IESTI01 - TinyML

Gesture Classification
Edge Impulse Studio Project

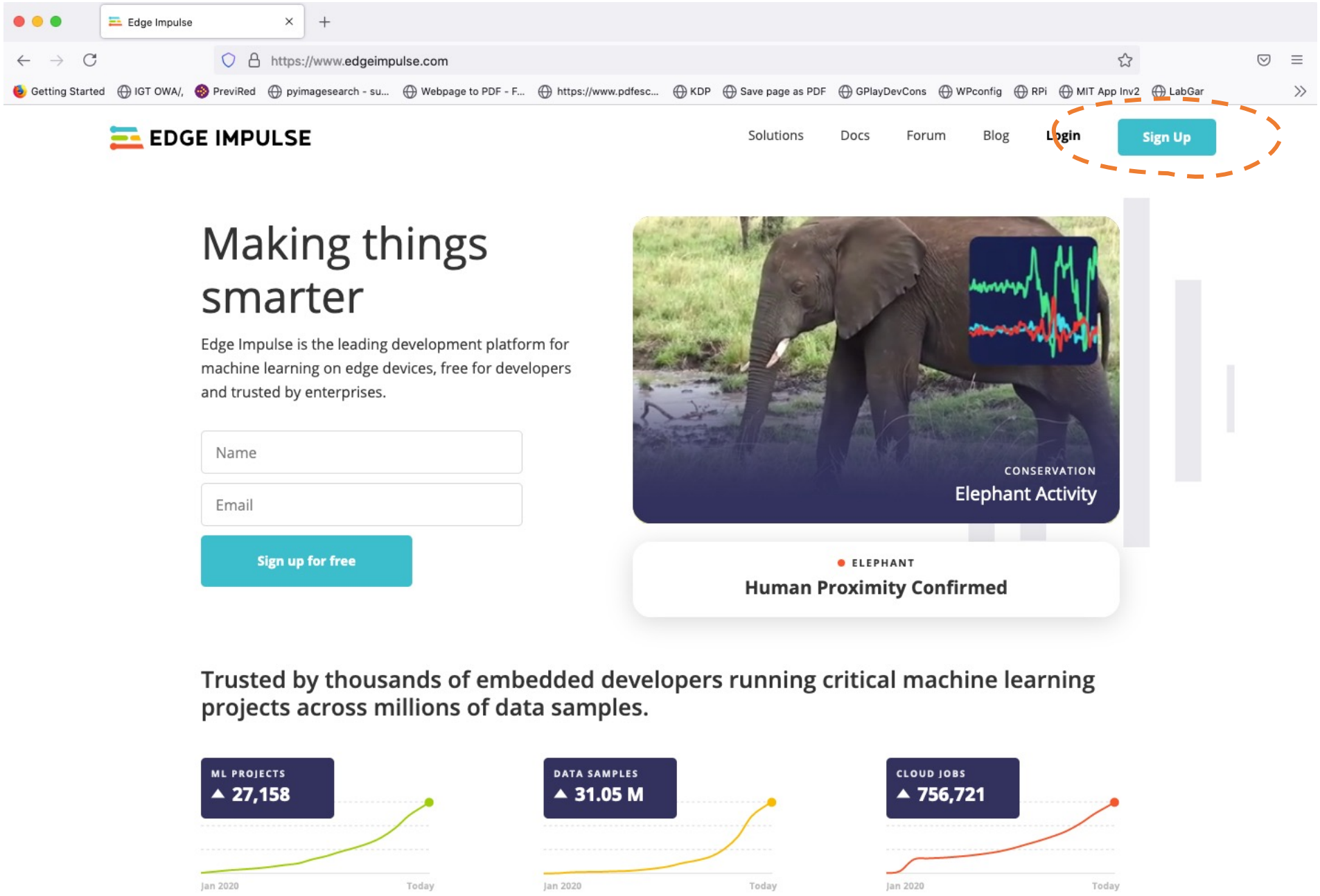
Prof. Marcelo Rovai

June 16th, 2021

Feature Extraction & Gesture Classification

Project Time!

ei-motion-project-nn-classifier.ipynb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pyimagesearch - su...
Webpage to PDF - F...
https://www.pdfesc...
KDP
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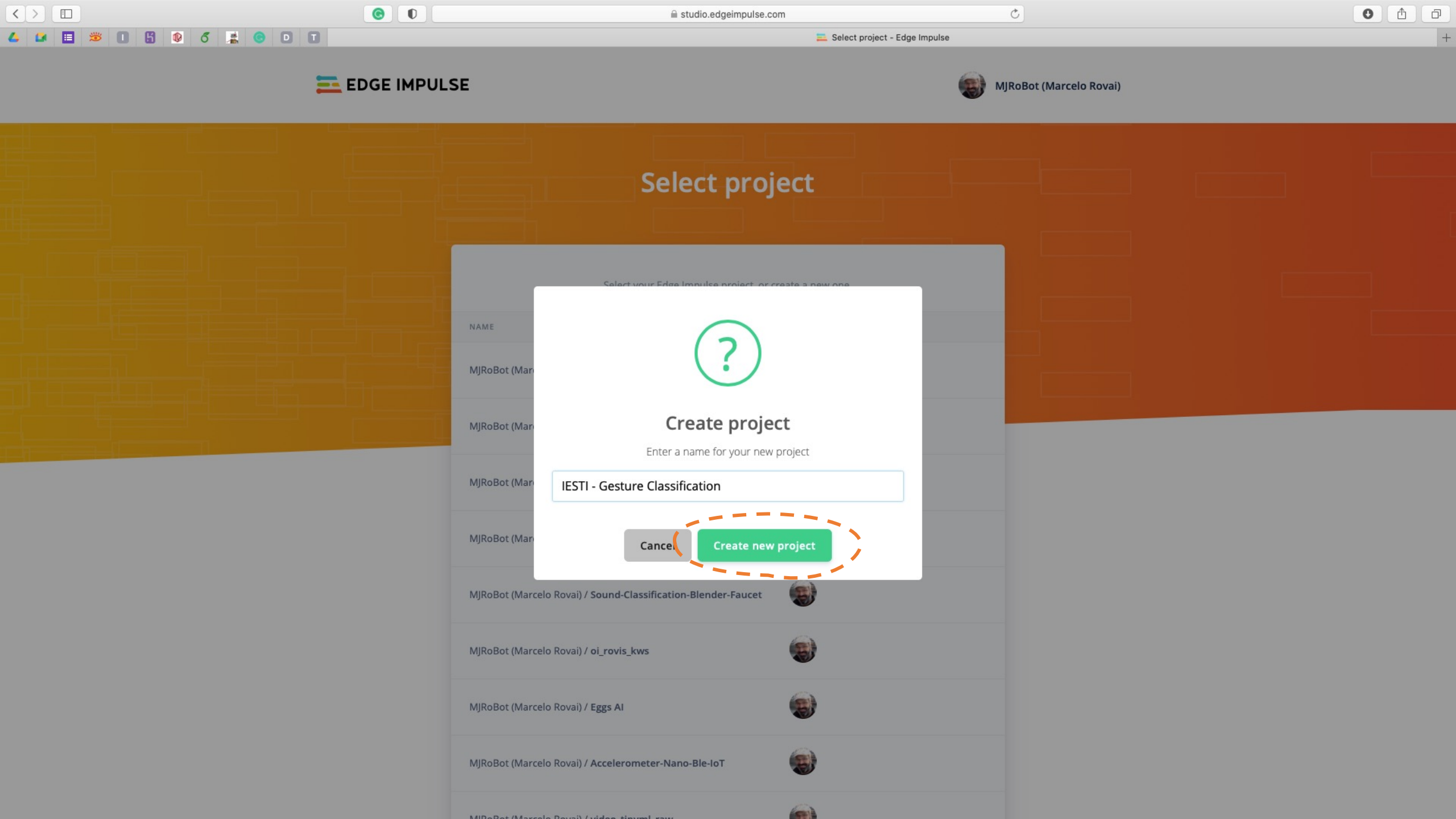
ML PROJECTS
▲ 27,158
Jan 2020
Today
DATA SAMPLES
▲ 31.05 M
Jan 2020
Today
CLOUD JOBS
▲ 756,721
Jan 2020
Today


studio.edgeimpulse.com
Select project - Edge Impulse
EDGE IMPULSE
MJRoBot (Marcelo Rovai)
Select project
NAME
MJRoBot (Mar
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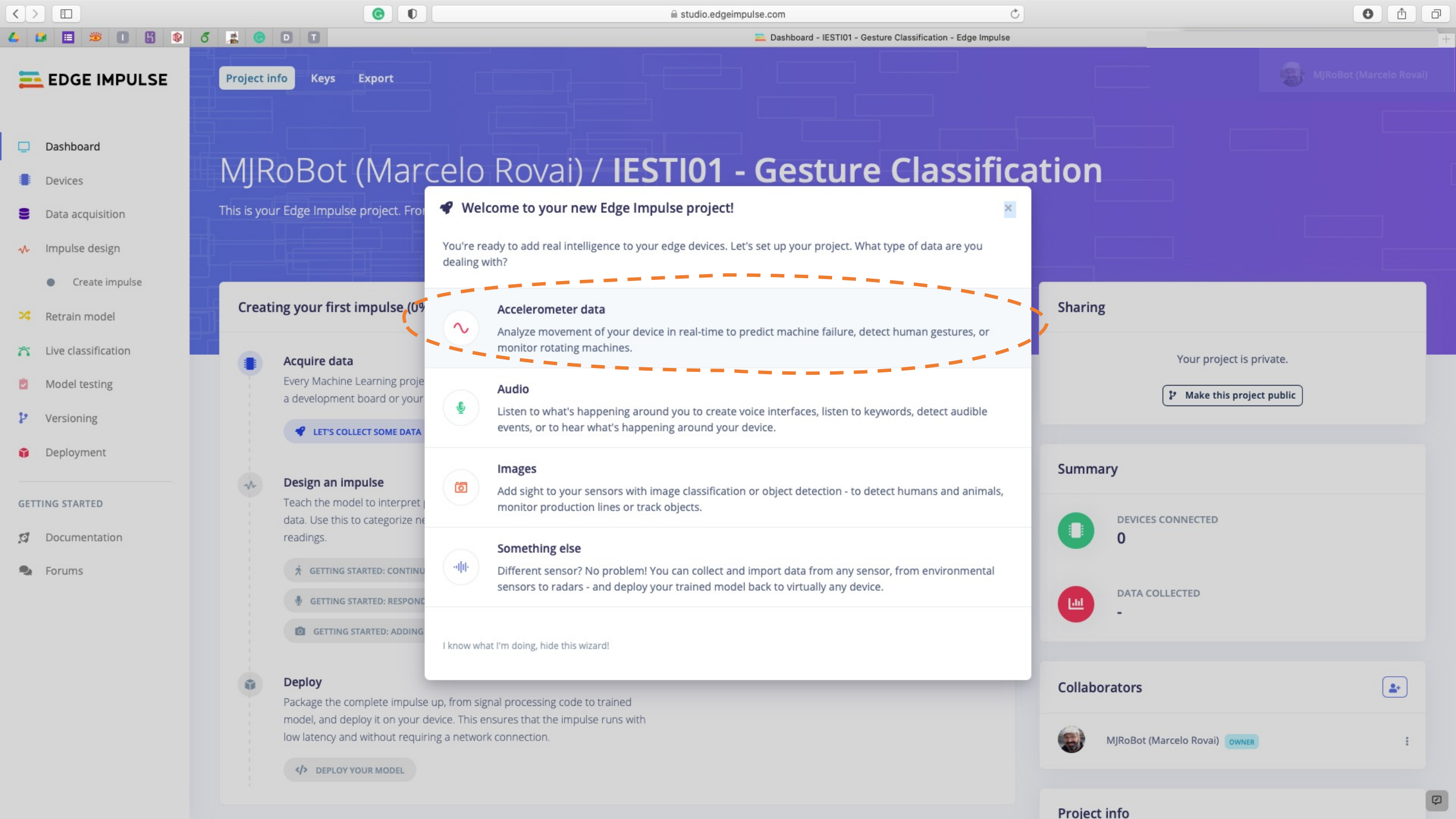
MJRoBot (Marcelo Rovai) / Sound-Classification-Blender-Faucet
MJRoBot (Marcelo Rovai) / oi_rovis_kws
MJRoBot (Marcelo Rovai) / Eggs AI
MJRoBot (Marcelo Rovai) / Accelerometer-Nano-Ble-IoT
Create project
Enter a name for your new project
IESTI - Gesture Classification
Cancel
Create new project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Keys
Export
MJRoBot (Marcelo Rovai)
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Live classification
Model testing
Versioning
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MJRoBot (Marcelo Rovai) / IESTI01 - Gesture Classification
This is your Edge Impulse project. Fro
Welcome to your new Edge Impulse project!
You're ready to add real intelligence to your edge devices. Let's set up your project. What type of data are you dealing with?
Accelerometer data
Analyze movement of your device in real-time to predict machine failure, detect human gestures, or monitor rotating machines.
Audio
Listen to what's happening around you to create voice interfaces, listen to keywords, detect audible events, or to hear what's happening around your device.
Images
Add sight to your sensors with image classification or object detection - to detect humans and animals, monitor production lines or track objects.
Something else
Different sensor? No problem! You can collect and import data from any sensor, from environmental sensors to radars - and deploy your trained model back to virtually any device.
I know what I'm doing, hide this wizard!
Creating your first impulse (0%
Acquire data
Every Machine Learning proje
a development board or your
LET'S COLLECT SOME DATA
Design an impulse
Teach the model to interpret
data. Use this to categorize ne
readings.
GETTING STARTED: CONTINU
GETTING STARTED: RESPOND
GETTING STARTED: ADDING
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
Sharing
Your project is private.
Make this project public
Summary
DEVICES CONNECTED
0
DATA COLLECTED
-
Collaborators
MJRoBot (Marcelo Rovai)
OWNER
Project info

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  - Create impulse
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- Versioning
- Deployment

GETTING STARTED

- Documentation
- Forums

MJRoBot (Marcelo Rovai) / **IESTI01 - Gesture Classification**

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

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

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

Sharing

Your project is private.

Make this project public

Summary

DEVICES CONNECTED
0

DATA COLLECTED
-

Collaborators

MJRoBot (Marcelo Rovai) OWNER

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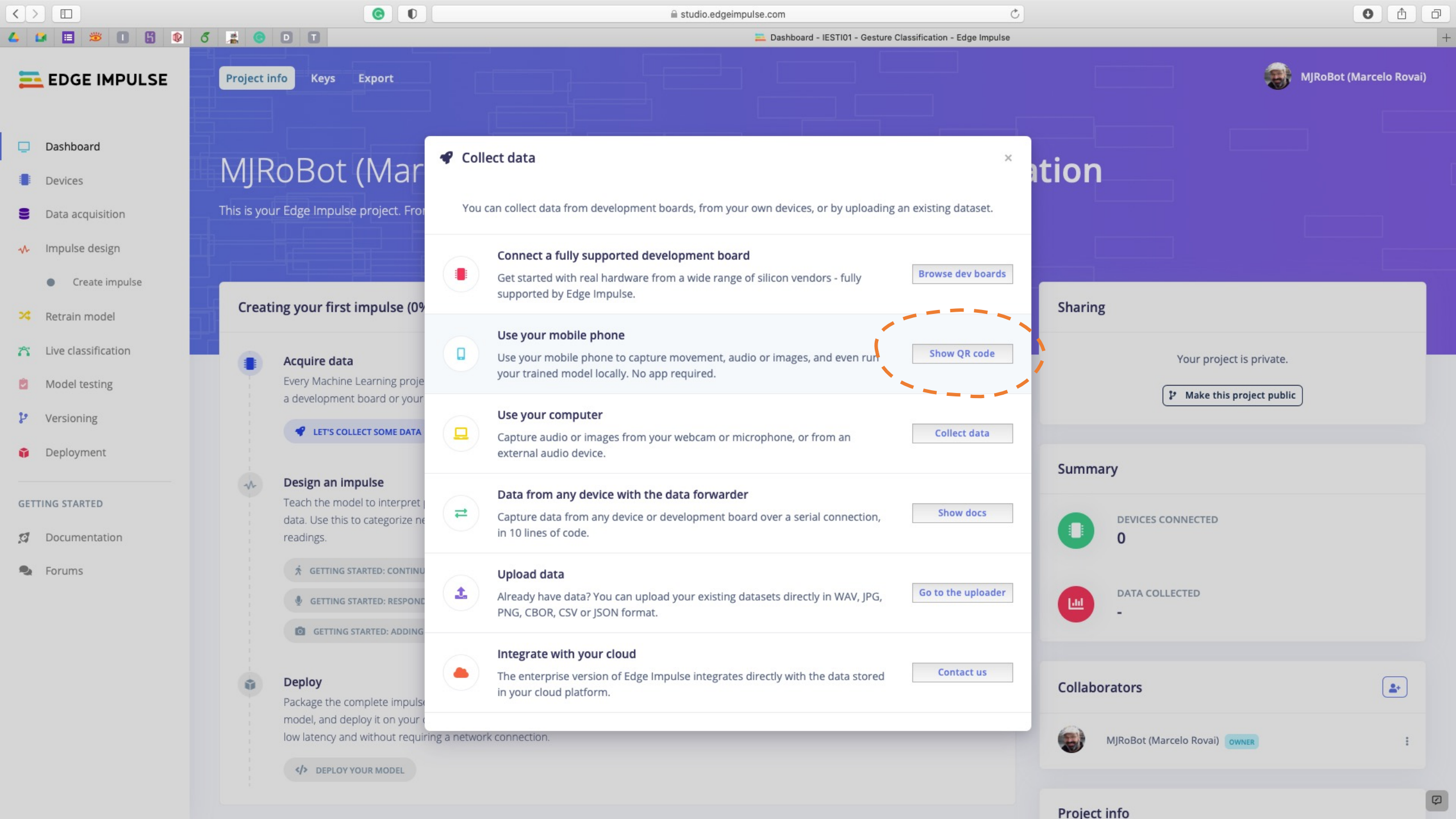
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data. Use this to categorize ne
readings.
GETTING STARTED: CONTINU
GETTING STARTED: RESPOND
GETTING STARTED: ADDING
Deploy
Package the complete impuls
model, and deploy it on your
low latency and without requiring a network connection.
DEPLOY YOUR MODEL
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 or JSON 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.
Contact us
Sharing
Your project is private.
Make this project public
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-
Collaborators
MJRoBot (Marcelo Rovai)
OWNER
Project info

EDGE IMPULSE

Project info | Keys | Export

MJRoBot (Marcelo Rovai)

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MJRoBot (Marcelo Rovai) / **IESTI01 - Gesture Classification**

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

Collect data

You can collect data from any smartphone. From your smartphone go to this URL, or scan the QR code below.

Creating your first impulse (0%

Acquire data

Every Machine Learning proje
a development board or your

LET'S COLLECT SOME DATA

Design an impulse

Teach the model to interpret
data. Use this to categorize ne
readings.

GETTING STARTED: CONTINU
GETTING STARTED: RESPOND
GETTING STARTED: ADDING

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

Sharing

Your project is private.

Make this project public

Summary

DEVICES CONNECTED
0

DATA COLLECTED
-

Collaborators

MJRoBot (Marcelo Rovai) OWNER

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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

Collect data

Device phone_kl72ebm0 is now connected

Get started!

Sharing

Your project is private.

Make this project public

Summary

DEVICES CONNECTED
0

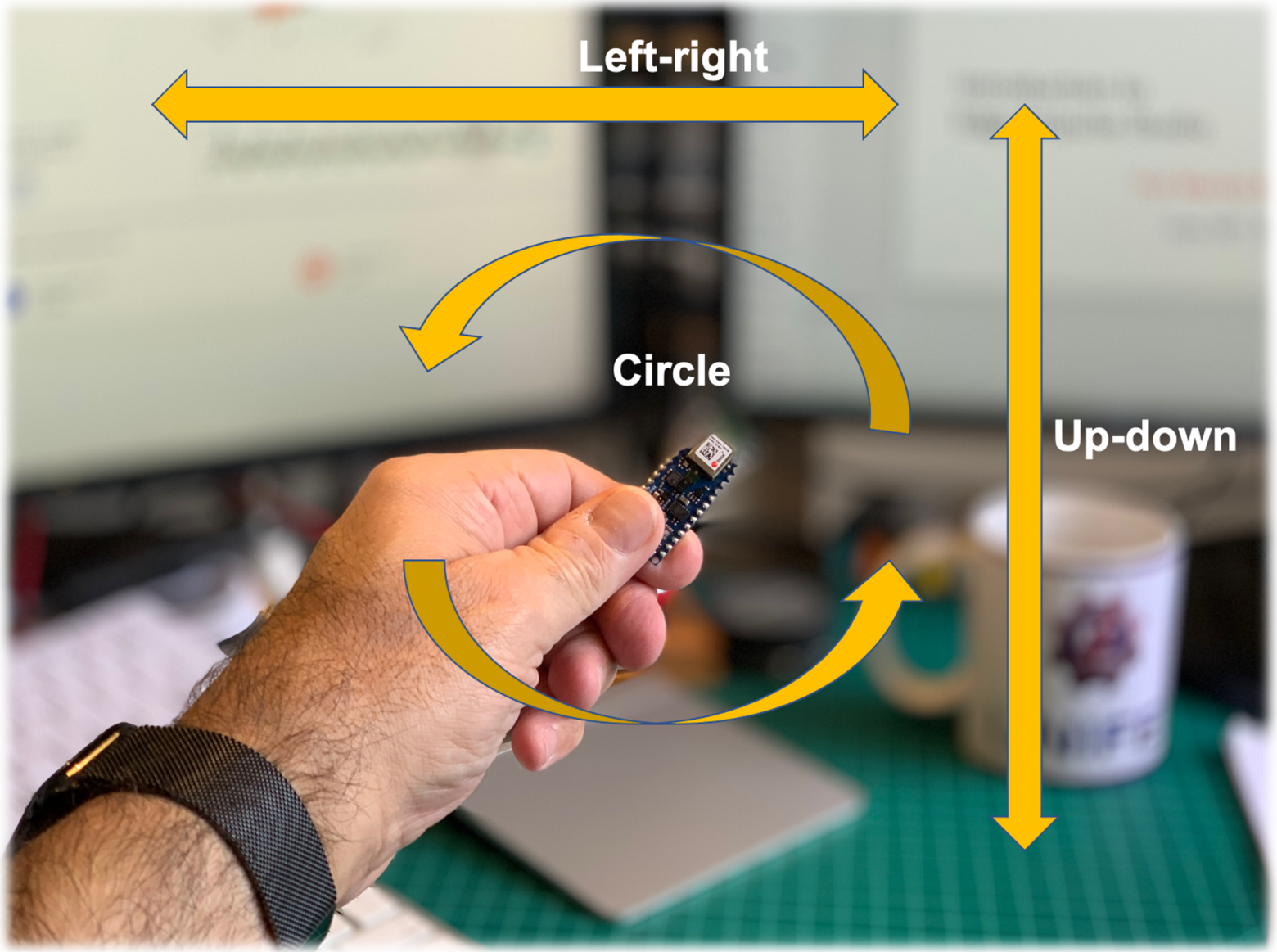
DATA COLLECTED
-

Collaborators

MJRoBot (Marcelo Rovai) OWNER

Project info

Gesture Data Capture



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DATA ACQUISITION (IESTI01 - GESTURE CLASSIFICATION)

MJRoBot (Marcelo Rovai)

Training data | Test data

Did you know? You can capture data from any device or development board, or upload your existing datasets - Show options

DATA COLLECTED
5m 24s

LABELS
4

Collected data

SAMPLE NAME	LABEL	ADDED	LENGTH
up_down.285cifl0	up_down	Today, 17:06:12	10s
up_down.285chk0u	up_down	Today, 17:05:44	5s
up_down.285cgt13	up_down	Today, 17:05:20	10s
left_right.285cfanr	left_right	Today, 17:04:29	10s
left_right.285ceqea	left_right	Today, 17:04:12	10s
left_right.285ce9b5	left_right	Today, 17:03:54	10s
left_right.285cdp4k	left_right	Today, 17:03:38	10s
left_right.285cd7mh	left_right	Today, 17:03:20	10s
left_right.285ccksh	left_right	Today, 17:03:01	10s
left_right.285cbio4	left_right	Today, 17:02:26	10s
left_right.285c9cui	left_right	Today, 17:01:14	10s

1 2 3

Record new data

Device
phone_kl72ebm0

Label
left_right

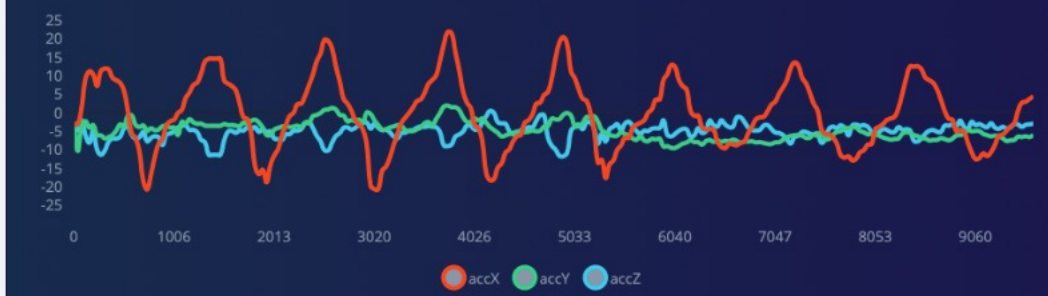
Sample length (ms.)
10000

Sensor
Accelerometer

Frequency
62.5Hz

Start sampling

RAW DATA
left_right.285cdp4k



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DATA ACQUISITION (IESTI01 - GESTURE CLASSIFICATION)

MJRoBot (Marcelo Rovai)

Training data | Test data

Did you know? You can capture data from any device or development board, or upload your existing datasets - Show options

DATA COLLECTED
5m 24s

LABELS
4

When finished, go to "Create Impulse"

Collected data

SAMPLE NAME	LABEL	ADDED	LENGTH
idle.285d4180	idle	Today, 17:15:47	10s
idle.285d3fb6	idle	Today, 17:15:29	10s
idle.285d2sbr	idle	Today, 17:15:09	10s
idle.285d28r0	idle	Today, 17:14:49	10s
idle.285d1mbb	idle	Today, 17:14:30	10s
idle.285d14km	idle	Today, 17:14:12	10s
idle.285d08ko	idle	Today, 17:13:43	7s
idle.285cv3pi	idle	Today, 17:13:06	6s
idle.285ctsf7	idle	Today, 17:12:25	10s
idle.285ctcve	idle	Today, 17:12:10	10s
circle.285csk7d	circle	Today, 17:11:44	10s
circle.285cqsc4	circle	Today, 17:10:47	10s

1 2 3

Refresh App at mobile if necessary

Record new data

Device
No devices connected

Label
idle

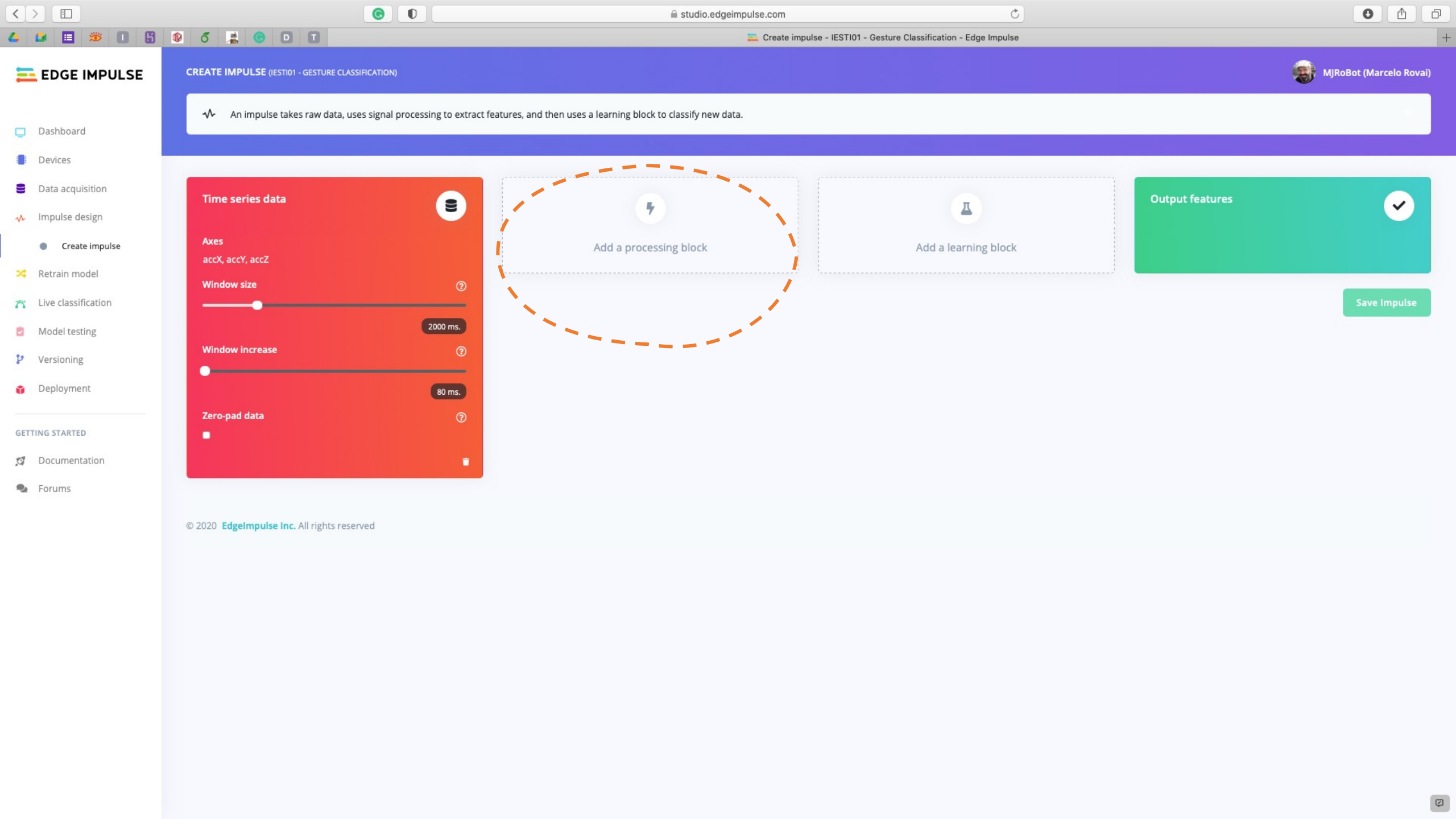
Sample length (ms.)
10000

Sensor

Frequency

Start sampling

RAW DATA
idle.285d4180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CREATE IMPULSE (IESTI01 - GESTURE CLASSIFICATION)
MJRoBot (Marcelo Rovai)
An impulse takes raw data, uses signal processing to extract features, and then uses a learning block to classify new data.
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Time series data
Axes
accX, accY, accZ
Window size
2000 ms.
Window increase
80 ms.
Zero-pad data
Add a processing block
Add a learning block
Output features
Save Impulse
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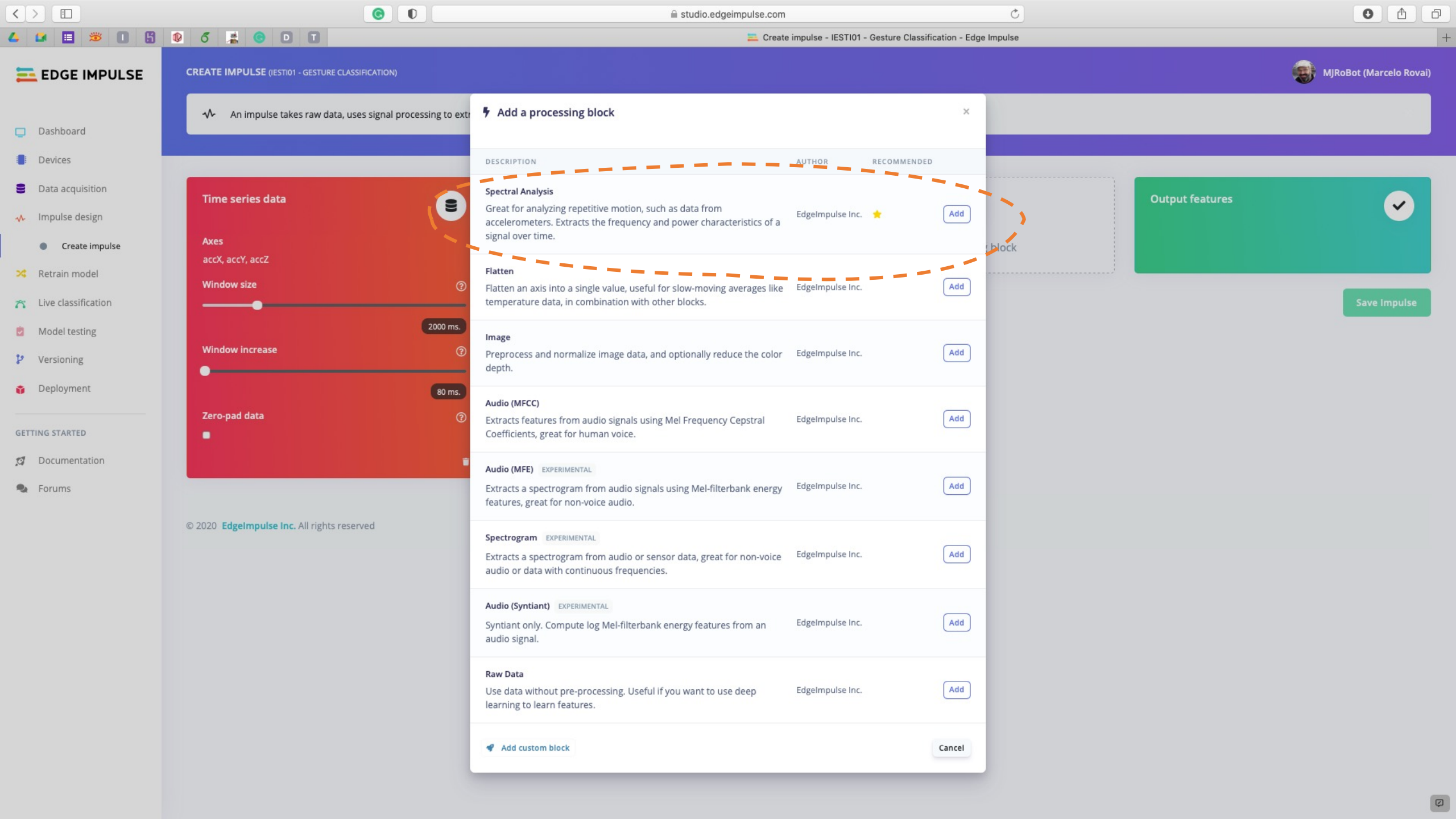
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Window size
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Zero-pad data
Output features
Save Impulse
Add a processing block
DESCRIPTION
AUTHOR
RECOMMENDED
Spectral Analysis
Great for analyzing repetitive motion, such as data from accelerometers. Extracts the frequency and power characteristics of a signal over time.
EdgeImpulse Inc.
Add
Flatten
Flatten an axis into a single value, useful for slow-moving averages like temperature data, in combination with other blocks.
EdgeImpulse Inc.
Add
Image
Preprocess and normalize image data, and optionally reduce the color depth.
EdgeImpulse Inc.
Add
Audio (MFCC)
Extracts features from audio signals using Mel Frequency Cepstral Coefficients, great for human voice.
EdgeImpulse Inc.
Add
Audio (MFE) EXPERIMENTAL
Extracts a spectrogram from audio signals using Mel-filterbank energy features, great for non-voice audio.
EdgeImpulse Inc.
Add
Spectrogram EXPERIMENTAL
Extracts a spectrogram from audio or sensor data, great for non-voice audio or data with continuous frequencies.
EdgeImpulse Inc.
Add
Audio (Syntiant) EXPERIMENTAL
Syntiant only. Compute log Mel-filterbank energy features from an audio signal.
EdgeImpulse Inc.
Add
Raw Data
Use data without pre-processing. Useful if you want to use deep learning to learn features.
EdgeImpulse Inc.
Add
Add custom block
Cancel
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EDGE IMPULSE

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An impulse takes raw data, uses signal processing to extract features, and then uses a learning block to classify new data.

Time series data

Axes
accX, accY, accZ

Window size
2000 ms.

Window increase
80 ms.

Zero-pad data

Spectral Analysis

Name
Spectral features

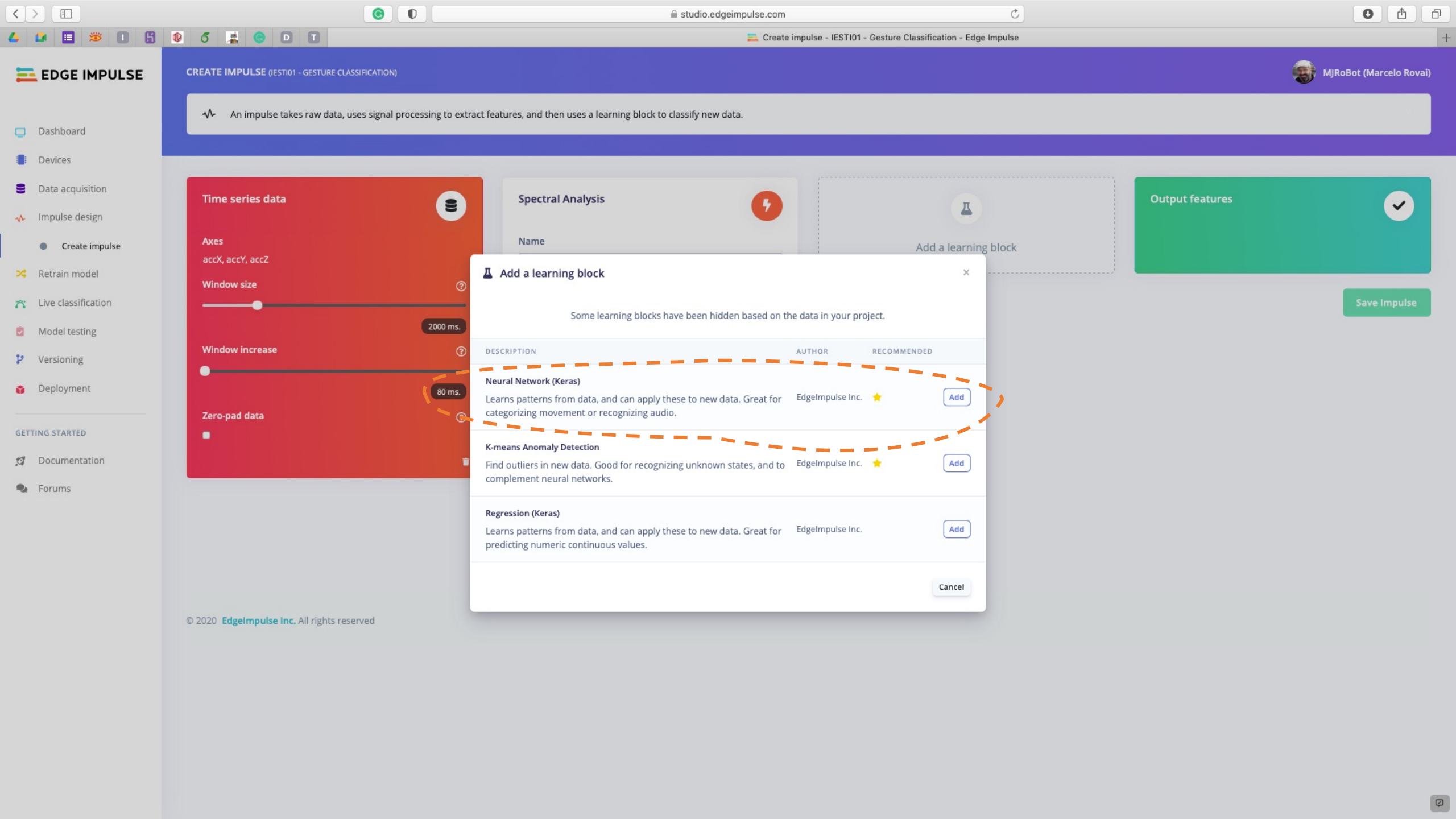
Input axes
- accX
- accY
- accZ

Add a processing block

Add a learning block

Output features

Save Impulse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Axes
accX, accY, accZ
Window size
2000 ms.
Window increase
80 ms.
Zero-pad data
Spectral Analysis
Name
Add a learning block
Output features
Save Impulse
Add a learning block
Some learning blocks have been hidden based on the data in your project.
DESCRIPTION
AUTHOR
RECOMMENDED
Neural Network (Keras)
Learns patterns from data, and can apply these to new data. Great for categorizing movement or recognizing audio.
EdgeImpulse Inc.
Add
K-means Anomaly Detection
Find outliers in new data. Good for recognizing unknown states, and to complement neural networks.
EdgeImpulse Inc.
Add
Regression (Keras)
Learns patterns from data, and can apply these to new data. Great for predicting numeric continuous values.
EdgeImpulse Inc.
Add
Cancel
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CREATE IMPULSE (IESTI01 - GESTURE CLASSIFICATION)

MJRoBot (Marcelo Rovai)

An impulse takes raw data, uses signal processing to extract features, and then uses a learning block to classify new data.

Time series data

Axes
accX, accY, accZ

Window size
2000 ms.

Window increase
80 ms.

Zero-pad data

Spectral Analysis

Name
Spectral features

Input axes
- [x] accX
- [x] accY
- [x] accZ

Neural Network (Keras)

Name
NN Classifier

Input features
- [x] Spectral features

Output features
4 (circle, idle, left_right, up_down)

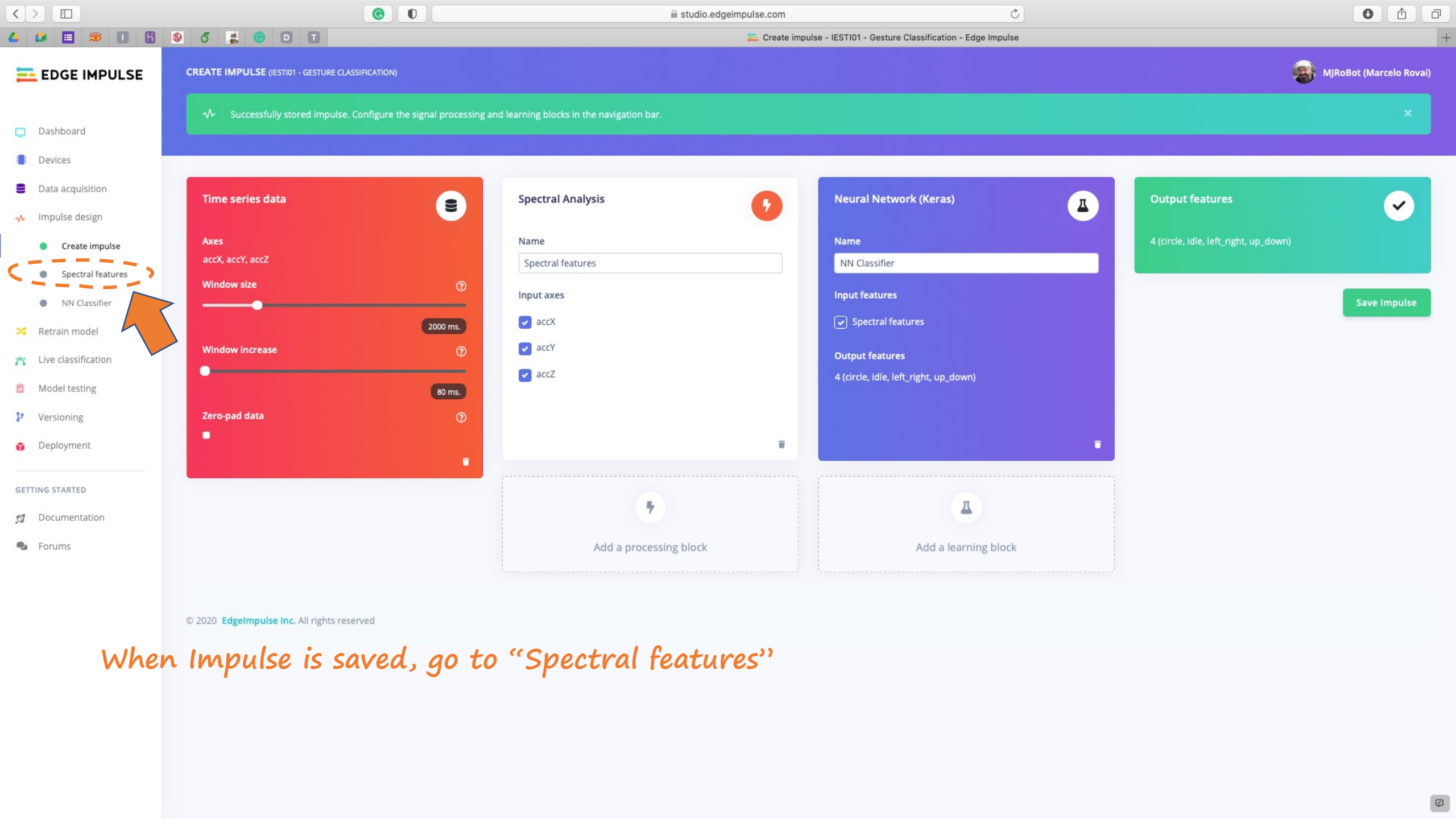
Output features

4 (circle, idle, left_right, up_down)

Save Impulse

Add a processing block

Add a learning block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CREATE IMPULSE (IESTI01 - GESTURE CLASSIFICATION)
MJRoBot (Marcelo Rovai)
Successfully stored impulse. Configure the signal processing and learning blocks in the navigation bar.
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Axes
accX, accY, accZ
Window size
2000 ms.
Window increase
80 ms.
Zero-pad data
Spectral Analysis
Name
Spectral features
Input axes
accX
accY
accZ
Neural Network (Keras)
Name
NN Classifier
Input features
Spectral features
Output features
4 (circle, idle, left_right, up_down)
Output features
4 (circle, idle, left_right, up_down)
Save Impulse
Add a processing block
Add a learning block
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When Impulse is saved, go to "Spectral features"

EDGE IMPULSE

SPECTRAL FEATURES (IESTI01 - GESTURE CLASSIFICATION)

MJRoBot (Marcelo Rovai)

Parameters | Generate features

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Raw data

left_right.285cd7mh (left_right)

Raw features

-8.7611, -2.9703, -8.5353, -11.3612, -3.4283, -8.0337, -12.3569, -3.5662, -7.5739, -13.2262, -3.2118, -6.1057, -13.3079, -4.7206, -4.7226, -14.6…

Parameters

Scaling

Scale axes	1

Filter

Type	low
Cut-off frequency	3
Order	6

Spectral power

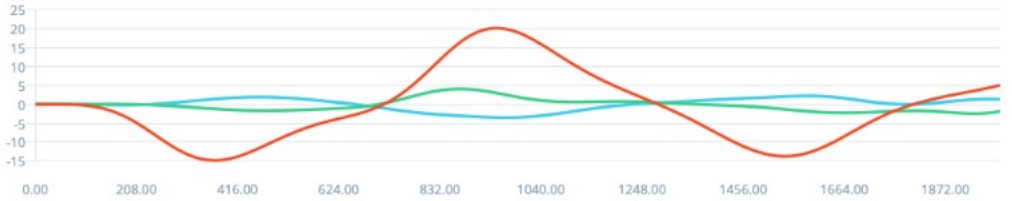
FFT length	128
No. of peaks	3
Peaks threshold	0.1
Power edges	0.1, 0.5, 1.0, 2.0, 5.0

1

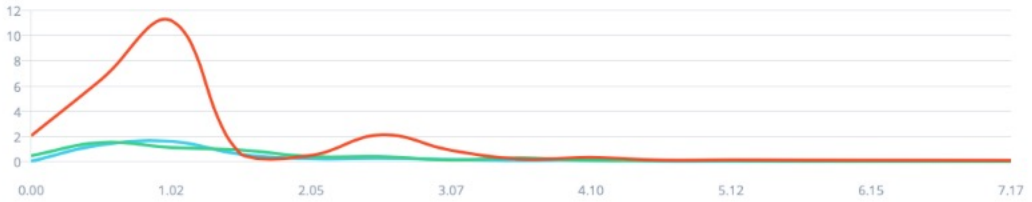
Save parameters

DSP result

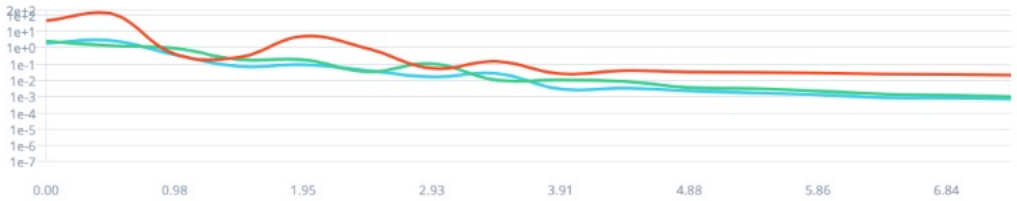
After filter



Frequency domain



Spectral power



Processed features

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Training set

Data in training set	5m 24s
Classes	4 (circle, idle, left_right, up_down)
Window length	2000 ms.
Window increase	80 ms.
Training windows	3,200

Generate features

Feature explorer

No features generated yet.

EDGE IMPULSE

Training set

Data in training set	5m 24s
Classes	4 (circle, idle, left_right, up_down)
Window length	2000 ms.
Window increase	80 ms.
Training windows	3,200

Generate features

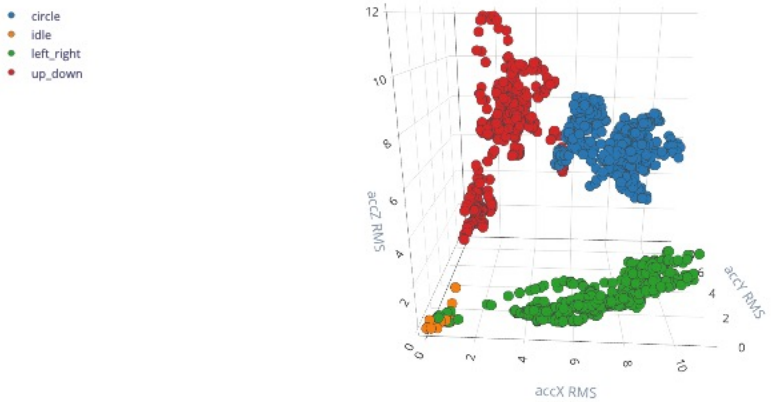
Feature generation output

Cancel

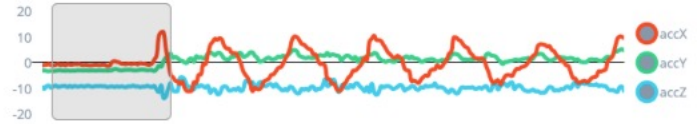
```
Scheduling job in cluster...
Job started
Creating windows from 35 files...
[ 1/35] Creating windows from files...
[35/35] Creating windows from files...
Created 3200 windows: circle: 773, idle: 886, left_right: 776, up_down: 765

Creating features
[   1/3200] Creating features...
[ 920/3200] Creating features...
[1840/3200] Creating features...
[2796/3200] Creating features...
[3200/3200] Creating features...
Created features

Job completed
```

Feature explorer (3,200 samples)

X Axis: accX RMS | Y Axis: accY RMS | Z Axis: accZ RMS



left_right.285cbio4
Window: 160 - 2160 ms.
Label: left_right
View sample
View features



On-device performance

PROCESSING TIME
7 ms.

PEAK RAM USAGE
5 KB

EDGE IMPULSE

NN CLASSIFIER (IESTI01 - GESTURE CLASSIFICATION)

#1 Click to set a description for this version

MJRoBot (Marcelo Rovai)

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Neural Network settings

Training settings

Number of training cycles: 30 ← EPOCHS

Learning rate: 0.0005 ← Lr

Minimum confidence rating: 0.60

Neural network architecture

Input layer (33 features)

Dense layer (20 neurons)

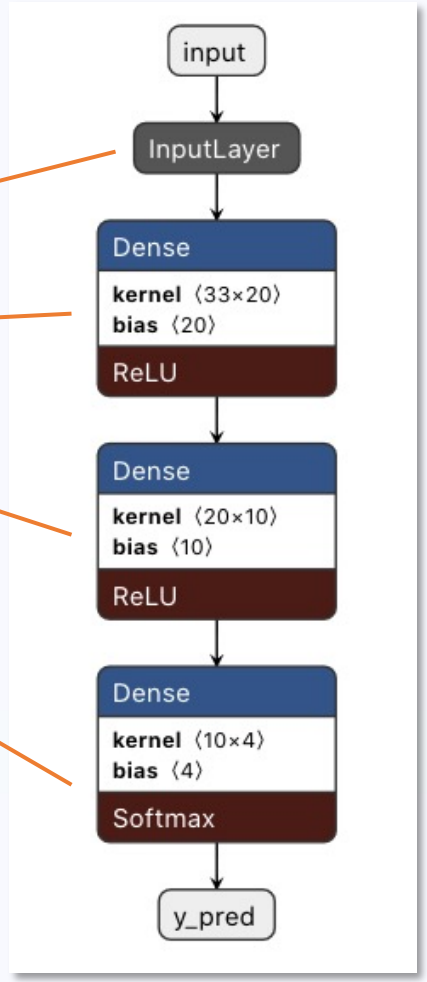
Dense layer (10 neurons)

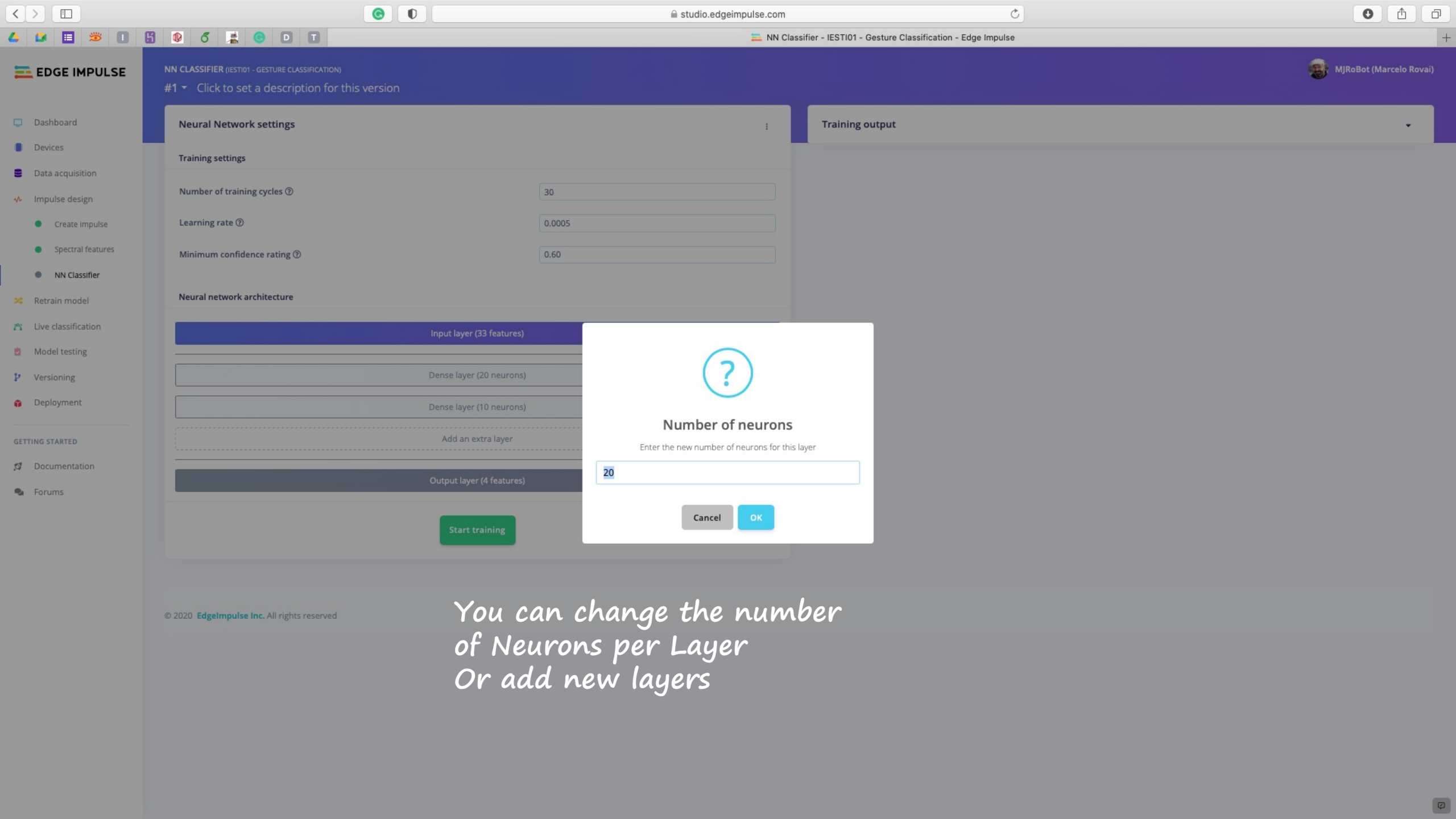
Add an extra layer

Output layer (4 features)

Start training

Training output




studio.edgeimpulse.com
NN Classifier - IESTI01 - Gesture Classification - Edge Impulse
EDGE IMPULSE
NN CLASSIFIER (IESTI01 - GESTURE CLASSIFICATION)
#1 Click to set a description for this version
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Neural Network settings
Training settings
Number of training cycles
30
Learning rate
0.0005
Minimum confidence rating
0.60
Neural network architecture
Input layer (33 features)
Dense layer (20 neurons)
Dense layer (10 neurons)
Add an extra layer
Output layer (4 features)
Start training
Training output
Number of neurons
Enter the new number of neurons for this layer
20
Cancel
OK
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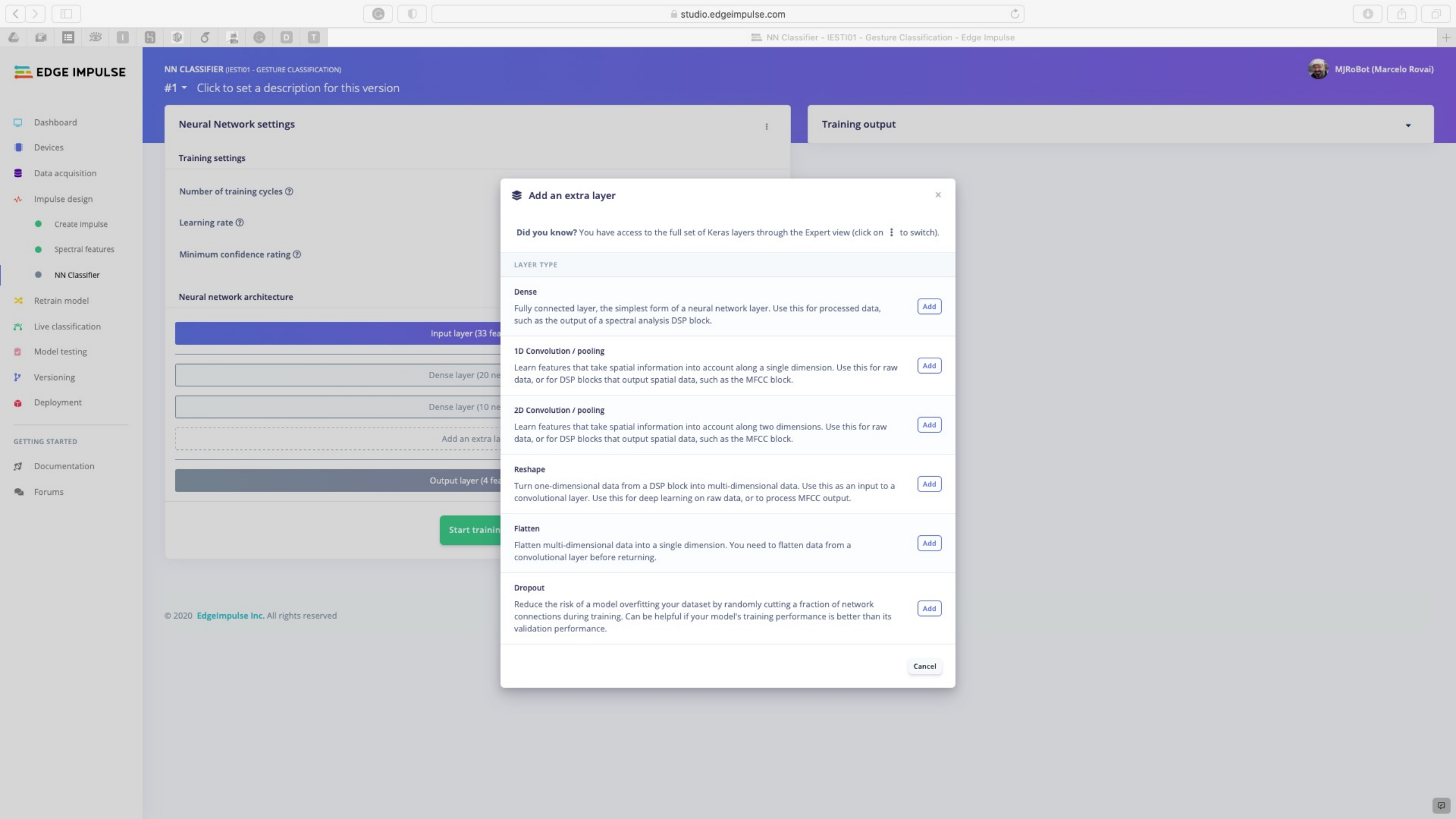
You can change the number
of Neurons per Layer
Or add new layers


studio.edgeimpulse.com
NN Classifier - IESTI01 - Gesture Classification - Edge Impulse
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NN CLASSIFIER (IESTI01 - GESTURE CLASSIFICATION)
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Number of training cycles
Learning rate
Minimum confidence rating
Neural network architecture
Input layer (33 fea
Dense layer (20 ne
Dense layer (10 ne
Add an extra la
Output layer (4 fea
Start trainin
Training output
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).
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.
Add
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.
Add
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.
Add
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.
Add
Flatten
Flatten multi-dimensional data into a single dimension. You need to flatten data from a convolutional layer before returning.
Add
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.
Add
Cancel
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Training settings

Number of training cycles: 30

Learning rate: 0.0005

Minimum confidence rating: 0.60

Neural network architecture

Input layer (33 features)

Dense layer (20 neurons)

Dense layer (10 neurons)

Add an extra layer

Output layer (4 features)

Start training

Training output

```
80/80 - 1s - loss: 0.0105 - accuracy: 0.9977 - val_loss: 0.0069 - val_accuracy: 0.9984
Epoch 24/30
80/80 - 1s - loss: 0.0098 - accuracy: 0.9980 - val_loss: 0.0063 - val_accuracy: 0.9984
Epoch 25/30
80/80 - 1s - loss: 0.0091 - accuracy: 0.9988 - val_loss: 0.0059 - val_accuracy: 1.0000
Epoch 26/30
80/80 - 1s - loss: 0.0086 - accuracy: 0.9988 - val_loss: 0.0054 - val_accuracy: 1.0000
Epoch 27/30
80/80 - 1s - loss: 0.0080 - accuracy: 0.9988 - val_loss: 0.0050 - val_accuracy: 1.0000
Epoch 28/30
80/80 - 1s - loss: 0.0076 - accuracy: 0.9992 - val_loss: 0.0047 - val_accuracy: 1.0000
Epoch 29/30
80/80 - 1s - loss: 0.0071 - accuracy: 0.9992 - val_loss: 0.0043 - val_accuracy: 1.0000
Epoch 30/30
80/80 - 1s - loss: 0.0067 - accuracy: 0.9992 - val_loss: 0.0040 - val_accuracy: 1.0000
Finished training
```

Model

Model version: Quantized (int8)

Last training performance (validation set)

ACCURACY 100.0%

LOSS 0.00

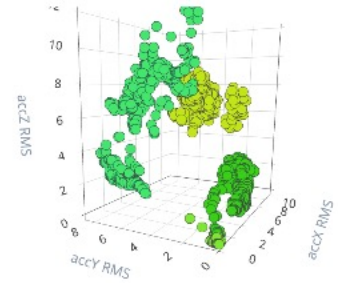
Confusion matrix (validation set)

	CIRCLE	IDLE	LEFT_RIGHT	UP_DOWN
CIRCLE	100%	0%	0%	0%
IDLE	0%	100%	0%	0%
LEFT_RIGHT	0%	0%	100%	0%
UP_DOWN	0%	0%	0%	100%
F1 SCORE	1.00	1.00	1.00	1.00

Feature explorer (full training set)

accX RMS | accY RMS | accZ RMS

- circle - correct
- idle - correct
- left_right - correct
- up_down - correct



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Did you know? Capture data from any device or development board into the *testing* category to live classify data - Show options

Classify new data

Device ⓘ: No devices connected

Sensor:

Sample length (ms.): 10000

Frequency:

Start sampling

Classify existing test sample

testing.285ganlg (testing)

Load sample

EDGE IMPULSE

LIVE CLASSIFICATION (IESTI01 - GESTURE CLASSIFICATION)

MJRoBot (Marcelo Rovai)

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Did you know? Capture data from any device or development board into the *testing* category to live classify data - Show options

Classify new data

Device: phone_kl72ebm0
Sensor: Accelerometer
Sample length (ms.): 10000
Frequency: 62.5Hz

Sampling... (5s left)

Classify existing test sample

left-right.285fs6p7 (left-right)

Load sample

Classification result

Summary

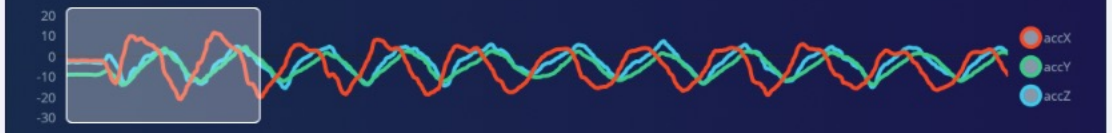
Name: testing.285g61cg
Expected outcome: testing

CATEGORY	COUNT
circle	97
idle	0
left_right	0
up_down	0
uncertain	0

Detailed result — Show only unknowns

TIMESTAMP	CIRCLE	IDLE	LEFT_RIGHT	UP_DOWN

RAW DATA
testing.285g61cg



Raw features
-2.1183, -9.0592, -3.1488, -2.2401, -9.0986, -3.1581, -2.2494, -9.0845, -3.1066, -2.3941, -8.9558, -3.0450, -2.3116, -9.0658, -2.8653, -2.2467, …

Spectral features (3,297 samples)

X Axis: accX RMS
Y Axis: accY RMS
Z Axis: accZ RMS

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Classification result

Summary

Name: testing.285g61cg

Expected outcome: testing

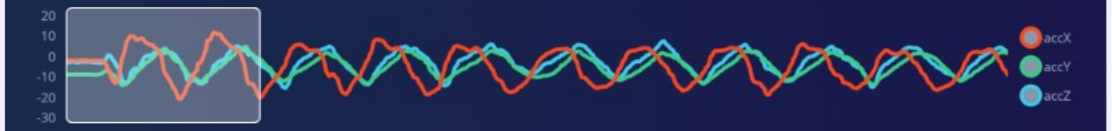
CATEGORY	COUNT
circle	97
idle	0
left_right	0
up_down	0
uncertain	0

Detailed result — Show only unknowns

TIMESTAMP	CIRCLE	IDLE	LEFT_RIGHT	UP_DOWN
0	0.98	0	0.02	0
80	1.00	0	0	0
160	1.00	0	0	0
240	1.00	0	0	0
320	1.00	0	0	0
400	1.00	0	0	0
480	1.00	0	0	0
560	1.00	0	0	0
640	1.00	0	0	0
720	1.00	0	0	0

RAW DATA

testing.285g61cg

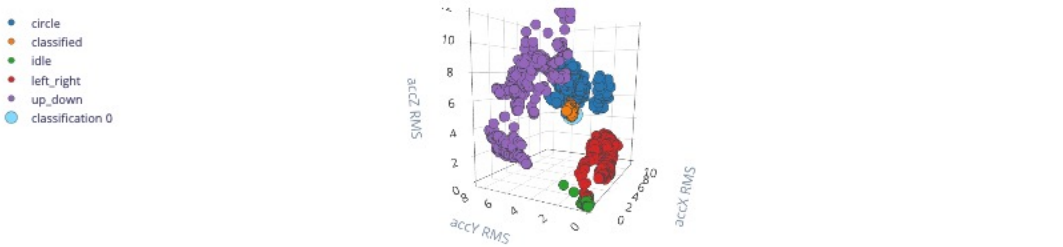


Raw features

-2.1183, -9.0592, -3.1488, -2.2401, -9.0986, -3.1581, -2.2494, -9.0845, -3.1066, -2.3941, -8.9558, -3.0450, -2.3116, -9.0658, -2.8653, -2.2467, …

Spectral features (3,297 samples)

X Axis: accX RMS | Y Axis: accY RMS | Z Axis: accZ RMS



Processed features

7.8824, 1.4881, 7.5658, 2.4802, 1.4722, 4.9603, 0.1052, 0.2894, 5.8086, 3.0277, 0.0688, 4.4396, 1.4881, 3.9708, 2.4802, 0.8712, 3.4722, 0.5139, …

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MODEL TESTING (IESTI01 - GESTURE CLASSIFICATION)

MJRoBot (Marcelo Rovai)

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

Test data

Classify all

Set the 'expected outcome' for each sample to the desired outcome to automatically score the impulse.

SAMPLE NAME	EXPECTED OUTCOME	LENGTH	ACCURACY	RESULT
testing.285gma46	up_down	10s	100%	97 up_down
testing.285ganlg	idle	4s	100%	24 idle
testing.285g61cg	circle	10s	100%	97 circle
testing.285g354a	left_right	10s	100%	97 left_right
left-right.285fs6p7	left_right	10s	100%	96 left_right

Validation output

```
Created features
Generating features for Spectral features OK

Classifying data for NN Classifier...
Copying features from DSP block...
Copying features from DSP block OK
Classifying data for float32 model...
Scheduling job in cluster...
Job started
Classifying data for NN Classifier OK


Job completed
```

Validation results

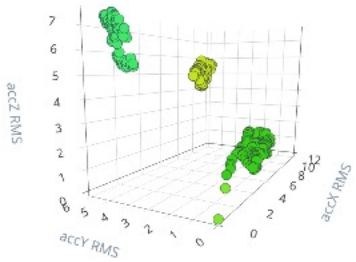
ACCURACY
100.00%

	CIRCLE	IDLE	LEFT_RIGHT	UP_DOWN	UNCERTAIN
CIRCLE	100%	0%	0%	0%	0%
IDLE	0%	100%	0%	0%	0%
LEFT_RIGHT	0%	0%	100%	0%	0%
UP_DOWN	0%	0%	0%	100%	0%

Feature explorer

accX RMS | accY RMS | accZ RMS

- circle - correct
- idle - correct
- left_right - correct
- up_down - correct



EDGE IMPULSE

NN CLASSIFIER (IESTI01 - GESTURE CLASSIFICATION)

#1 Click to set a description for this version

MJRoBot (Marcelo Rovai)

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Neural Network settings

Switch to Keras (expert) mode
Edit as iPython notebook

Training settings

Number of training cycles: 30

Learning rate: 0.0005

Minimum confidence rating: 0.60

Neural network architecture

Input layer (33 features)

Dense layer (20 neurons)

Dense layer (10 neurons)

Add an extra layer

Output layer (4 features)

Start training

Training output

Model

Model version: Quantized (int8)

Last training performance (validation set)

ACCURACY 100.0%

LOSS 0.00

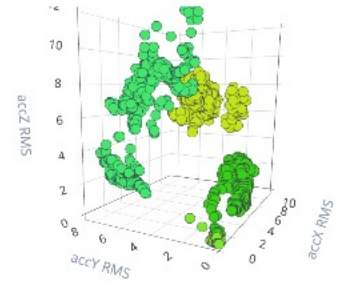
Confusion matrix (validation set)

	CIRCLE	IDLE	LEFT_RIGHT	UP_DOWN
CIRCLE	100%	0%	0%	0%
IDLE	0%	100%	0%	0%
LEFT_RIGHT	0%	0%	100%	0%
UP_DOWN	0%	0%	0%	100%
F1 SCORE	1.00	1.00	1.00	1.00

Feature explorer (full training set)

accX RMS | accY RMS | accZ RMS

- circle - correct
- idle - correct
- left_right - correct
- up_down - correct



On-device performance

INFERENCING TIME 1 ms.

PEAK RAM USAGE 1.5K

ROM USAGE 15.4K

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Neural Network settings

Training settings

Minimum confidence rating ⓘ 0.60

Neural network architecture

```python
import tensorflow as tf
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, InputLayer, Dropout, Conv1D, Conv2D, Flatten, Reshape, MaxPooling1D,
    MaxPooling2D, BatchNormalization
from tensorflow.keras.optimizers import Adam
sys.path.append('./resources/libraries')
import ei_tensorflow.training

# model architecture
model = Sequential()
model.add(Dense(20, activation='relu',
    activity_regularizer=tf.keras.regularizers.l1(0.00001)))
model.add(Dense(10, activation='relu',
    activity_regularizer=tf.keras.regularizers.l1(0.00001)))
model.add(Dense(classes, activation='softmax', name='y_pred'))

# this controls the learning rate
opt = Adam(lr=0.0005, beta_1=0.9, beta_2=0.999)
# this controls the batch size, or you can manipulate the tf.data.Dataset objects yourself
BATCH_SIZE = 32
train_dataset = train_dataset.batch(BATCH_SIZE, drop_remainder=False)
validation_dataset = validation_dataset.batch(BATCH_SIZE, drop_remainder=False)
callbacks.append(BatchLoggerCallback(BATCH_SIZE, train_sample_count))

# train the neural network
model.compile(loss='categorical_crossentropy', optimizer=opt, metrics=['accuracy'])
model.fit(train_dataset, epochs=30, validation_data=validation_dataset, verbose=2, callbacks=callbacks)
```

Start training

Training output

Model

Model version: ⓘ Quantized (int8)

Last training performance (validation set)

ACCURACY 100.0%

LOSS 0.00

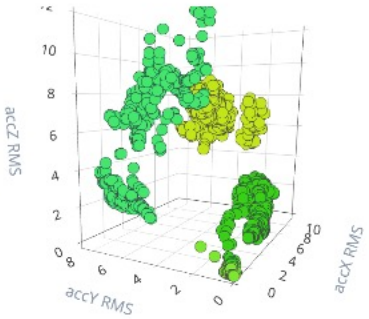
Confusion matrix (validation set)

	CIRCLE	IDLE	LEFT_RIGHT	UP_DOWN
CIRCLE	100%	0%	0%	0%
IDLE	0%	100%	0%	0%
LEFT_RIGHT	0%	0%	100%	0%
UP_DOWN	0%	0%	0%	100%
F1 SCORE	1.00	1.00	1.00	1.00

Feature explorer (full training set) ⓘ

accX RMS | accY RMS | accZ RMS

- circle - correct
- idle - correct
- left_right - correct
- up_down - correct



On-device performance ⓘ

INFERENCING TIME 1 ms.

PEAK RAM USAGE 1.5K

ROM USAGE 15.4K

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)
- Text Book: "TinyML" by Pete Warden, Daniel Situnayake

I want to thank Shawn Hymel and Edge Impulse, Laurence Moroney from Google, Harvard professor Vijay Janapa Reddi, Ph.D. student Brian Plancher and their staff 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

And stay safe!