SciTinyML - ICTP workshop

Scientific Use of Machine Learning on Low Power Devices

Setting up the software tools

Prof. Marcelo José Rovai
UNIFEI - Universidade Federal de Itajubá, Brazil
Web: https://github.com/Mjrovai

Who I am

- Brazilian from São Paulo, **Data Science Master's degree by UDD, Chile**, and MBA by IBMEC (INSPER), Brazil.
- Graduated in 1982 as an **Engineer from UNIFEI** with Specialization from Poli/USP, both in Brazil.
- Worked as a **teacher, engineer, and executive** in several technology companies such as CDT/ETEP, AVIBRAS Aeroespacial, SID Informática, ATT-GIS, NCR, DELL, COMPAQ (HP), and more recently at IGT, where I continue as a Senior Advisor for Latin America.
- **Write about electronics**, publishing my works in sites as MJRoBot.org (Editor/Writer), Hackster.io (#1 Contributor), Instructables.com, and Medium.com (TDS – Towards Data Science).
- **Volunteer Professor** at UNIFEI Engineering Institute: "Machine Learning applied to Embedded Devices" course (IESTI01).
- Active member of the **TinyML4D group**, an initiative to bring TinyML education to developing countries.

Marcelo Rovai

What is Tiny Machine Learning (**TinyML**)?

TinyML

Fastest-growing field of **ML**

Algorithms, hardware, software

On-device sensor analytics

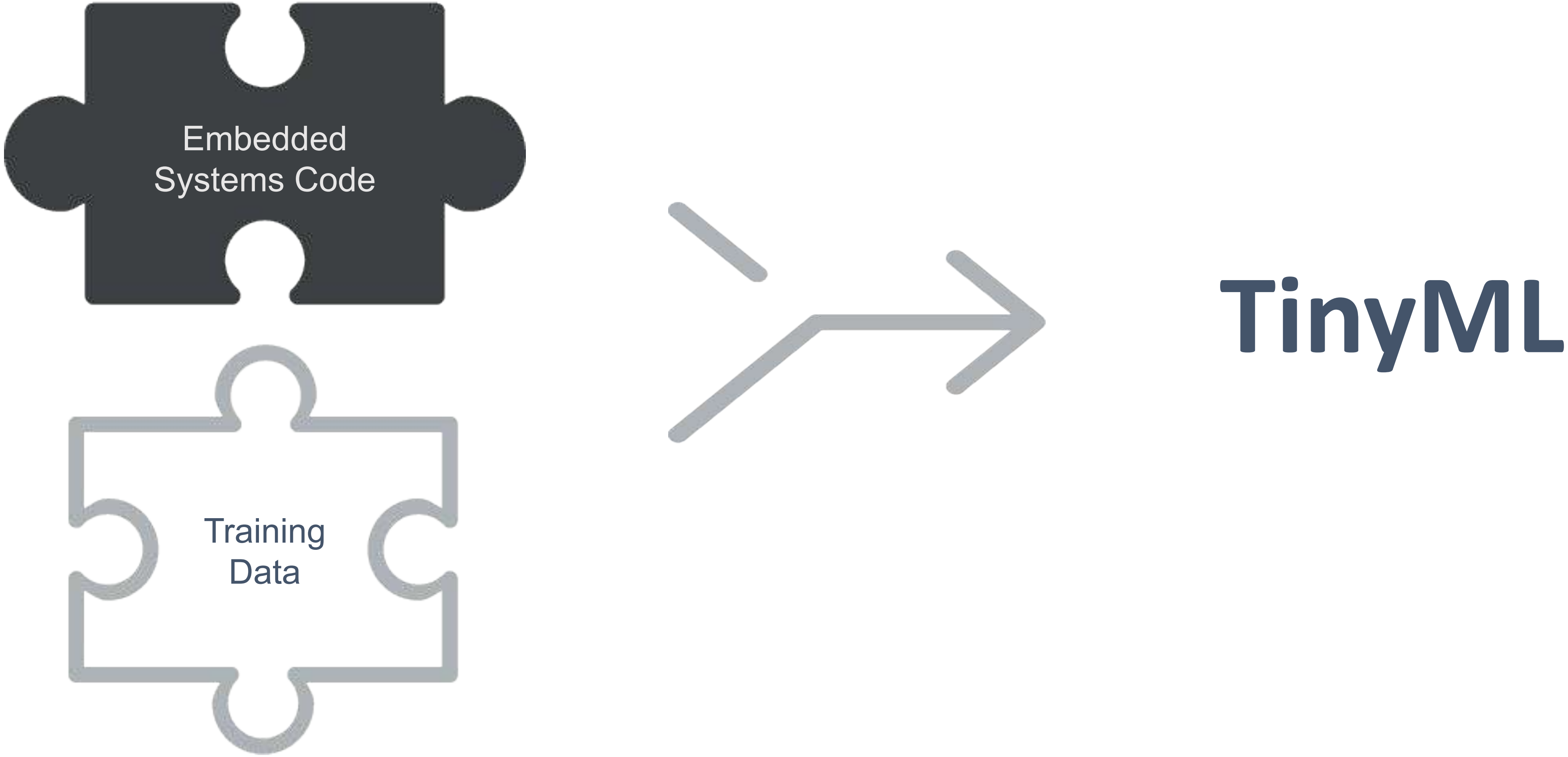
Low power consumption

Always-on ML

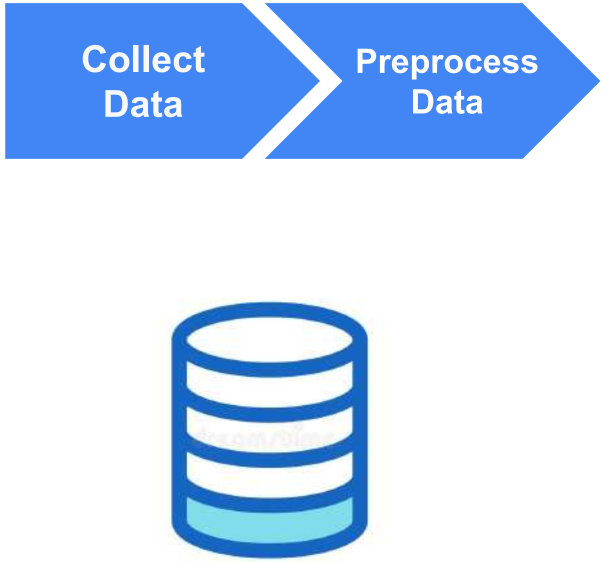
Battery-operated

Source: TinyML4D seminar: "Why The Future of ML is Tiny and Bright" by Vijay Janapa Reddi

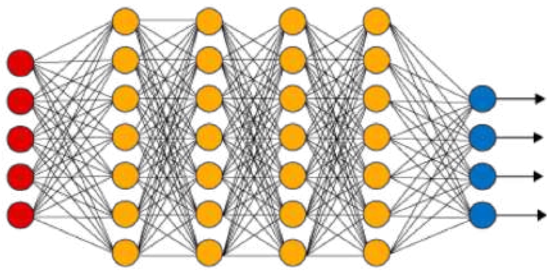
What Makes TinyML?



Machine Learning Workflow

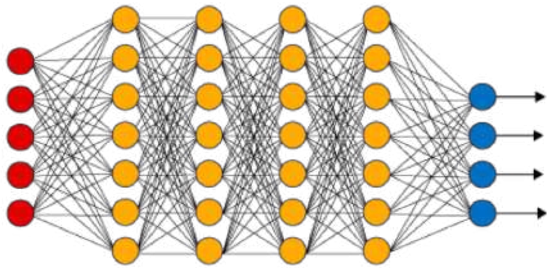


Machine Learning Workflow



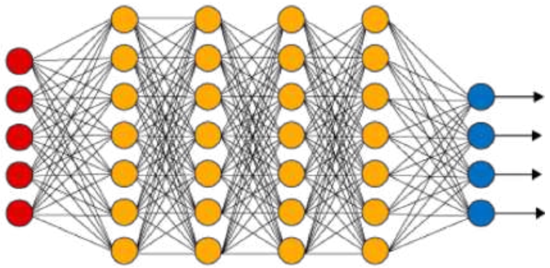
Collect Data → Preprocess Data → Design a Model → Train a Model

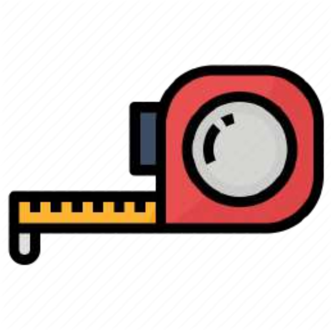
Machine Learning Workflow



Collect Data → Preprocess Data → Design a Model → Train a Model → Evaluate Optimize → Convert Model

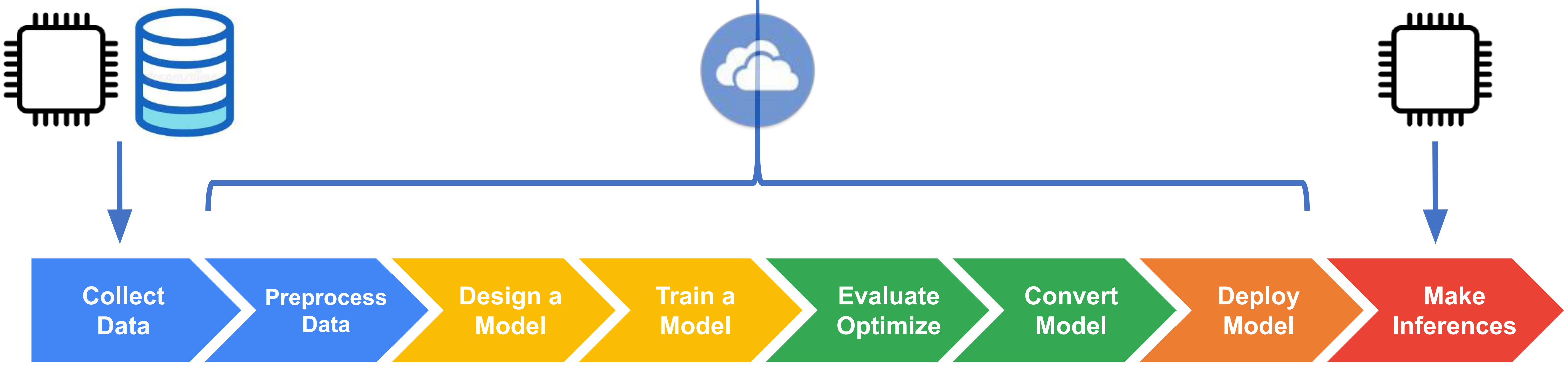
Machine Learning Workflow ("What")



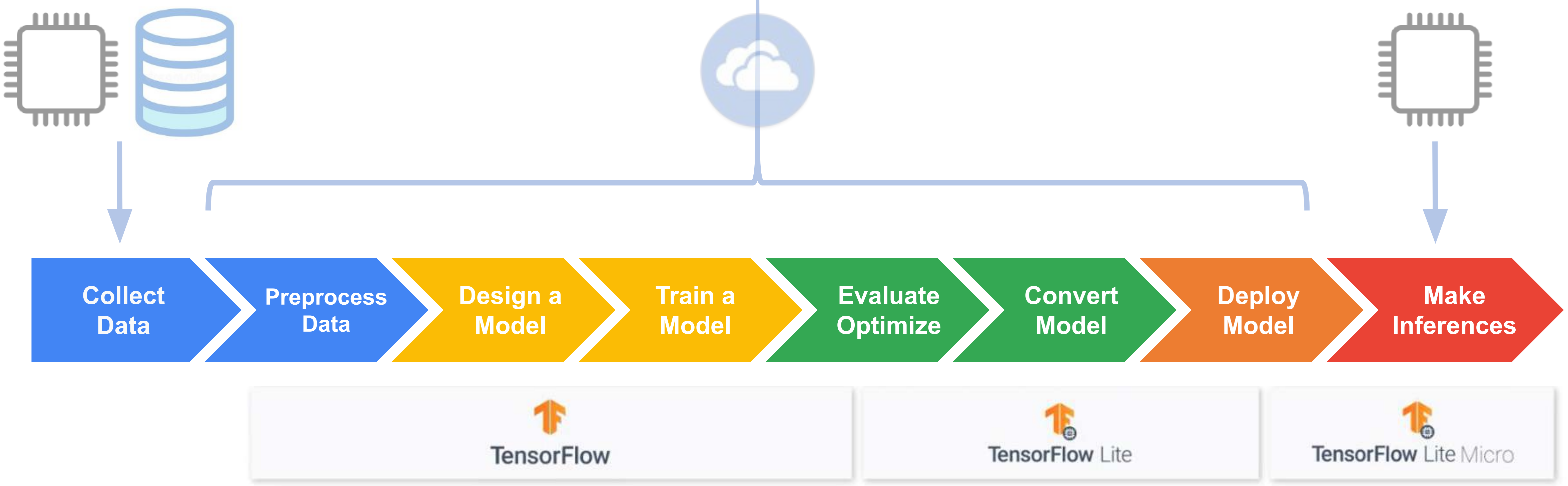


Collect Data → Preprocess Data → Design a Model → Train a Model → Evaluate Optimize → Convert Model → Deploy Model → Make Inferences

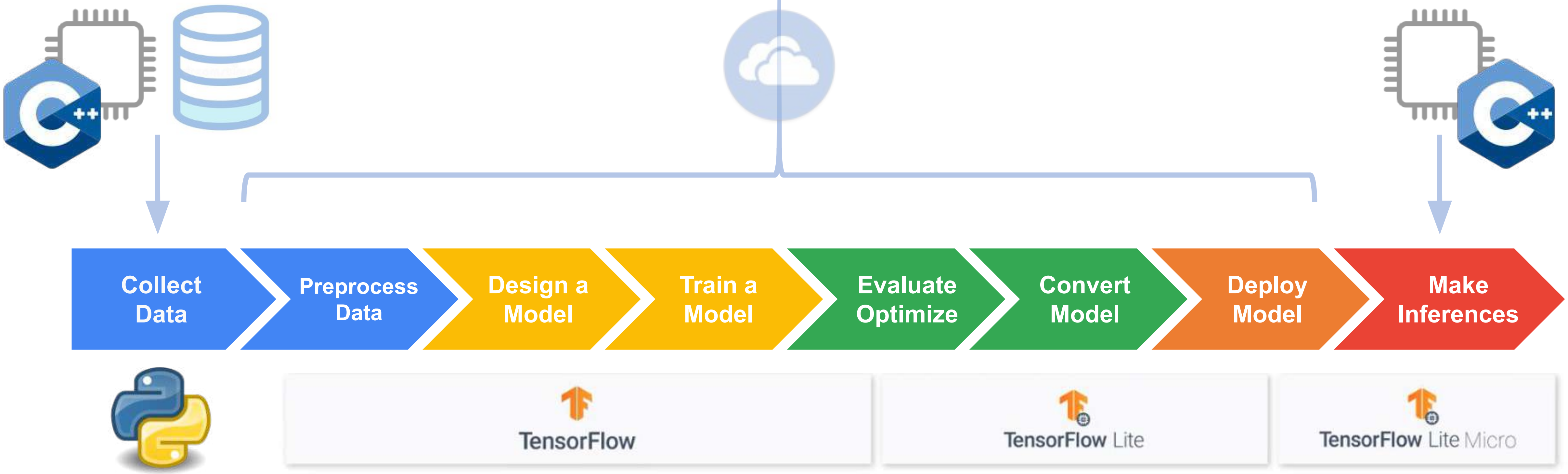
Machine Learning Workflow ("Where")



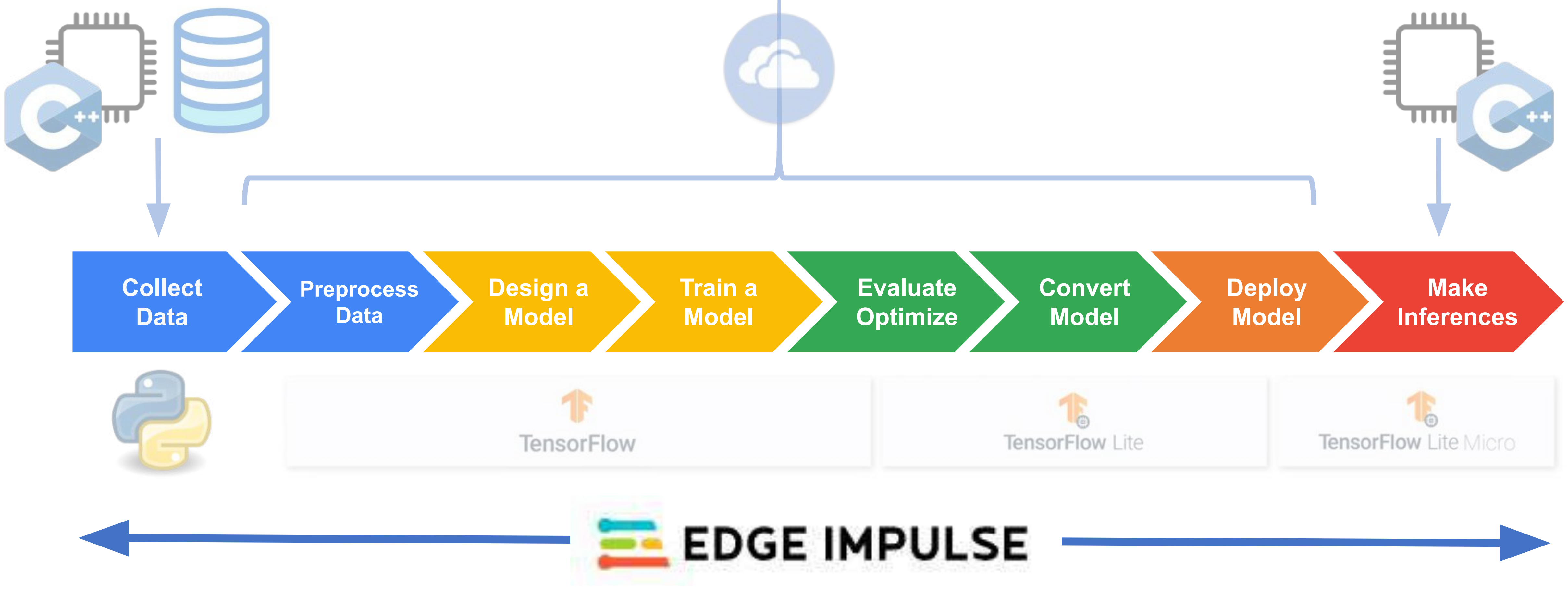
Machine Learning Workflow ("How")



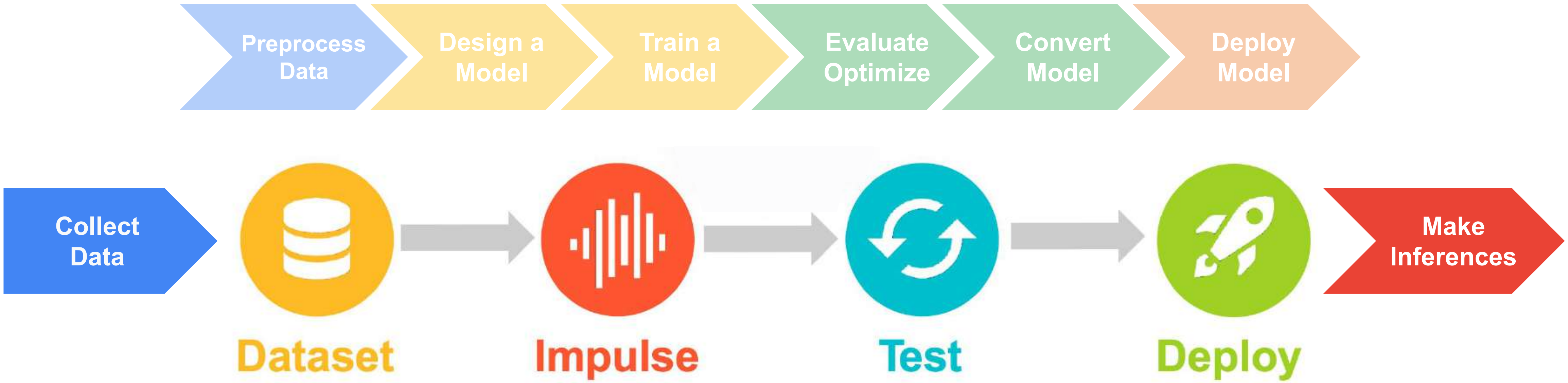
Machine Learning Workflow ("How")

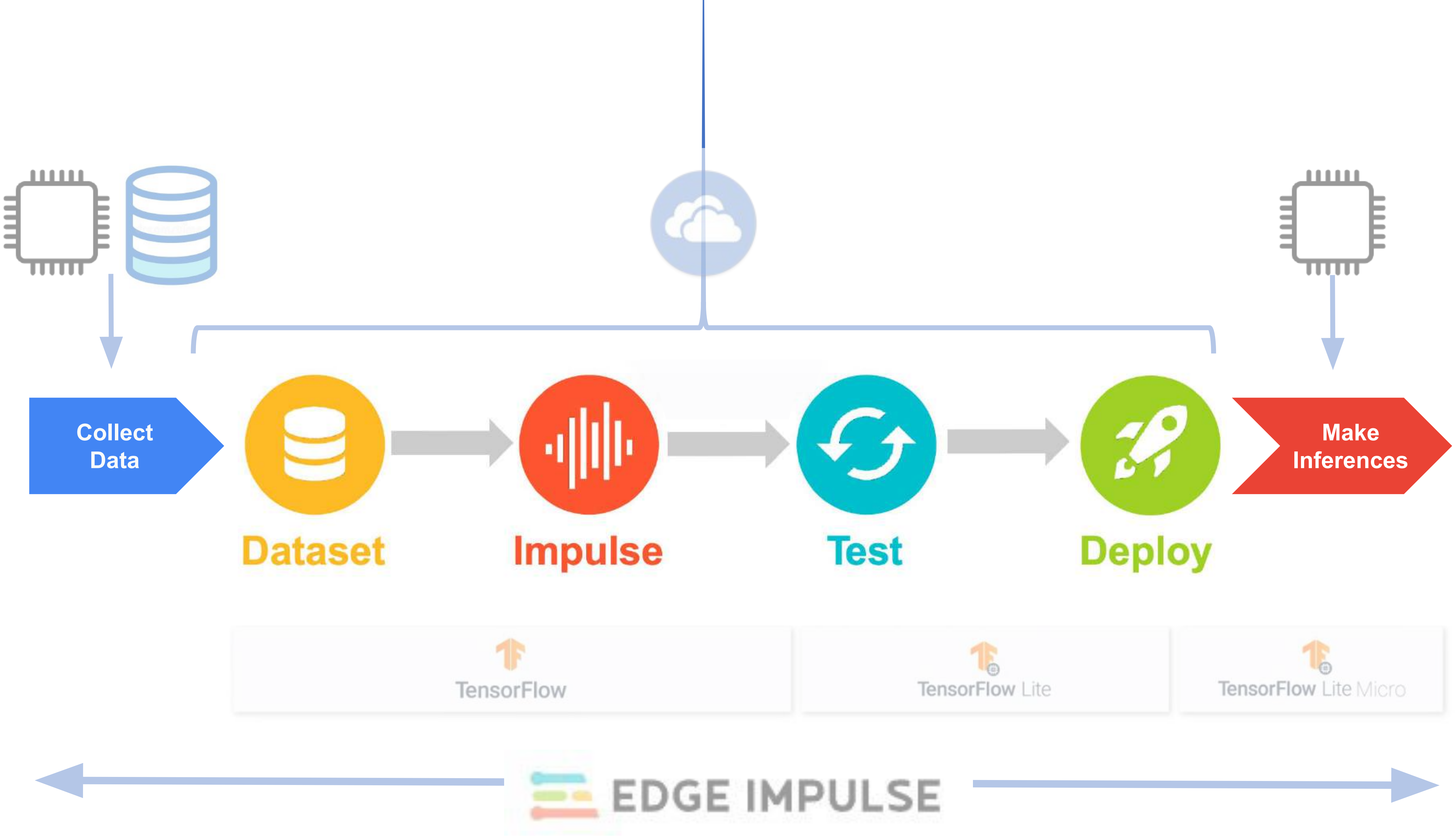


Machine Learning Workflow ("How")



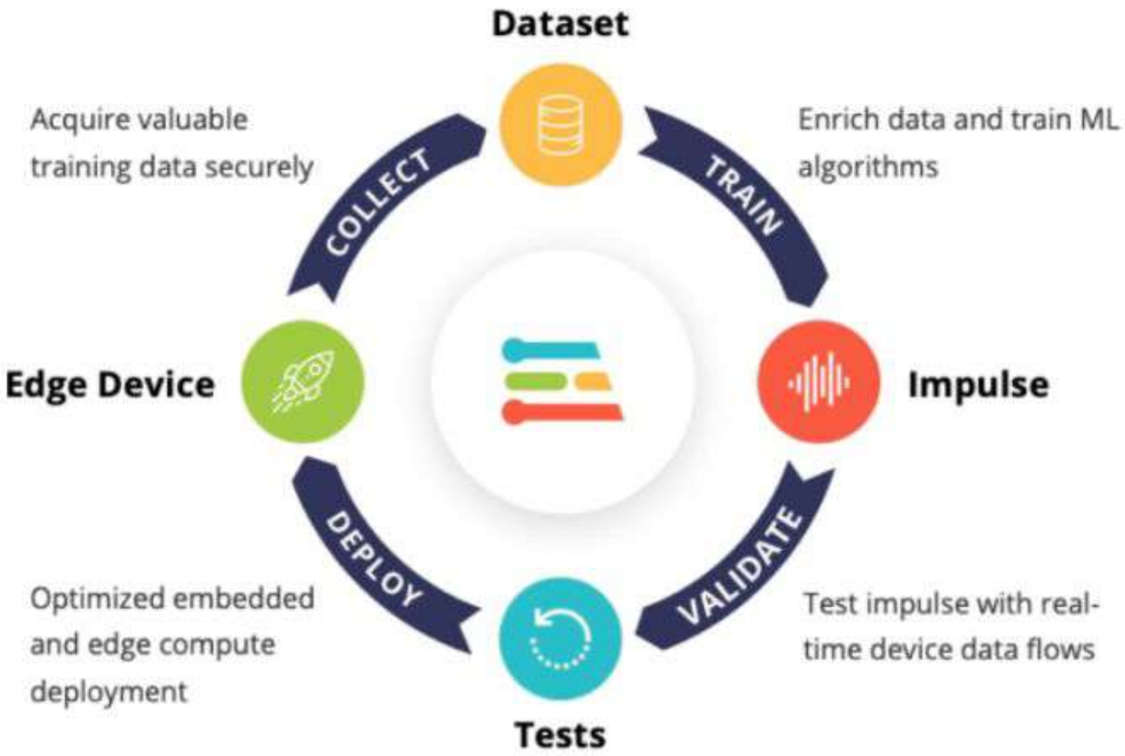

Collect Data
Preprocess Data
Design a Model
Train a Model
Evaluate Optimize
Convert Model
Deploy Model
Make Inferences

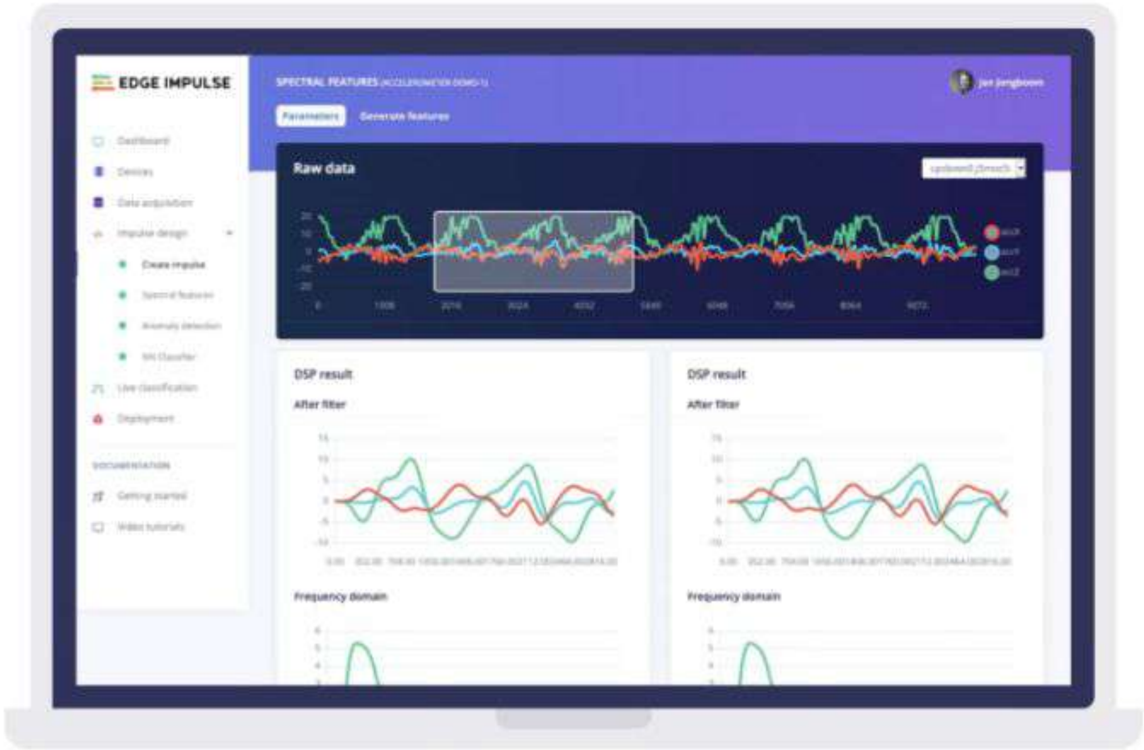

Preprocess Data
Design a Model
Train a Model
Evaluate Optimize
Convert Model
Deploy Model
Collect Data
Dataset
Impulse
Test
Deploy
Make Inferences



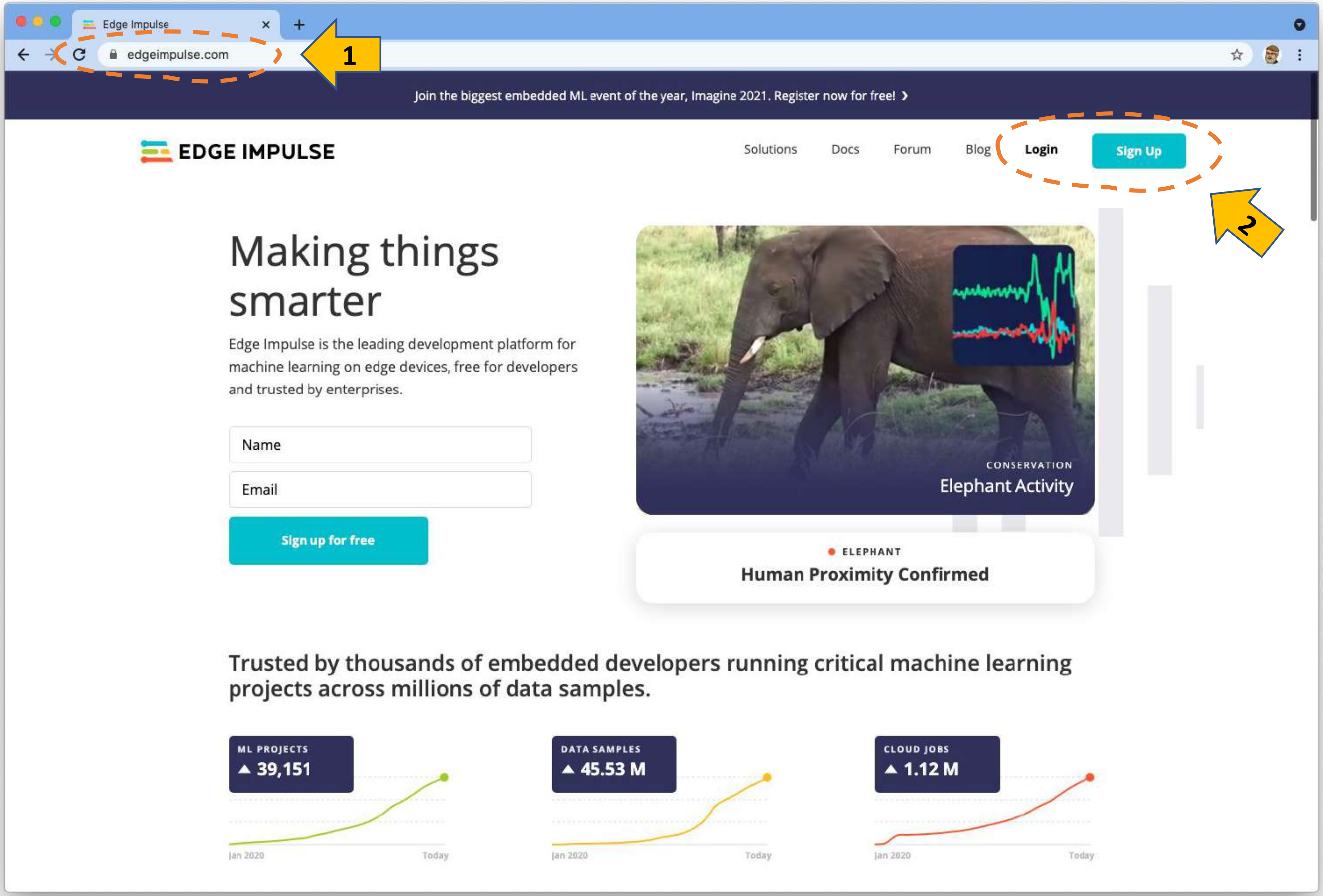
Collect Data
Dataset
Impulse
Test
Deploy
Make Inferences
TensorFlow
TensorFlow Lite
TensorFlow Lite Micro
EDGE IMPULSE

EI Studio - Embedded ML platform





Learn more at http://edgeimpulse.com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39,151
DATA SAMPLES
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CLOUD JOBS
1.12 M
Jan 2020
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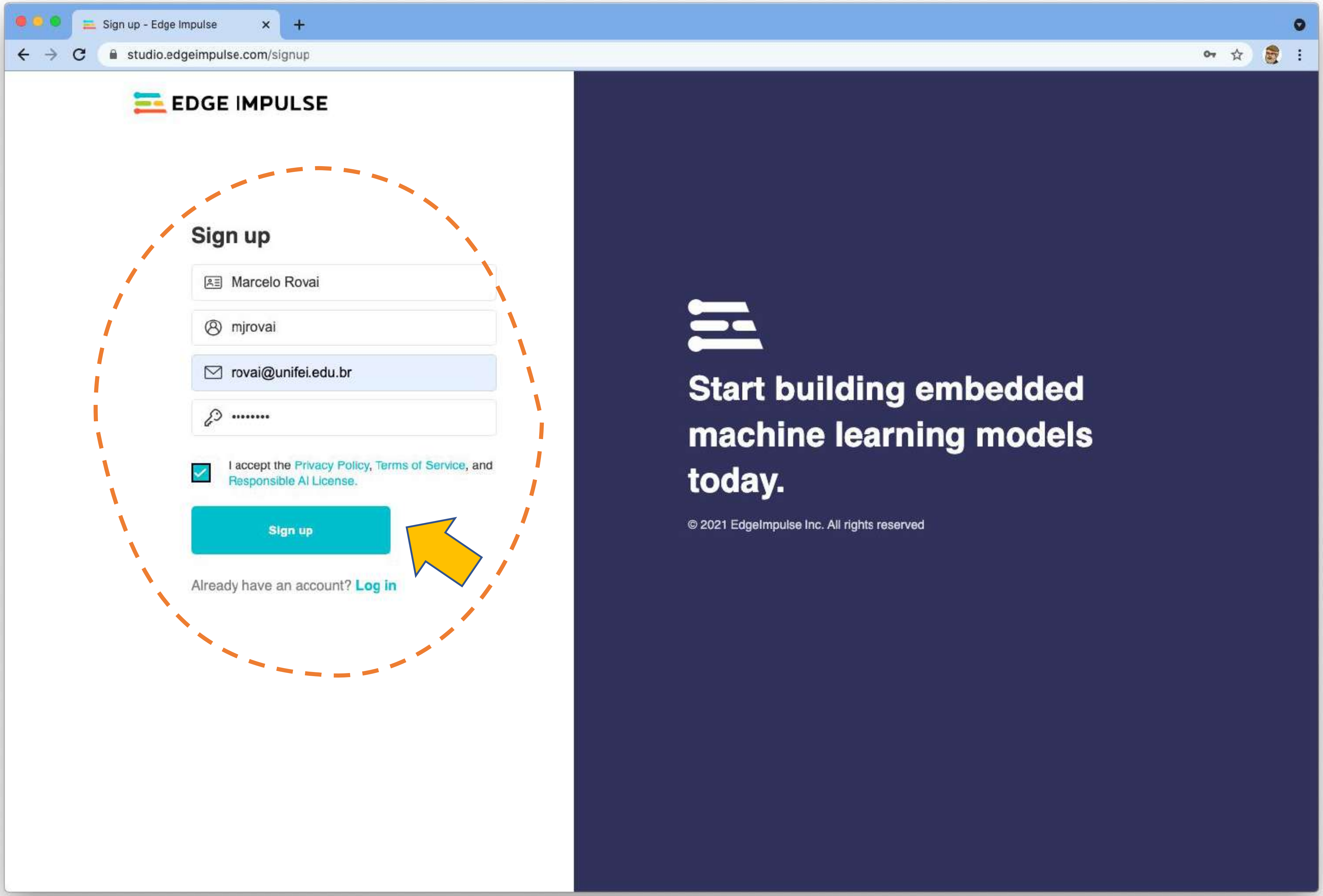
Jan 2020
Today
Jan 2020
Today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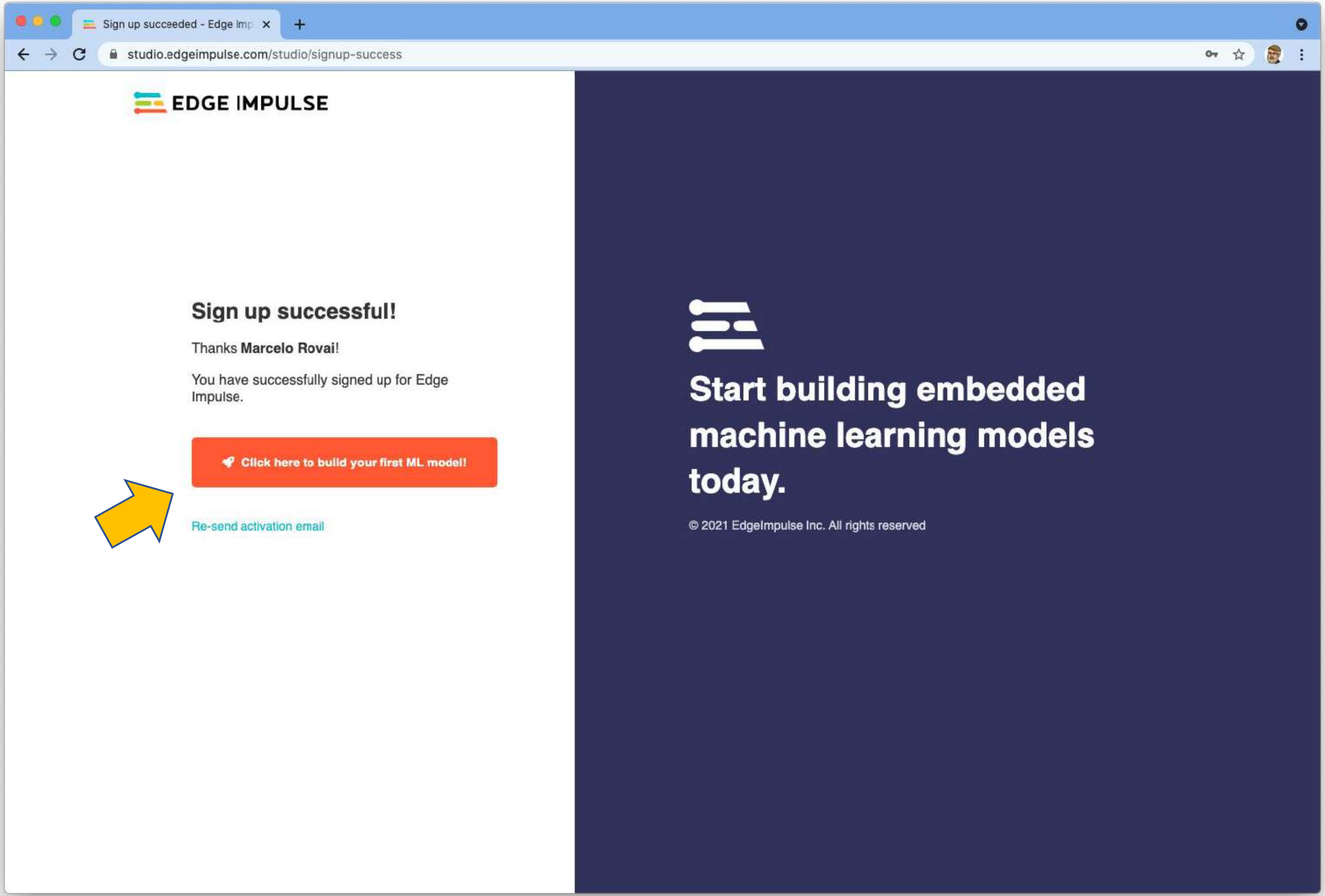

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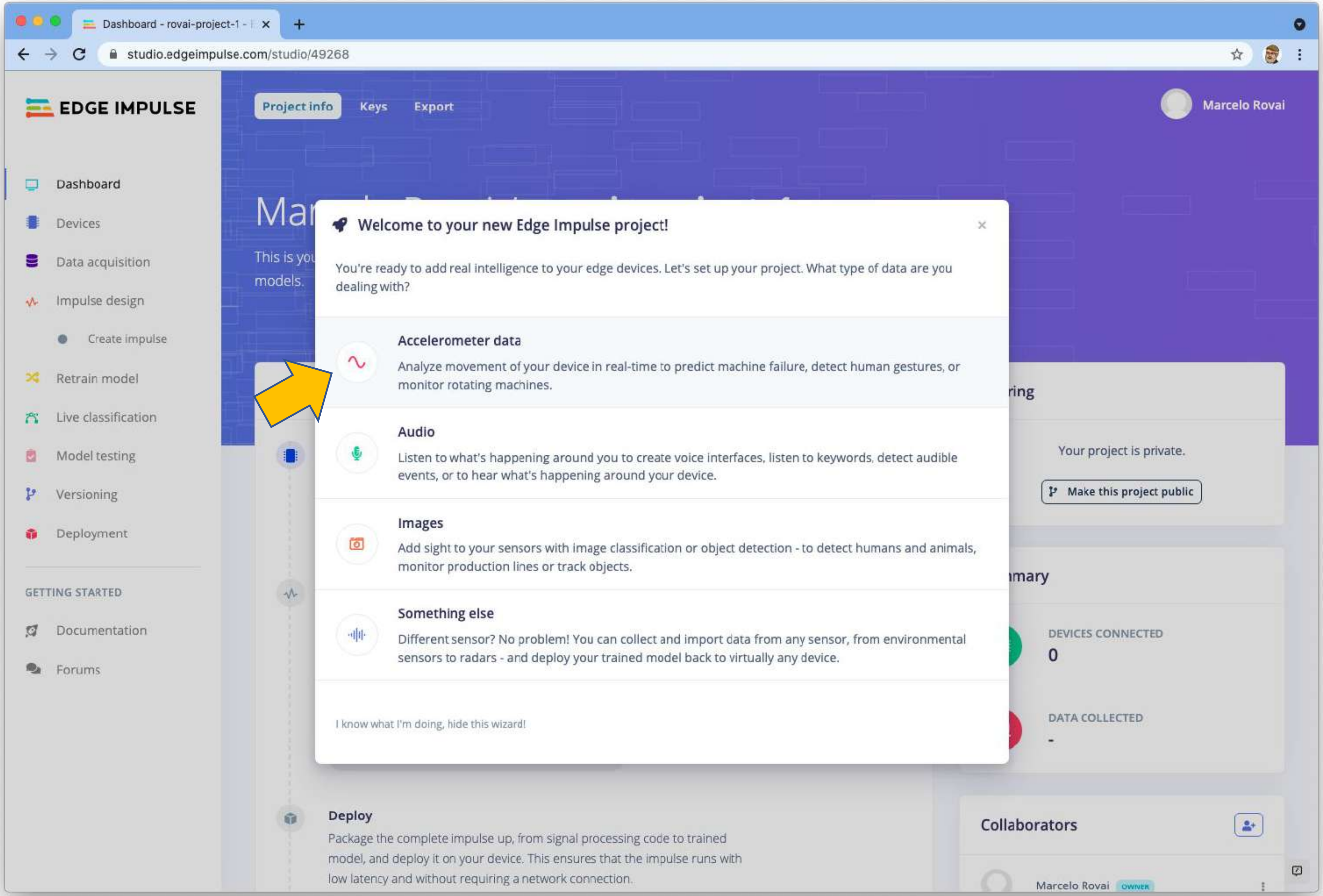
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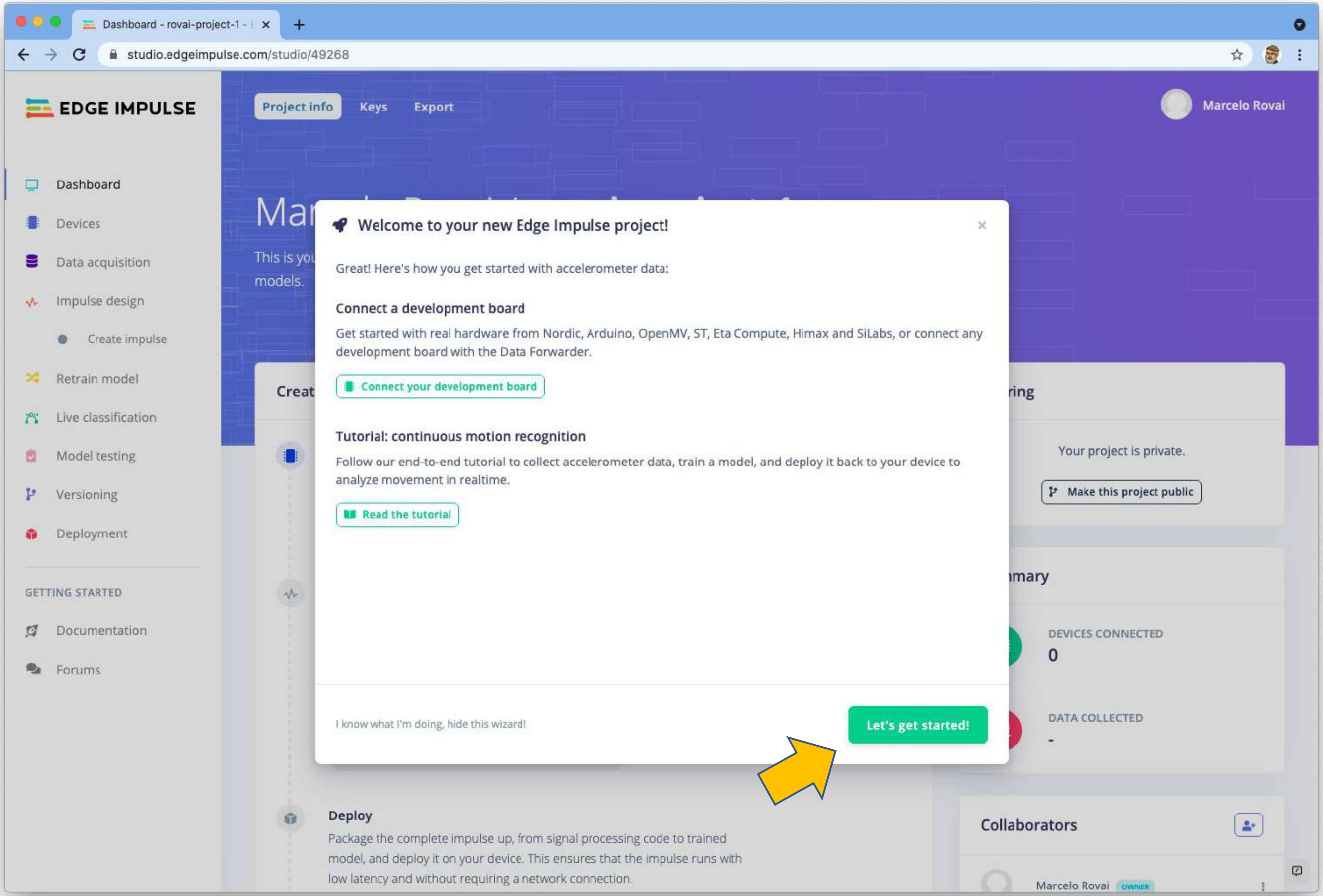
Welcome to your new Edge Impulse project!
You're ready to add real intelligence to your edge devices. Let's set up your project. What type of data are you dealing with?
Accelerometer data
Analyze movement of your device in real-time to predict machine failure, detect human gestures, or monitor rotating 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!
Your project is private.
Make this project public
DEVICES CONNECTED
0
DATA COLLECTED
-
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.
Collaborators
Marcelo Rovai
OWNER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Welcome to your new Edge Impulse project!
Great! Here's how you get started with accelerometer data:
Connect a development board
Get started with real hardware from Nordic, Arduino, OpenMV, ST, Eta Compute, Himax and SiLabs, or connect any development board with the Data Forwarder.
Connect your development board
Tutorial: continuous motion recognition
Follow our end-to-end tutorial to collect accelerometer data, train a model, and deploy it back to your device to analyze movement in realtime.
Read the tutorial
I know what I'm doing, hide this wizard!
Let's get started!
Your project is private.
Make this project public
DEVICES CONNECTED
0
DATA COLLECTED
-
Collaborators
Marcelo Rovai
OWNER
Deploy
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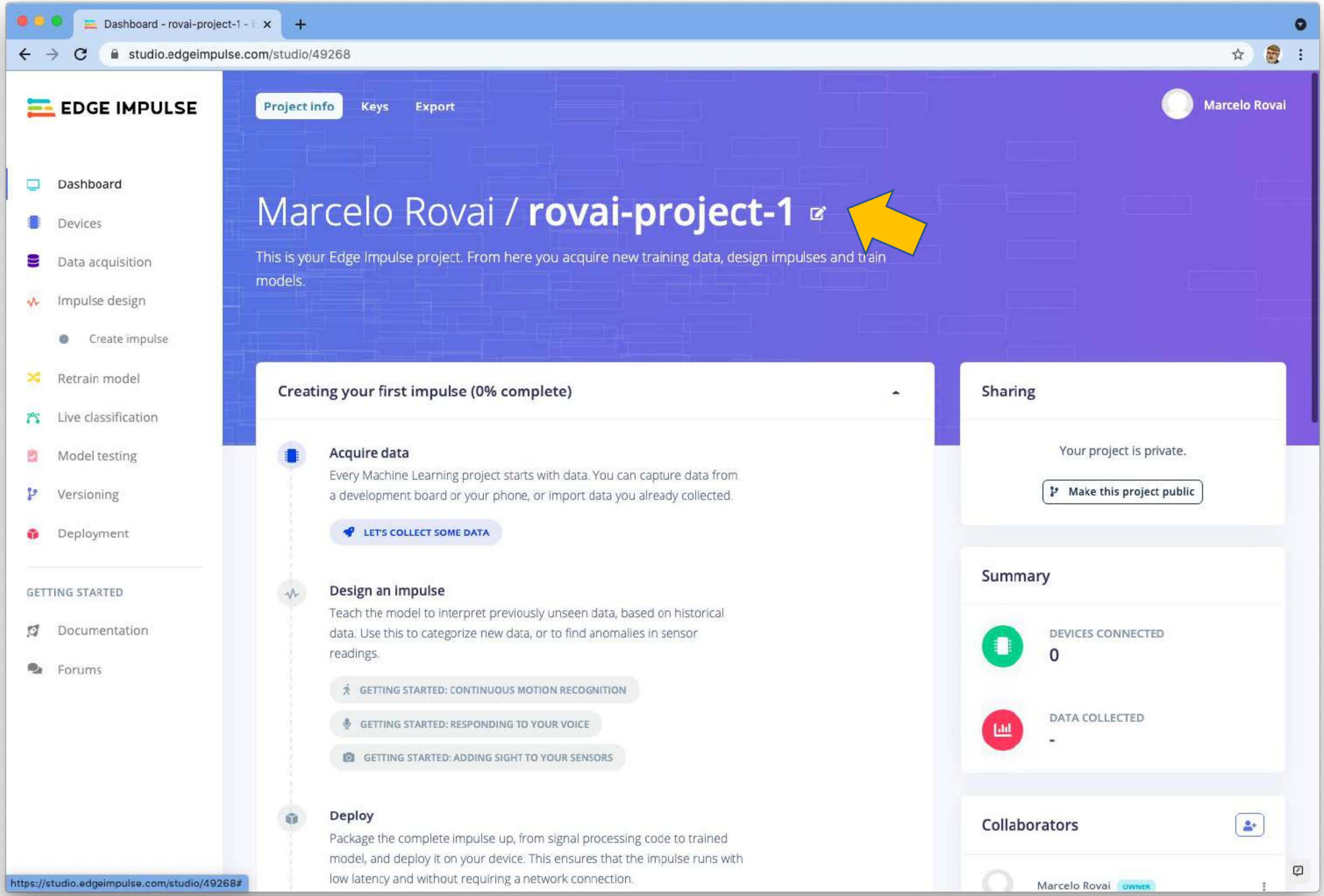
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Marcelo Rovai / rovai-project-1
This is your Edge Impulse project. From here you acquire new training data, design impulses and train models.
Creating your first impulse (0% complete)
Acquire data
Every Machine Learning project starts with data. You 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.
Sharing
Your project is private.
Make this project public
Summary
DEVICES CONNECTED
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DATA COLLECTED
-
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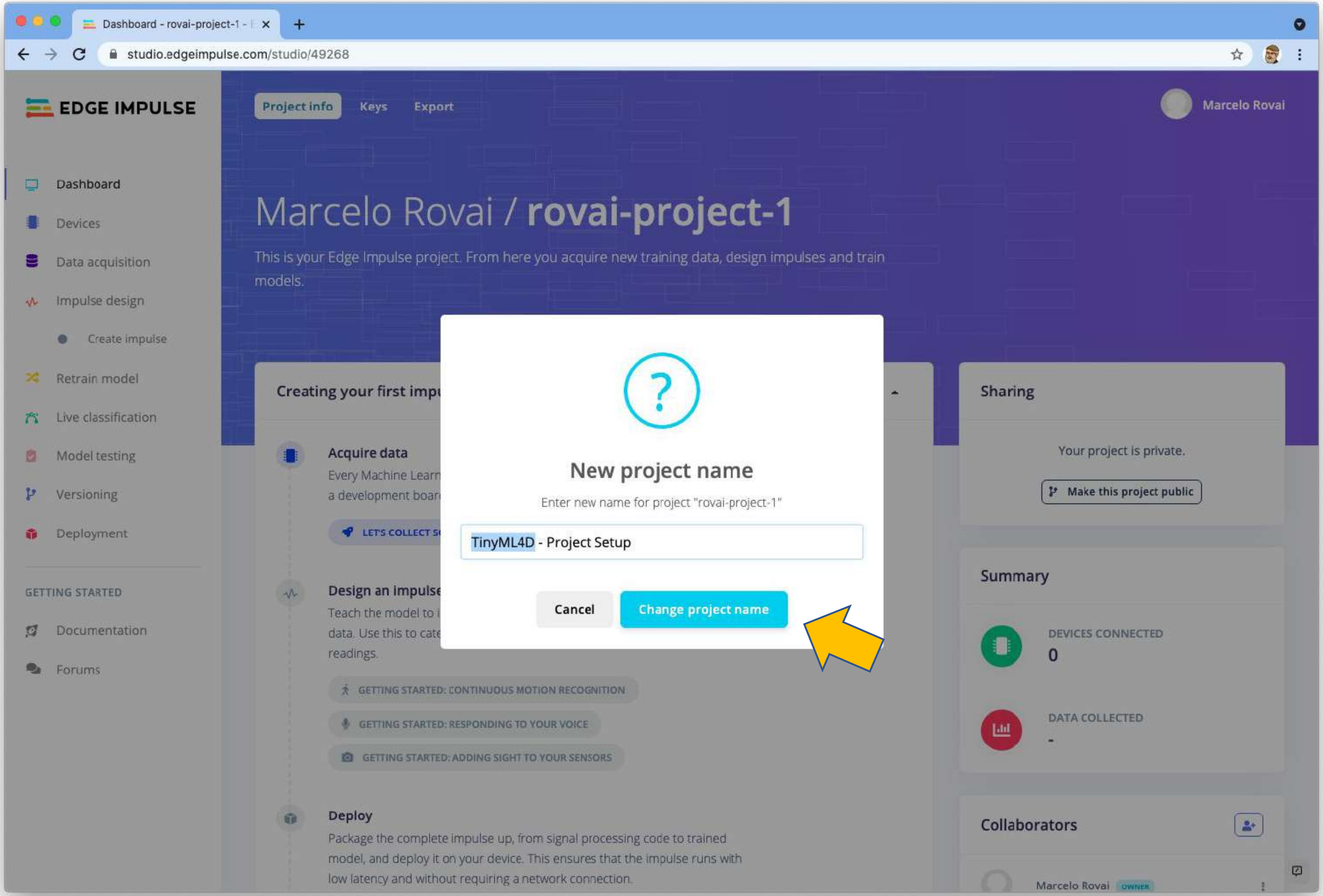
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Marcelo Rovai / rovai-project-1
This is your Edge Impulse project. From here you acquire new training data, design impulses and train models.
New project name
Enter new name for project "rovai-project-1"
TinyML4D - Project Setup
Cancel
Change project name
Sharing
Your project is private.
Make this project public
Summary
DEVICES CONNECTED
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DATA COLLECTED
-
Collaborators
Marcelo Rovai
OWNER
Acquire data
Design an impulse
GETTING STARTED: CONTINUOUS MOTION RECOGNITION
GETTING STARTED: RESPONDING TO YOUR VOICE
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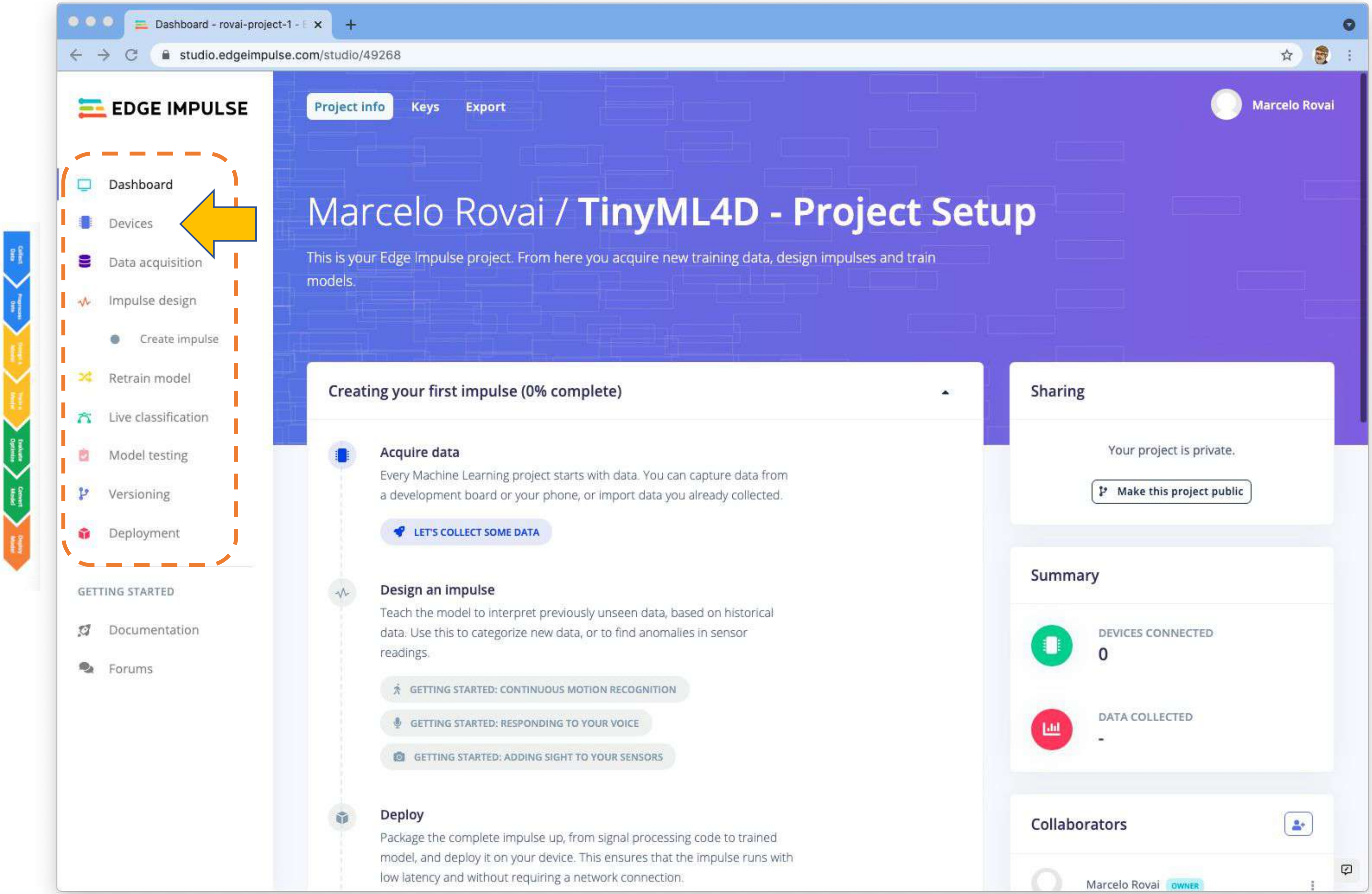

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Marcelo Rovai / TinyML4D - Project Setup
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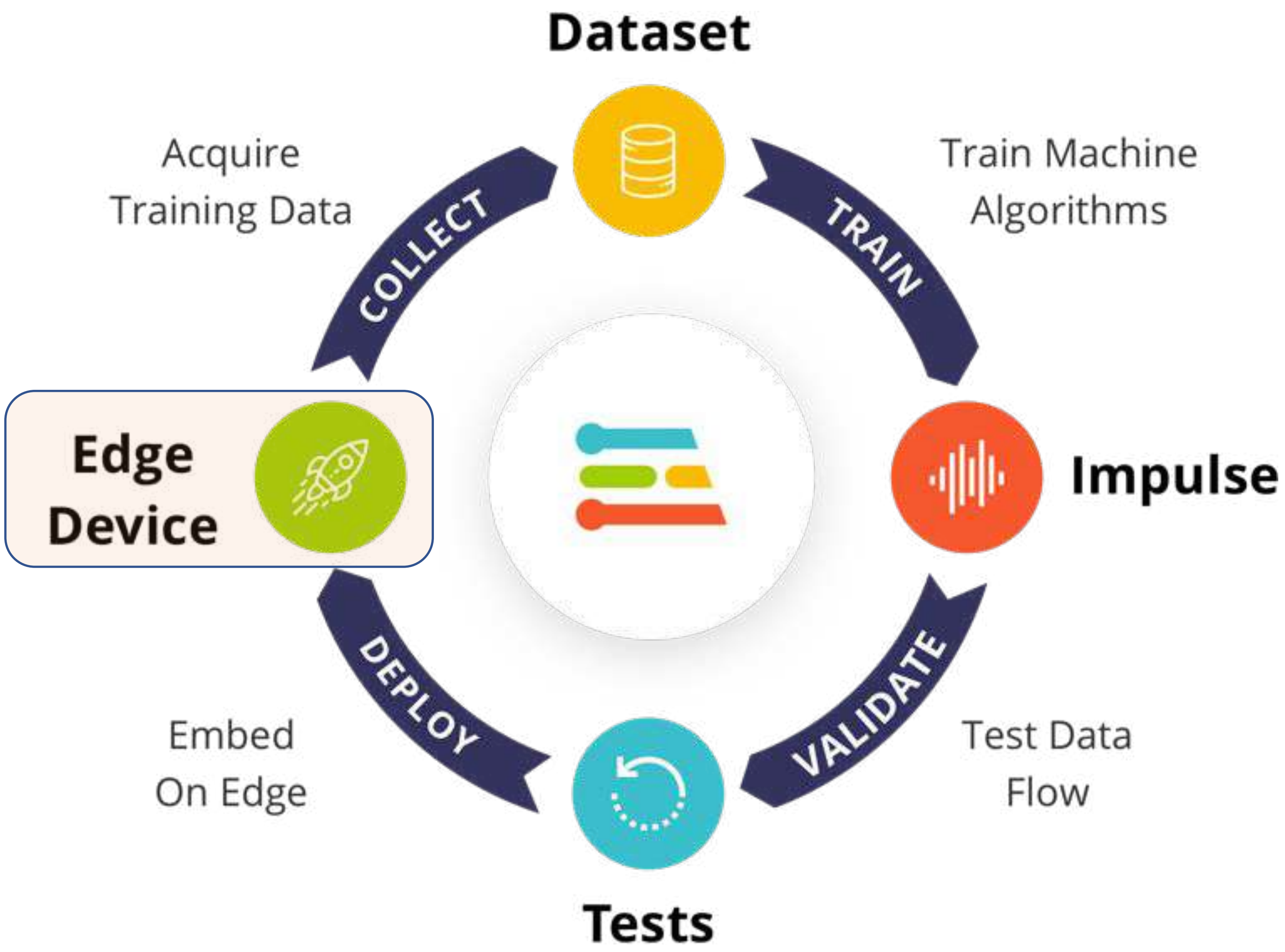
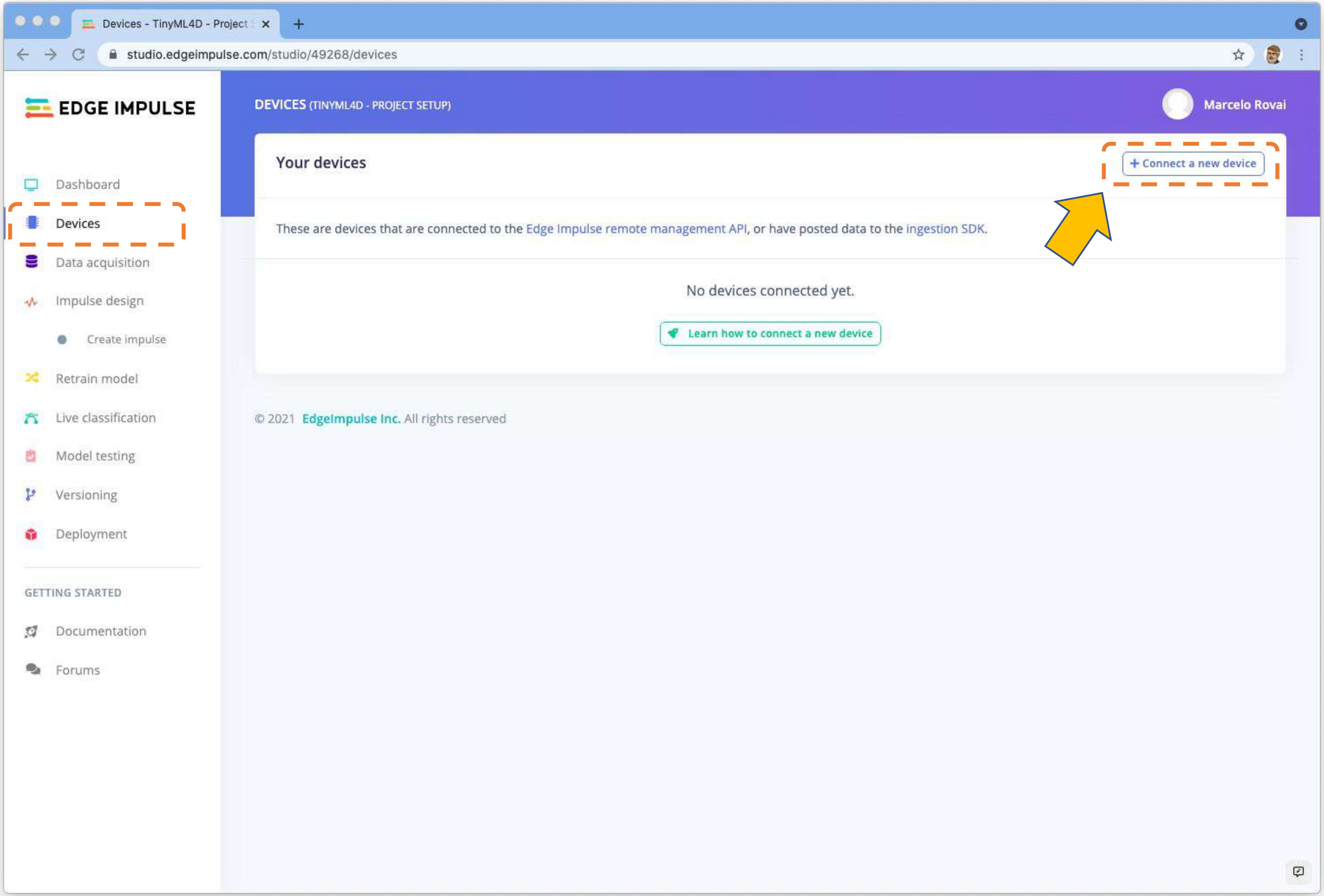


- Pre-Processing Data
- Design a Model
- Train a Model



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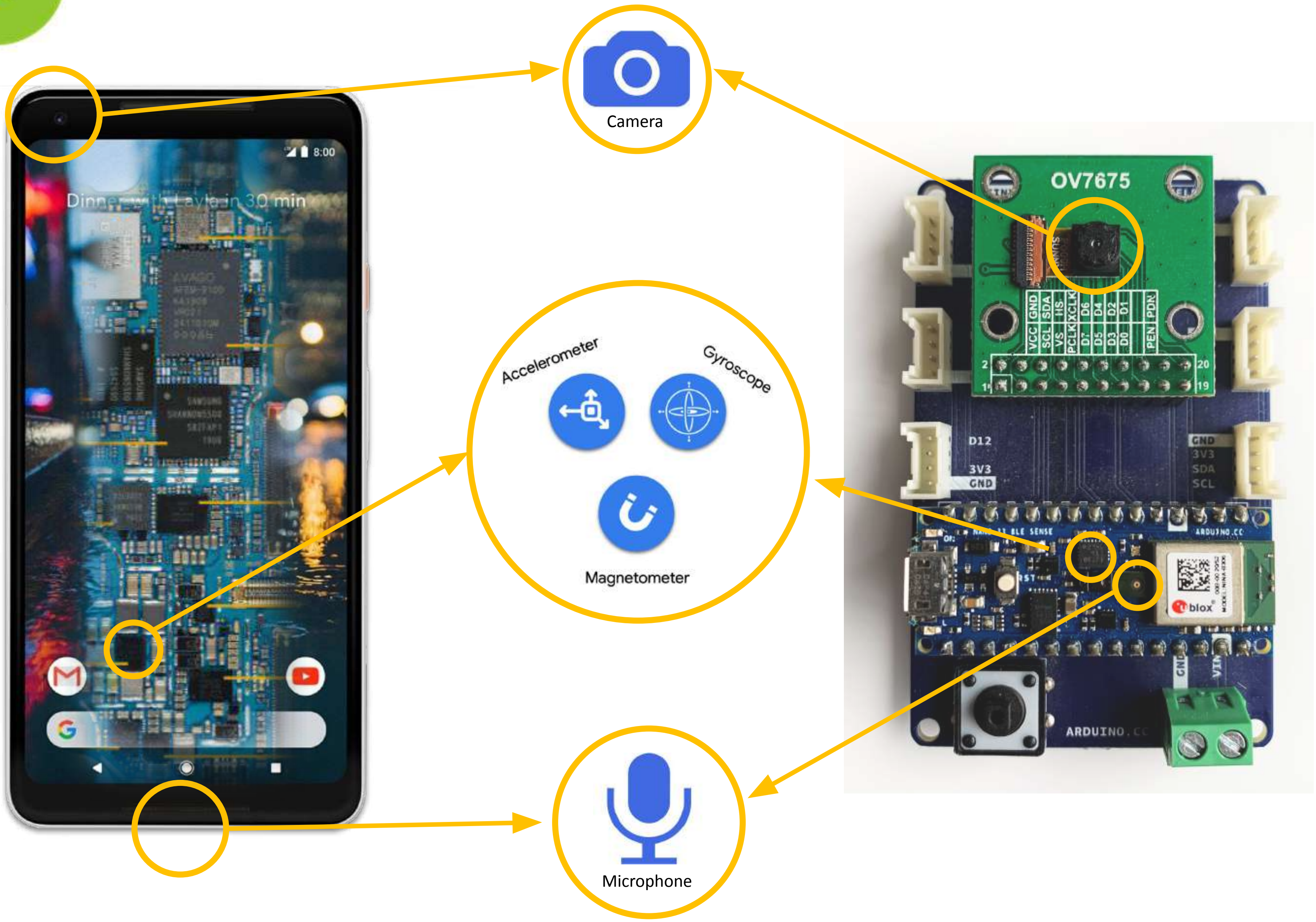
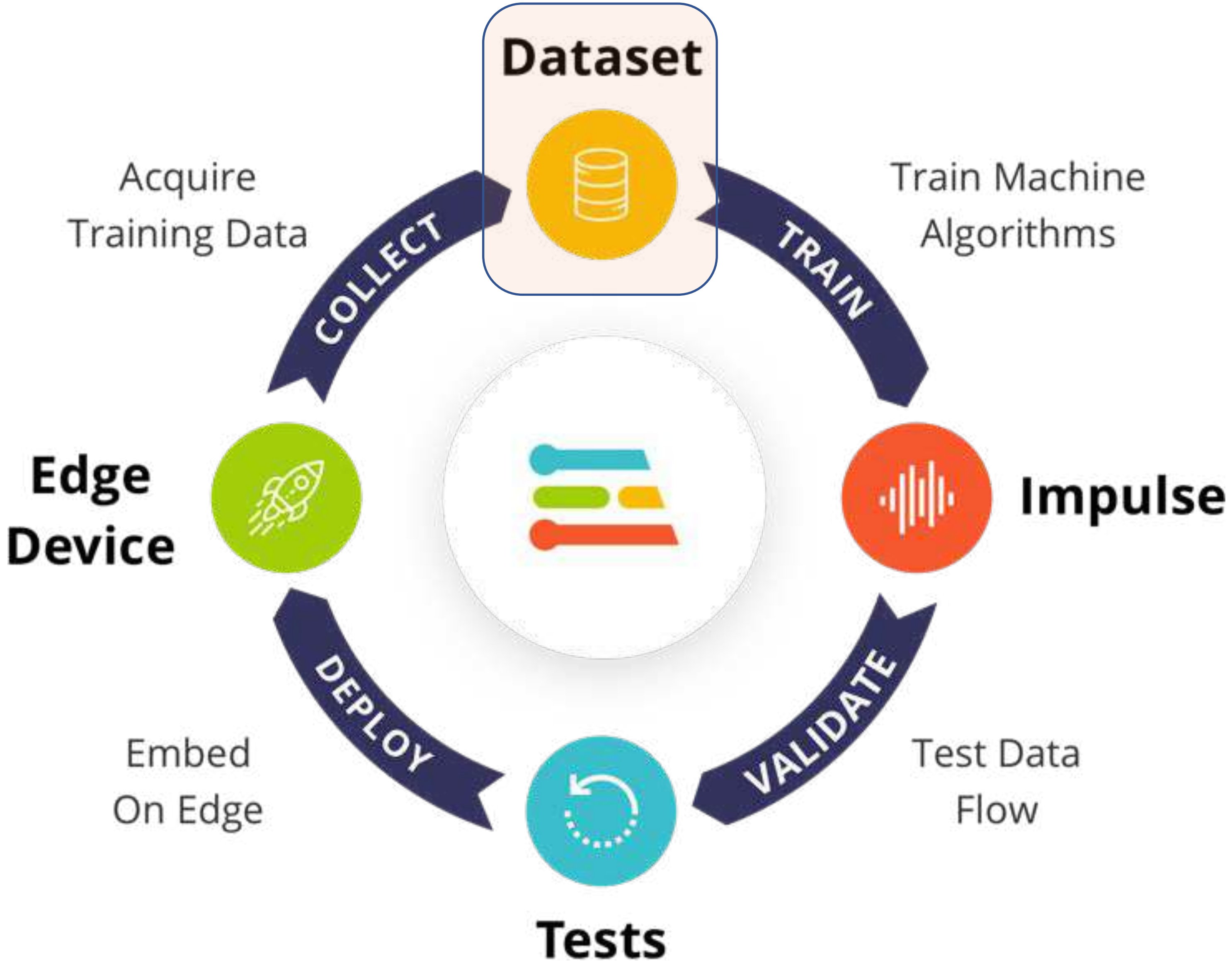
Edge Device & Sensors

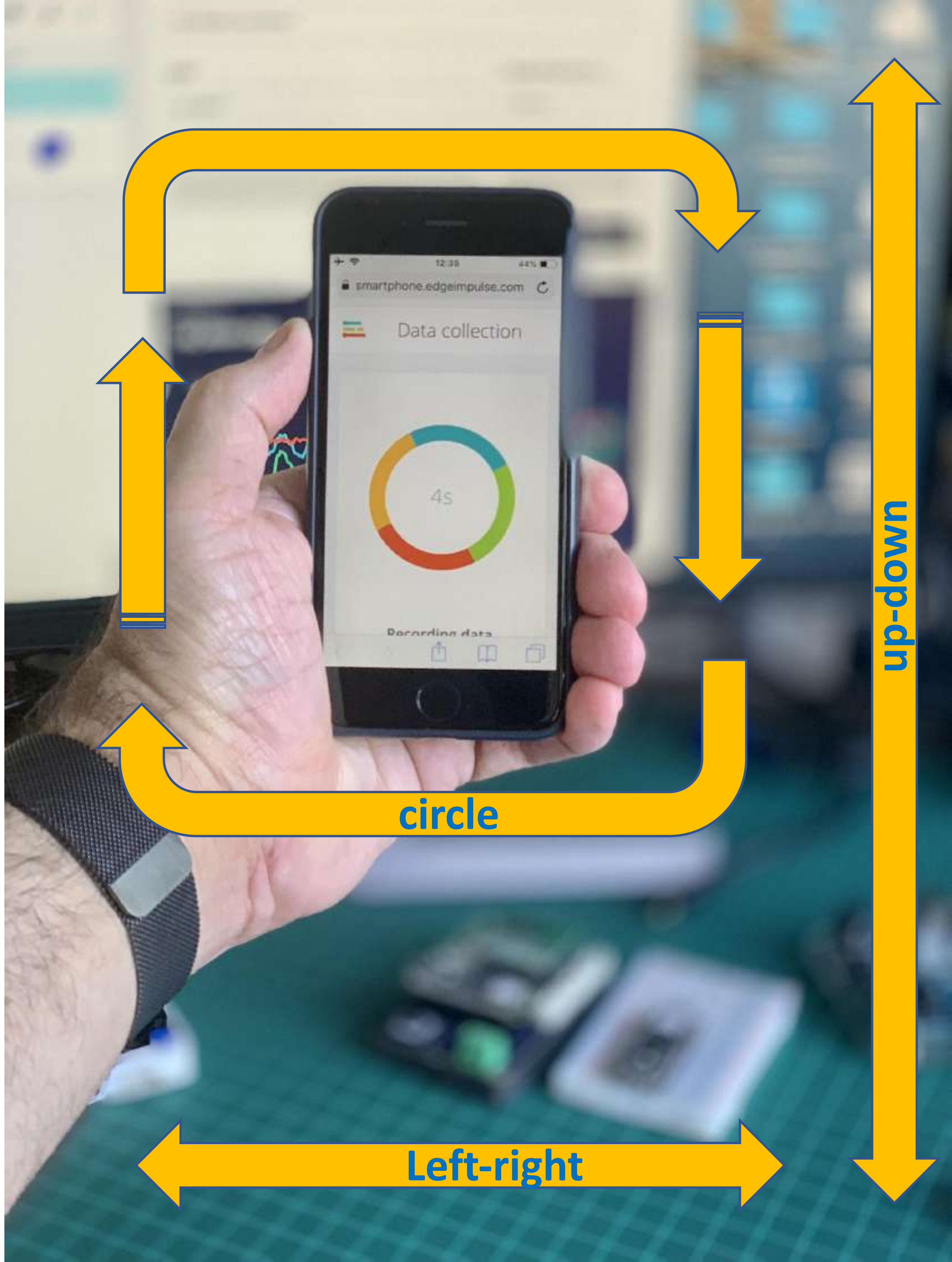




- Pre-Processing Data
- Design a Model
- Train a Model

Gesture Classification

- Manual gestures ("labels"):
  - up-down
  - left-right
  - circle
  - idle



Gesture Classification

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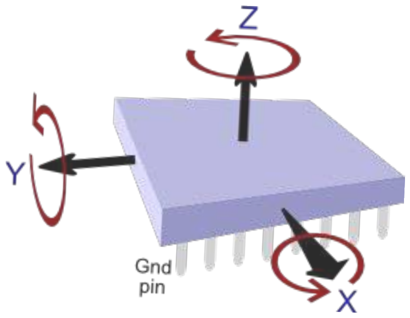
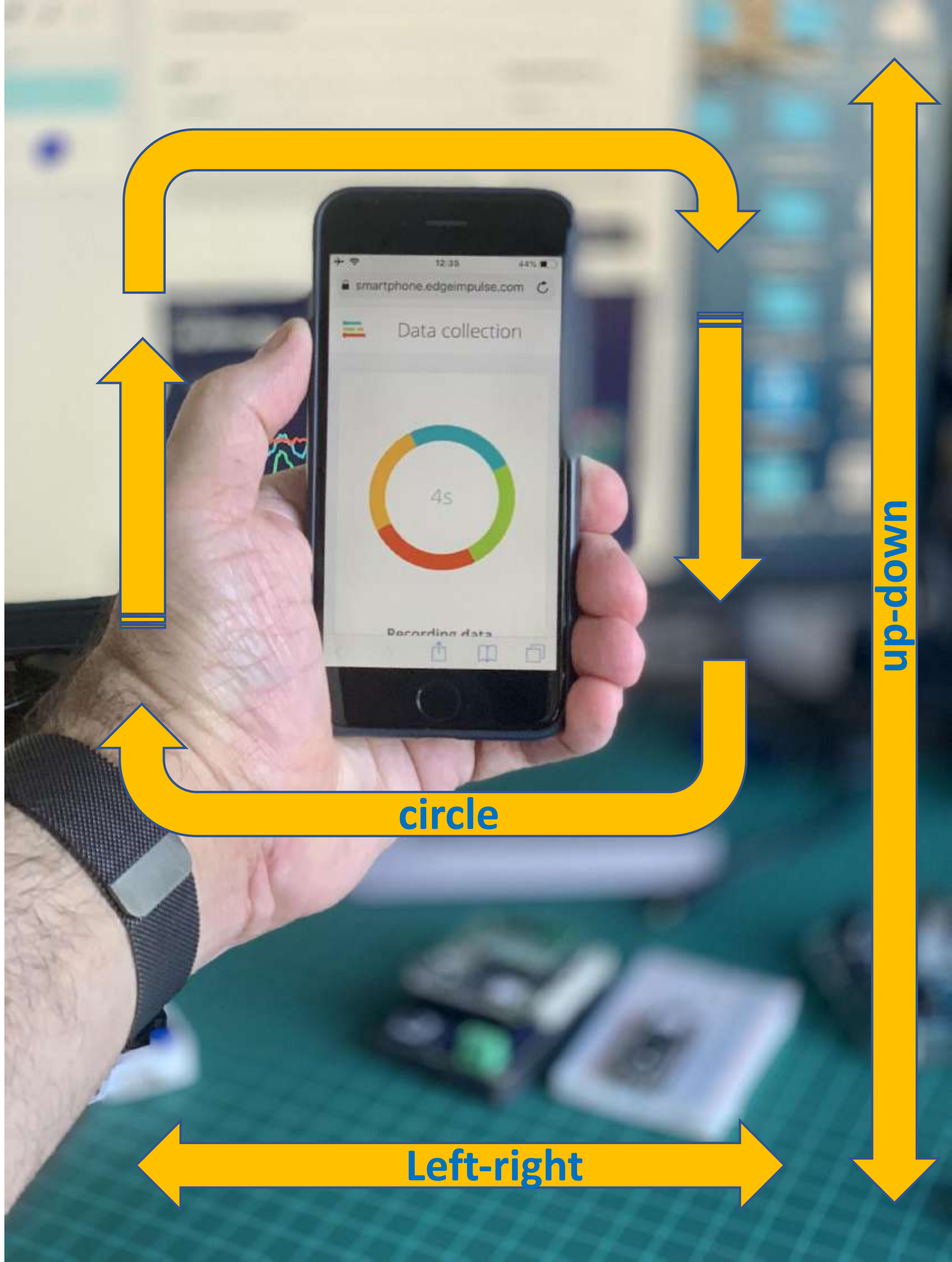
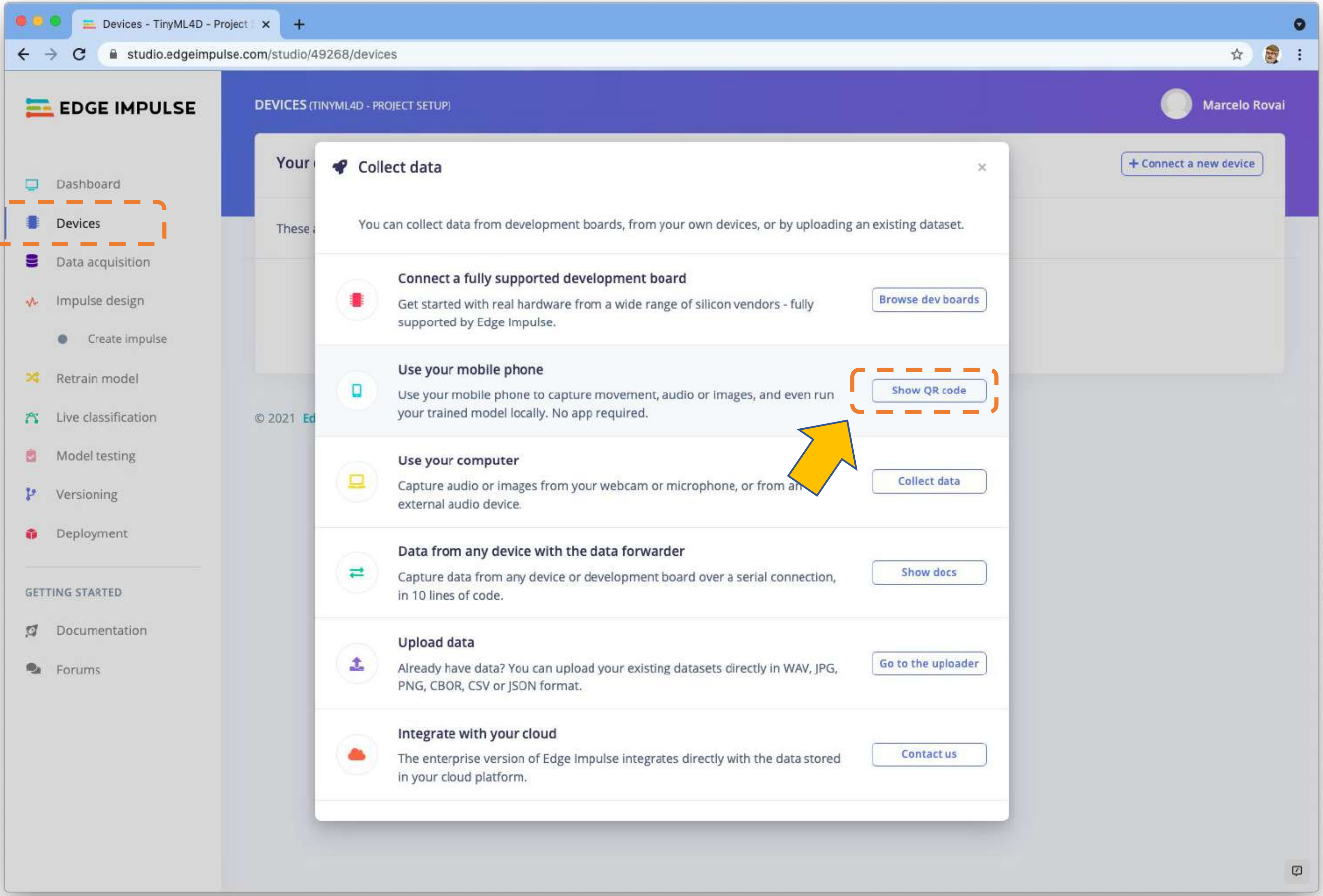


- Data: collect & test using accelerometer as sensor





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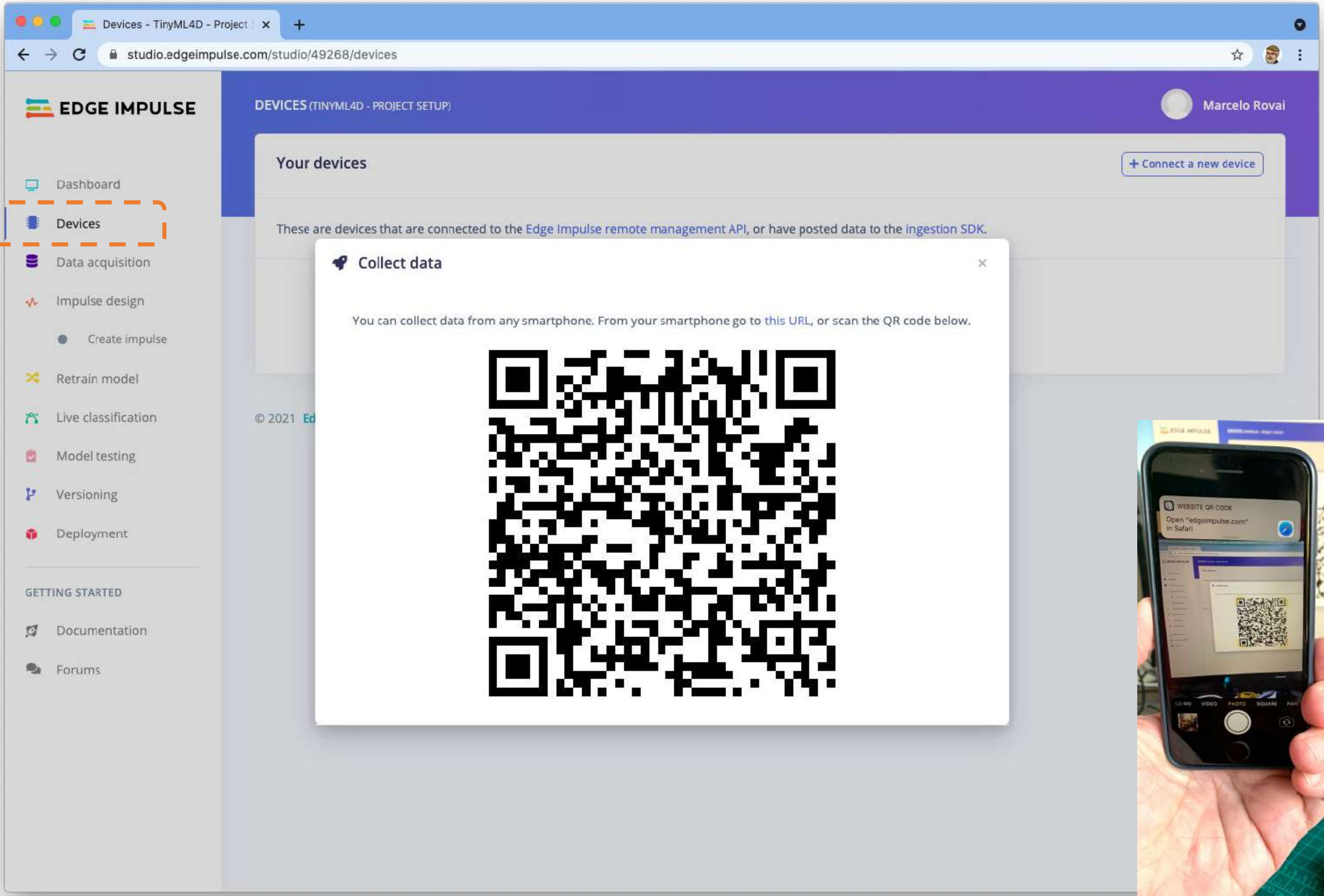
+ Connect a new device
Collect data
You can collect data from development boards, from your own devices, or by uploading an existing dataset.
Connect a fully supported development board
Get started with real hardware from a wide range of silicon vendors - fully supported by Edge Impulse.
Browse dev boards
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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Collect data
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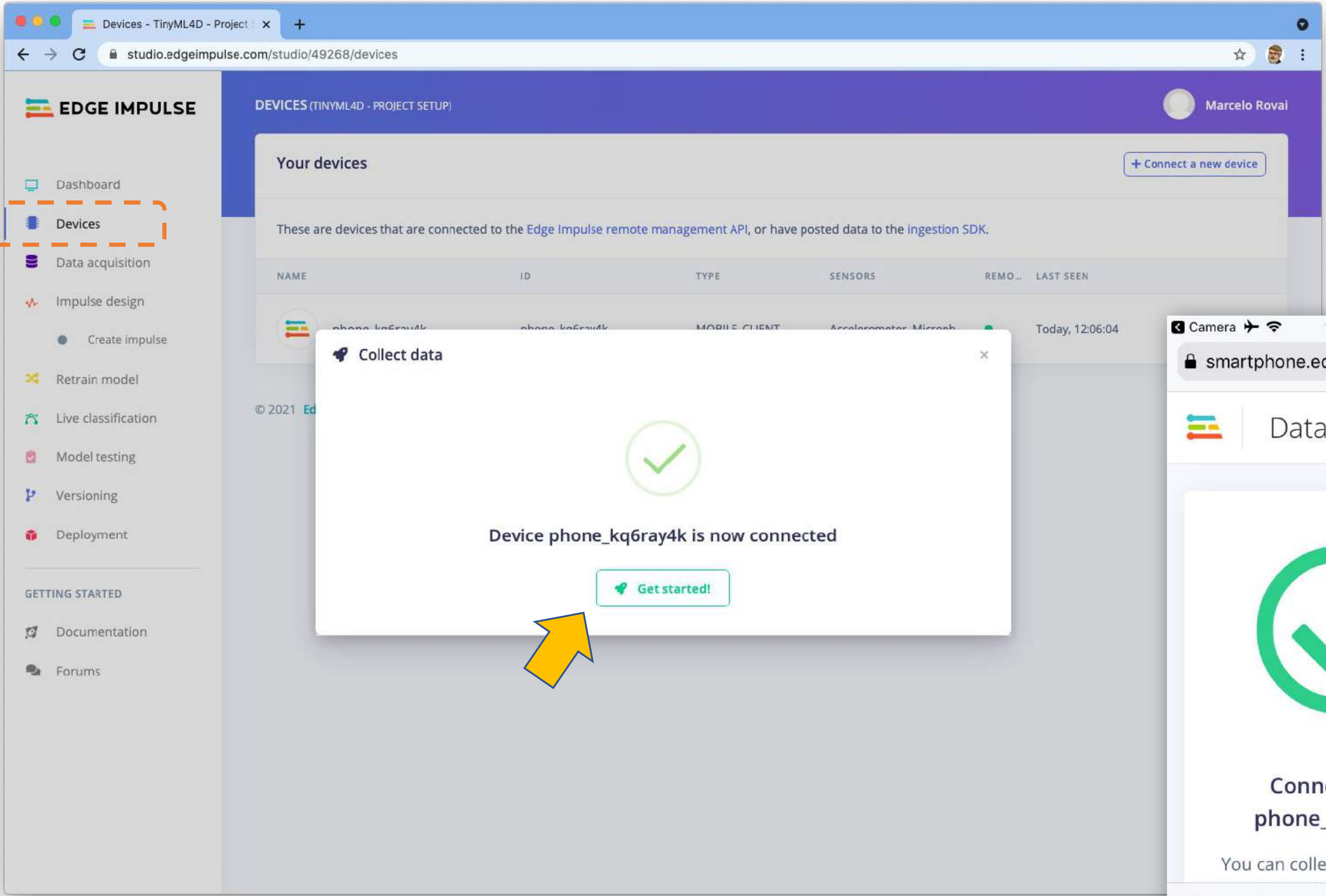
Open "edgeimpulse.com" in Safari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NAME
ID
TYPE
SENSORS
REMO...
LAST SEEN
Today, 12:06:04
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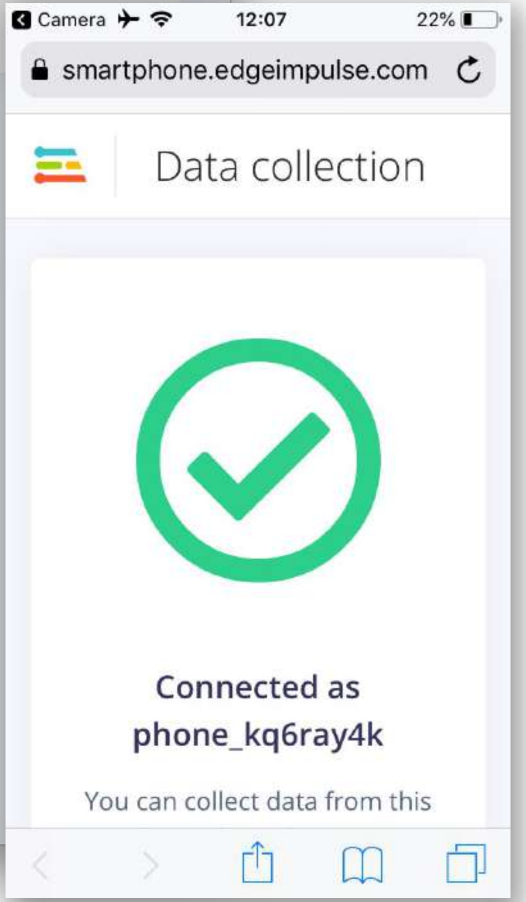
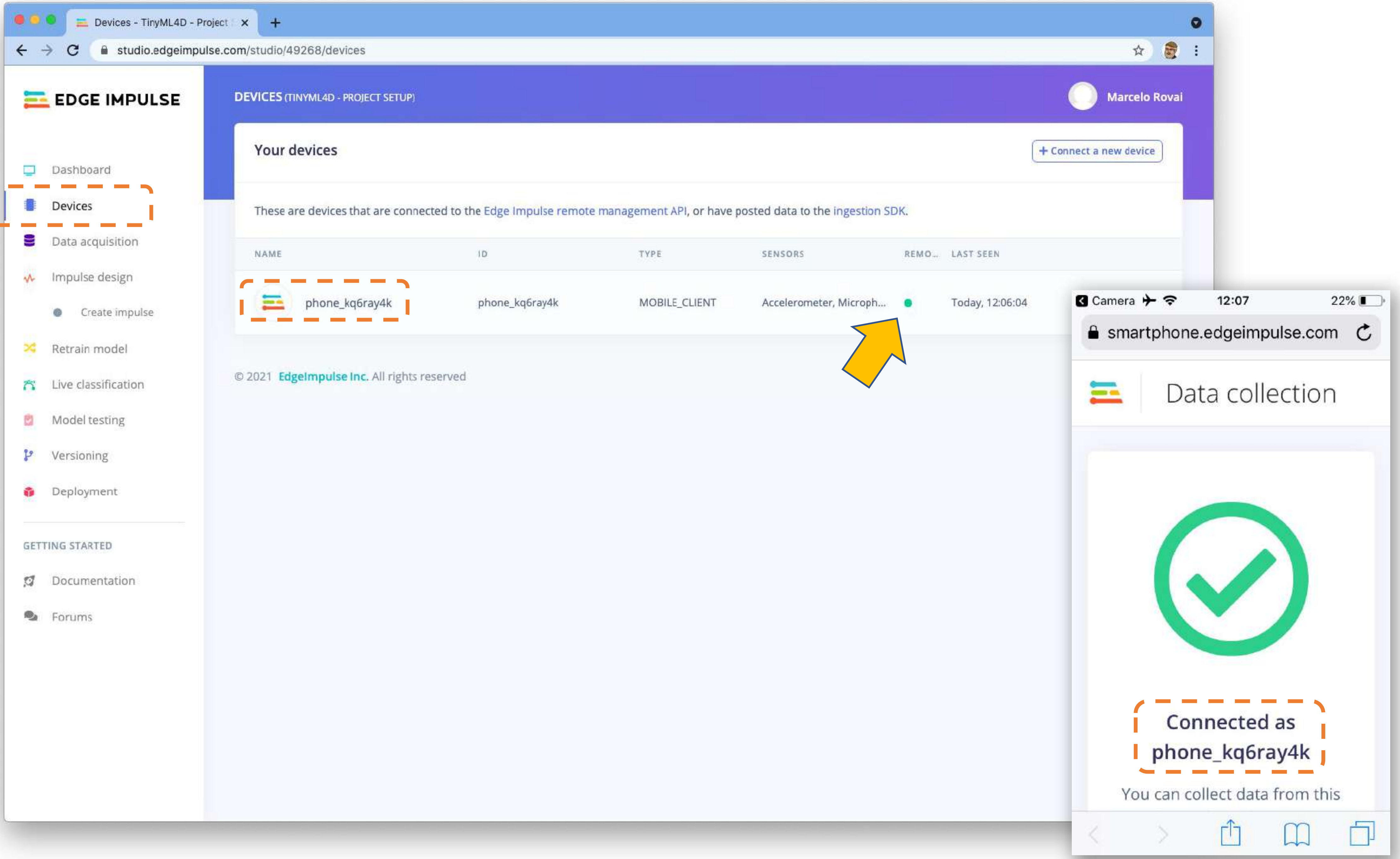
Collect data
Device phone_kq6ray4k is now connected
Get started!

Camera
12:07
22%
smartphone.edgeimpulse.com
Data collection
Connected as phone_kq6ray4k
You can collect data from this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NAME
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TYPE
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LAST SEEN
phone_kq6ray4k
phone_kq6ray4k
MOBILE_CLIENT
Accelerometer, Microph...
Today, 12:06:04
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Camera
12:07
22%
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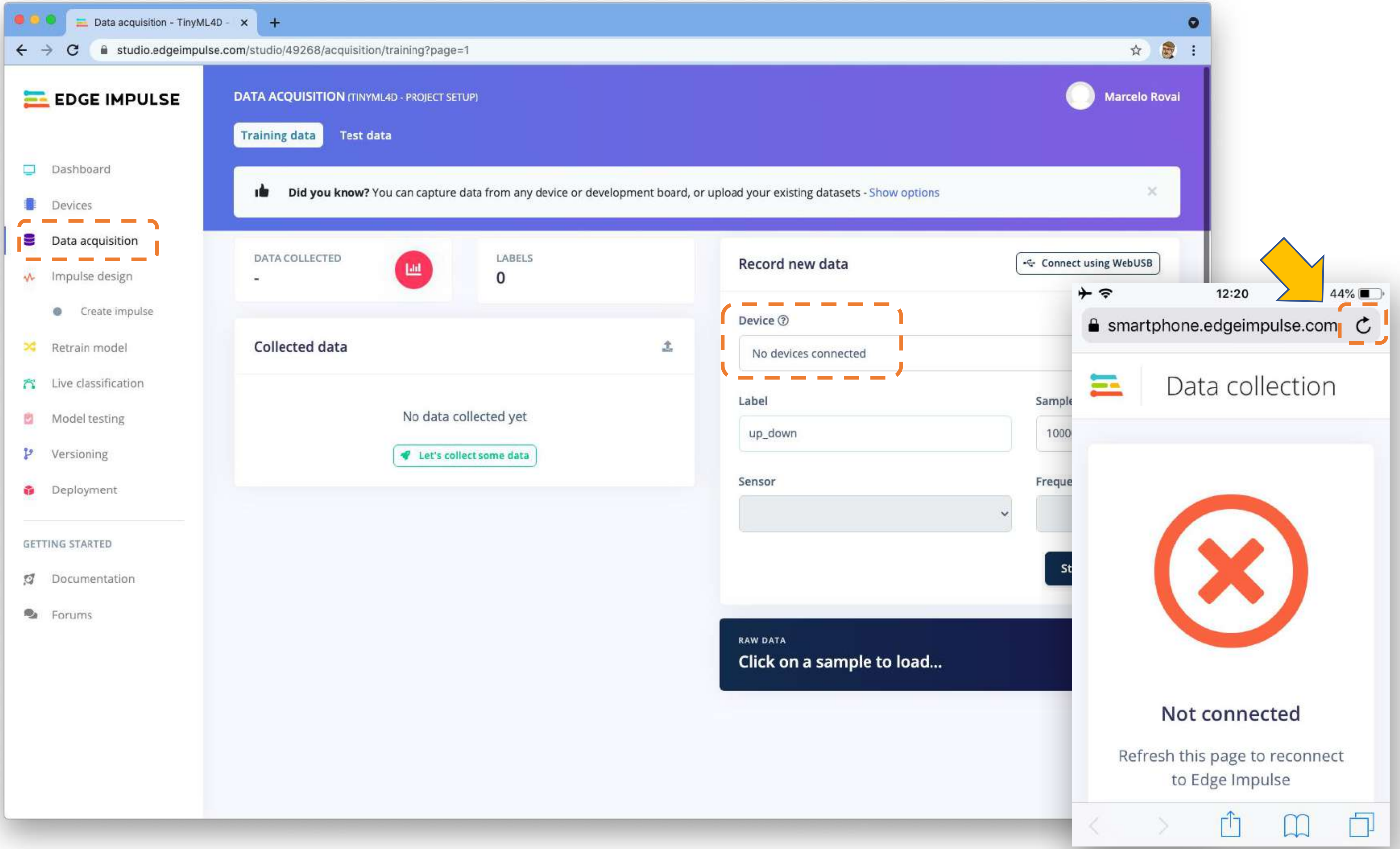
Data collection
Connected as phone_kq6ray4k
You can collect data from this



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DATA ACQUISITION (TINYML4D - PROJECT SETUP)
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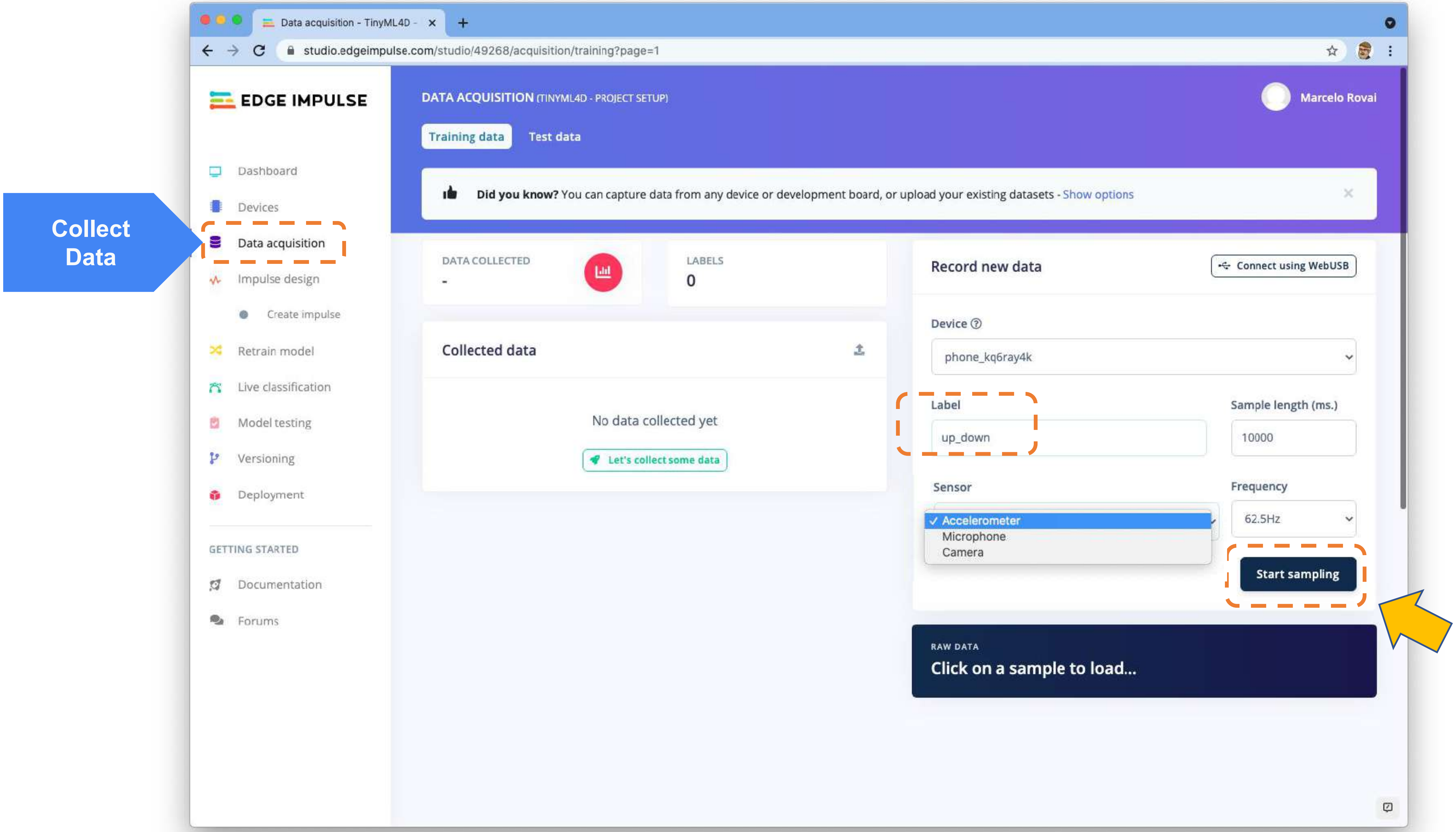
Training data
Test data
Did you know? You can capture data from any device or development board, or upload your existing datasets - Show options
Dashboard
Devices
Data acquisition
Impulse design
Create impulse
Retrain model
Live classification
Model testing
Versioning
Deployment
GETTING STARTED
Documentation
Forums
DATA COLLECTED
-
LABELS
0
Collected data
No data collected yet
Let's collect some data
Record new data
Connect using WebUSB
Device
No devices connected
Label
up_down
Sensor
RAW DATA
Click on a sample to load...
12:20
44%
smartphone.edgeimpulse.com
Data collection
Not connected
Refresh this page to reconnect to Edge Impulse


Collect Data
Data acquisition - TinyML4D -
studio.edgeimpulse.com/studio/49268/acquisition/training?page=1
EDGE IMPULSE
DATA ACQUISITION (TINYML4D - PROJECT SETUP)
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
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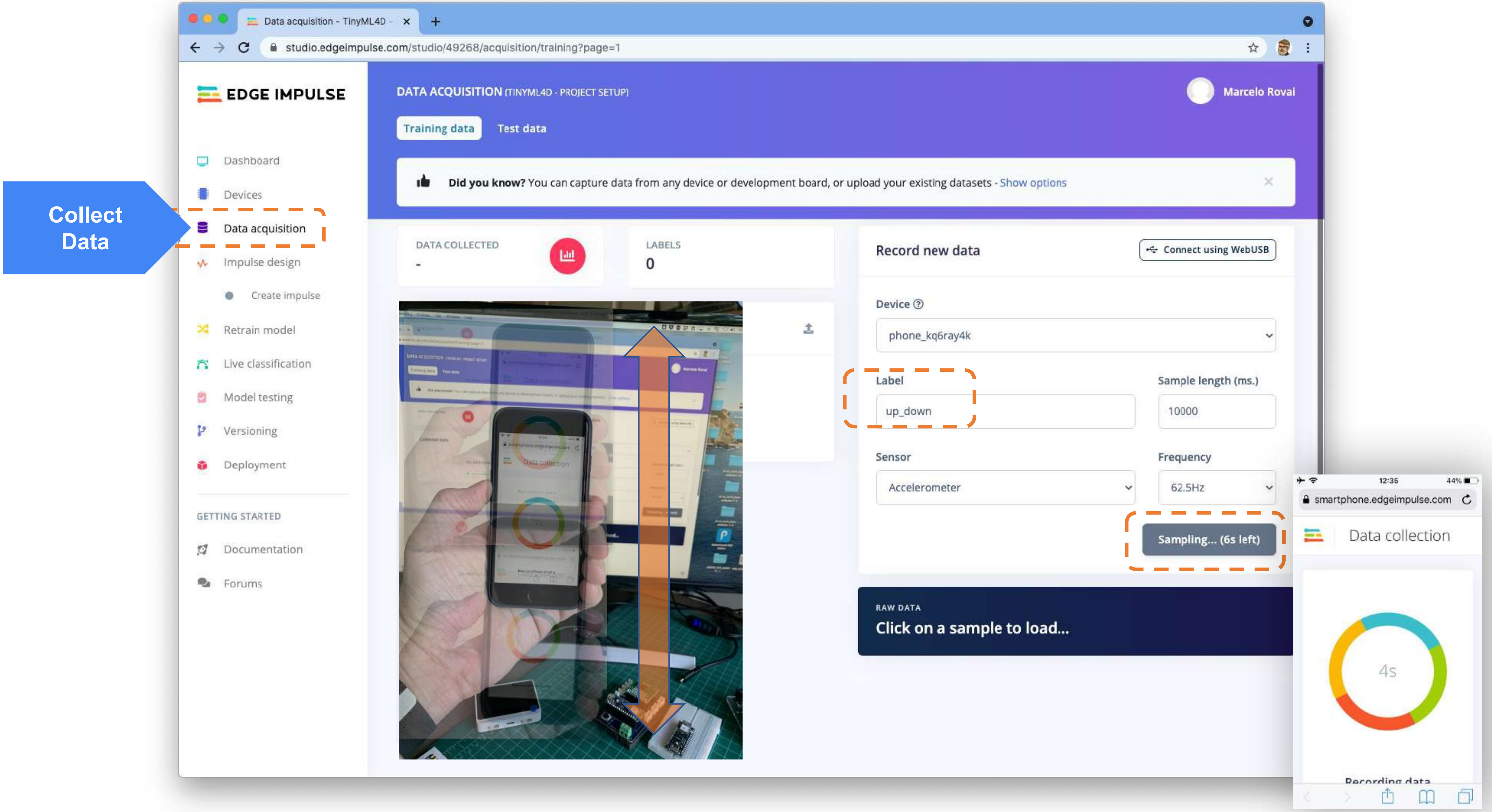
Versioning
Deployment
GETTING STARTED
Documentation
Forums
DATA COLLECTED
-
LABELS
0
Collected data
No data collected yet
Let's collect some data
Record new data
Connect using WebUSB
Device
phone_kq6ray4k
Label
up_down
Sample length (ms.)
10000
Sensor
Accelerometer
Microphone
Camera
Frequency
62.5Hz
Start sampling
RAW DATA
Click on a sample to load...



Collect Data
Data acquisition - TinyML4D -
studio.edgeimpulse.com/studio/49268/acquisition/training?page=1
EDGE IMPULSE
Dashboard
Devices
Data acquisition
Impulse design
Create impulse
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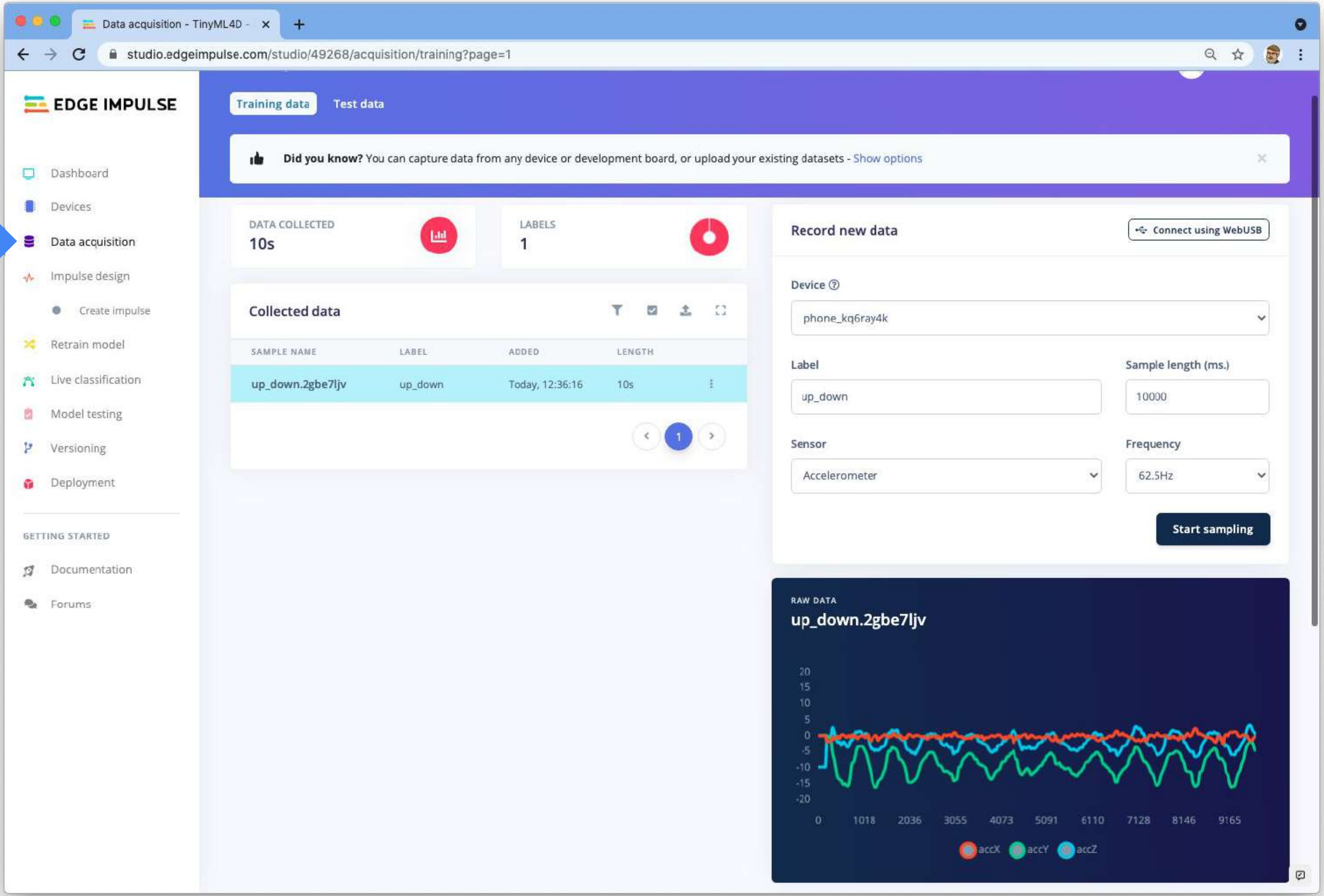
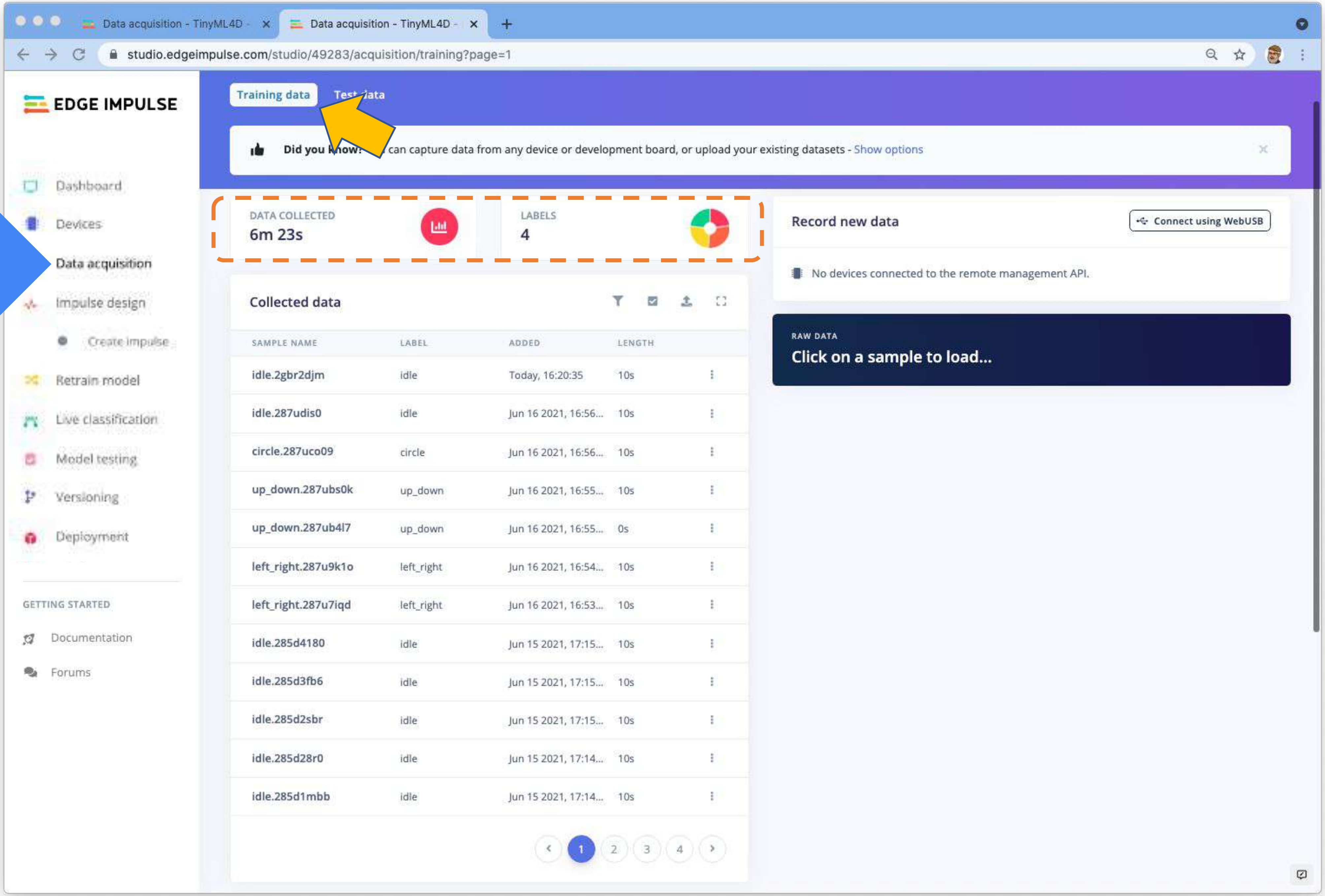
GETTING STARTED
Documentation
Forums
DATA ACQUISITION (TINYML4D - PROJECT SETUP)
Marcelo Rovai
Training data
Test data
Did you know? You can capture data from any device or development board, or upload your existing datasets - Show options
DATA COLLECTED
-
LABELS
0
Record new data
Connect using WebUSB
Device
phone_kq6ray4k
Label
up_down
Sample length (ms.)
10000
Sensor
Accelerometer
Frequency
62.5Hz
Sampling... (6s left)
RAW DATA
Click on a sample to load...
12:35
44%
smartphone.edgeimpulse.com
Data collection
4s
Recording data

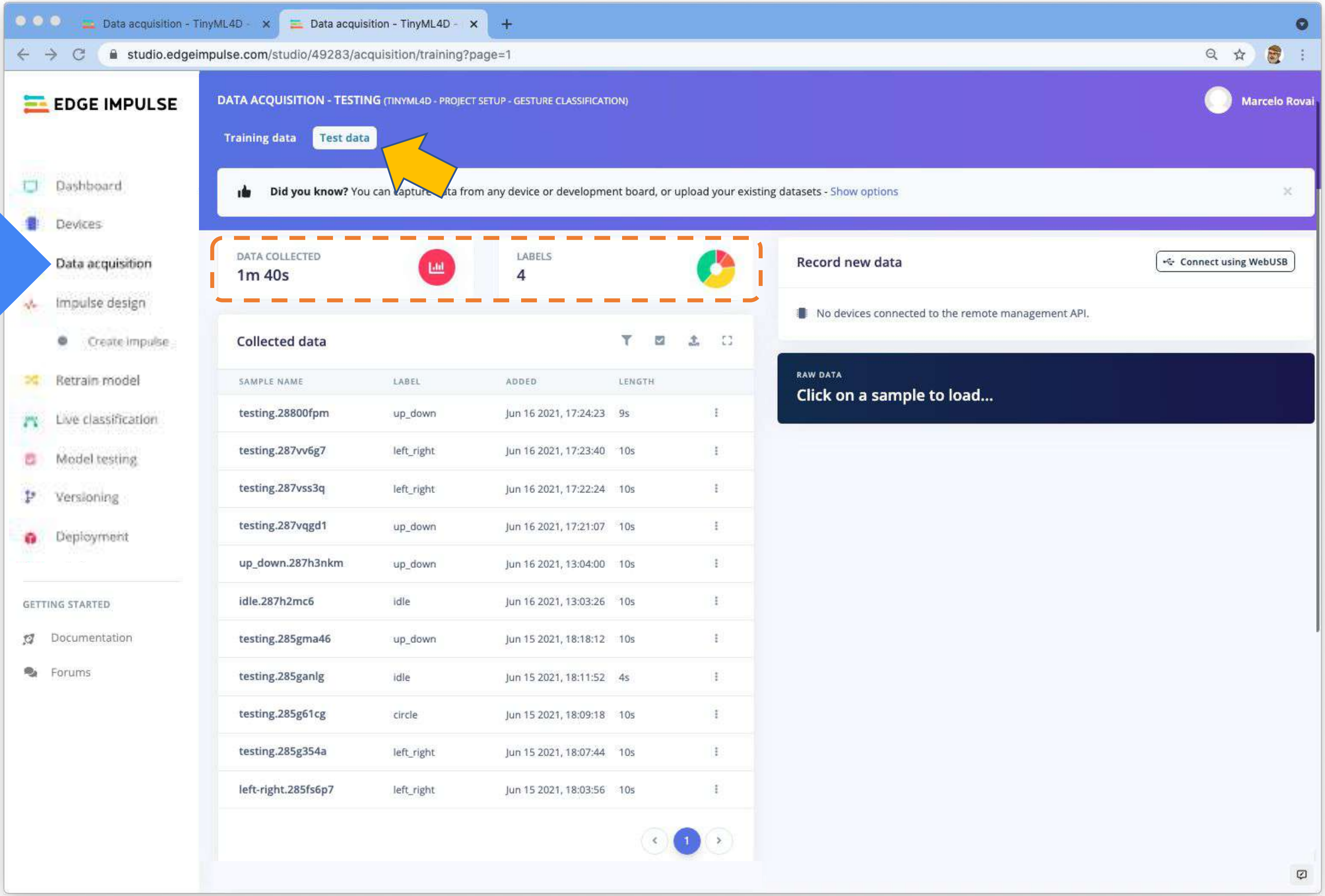
Collect Data

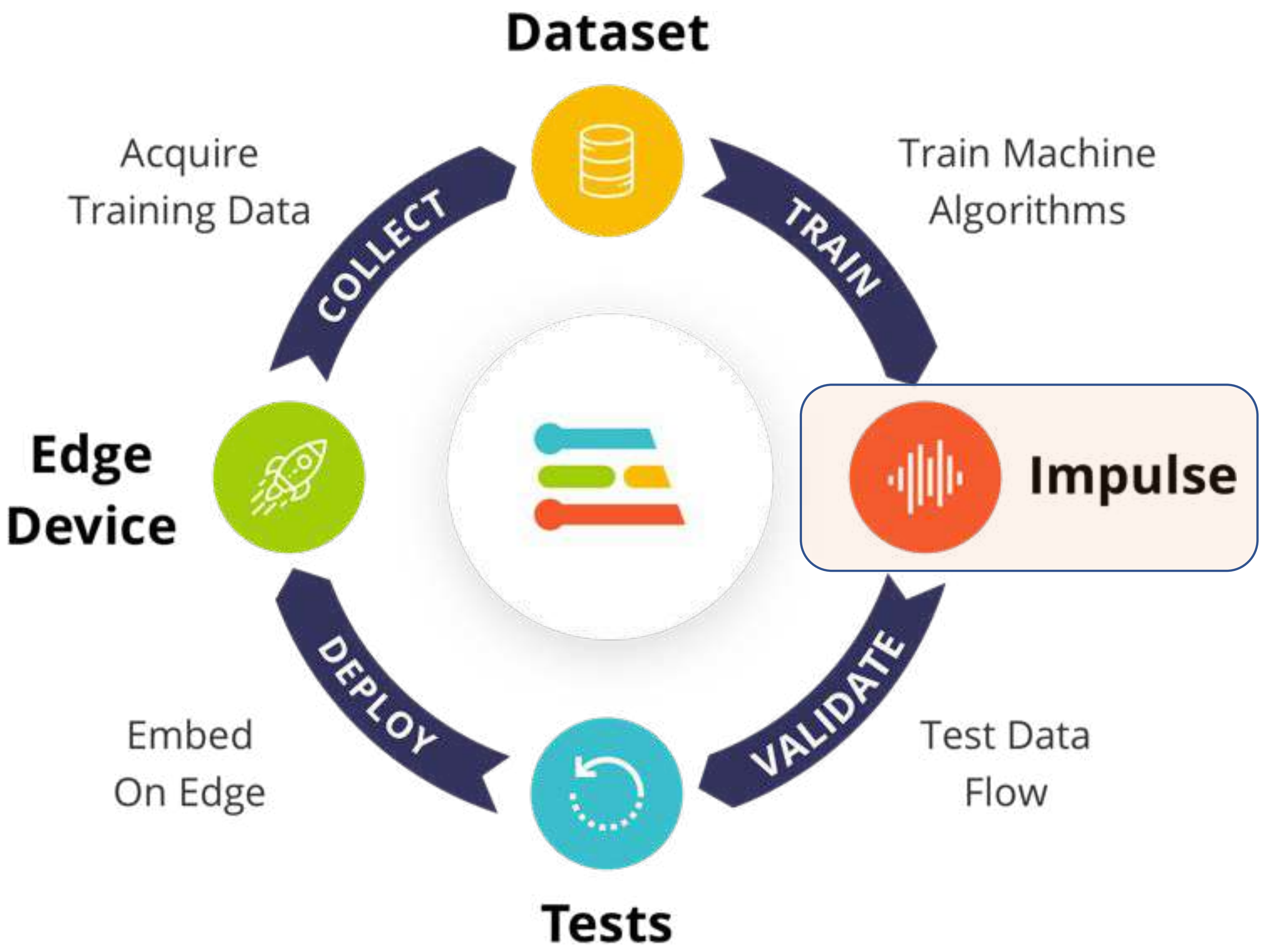


Collect Data

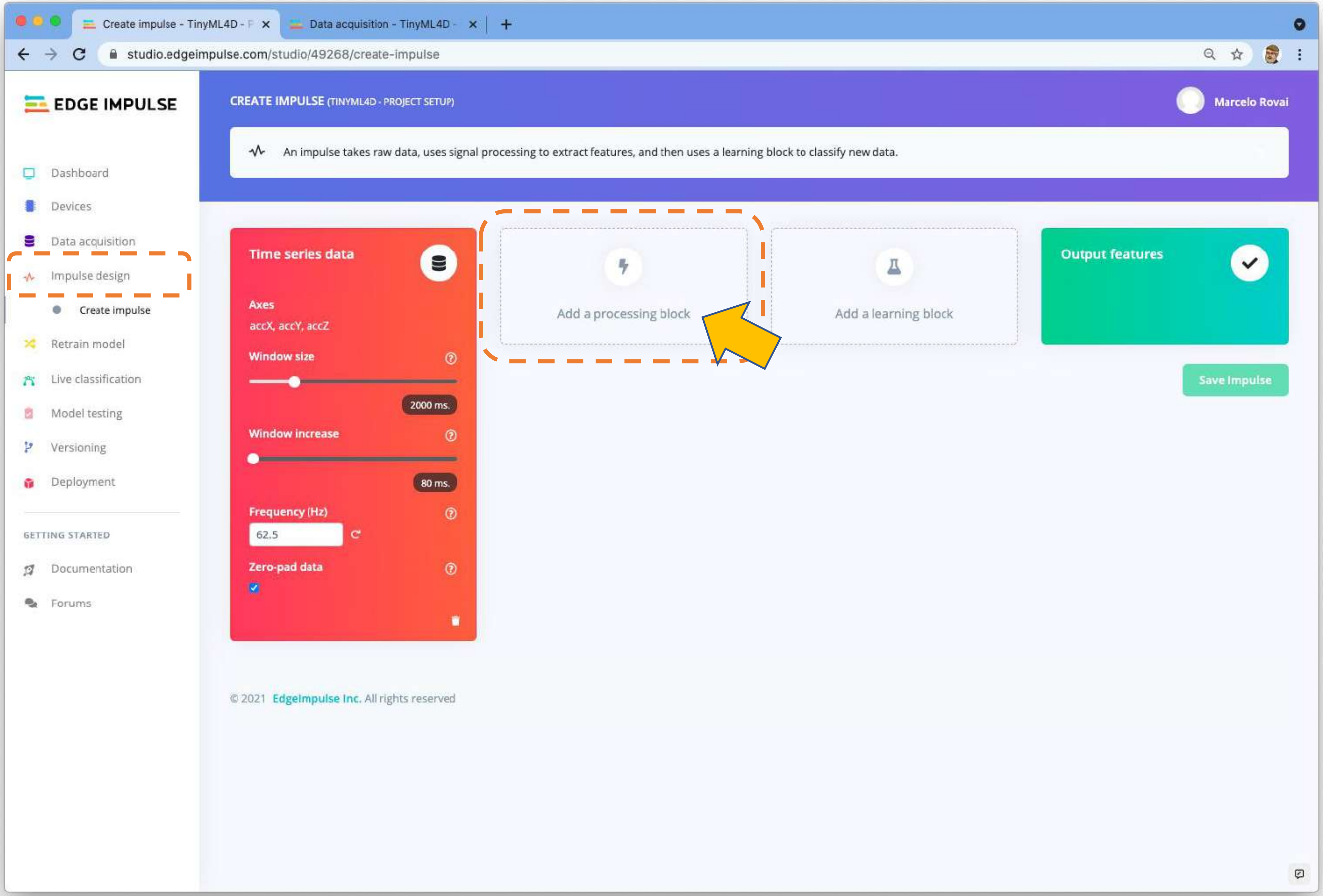


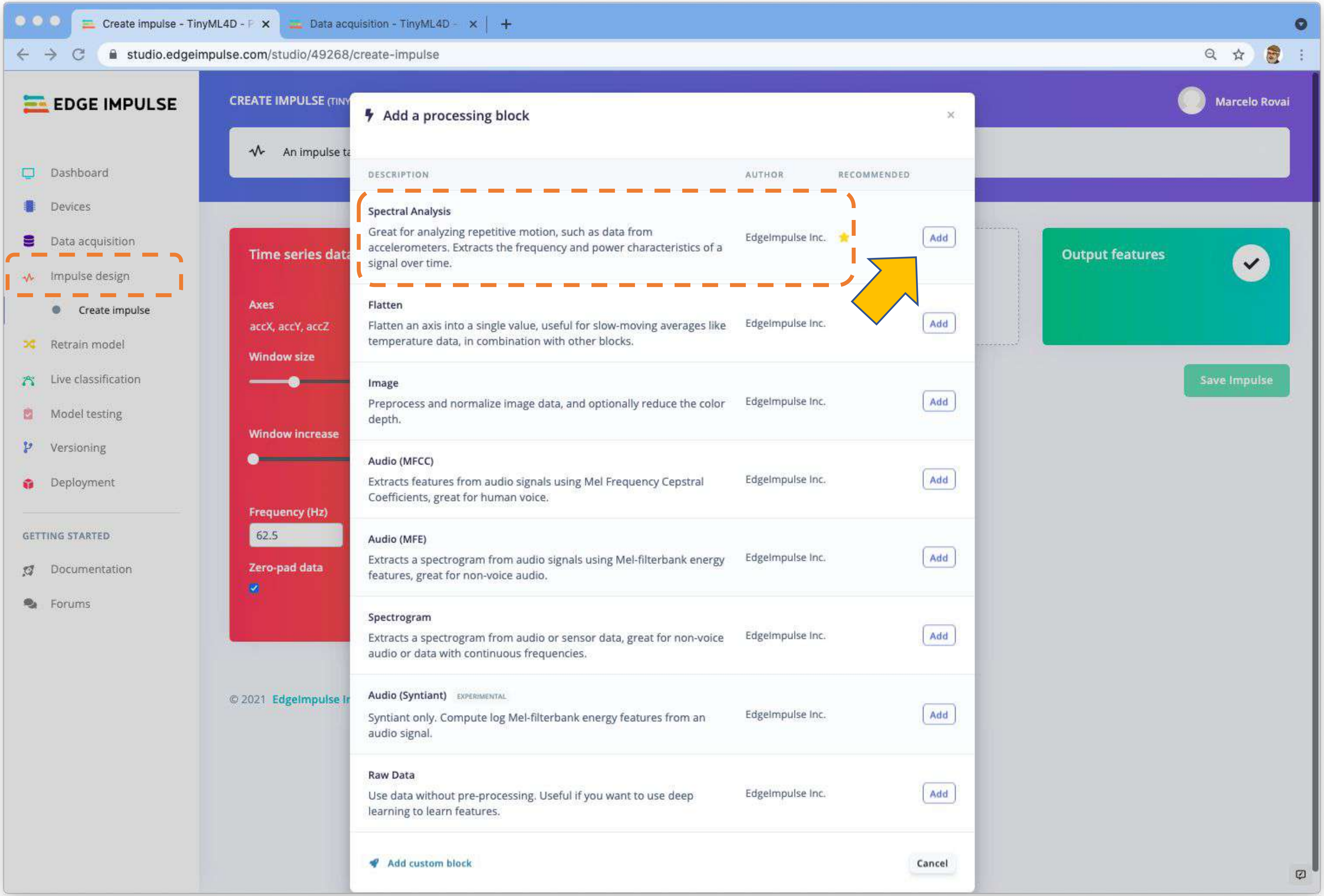
Collect Data





- Pre-Processing Data
- Design a Model
- Train a Model


Create impulse - TinyML4D - F
Data acquisition - TinyML4D -
studio.edgeimpulse.com/studio/49268/create-impulse
EDGE IMPULSE
CREATE IMPULSE (TINYML4D - PROJECT SETUP)
Marcelo Rovai
An impulse takes raw data, uses signal processing to extract features, and then uses a learning block to classify new data.
Dashboard
Devices
Data acquisition
Impulse design
Create impulse
Retrain model
Live classification
Model testing
Versioning
Deployment
GETTING STARTED
Documentation
Forums
Time series data
Axes
accX, accY, accZ
Window size
2000 ms.
Window increase
80 ms.
Frequency (Hz)
62.5
Zero-pad data
Add a processing block
Add a learning block
Output features
Save Impulse
© 2021 EdgeImpulse Inc. All rights reserved


Create impulse - TinyML4D
Data acquisition - TinyML4D
studio.edgeimpulse.com/studio/49268/create-impulse
EDGE IMPULSE
CREATE IMPULSE
Marcelo Rovai
Dashboard
Devices
Data acquisition
Impulse design
Create impulse
Retrain model
Live classification
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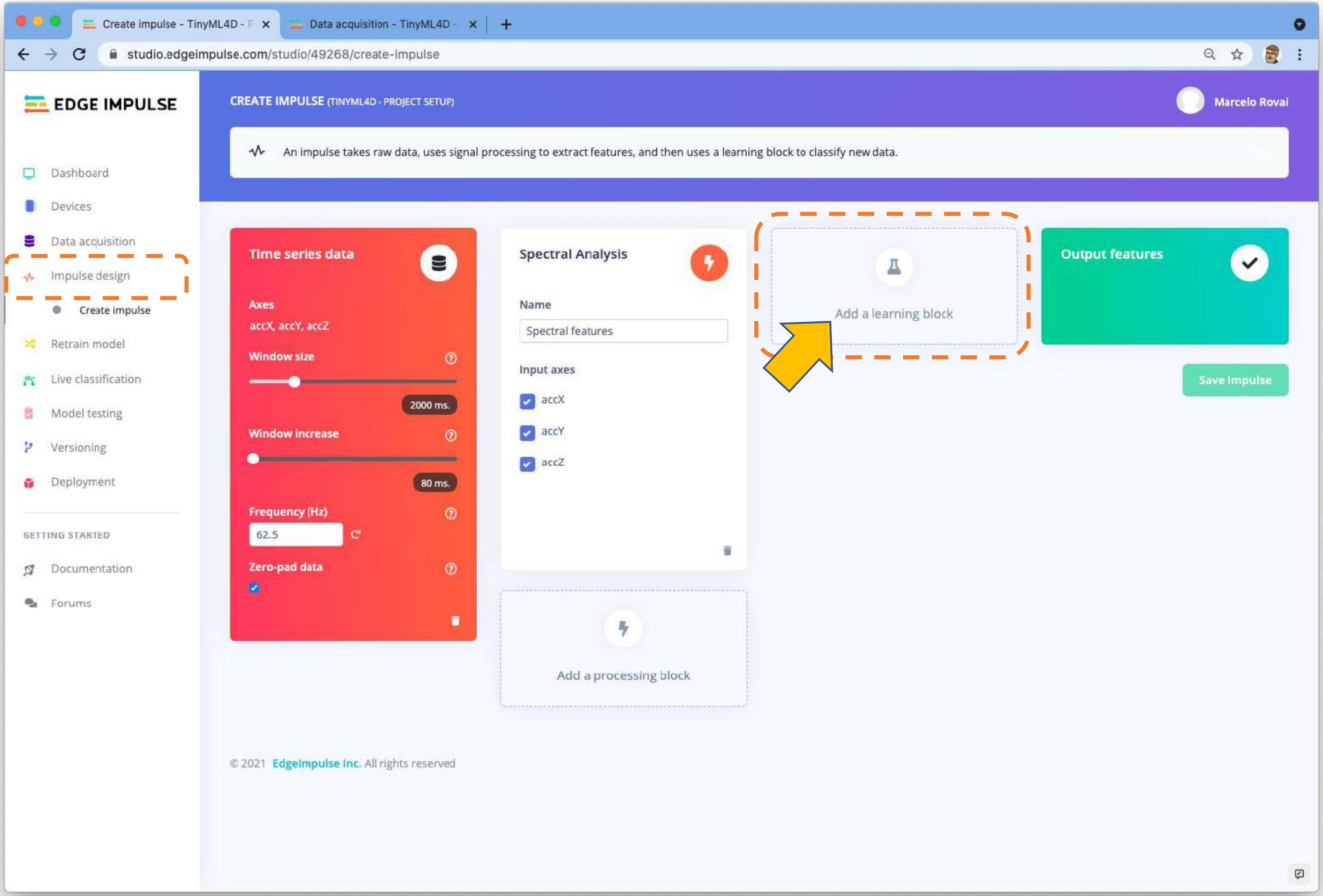
Time series data
Axes
accX, accY, accZ
Window size
Window increase
Frequency (Hz)
62.5
Zero-pad data
Output features
Save Impulse
© 2021 EdgeImpulse
Add a processing block
DESCRIPTION
AUTHOR
RECOMMENDED
Spectral Analysis
Great for analyzing repetitive motion, such as data from accelerometers. Extracts 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)
Extracts a spectrogram from audio signals using Mel-filterbank energy features, great for non-voice audio.
EdgeImpulse Inc.
Add
Spectrogram
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


Create impulse - TinyML4D
Data acquisition - TinyML4D
studio.edgeimpulse.com/studio/49268/create-impulse
EDGE IMPULSE
CREATE IMPULSE (TINYML4D - PROJECT SETUP)
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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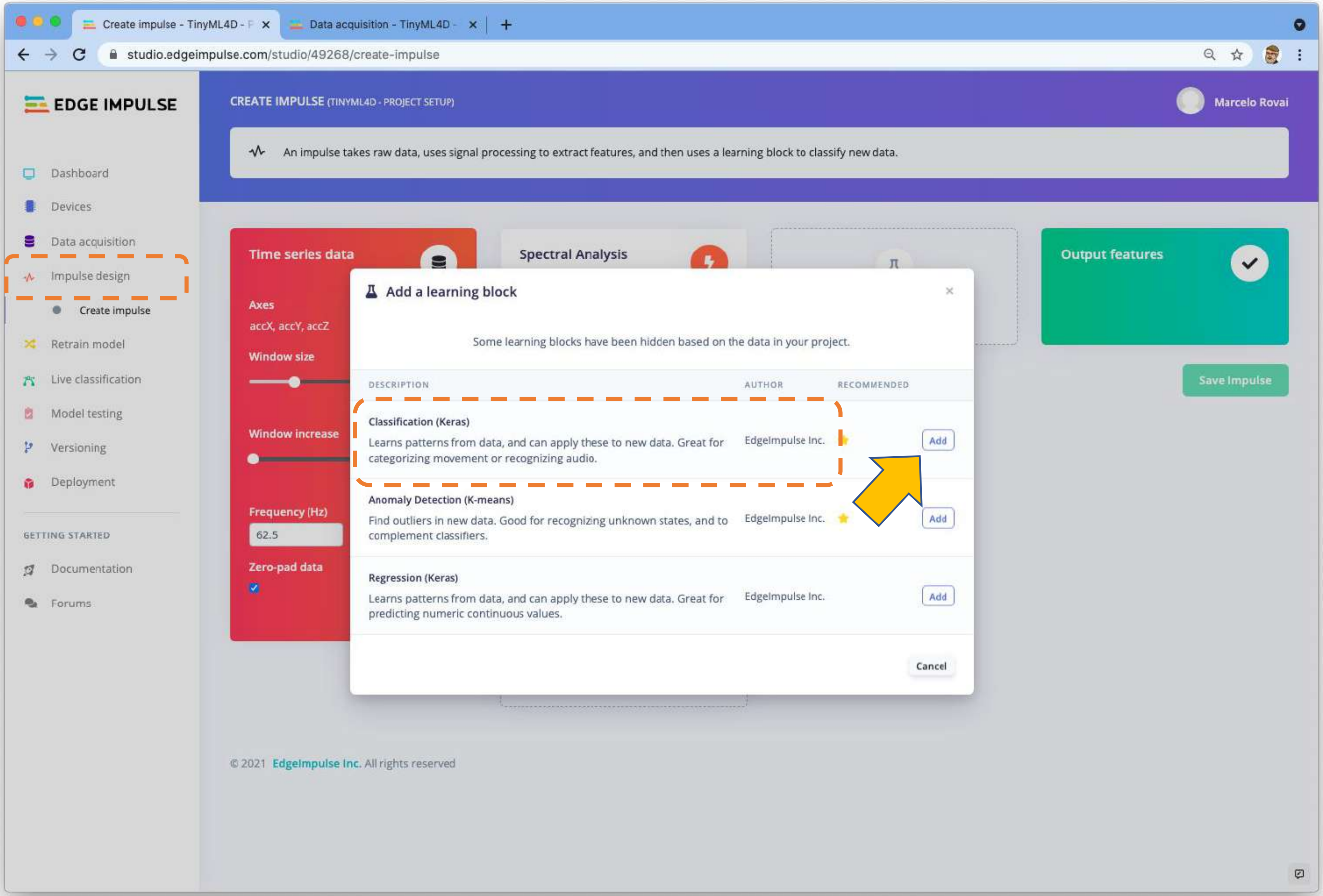
Data acquisition
Impulse design
Create impulse
Retrain model
Live classification
Model testing
Versioning
Deployment
GETTING STARTED
Documentation
Forums
Time series data
Axes
accX, accY, accZ
Window size
2000 ms.
Window increase
80 ms.
Frequency (Hz)
62.5
Zero-pad data
Spectral Analysis
Name
Spectral features
Input axes
accX
accY
accZ
Add a processing block
Add a learning block
Output features
Save Impulse
© 2021 EdgeImpulse Inc. All rights reserved


Create impulse - TinyML4D
Data acquisition - TinyML4D
studio.edgeimpulse.com/studio/49268/create-impulse
EDGE IMPULSE
CREATE IMPULSE (TINYML4D - PROJECT SETUP)
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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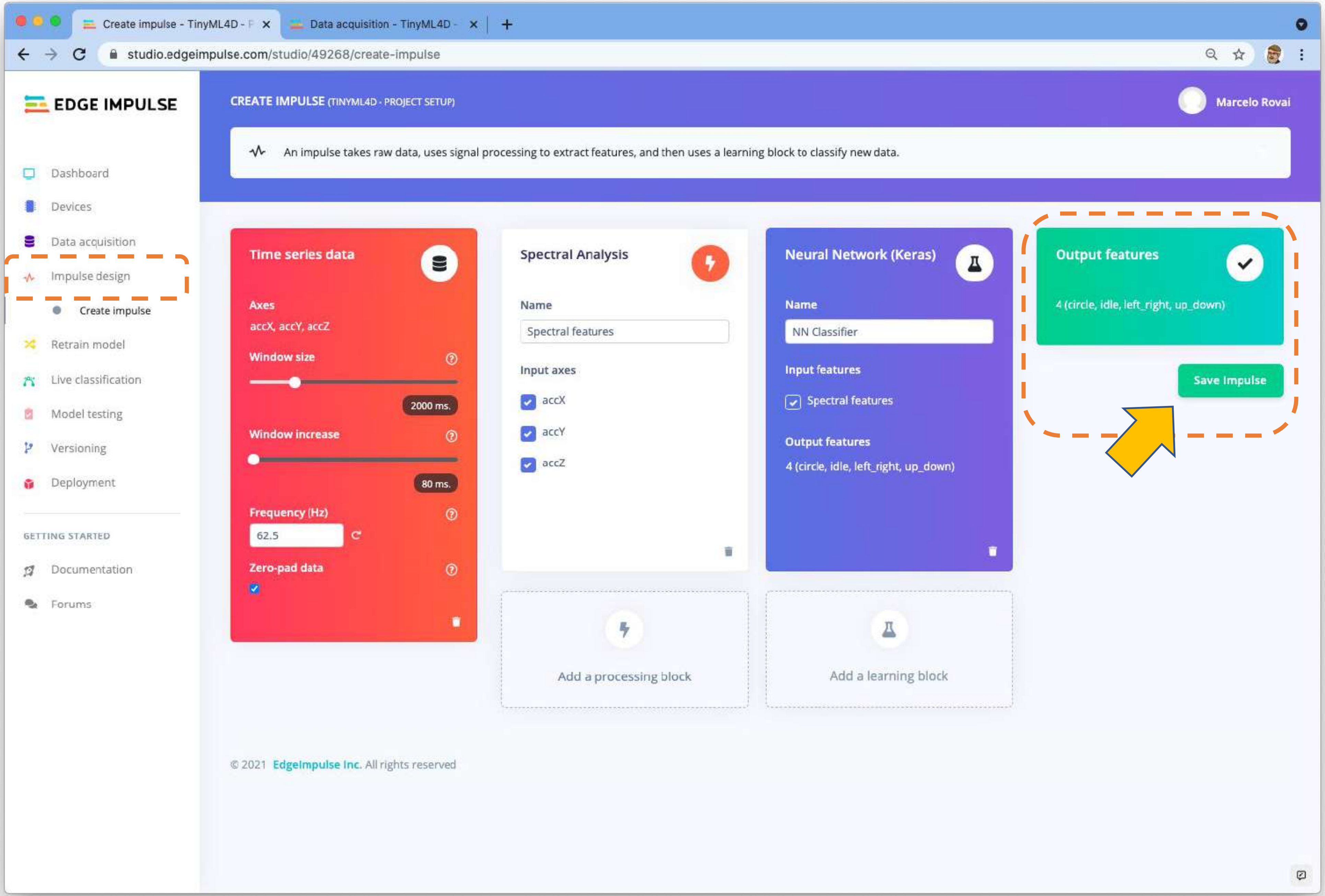
Live classification
Model testing
Versioning
Deployment
GETTING STARTED
Documentation
Forums
Time series data
Axes
accX, accY, accZ
Window size
Window increase
Frequency (Hz)
62.5
Zero-pad data
Spectral Analysis
Output features
Save Impulse
Add a learning block
Some learning blocks have been hidden based on the data in your project.
DESCRIPTION
AUTHOR
RECOMMENDED
Classification (Keras)
Learns patterns from data, and can apply these to new data. Great for categorizing movement or recognizing audio.
EdgeImpulse Inc.
Add
Anomaly Detection (K-means)
Find outliers in new data. Good for recognizing unknown states, and to complement classifiers.
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
© 2021 EdgeImpulse Inc. All rights reserved


Create impulse - TinyML4D
Data acquisition - TinyML4D
studio.edgeimpulse.com/studio/49268/create-impulse
EDGE IMPULSE
CREATE IMPULSE (TINYML4D - PROJECT SETUP)
Marcelo Rovai
An impulse takes raw data, uses signal processing to extract features, and then uses a learning block to classify new data.
Dashboard
Devices
Data acquisition
Impulse design
Create impulse
Retrain model
Live classification
Model testing
Versioning
Deployment
GETTING STARTED
Documentation
Forums
Time series data
Axes
accX, accY, accZ
Window size
2000 ms.
Window increase
80 ms.
Frequency (Hz)
62.5
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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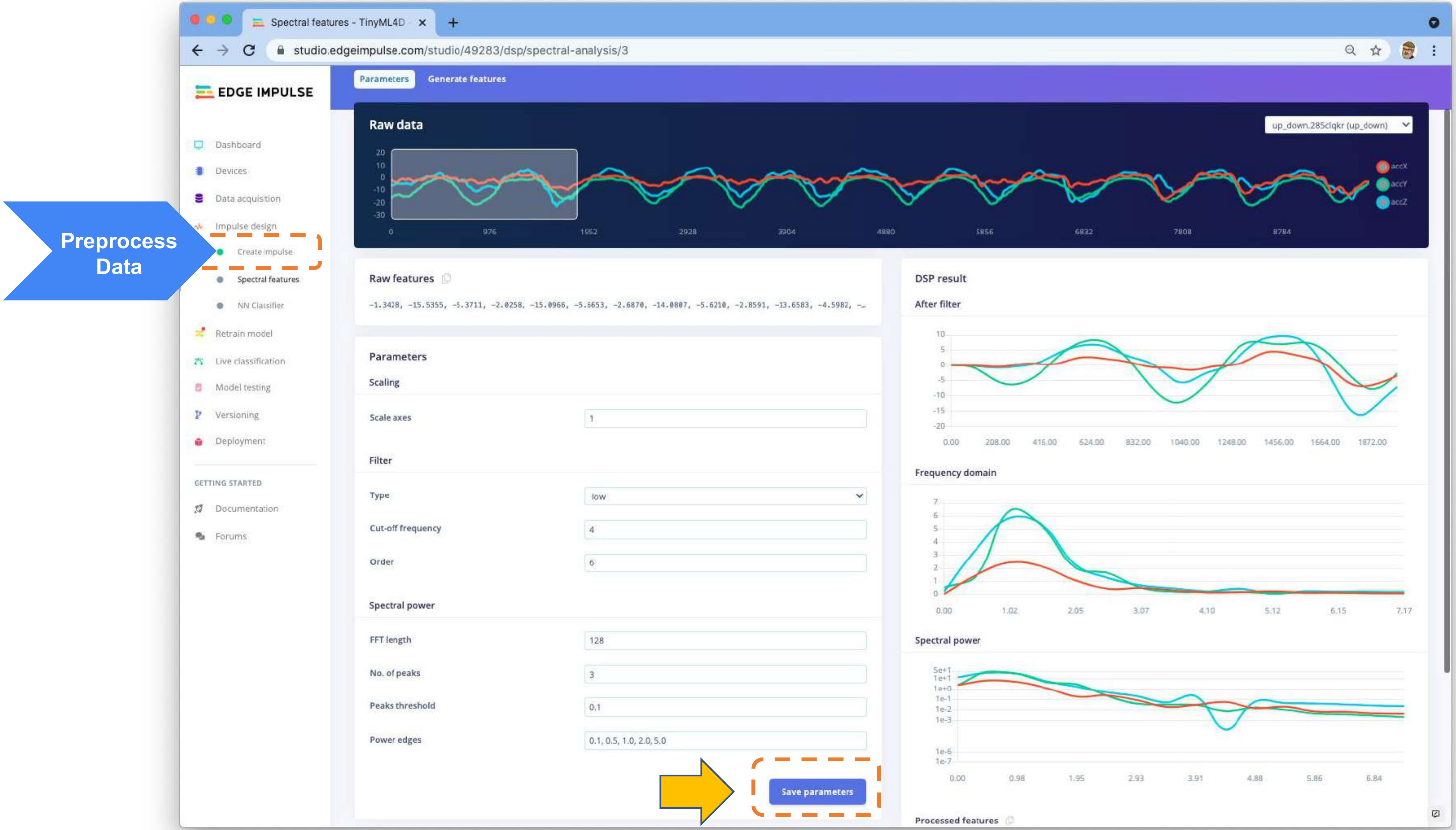
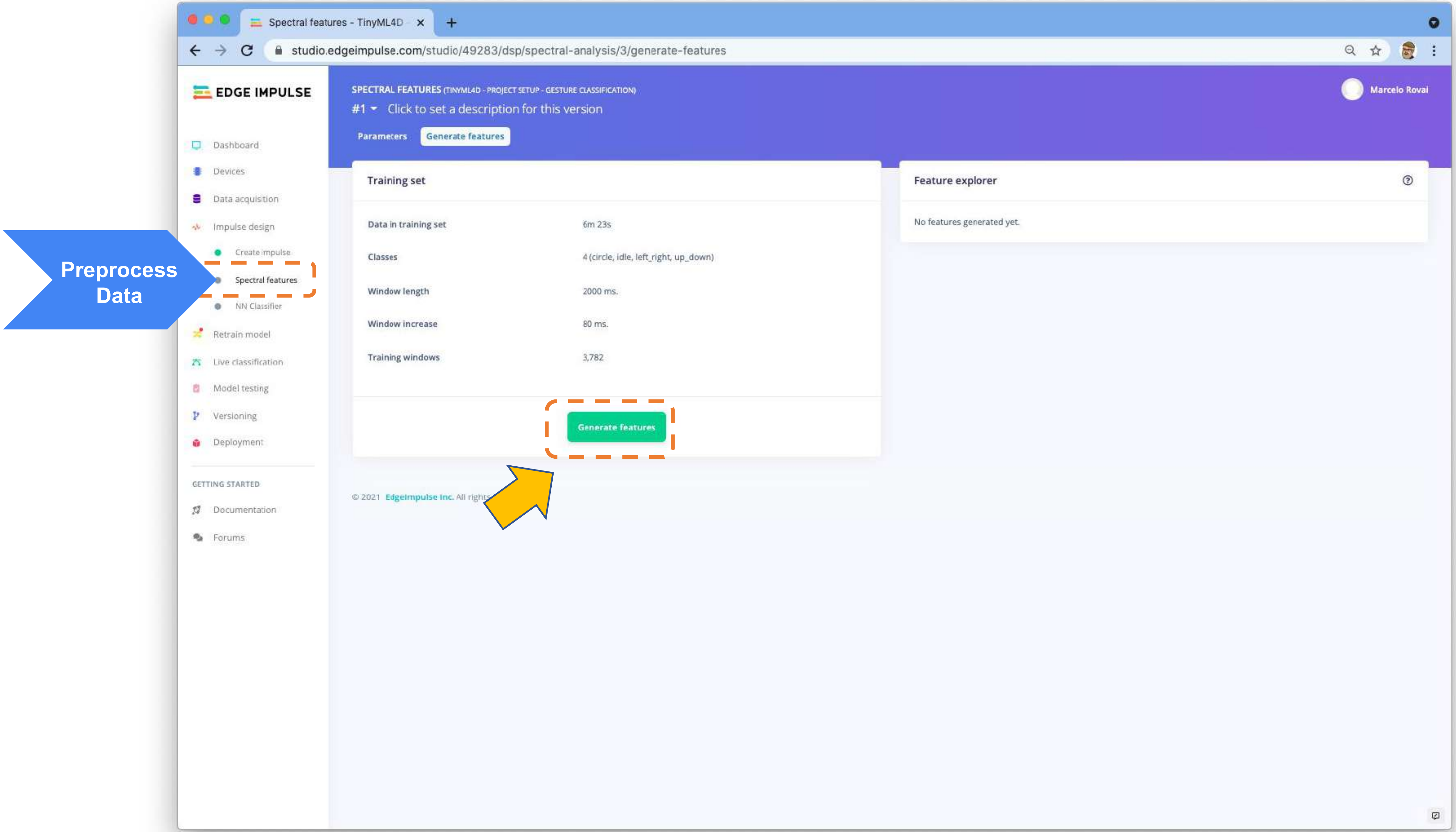


Preprocess Data
Spectral features - TinyML4D
studio.edgeimpulse.com/studio/49283/dsp/spectral-analysis/3
EDGE IMPULSE
Dashboard
Devices
Data acquisition
Impulse design
Create impulse
Spectral features
NN Classifier
Retrain model
Live classification
Model testing
Versioning
Deployment
GETTING STARTED
Documentation
Forums
Parameters
Generate features
Raw data
up_down.285clqkr (up_down)
accX
accY
accZ
Raw features
-1.3428, -15.5355, -5.3711, -2.0258, -15.0966, -5.6653, -2.6870, -14.0807, -5.6210, -2.8591, -13.6583, -4.5982, -…
Parameters
Scaling
Scale axes
1
Filter
Type
low
Cut-off frequency
4
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
Save parameters
DSP result
After filter
Frequency domain
Spectral power
Processed features


Preprocess Data
Spectral features - TinyML4D
studio.edgeimpulse.com/studio/49283/dsp/spectral-analysis/3/generate-features
EDGE IMPULSE
Dashboard
Devices
Data acquisition
Impulse design
Create impulse
Spectral features
NN Classifier
Retrain model
Live classification
Model testing
Versioning
Deployment
GETTING STARTED
Documentation
Forums
SPECTRAL FEATURES (TINYML4D - PROJECT SETUP - GESTURE CLASSIFICATION)
#1 Click to set a description for this version
Parameters
Generate features
Marcelo Rovai
Training set
Data in training set
6m 23s
Classes
4 (circle, idle, left_right, up_down)
Window length
2000 ms.
Window increase
80 ms.
Training windows
3,782
Generate features
Feature explorer
No features generated yet.
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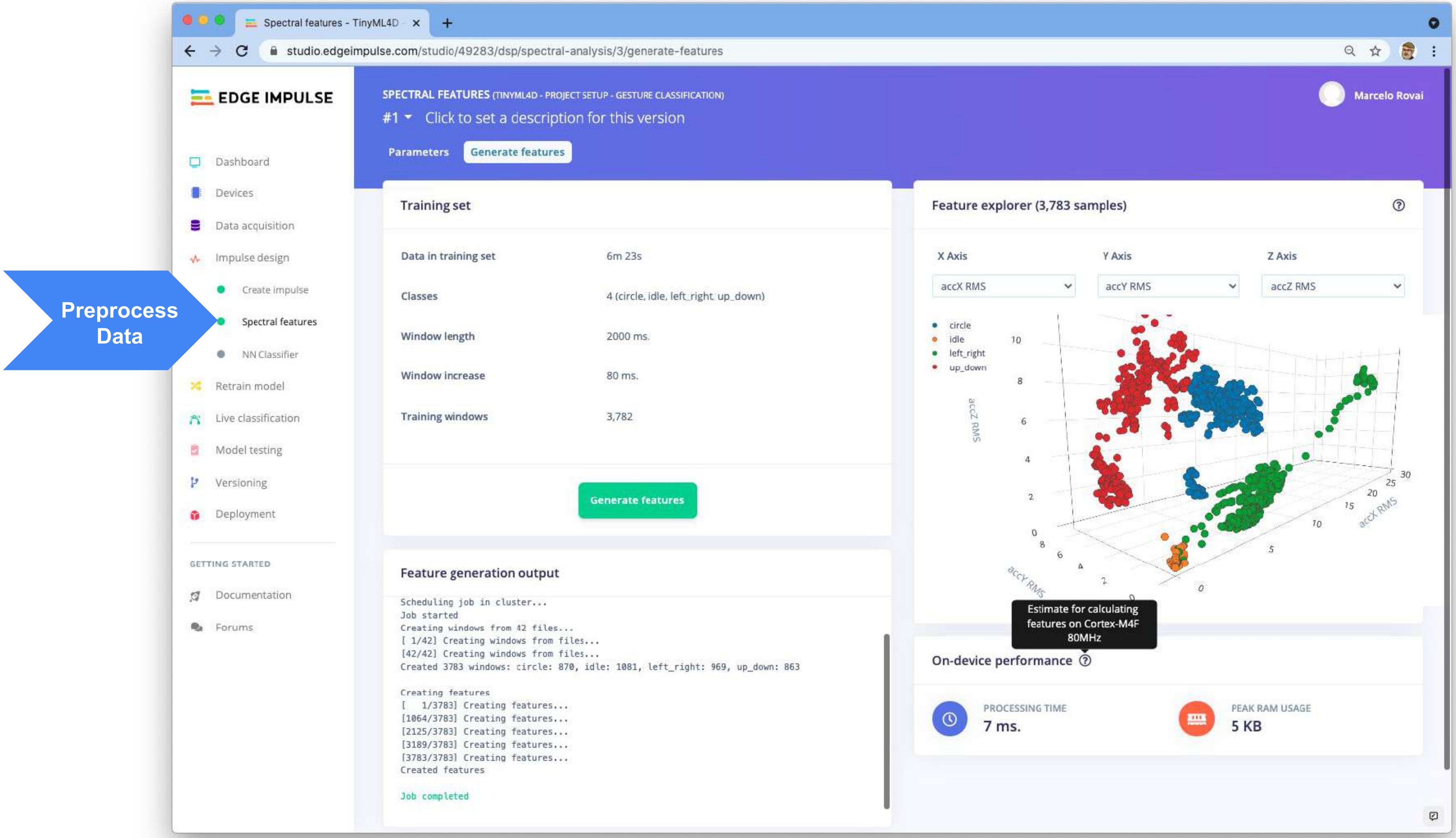
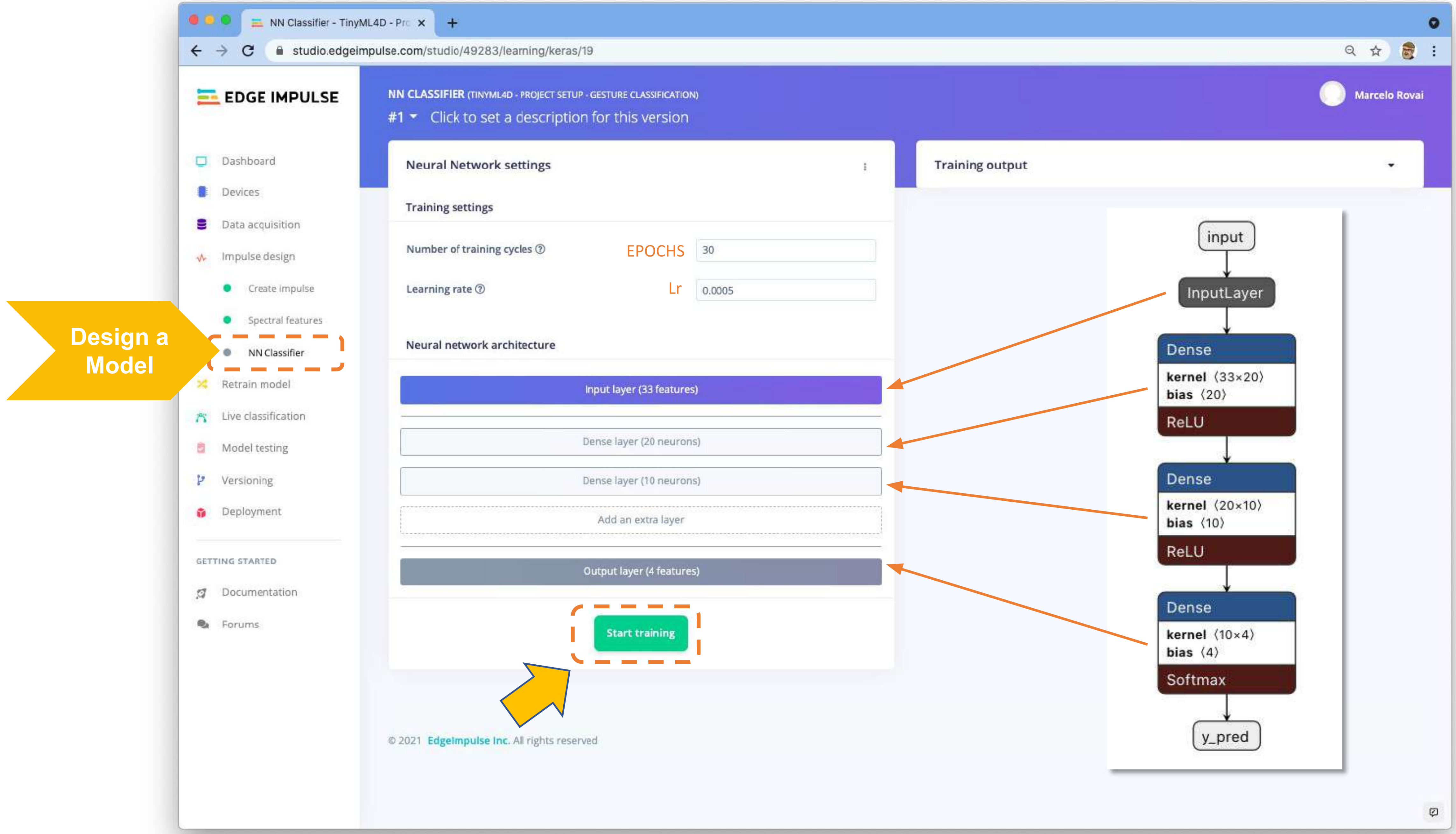

Preprocess Data
Spectral features - TinyML4D
studio.edgeimpulse.com/studio/49283/dsp/spectral-analysis/3/generate-features
EDGE IMPULSE
Dashboard
Devices
Data acquisition
Impulse design
Create impulse
Spectral features
NN Classifier
Retrain model
Live classification
Model testing
Versioning
Deployment
GETTING STARTED
Documentation
Forums
SPECTRAL FEATURES (TINYML4D - PROJECT SETUP - GESTURE CLASSIFICATION)
#1 Click to set a description for this version
Marcelo Rovai
Parameters
Generate features
Training set
Data in training set 6m 23s
Classes 4 (circle, idle, left_right, up_down)
Window length 2000 ms.
Window increase 80 ms.
Training windows 3,782
Generate features
Feature generation output
Scheduling job in cluster...
Job started
Creating windows from 42 files...
[1/42] Creating windows from files...
[42/42] Creating windows from files...
Created 3783 windows: circle: 870, idle: 1081, left_right: 969, up_down: 863
Creating features
[1/3783] Creating features...
[1064/3783] Creating features...
[2125/3783] Creating features...
[3189/3783] Creating features...
[3783/3783] Creating features...
Created features
Job completed
Feature explorer (3,783 samples)
X Axis
Y Axis
Z Axis
accX RMS
accY RMS
accZ RMS
circle
idle
left_right
up_down
Estimate for calculating features on Cortex-M4F 80MHz
On-device performance
PROCESSING TIME
7 ms.
PEAK RAM USAGE
5 KB


NN Classifier - TinyML4D - Pro
studio.edgeimpulse.com/studio/49283/learning/keras/19
EDGE IMPULSE
NN CLASSIFIER (TINYML4D - PROJECT SETUP - GESTURE CLASSIFICATION)
#1 Click to set a description for this version
Marcelo Rovai
Dashboard
Devices
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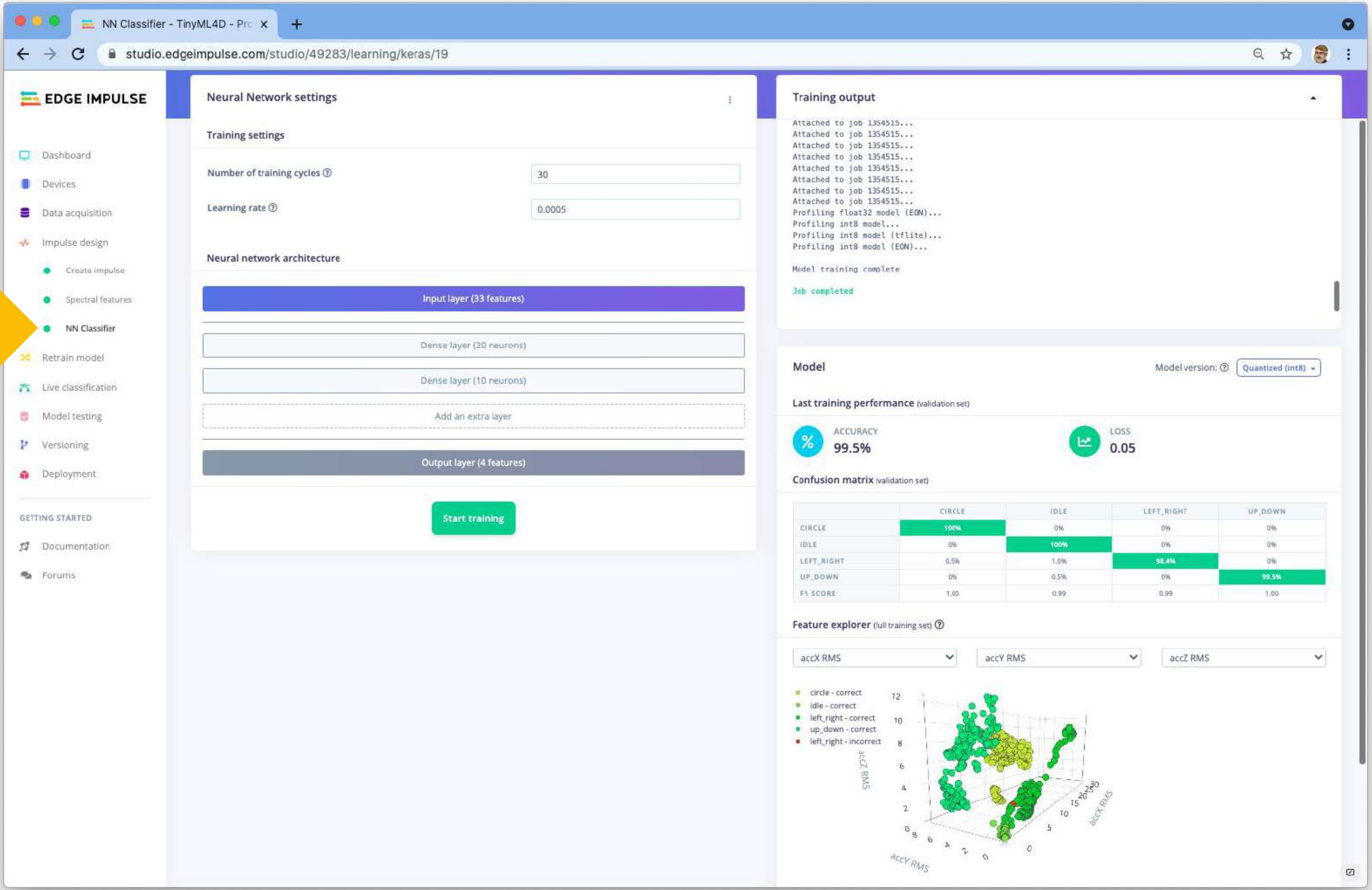
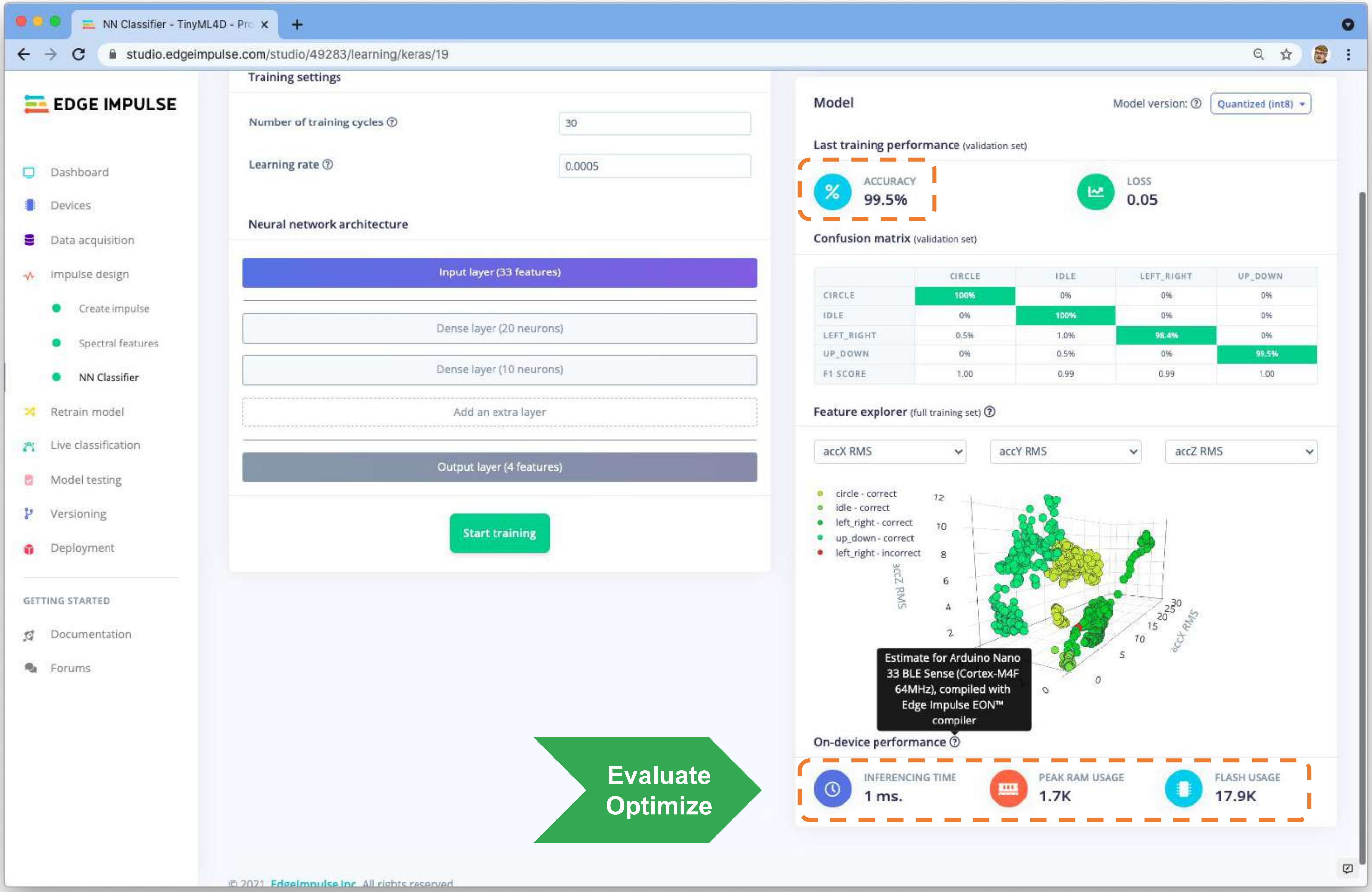
Create impulse
Spectral features
NN Classifier
Retrain model
Live classification
Model testing
Versioning
Deployment
GETTING STARTED
Documentation
Forums
Design a Model
Neural Network settings
Training settings
Number of training cycles
EPOCHS
30
Learning rate
Lr
0.0005
Neural network architecture
Input layer (33 features)
Dense layer (20 neurons)
Dense layer (10 neurons)
Add an extra layer
Output layer (4 features)
Start training
© 2021 EdgeImpulse Inc. All rights reserved
Training output
input
InputLayer
Dense
kernel ⟨33×20⟩
bias ⟨20⟩
ReLU
Dense
kernel ⟨20×10⟩
bias ⟨10⟩
ReLU
Dense
kernel ⟨10×4⟩
bias ⟨4⟩
Softmax
y_pred

Train a Model




NN Classifier - TinyML4D - Pro
studio.edgeimpulse.com/studio/49283/learning/keras/19
EDGE IMPULSE
Dashboard
Devices
Data acquisition
Impulse design
Create impulse
Spectral features
NN Classifier
Retrain model
Live classification
Model testing
Versioning
Deployment
GETTING STARTED
Documentation
Forums
Training settings
Number of training cycles
30
Learning rate
0.0005
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
Model
Model version:
Quantized (int8)
Last training performance (validation set)
ACCURACY
99.5%
LOSS
0.05
Confusion matrix (validation set)
CIRCLE IDLE LEFT_RIGHT UP_DOWN
CIRCLE 100% 0% 0% 0%
IDLE 0% 100% 0% 0%
LEFT_RIGHT 0.5% 1.0% 98.4% 0%
UP_DOWN 0% 0.5% 0% 99.5%
F1 SCORE 1.00 0.99 0.99 1.00
Feature explorer (full training set)
accX RMS
accY RMS
accZ RMS
circle - correct
idle - correct
left_right - correct
up_down - correct
left_right - incorrect
Estimate for Arduino Nano 33 BLE Sense (Cortex-M4F 64MHz), compiled with Edge Impulse EON™ compiler
On-device performance
INFERENCING TIME
1 ms.
PEAK RAM USAGE
1.7K
FLASH USAGE
17.9K
Evaluate
Optimize
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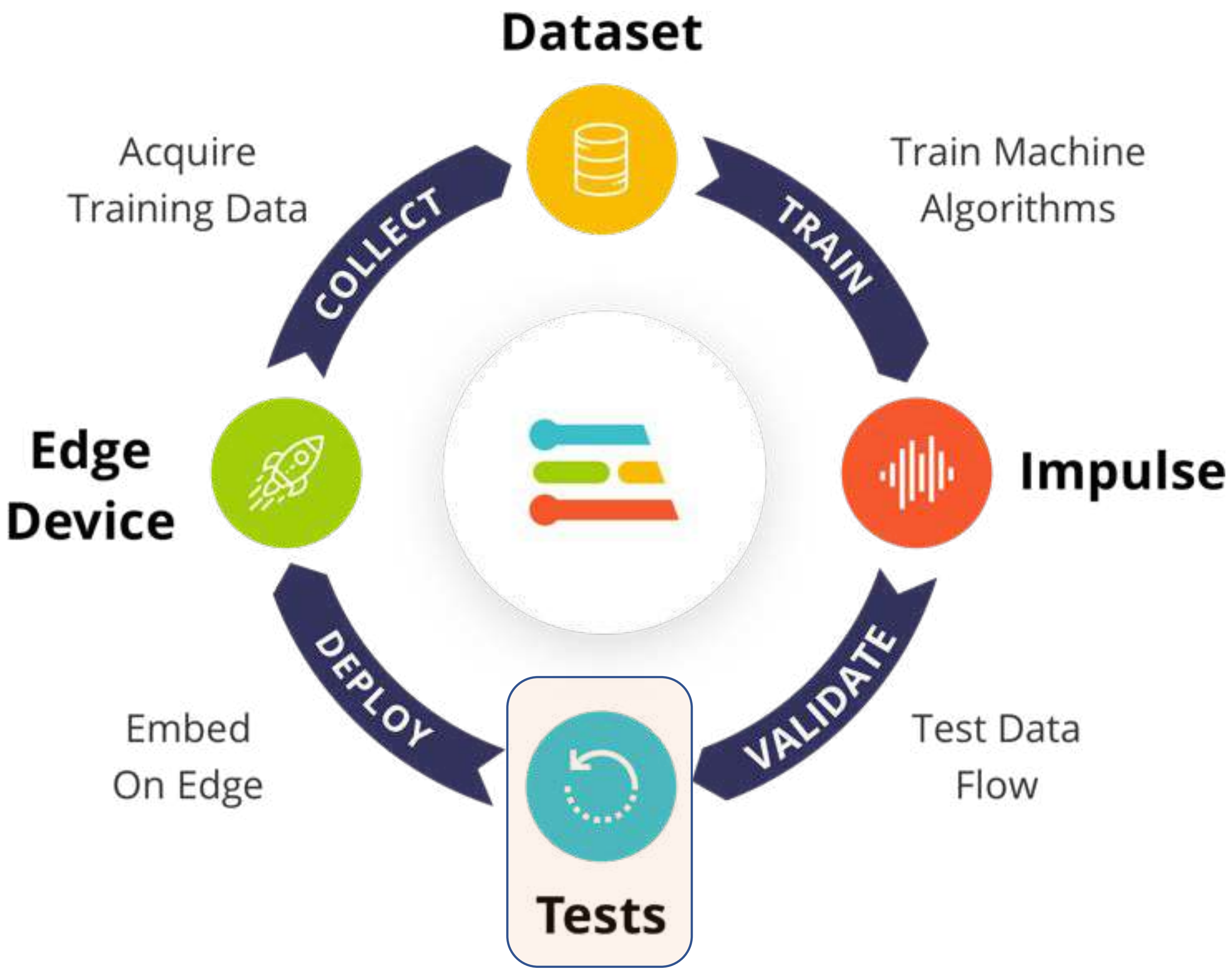
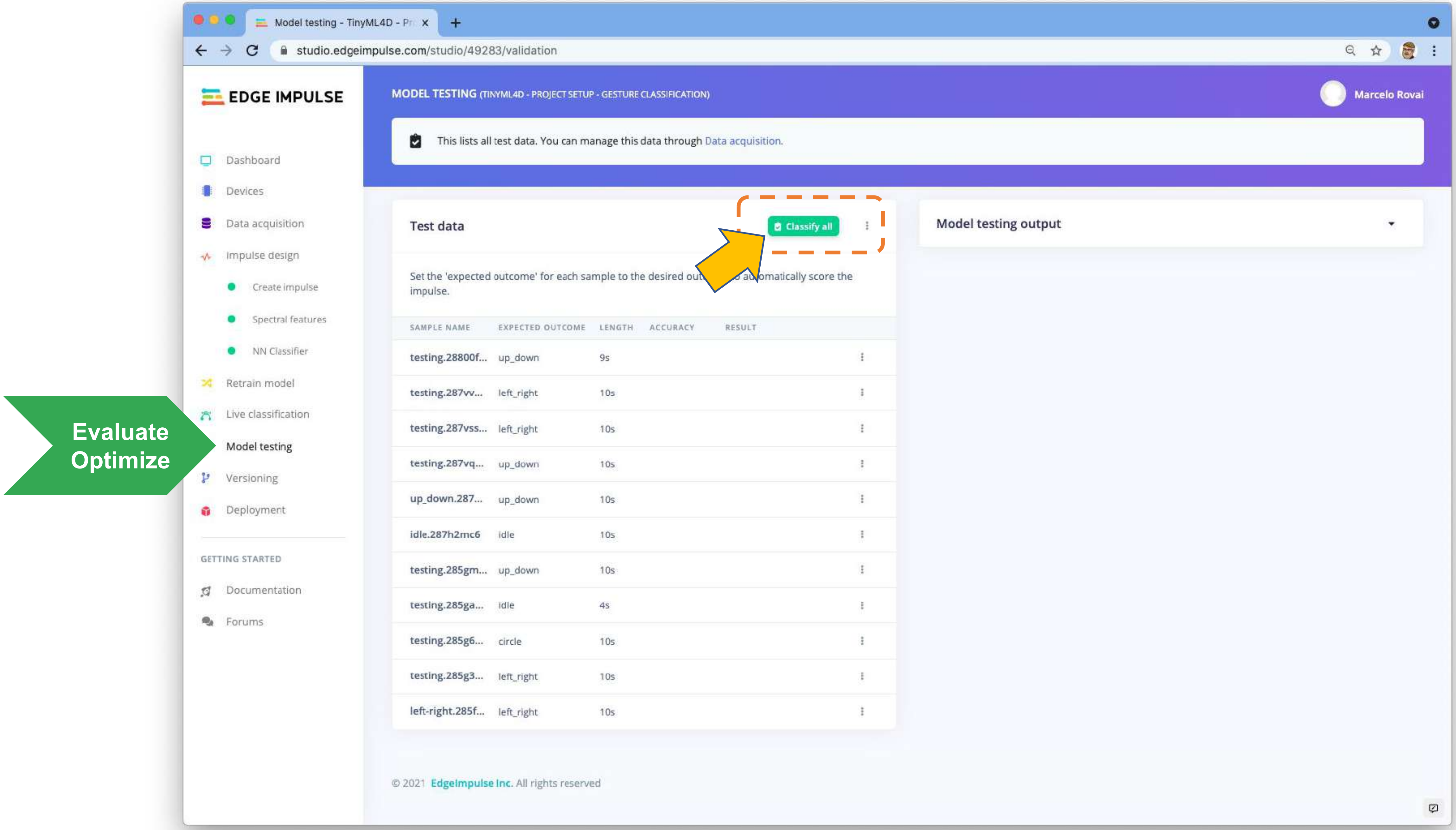
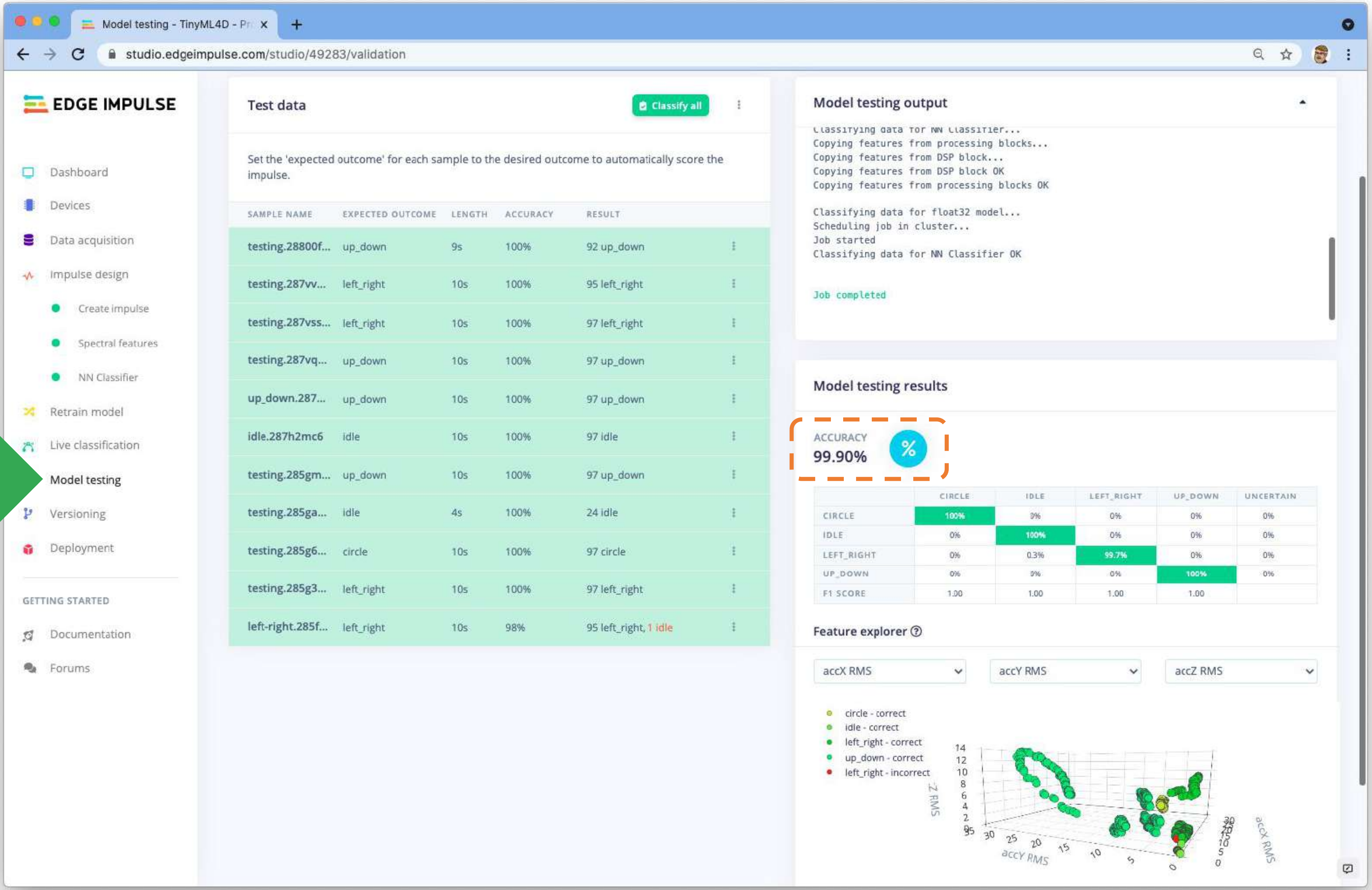
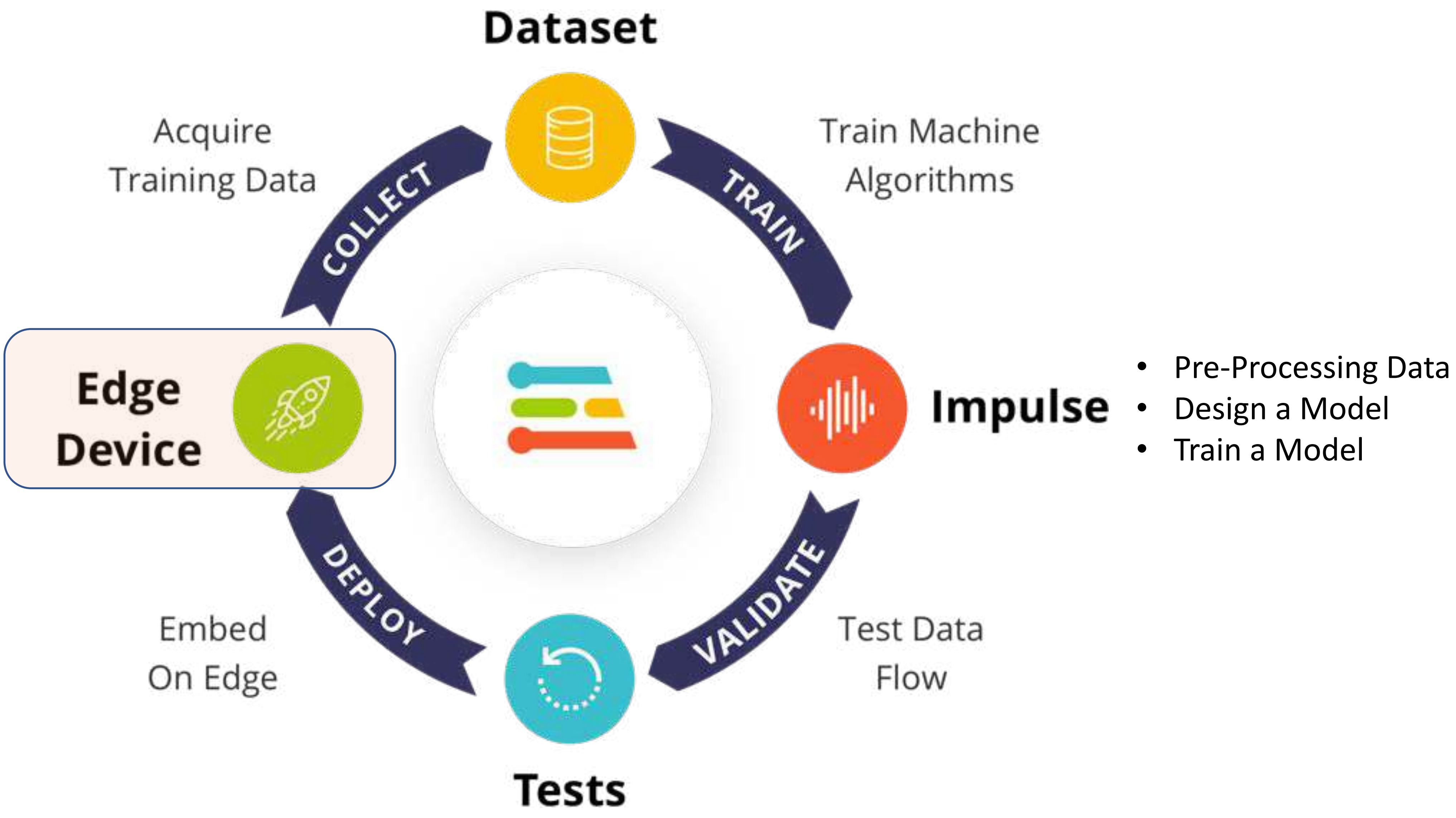


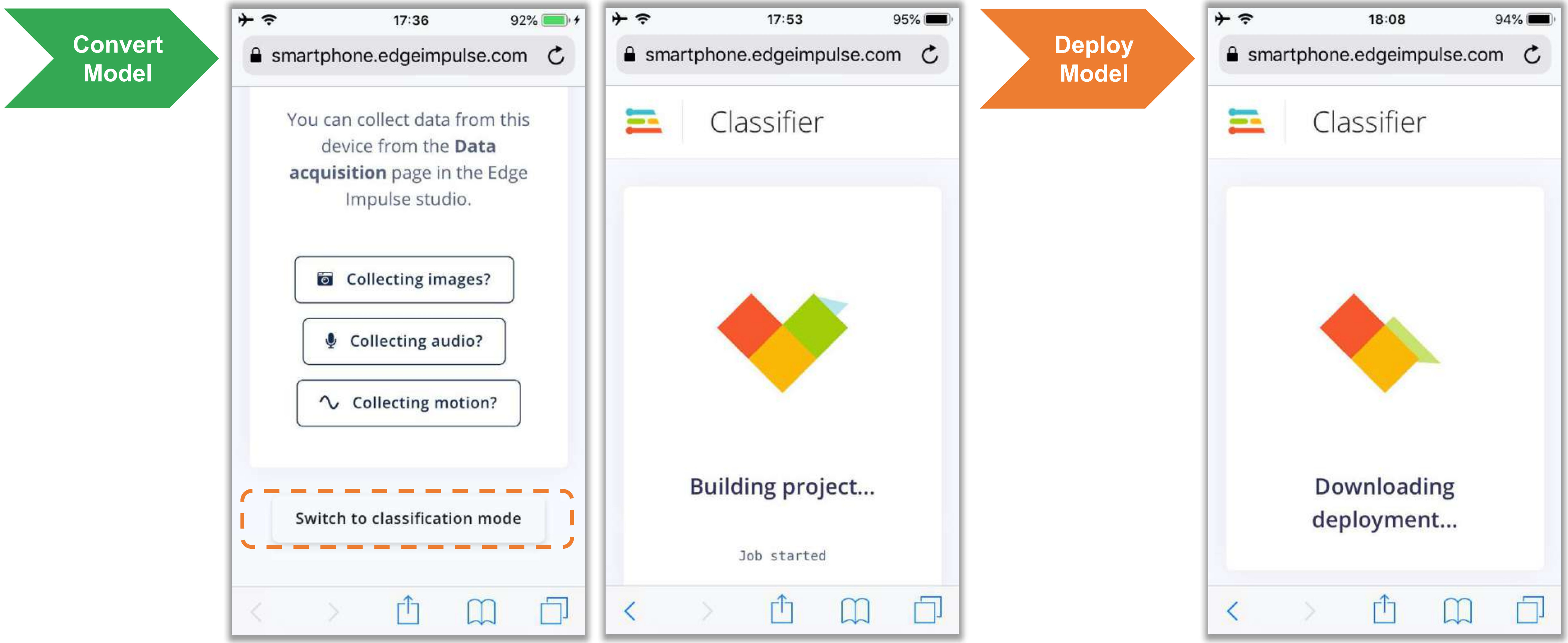
- Pre-Processing Data
- Design a Model
- Train a Model


Evaluate
Optimize
Model testing - TinyML4D - Pr
studio.edgeimpulse.com/studio/49283/validation
EDGE IMPULSE
MODEL TESTING (TINYML4D - PROJECT SETUP - GESTURE CLASSIFICATION)
Marcelo Rovai
This lists all test data. You can manage this data through Data acquisition.
Dashboard
Devices
Data acquisition
Impulse design
Create impulse
Spectral features
NN Classifier
Retrain model
Live classification
Model testing
Versioning
Deployment
GETTING STARTED
Documentation
Forums
Test data
Classify all
Model testing output
Set the 'expected outcome' for each sample to the desired out
omatically score the impulse.
SAMPLE NAME
EXPECTED OUTCOME
LENGTH
ACCURACY
RESULT
testing.28800f... up_down 9s
testing.287vv... left_right 10s
testing.287vss... left_right 10s
testing.287vq... up_down 10s
up_down.287... up_down 10s
idle.287h2mc6 idle 10s
testing.285gm... up_down 10s
testing.285ga... idle 4s
testing.285g6... circle 10s
testing.285g3... left_right 10s
left-right.285f... left_right 10s
© 2021 EdgeImpulse Inc. All rights reserved

Evaluate
Optimize

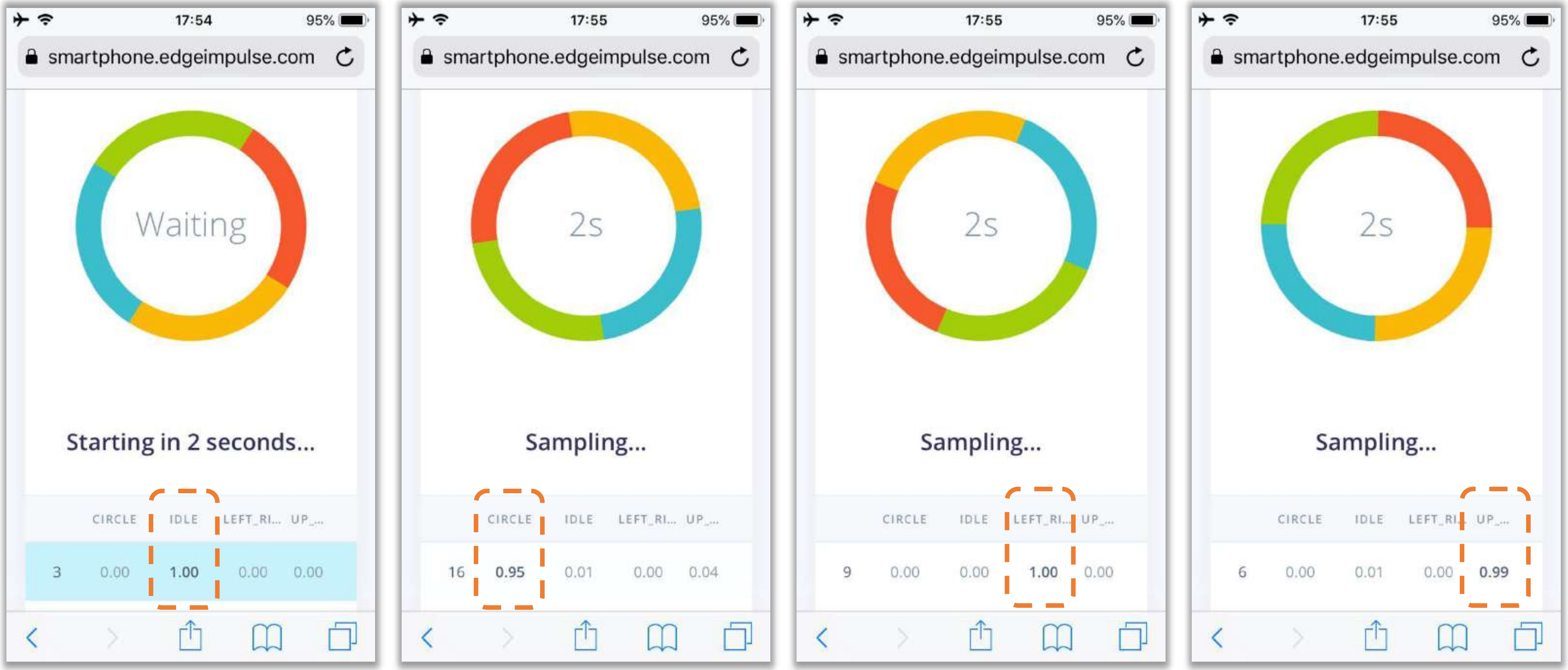



Dataset
Acquire
Training Data
COLLECT
TRAIN
Train Machine
Algorithms
Edge
Device
Impulse
• Pre-Processing Data
• Design a Model
• Train a Model
DEPLOY
VALIDATE
Embed
On Edge
Test Data
Flow
Tests



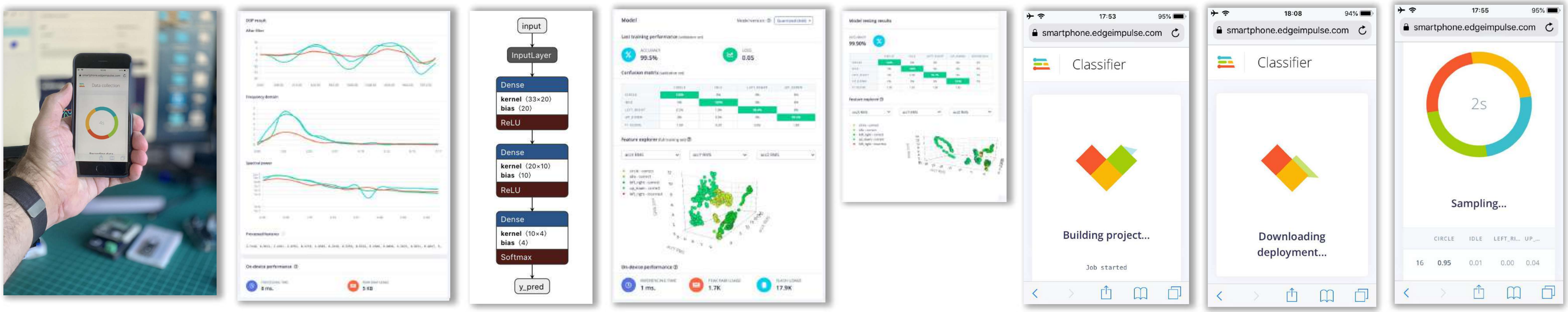
Convert Model
17:36
92%
smartphone.edgeimpulse.com
You can collect data from this device from the Data acquisition page in the Edge Impulse studio.
Collecting images?
Collecting audio?
Collecting motion?
Switch to classification mode
17:53
95%
smartphone.edgeimpulse.com
Classifier
Building project...
Job started
Deploy Model
18:08
94%
smartphone.edgeimpulse.com
Classifier
Downloading deployment...

Make Inferences



Summary

Collect Data → Preprocess Data → Design a Model → Train a Model → Evaluate Optimize → Convert Model → Deploy Model → Make Inferences



Additional Free Resources

Google CoLab

Google Colaboratory or CoLab for short, allows you to write and execute Python in your browser, with zero configuration required, free access to GPUs and easy sharing. Google Colab is also an online integrated developer environment to design, train, and test our machine learning models. Here is an introduction to Google Colab. Watch Jake VanderPlas from Google give a wonderful intro to Colab.

Python for Data Science and ML Review

- A Whirlwind Tour of Python by Jake VanderPlas (e-book content)
- Learn the most important language for data science: Kaggle Python Tutorial
- Use TensorFlow and Keras to build and train neural networks for structured data: Kaggle Intro to Deep Learning

Hackster TinyML Tutorials

- "Listening Temperature" with Arduino Nano (Audio)
- Motion Recognition Using Raspberry Pi Pico (Accelerometers)
- Coffee disease classification with Seeed Maix Bit RISC-V board (Vision)

Imagine 2021 Day 3: Community Showcase

SciTinyML - ICTP workshop

Scientific Use of Machine Learning on Low Power Devices

Setting up the software tools

Prof. Marcelo José Rovai
UNIFEI - Universidade Federal de Itajubá, Brazil
Web: https://github.com/Mjrovai