Track 7

Inteligencia Artificial Aplicada

11. Image Classification Intro & Hands-On

Prof. Marcelo José Rovai
rovai@unifei.edu.br

UNIFEI - Universidade Federal de Itajubá, Brazil

Vision

Sound

Vibration

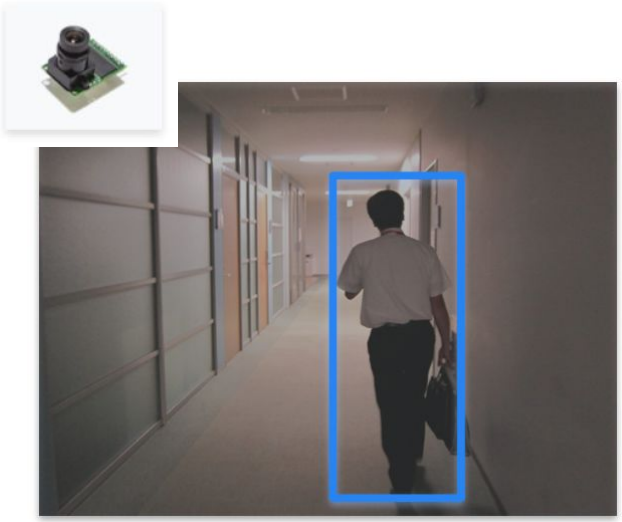


Image Classification Application:
Design, Train, Test and Deploy

Computer Vision Main Types

Image Classification

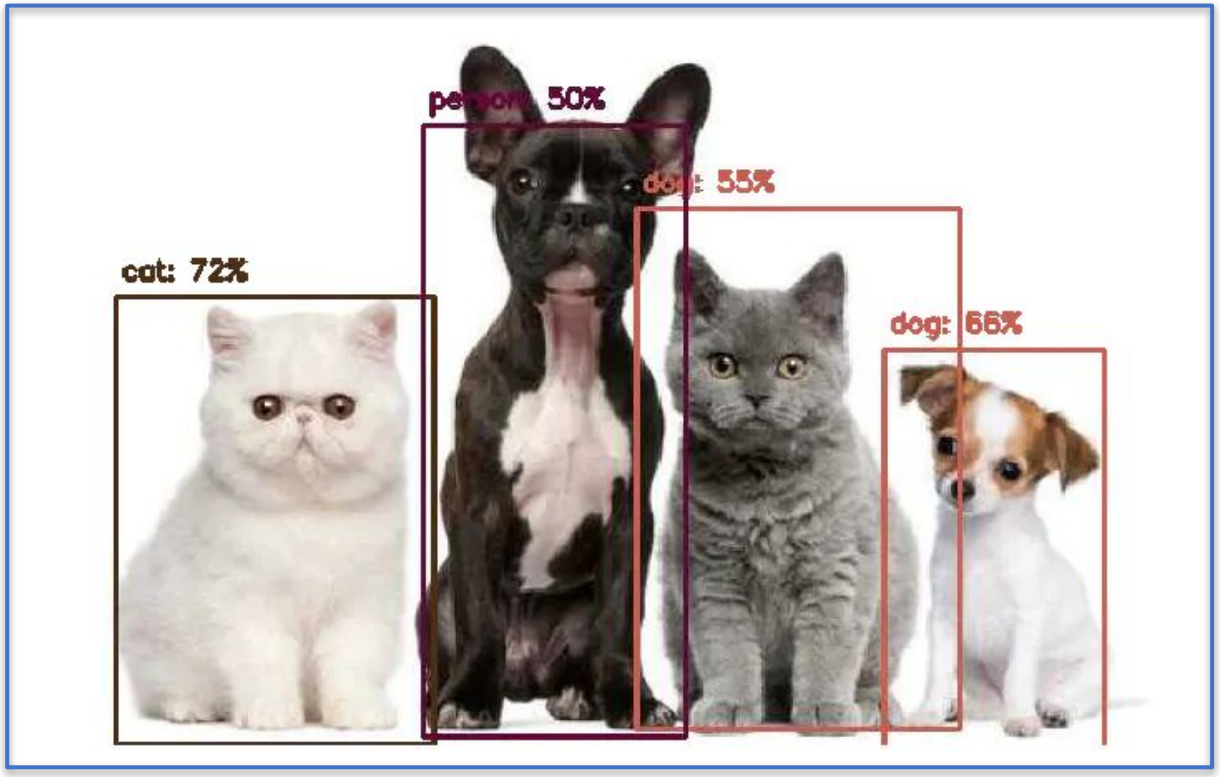
(**Multi-Class** Classification)

Cat: 70%

Dog: 80%

Object Detection

Multi-Label Classification + Object **Localization**



Computer Vision Main Types

Image Classification

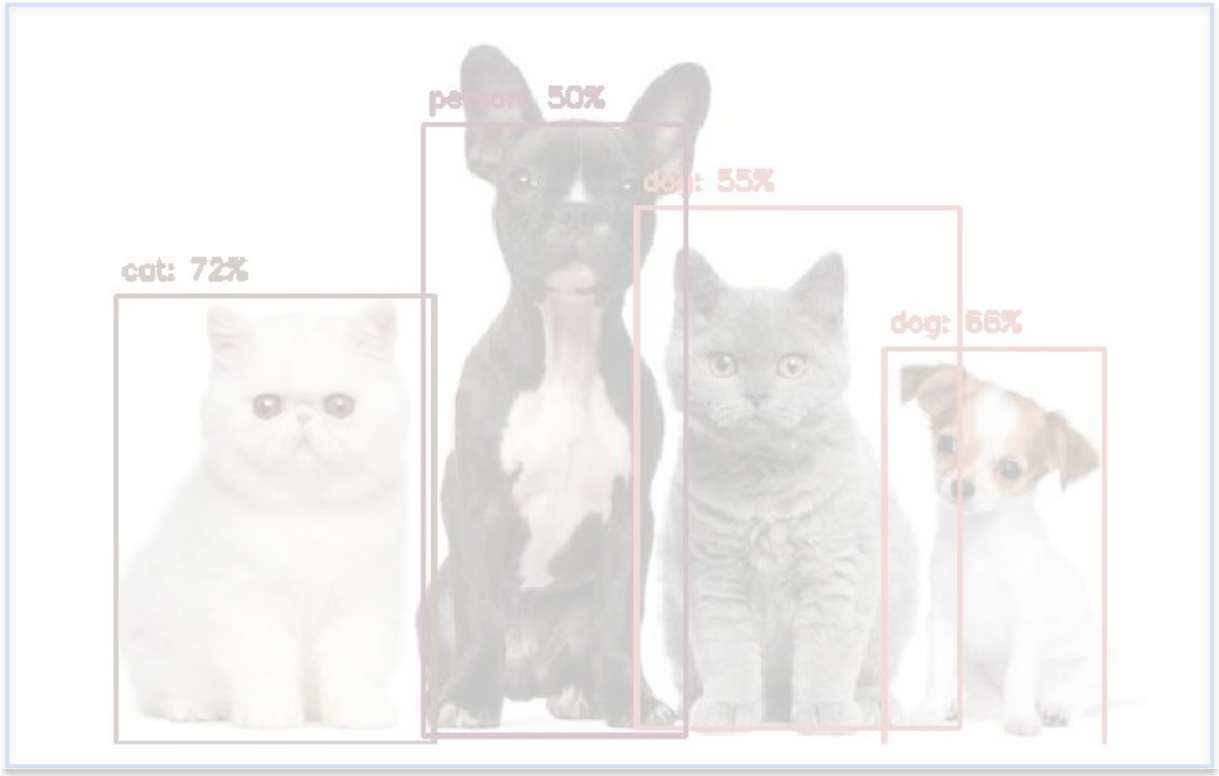
(**Multi-Class** Classification)

Cat: 70%

Dog: 80%

Object Detection

Multi-Label Classification + Object **Localization**



Forest Fire Detection

TinyML Aerial Forest Fire Detection

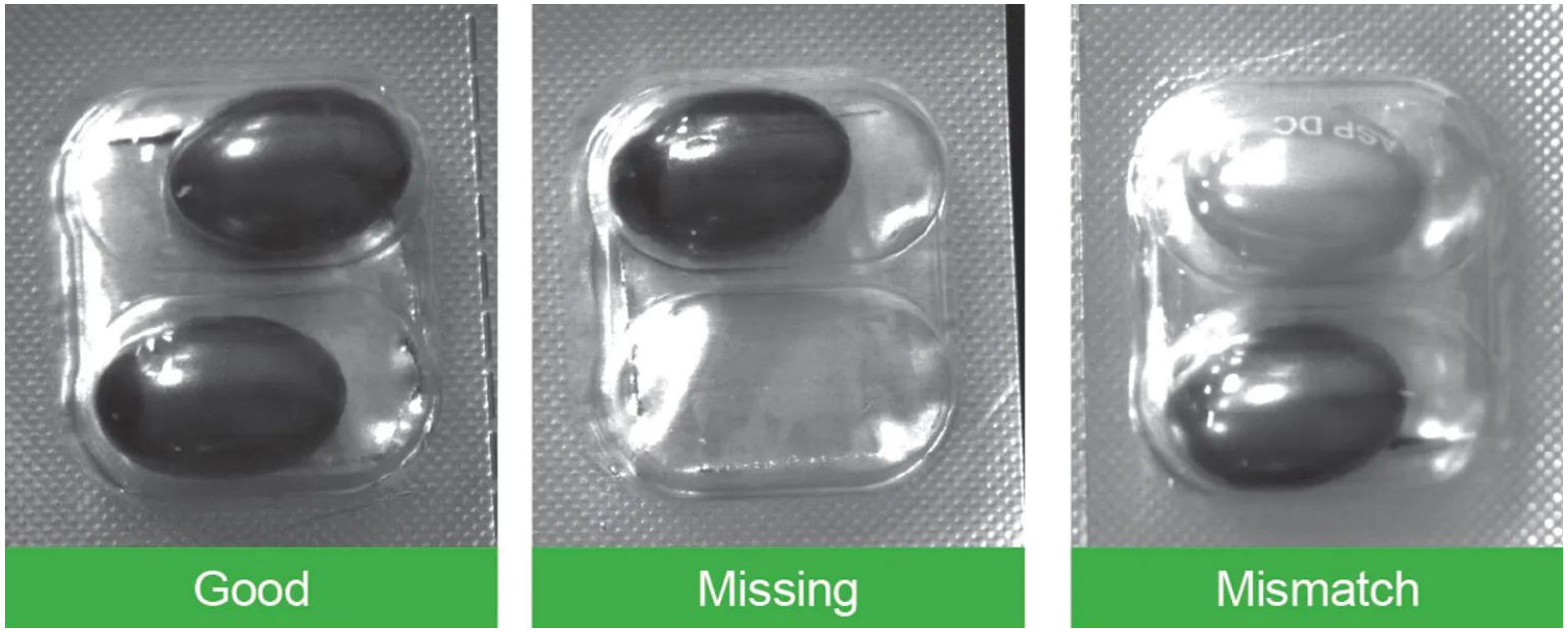
IESTI01 - Forest Fire Detection – Proof of Concept

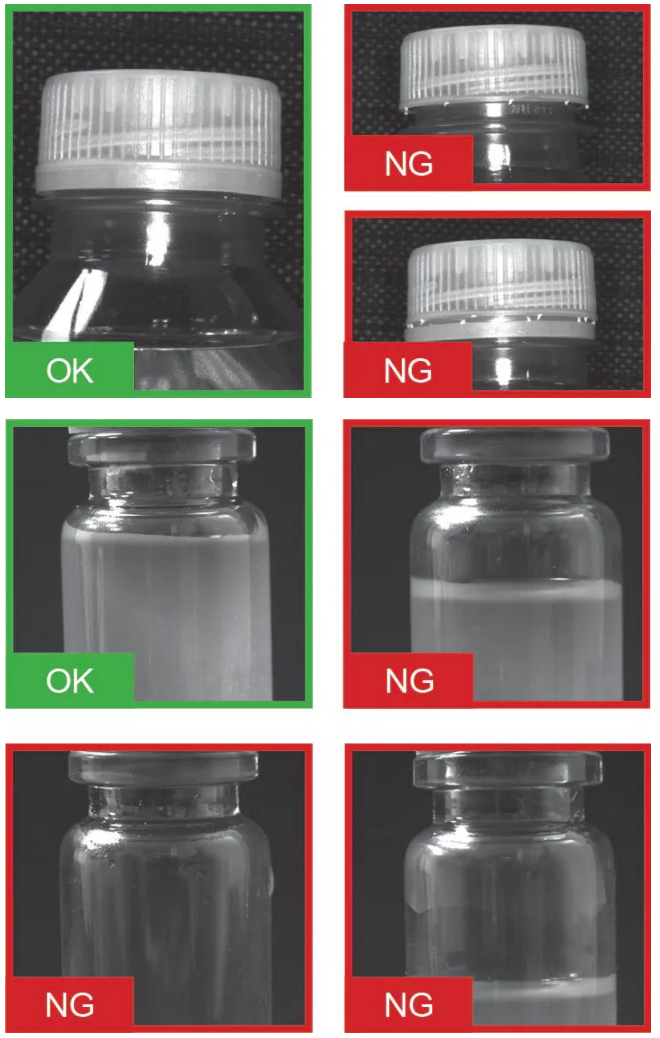
Coffee Disease Classification

João Vitor Yukio Bordin Yamashita
Graduando em Engenharia Eletrônica pela UNIFEI

https://www.hackster.io/Yukio/coffee-disease-classification-with-ml-b0a3fc

Package Inspection



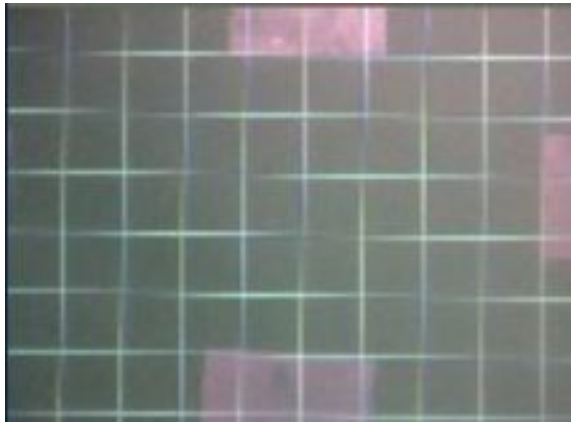


[Deep Learning at the Edge Simplifies Package Inspection]

Image Classification Project 1

Decide a Goal

- Possible Images:
  - medicine
  - background



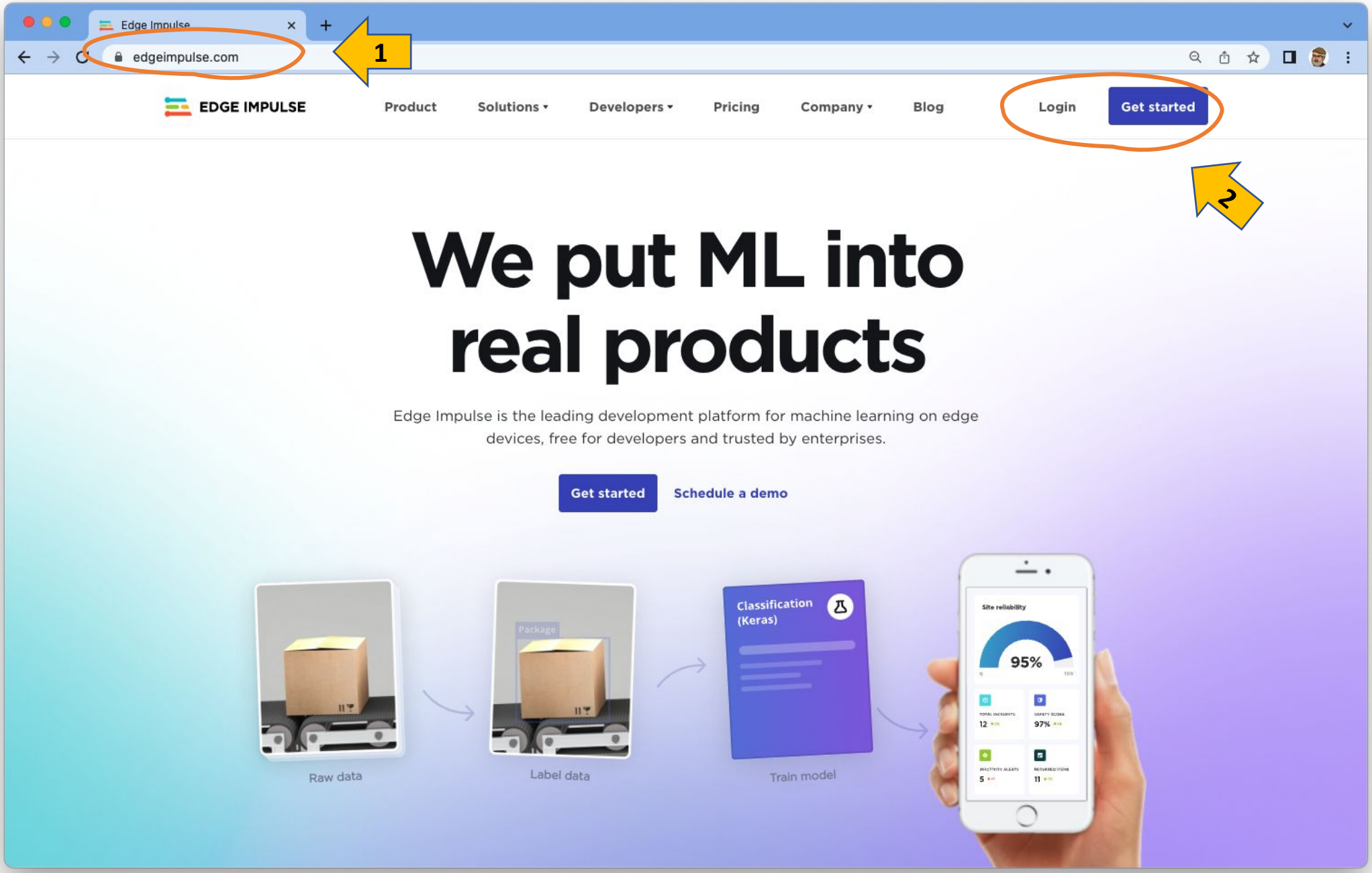
https://studio.edgeimpulse.com/public/114253/latest

Image Classification Project 2

Decide a Goal

- Possible Images:
  - mug
  - background

https://studio.edgeimpulse.com/public/139479/latest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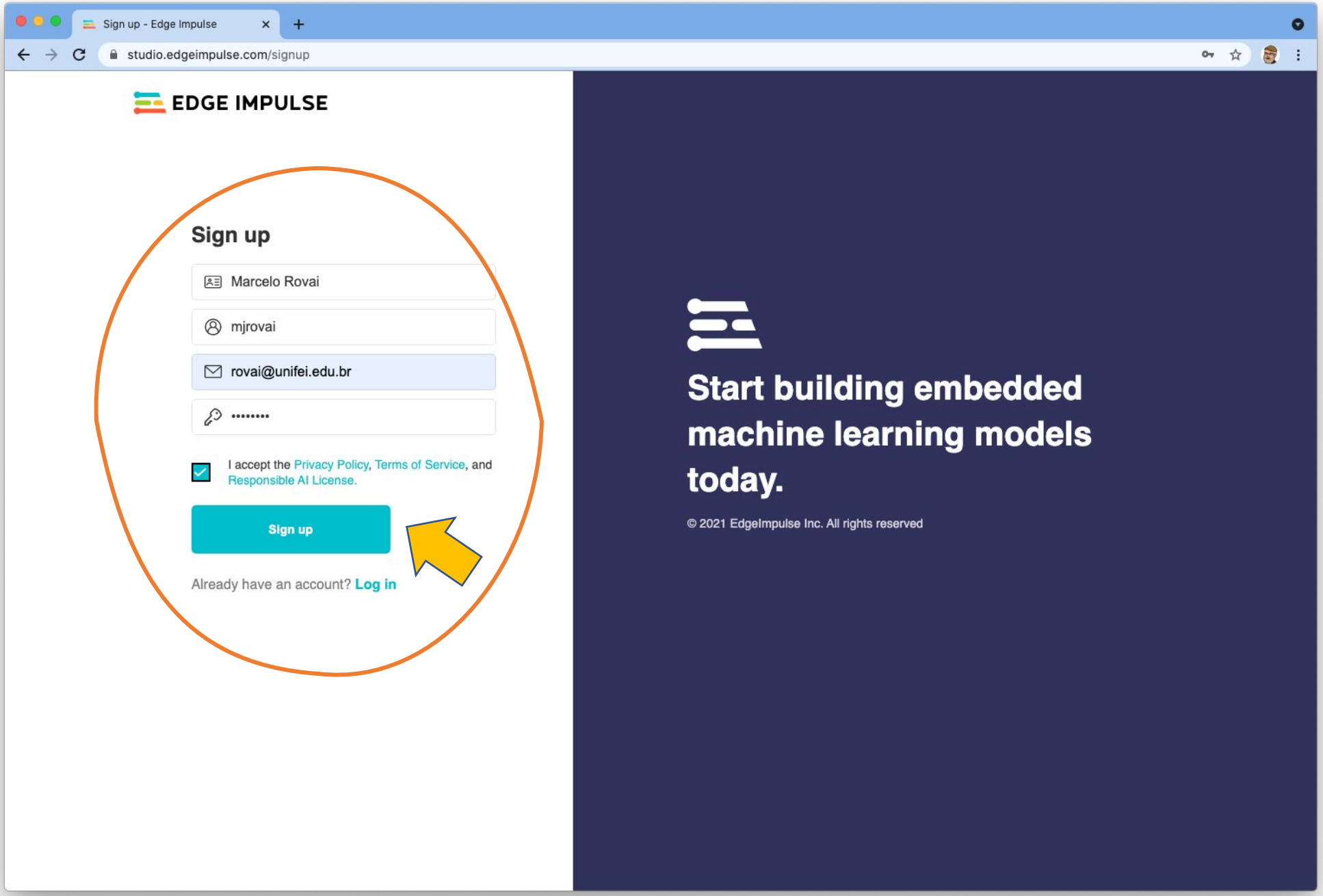
Get started
Schedule a demo
Raw data
Label data
Classification (Keras)
Train model
Site reliability
95%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mjrovai
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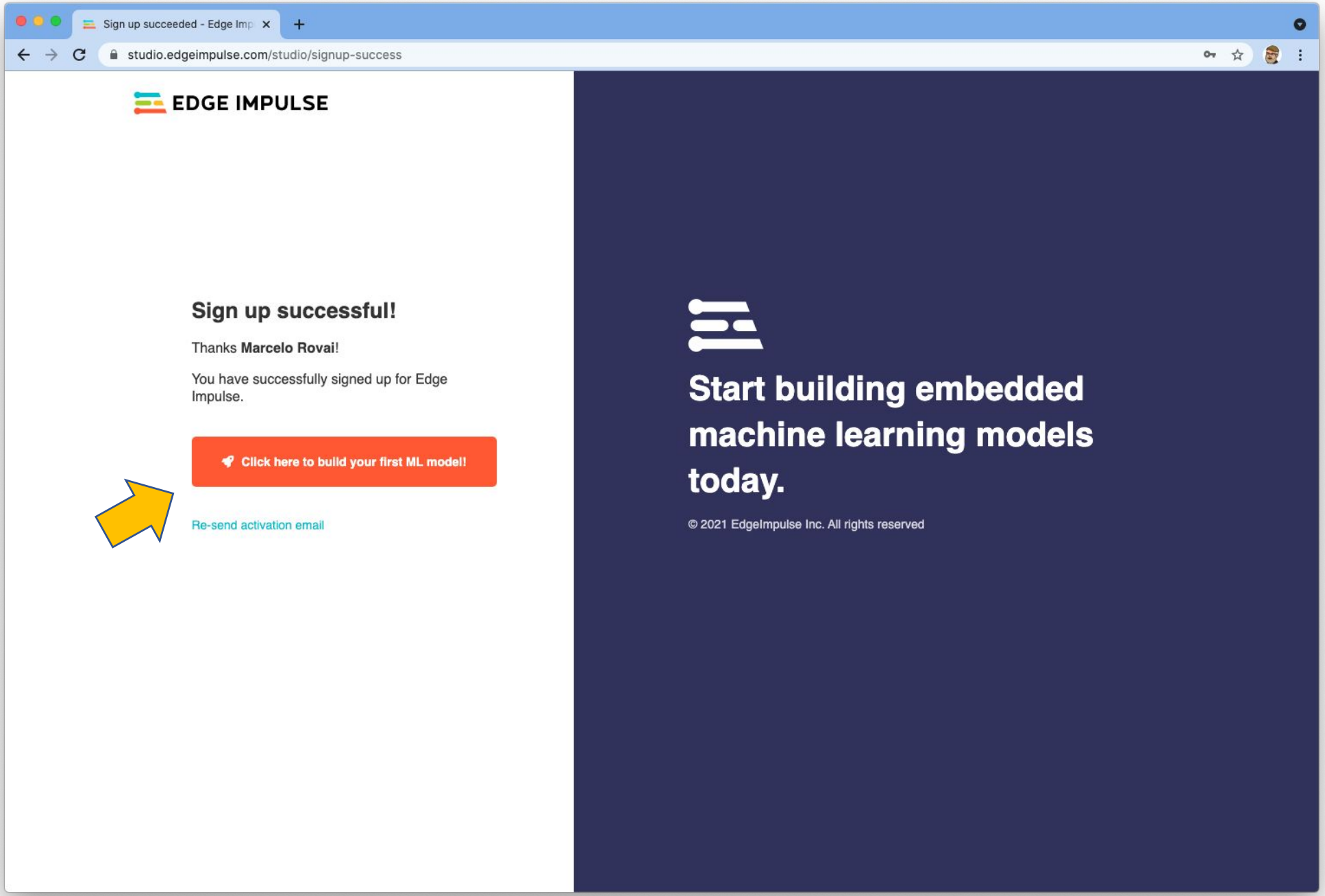
Sign up succeeded - Edge Imp
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Thanks Marcelo Rovai!
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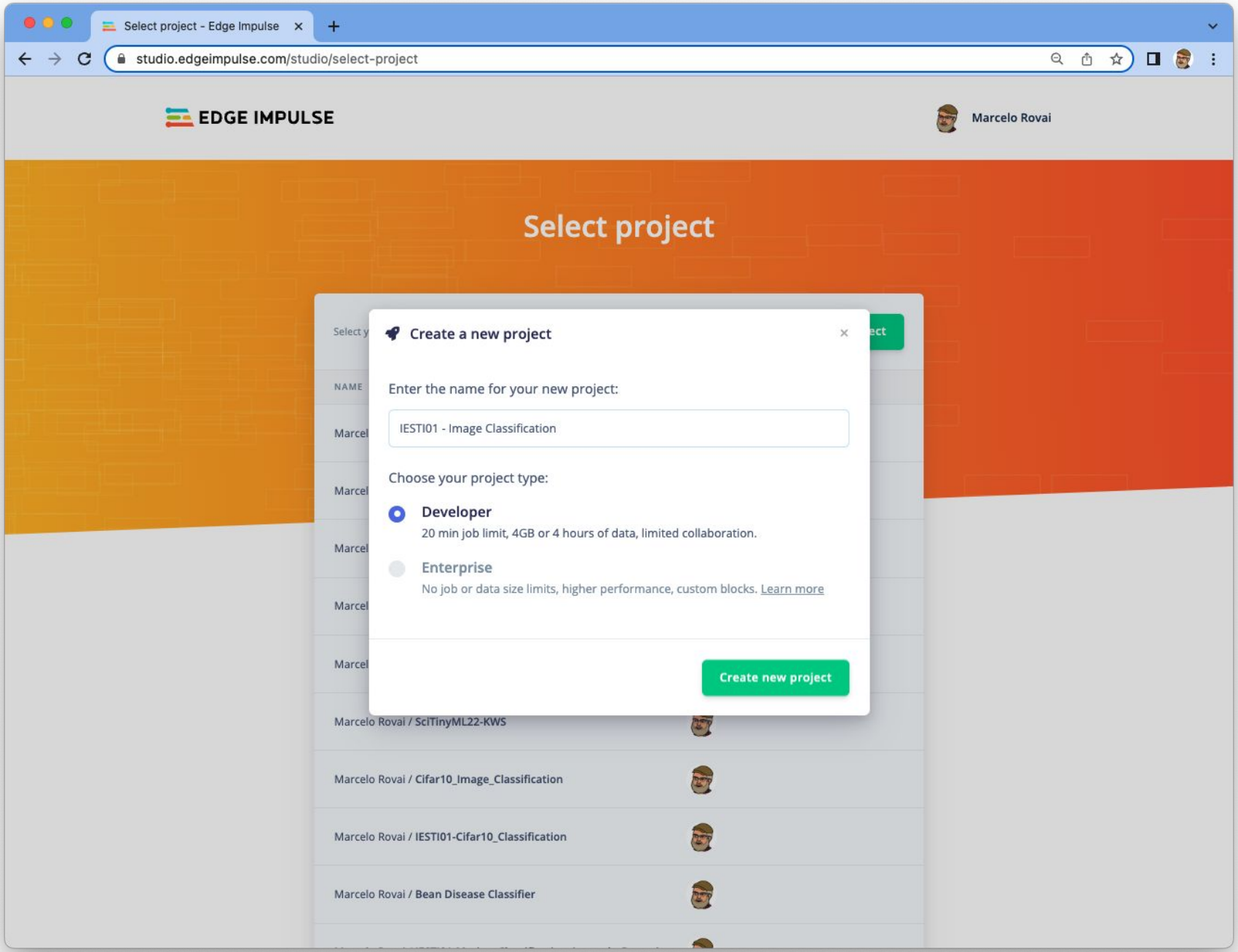
Select project - Edge Impulse
studio.edgeimpulse.com/studio/select-project
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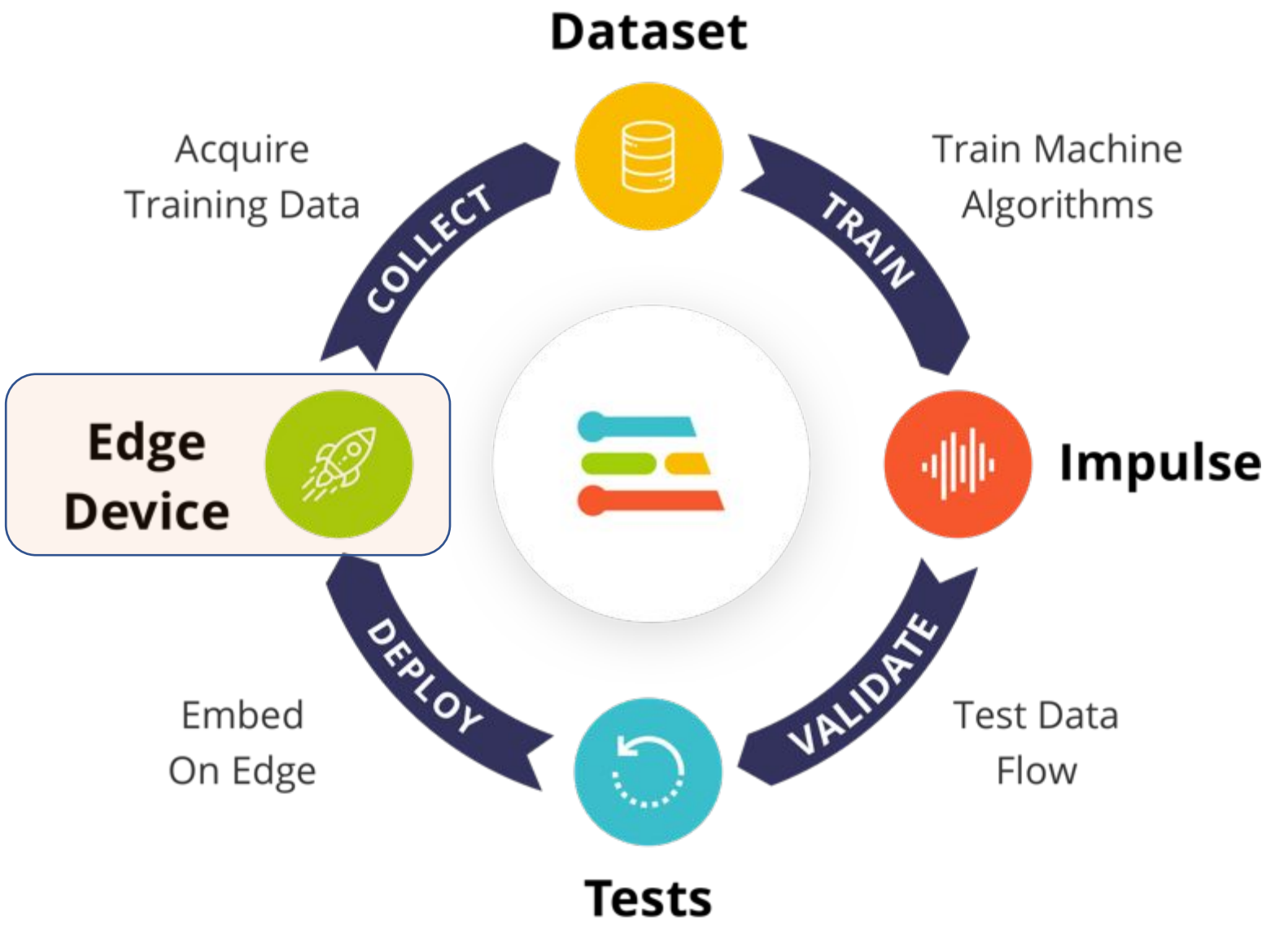
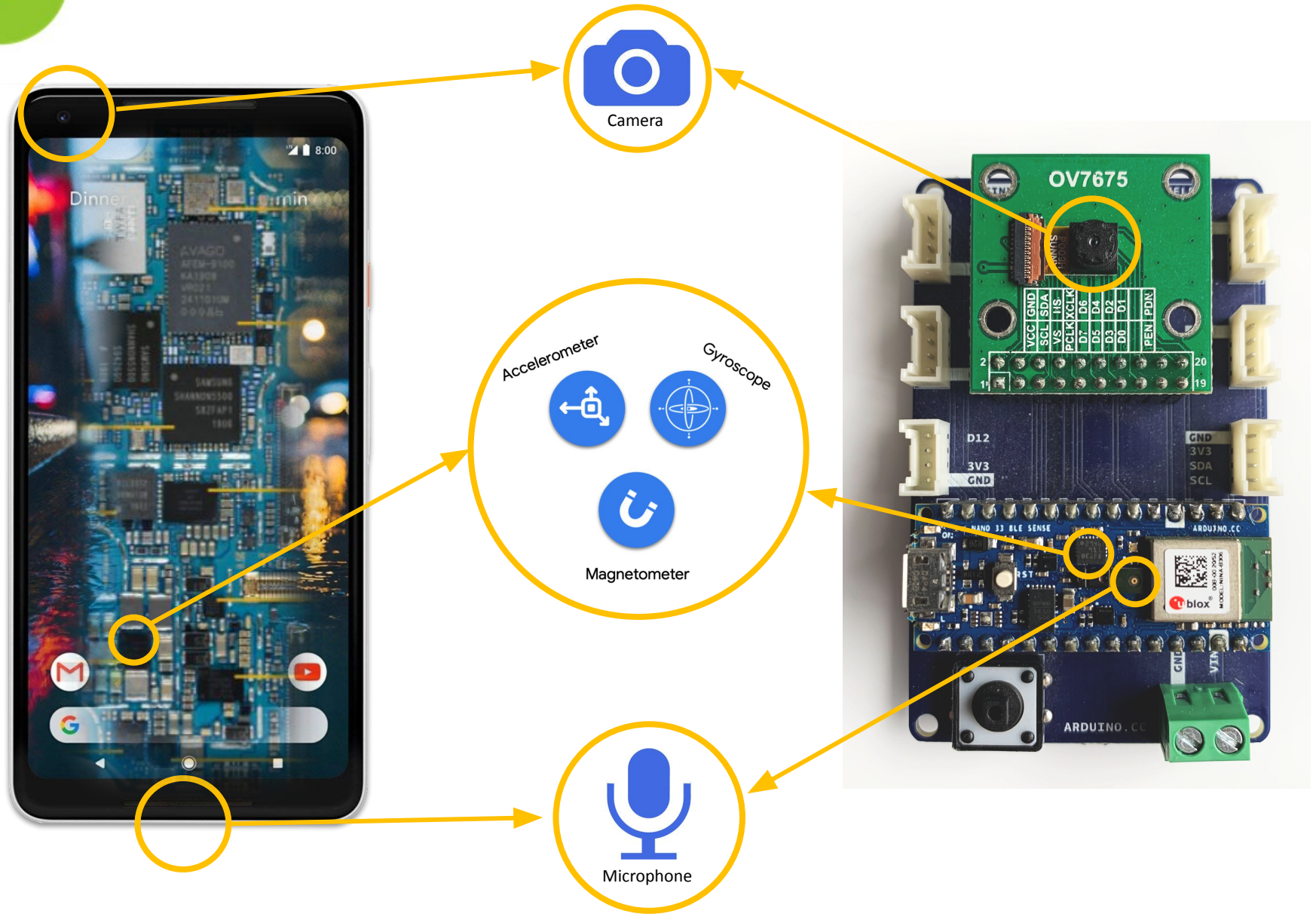
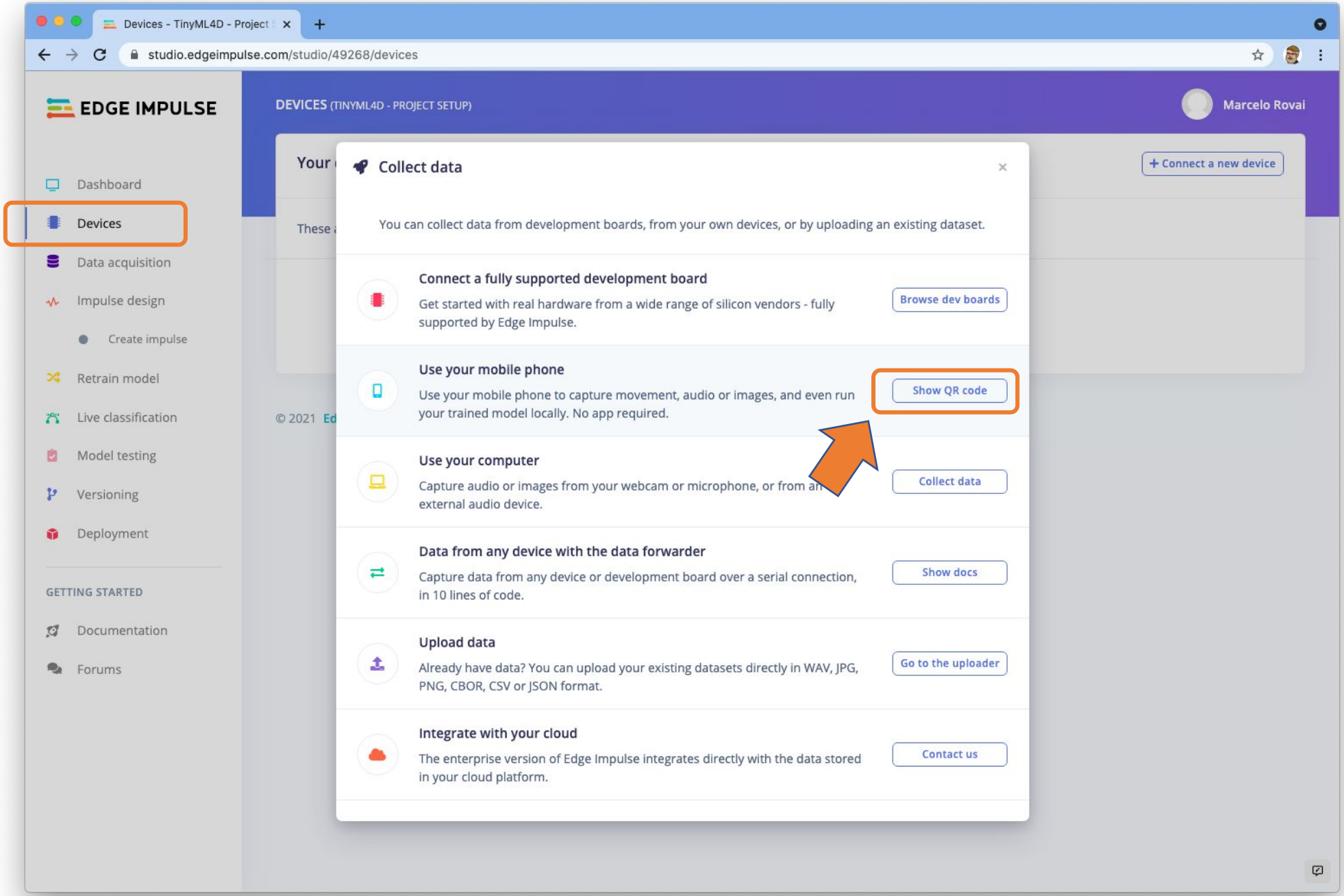
Marcelo Rovai
Select project
Create a new project
Enter the name for your new project:
IESTI01 - Image Classification
Choose your project type:
Developer
20 min job limit, 4GB or 4 hours of data, limited collaboration.
Enterprise
No job or data size limits, higher performance, custom blocks. Learn more
Create new project
NAME
Marcelo Rovai / SciTinyML22-KWS
Marcelo Rovai / Cifar10_Image_Classification
Marcelo Rovai / IESTI01-Cifar10_Classification
Marcelo Rovai / Bean Disease Classifier



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

Edge Device & Sensors




Devices - TinyML4D - Project
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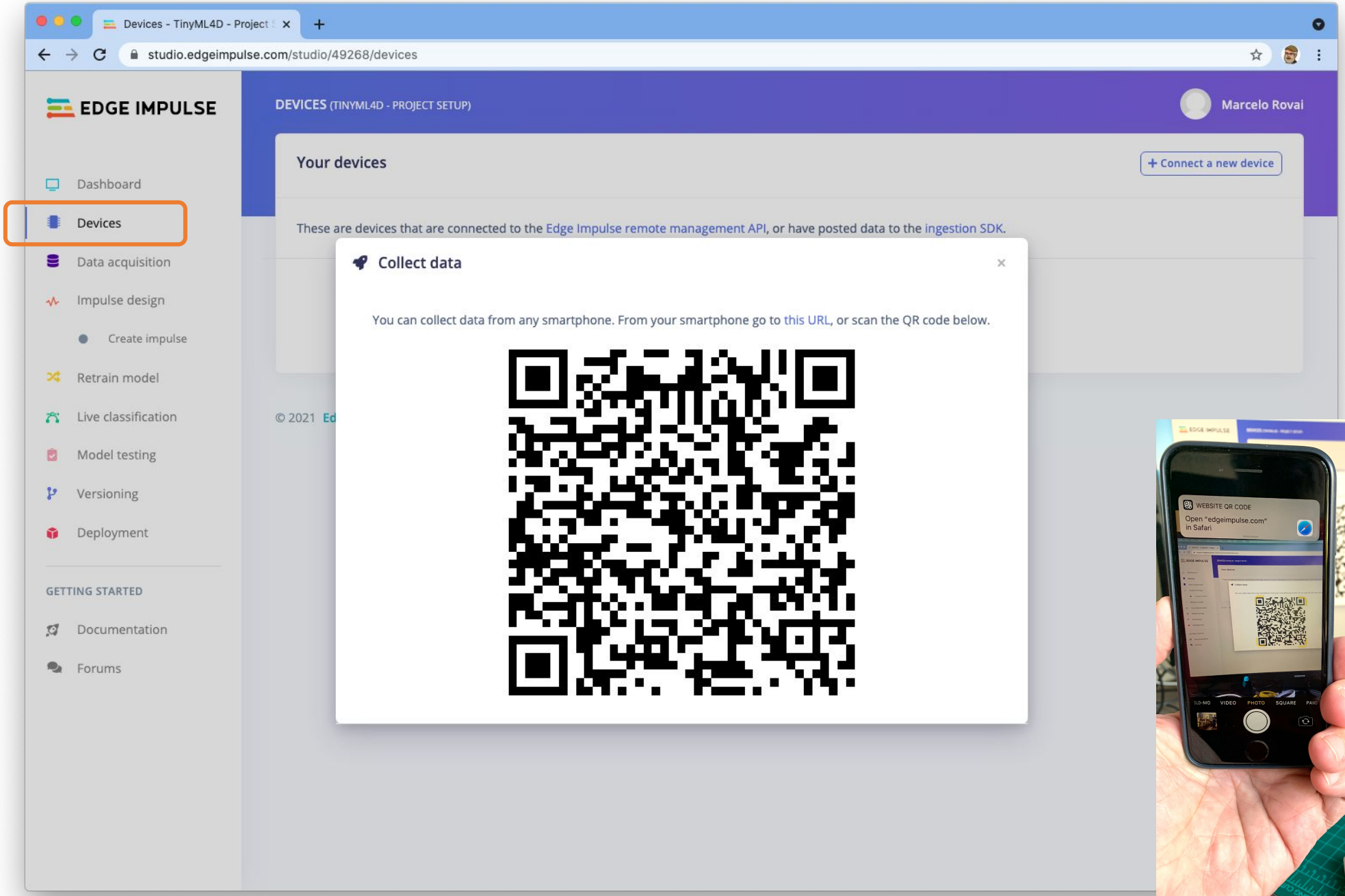
DEVICES (TINYML4D - PROJECT SETUP)
Marcelo Rovai
Dashboard
Devices
Data acquisition
Impulse design
Create impulse
Retrain model
Live classification
Model testing
Versioning
Deployment
GETTING STARTED
Documentation
Forums
+ Connect a new device
Collect data
You can collect data from development boards, 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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These are devices that are connected to the Edge Impulse remote management API, or have posted data to the ingestion SDK.
Collect data
You can collect data from any smartphone. From your smartphone go to this URL, or scan the QR code below.
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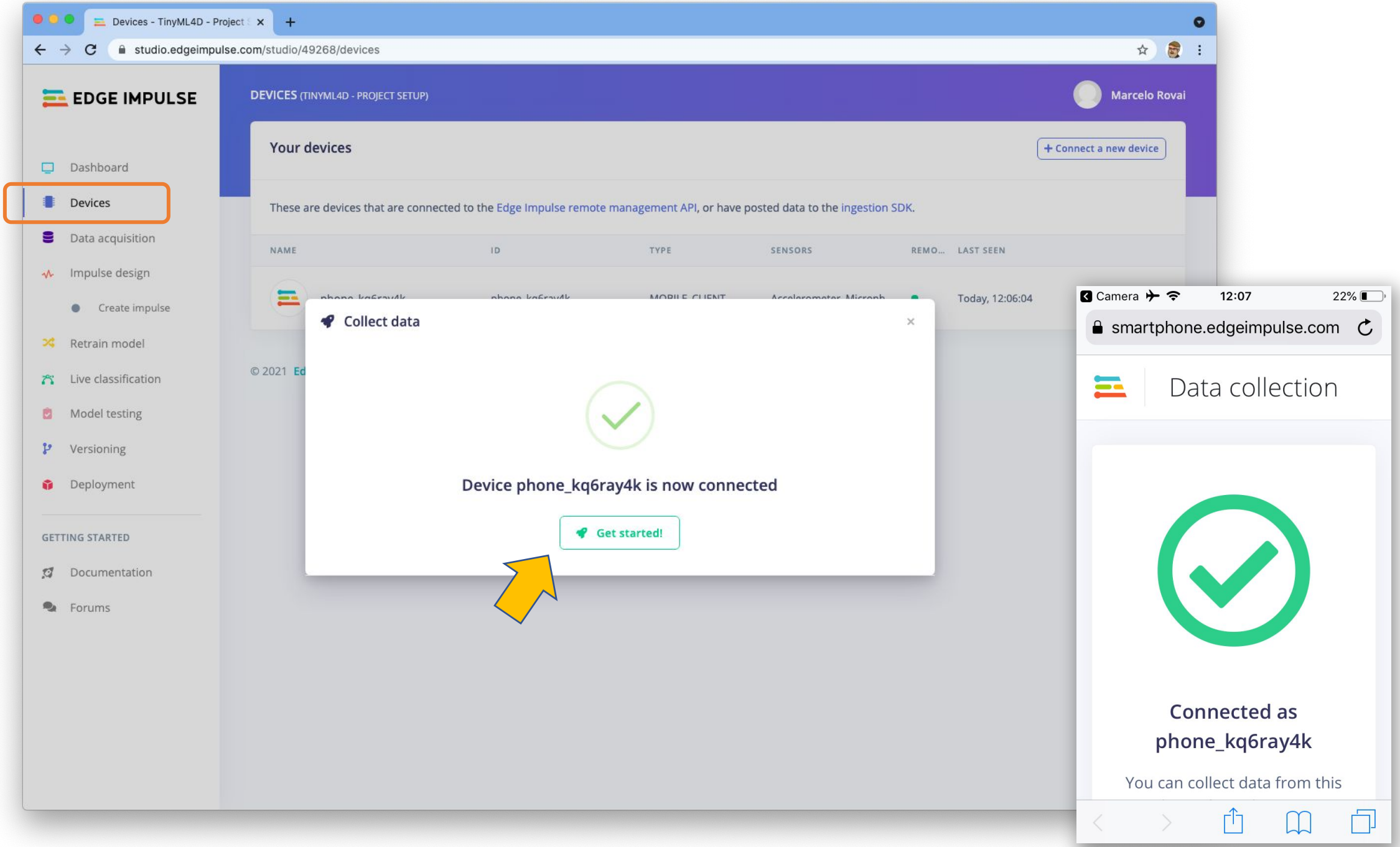
WEBSITE QR CODE
Open "edgeimpulse.com" in Safari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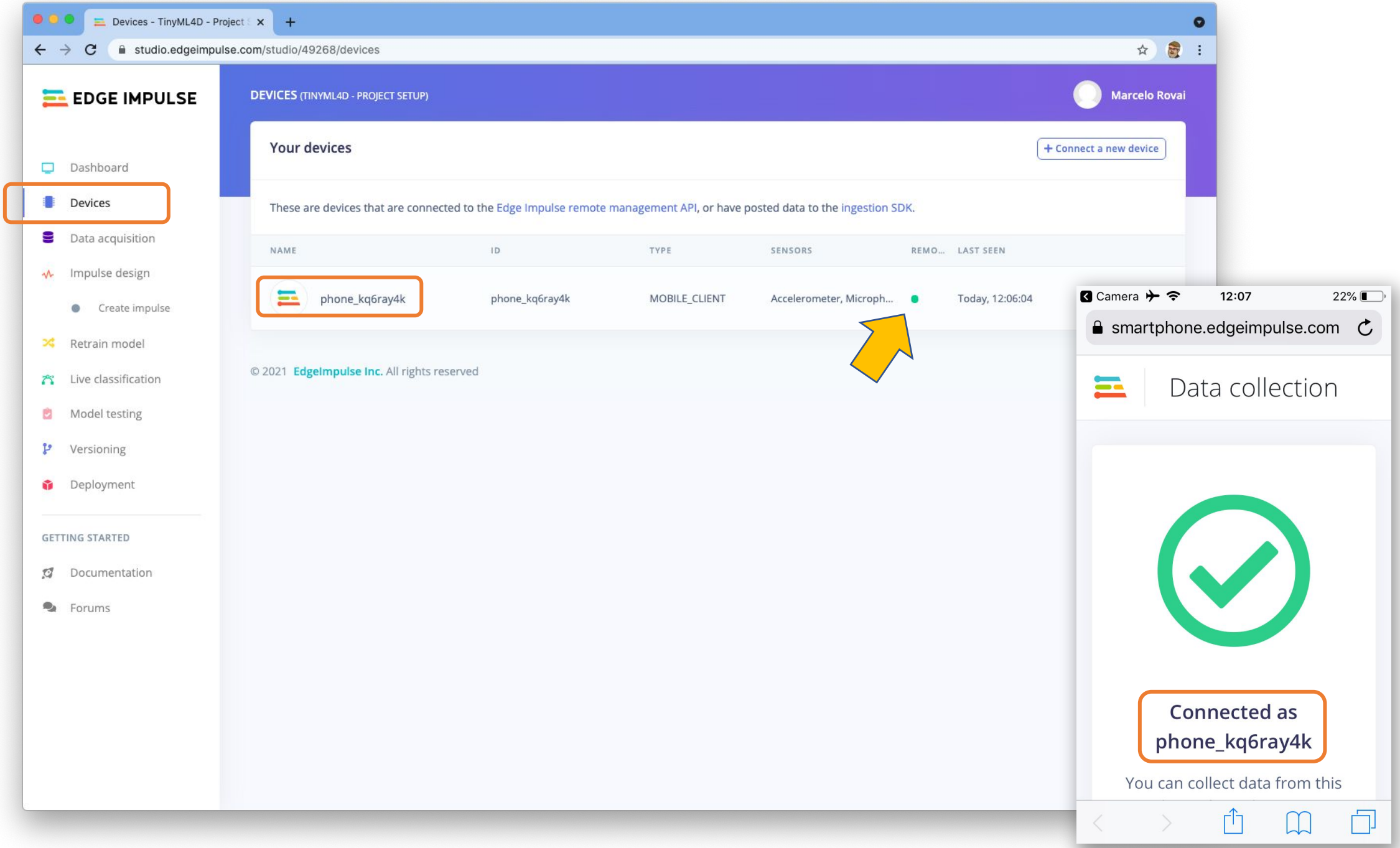
NAME
ID
TYPE
SENSORS
REMO...
LAST SEEN
Today, 12:06:04
© 2021
Collect data
Device phone_kq6ray4k is now connected
Get started!
Camera
12:07
22%
smartphone.edgeimpulse.com
Data collection
Connected as
phone_kq6ray4k
You can collect data from this


Devices - TinyML4D - Project
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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
REMO...
LAST SEEN
phone_kq6ray4k
phone_kq6ray4k
MOBILE_CLIENT
Accelerometer, Microph...
Today, 12:06:04
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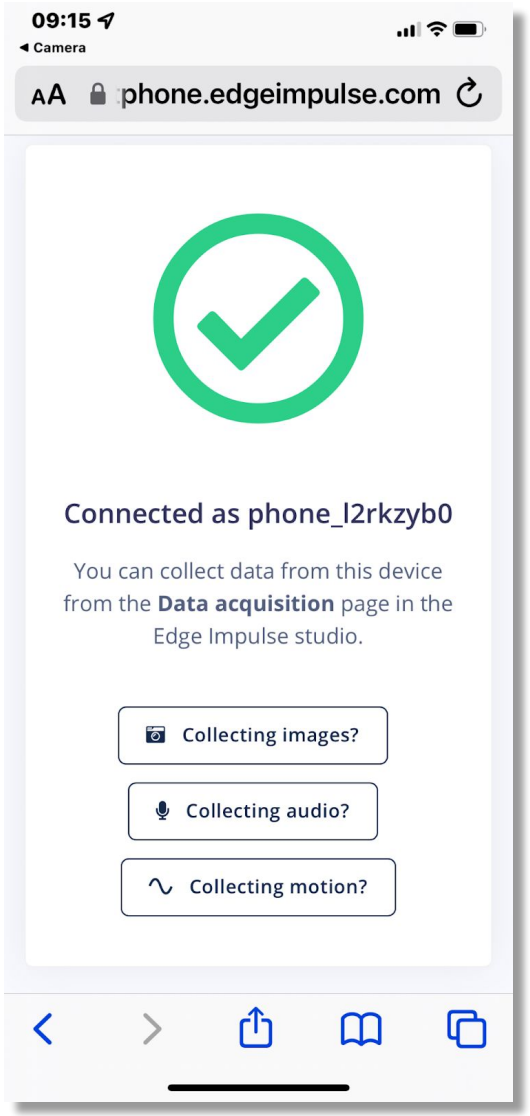
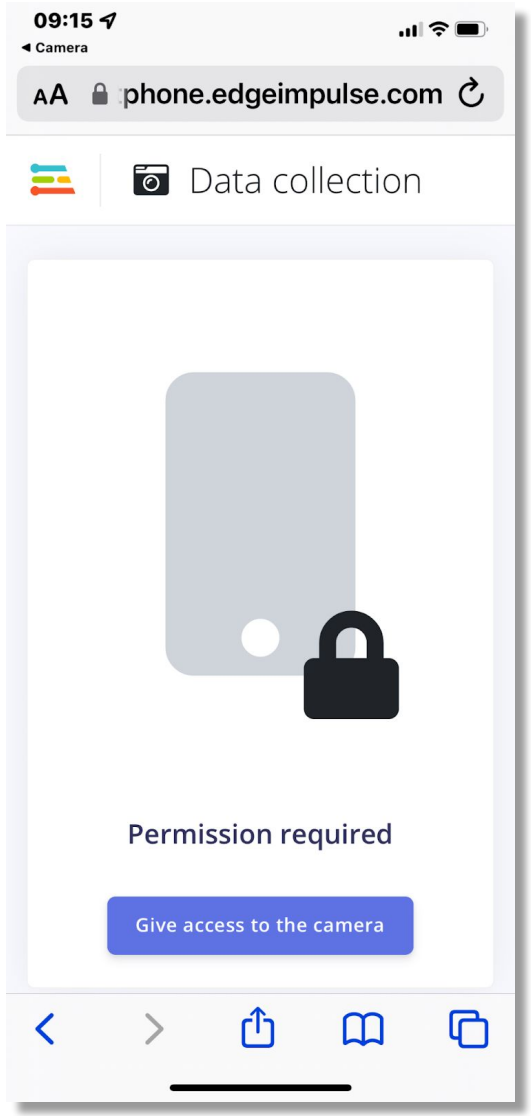
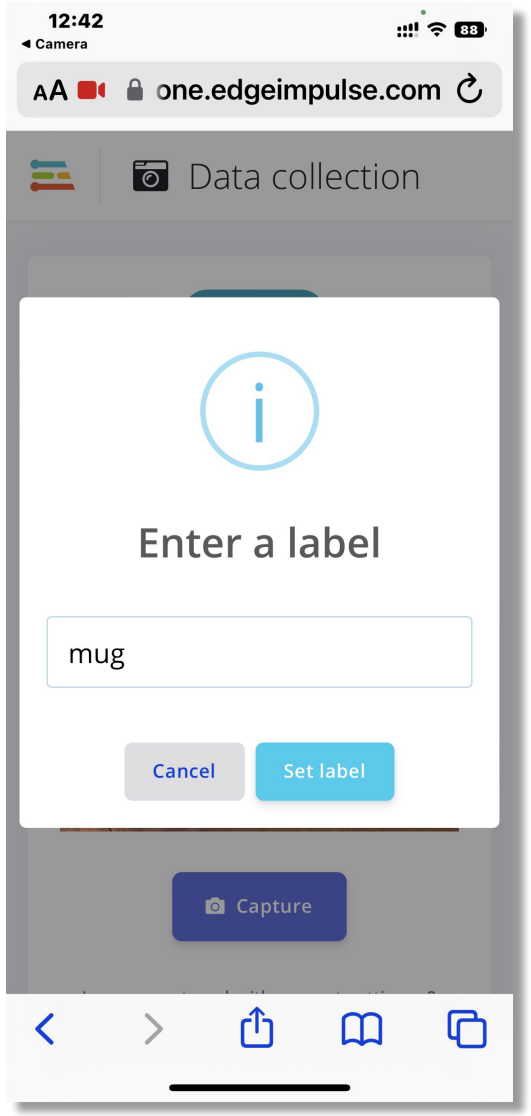
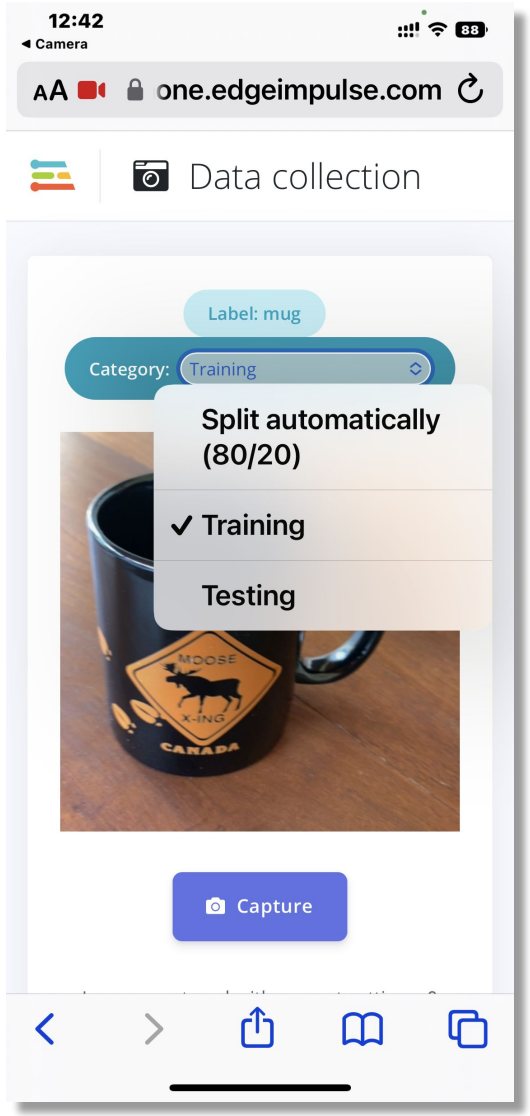
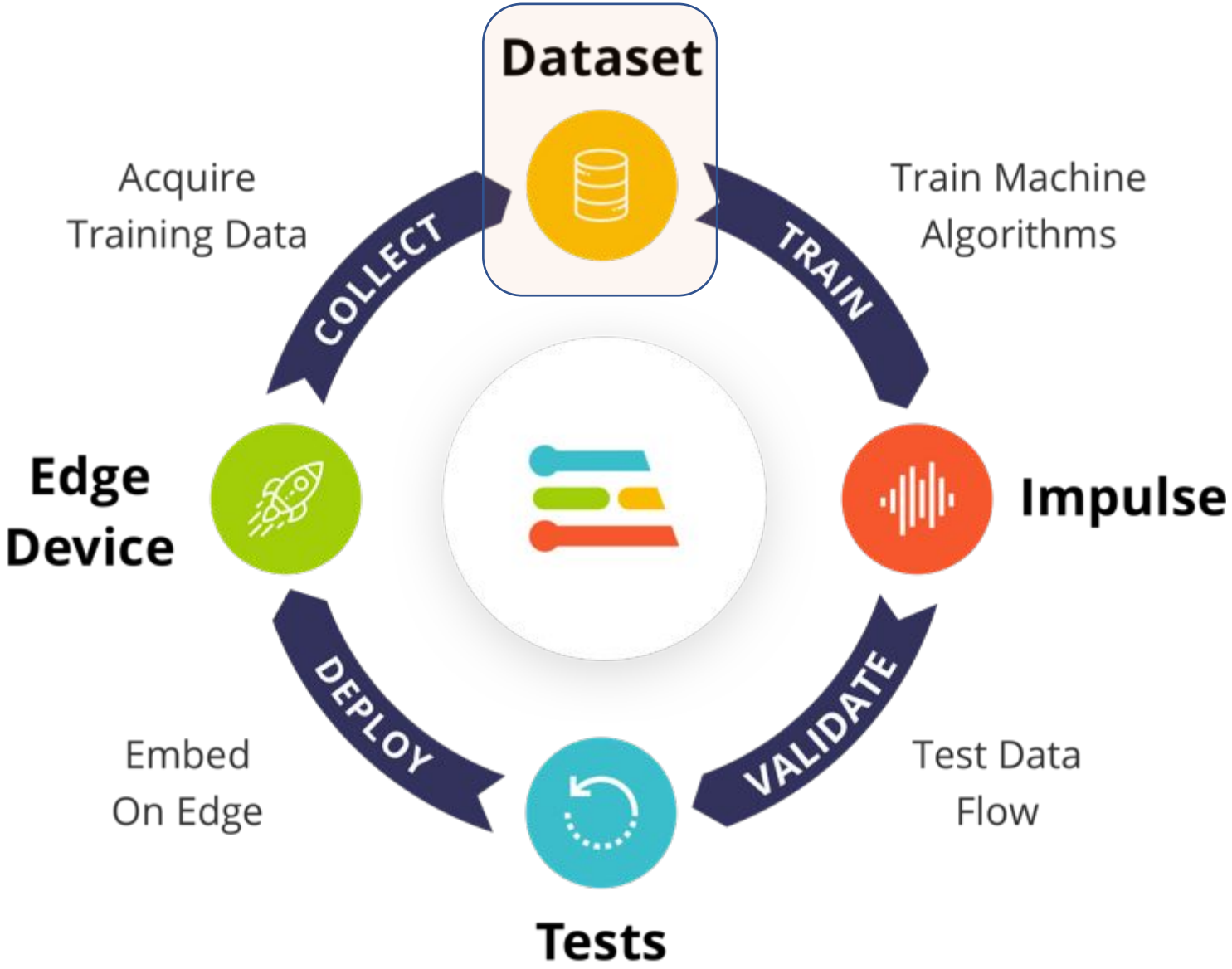
Camera
12:07
22%
smartphone.edgeimpulse.com
Data collection
Connected as
phone_kq6ray4k
You can collect data from this


09:15
Camera
phone.edgeimpulse.com
Connected as phone_l2rkzyb0
You can collect data from this device from the Data acquisition page in the Edge Impulse studio.
Collecting images?
Collecting audio?
Collecting motion?

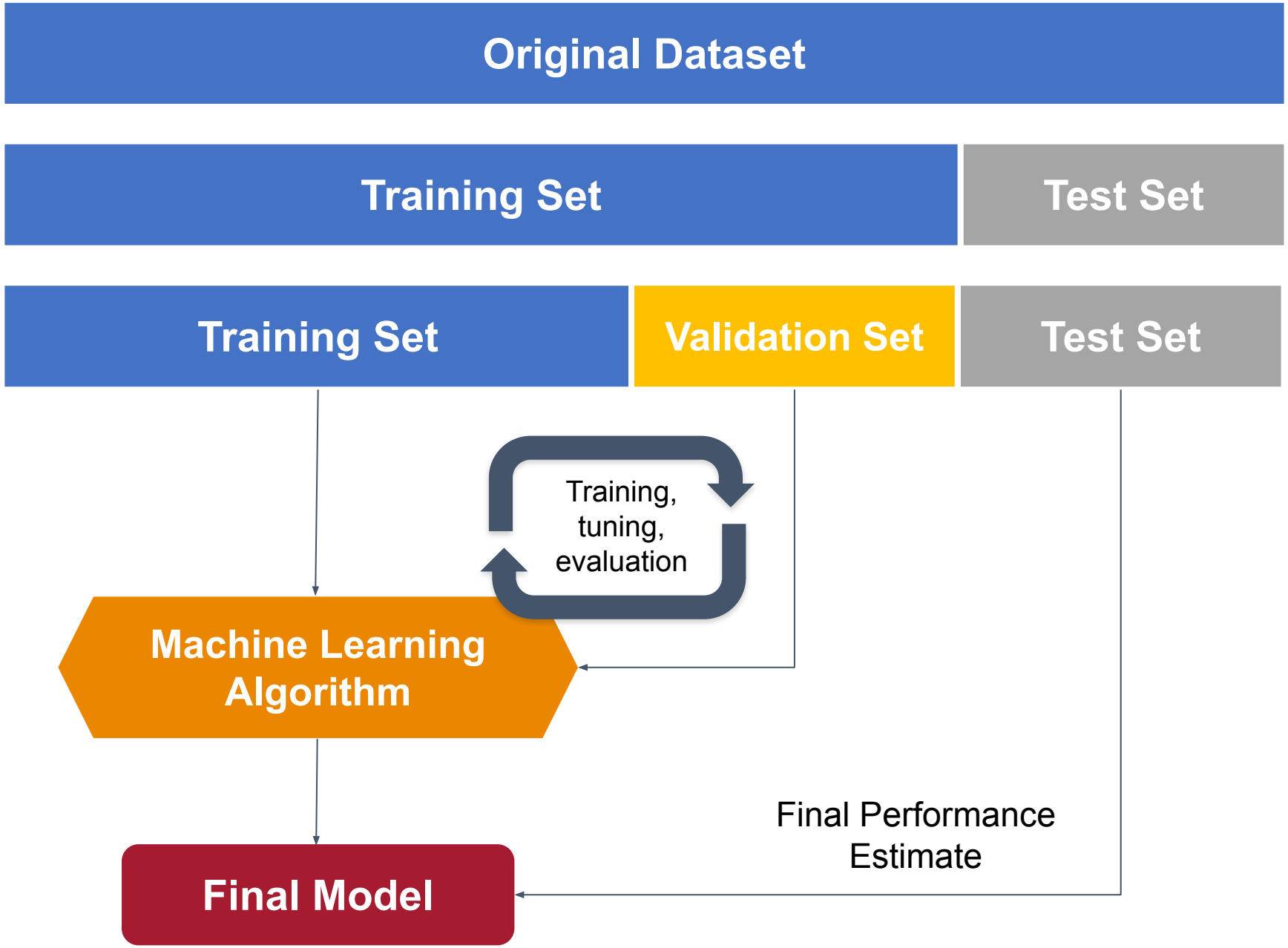

09:15
Camera
phone.edgeimpulse.com
Data collection
Permission required
Give access to the camera


12:42
Camera
one.edgeimpulse.com
Data collection
Enter a label
mug
Cancel
Set label
Capture


12:42
Camera
one.edgeimpulse.com
Data collection
Label: mug
Category: Training
Split automatically (80/20)
Training
Testing
Capture



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


Original Dataset
Training Set
Test Set
Training Set
Validation Set
Test Set
Training,
tuning,
evaluation
Machine Learning
Algorithm
Final Performance
Estimate
Final Model

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  - Create impulse
- EON Tuner
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GETTING STARTED

- Documentation
- Forums

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

DATA COLLECTED
112 items

TRAIN / TEST SPLIT
100% / 0%

Record new data

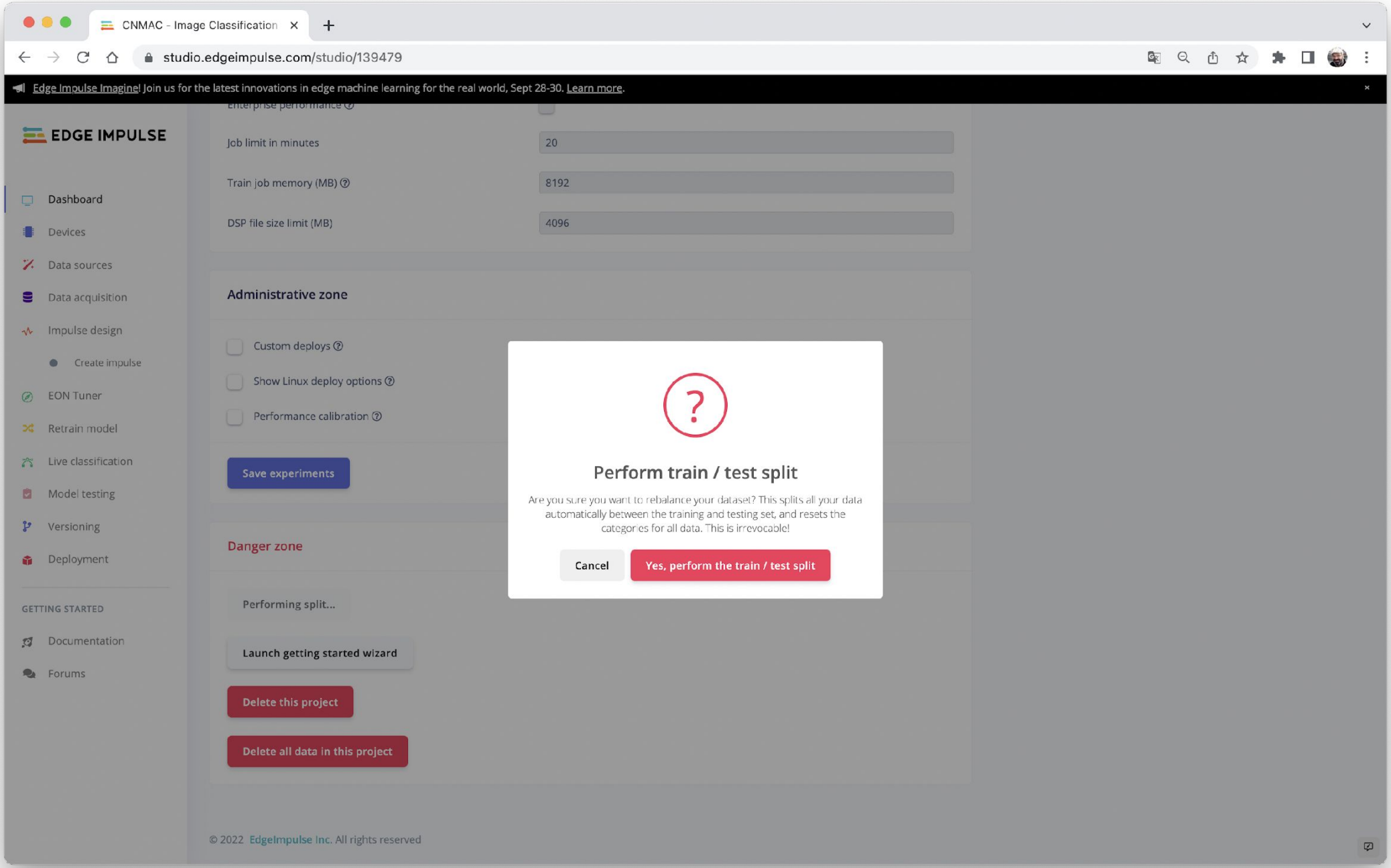
Connect using WebUSB

No devices connected to the remote management API.

Collected data

SAMPLE NAME	LABEL	ADDED
background.3dd0bqga	background	Today, 12:47:34
background.3dd0bmck	background	Today, 12:47:29
background.3dd0b81r	background	Today, 12:47:15
background.3dd0b2vc	background	Today, 12:47:10
background.3dd0b1th	background	Today, 12:47:09
background.3dd0b1ls	background	Today, 12:47:08
mug.3dd09nrm	mug	Today, 12:46:25
mug.3dd09m8k	mug	Today, 12:46:24
mug.3dd09l9i	mug	Today, 12:46:23
mug.3dd09hj2	mug	Today, 12:46:19
mug.3dd09gj3	mug	Today, 12:46:18
mug.3dd09esl	mug	Today, 12:46:16

RAW DATA
mug.3dd09hj2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Job limit in minutes
20
Train job memory (MB)
8192
DSP file size limit (MB)
4096
Administrative zone
Custom deploys
Show Linux deploy options
Performance calibration
Save experiments
Danger zone
Performing split...
Launch getting started wizard
Delete this project
Delete all data in this project
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
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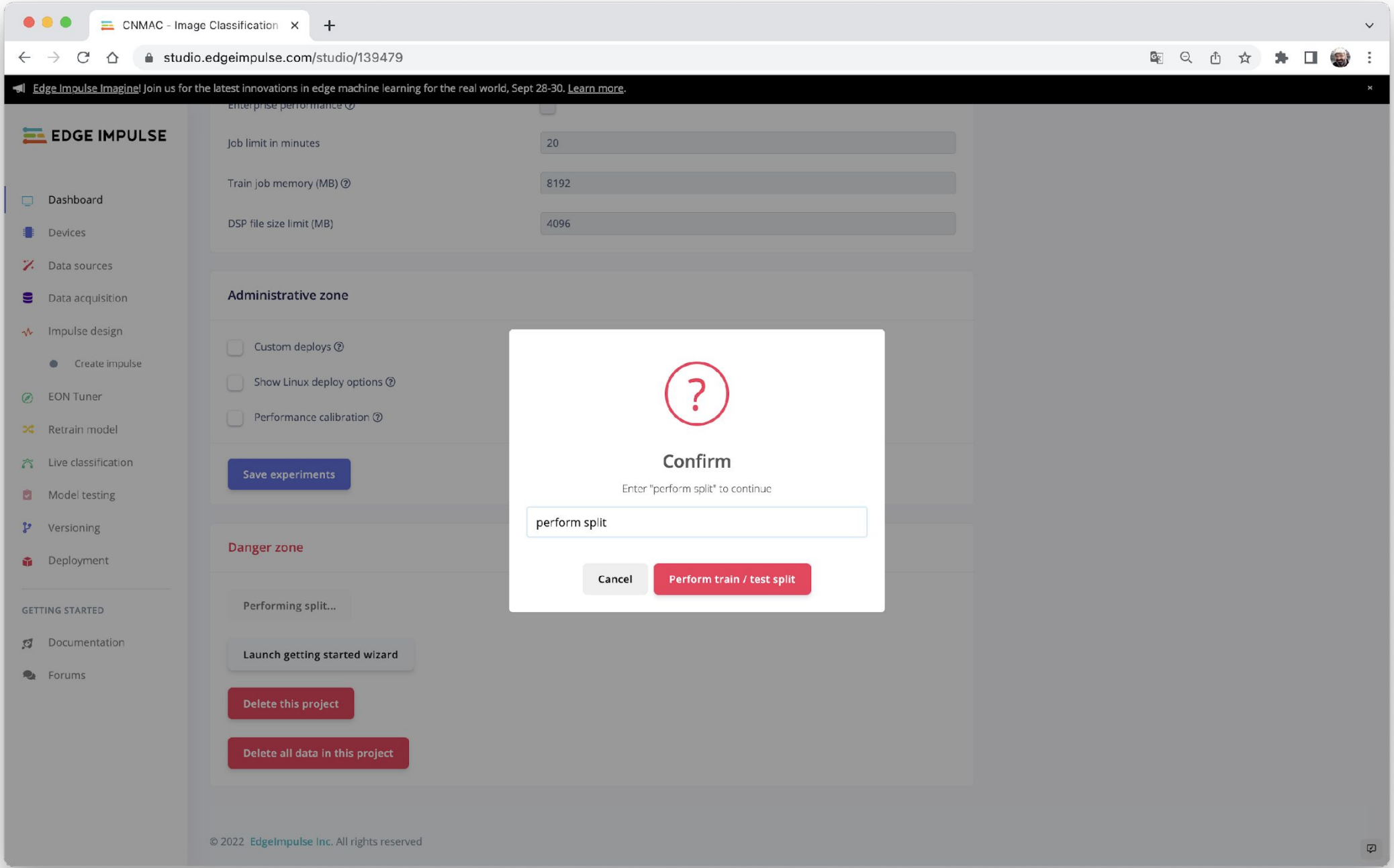
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20
Train job memory (MB)
8192
DSP file size limit (MB)
4096
Administrative zone
Custom deploys
Show Linux deploy options
Performance calibration
Save experiments
Danger zone
Performing split...
Launch getting started wizard
Delete this project
Delete all data in this project
Confirm
Enter "perform split" to continue
perform split
Cancel
Perform train / test split
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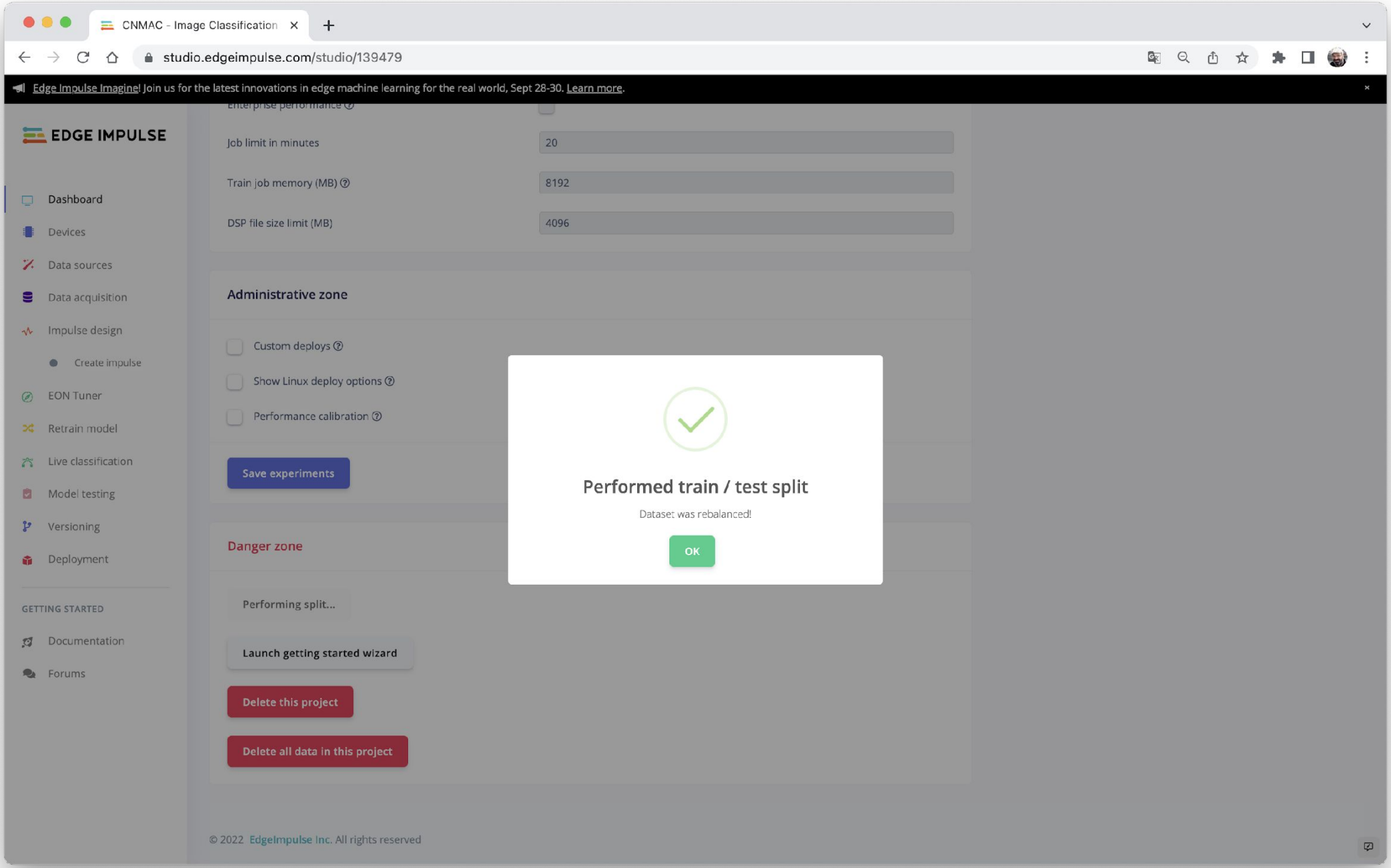
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Train job memory (MB)
8192
DSP file size limit (MB)
4096
Administrative zone
Custom deploys
Show Linux deploy options
Performance calibration
Save experiments
Performed train / test split
Dataset was rebalanced!
OK
Danger zone
Performing split...
Launch getting started wizard
Delete this project
Delete all data in this project
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GETTING STARTED

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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

mug
45 items

DATA COLLECTED
89 items

TRAIN / TEST SPLIT
79% / 21%

Record new data

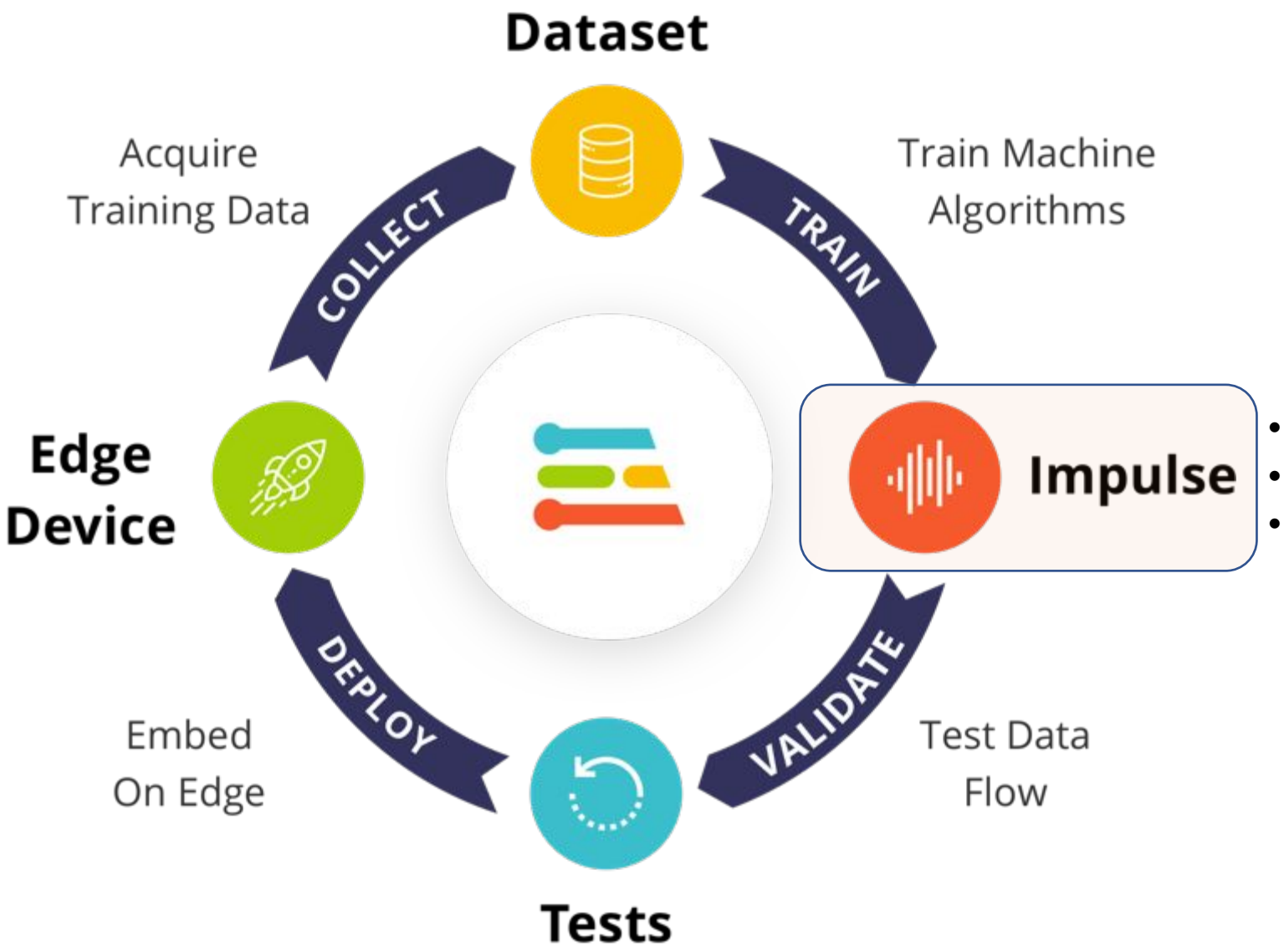
Connect using WebUSB

No devices connected to the remote management API.

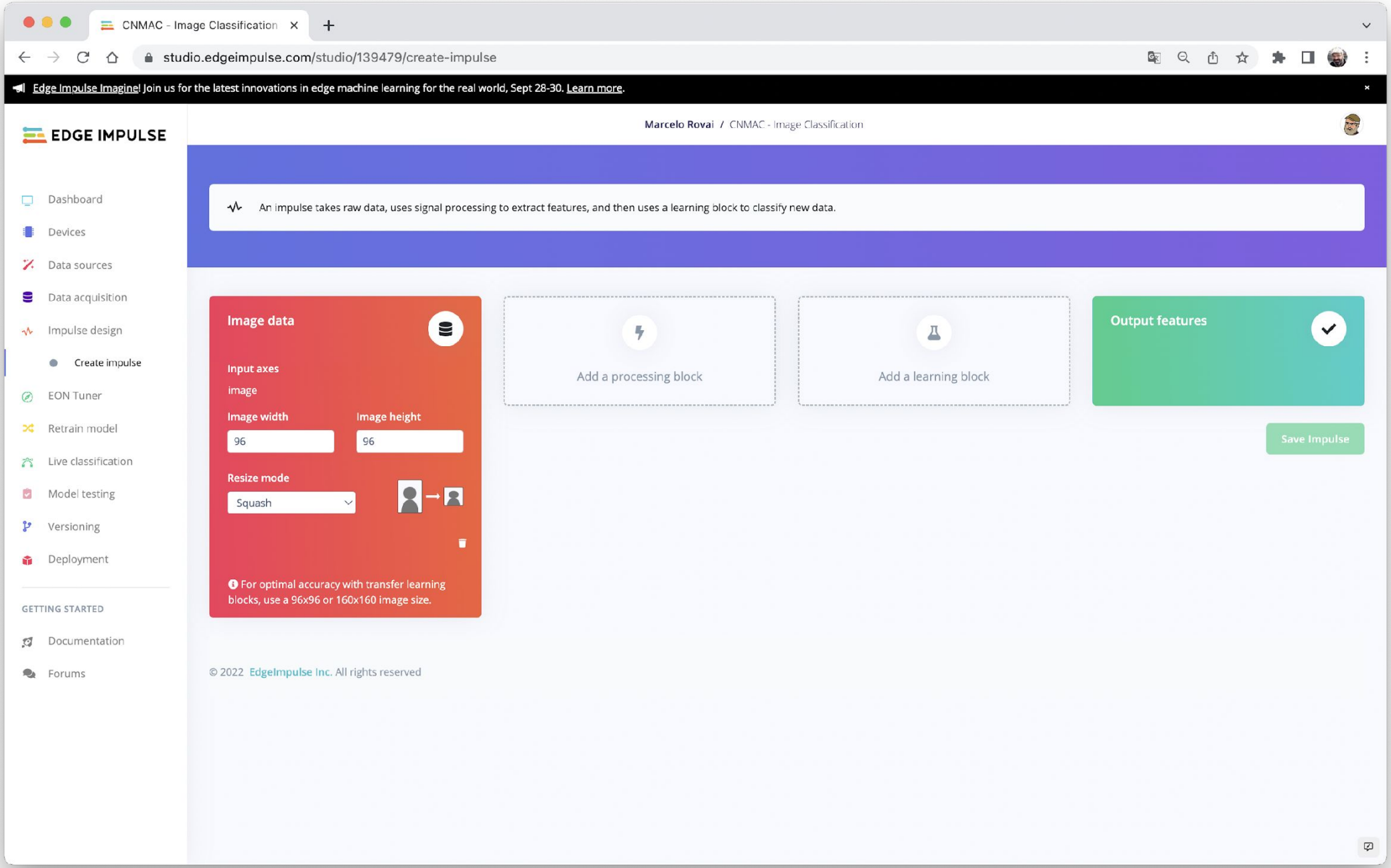
Collected data

SAMPLE NAME	LABEL	ADDED
background.3dd0bqga	background	Today, 12:47:34
background.3dd0b81r	background	Today, 12:47:15
background.3dd0b2vc	background	Today, 12:47:10
background.3dd0b1th	background	Today, 12:47:09
mug.3dd09nrm	mug	Today, 12:46:25
mug.3dd09m8k	mug	Today, 12:46:24
mug.3dd09l9i	mug	Today, 12:46:23
mug.3dd09hj2	mug	Today, 12:46:19
mug.3dd09gj3	mug	Today, 12:46:18
mug.3dd09d81	mug	Today, 12:46:15
mug.3dd09c6f	mug	Today, 12:46:14
mug.3dd09atk	mug	Today, 12:46:12

RAW DATA
mug.3dd09nrm



- Pre-Processing Data
- Design a Model
- Train a Model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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.
Image data
Input axes
image
Image width
96
Image height
96
Resize mode
Squash
For optimal accuracy with transfer learning blocks, use a 96x96 or 160x160 image size.
Add a processing block
Add a learning block
Output features
Save Impulse
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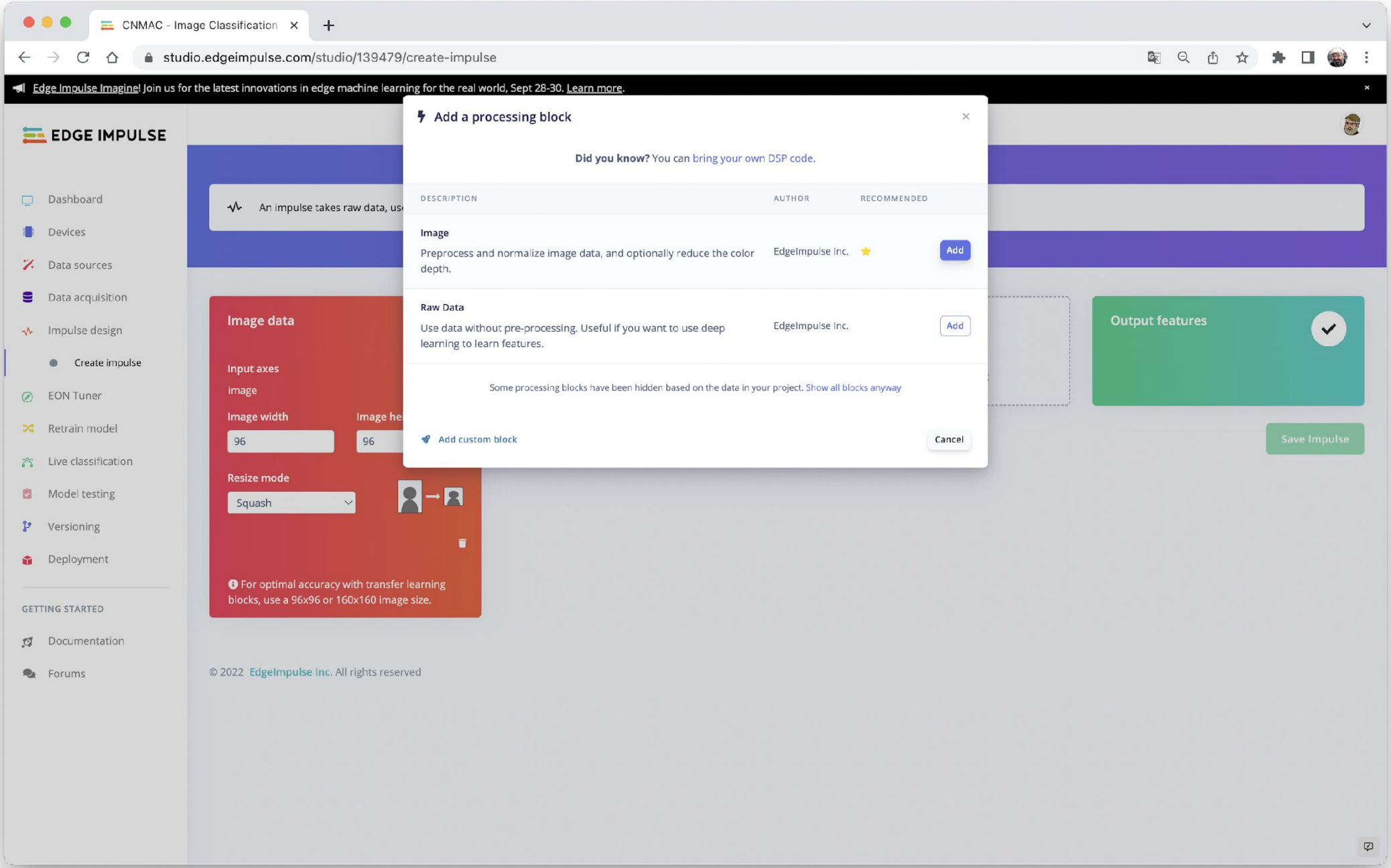
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Impulse design
Create impulse
EON Tuner
Retrain model
Live classification
Model testing
Versioning
Deployment
GETTING STARTED
Documentation
Forums
An impulse takes raw data, us
Image data
Input axes
image
Image width
96
Image he
96
Resize mode
Squash
For optimal accuracy with transfer learning blocks, use a 96x96 or 160x160 image size.
Output features
Save Impulse
Add a processing block
Did you know? You can bring your own DSP code.
DESCRIPTION
AUTHOR
RECOMMENDED
Image
Preprocess and normalize image data, and optionally reduce the color depth.
EdgeImpulse Inc.
Add
Raw Data
Use data without pre-processing. Useful if you want to use deep learning to learn features.
EdgeImpulse Inc.
Add
Some processing blocks have been hidden based on the data in your project. Show all blocks anyway
Add custom block
Cancel
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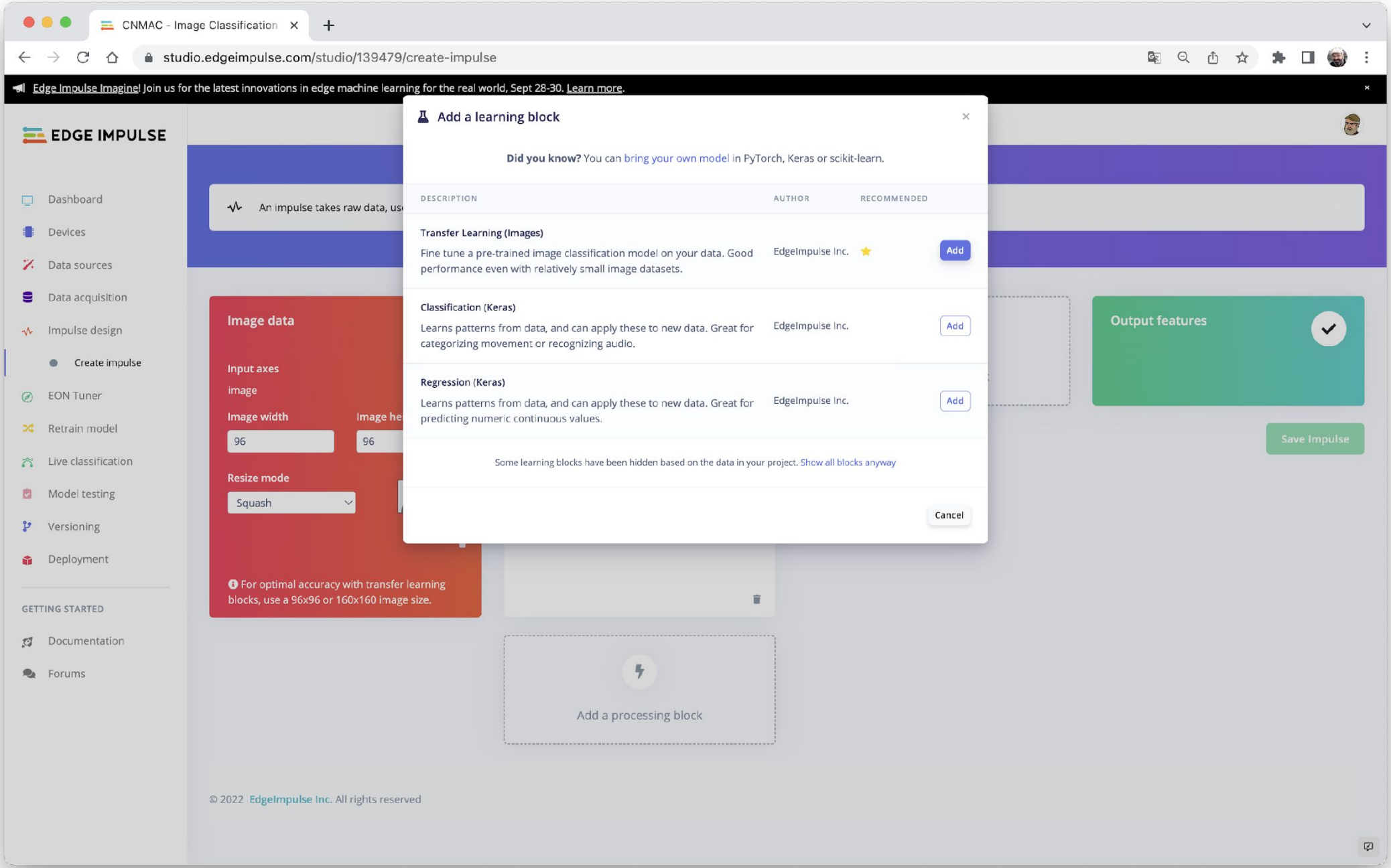
CNMAC - Image Classification
studio.edgeimpulse.com/studio/139479/create-impulse
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An impulse takes raw data, us
Image data
Input axes
image
Image width
96
Image he
96
Resize mode
Squash
For optimal accuracy with transfer learning blocks, use a 96x96 or 160x160 image size.
Output features
Save Impulse
Add a processing block
Add a learning block
Did you know? You can bring your own model in PyTorch, Keras or scikit-learn.
DESCRIPTION
AUTHOR
RECOMMENDED
Transfer Learning (Images)
Fine tune a pre-trained image classification model on your data. Good performance even with relatively small image datasets.
EdgeImpulse Inc.
Add
Classification (Keras)
Learns patterns from data, and can apply these to new data. Great for categorizing movement or recognizing audio.
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
Some learning blocks have been hidden based on the data in your project. Show all blocks anyway
Cancel
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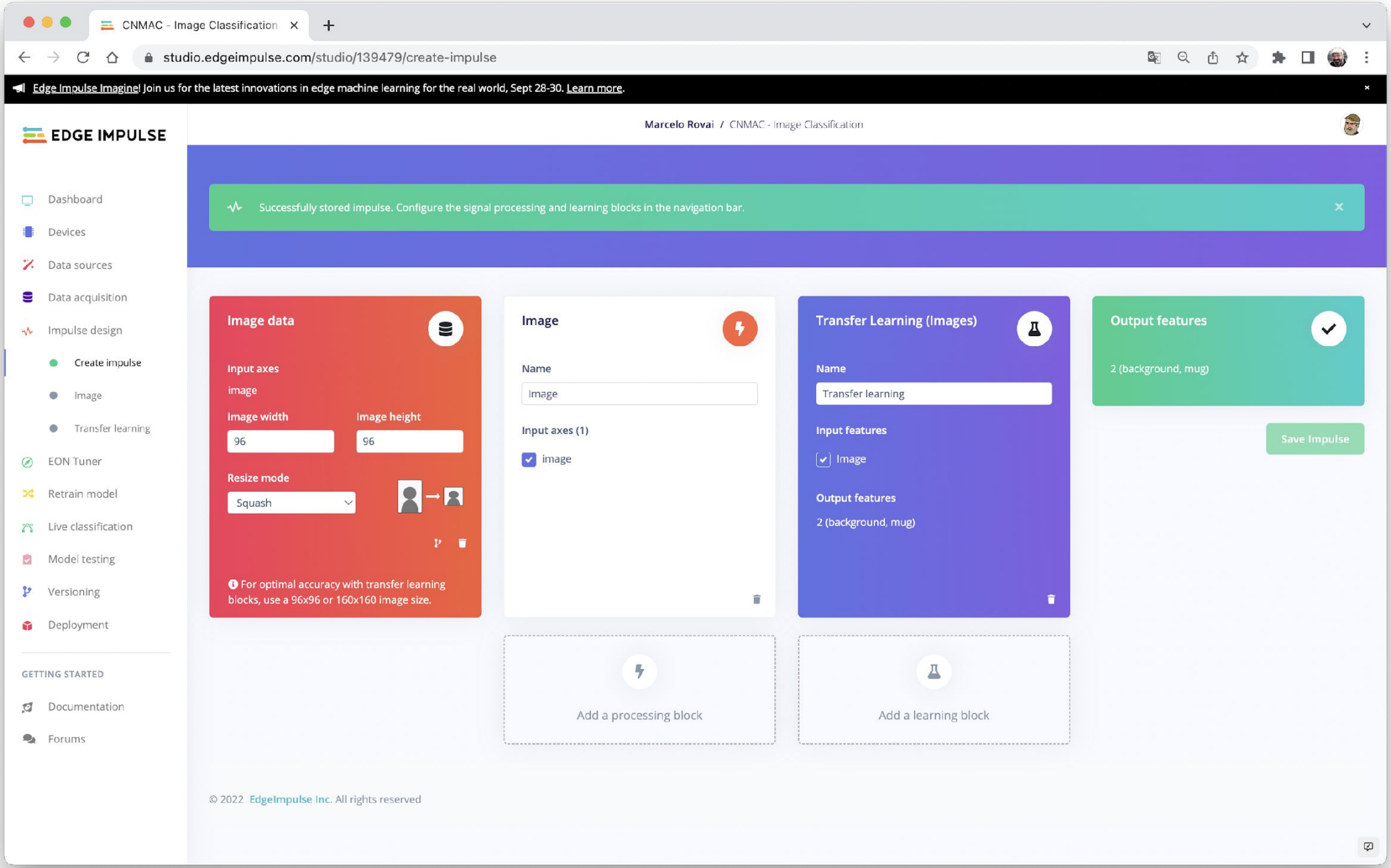
CNMAC - Image Classification
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GETTING STARTED
Documentation
Forums
Successfully stored impulse. Configure the signal processing and learning blocks in the navigation bar.
Image data
Input axes
image
Image width
96
Image height
96
Resize mode
Squash
For optimal accuracy with transfer learning blocks, use a 96x96 or 160x160 image size.
Image
Name
Image
Input axes (1)
image
Transfer Learning (Images)
Name
Transfer learning
Input features
Image
Output features
2 (background, mug)
Output features
2 (background, mug)
Save Impulse
Add a processing block
Add a learning block
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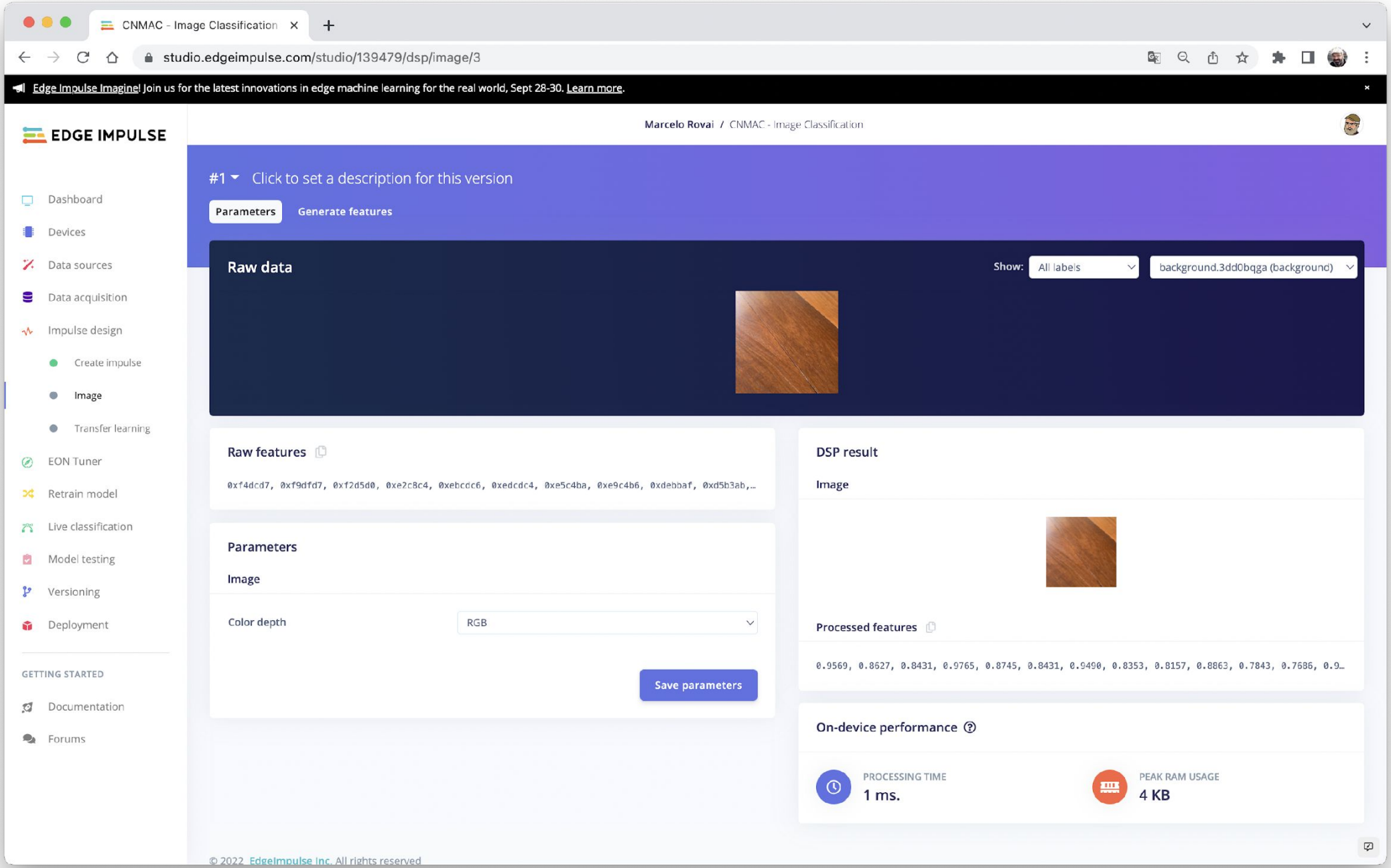
CNMAC - Image Classification
studio.edgeimpulse.com/studio/139479/dsp/image/3
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Create impulse
Image
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EON Tuner
Retrain model
Live classification
Model testing
Versioning
Deployment
GETTING STARTED
Documentation
Forums
#1 Click to set a description for this version
Parameters
Generate features
Raw data
Show: All labels
background.3dd0bqga (background)
Raw features
0xf4dcd7, 0xf9dfd7, 0xf2d5d0, 0xe2c8c4, 0xebcdc6, 0xedcdc4, 0xe5c4ba, 0xe9c4b6, 0xdebbaf, 0xd5b3ab,…
Parameters
Image
Color depth
RGB
Save parameters
DSP result
Image
Processed features
0.9569, 0.8627, 0.8431, 0.9765, 0.8745, 0.8431, 0.9490, 0.8353, 0.8157, 0.8863, 0.7843, 0.7686, 0.9…
On-device performance
PROCESSING TIME
1 ms.
PEAK RAM USAGE
4 KB
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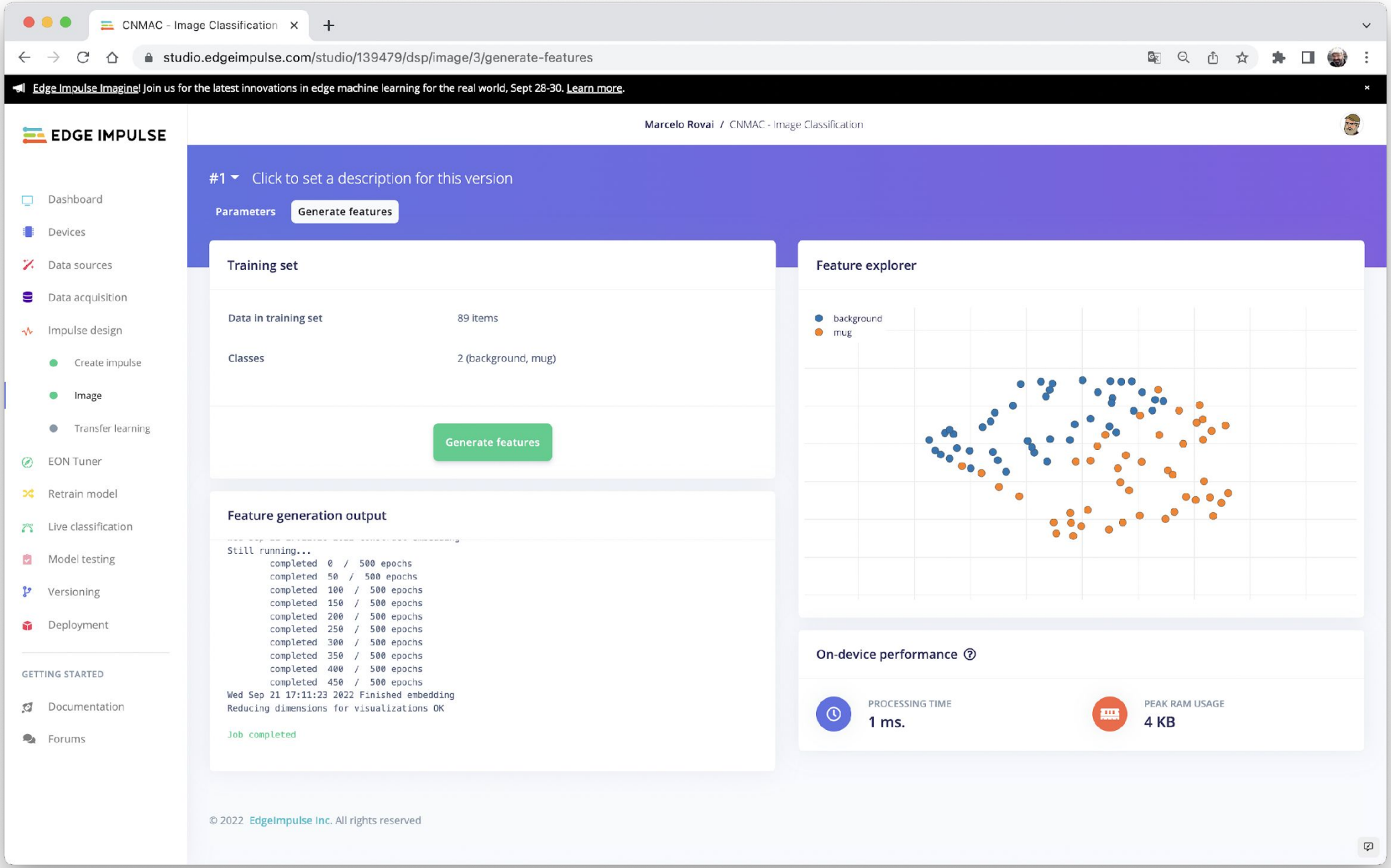
CNMAC - Image Classification
studio.edgeimpulse.com/studio/139479/dsp/image/3/generate-features
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Versioning
Deployment
GETTING STARTED
Documentation
Forums
#1 Click to set a description for this version
Parameters
Generate features
Training set
Data in training set
89 items
Classes
2 (background, mug)
Generate features
Feature generation output
Still running...
completed 0 / 500 epochs
completed 50 / 500 epochs
completed 100 / 500 epochs
completed 150 / 500 epochs
completed 200 / 500 epochs
completed 250 / 500 epochs
completed 300 / 500 epochs
completed 350 / 500 epochs
completed 400 / 500 epochs
completed 450 / 500 epochs
Wed Sep 21 17:11:23 2022 Finished embedding
Reducing dimensions for visualizations OK
Job completed
Feature explorer
background
mug
On-device performance
PROCESSING TIME
1 ms.
PEAK RAM USAGE
4 KB
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Model Design

MobileNetV1 96x96 0.1

Uses around 53.2K RAM and 101K ROM with default settings and optimizations. Works best with 96x96 input size. Supports both RGB and grayscale.

Model

MobileNetV2 96x96 0.35

Uses around 296.8K RAM and 575.2K ROM with default settings and optimizations. Works best with 96x96 input size. Supports both RGB and grayscale.

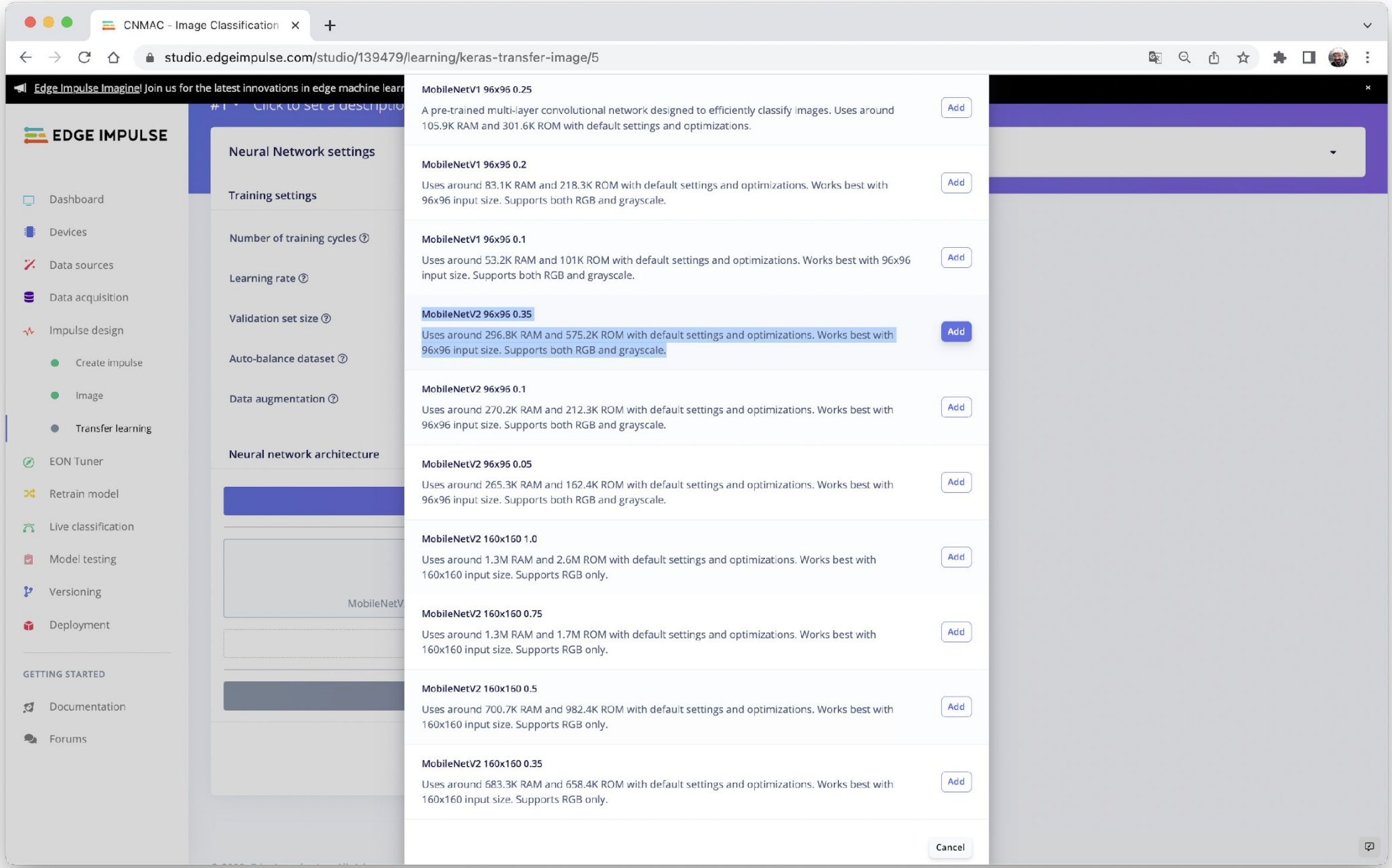
Image Size

MobileNetV2 96x96 0.1

Uses around 270.2K RAM and 212.3K ROM with default settings and optimizations. Works best with 96x96 input size. Supports both RGB and grayscale.

MobileNetV2 96x96 0.05 Alpha

Uses around 265.3K RAM and 162.4K ROM with default settings and optimizations. Works best with 96x96 input size. Supports both RGB and grayscale.


CNMAC - Image Classification
studio.edgeimpulse.com/studio/139479/learning/keras-transfer-image/5
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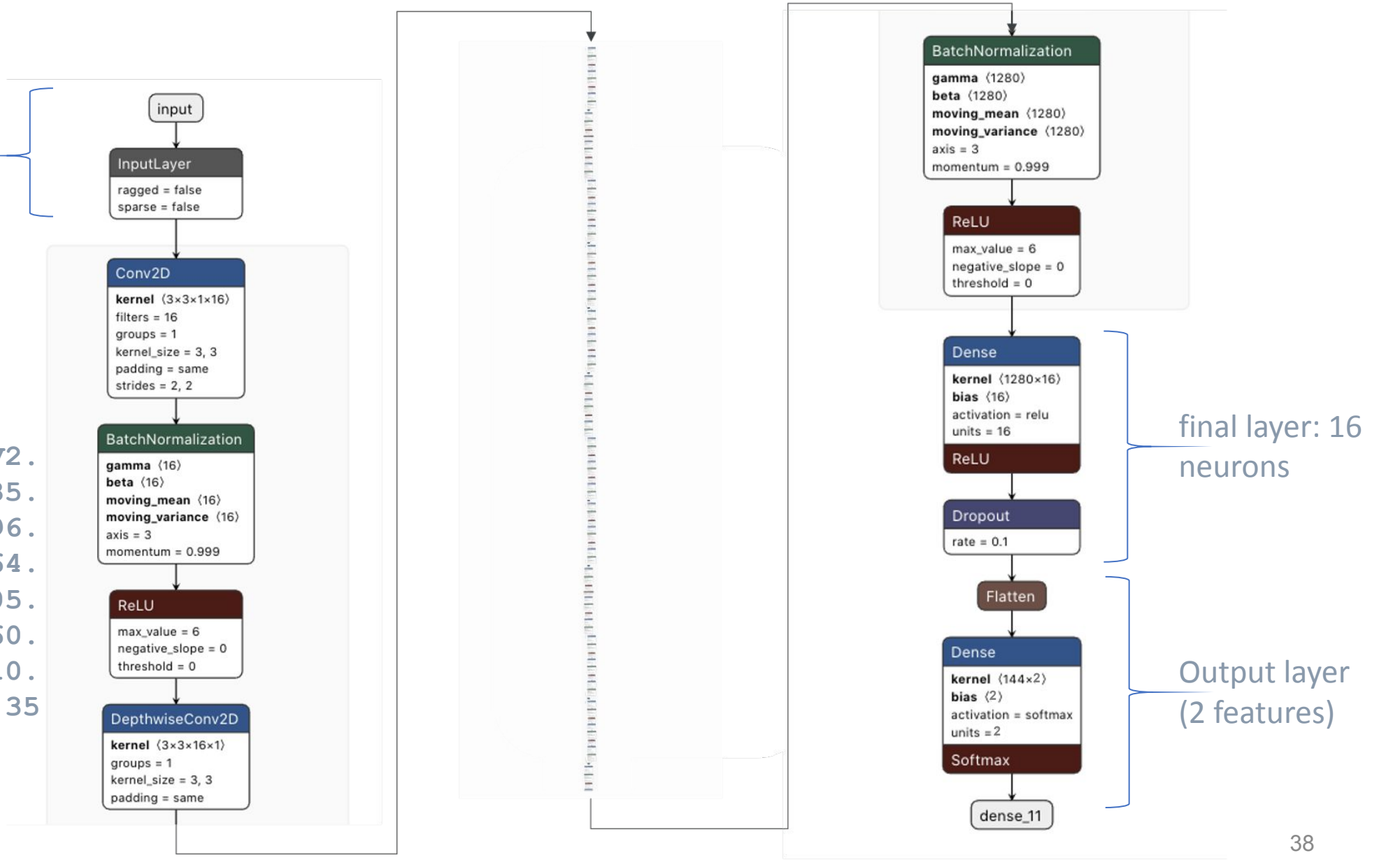
GETTING STARTED
Documentation
Forums
Neural Network settings
Training settings
Number of training cycles
Learning rate
Validation set size
Auto-balance dataset
Data augmentation
Neural network architecture
MobileNetV1 96x96 0.25
A pre-trained multi-layer convolutional network designed to efficiently classify images. Uses around 105.9K RAM and 301.6K ROM with default settings and optimizations.
Add
MobileNetV1 96x96 0.2
Uses around 83.1K RAM and 218.3K ROM with default settings and optimizations. Works best with 96x96 input size. Supports both RGB and grayscale.
Add
MobileNetV1 96x96 0.1
Uses around 53.2K RAM and 101K ROM with default settings and optimizations. Works best with 96x96 input size. Supports both RGB and grayscale.
Add
MobileNetV2 96x96 0.35
Uses around 296.8K RAM and 575.2K ROM with default settings and optimizations. Works best with 96x96 input size. Supports both RGB and grayscale.
Add
MobileNetV2 96x96 0.1
Uses around 270.2K RAM and 212.3K ROM with default settings and optimizations. Works best with 96x96 input size. Supports both RGB and grayscale.
Add
MobileNetV2 96x96 0.05
Uses around 265.3K RAM and 162.4K ROM with default settings and optimizations. Works best with 96x96 input size. Supports both RGB and grayscale.
Add
MobileNetV2 160x160 1.0
Uses around 1.3M RAM and 2.6M ROM with default settings and optimizations. Works best with 160x160 input size. Supports RGB only.
Add
MobileNetV2 160x160 0.75
Uses around 1.3M RAM and 1.7M ROM with default settings and optimizations. Works best with 160x160 input size. Supports RGB only.
Add
MobileNetV2 160x160 0.5
Uses around 700.7K RAM and 982.4K ROM with default settings and optimizations. Works best with 160x160 input size. Supports RGB only.
Add
MobileNetV2 160x160 0.35
Uses around 683.3K RAM and 658.4K ROM with default settings and optimizations. Works best with 160x160 input size. Supports RGB only.
Add
Cancel

MobileNetV2 96x96 0.35

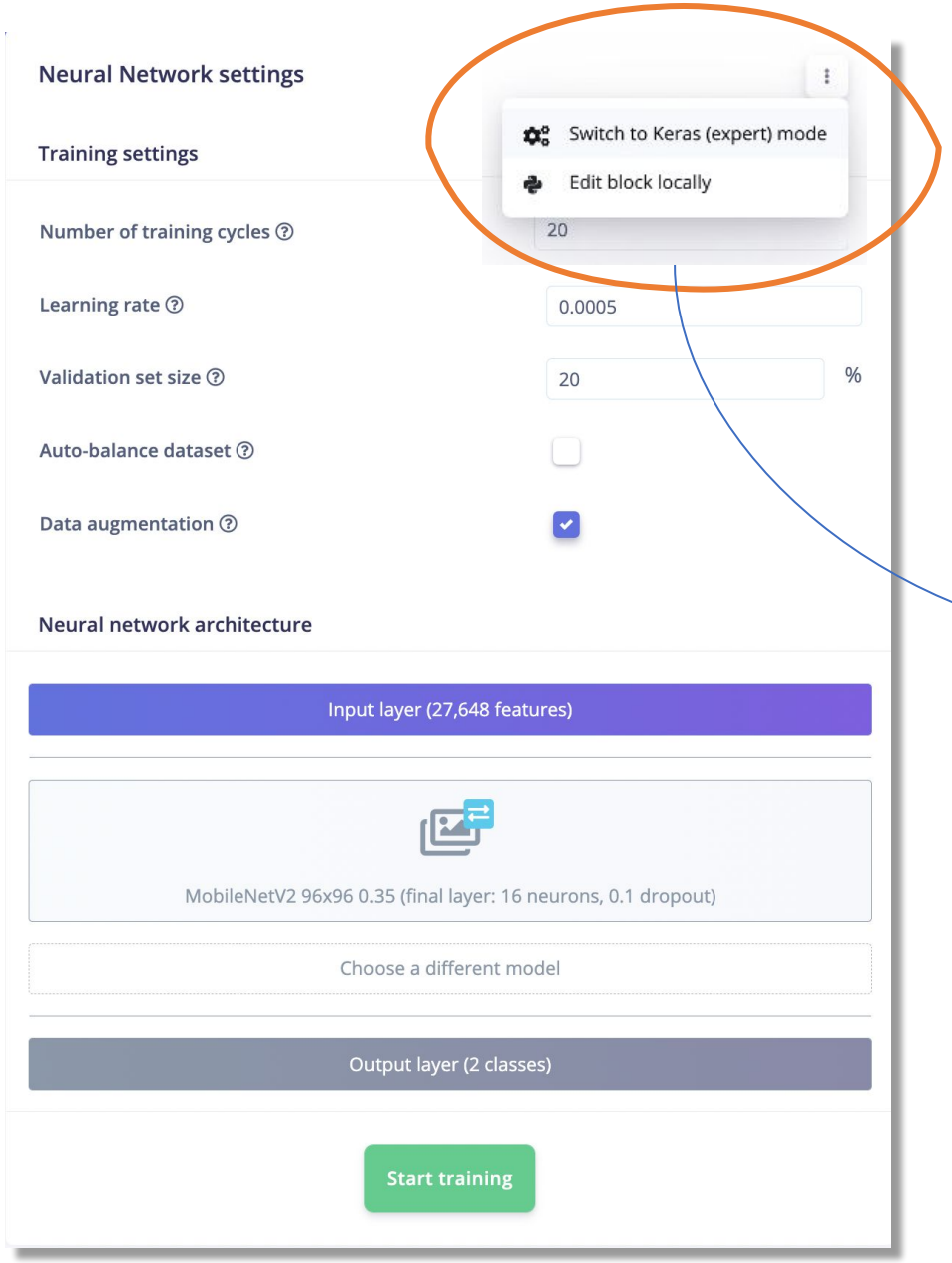
Input layer
INPUT_SHAPE =
(96, 96, 3)

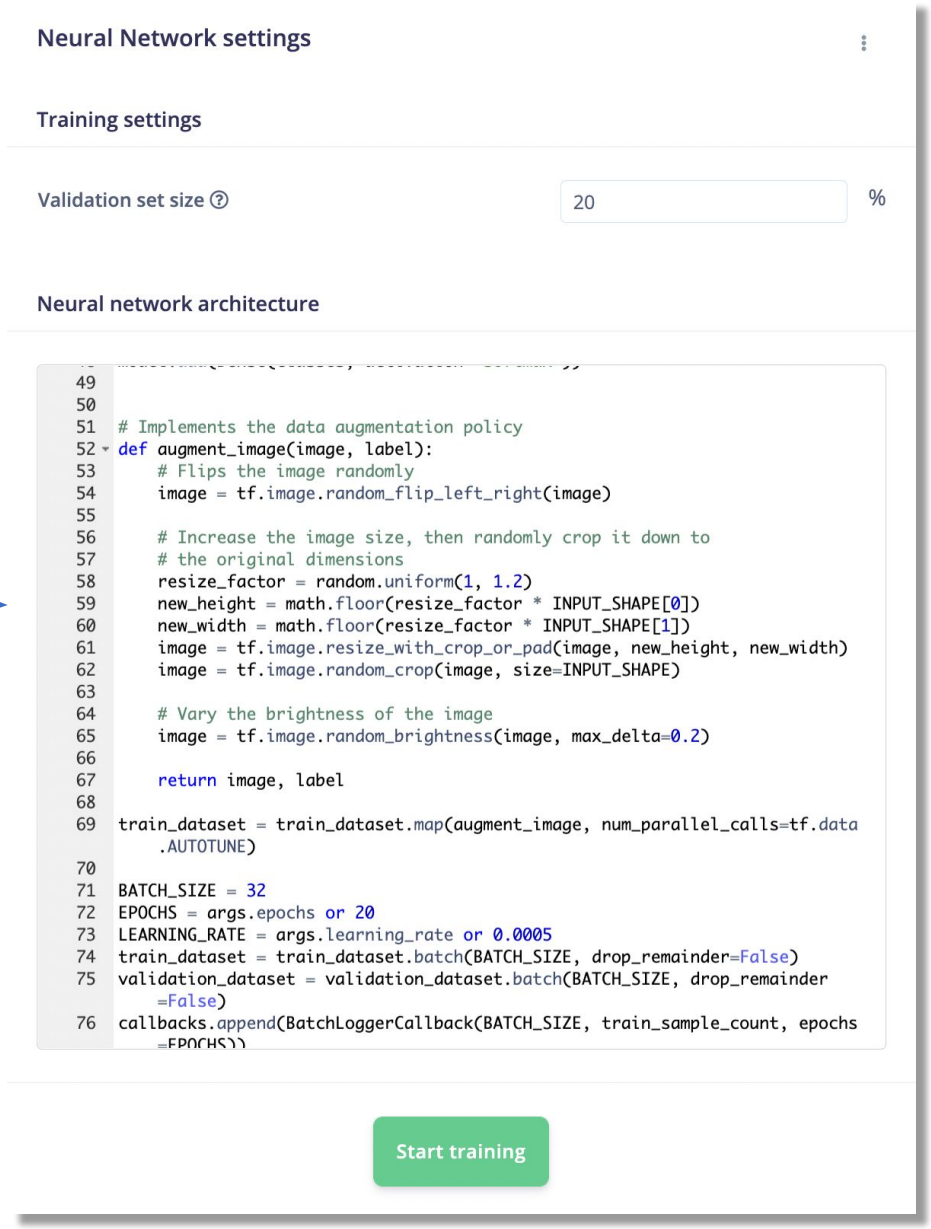
`MobileNetV2.`
`0_35.`
`96x96.`
`bsize_64.`
`lr_0_005.`
`epoch_260.`
`val_loss_3.10.`
`val_accuracy_0.35`

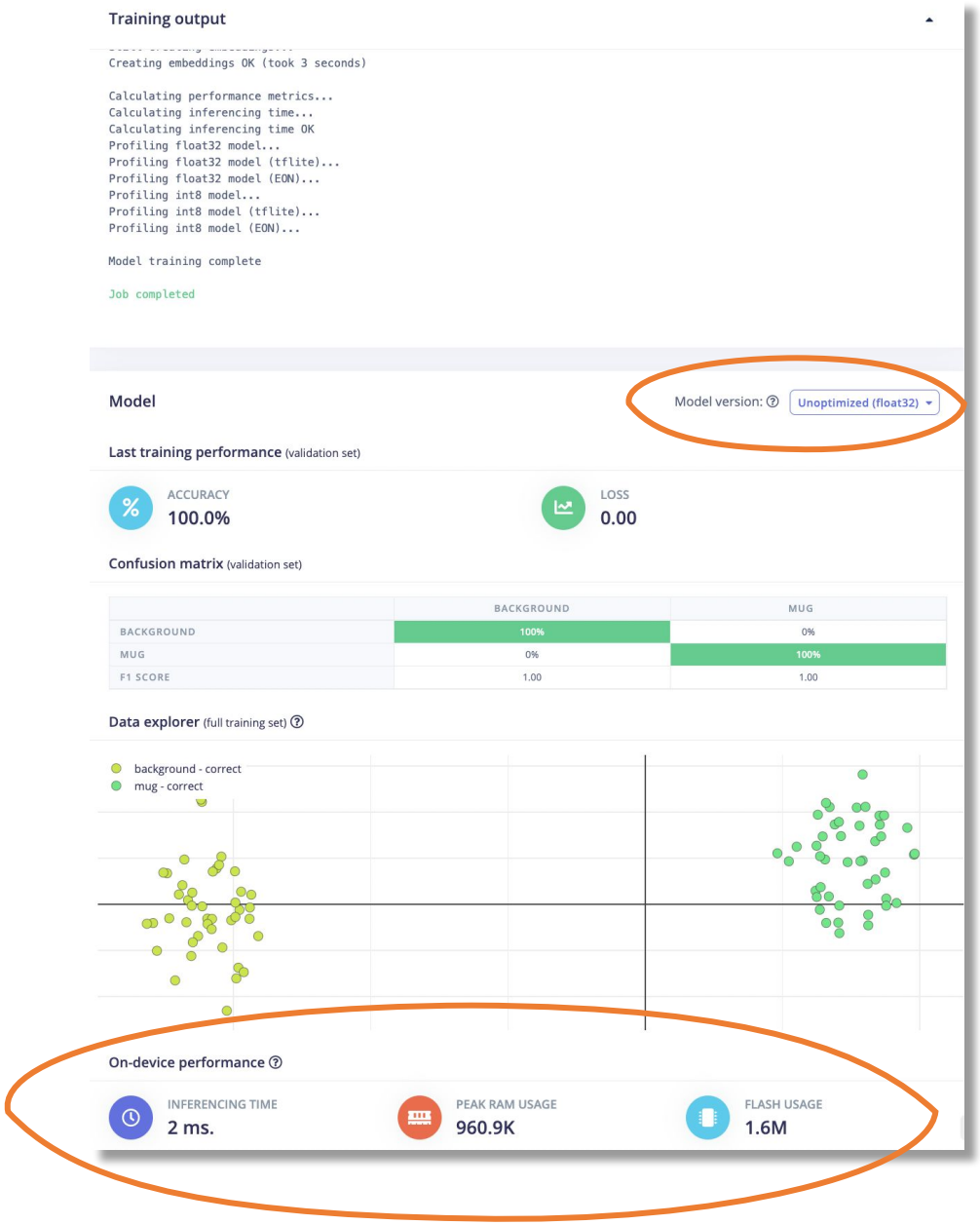


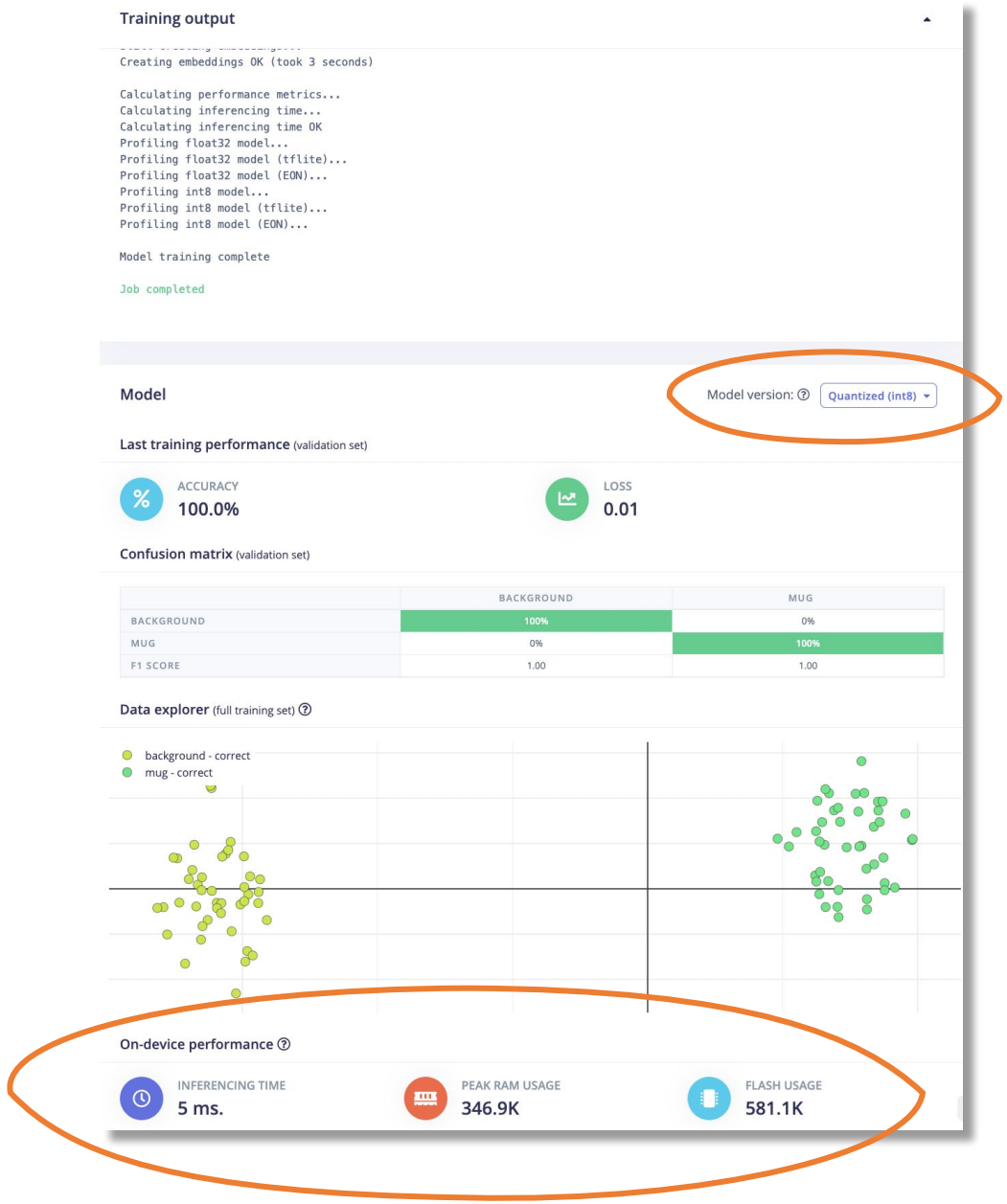
final layer: 16 neurons

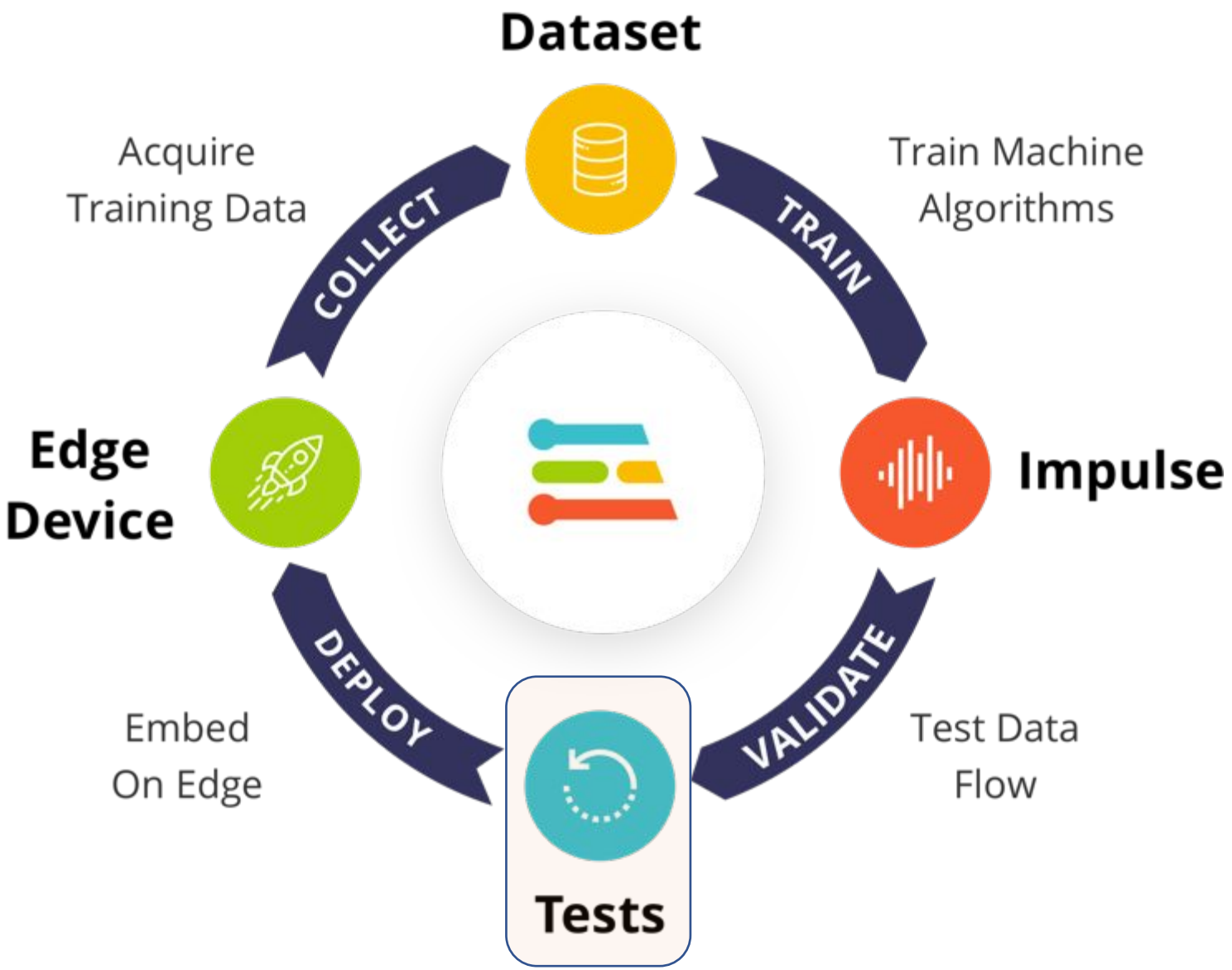
Output layer (2 features)


Neural Network settings
Training settings
Switch to Keras (expert) mode
Edit block locally
Number of training cycles
20
Learning rate
0.0005
Validation set size
20
%
Auto-balance dataset
Data augmentation
Neural network architecture
Input layer (27,648 features)
MobileNetV2 96x96 0.35 (final layer: 16 neurons, 0.1 dropout)
Choose a different model
Output layer (2 classes)
Start training

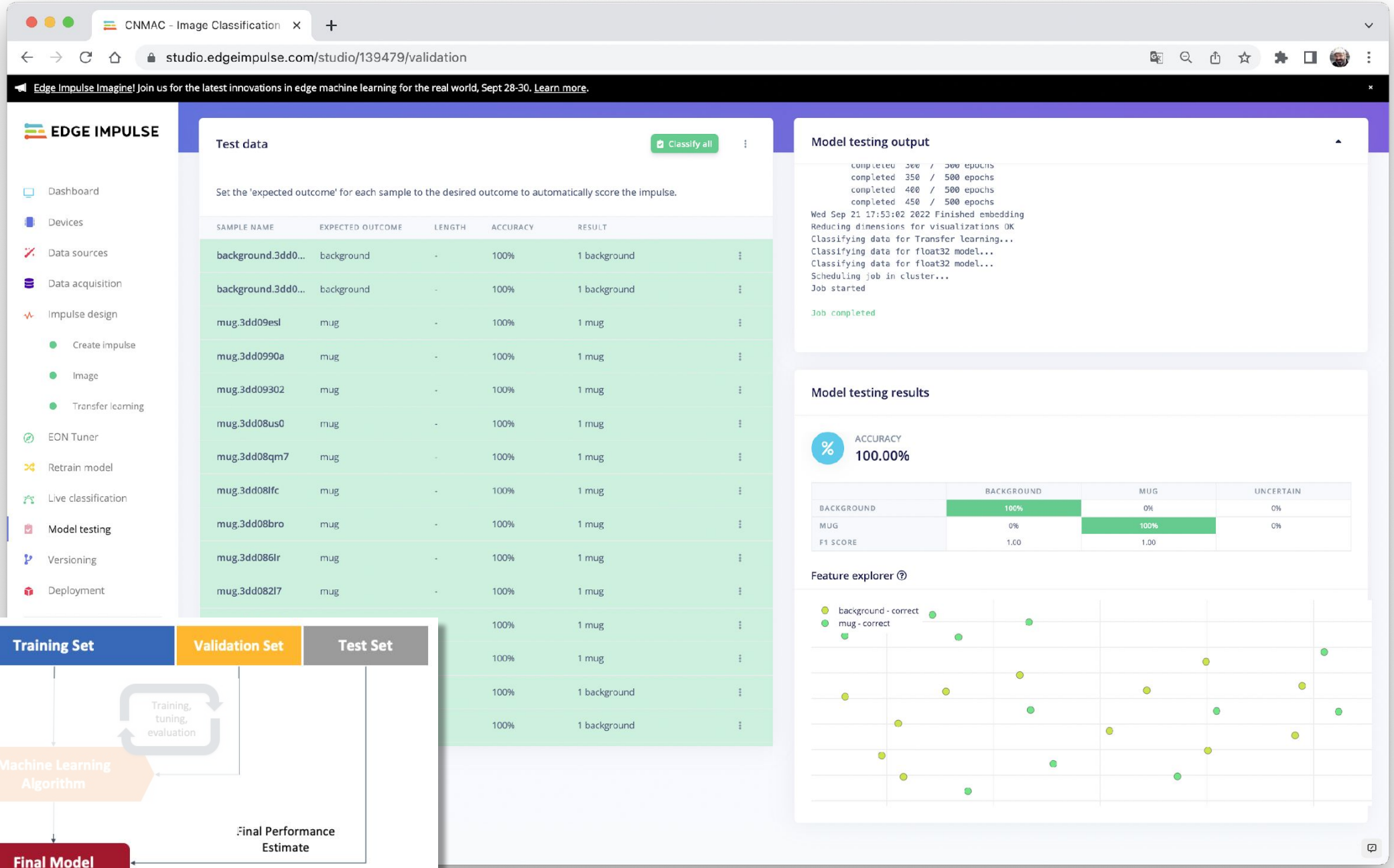

Neural Network settings
Training settings
Validation set size
20
%
Neural network architecture
49
50
51 # Implements the data augmentation policy
52 def augment_image(image, label):
53 # Flips the image randomly
54 image = tf.image.random_flip_left_right(image)
55
56 # Increase the image size, then randomly crop it down to
57 # the original dimensions
58 resize_factor = random.uniform(1, 1.2)
59 new_height = math.floor(resize_factor * INPUT_SHAPE[0])
60 new_width = math.floor(resize_factor * INPUT_SHAPE[1])
61 image = tf.image.resize_with_crop_or_pad(image, new_height, new_width)
62 image = tf.image.random_crop(image, size=INPUT_SHAPE)
63
64 # Vary the brightness of the image
65 image = tf.image.random_brightness(image, max_delta=0.2)
66
67 return image, label
68
69 train_dataset = train_dataset.map(augment_image, num_parallel_calls=tf.data
.AUTOTUNE)
70
71 BATCH_SIZE = 32
72 EPOCHS = args.epochs or 20
73 LEARNING_RATE = args.learning_rate or 0.0005
74 train_dataset = train_dataset.batch(BATCH_SIZE, drop_remainder=False)
75 validation_dataset = validation_dataset.batch(BATCH_SIZE, drop_remainder
=False)
76 callbacks.append(BatchLoggerCallback(BATCH_SIZE, train_sample_count, epochs
Start training


Training output
Creating embeddings OK (took 3 seconds)
Calculating performance metrics...
Calculating inferencing time...
Calculating inferencing time OK
Profiling float32 model...
Profiling float32 model (tflite)...
Profiling float32 model (EON)...
Profiling int8 model...
Profiling int8 model (tflite)...
Profiling int8 model (EON)...
Model training complete
Job completed
Model
Model version: Unoptimized (float32)
Last training performance (validation set)
ACCURACY
100.0%
LOSS
0.00
Confusion matrix (validation set)
BACKGROUND
MUG
BACKGROUND 100% 0%
MUG 0% 100%
F1 SCORE 1.00 1.00
Data explorer (full training set)
background - correct
mug - correct
On-device performance
INFERENCING TIME
2 ms.
PEAK RAM USAGE
960.9K
FLASH USAGE
1.6M


Training output
Creating embeddings OK (took 3 seconds)
Calculating performance metrics...
Calculating inferencing time...
Calculating inferencing time OK
Profiling float32 model...
Profiling float32 model (tflite)...
Profiling float32 model (EON)...
Profiling int8 model...
Profiling int8 model (tflite)...
Profiling int8 model (EON)...
Model training complete
Job completed
Model
Model version: Quantized (int8)
Last training performance (validation set)
ACCURACY
100.0%
LOSS
0.01
Confusion matrix (validation set)
BACKGROUND
MUG
BACKGROUND 100% 0%
MUG 0% 100%
F1 SCORE 1.00 1.00
Data explorer (full training set)
background - correct
mug - correct
On-device performance
INFERENCING TIME
5 ms.
PEAK RAM USAGE
346.9K
FLASH USAGE
581.1K



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


CNMAC - Image Classification
studio.edgeimpulse.com/studio/139479/validation
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Versioning
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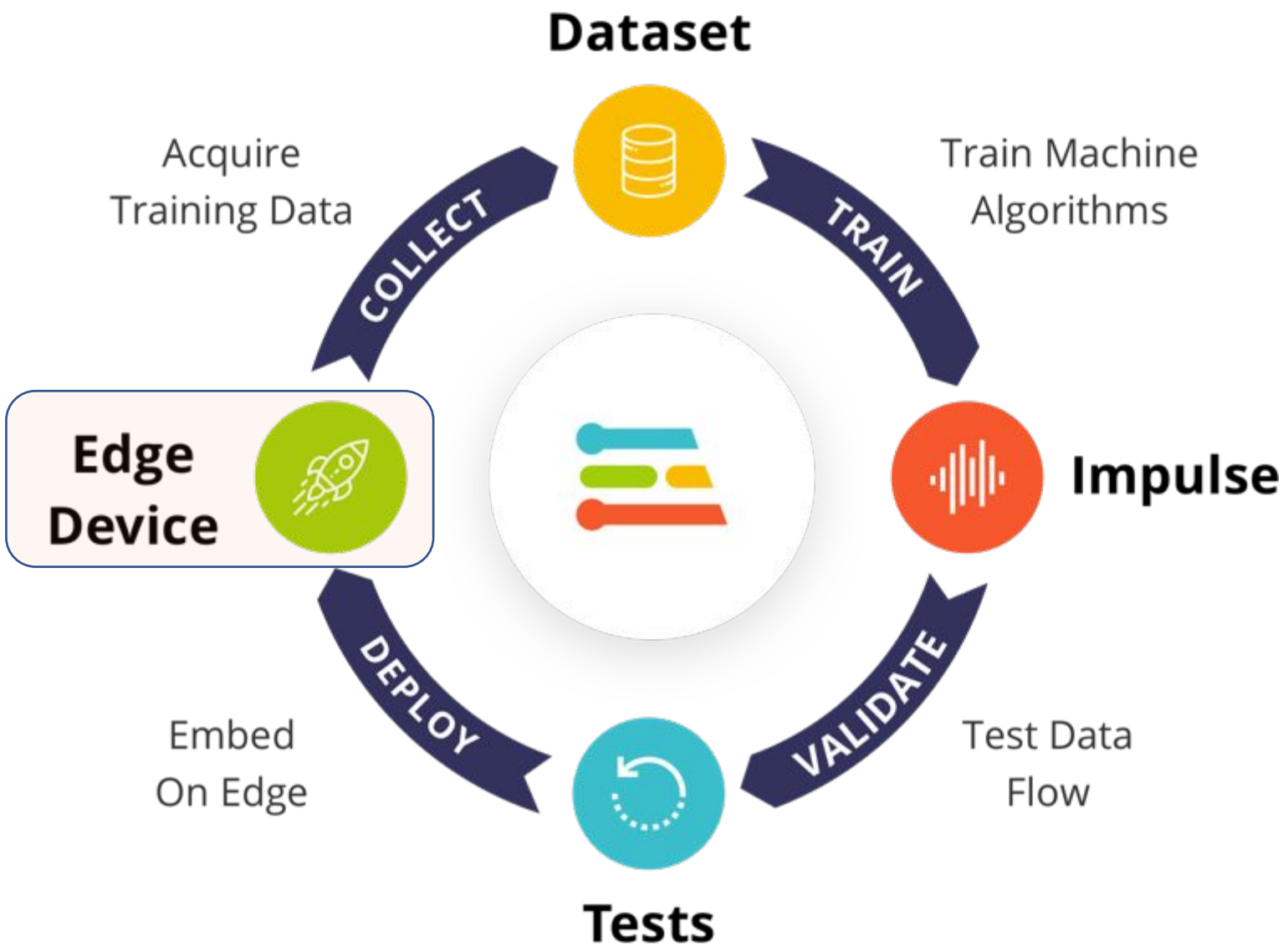
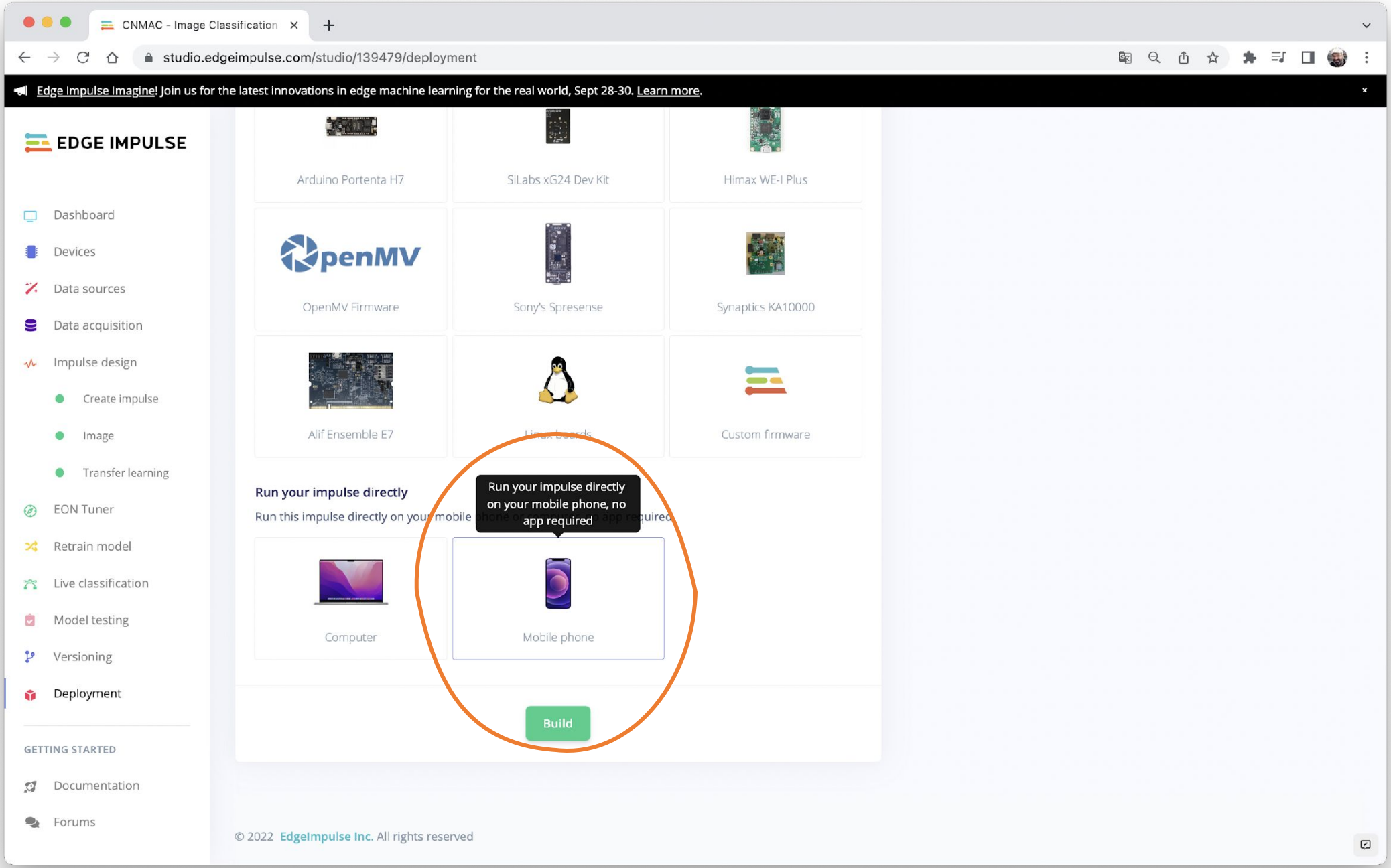
Test data
Classify all
Set the 'expected outcome' for each sample to the desired outcome to automatically score the impulse.
SAMPLE NAME
EXPECTED OUTCOME
LENGTH
ACCURACY
RESULT
background.3dd0... background - 100% 1 background
background.3dd0... background - 100% 1 background
mug.3dd09esl mug - 100% 1 mug
mug.3dd0990a mug - 100% 1 mug
mug.3dd09302 mug - 100% 1 mug
mug.3dd08us0 mug - 100% 1 mug
mug.3dd08qm7 mug - 100% 1 mug
mug.3dd08lfc mug - 100% 1 mug
mug.3dd08bro mug - 100% 1 mug
mug.3dd086lr mug - 100% 1 mug
mug.3dd082l7 mug - 100% 1 mug
100% 1 mug
100% 1 mug
100% 1 background
100% 1 background
Model testing output
completed 350 / 500 epochs
completed 400 / 500 epochs
completed 450 / 500 epochs
Wed Sep 21 17:53:02 2022 Finished embedding
Reducing dimensions for visualizations OK
Classifying data for Transfer learning...
Classifying data for float32 model...
Classifying data for float32 model...
Scheduling job in cluster...
Job started
Job completed
Model testing results
ACCURACY
100.00%
BACKGROUND MUG UNCERTAIN
BACKGROUND 100% 0% 0%
MUG 0% 100% 0%
F1 SCORE 1.00 1.00
Feature explorer
background - correct
mug - correct
Training Set
Validation Set
Test Set
Training, tuning, evaluation
Machine Learning Algorithm
Final Performance Estimate
Final Model



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


CNMAC - Image Classification
studio.edgeimpulse.com/studio/139479/deployment
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Arduino Portenta H7
SiLabs xG24 Dev Kit
Himax WE-I Plus
OpenMV Firmware
Sony's Spresense
Synaptics KA10000
Alif Ensemble E7
Custom firmware
Run your impulse directly
Run this impulse directly on your mobile phone, no app required
Run your impulse directly on your mobile phone, no app required
Computer
Mobile phone
Build
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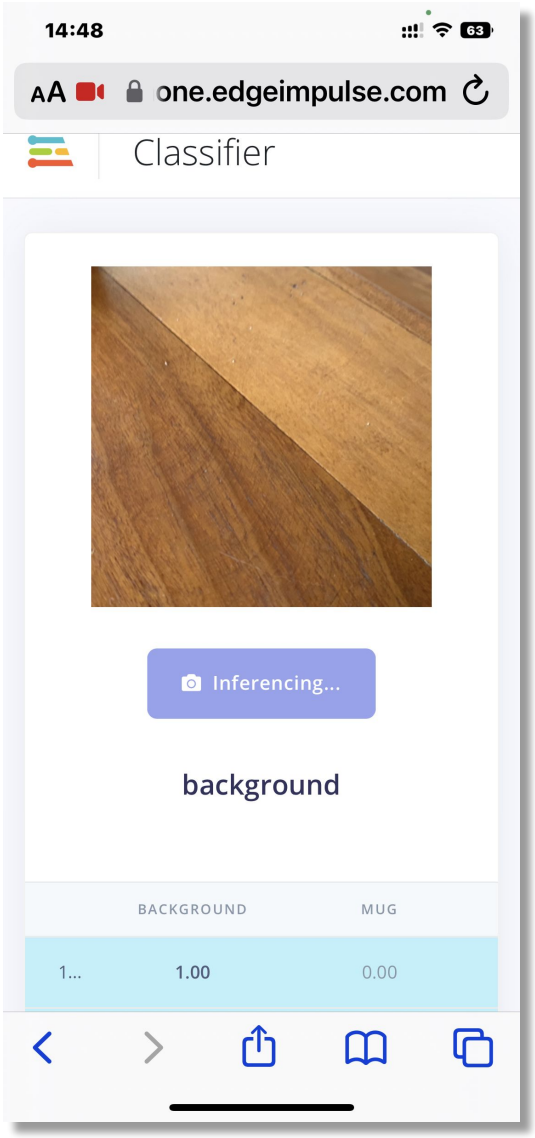
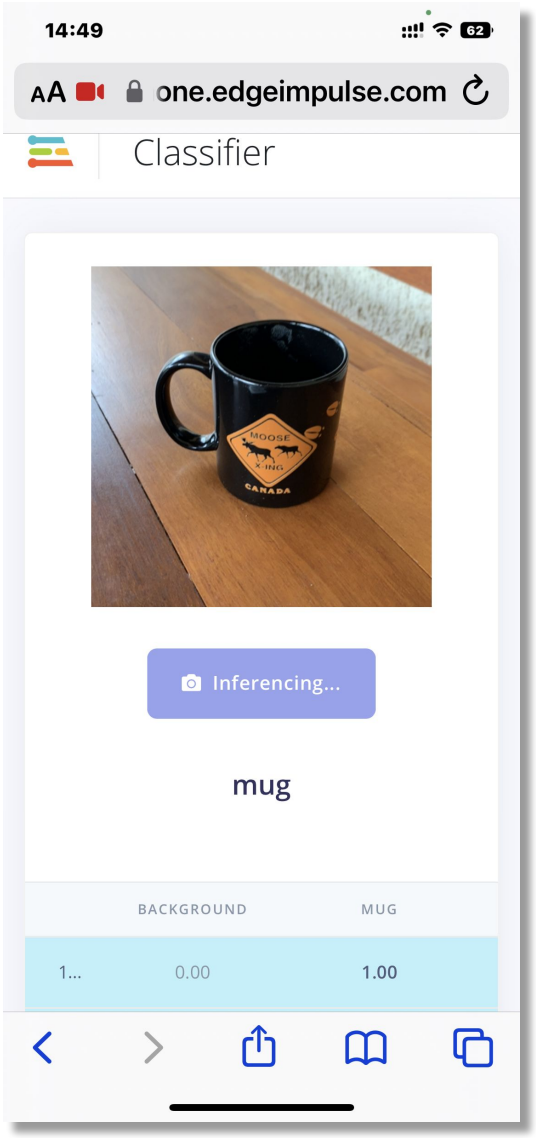
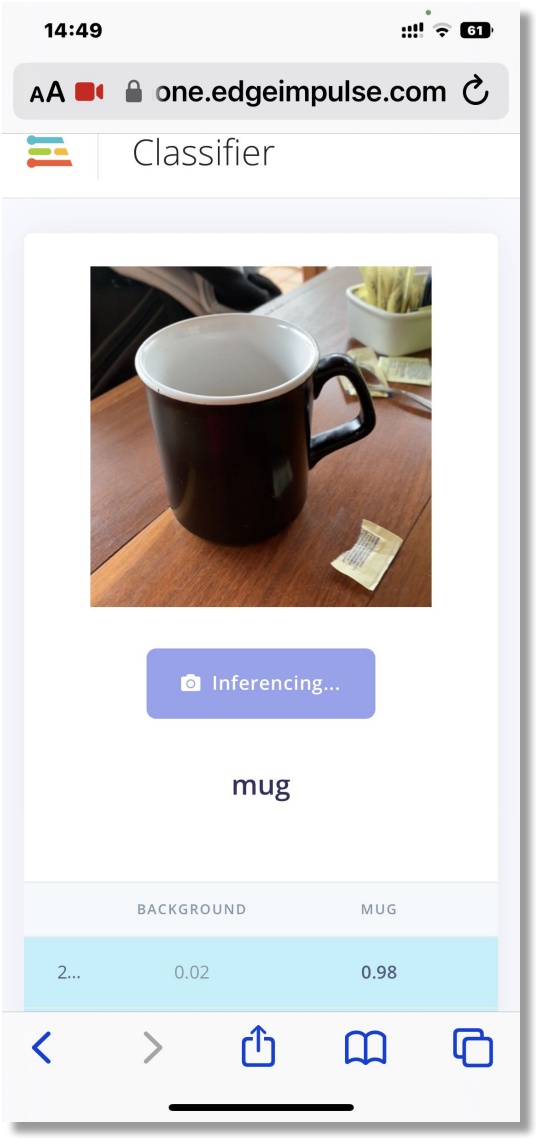
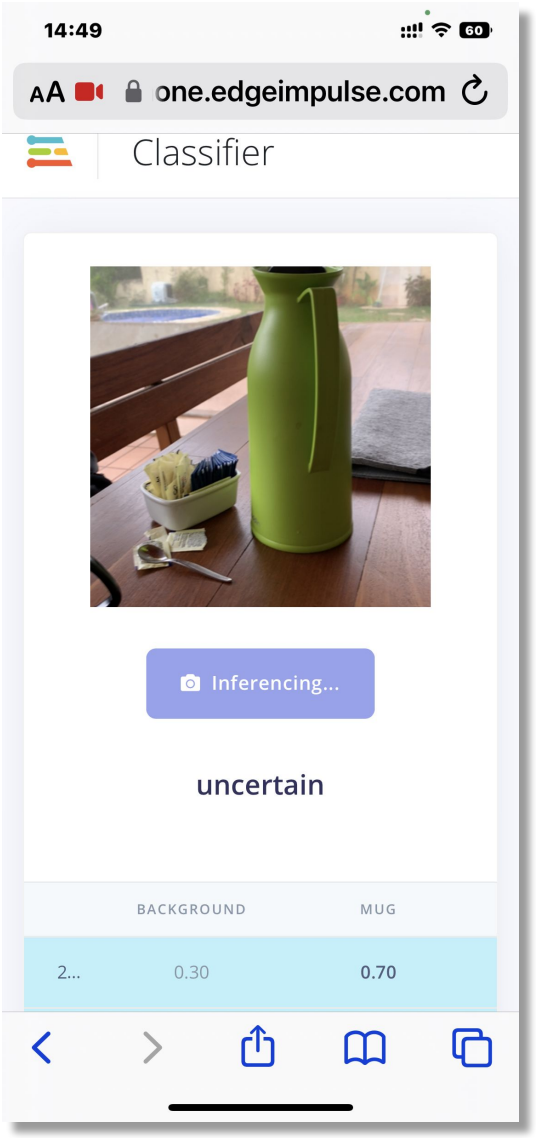

14:48
one.edgeimpulse.com
Classifier
Inferencing...
background
BACKGROUND
MUG
1...
1.00
0.00


14:49
one.edgeimpulse.com
Classifier
Inferencing...
mug
BACKGROUND
MUG
1...
0.00
1.00


14:49
one.edgeimpulse.com
Classifier
Inferencing...
mug
BACKGROUND
MUG
2...
0.02
0.98


14:49
one.edgeimpulse.com
Classifier
Inferencing...
uncertain
BACKGROUND
MUG
2...
0.30
0.70

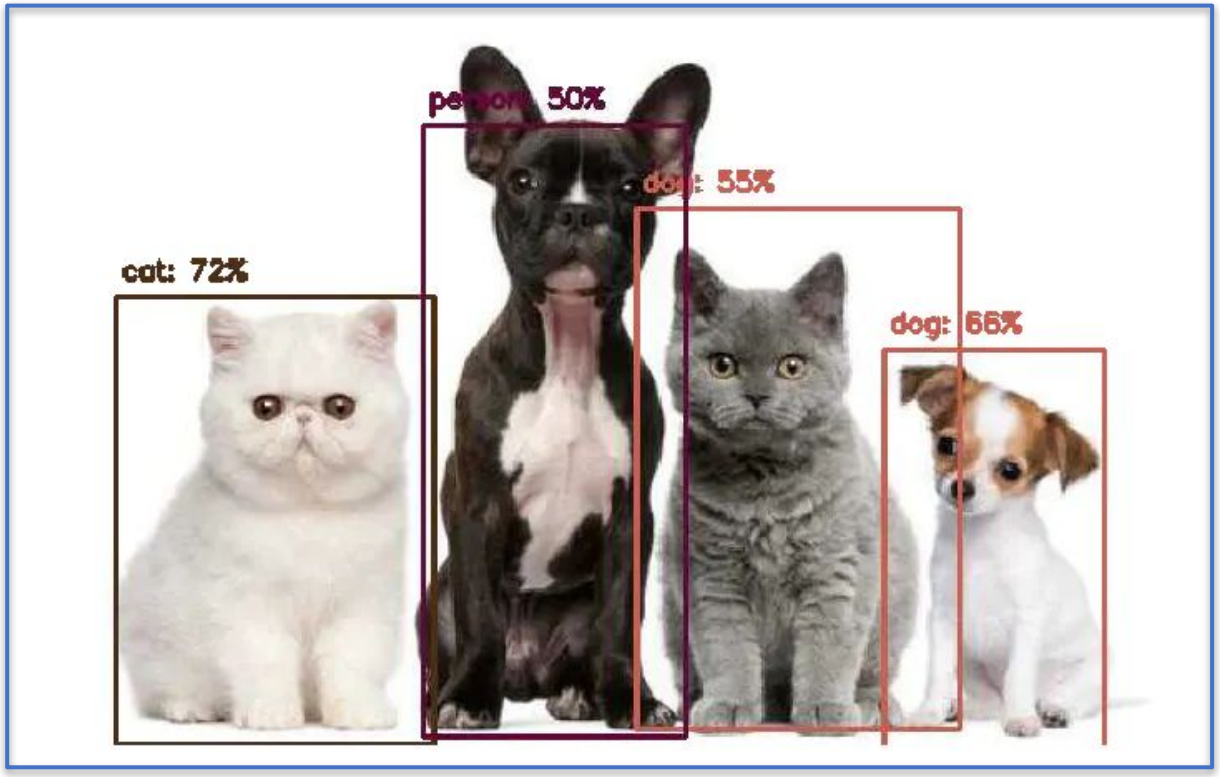
Computer Vision Main Types

Image Classification
(**Multi-Class** Classification)

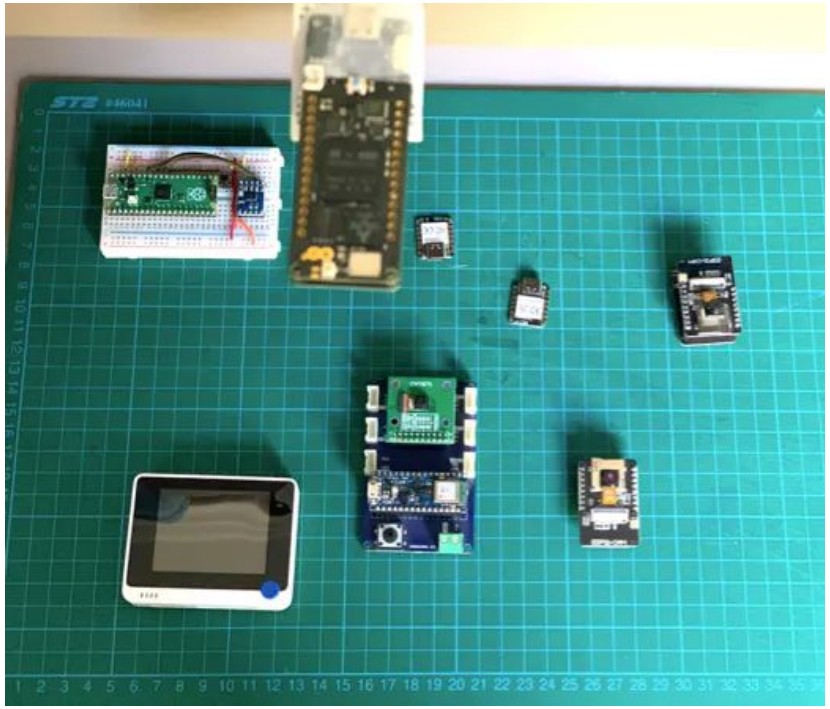
Cat: 70%

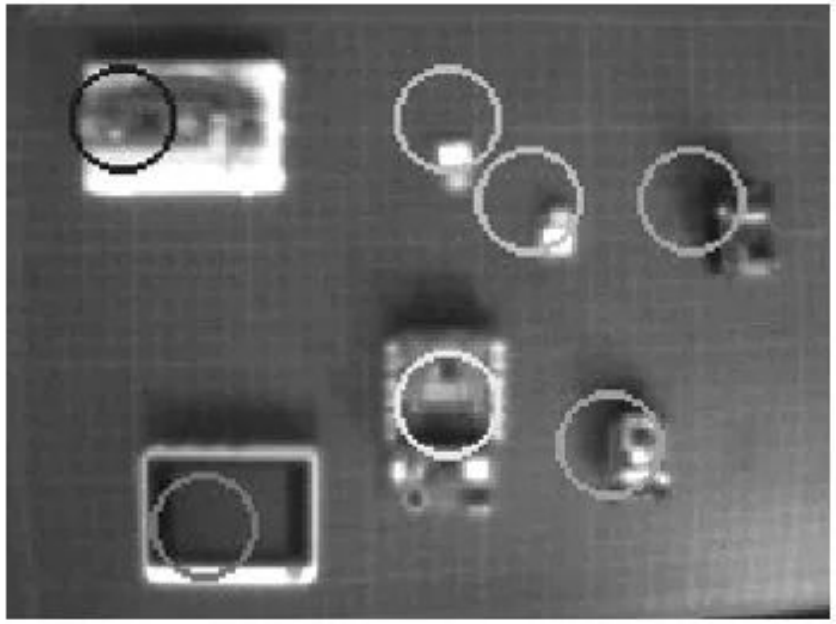
Dog: 80%

Object Detection
Multi-Label Classification + Object **Localization**



Detecting Objects using TinyML (FOMO)

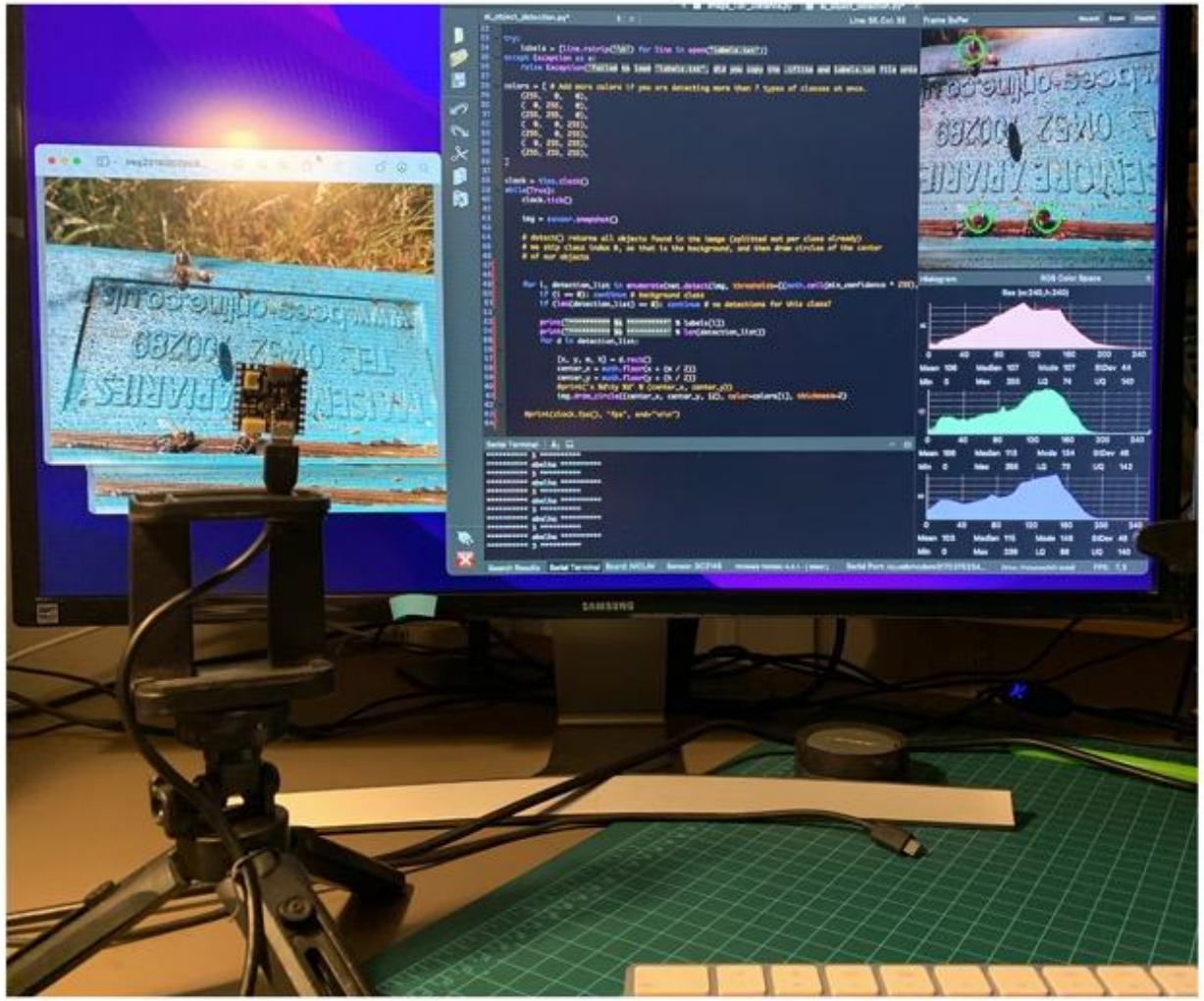


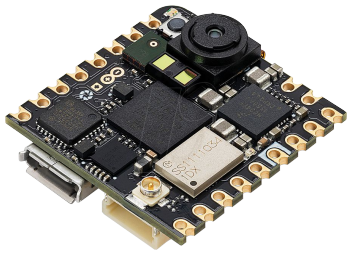


```
********** espcam **********
x 70    y 150
x 130   y 170
********** nano **********
x 70    y 110
********** pico **********
x 150   y 30
********** wio **********
x 50    y 50
********** xiao **********
x 150   y 110
x 130   y 130
6.97512 fps
```

[EdgeAI made simple - Exploring Image Processing (Object Detection) on microcontrollers with Arduino Portenta, Edge Impulse FOMO, and OpenMV]

Detecting Objects using TinyML (FOMO)





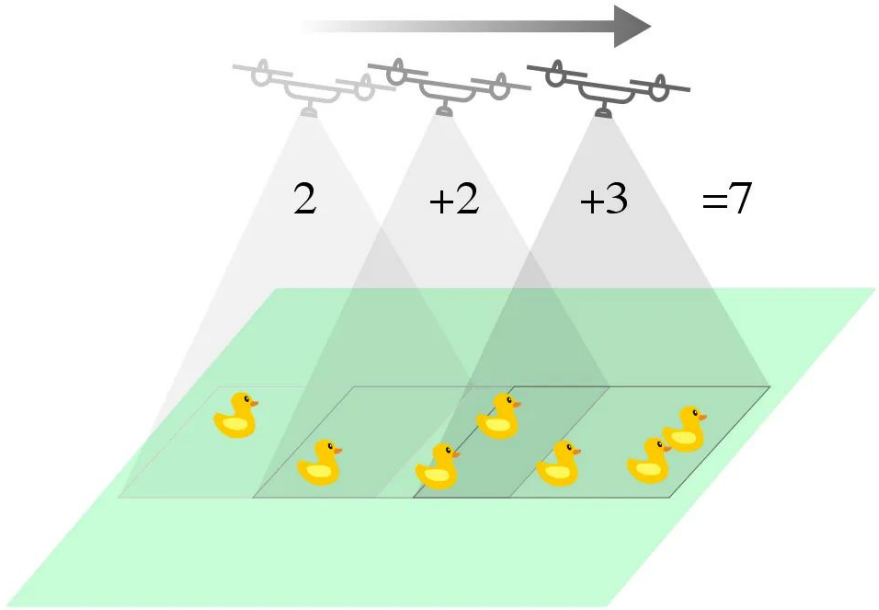
OpenMV

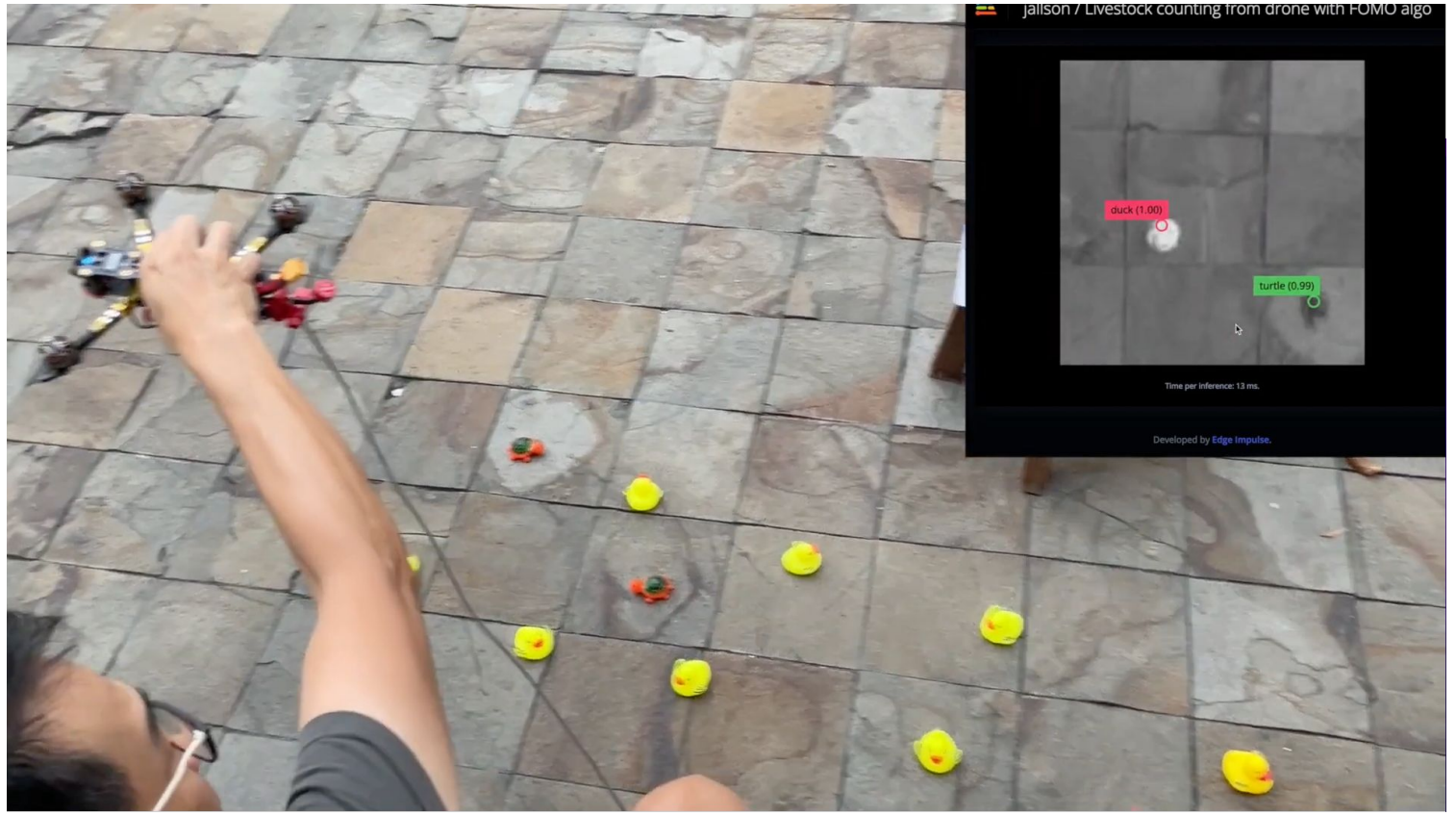
MicroPython

EDGE IMPULSE

https://youtu.be/MYuc3QISquw

Livestock / Wildlife Counting from Drone with FOMO





https://www.hackster.io/jallsonsuryo/livestock-wildlife-counting-from-drone-with-fomo-algorithm-a2f734

To learn more about Edge AI

- UNIFEI - IESTI01 TinyML - Machine Learning for Embedding Devices
- Professional Certificate in Tiny Machine Learning (TinyML) – edX/Harvard
- Introduction to Embedded Machine Learning - Coursera/Edge Impulse
- Computer Vision with Embedded Machine Learning - Coursera/Edge Impulse
- "Deep Learning with Python" book by François Chollet
- "TinyML" book by Pete Warden, Daniel Situnayake
- "TinyML Cookbook" by Gian Marco Iodice
- "AI at the Edge" book by Daniel Situnayake, Jenny Plunkett

Thanks

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