



DesignNews

Developing Machine-Learning Applications on the Raspberry Pi Pico

DAY 3 : Collecting Sensor Data Using Edge Impulse

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Webinar Logistics

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- Participate in ‘Group Chat’ by maximizing the chat widget in your dock.
- Submit questions for the lecturer using the Q&A widget. They will follow-up after the lecture portion concludes.

THE SPEAKER



Jacob Beningo

Visit 'Lecturer Profile'

Beningo Embedded Group - President

Focus: Embedded Software Consulting

An independent consultant who specializes in the design of real-time, microcontroller based embedded software.

He has published two books:

- [Reusable Firmware Development](#)
- [MicroPython Projects](#)
- [Embedded Software Design \(https://bit.ly/3PZCtNO\)](https://bit.ly/3PZCtNO)

Writes a weekly blog for DesignNews.com focused on embedded system design techniques and challenges.

Visit www.benigo.com to learn more ...

Visit 'Lecturer Profile' in your console for more details.

Course Sessions

- Getting Started with the Raspberry Pi Pico and Machine Learning
- Machine-Learning Tools and Process Flow
- **Collecting Sensor Data Using Edge Impulse**
- Designing and Testing a Machine-Learning Model
- Deploying Machine-Learning Models and Next Steps

1

Raspberry Pi Pico Board Setup

Do you plan on following along while we set up the board?

- Yes
- No

Edge Impulse

Edge Impulse was designed for software developers, engineers and domain experts to solve real problems using machine learning on edge devices without a PhD in machine learning.

www.edgeimpulse.com

EDGE IMPULSE

- Dashboard
- Devices
- Data acquisition
- Impulse design
 - Create impulse
 - Spectral features
 - Spectrogram
 - NN Classifier
 - Anomaly detection
- Retrain model
- Live classification
- Model testing
- Versioning

Creating your first impulse (100% complete)

- Acquire data**

Every Machine Learning project starts with data. You can capture data from a development board or your phone, or import data you already collected.

LET'S COLLECT SOME DATA
- Design an impulse**

Teach the model to interpret previously unseen data, based on historical data. Use this to categorize new data, or to find anomalies in sensor readings.

GETTING STARTED: CONTINUOUS MOTION RECOGNITION

GETTING STARTED: RESPONDING TO YOUR VOICE

GETTING STARTED: ADDING SIGHT TO YOUR SENSORS
- Deploy**

Package the complete impulse up, from signal processing code to trained model, and deploy it on your device. This ensures that the impulse runs with low latency and without requiring a network connection.

DEPLOY YOUR MODEL

Edge Impulse



Sign up

I accept the [Privacy Policy](#), [Terms of Service](#),
and [Responsible AI License](#).

Sign up

Already have an account? [Log in](#)



Start building embedded
machine learning
models today.

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Edge Impulse

DevBoards Running EdgImpulse Software

**Data Collection
Model Design**

**Training
Live Testing
Model Validation**

EDGE IMPULSE

Dashboard

Devices

Data acquisition

Impulse design

- Create impulse
- Spectral features
- Spectrogram
- NN Classifier
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Retrain model

Live classification

Model testing

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DEPLOY YOUR MODEL

Design Space

Edge Impulse – Board Setup

Visit <https://docs.edgeimpulse.com/docs>

Officially supported MCU targets

- OpenMV Cam H7 Plus
- Silicon Labs xG24 Dev Kit
- Silicon Labs Thunderboard Sense 2
- Sony's Spresense
- ST B-L475E-IOT01A
- Synaptics Katana EVK
- Syntiant TinyML Board
- TI CC1352P Launchpad
- Raspberry Pi RP2040

Edge Impulse – Board Setup

Installation - macOS and Windows

1. Install [Python 3](#) on your host computer.
2. 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.
3. Install the CLI tools via:

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

You should now have the tools available in your PATH.

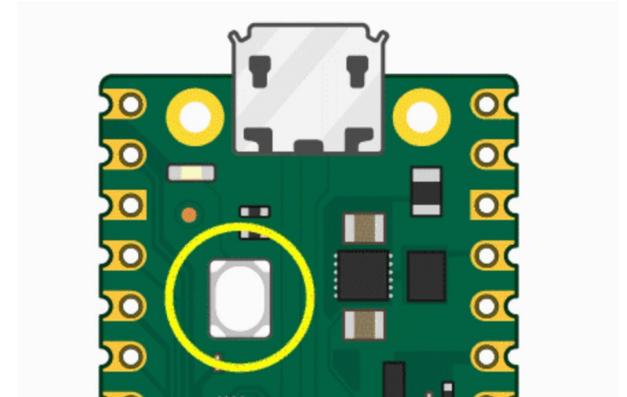
1. If you haven't already, create an [edge impulse account](#). Many of our CLI tools require the user to log in to connect with the Edge Impulse Studio.

Edge Impulse Board Setup

1 Download the Edge Impulse RP2040 Firmware at:

Power on the Pico while holding the bootsel pin

Unzip and drag the uf2 image to the mass storage device folder



Edge Impulse – Board Setup

2 Update Firmware

- 1) The development board is mounted as a USB mass-storage device (like a USB flash drive). Make sure you can see this drive.
- 2) Download the latest Edge Impulse firmware from:
 - <https://cdn.edgeimpulse.com/firmware/pi-rp2040.zip> **(Warning! Will not be deployable!)**
 - <https://github.com/edgeimpulse/firmware-pi-rp2040>
- 3) Drag the ei_rp2040_firmware.uf2 file to the drive.
- 4) Give the board a minute to finish updating the firmware. There is no need to power cycle the board.



Edge Impulse – Board Setup

3 Setting keys and WiFi credentials

From a command prompt or terminal, run:

```
$ edge-impulse-daemon
```

This will start a wizard which will ask you to log in, choose an Edge Impulse project, and set up your WiFi network. If you want to switch projects run the command with --clean.

```
beningo — node /usr/local/bin/edge-impulse-daemon — 119x23
beningo@Jacobs-MacBook-Pro ~ % edge-impulse-daemon
Edge Impulse serial daemon v1.16.0
Endpoints:
  Websocket: wss://remote-mgmt.edgeimpulse.com
  API:       https://studio.edgeimpulse.com
  Ingestion: https://ingestion.edgeimpulse.com

[SER] Connecting to /dev/tty.usbmodem2141401
[SER] Serial is connected, trying to read config...
[SER] Retrieved configuration
[SER] Device is running AT command version 1.6.0

Setting upload host in device... OK
Configuring remote management settings... OK
Configuring API key in device... OK
Configuring HMAC key in device... OK
[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? PicoBoard
[WS ] Device "PicoBoard" is now connected to project "Beningo-project-1"
[WS ] Go to https://studio.edgeimpulse.com/studio/25637/acquisition/training to build your m
█
```

\$ edge-impulse-daemon
This will start a wizard which will ask you to log in, choose an Edge Impulse project, and set up your WiFi network. If you want to switch projects run the command with
-clean



Edge Impulse – Board Setup

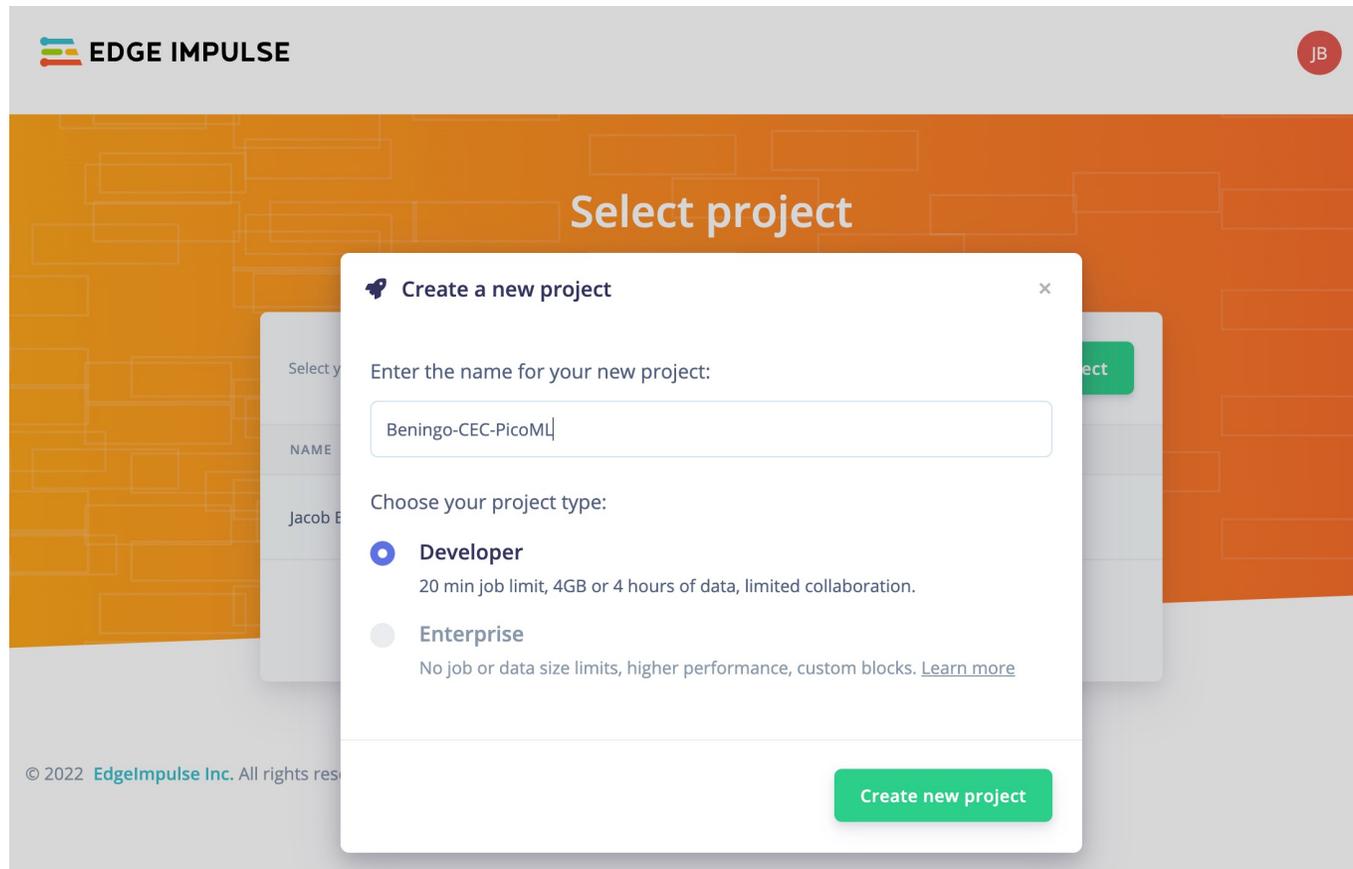
4 Verify that the device is connected

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	REMOTE ...	LAST SEEN
 PicoBoard	45:36:31:33:38:39	RASPBERRY_PI_RP2040	Ultrasonic ranger, ADC sensor, Ultr...		Today, 11:52:00
 C4:7F:51:03:EC:54	C4:7F:51:03:EC:54	DISCO_L475VG_IOT01A	Built-in accelerometer, Built-in micr...		Apr 24 2021, 21:31:01

Edge Impulse – Project Creation



The screenshot shows the Edge Impulse web interface. At the top left is the 'EDGE IMPULSE' logo. At the top right is a user profile icon with the initials 'JB'. The main heading is 'Select project'. A modal dialog box titled 'Create a new project' is open in the center. It contains the following fields and options:

- Enter the name for your new project:
- Choose your project type:
 - Developer**
20 min job limit, 4GB or 4 hours of data, limited collaboration.
 - Enterprise**
No job or data size limits, higher performance, custom blocks. [Learn more](#)

At the bottom right of the dialog is a green button labeled 'Create new project'. At the bottom left of the page, there is a copyright notice: '© 2022 EdgImpulse Inc. All rights reserved.'

2

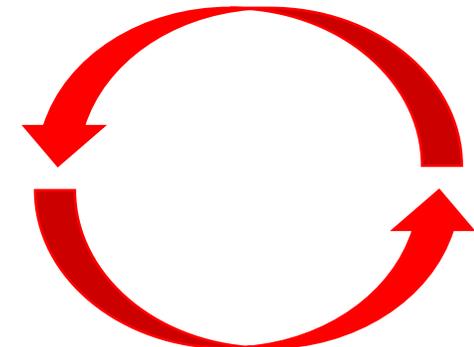
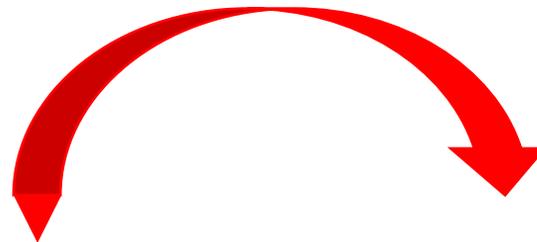
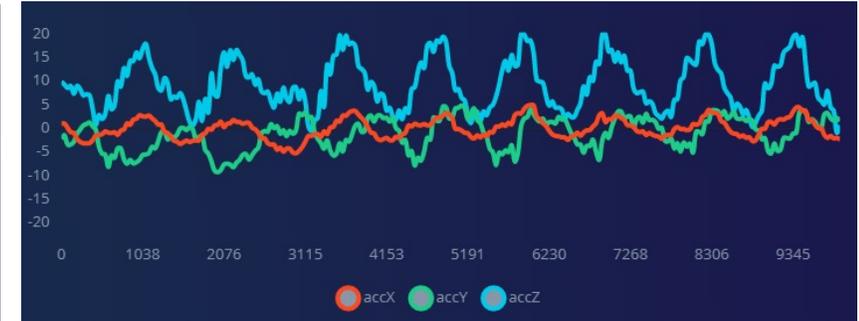
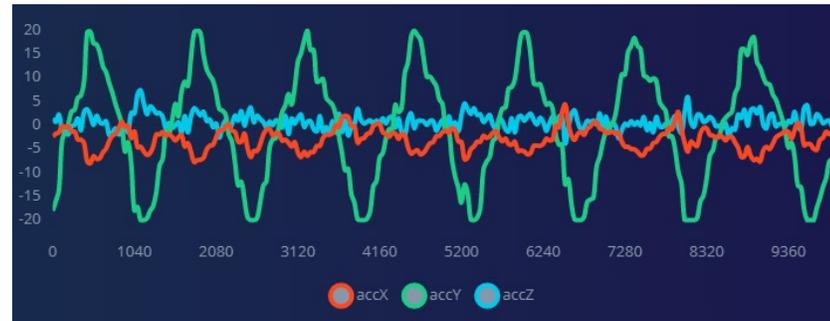
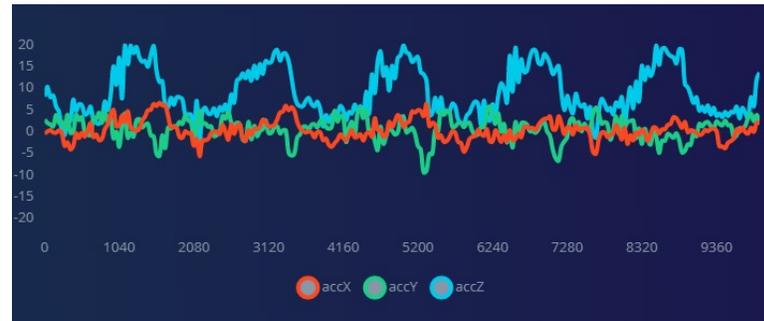
Collecting Sensor Data

Example Application – Gesture Classification

Label 1 – Up and Down

Label 2 – Wave

Label 3 – Circle



Connect the Pico to our Project

```
beningo@Jacobs-MacBook-Pro ~ % edge-impulse-daemon --clean
Edge Impulse serial daemon v1.16.0
? What is your user name or e-mail address (edgeimpulse.com)? jacob@beningo.com
? What is your password? [hidden]
Endpoints:
  Websocket: wss://remote-mgmt.edgeimpulse.com
  API:       https://studio.edgeimpulse.com
  Ingestion: https://ingestion.edgeimpulse.com

[SER] Connecting to /dev/tty.usbmodem2141401
[SER] Serial is connected, trying to read config...
[SER] Clearing configuration
[SER] Clearing configuration OK
[SER] Retrieved configuration
[SER] Device is running AT command version 1.6.0

? To which project do you want to connect this device? (Use arrow keys)
> Jacob Beningo / Beningo-project-1
Jacob Beningo / Beningo-CEC-PicoML
```

Summary



DEVICES CONNECTED

1



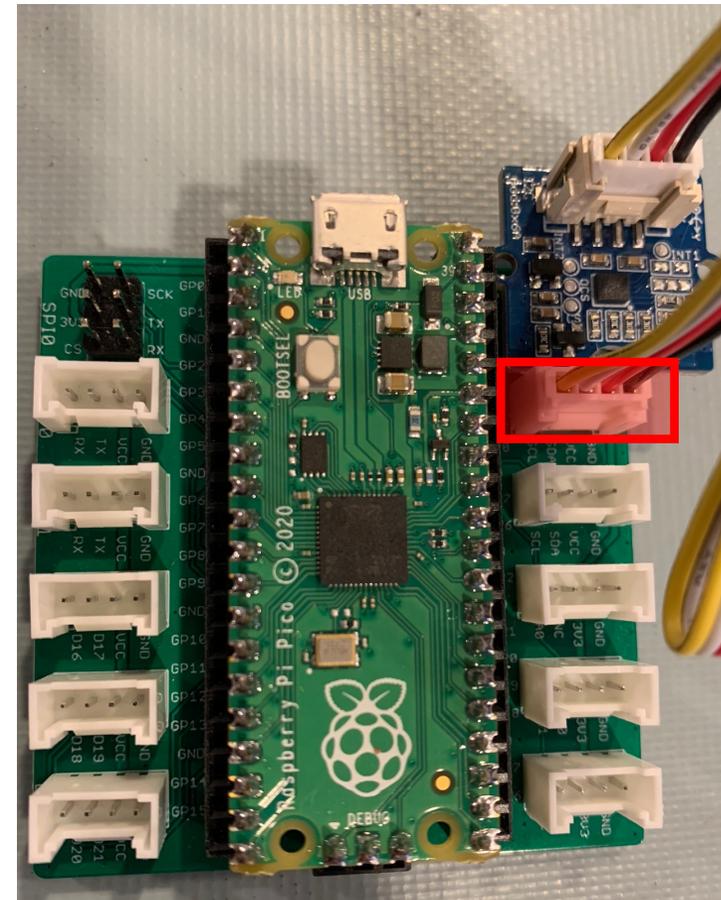
DATA COLLECTED

-

Connect the LSM6DS3 Accelerometer

- 3-axis accelerometer
- 3-axis gyroscope
- Connects to I2C1

Parameter	Value
Analog supply voltage:	5V/3.3V(DC)
Power consumption:	0.9 mA in combo normal mode and 1.25 mA in combo high-performance mode up to 1.6 kHz
Linear acceleration measurement range	$\pm 2/\pm 4/\pm 8/\pm 16$ g full scale (typical value)
Angular rate measurement range	$\pm 125, \pm 245, \pm 500, \pm 1000, \pm 2000$ dps (typical value)
Linear acceleration sensitivity	0.061(FS = ± 2), 0.122(FS = ± 4), 0.244(FS = ± 8), 0.488(FS = ± 16) mg/LSB
Angular rate sensitivity	4.375(FS = ± 125), 8.75(FS = ± 245), 17.50(FS = ± 500), 35(FS = ± 1000), 70(FS = ± 2000)



Capturing and Labeling Data

Creating your first impulse (0% complete)



Acquire data

Every Machine Learning project starts with data. You can capture data from a development board or your phone, or import data you already collected.

[LET'S COLLECT SOME DATA](#)

Collect data

You can collect data from development boards, from your own devices, or by uploading an existing dataset.



Connect a fully supported development board

Get started with real hardware from a wide range of silicon vendors - fully supported by Edge Impulse.

[Browse dev boards](#)



Use your mobile phone

Use your mobile phone to capture movement, audio or images, and even run your trained model locally. No app required.

[Show QR code](#)



Use your computer

Capture audio or images from your webcam or microphone, or from an external audio device.

[Collect data](#)



Data from any device with the data forwarder

Capture data from any device or development board over a serial connection, in 10 lines of code.

[Show docs](#)



Upload data

Already have data? You can upload your existing datasets directly in WAV, JPG, PNG, CBOR, CSV, JSON, MP4 or AVI format.

[Go to the uploader](#)



Integrate with your cloud

The enterprise version of Edge Impulse integrates directly with the data stored in your cloud platform.

[Learn more...](#)

Capturing and Labeling Data

EDGE IMPULSE

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

Jacob Beningo / Beningo-CEC-PicoML

JB

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](#)

Collected data

No data collected yet

Let's collect some data

Record new data

Connect using WebUSB

Device

PicoBoard

Label

Label name

Sample length (ms.)

10000

Sensor

ADC sensor

Frequency

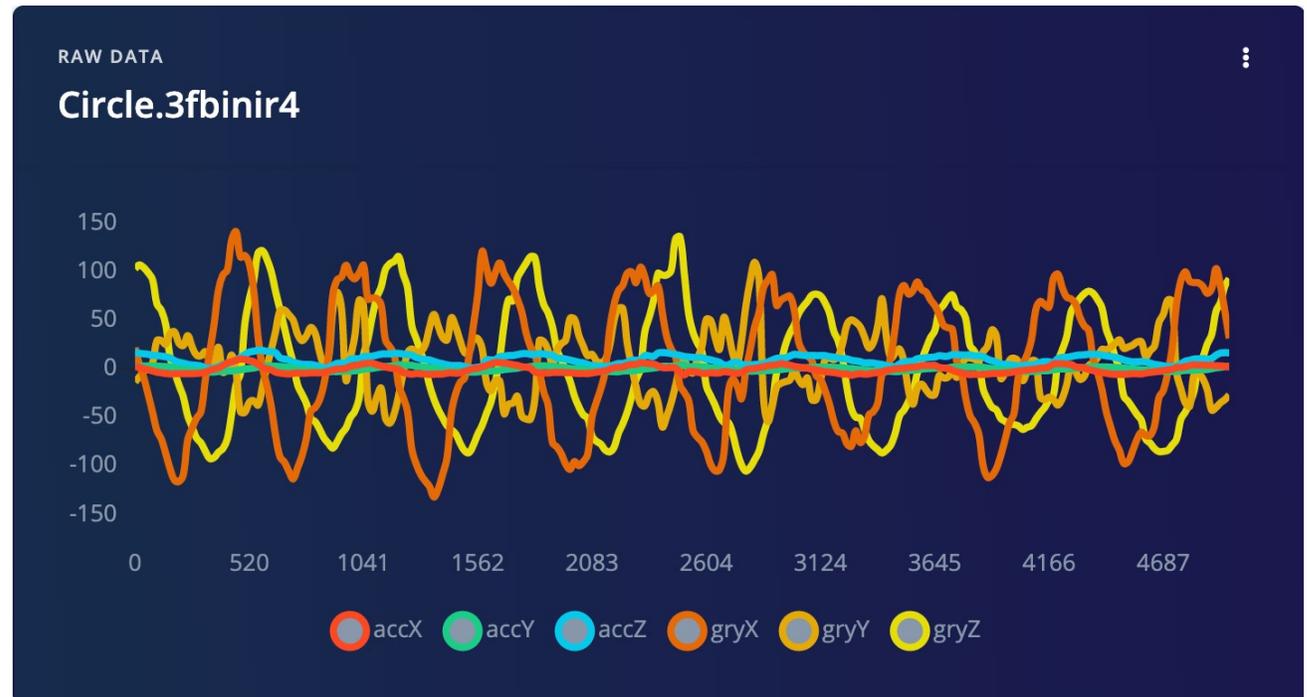
100Hz

Start sampling

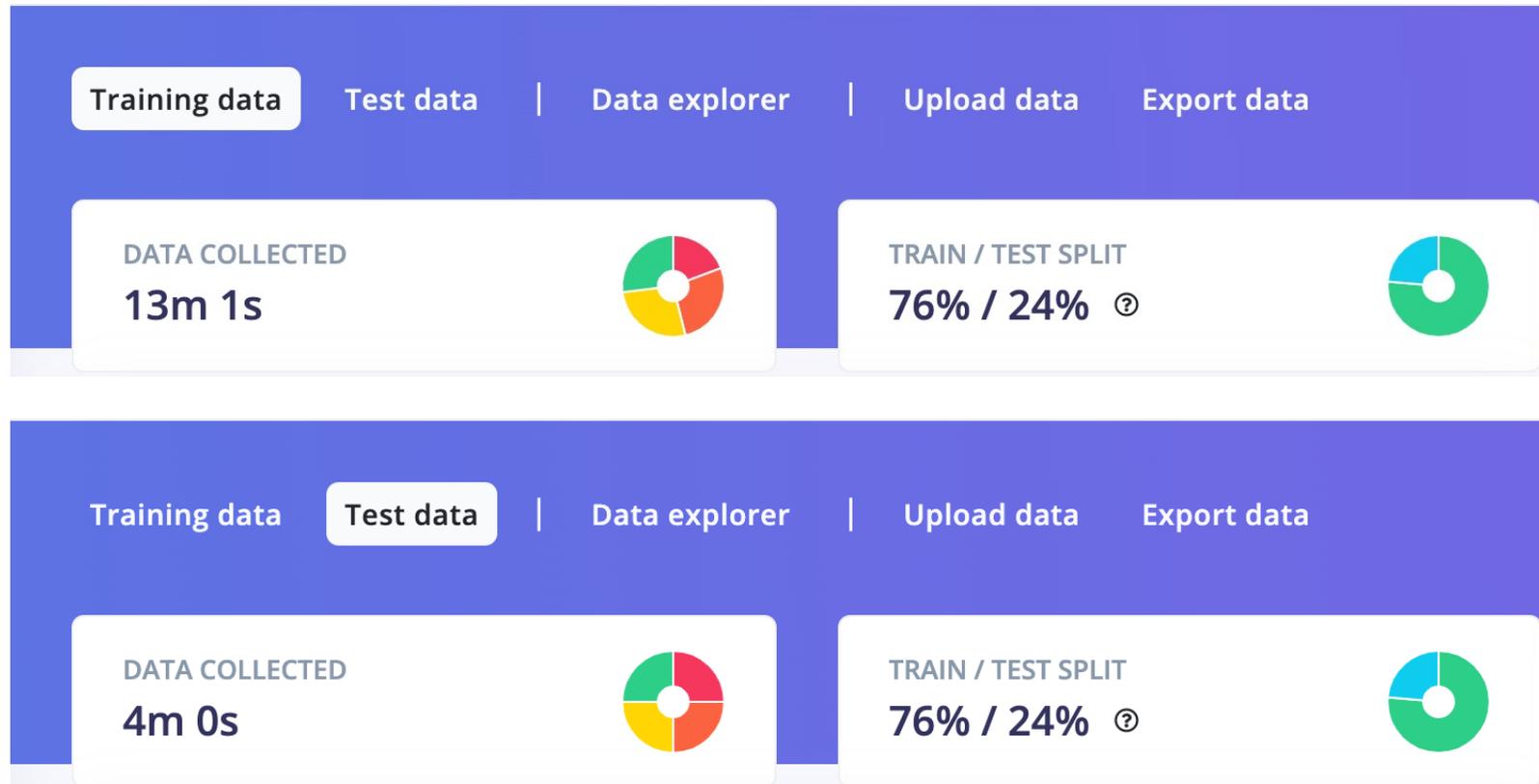
Capturing and Labeling Data

Gestures

- Idle
- Up / Down
- Wave
- Circle
- Snake
- etc



Capturing and Labeling Data



Do you plan on collecting your own data so that you can train your own model during tomorrows class?

- Yes
- No
- undecided

4

Going Further

Thank you for attending

Please consider the resources below:

- www.beningo.com
 - Blog, White Papers, Courses
 - Embedded Bytes Newsletter
 - <http://bit.ly/1BAHYXm>
 - Embedded Software Design
 - <https://bit.ly/3PZCtNO>



From www.beningo.com under

- Blog > CEC – Developing Machine-Learning Applications on the Raspberry Pi Pico



Thank You

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