EECE-4710 "IoT and TinyML"

TinyML Kit Overview: Arduino Nano 33 BLE Sense

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BE THE DIFFERENCE.

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TinyML Kit Overview

Arduino

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https://store-usa.arduino.cc/products/arduino-tiny-machine-learning-kit

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Arduino Nano 33 BLE Sense

- **MCU**
  - 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 LED

**Not included in some packages*

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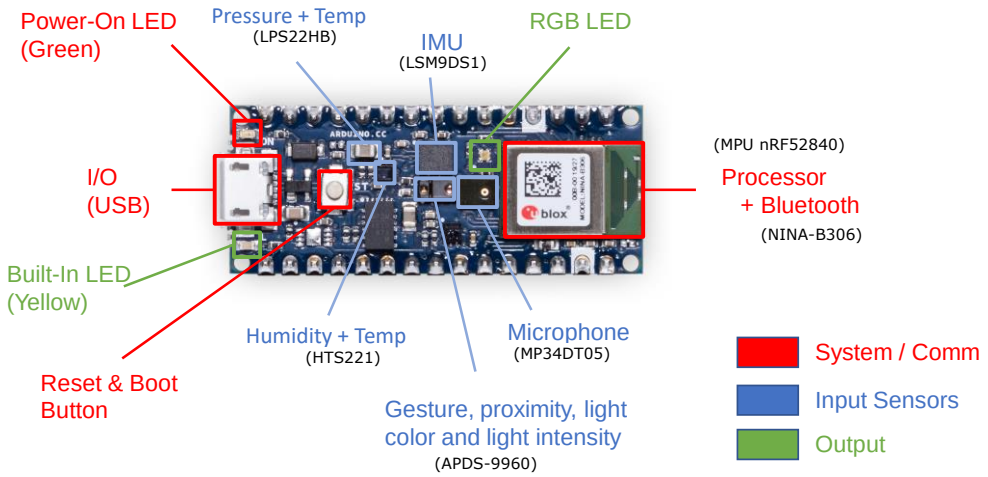
Nano 33 BLE Sense (Development board)

https://docs.arduino.cc/hardware/nano-33-ble-sense
https://store-usa.arduino.cc/products/arduino-nano-33-ble-sense



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OV7675 Camera Module

- **0.3 MP** CMOS image sensor
- active array size: **640×480**
- output formats: YUV422, Raw RGB, ITU656, RGB565
- input clock frequency: 1.5 ~ 27 MHz
- maximum image transfer rate: VGA 30fps, QVGA 60fps, QQVGA 240pfs
- pixel size: 2.5 µm x 2.5 µm
- image area: 1640 µm x 1220 µm

https://www.arducam.com/products/camera-breakout-board/0-3mp-ov7675/
https://github.com/ArduCAM/ArduCAM_USB_Camera_Shield
https://github.com/ArduCAM/Arduino

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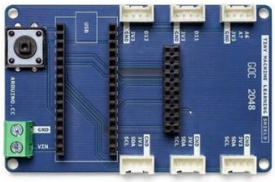
Tiny Machine Learning Shield



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)

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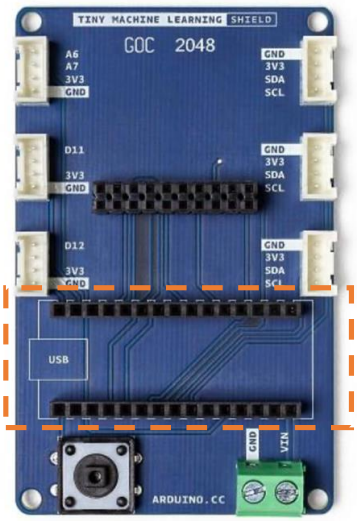
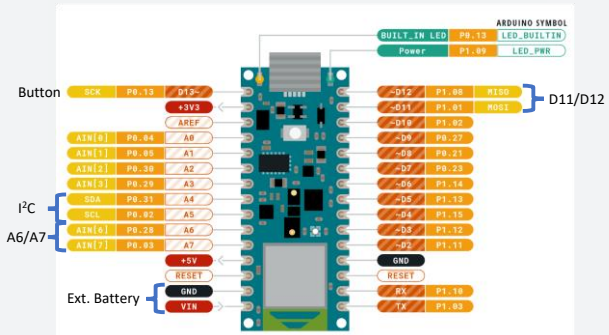


TinyML Shield

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



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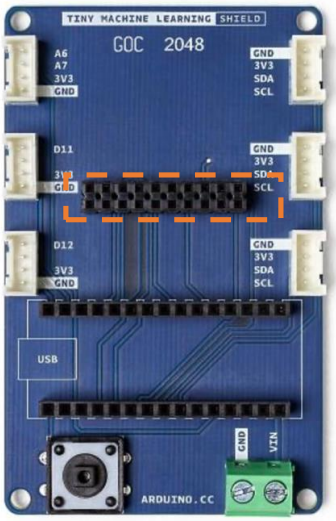

TinyML Shield

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

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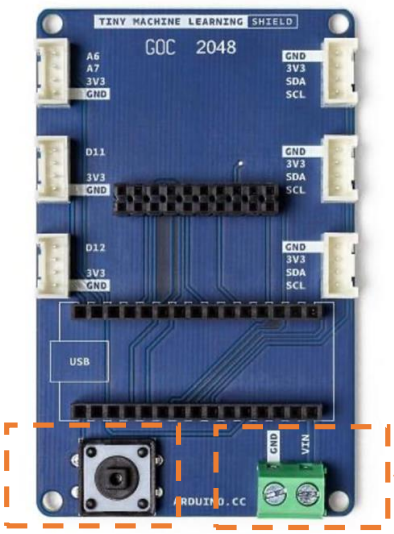
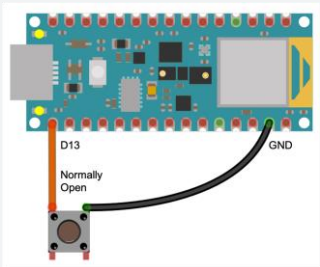


TinyML Shield

A easily programmable button on the left



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

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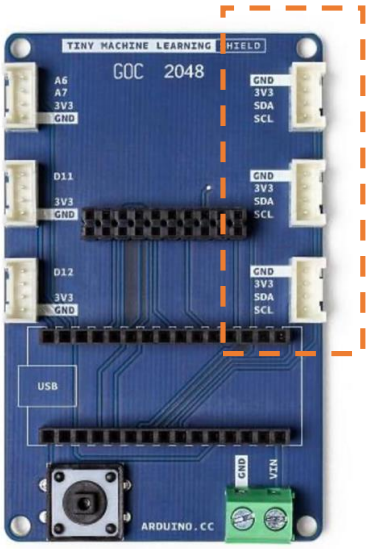

TinyML Shield

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

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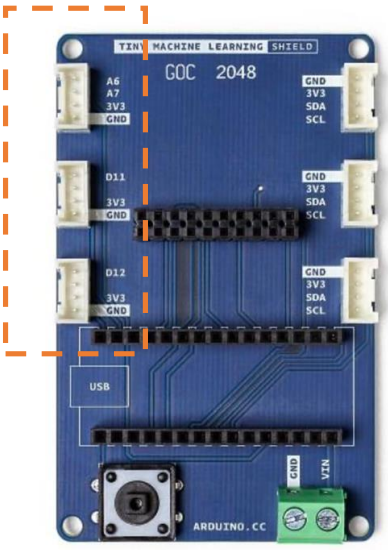

TinyML Shield

Grove connectors that break out analog and digital GPIO

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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

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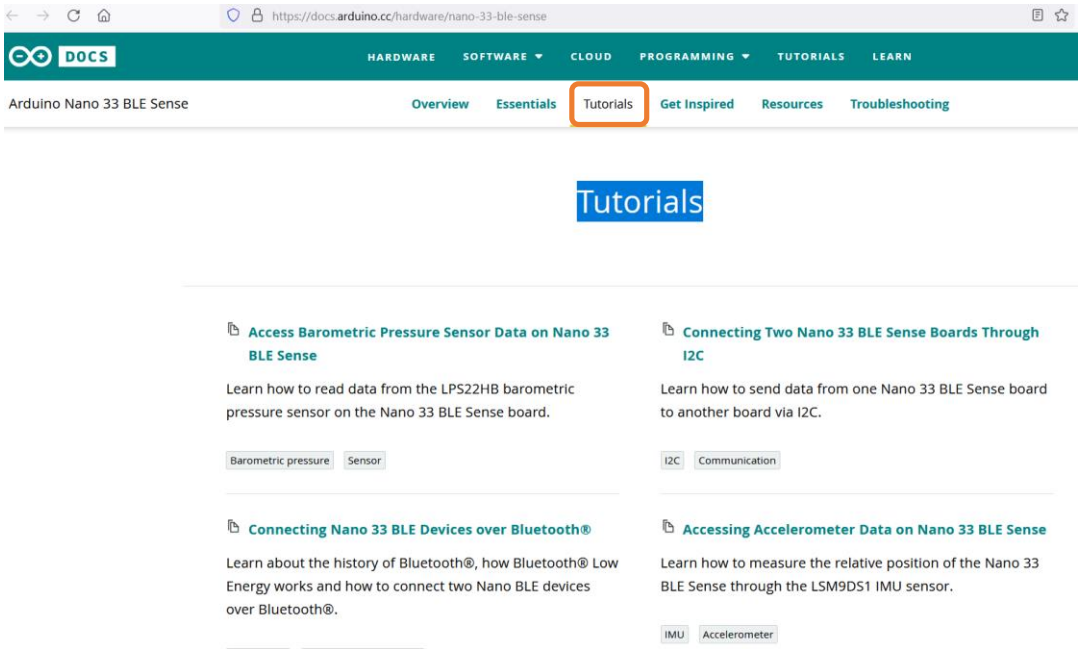

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Credits

- A previous edition of this course was developed in collaboration with Dr. Susan C. Schneider of Marquette University.
- We are very grateful and thank all the following professors, researchers, and practitioners for jump-starting courses on TinyML and for sharing their teaching materials:

- Prof. Marcelo Rovai - TinyML - Machine Learning for Embedding Devices, UNIFEI
  - https://github.com/Mjrovai/UNIFEI-IESTI01-TinyML-2022.1
- Prof. Vijay Janapa Reddi - CS249r: Tiny Machine Learning, Applied Machine Learning on Embedded IoT Devices, Harvard
  - https://sites.google.com/g.harvard.edu/tinyml/home
- Prof. Rahul Mangharam – ESE3600: Tiny Machine Learning, Univ. of Pennsylvania
  - https://tinyml.seas.upenn.edu/#
- Prof. Brian Plancher - Harvard CS249r: Tiny Machine Learning (TinyML), Barnard College, Columbia University
  - https://a2r-lab.org/courses/cs249r_tinyml/

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References

- Additional references from where information and other teaching materials were gathered include:

- Applications & Deploy textbook: “TinyML” by Pete Warden, Daniel Situnayake
  - https://www.oreilly.com/library/view/tinyml/9781492052036/
- Deploy textbook “TinyML Cookbook” by Gian Marco Iodice
  - https://github.com/PacktPublishing/TinyML-Cookbook
- Jason Brownlee
  - https://machinelearningmastery.com/
- TinyMLedu
  - https://tinyml.seas.harvard.edu/
- Professional Certificate in Tiny Machine Learning (TinyML) – edX/Harvard
  - https://www.edx.org/professional-certificate/harvardx-tiny-machine-learning
- Introduction to Embedded Machine Learning - Coursera/Edge Impulse
  - https://www.coursera.org/learn/introduction-to-embedded-machine-learning
- Computer Vision with Embedded Machine Learning - Coursera/Edge Impulse
  - https://www.coursera.org/learn/computer-vision-with-embedded-machine-learning

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