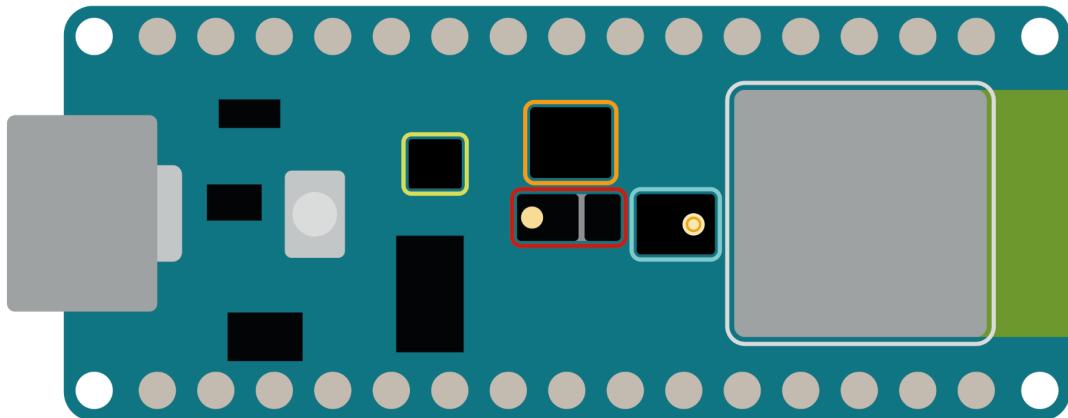


Machine Learning

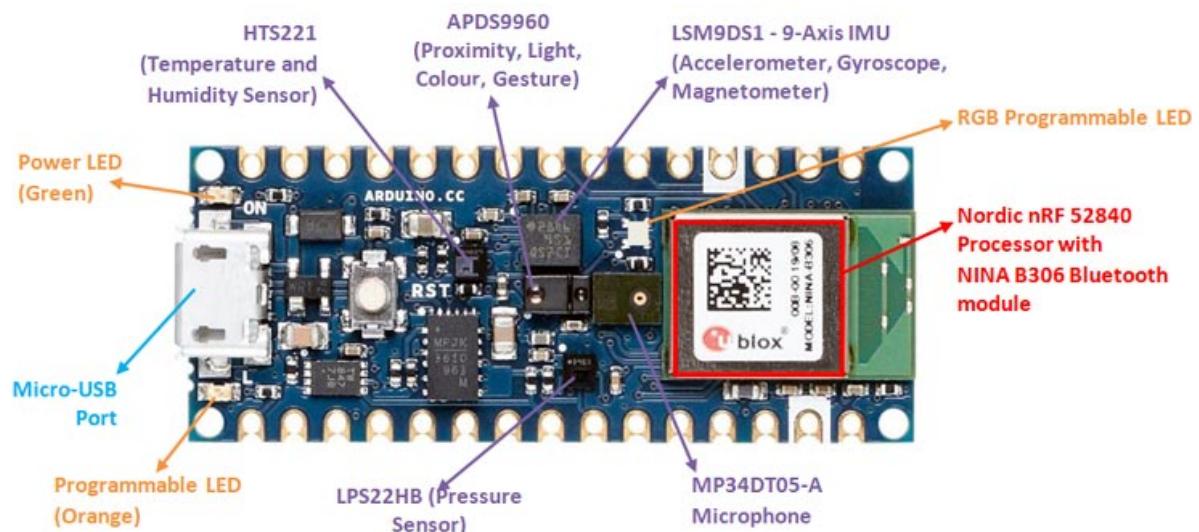
with the Arduino

Pinouts i sensory

NANO 33 BLE SENSE



- ◆ Color, brightness, proximity and gesture sensor
- ◆ Digital microphone
- ◆ Motion, vibration and orientation sensor
- ◆ Temperature, humidity and pressure sensor
- ◆ Arm Cortex-M4 microcontroller and BLE module



- Bluetooth w standardzie 5.0 LE
- Programowalny LED RGB
- HTS221 - czujnik temperatury i wilgotności
- APDS9960 - czujnik zbliżenia, światła, koloru i gestów
- LSM9DS1 - 3 osiowy żyroskop, akcelerometr i magnetometr
- MP34DT05-A - czujnik dźwięku
- LPS22HB - czujnik ciśnienia

Instalacja środowiska oraz bibliotek

W pierwszej kolejności instalujemy środowisko Arduino IDE 1.8.19
<https://www.arduino.cc/en/software>

The screenshot shows the Arduino Software (IDE) download page. The top navigation bar includes links for HARDWARE, SOFTWARE (which is highlighted in yellow), CLOUD, DOCUMENTATION, COMMUNITY, BLOG, and ABOUT. Below the navigation, the text "Legacy IDE (1.8.X)" is displayed. A large central box contains the "Arduino IDE 1.8.19" download section, which includes a logo, the version number, a brief description, and a "Get" button. To the right of this box is a "DOWNLOAD OPTIONS" sidebar listing download links for Windows, Linux, and Mac OS X. At the bottom of the main content area are links for "Previous Releases" and "Help".

Instalacja biblioteki płytki Arduino Nano 33 BLE

The screenshot shows the Arduino IDE menu with the "Tools" menu open. The "Boards" submenu is selected, showing a list of available boards. The "Menedżer płyt..." option is highlighted with a blue selection bar. The menu also lists other options like "Automatyczne formatowanie", "Archiwizuj szkic", and "Popraw kodowanie i przeladuj".

Wyszukujemy *Arduino Nano 33*

Arduino Mbed OS Nano Boards

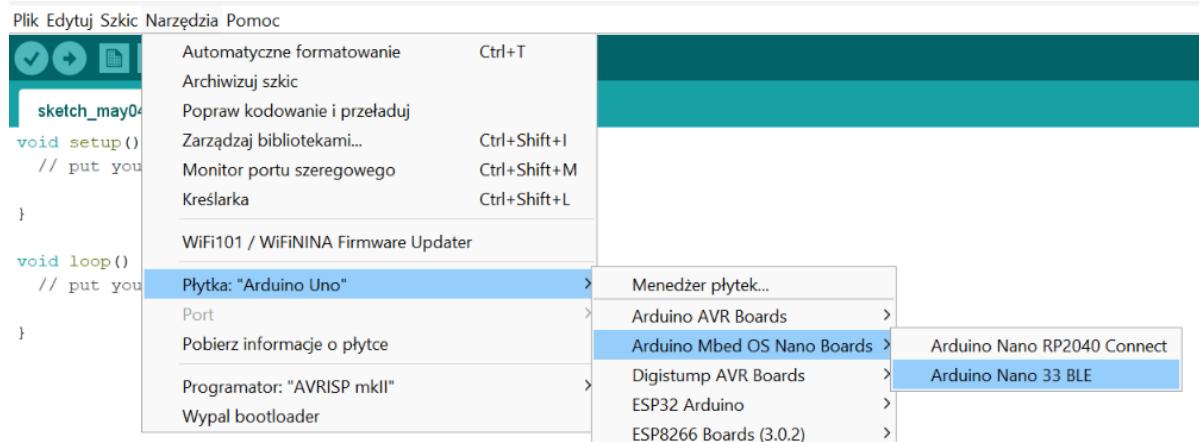
by Arduino wersja 4.0.2 INSTALLED

Płytki dołączone w tej paczce:

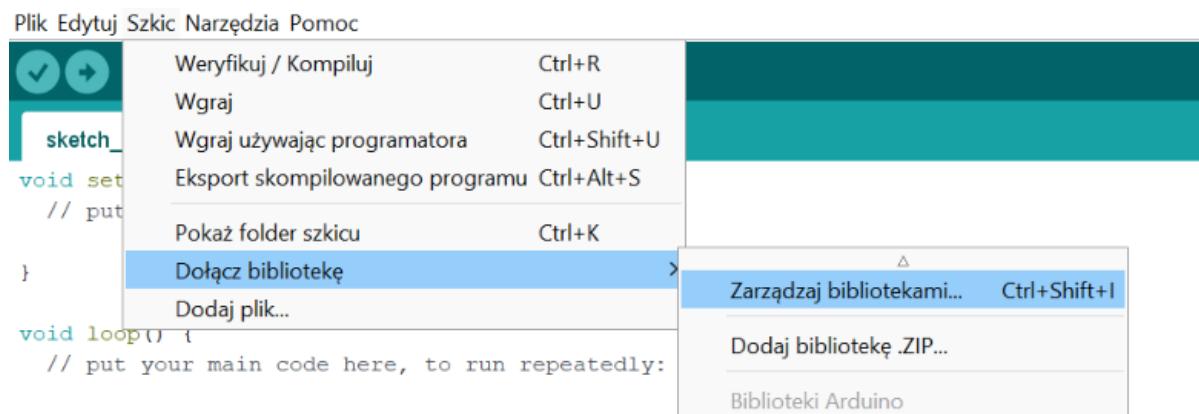
Arduino Nano 33 BLE, Arduino Nano 33 BLE Sense, Arduino Nano RP2040 Connect.

[Online Help](#)

[More Info](#)



Instalacja bibliotek do sensorów



Instalujemy następujące biblioteki:

- Arduino_APDS9960
- LPS22HB
- ArduinoHTS221
- Arduino_LSM9DS1
- Adafruit Zero PDM Library
- Adafruit TensorFlow Lite
- Harvard_TinyMLx

Menedżer bibliotek X

Wpisz Wszystko Temat Wszystko APDS9960

Arduino_APDS9960
by Arduino Wersja 1.0.4 **INSTALLED**
A library for the APDS-9960 sensor allows reading gestures, color, and proximity on your Arduino Nano 33 BLE Sense board and other boards with a sensor attached via I2C.
[More info](#)

Wybierz wersję Instaluj

Adafruit APDS9960 Library
by Adafruit Wersja 1.2.3 **INSTALLED**
This is a library for the Adafruit APDS9960 gesture/proximity/color/light sensor. This is a library for the Adafruit APDS9960 gesture/proximity/color/light sensor.
[More info](#)

Deneyap Hareket Isik Renk Algilayici Mesafe Olcer
by Turkish Technlogy Team Foundation (T3)
Arduino library for Deneyap Gesture, Color, Proximity Sensor APDS9960 A simple and efficient library to use Deneyap Gesture, Color, Proximity Sensor APDS9960 via I2C peripheral.
[More info](#)

Melopero APDS9960
by Leonardo La Rocca
A driver library for the APDS9960 sensor. This library allows an Arduino board to communicate with the APDS9960 sensor.

Zamknij

Menedżer bibliotek X

Wpisz Wszystko Temat Wszystko LPS22HB

Arduino_LPS22HB
by Arduino Wersja 1.0.2 **INSTALLED**
Allows you to read the pressure sensor of your Nano 33 BLE Sense.
[More info](#)

Wybierz wersję Instaluj

LPS35HW
by Pavel Slama
LPS35HW pressure sensor library compatible also with LPS22HB, LPS33W, LPS33HW
[More info](#)

ReefwingLPS22HB
by David Such
Arduino Library for the LPS22HB Pressure Sensor. Targets the Arduino Nano 33 BLE SENSE Hardware.
[More info](#)

Sodaq_LPS22HB
by Alex Tsamakos,SODAQ
An Arduino library for the LPS22HB sensor. Supports barometric and temperature sensors.
[More info](#)

Zamknij

Menedżer bibliotek

Wpisz Wszystko Temat Wszystko HTS221

Arduino_HTS221
by Arduino Wersja 1.0.0 **INSTALLED**
Allows you to read the temperature and humidity sensors of your Nano 33 BLE Sense.
[More info](#)

Adafruit HTS221
by Adafruit
Arduino library for the HTS221 sensors in the Adafruit shop Arduino library for the HTS221 sensors in the Adafruit shop
[More info](#)

FaBo 208 Humidity HTS221
by Akira Sasaki
A library for FaBo Humidity I2C Brick HTS221 is humidity and temperature sensor.
[More info](#)

SmartEverything HTS221
by axelettronica
Library code for HTS221 Capacitive digital sensor for relative humidity and temperature The HTS221 is an ultra compact sensor for relative humidity and temperature.
It includes a sensing element and a mixed signal ASIC to provide the measurement information through digital serial interfaces.
The sensing element consists of a polymer dielectric planar capacitor structure capable of detecting relative humidity variations and is manufactured

Zamknij

Menedżer bibliotek

Wpisz Wszystko Temat Wszystko LSM9DS1

Arduino_LSM9DS1
by Arduino Wersja 1.1.1 **INSTALLED**
Allows you to read the accelerometer, magnetometer and gyroscope values from the LSM9DS1 IMU on your Arduino Nano 33 BLE Sense.
[More info](#)

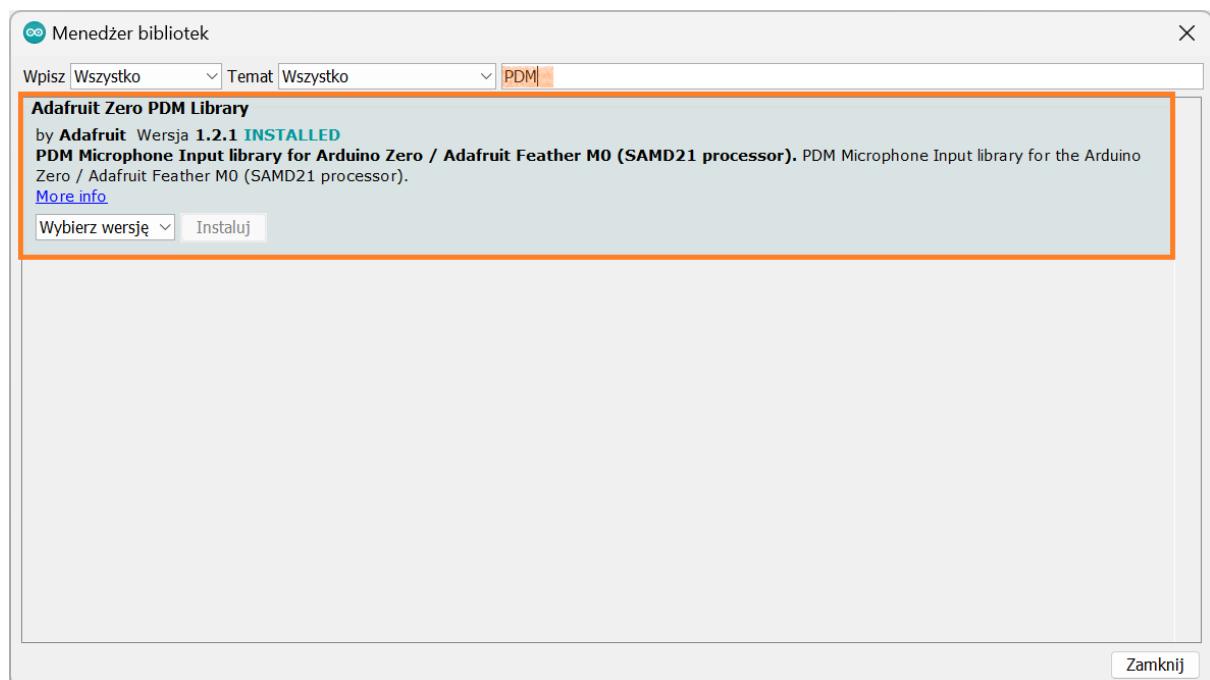
Wybierz wersję Instaluj

Adafruit LSM9DS1 Library
by Adafruit
Arduino library for LSM9DS1 9-DOF sensor board. Arduino library for LSM9DS1 9-DOF sensor board.
[More info](#)

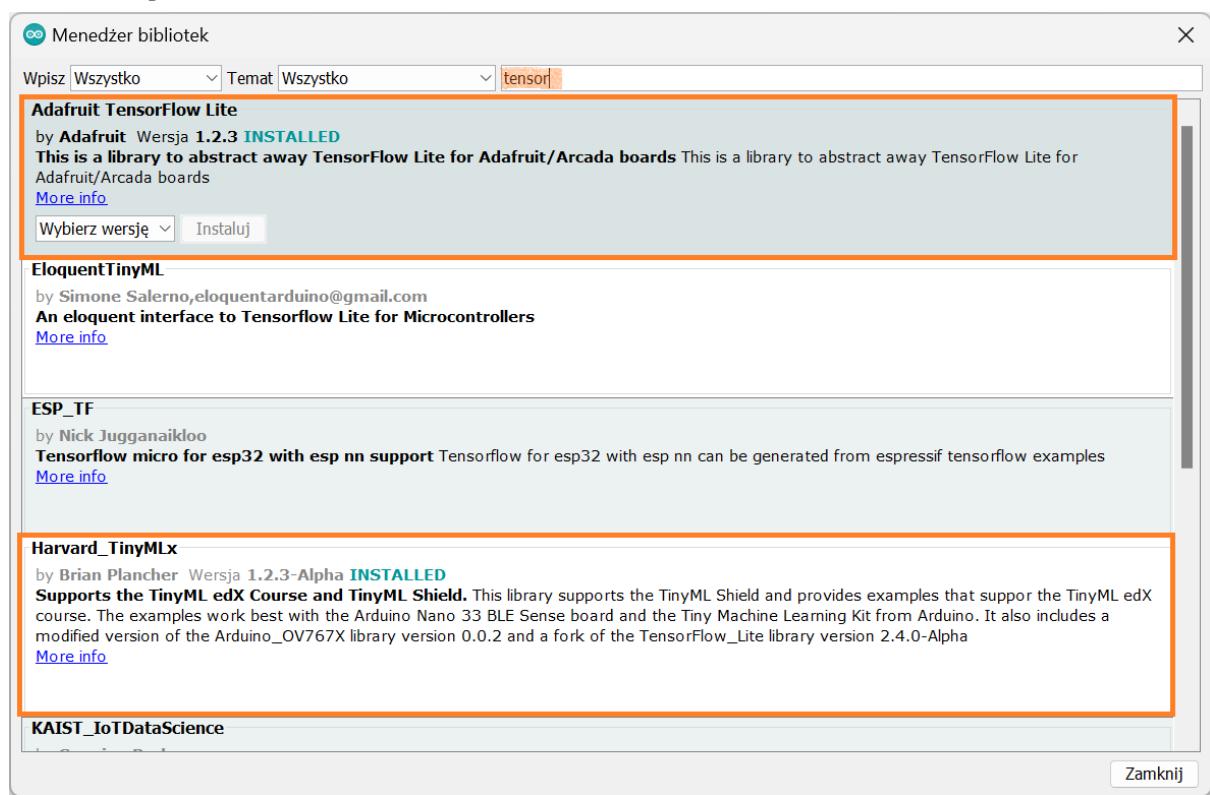
Melopero LSM9DS1
by Leonardo La Rocca
A driver library for the LSM9DS1 9-DOF IMU. This library allows an Arduino board to communicate with the LSM9DS1 sensor via SPI or I2C for reading the accelerometer, gyroscope and magnetometer data. Accelerometer / gyroscope and magnetometer interrupts are supported.
[More info](#)

Reefwing_imuTypes
by David Such
common structs and enums used by the Reefwing IMU Libraries. Used by ReefwingAHRS, ReefwingLSM9DS1 & Reefwing_xIMU3
[More info](#)

Zamknij



Instalacja bibliotek AI



Instalacja biblioteki BLE

<https://github.com/arduino-libraries/ArduinoBLE>

Test biblioteki sensorów

Przykłady i obsługa sensorów

Dioda RGB

- Jest to standardowa dioda RGB 4 pinowa. W celu włączenia odpowiednich kolorów należy zaprogramować odpowiednie piny na stan wysoki. Ze względu na brak PWM na pinach możliwe jest uzyskanie tylko 7 kolorów.
 - ◆ Red - pin 22
 - ◆ Green - pin 23
 - ◆ Blue - pin 24

APDS9960

- **ColorSensor - RGB** - przykładowy kod służy do prostego rozpoznawania składowych koloru RGB
- **ProximitySensor** - wykrywanie zbliżenia, nie zwraca dokładniej wartości dystansu, a jedynie informacje czy coś jest blisko czy daleko (0 => close; 255 => far)
- **GestureSensor** - rozpoznaje kierunek ręki nad sensorem (Up, Down, Left, Right)
 - ◆ APDS.begin()
 - ◆ APDS.gestureAvailable()
 - ◆ int gesture = APDS.readGesture()

HTS221

- **ReadSensors** - pozwala na odczyt wartości temperatury i wilgotności powietrza
 - ◆ HTS.begin()
 - ◆ float temperature = HTS.readTemperature()
 - ◆ float humidity = HTS.readHumidity()

LSM9DS1

```
IMU.begin()
    → SimpleAccelerometer
        ◆ IMU.begin()
        ◆ IMU.accelerationSampleRate()
        ◆ IMU.accelerationAvailable()
        ◆ IMU.readAcceleration(x, y, z)
    → SimpleGyroscope
        ◆ IMU.gyroscopeSampleRate()
        ◆ IMU.gyroscopeAvailable()
        ◆ IMU.readGyroscope(x, y, z)
    → SimpleMagnetometer
        ◆ IMU.magneticFieldSampleRate()
```

- ◆ IMU.magneticFieldAvailable()
- ◆ IMU.readMagneticField(x, y, z)

LPS22HB

→ **ReadPressure**

- ◆ BARO.begin()
- ◆ BARO.readPressure()
- ◆ BARO.readTemperature()

Adafruit PDM - Microphone

→

- ◆ PDM.onReceive(onPDMdata)
- ◆ PDM.setGain(30) – domyślnie jest 20
- ◆ PDM.begin(1, 16000)
- ◆ onPDMdata
- ◆ int bytesAvailable = PDM.available();
- ◆ PDM.read(sampleBuffer, bytesAvailable)

→ <https://www.szynalski.com/tone-generator/>

Harvard_TinyMLx

→ **micro_speech**

Ten kod to implementacja modelu uczenia maszynowego opartego na sieci neuronowej, który rozpoznaje krótkie fragmenty mowy i przypisuje im jedną z trzech etykiet: "yes", "no" lub "silence".

Kod zawiera różne pliki nagłówkowe, które zawierają dane i parametry potrzebne do działania modelu. Są to m.in. dane opisujące cechy dźwięków ("micro_features"), dane treningowe dla poszczególnych etykiet ("yes_micro_features_data", "no_micro_features_data", "silence_micro_features_data") oraz parametry modelu ("tiny_conv_micro_features_params", "yes_micro_features_params", "no_micro_features_params", "silence_micro_features_params").

W kodzie jest również zdefiniowany obiekt "error_reporter", który służy do raportowania błędów oraz obiekt "recognizer", który zawiera funkcje służące do uruchomienia modelu i przetworzenia sygnału dźwiękowego.

Cały kod składa się z pętli "loop", która w każdym cyklu odczytuje wartości z mikrofonu i przetwarza je za pomocą modelu. Jeśli model rozpozna jedną z etykiet, odpowiednia informacja zostanie wyświetlona na ekranie. Kod można dostosować do różnych zastosowań, np. sterowania urządzeniami na podstawie mowy lub monitorowania hałasu w pomieszczeniu.

→ **magic_wand**

To implementacja modelu uczenia maszynowego opartego na sieci neuronowej, który wykorzystuje akcelerometr do rozpoznawania ruchów ręki i reprezentuje go za pomocą uproszczonego schematu.

Kod składa się z plików nagłówkowych i źródłowych oraz dwóch funkcji głównych: "setup" i "loop". Funkcja "setup" inicjalizuje akcelerometr i model, a także ustawia parametry działania programu. Funkcja "loop" działa w pętli, odczytuje dane z akcelerometru i przetwarza je za pomocą modelu.

→ **person_detection**

Kod person_detection jest przykładem implementacji sieci neuronowej do detekcji ludzi na zdjęciach przy użyciu mikrokontrolera. W skrócie, kod ten pobiera obraz z kamery video, a następnie analizuje go, aby wykryć, czy w obrazie znajduje się osoba.

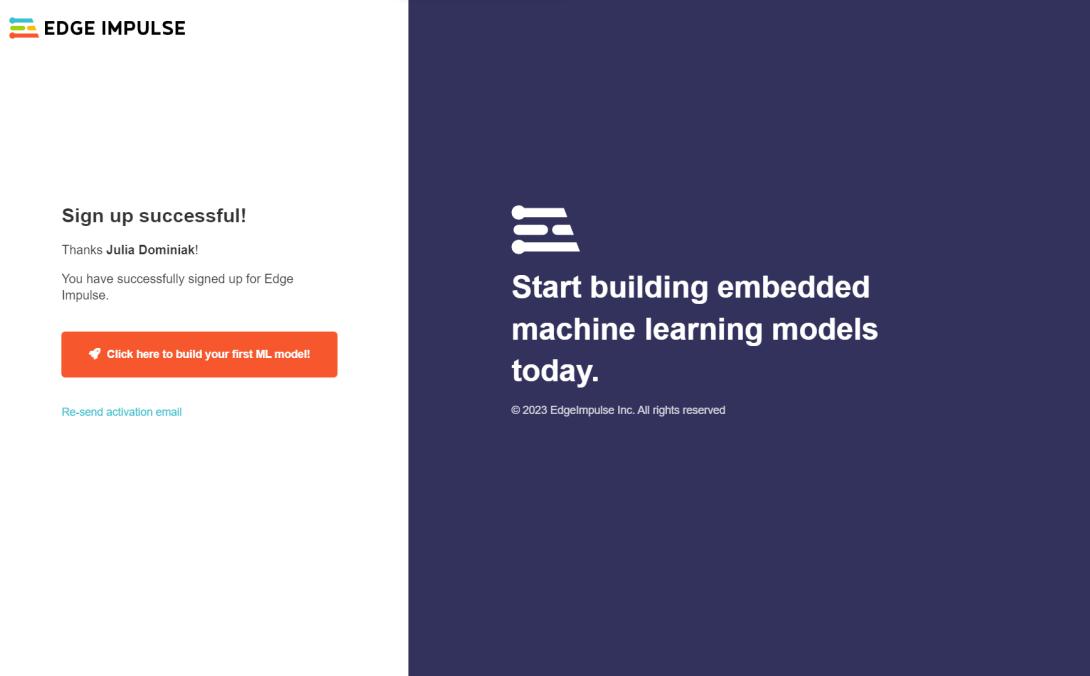
Cały kod składa się z kilku plików, w tym plików nagłówkowych, plików źródłowych oraz pliku konfiguracyjnego. W głównym pliku źródłowym, o nazwie "person_detection.cpp", znajduje się funkcja "run_person_detection()", która jest głównym interfejsem dla programu.

Funkcja ta inicjuje wszystkie niezbędne moduły, takie jak kamerę, wyświetlacz i sieć neuronową. Następnie, w pętli nieskończonej, funkcja pobiera obraz z kamery, przekształca go na wymagany przez sieć neuronową format i wywołuje funkcję "invoke()", która jest odpowiedzialna za przeprowadzenie detekcji osoby.

W funkcji "invoke()" sieć neuronowa jest zainicjowana, a następnie obraz jest podawany do sieci jako wejście. Sieć neuronowa zwraca wynik detekcji w postaci dwóch wartości: prawdopodobieństwa obecności osoby na zdjęciu i jej braku.

Przygotowanie środowiska

→ wchodzimy na stronę <https://www.edgeimpulse.com/>



- zakładamy konto
- tworzymy nowy projekt

A screenshot of the Edge Impulse project creation interface. The top navigation bar shows 'Julia Dominiak / JuliaDominiak-project-1' and a user icon. The main area has tabs for 'Project info', 'Keys', 'Export', and 'Jobs'. The title 'Julia Dominiak / JuliaDominiak-project-1' is displayed with a gear icon. Below it, a message says 'This is your Edge Impulse project. From here you acquire new training data, design impulses and train models.' A 'New tag' button is visible. The left sidebar has a tree view with nodes like 'Dashboard', 'Devices', 'Data acquisition', 'Impulse design', 'Create impulse', 'EON Tuner', 'Retrain model', 'Live classification', 'Model testing', 'Versioning', and 'Deployment'. Under 'GETTING STARTED', there are links for 'Documentation' and 'Forums'. A URL 'https://studio.edgeimpulse.com/studio/222639#' is at the bottom. The central area has sections for 'Getting started' (with buttons for 'Add existing data', 'Collect new data', and 'Upload your model'), 'Sharing' (with a note 'Your project is private.' and a 'Make this project public' button), 'Collaborators (1/4)' (listing 'Julia Dominiak OWNER'), and a 'Summary' section with a 'Continue with the wizard' button.

EDGE IMPULSE

- Dashboard
- Devices
- Data acquisition
- Impulse design
 - Create impulse
- EON Tuner
- Retrain model
- Live classification
- Model testing
- Versioning
- Deployment

GETTING STARTED

- Documentation
- Forums

Project info Keys Export Jobs

Julia Dominiak / ArduinoTest

This is your Edge Impulse project. From here you acquire new training data, design impulses and train models.

+ New tag

Getting started

Start building your dataset or validate your model's on-device performance:

- Add existing data
- Collect new data
- Upload your model

Sharing

Your project is private.

Make this project public

Collaborators (1/4)

JB Julia Dominiak OWNER

Summary

Continue with the wizard

- w projekcie zaznaczamy że będziemy korzystać z kompatybilnej płytki (bo taką jest Arduino BLE33)
- następnie przechodzimy jak ją połączyć
- tutaj są informacje co musimy zainstalować
<https://docs.edgeimpulse.com/docs/development-platforms/officially-supported-mcu-targets/arduino-nano-33-ble-sense>

EDGE IMPULSE

Home Guides Projects Forum Q Search X

Getting Started

Getting Started: Next Steps

API and SDK references

What is embedded ML, anyway?

Frequently asked questions

EDGE IMPULSE STUDIO

Dashboard

Devices

Data sources

Data acquisition

Data explorer

Impulse design

Bring your own model (BYOM)

Processing blocks

Learning blocks

EON Tuner

Retrain model

Live classification

Model testing

Powered By GitBook

Arduino Nano 33 BLE Sense

The Arduino Nano 33 BLE Sense is a tiny development board with a Cortex-M4 microcontroller, motion sensors, a microphone and BLE - and it's fully supported by Edge Impulse. You'll be able to sample raw data, build models, and deploy trained machine learning models directly from the studio. It's available for around 30 USD from [Arduino](#) and a wide range of distributors.

You can also use the [Arduino Tiny Machine Learning Kit](#) to run image classification models on the edge with the Arduino Nano and attached OV7675 camera module (or [connect the hardware together via jumper wire and a breadboard](#) if purchased separately).

The Edge Impulse firmware for this development board is open source and hosted on GitHub: [edgeimpulse/firmware-arduino-nano-33-ble-sense](#).

Arduino Nano 33 BLE Sense rev2?

Arduino recently released a new version of the Arduino Nano 33 BLE Sense, the rev2 version which has different sensors than the original version. We are working on adding a dedicated "official firmware" so you can easily flash this board version. In the meantime, to ingest data, please have a look at [Data Ingestion \(API\)](#), [Data Forwarder \(CLI\)](#) or [Data Uploader \(CLI and Studio\)](#)

EDGE IMPULSE

- Getting Started
- Getting Started: Next Steps
- API and SDK references
- What is embedded ML, anyway?
- Frequently asked questions
- EDGE IMPULSE STUDIO
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- Bring your own model (BYOM)
- Processing blocks >
- Learning blocks >
- EON Tuner >
- Retrain model
- Live classification
- Model testing

Powered By GitBook

Installing dependencies

To set this device up in Edge Impulse, you will need to install the following software:

1. [Edge Impulse CLI](#).
2. [Arduino CLI](#).
 - Here's an [instruction video for Windows](#).
 - The [Arduino website](#) has instructions for macOS and Linux.
3. On Linux:
 - GNU Screen: install for example via `sudo apt install screen`.

Problems installing the CLI?
See the [Installation and troubleshooting guide](#).

Connecting to Edge Impulse

With all the software in place it's time to connect the development board to Edge Impulse.

Do obejrze... Udostępnij

- po kliknięciu na [Edge Impulse CLI](#) przekierowuje nas na stronę dotyczącą przygotowania środowiska
<https://docs.edgeimpulse.com/docs/edge-impulse-cli/cli-installation>

EDGE IMPULSE

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- Impulse design
- Bring your own model (BYOM)
- Processing blocks >
- Learning blocks >
- EON Tuner >
- Retrain model
- Live classification
- Model testing
- Performance calibration
- Deployment >
- Organizations >

Powered By GitBook

Installation

This Edge Impulse CLI is used to control local devices, act as a proxy to synchronise data for devices that don't have an internet connection, and to upload and convert local files. The CLI consists of seven tools:

- `edge-impulse-daemon` - configures devices over serial, and acts as a proxy for devices that do not have an IP connection.
- `edge-impulse-uploader` - allows uploading and signing local files.
- `edge-impulse-data-forwarder` - a very easy way to collect data from any device over a serial connection, and forward the data to Edge Impulse.
- `edge-impulse-run-impuse` - show the impulse running on your device.
- `edge-impulse-blocks` - create organizational transformation, custom dsp, custom deployment and custom transfer learning blocks.
- `himax-flash-tool` - to flash the Himax WE-I Plus.

Connect to devices without the CLI? Recent versions of Google Chrome and Microsoft Edge can connect directly to fully-supported development boards, without the CLI. See [this blog post](#) for more information.

Installation - Windows

1. Create an [Edge Impulse account](#).
2. Install [Python 3](#) on your host computer.
3. Install [Node.js](#) v14 or higher on your host computer.
 - For Windows users, install the [Additional Node.js tools](#) (called [Tools for Native Modules](#) on newer versions) when prompted.
4. Install the CLI tools via:
`npm install -g edge-impulse-cli --force`

You should now have the tools available in your PATH.

[Installation - Linux Ubuntu Mac OS and Raspbian OS](#)

- przed wszystkim należy pobrać pythona3 (3.11.4) i node.js (18.16.1 LST) aby uruchomić aplikację do kontroli i zbierania

danych z lokalnego mikrokontrolera

Installation - Windows

1. Create an [Edge Impulse account](#).
2. Install [Python 3](#) on your host computer.
3. Install [Node.js v14](#) or higher on your host computer.
 - For Windows users, install the **Additional Node.js tools** (called **Tools for Native Modules** on newer versions) when prompted.
4. Install the CLI tools via:

```
npm install -g edge-impulse-cli --force
```

You should now have the tools available in your PATH.

The screenshot shows the Node.js download page. At the top, it says "Node.js® is an open-source, cross-platform JavaScript runtime environment." Below that is a green banner with the text "Security releases now available". In the center, there are two main download buttons: a green one for "18.16.1 LTS" labeled "Recommended For Most Users" and a blue one for "20.3.1 Current" labeled "Latest Features". Below these buttons are links to "Other Downloads", "Changelog", and "API Docs" for both versions. At the bottom, it says "For information about supported releases, see the [release schedule](#)".

The screenshot shows the Python download page. At the top, there's a Python logo and navigation links for "About", "Downloads", "Documentation", "Community", "Success Stories", and "News". A search bar and a "Donate" button are also at the top. On the left, there's a code snippet window showing Python code. The main content area has a sidebar with links like "All releases", "Source code", "Windows", "macOS", "Other Platforms", "License", and "Alternative Implementations". To the right, there's a section titled "Download for Windows" with a button for "Python 3.11.4". Below it, a note says "Note that Python 3.9+ cannot be used on Windows 7 or earlier." and "Not the OS you are looking for? Python can be used on many operating systems and environments." There's also a link to "View the full list of downloads".

- ważne jest aby node.js zainstalować ze wszystkimi niezbędnymi dodatkami
- następnie w Wierszu Poleceń użyć komendy
`npm install -g edge-impulse-cli --force`

```
Wiersz polecenia + ▾
Microsoft Windows [Version 10.0.22621.1555]
(c) Microsoft Corporation. Wszelkie prawa zastrzeżone.

C:\Users\prelu>npm install -g edge-impulse-cli --force|
```

```
Wiersz polecenia + ▾
Microsoft Windows [Version 10.0.22621.1555]
(c) Microsoft Corporation. Wszelkie prawa zastrzeżone.

C:\Users\prelu>npm install -g edge-impulse-cli --force
npm WARN using --force Recommended protections disabled.
npm WARN deprecated @zeit/dockerignore@0.0.5: "@zeit/dockerignore" is no longer maintained
npm WARN deprecated har-validator@5.1.5: this library is no longer supported
npm WARN deprecated request-promise@4.2.4: request-promise has been deprecated because it extends the now deprecated request package, see https://github.com/request/request/issues/3142
npm WARN deprecated debug@4.1.1: Debug versions >=3.2.0 <3.2.7 || >=4 <4.3.1 have a low-severity ReDos regression when used in a Node.js environment. It is recommended you upgrade to 3.2.7 or 4.3.1. (https://github.com/visionmedia/debug/issues/797)
npm WARN deprecated debug@4.1.1: Debug versions >=3.2.0 <3.2.7 || >=4 <4.3.1 have a low-severity ReDos regression when used in a Node.js environment. It is recommended you upgrade to 3.2.7 or 4.3.1. (https://github.com/visionmedia/debug/issues/797)
npm WARN deprecated debug@4.1.1: Debug versions >=3.2.0 <3.2.7 || >=4 <4.3.1 have a low-severity ReDos regression when used in a Node.js environment. It is recommended you upgrade to 3.2.7 or 4.3.1. (https://github.com/visionmedia/debug/issues/797)
npm WARN deprecated uuid@3.4.0: Please upgrade to version 7 or higher. Older versions may use Math.random() in certain circumstances, which is known to be problematic. See https://v8.dev/blog/math-random for details.
npm WARN deprecated request@2.88.0: request has been deprecated, see https://github.com/request/request/issues/3142

added 372 packages in 13s

13 packages are looking for funding
  run `npm fund` for details

C:\Users\prelu>
```

- po przejściu tych instrukcji i zainstalowaniu należy przejść do sekcji aktualizacji firmwaru



[Export as PDF](#)

[Copy link](#)

ON THIS PAGE

[Installing dependencies](#)

[Connecting to Edge Impulse](#)

[Next steps: building a machine ...](#)

[Troubleshooting](#)

Arduino Nano 33 BLE Sense

Installing dependencies

To set this device up in Edge Impulse, you will need to install the following software:

1. [Edge Impulse CLI](#).
2. [Arduino CLI](#).
 - Here's an [instruction video for Windows](#).
 - The [Arduino website](#) has instructions for macOS and Linux.

- przechodzimy do Arduino CLI

A screenshot of the Arduino CLI documentation website. The top navigation bar shows "Arduino CLI 0.32". The left sidebar lists topics like Home, Installation, Upgrading, Getting started, etc. The main content area is titled "Home" and describes the Arduino CLI as an all-in-one solution for managing boards and sketches. It includes sections for "Installation", "Getting started", and "Using the gRPC interface".

Installation

You have several options to install the latest version of the Arduino CLI on your system, see the [installation](#) page.

- i wybieramy interesującą nas opcję (w tym przypadku Windows exe)

Latest release

Platform		
Linux	32 bit	64 bit
Linux ARM	32 bit	64 bit
Linux ARMv6	32 bit	
Windows exe	32 bit	64 bit
Windows msi		64 bit
macOS		64 bit
macOS ARM		64 bit

→ pobieramy również Edge Impulse firmware

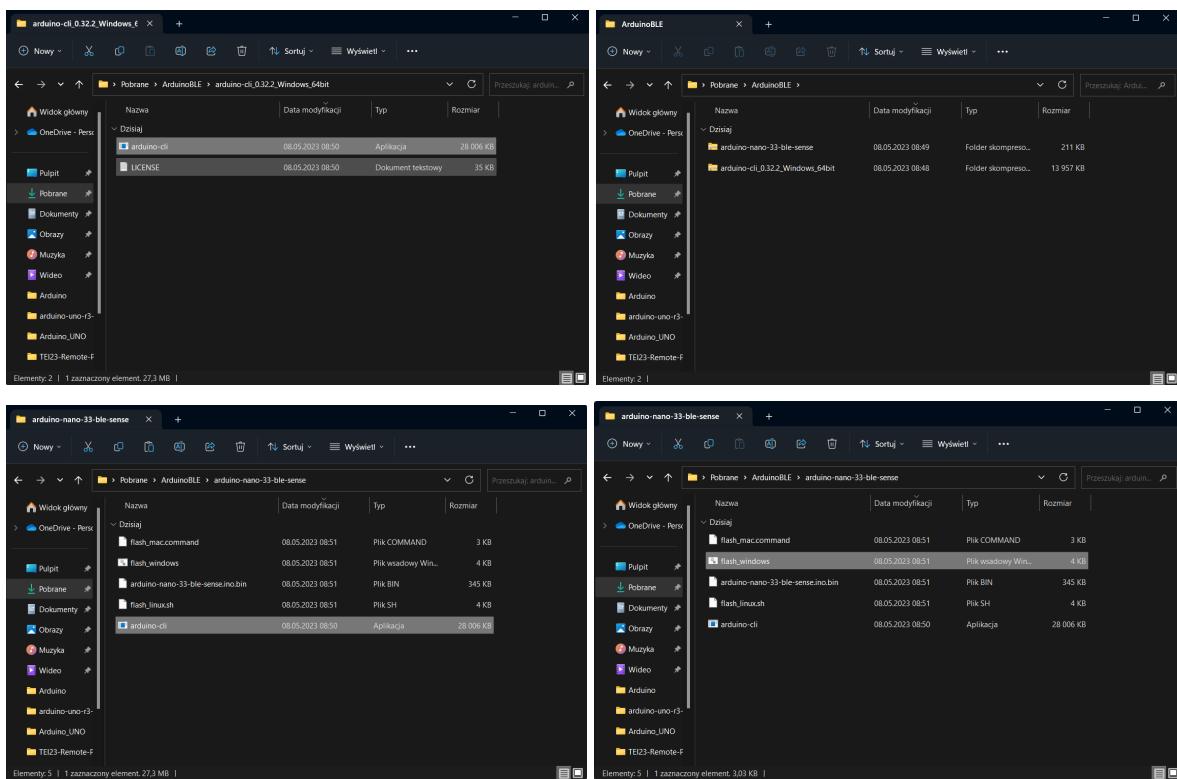
The screenshot shows the Edge Impulse website's 'Getting Started' page. On the left, there's a sidebar with navigation links like 'Getting Started', 'EDGE IMPULSE STUDIO', and various project and development options. The main content area features a photograph of a small, rectangular development board being held between fingers. Below the photo, text instructions say 'Press RESET twice quickly to launch the bootloader on the Arduino Nano 3.3 BLE Sense.' To the right of the main content, there's a sidebar with links for 'ON THIS PAGE' such as 'Installing dependencies', 'Connecting to Edge I...', and 'Troubleshooting'.

2. Update the firmware

The development board does not come with the right firmware yet. To update the firmware:

1. Download the latest Edge Impulse firmware, and unzip the file.
2. Open the flash script for your operating system (`flash_windows.bat`, `flash_mac.command` or `flash_linux.sh`) to flash the firmware.
3. Wait until flashing is complete, and press the RESET button once to launch the new firmware.

→ po pobraniu firmware'u należy przenieść do folderu plik .exe z wypakowanego folderu Arduino CLI



- następnie uruchomić `flash_windows.bat`
- komputer powinien wykryć Arduino na COM-ie i wgrać odpowiednie oprogramowanie (ważne - jest to program do przesyłu danych, po wgraniu innego kodu ponownie należy uruchomić plik)

```

C:\WINDOWS\system32\cmd. x + v

You're using an untested version of Arduino CLI, this might cause issues (found: 0.32.2, expected: 0.18.x
Finding Arduino Mbed core...
arduino:mbed_nano 4.0.2      4.0.2  Arduino Mbed OS Nano Boards
Finding Arduino Mbed core OK
Finding Arduino Nano 33 BLE...
Finding Arduino Nano 33 BLE OK at COM3
arduino:mbed_nano 4.0.2      4.0.2  Arduino Mbed OS Nano Boards
|
```

- kolejnym krokiem jest połączenie urządzenia z kontem na Edge Impulse za pomocą komendy w Wierszu Poleceń uruchamiamy połączenie z naszym kontem (standardowo logujemy się za pomocą maila i hasła)

edge-impulse-daemon

```

C:\WINDOWS\system32\cmd. + 
Edge Impulse serial daemon v1.18.1
? What is your user name or e-mail address (edgeimpulse.com)? julia.domiak@p.lodz.pl
? What is your password? [Hidden]
[CFG] Creating developer profile...
[CFG] Creating developer profile OK
Endpoints:
  Websocket: wss://remote-mgmt.edgeimpulse.com
  API: https://studio.edgeimpulse.com
  Ingestion: https://ingestion.edgeimpulse.com

[SER] Connecting to COM4
[SER] Serial is connected, trying to read config...
Failed to parse snapshot line []
[SER] Retrieved configuration
[SER] Device is running AT command version 1.7.0

Setting upload host in device... OK
Configuring remote management settings... OK
Configuring API key in device... OK
Configuring HMAC key in device... OK
Failed to parse snapshot line []
Failed to parse snapshot line []
[SER] Device is not connected to remote management API, will use daemon
[WS ] Connecting to wss://remote-mgmt.edgeimpulse.com
[WS ] Connected to wss://remote-mgmt.edgeimpulse.com
? What name do you want to give this device? ArduinoNano
[WS ] Device "ArduinoNano" is now connected to project "ArduinoTest". To connect to another project, run 'edge-impulse-daemon --clean'.
[WS ] Go to https://studio.edgeimpulse.com/studio/222639/acquisition/training to build your machine learning model!
|
```

→ po tym etapie na stronie projektu w Edge Impulse na liście "Devices" pojawi się nasze urządzenie

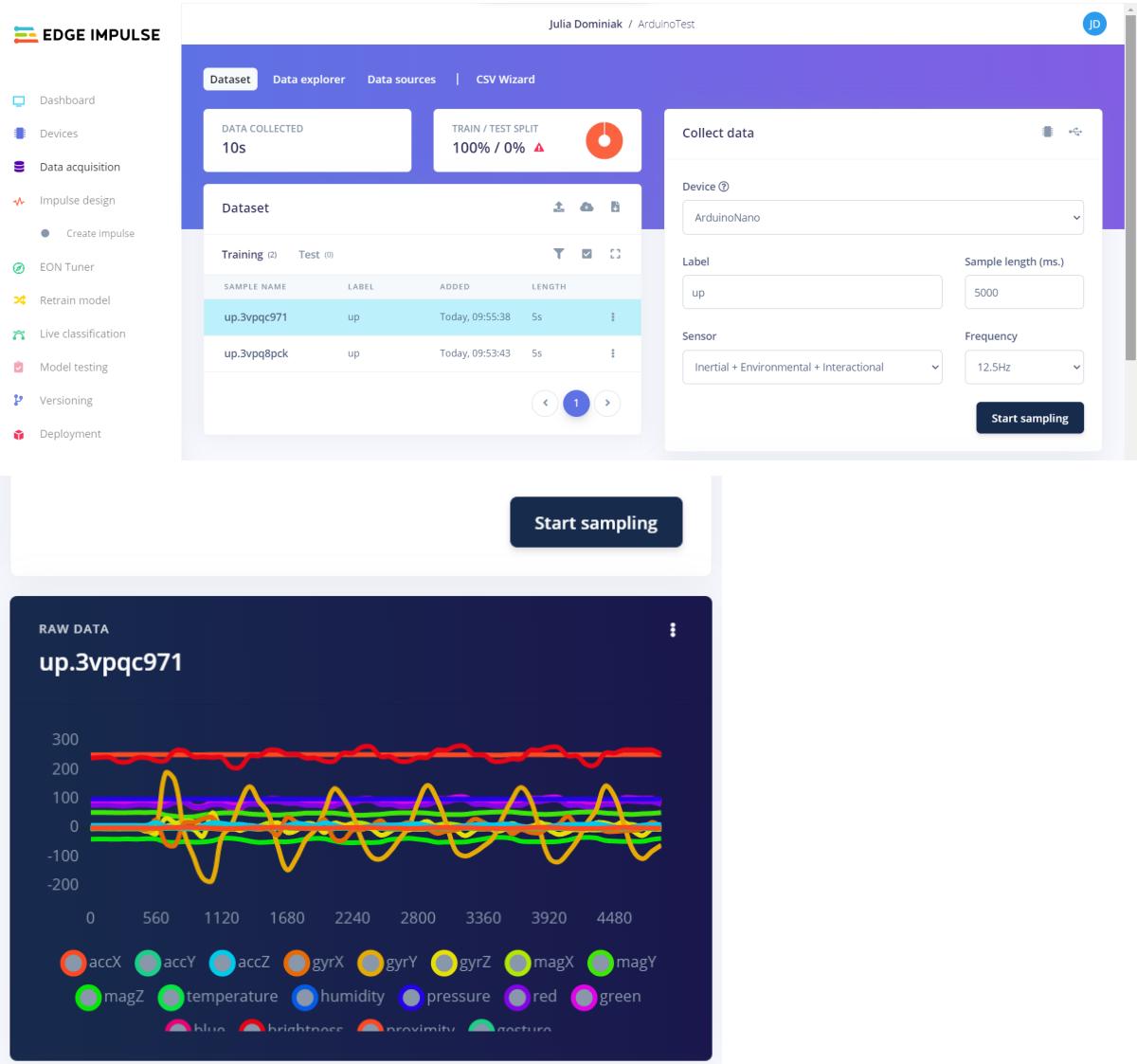
NAME	ID	TYPE	SENSORS	REMO...	LAST SEEN
ArduinoNano	68:24:8C:1B:C7:E9	ARDUINO_NANO33BLE	Built-in microphone, Inert...	●	Today, 08:57:02

Zbieranie danych i uczenie modelu

→ po podłączeniu mikrokontrolera możemy przejść do zbierania danych (Data acquisition)

The screenshot shows the Edge Impulse web interface. On the left, a sidebar menu includes: Dashboard, Devices, Data acquisition (selected), Impulse design (Create impulse), EON Tuner, Retrain model, Live classification, Model testing, Versioning, Deployment, and links to GETTING STARTED, Documentation, and Forums. The main area has tabs for Dataset, Data explorer, Data sources, and CSV Wizard. The Dataset tab shows a 'Dataset' section with a central 'Add data' button and a 'Collect data' section. In the 'Collect data' section, the 'Device' dropdown is set to 'ArduinoNano'. The 'Label' section contains 'Label name' and 'Sample length (ms.)' fields (set to 10000). The 'Sensor' section contains 'Inertial' and 'Frequency' (set to 100Hz) dropdowns. A large 'Start sampling' button is at the bottom right. A red 'Continue with the wizard' button is located at the bottom right of the main content area.

- w tym celu należy przejść do zakładki Data acquisition
- ◆ sprawdzić nazwę urządzenia
 - ◆ opisać Label czyli nazwę która będzie przyporządkowana zebranym danom
 - ◆ długość trwania próbki
 - ◆ sensory
 - Interactional - RGB, jasność, zblżenie, gesty
 - Environmental - temperatura, wilgotność, ciśnienie
 - Internal - akcelerometr, żyroskop, magnetometr
- w zależności od wybranego sensora tworzymy zbiór danych poprzez "Start sampling"
- ◆ w przypadku zbierania danych z mikrofonu podczas jednej sesji zbierania danych możemy kilkukrotnie wypowiedzieć komendę a następnie próbkę podzielić



- w przypadku uczenia dwóch stanów, minimalną ilością będzie około 20–30 sesji nagrywania danych (ok. 1 minuty)
- należy też pamiętać o zebraniu takiej samej ilości dla stanu neutralnego/błędnego/nieokreślonego
- po ukończeniu nagrywania należy zoptymalizować i podzielić dane na mniejsze porcje w tym celu wchodzimy w Dashboard i na samym dole wybieramy Perform train/test split

DSP file size limit (MB) 4096

Administrative zone

- Custom deploys ?
- Show Linux deploy options ?

Save experiments

Danger zone

- Perform train / test split**
- Launch getting started wizard**
- Delete this project**
- Delete all data in this project**

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Continue with the wizard



Perform train / test split

Are you sure you want to rebalance your dataset? This splits all your data automatically between the training and testing set, and resets the categories for all data. This is irrevocable!

Cancel

Yes, perform the train / test split



Performed train / test split

Dataset was rebalanced!

OK

- kolejnym krokiem jest stworzenie "Impulsu" czyli pipelinu dla uczenia maszynowego
- ◆ blok wejściowy - wskazuje typ danych wejściowych
 - lista wszystkich osi wejściowych
 - rozmiar okna to rozmiar nieprzetworzonych funkcji używanych do trenowania
 - zwiększenie okna służy do sztucznego tworzenia większej ilości funkcji
 - częstotliwość jest obliczana automatycznie na podstawie próbek treningowych i nie jest wskazane jej zmienianie
 - w tym bloku istnieje również opcja wypełnienia brakujących funkcji wartościami zerowymi

- ◆ processing block - blok składa się z operacji DSP (Digital Signal Processing), która służy do wyodrębnienia funkcji, na których uczy się nasz model
- operacja różni się w zależności od używanych danych i to my wybieramy stosowany blok
 - najbardziej zalecane bloki są oznaczane gwiazdką
 - mamy tu również możliwość wybrania istotnych odczytów dla naszego uczenia

The screenshot shows the Edge Impulse interface with a purple header bar containing the text: "An impulse takes raw data, uses signal processing to extract features, and then uses a learning block to classify new data." Below the header, there's a sidebar with navigation links like Dashboard, Devices, Data acquisition, and Impulse design. The main area has a red-themed 'Time series data' block on the left and a 'Spectral Analysis' block on the right. The 'Spectral Analysis' block has a 'Name' field set to "Spectral features". Under 'Input axes (6)', several checkboxes are checked: accX, accY, accZ, gyrX, gyrY, and gyrZ. A green 'Save Impulse' button is visible at the bottom right.

- ◆ learning block – tutaj nadchodzi wybór sieci neuronowej wyszkolonej do uczenia się na danych
 - tutaj też wybór zależy od nas, a polecone wybory są oznaczone gwiazdką

The screenshot shows the Edge Impulse interface with a modal dialog titled "Add a learning block". The dialog lists several learning blocks:

- Classification**: "Learns patterns from data, and can apply these to new data. Great for categorizing movement or recognizing audio." by Edge Impulse. An "Add" button is shown.
- Anomaly Detection (K-means)**: "Find outliers in new data. Good for recognizing unknown states, and to complement classifiers. Works best with low dimensionality features like the output of the spectral features block." by Edge Impulse. An "Add" button is shown.
- Regression**: "Learns patterns from data, and can apply these to new data. Great for predicting numeric continuous values." by Edge Impulse. An "Add" button is shown.
- Classification (Keras) - BrainChip Akida™**: "Learns patterns from data, and can apply these to new data. Great for categorizing movement or recognizing audio." by BrainChip. An "Add" button is shown.

 A note at the bottom of the dialog says: "Some learning blocks have been hidden based on the data in your project. Show all blocks anyway". A "Cancel" button is at the bottom right of the dialog.

→ po dostosowaniu wszystkich bloków zapisujemy impuls

→ kolejnym krokiem w tworzeniu impulsu jest wygenerowanie spectral features

- ◆ jest to wyodrębnienie częstotliwości, mocy innych cech sygnału
- ◆ po tym etapie będzie już możliwe rozróżnienie cech dla poszczególnych zbiorów danych (labels)

- ostatnim etapem jest zrealizowanie uczenia (w poniższym przykładzie jest to klasyfikator - Classifier)
- ◆ oprócz ustawień sieci, możemy jeszcze edytować architekture
 - zalecane jest dodanie trzeciej warstwy (Dense) której liczba neuronów będzie równa liczbie zbiorów które rozpoznajemy
 - po dodaniu rozpoczynamy trenowanie sieci - Strat traing

EDGE IMPULSE

Julia Dominiak / ArduinoTest

#1 Click to set a description for this version

Neural Network settings

Training settings

Number of training cycles: 30

Learning rate: 0.0005

Advanced training settings

Neural network architecture

Input layer (78 features)

Dense layer (20 neurons)

Dense layer (10 neurons)

Add an extra layer

Output layer (3 classes)

Start training

Training output

Target: Cortex-M4F 80MHz

(0)

Continue with the wizard

EDGE IMPULSE

Julia Dominiak / ArduinoTest

#1 Click to set a description for this version

Neural network architecture

Add an extra layer

Did you know? You have access to the full set of Keras layers through the Expert view (click on to switch), or can even bring your own model (in PyTorch, Keras or scikit-learn).

LAYER TYPE

Dense
Fully connected layer, the simplest form of a neural network layer. Use this for processed data, such as the output of a spectral analysis DSP block.

1D Convolution / pooling
Learn features that take spatial information into account along a single dimension. Use this for raw data, or for DSP blocks that output spatial data, such as the MFCC block.

2D Convolution / pooling
Learn features that take spatial information into account along two dimensions. Use this for raw data, or for DSP blocks that output spatial data, such as the MFCC block.

Reshape
Turn one-dimensional data from a DSP block into multi-dimensional data. Use this as an input to a convolutional layer. Use this for deep learning on raw data, or to process MFCC output.

Flatten
Flatten multi-dimensional data into a single dimension. You need to flatten data from a convolutional layer before returning.

Dropout
Reduce the risk of a model overfitting your dataset by randomly cutting a fraction of network connections during training. Can be helpful if your model's training performance is better than its validation performance.

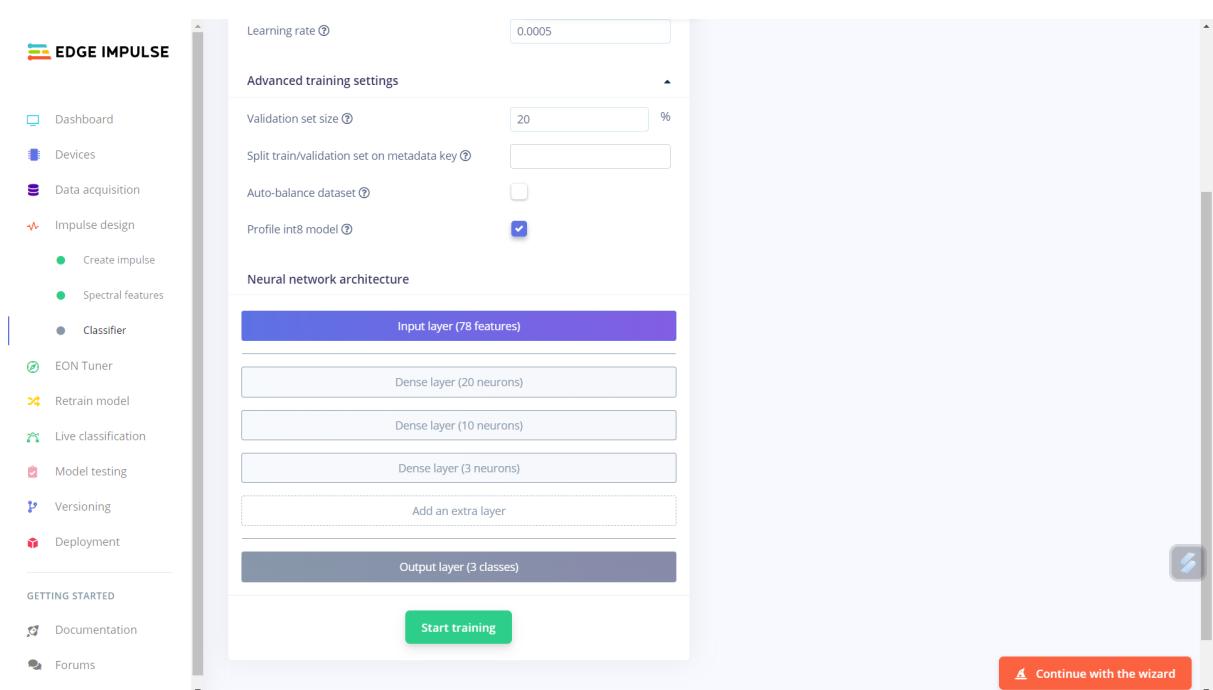
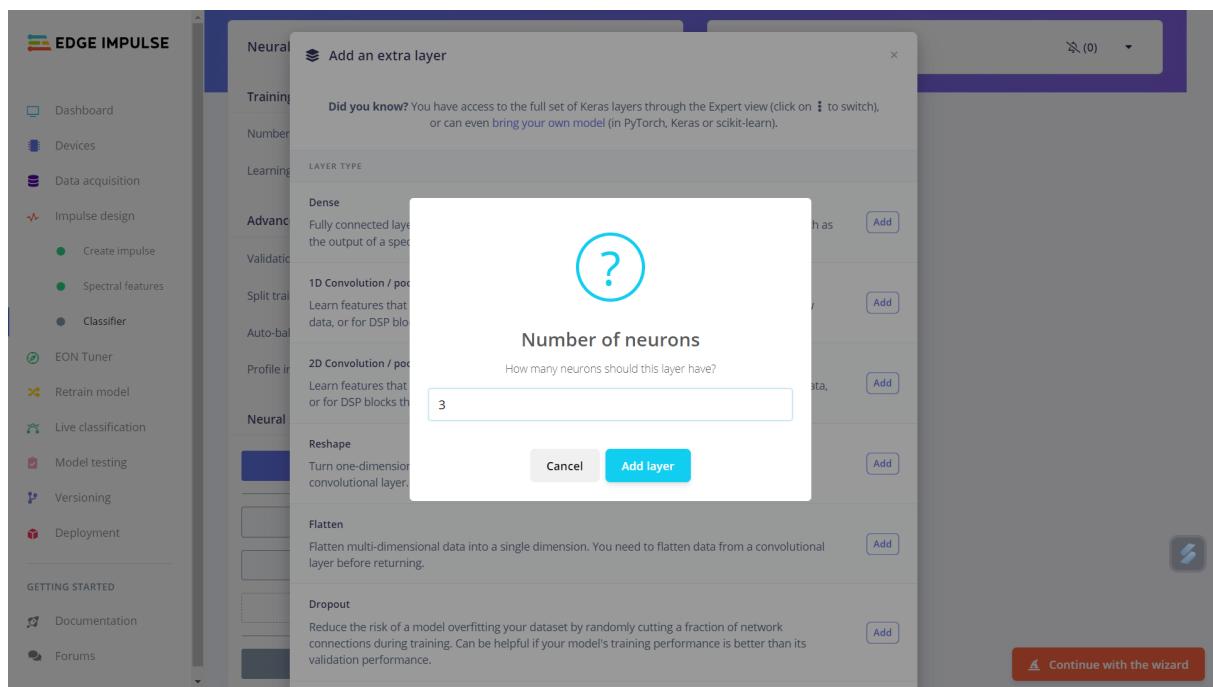
Start training

Training output

Target: Cortex-M4F 80MHz

(0)

Continue with the wizard



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

```

    graph TD
        Input[Input layer (78 features)] --> Dense1[Dense layer (20 neurons)]
        Dense1 --> Dense2[Dense layer (10 neurons)]
        Dense2 --> Dense3[Dense layer (3 neurons)]
        Dense3 --> Output[Output layer (3 classes)]
    
```

Start training

Attached to job 8771725...
Attached to job 8771725...
Profiling int8 model...
Profiling int8 model (TensorFlow Lite Micro)...
Profiling int8 model (EOM)...
Attached to job 8771725...
Attached to job 8771725...

Model training complete
Job completed

Model Model version: Quantized (int8)

Last training performance (validation set)

ACCURACY	100.0%	LOSS	0.42
----------	--------	------	------

Confusion matrix (validation set)

	LEFT	NO	UP
LEFT	100%	0%	0%
NO	0%	100%	0%
UP	0%	0%	100%
F1 SCORE	1.00	1.00	1.00

Data explorer (full training set)

Legend: left - correct (green), no - correct (blue), up - correct (orange), up - incorrect (red)

Continue with the wizard

- po wyuczeniu sieci zalecane jest jej przetestowanie na próbkach które były oddzielone od zbioru na którym sieć była uczona
- ◆ wybieramy z listy Model testing i uruchamiamy proces

This lists all test data. You can manage this data through Data acquisition.

Test data Model testing output

SAMPLE NAME	EXPECTED OUTCOME	LENGTH	ACCURACY	RESULT
left.3vp...uo...	left	5s		
left.3vpuni...	left	5s		
no.3vpumj...	no	5s		
no.3vpum...	no	5s		
no.3vpulfle	no	5s		
up.3vpuki0t	up	5s		

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Continue with the wizard

- po sprawdzeniu sieci ostatnim etapem jest wyeksportowanie pliku który będzie możliwy do wgrania w Arduino IDE
- ◆ z listy wybieramy Deployment
 - ◆ Arduino
 - ◆ dokonujemy Analyze optimizations
 - ◆ Build

EDGE IMPULSE

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

GETTING STARTED

- Documentation
- Forums

Deploy your impulse

You can deploy your impulse to any device. This makes the model run without an internet connection, minimizes latency, and runs with minimal power consumption. [Read more.](#)

Create library

Turn your impulse into optimized libraries for your device.

WebAssembly	NVIDIA TensorRT library	Ethos-U library
Tensal Flow library	Meta TF Model	TIDL-RT Library
LIRRA library	Blinka library	CUSTOM library

[Continue with the wizard](#)

EDGE IMPULSE

- Dashboard
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- Retrain model
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- Deployment**

GETTING STARTED

- Documentation
- Forums

Select optimizations (optional)

Model optimizations can increase on-device performance but may reduce accuracy. Click below to analyze optimizations and see the recommended choices for your target. Or, just click Build to use the currently selected options.

Enable EON™ Compiler
Same accuracy, up to 50% less memory. Open source.

Available optimizations for Classifier

	RAM USAGE	LATENCY
Quantized (int8) Currently selected	1,4K	1 ms
	FLASH USAGE	ACCURACY
	15,7K	-
Unoptimized (float32) Click to select	RAM USAGE	LATENCY
	1,6K	8 ms
	FLASH USAGE	ACCURACY
	16,8K	-

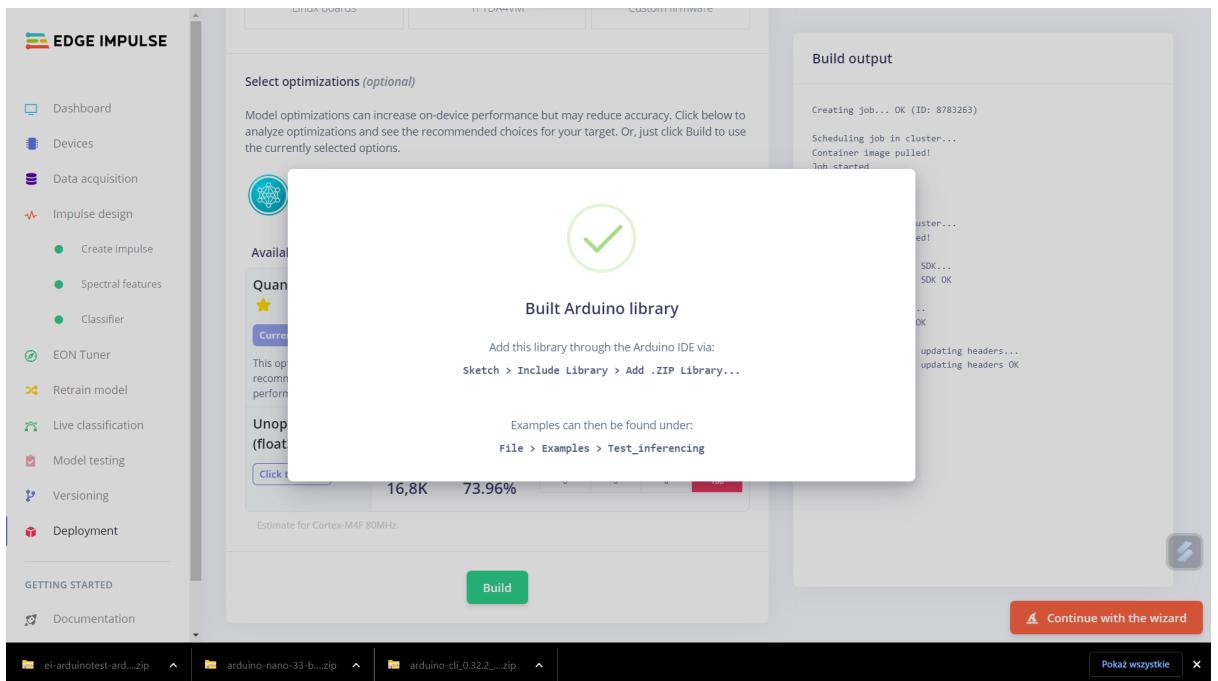
Estimate for Cortex-M4F 80MHz.

[Analyze optimizations](#)

[Build](#)

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[Continue with the wizard](#)



- uzyskany plik wgrywamy do Arduino IDE w postaci biblioteki .zip
- testujemy nasz model

