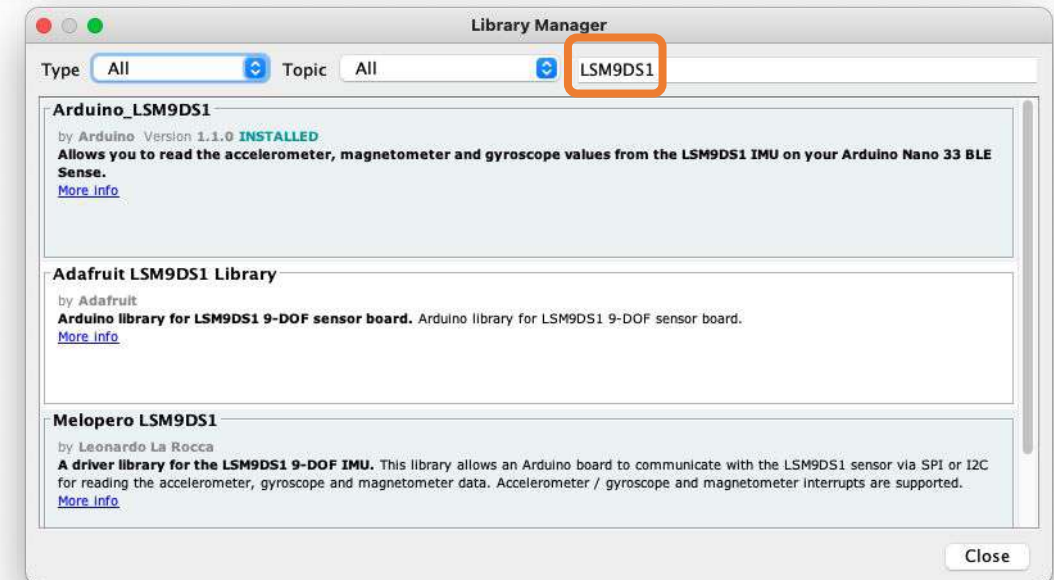
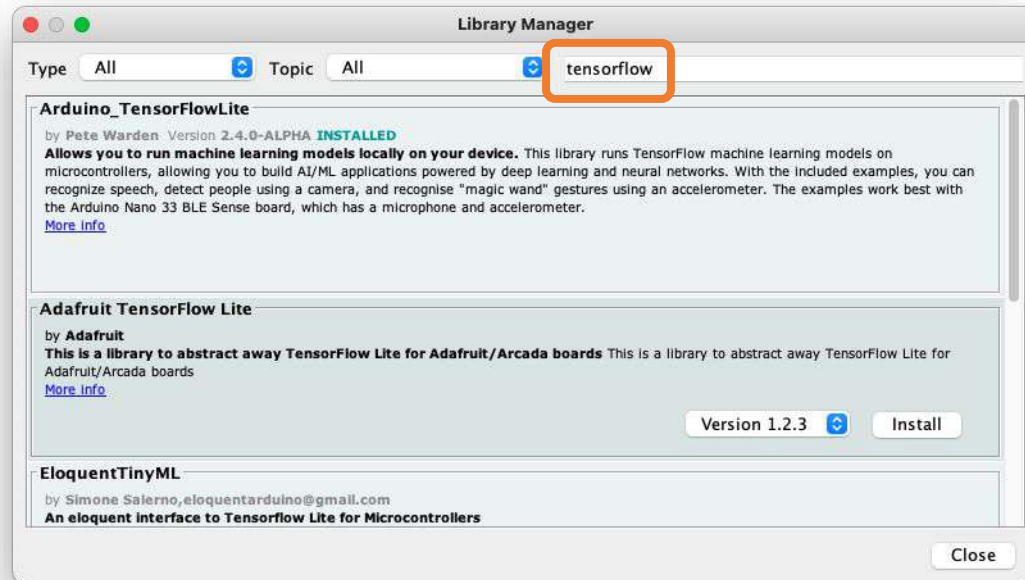
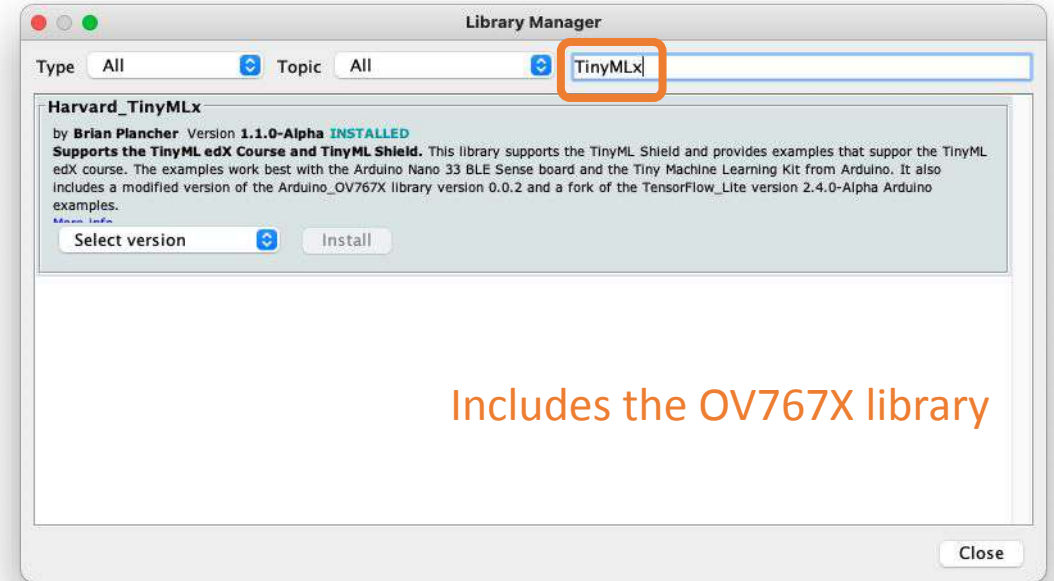
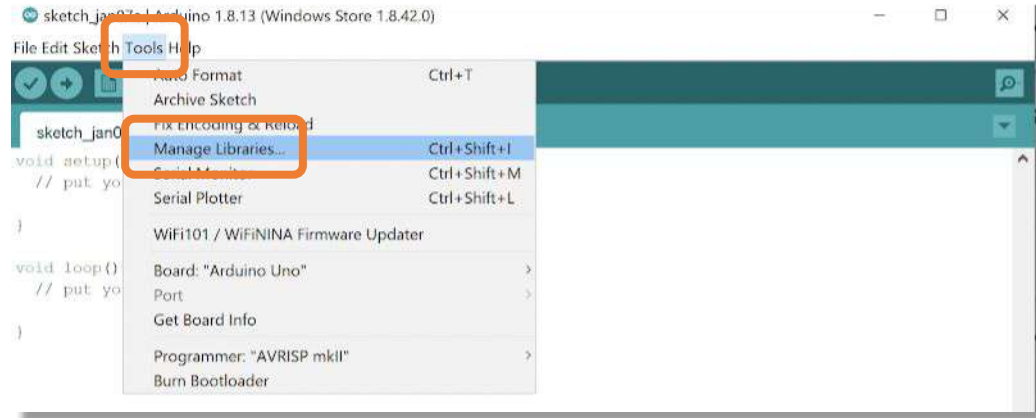
Console



Installing the Board Files

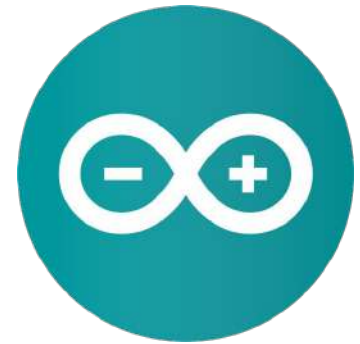


Installing the Main Libraries

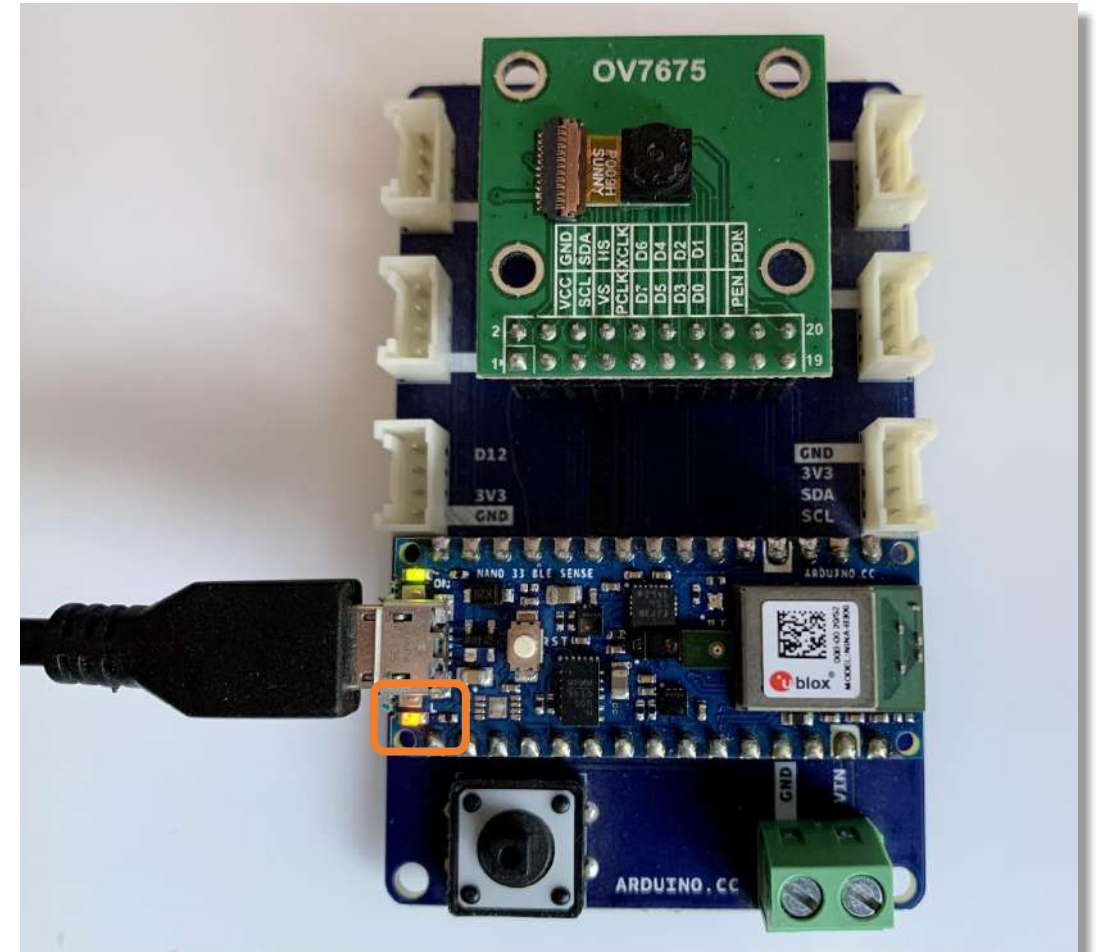
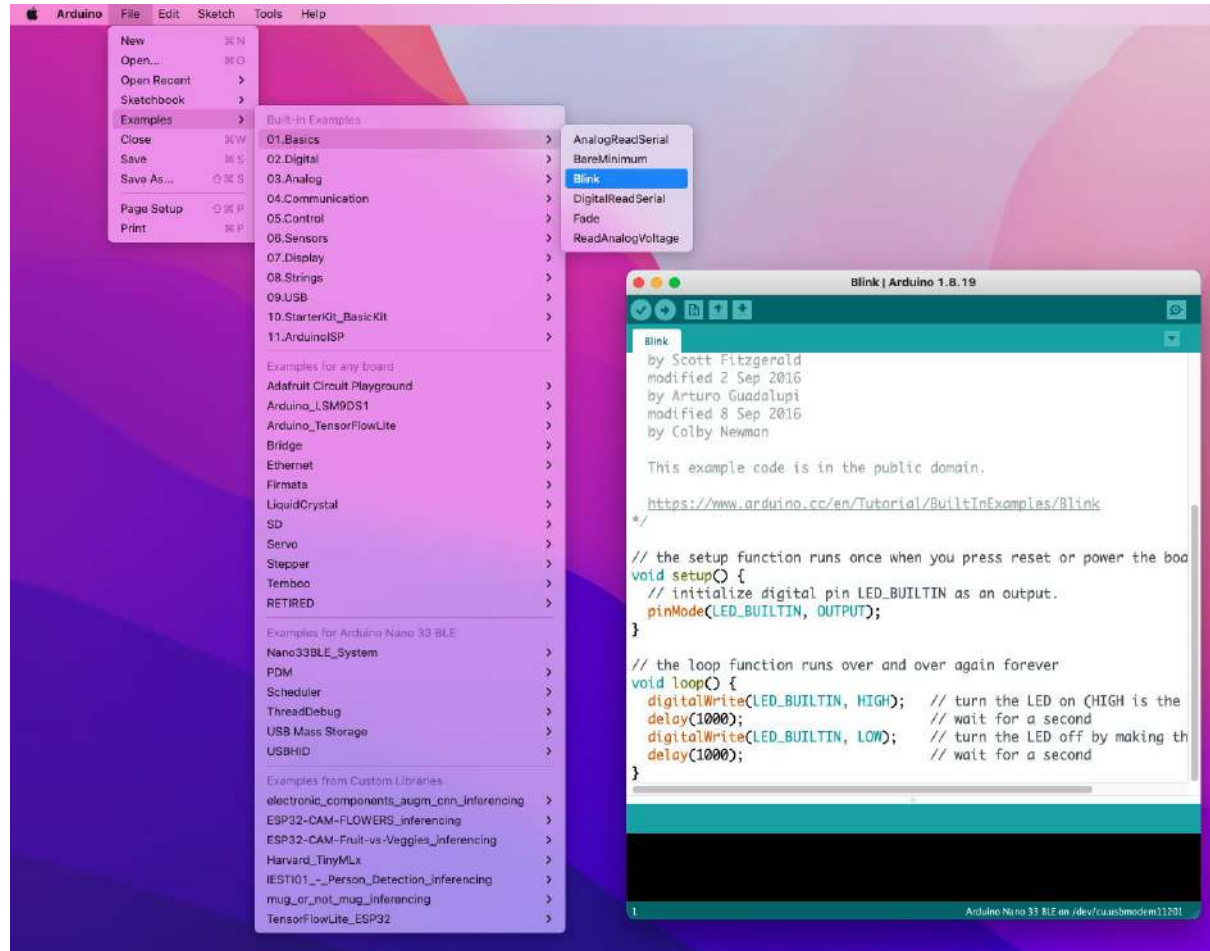


TinyML Kit Test

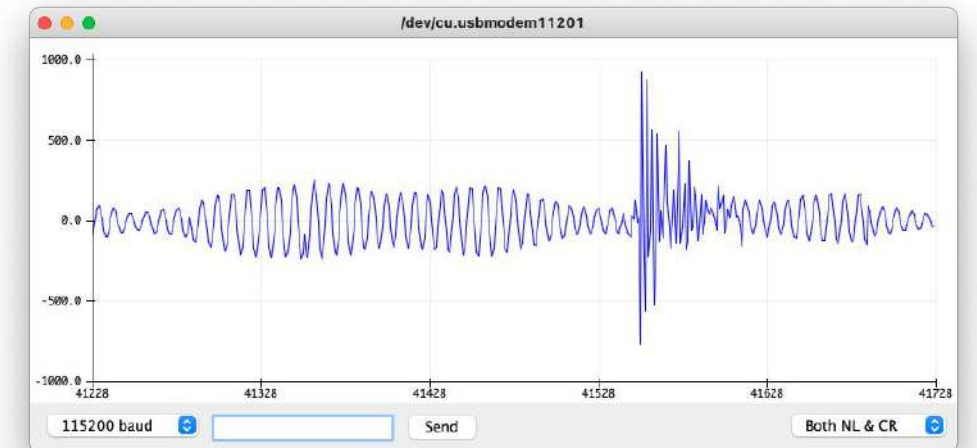
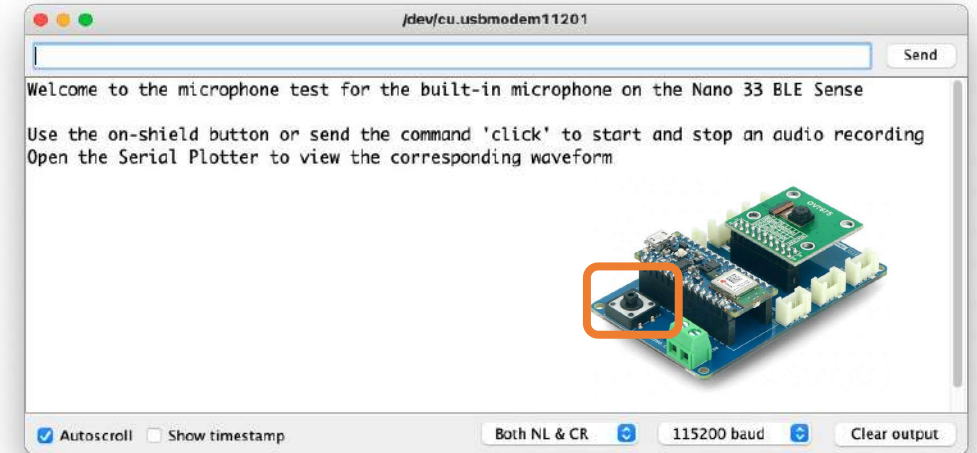
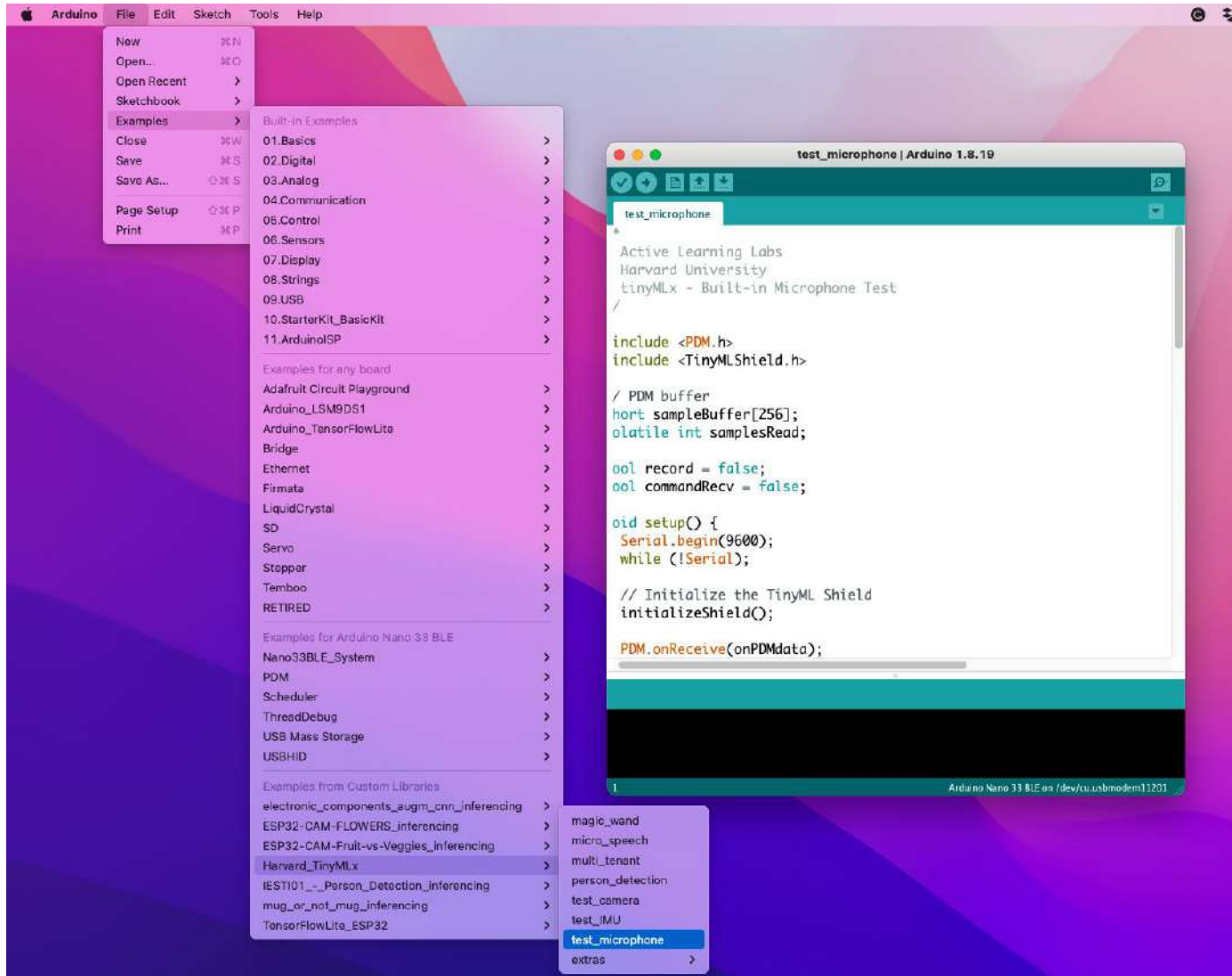
- MCU test (Blink)
- Sensors Test (IMU, MIC, CAMERA)



MCU installation test (Blink)

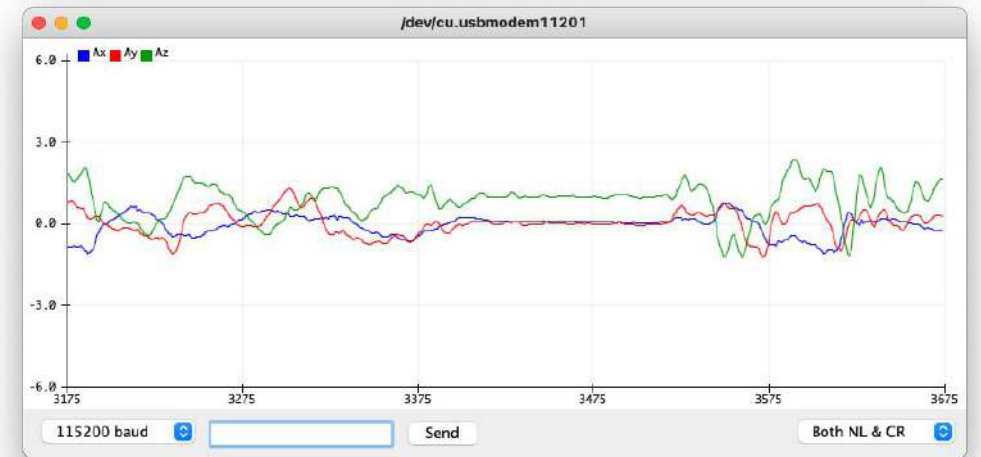
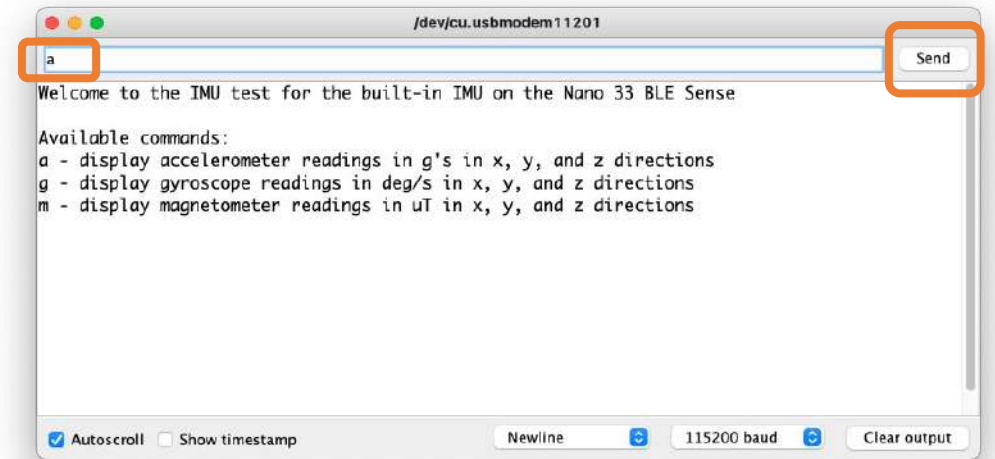
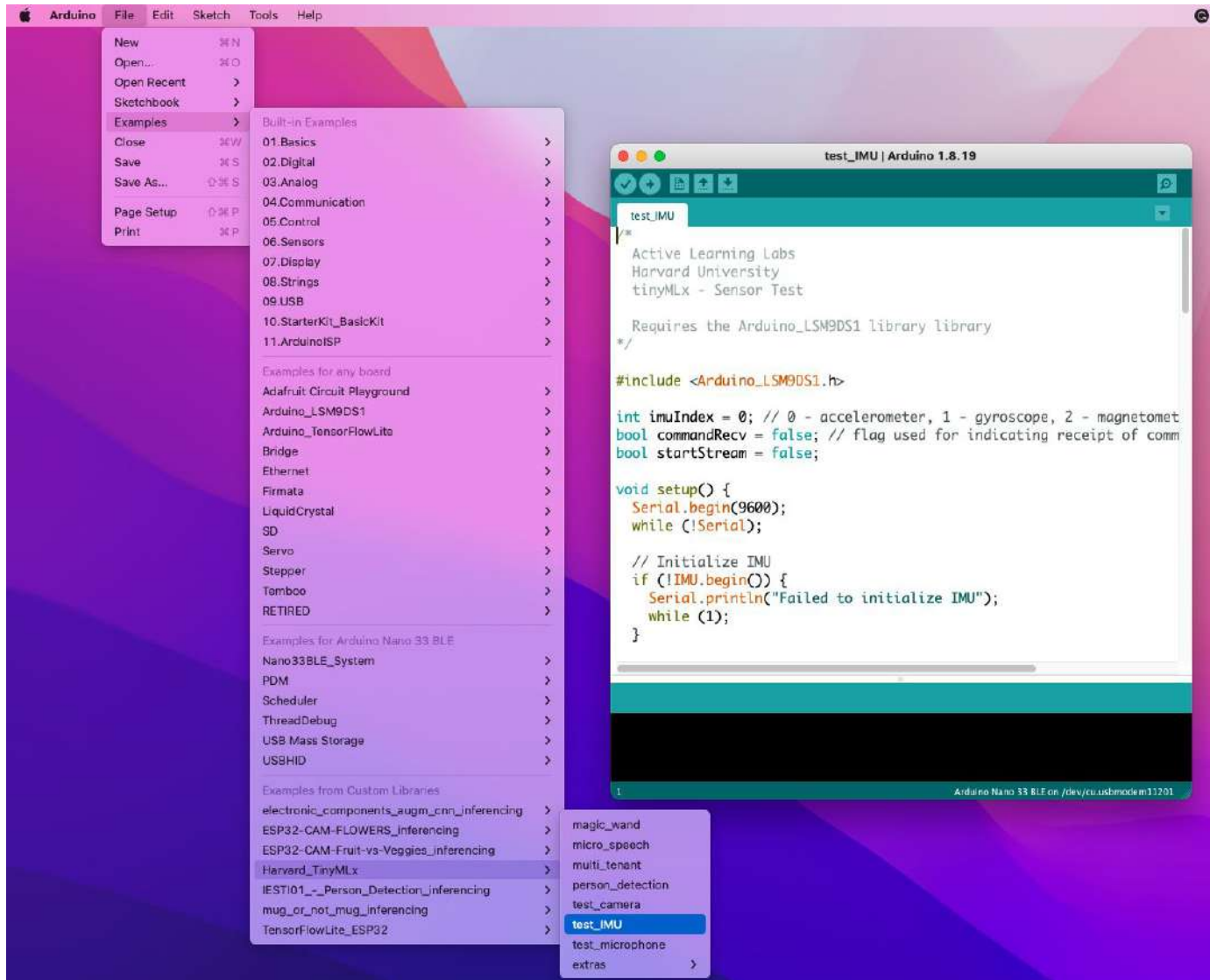


Testing Microphone



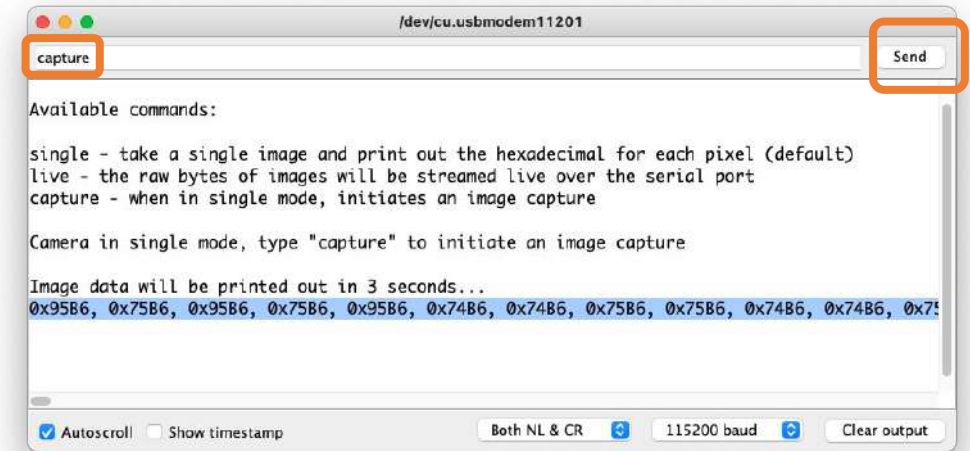
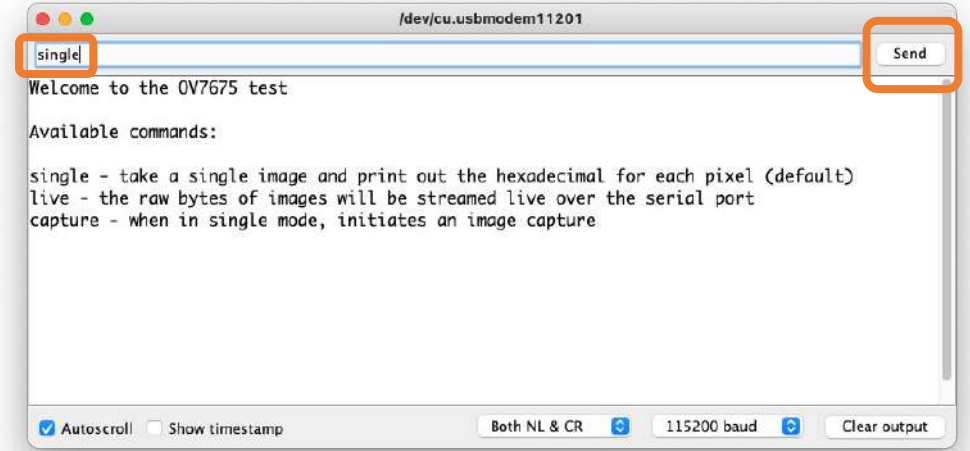
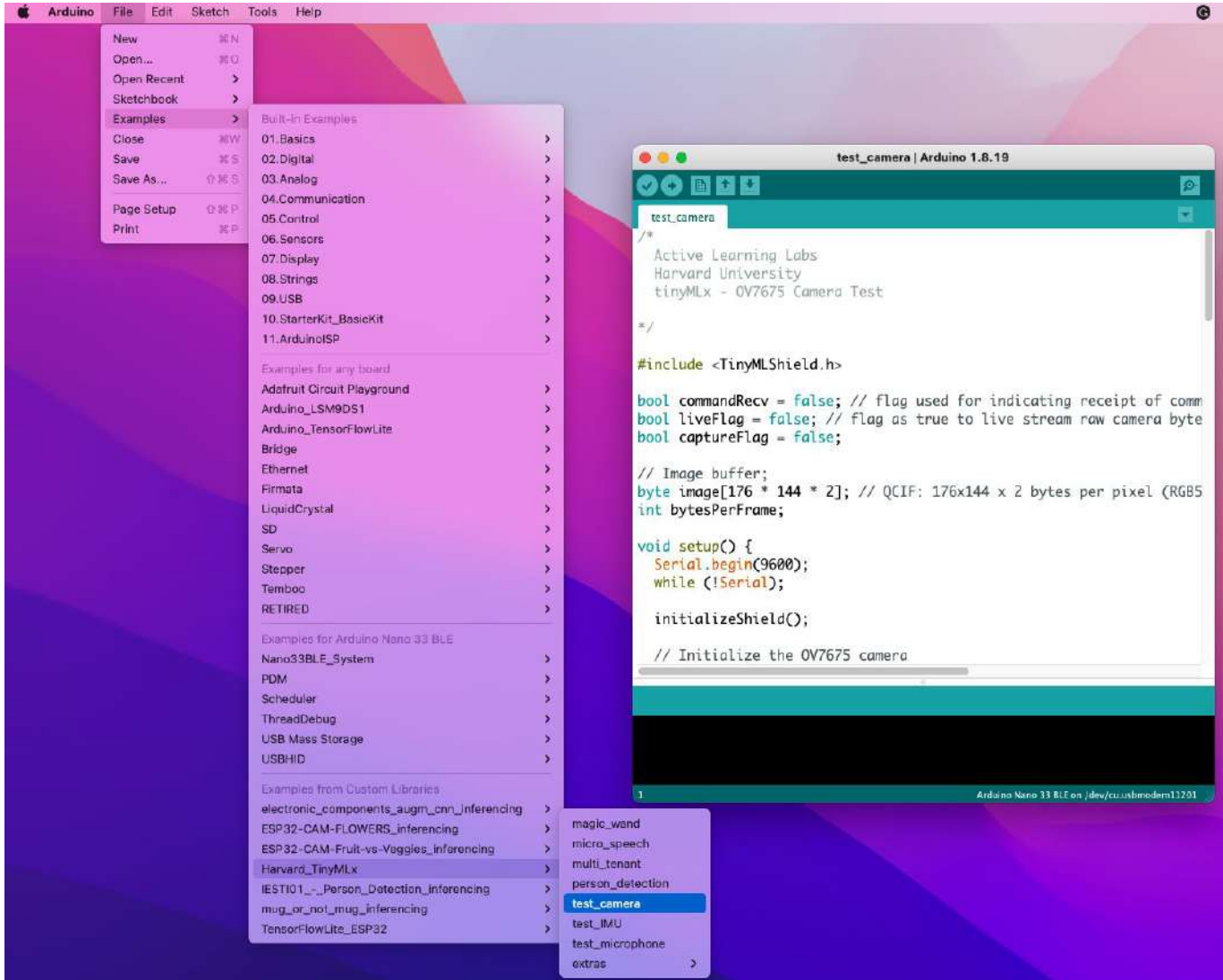
Note: Close the Serial Monitor before open the Plotter

Testing IMU



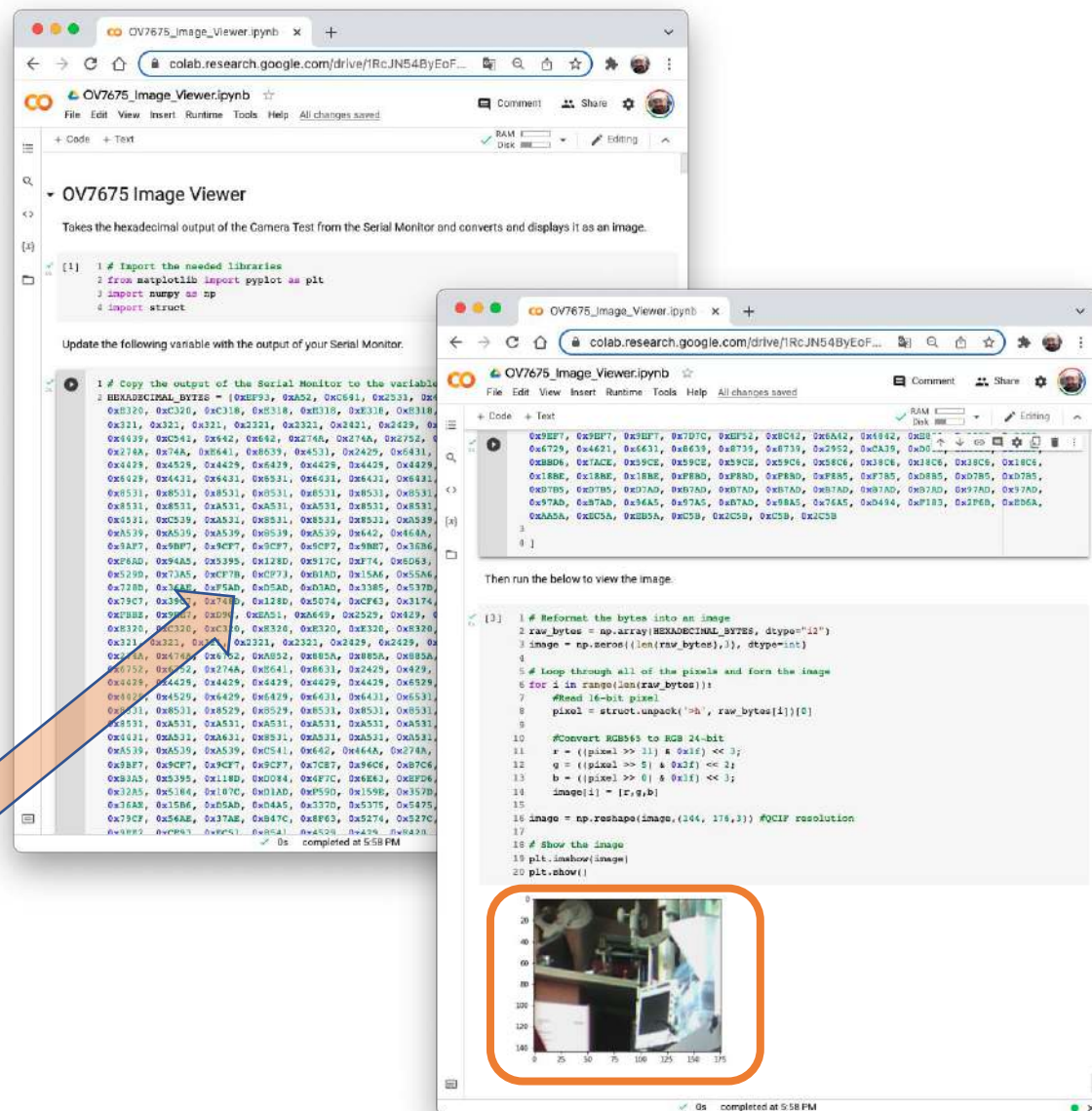
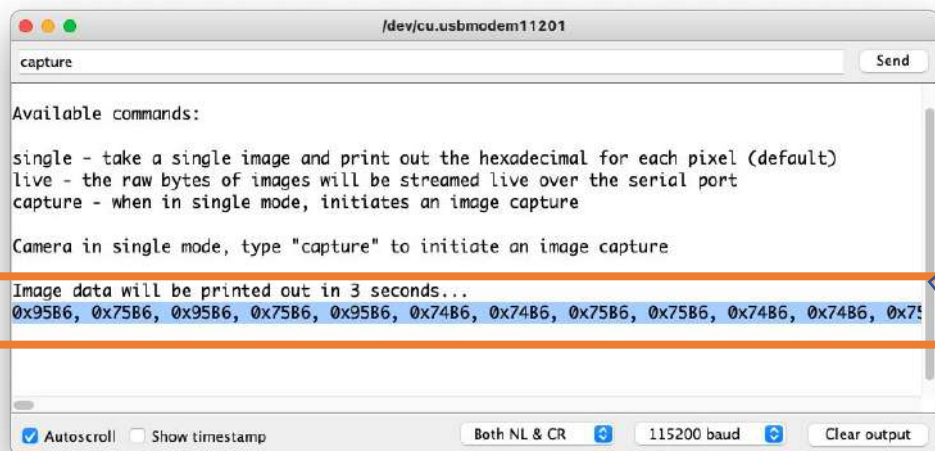
Notes: Close the Serial Monitor before open the Plotter
Repeat test for 'g' and 'm'

Testing Camera



Note: You can Press Button insteady send 'capture'

Testing Camera



Optional Tests (RGB LEDs)

```
blink_RGB | Arduino 1.8.19

blink_RGB

void setup() {

  // Pins for the built-in RGB LEDs on the Arduino Nano 33 BLE Sense
  pinMode(LED_R, OUTPUT);
  pinMode(LED_G, OUTPUT);
  pinMode(LED_B, OUTPUT);

  // Note: The RGB LEDs are ON when the pin is LOW and off when HIGH.
  digitalWrite(LED_R, HIGH);
  digitalWrite(LED_G, HIGH);
  digitalWrite(LED_B, HIGH);
}

void loop() {
  digitalWrite(LED_R, LOW);
  delay(1000);
  digitalWrite(LED_R, HIGH);
  delay(1000);

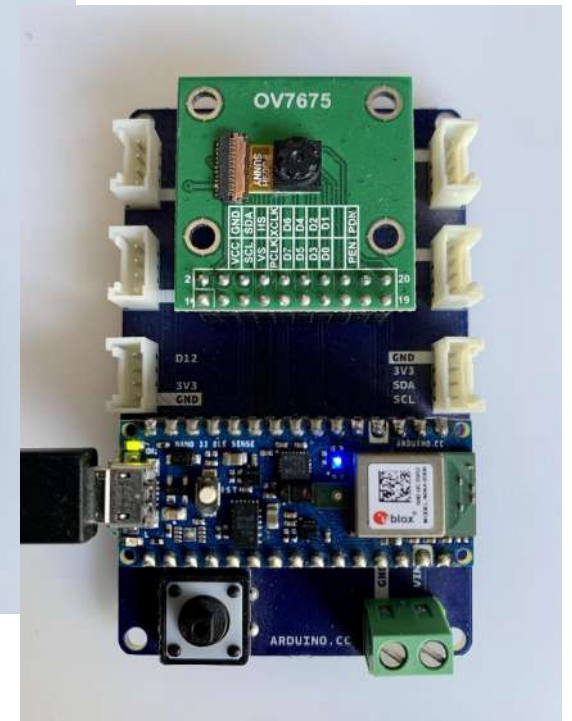
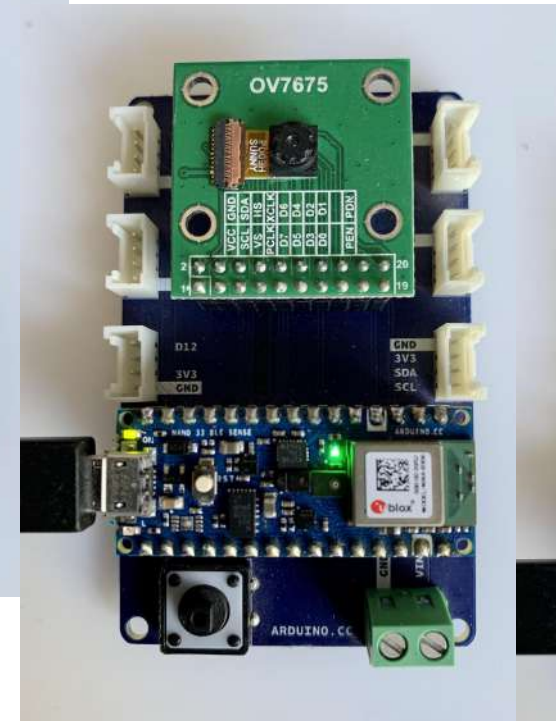
  digitalWrite(LED_G, LOW);
  delay(1000);
  digitalWrite(LED_G, HIGH);
  delay(1000);

  digitalWrite(LED_B, LOW);
  delay(1000);
  digitalWrite(LED_B, HIGH);
  delay(1000);
}

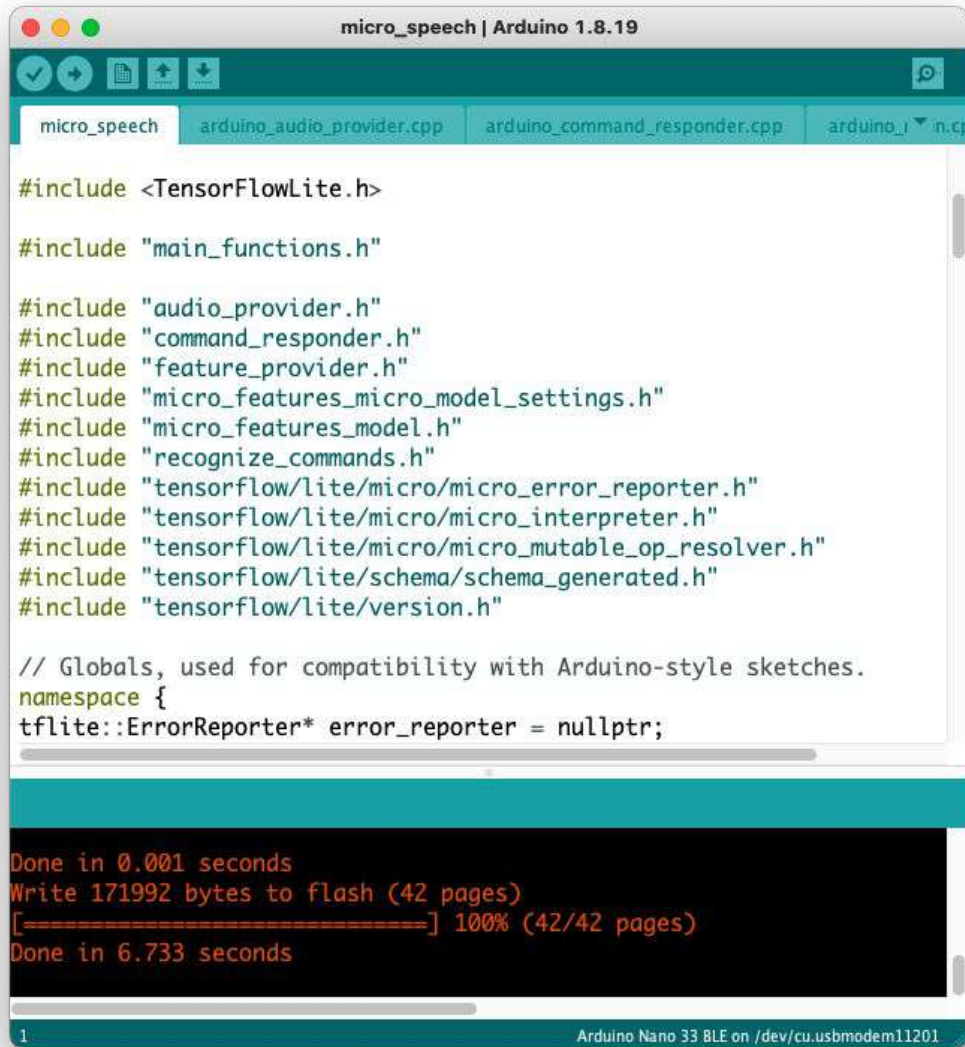
Done uploading.

Done in 0.001 seconds
Write 83944 bytes to flash (21 pages)
[=====] 100% (21/21 pages)
Done in 3.378 seconds

28 Arduino Nano 33 BLE on /dev/cu.usbmodem11201
```



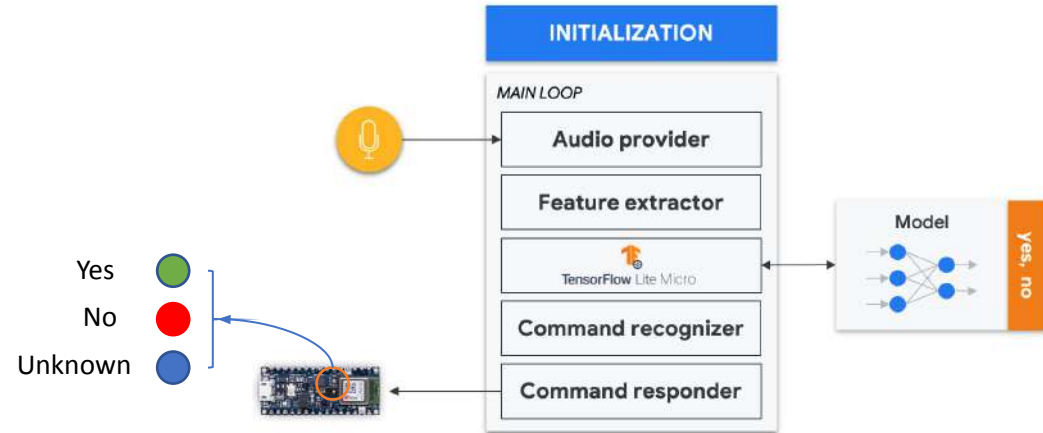
Optional Tests (KeyWord Spotting)



```
#include <TensorFlowLite.h>
#include "main_functions.h"
#include "audio_provider.h"
#include "command_responder.h"
#include "feature_provider.h"
#include "micro_features_micro_model_settings.h"
#include "micro_features_model.h"
#include "recognize_commands.h"
#include "tensorflow/lite/micro/micro_error_reporter.h"
#include "tensorflow/lite/micro/micro_interpreter.h"
#include "tensorflow/lite/micro/micro_mutable_op_resolver.h"
#include "tensorflow/lite/schema/schema_generated.h"
#include "tensorflow/lite/version.h"

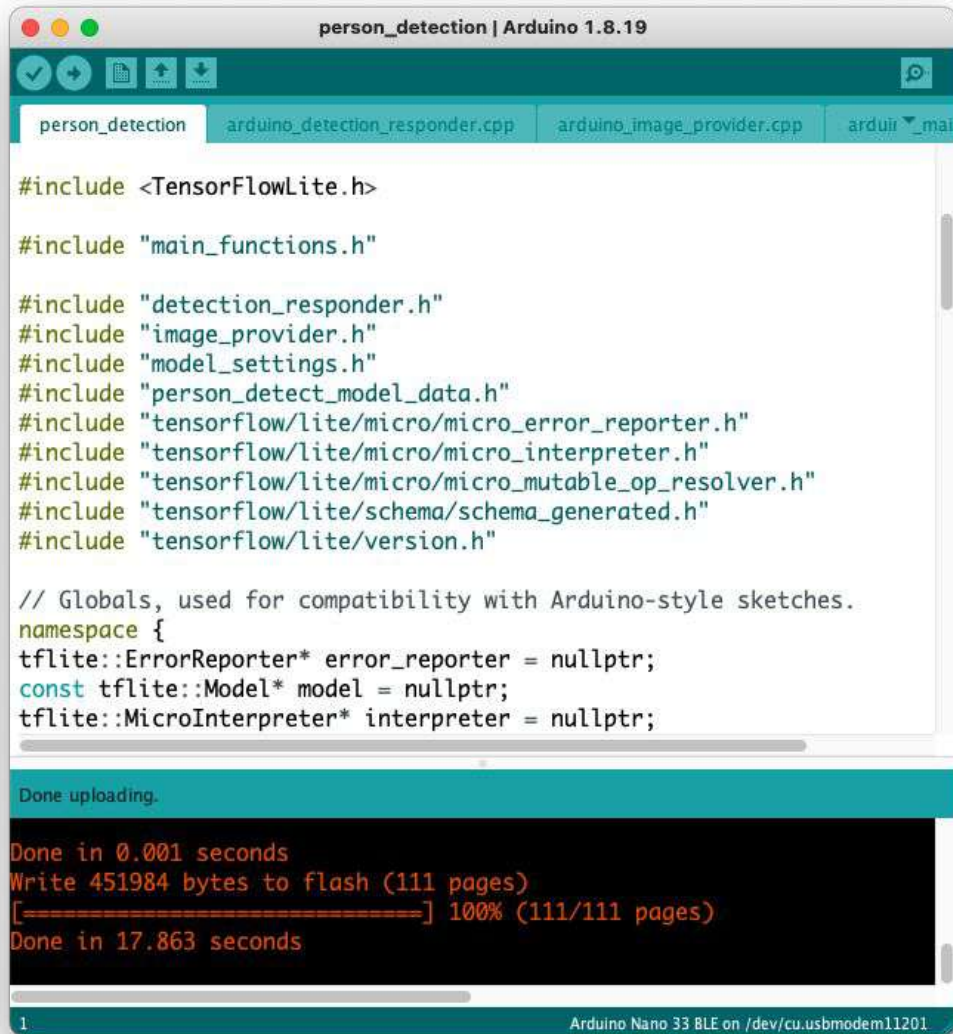
// Globals, used for compatibility with Arduino-style sketches.
namespace {
tflite::ErrorReporter* error_reporter = nullptr;
```

Done in 0.001 seconds
Write 171992 bytes to flash (42 pages)
[=====] 100% (42/42 pages)
Done in 6.733 seconds



```
Heard silence (204) @1408ms
Heard yes (204) @6416ms
Heard yes (201) @8784ms
Heard unknown (207) @11280ms
Heard yes (209) @16656ms
Heard no (201) @25312ms
Heard no (201) @28608ms
Heard unknown (202) @35552ms
```


Optional Tests (Person Detection)



```
person_detection | Arduino 1.8.19

person_detection  arduino_detection_responder.cpp  arduino_image_provider.cpp  arduino_main.cpp

#include <TensorFlowLite.h>

#include "main_functions.h"

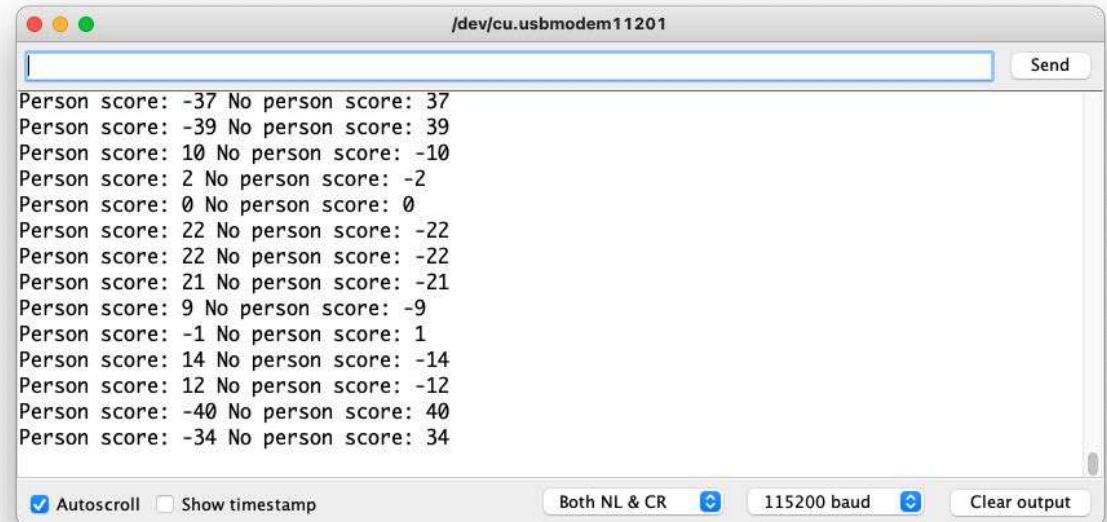
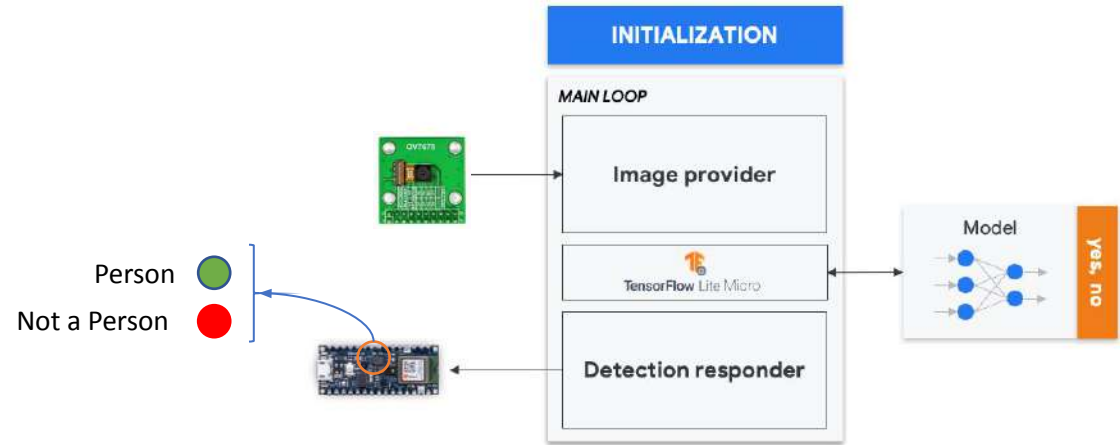
#include "detection_responder.h"
#include "image_provider.h"
#include "model_settings.h"
#include "person_detect_model_data.h"
#include "tensorflow/lite/micro/micro_error_reporter.h"
#include "tensorflow/lite/micro/micro_interpreter.h"
#include "tensorflow/lite/micro/micro_mutable_op_resolver.h"
#include "tensorflow/lite/schema/schema_generated.h"
#include "tensorflow/lite/version.h"

// Globals, used for compatibility with Arduino-style sketches.
namespace {
tflite::ErrorReporter* error_reporter = nullptr;
const tflite::Model* model = nullptr;
tflite::MicroInterpreter* interpreter = nullptr;

Done uploading.

Done in 0.001 seconds
Write 451984 bytes to flash (111 pages)
[=====] 100% (111/111 pages)
Done in 17.863 seconds

1 Arduino Nano 33 BLE on /dev/cu.usbmodem11201
```



```
/dev/cu.usbmodem11201

Person score: -37 No person score: 37
Person score: -39 No person score: 39
Person score: 10 No person score: -10
Person score: 2 No person score: -2
Person score: 0 No person score: 0
Person score: 22 No person score: -22
Person score: 22 No person score: -22
Person score: 21 No person score: -21
Person score: 9 No person score: -9
Person score: -1 No person score: 1
Person score: 14 No person score: -14
Person score: 12 No person score: -12
Person score: -40 No person score: 40
Person score: -34 No person score: 34

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

Thanks
And stay safe!



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