CEC Continuing Education Center

DesignNews

Developing Machine-Learning Applications on the Raspberry Pi Pico

DAY 4 : Designing and Testing a Machine-Learning Model

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THE SPEAKER

Jacob Beningo

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Beningo Embedded Group - President

Focus: Embedded Software Consulting

An independent consultant who specializes in the design of real-time, microcontroller based embedded software.
He has published two books:

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

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

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Course Sessions

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

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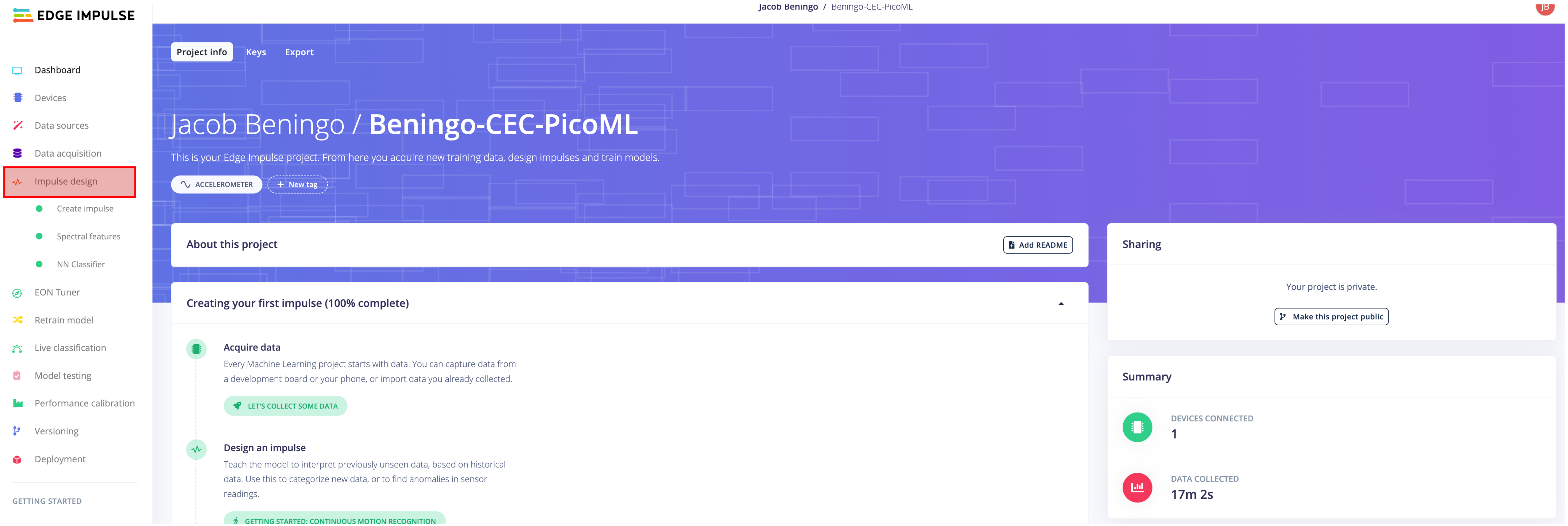
1 Designing the ML Model

Designing the ML Model – Impulse Designer



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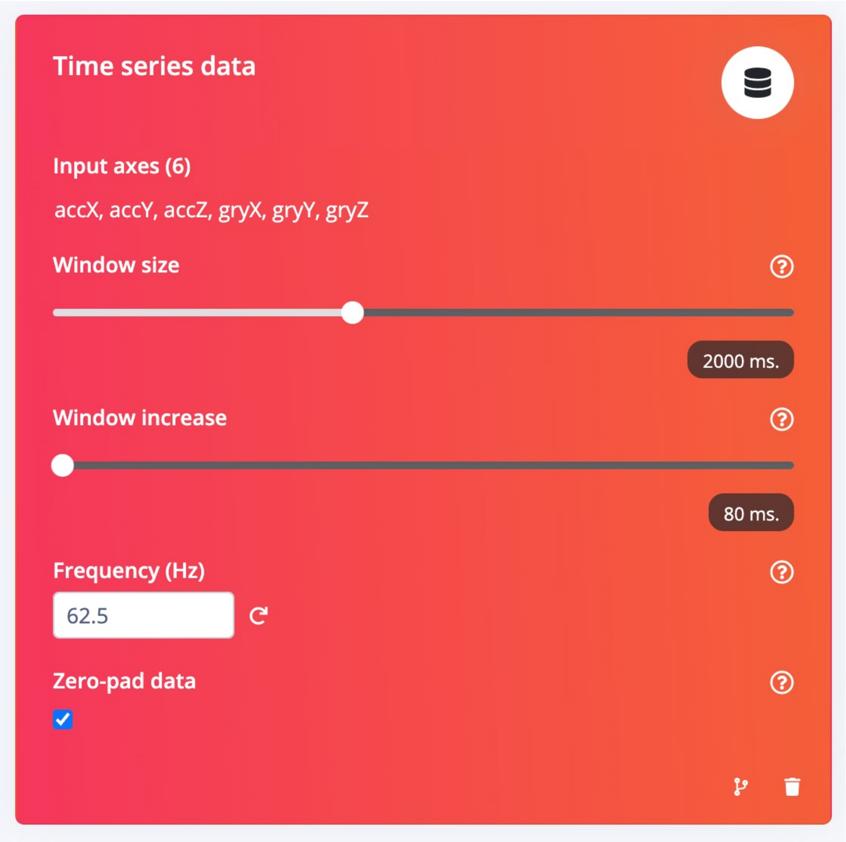
Designing the ML Model – Impulse Designer



- **Window Size** – the size of the data that we will slide across to analyze data features
- **Window Increase** – the size of the window steps
- **Zero-pad** – If the sample data set is smaller than the window, pad remaining space with 0's.

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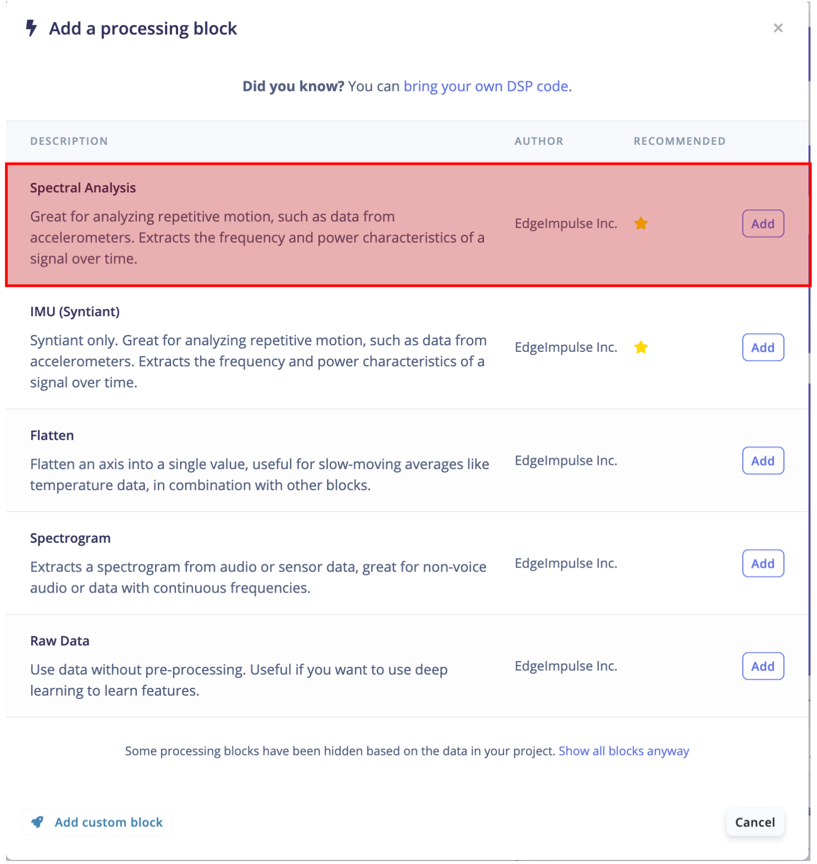
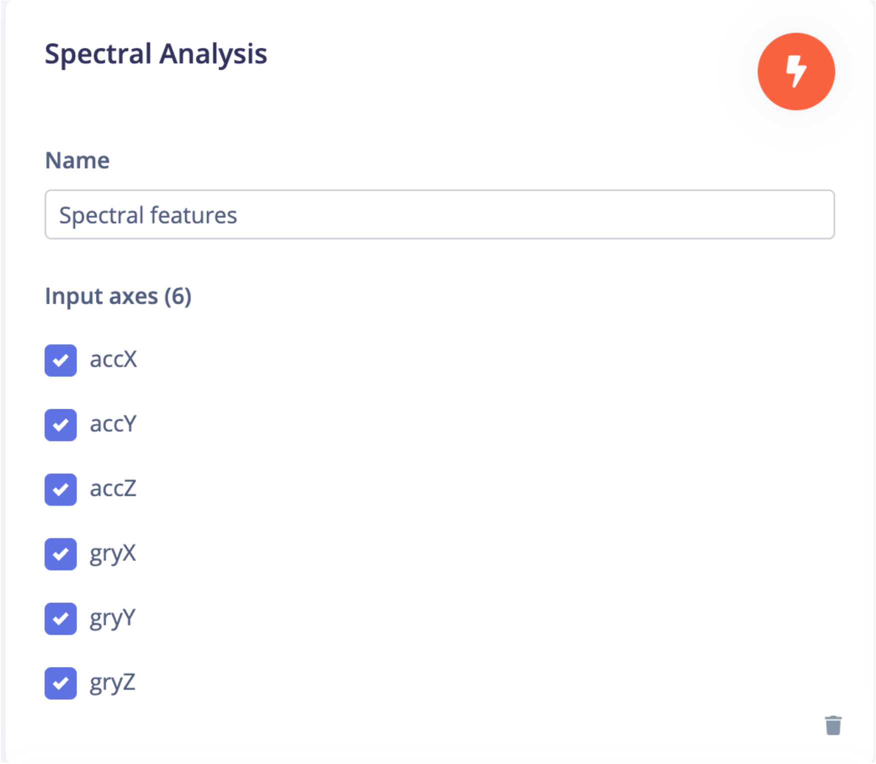
Designing the ML Model – Impulse Designer





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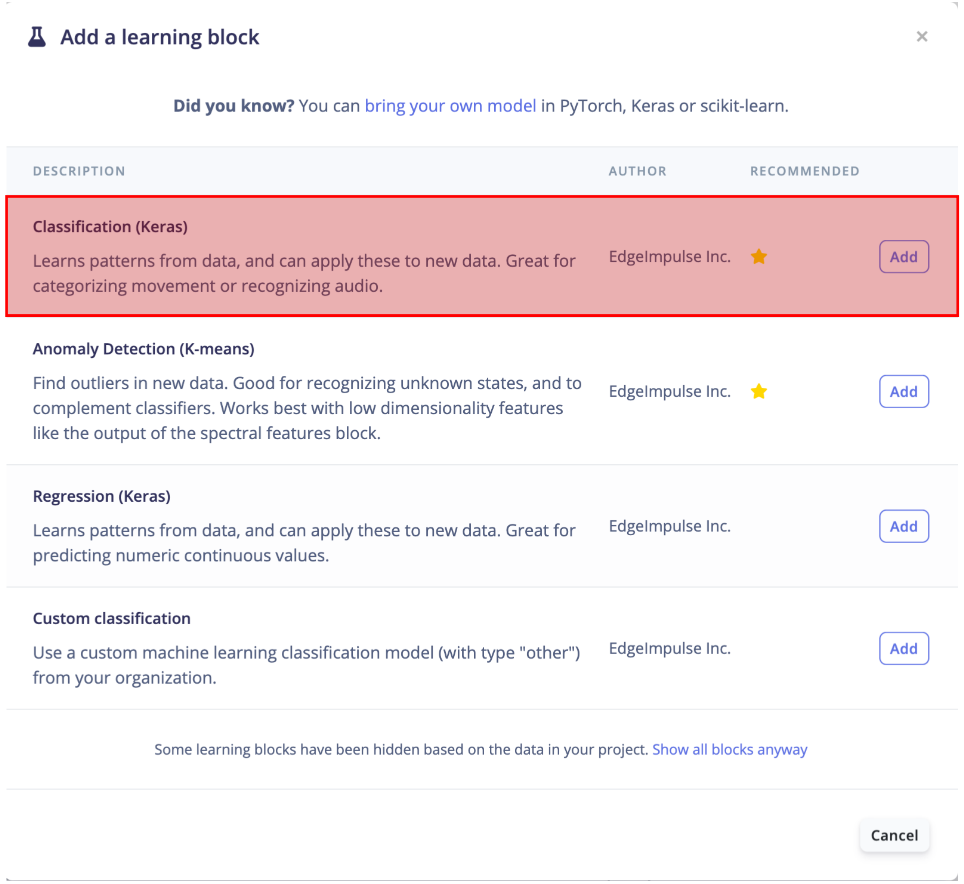
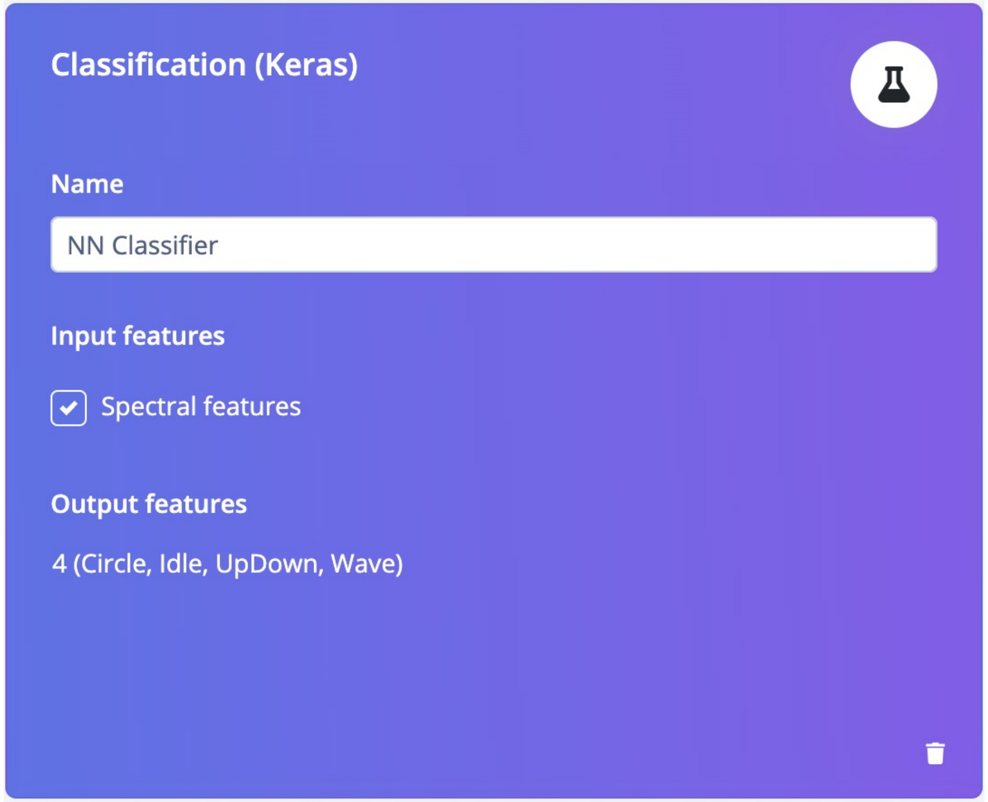
Designing the ML Model – Impulse Designer





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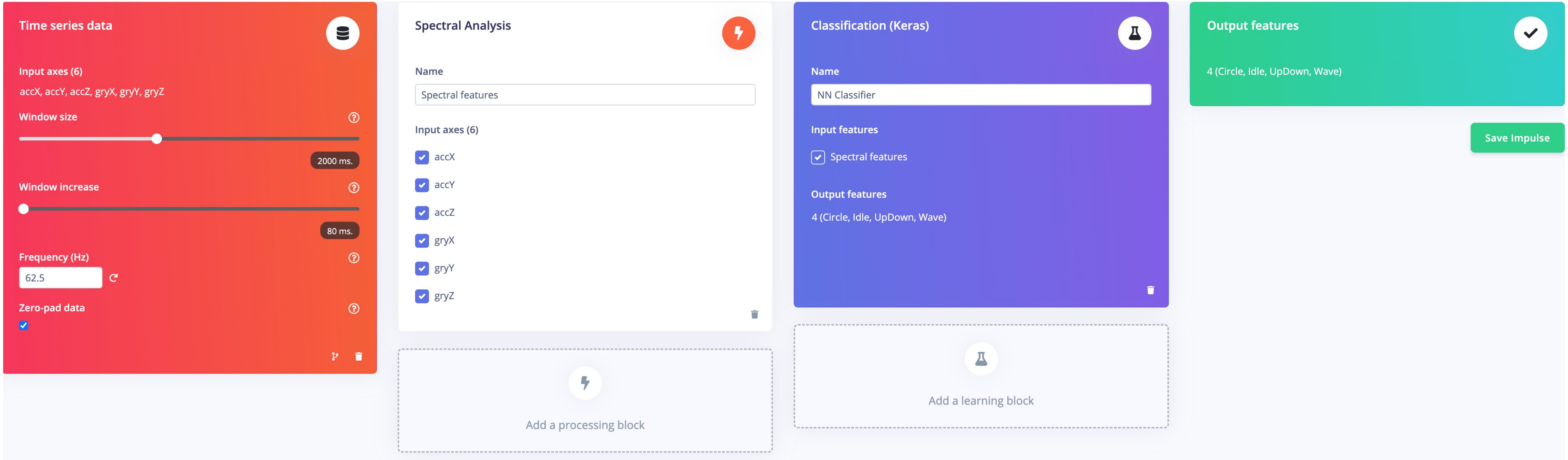
Designing the ML Model – Impulse Designer



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Did you expect creating the ML model to be this simple?

1) Yes
2) No

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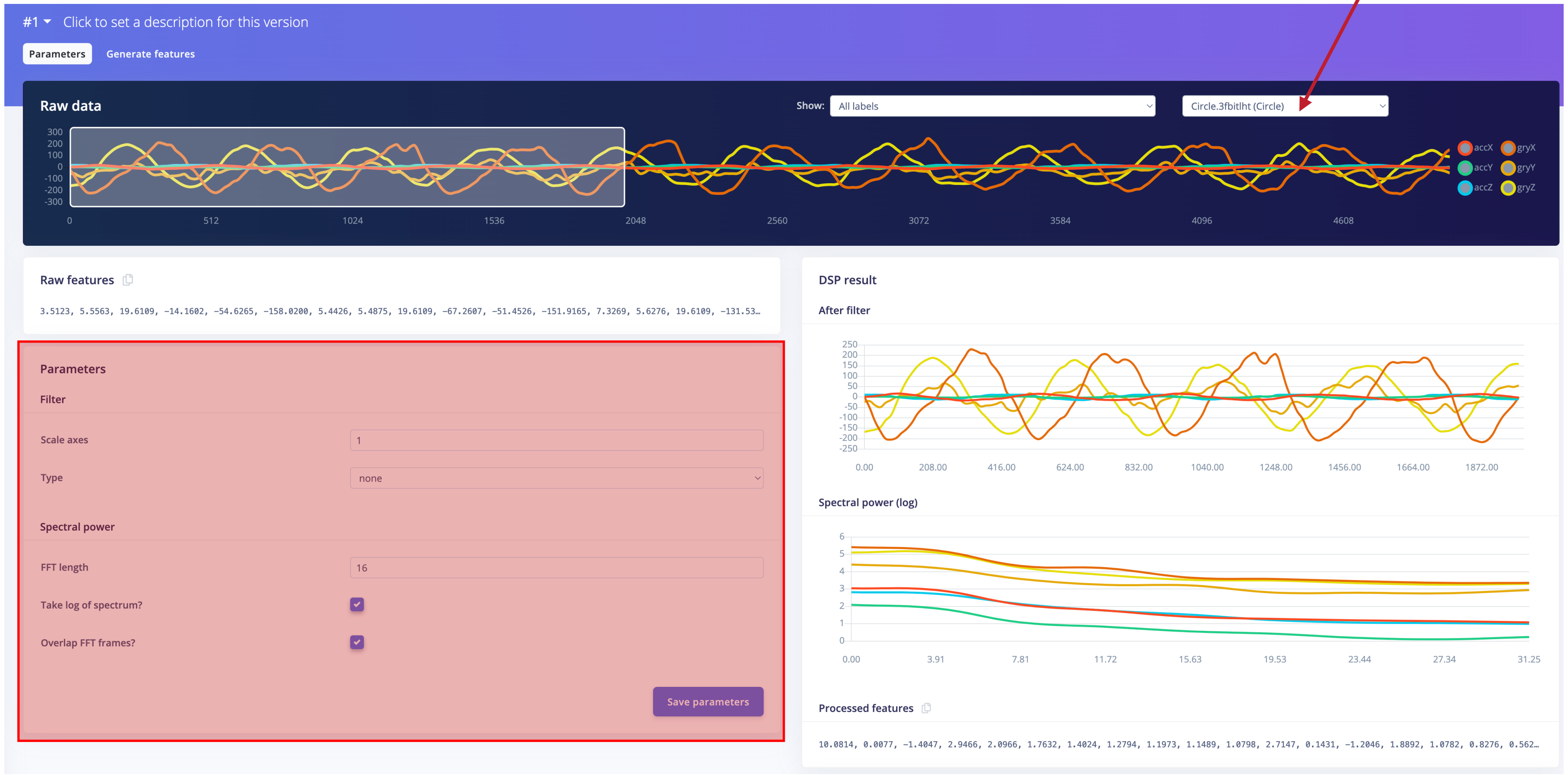
2

Spectral Feature Tuning

Spectral Feature Tuning

Change Data



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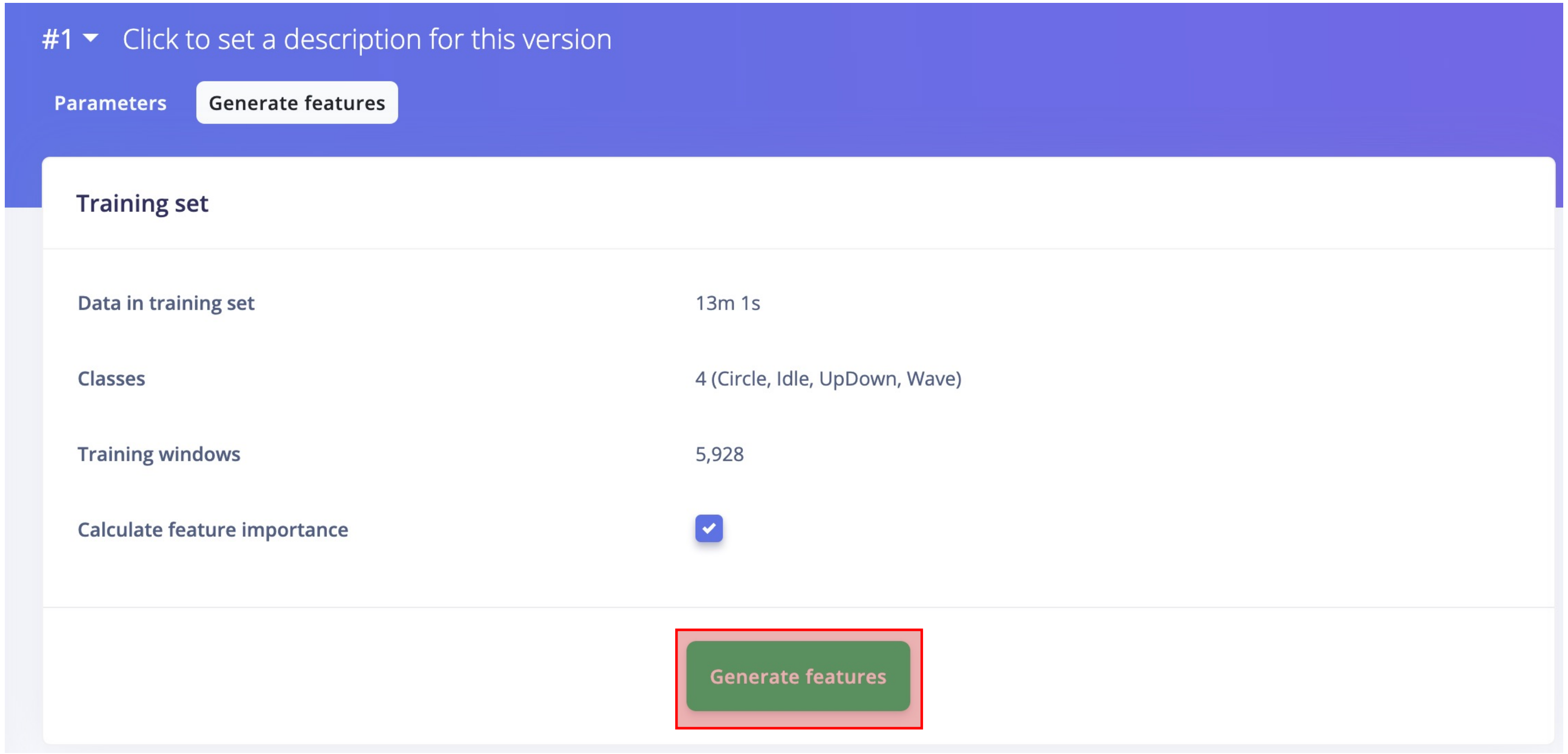
Spectral Feature - Tuning



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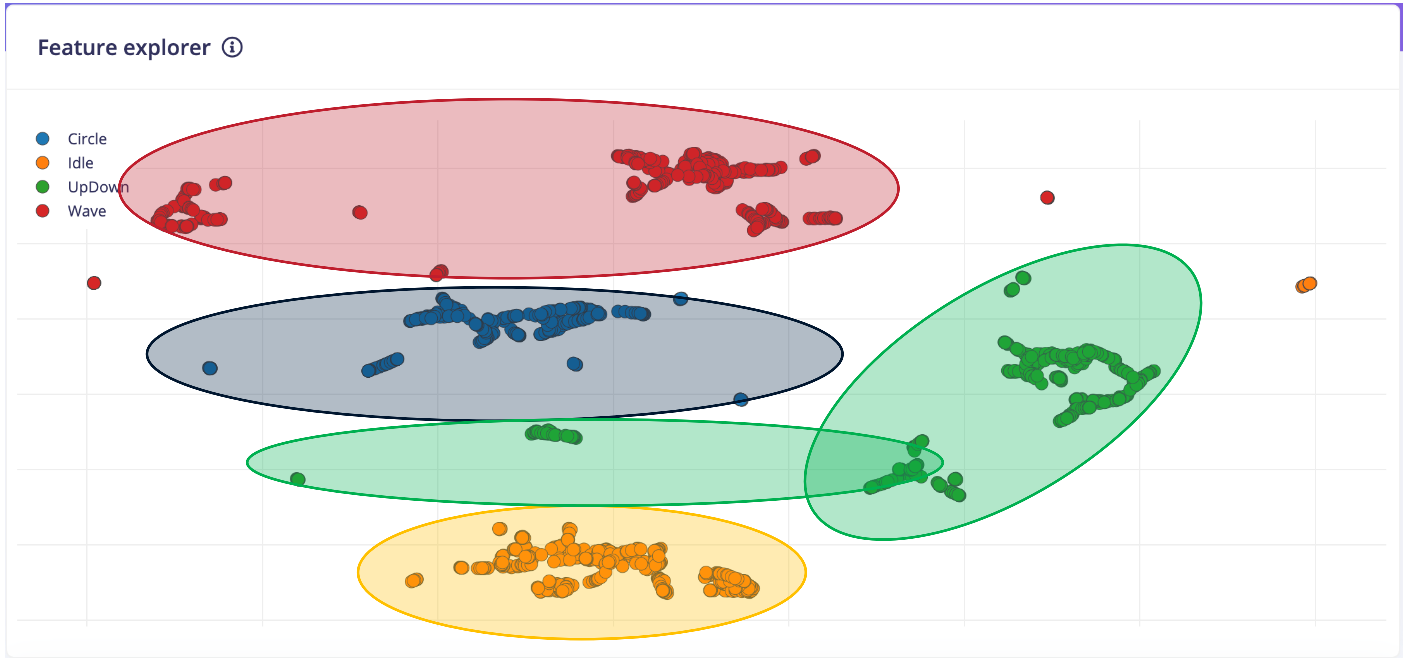
Spectral Feature - Tuning



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Spectral Feature - Tuning

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What should you look for in the feature set to determine if the model will be successful?
- Datasets that overlap
- Datasets that are clearly separated
- Datasets that intermix
- Other

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3 Training the Model

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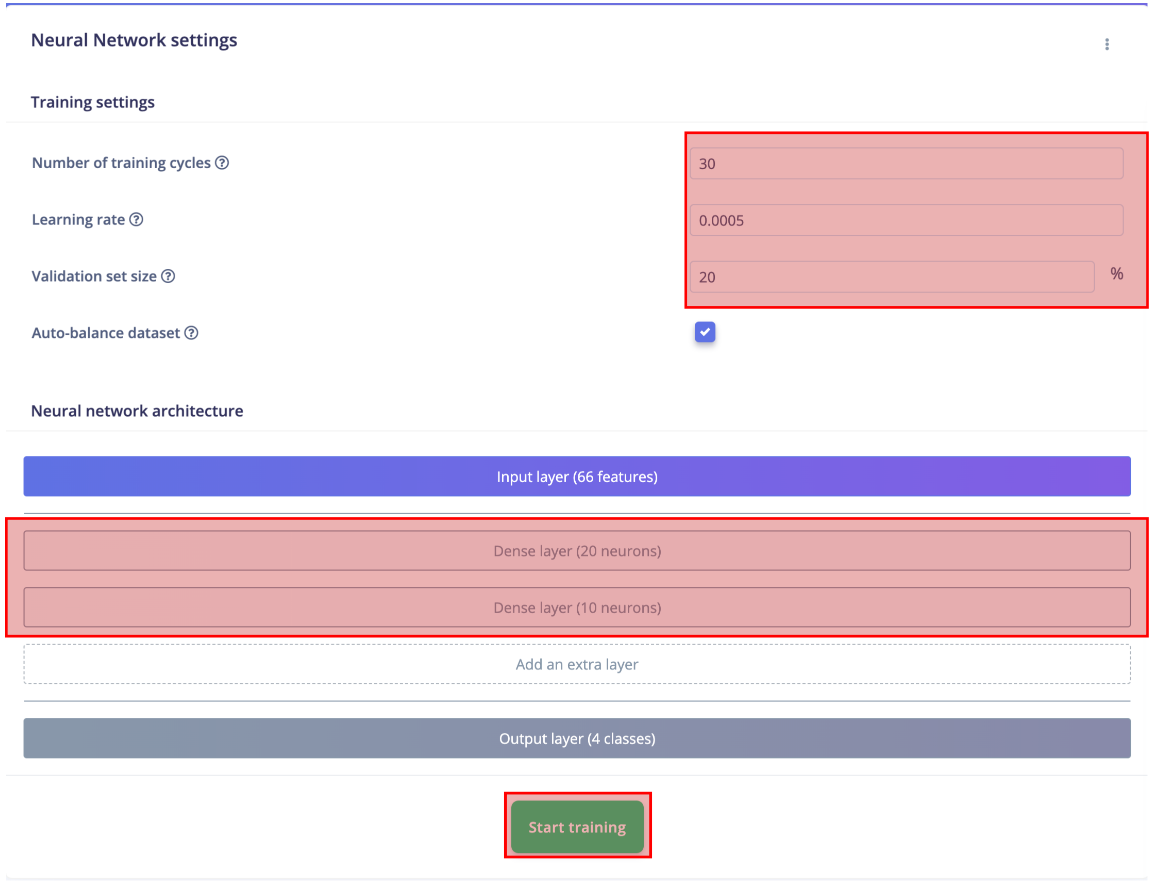
Training the Model



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Training the Model

Training output Cancel

```
Epoch 11/30
149/149 - 1s - loss: 0.2765 - accuracy: 0.9224 - val_loss: 0.1957 - val_accuracy: 0.9098 - 776ms/epoch - 5ms/step
Epoch 12/30
149/149 - 1s - loss: 0.1407 - accuracy: 0.9344 - val_loss: 0.1286 - val_accuracy: 0.9511 - 779ms/epoch - 5ms/step
Epoch 13/30
149/149 - 1s - loss: 0.0941 - accuracy: 0.9791 - val_loss: 0.0774 - val_accuracy: 0.9933 - 700ms/epoch - 5ms/step
Epoch 14/30
149/149 - 1s - loss: 0.0451 - accuracy: 0.9968 - val_loss: 0.0267 - val_accuracy: 1.0000 - 719ms/epoch - 5ms/step
Epoch 15/30
149/149 - 1s - loss: 0.0203 - accuracy: 0.9992 - val_loss: 0.0148 - val_accuracy: 1.0000 - 770ms/epoch - 5ms/step
Epoch 16/30
149/149 - 1s - loss: 0.0132 - accuracy: 0.9996 - val_loss: 0.0104 - val_accuracy: 1.0000 - 708ms/epoch - 5ms/step
Epoch 17/30
149/149 - 1s - loss: 0.0098 - accuracy: 1.0000 - val_loss: 0.0081 - val_accuracy: 1.0000 - 715ms/epoch - 5ms/step
Epoch 18/30
```


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Training the Model

Model

Model version: Quantized (int8)

Last training performance (validation set)

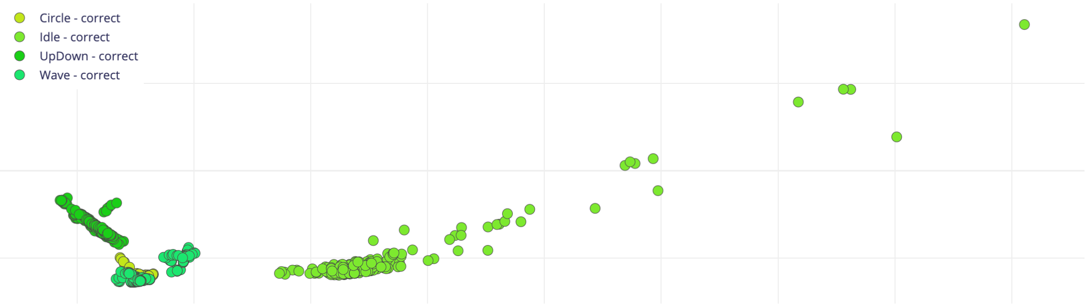
ACCURACY
100.0%

LOSS
0.00

Confusion matrix (validation set)

	CIRCLE	IDLE	UPDOWN	WAVE
CIRCLE	100%	0%	0%	0%
IDLE	0%	100%	0%	0%
UPDOWN	0%	0%	100%	0%
WAVE	0%	0%	0%	100%
F1 SCORE	1.00	1.00	1.00	1.00

Data explorer (full training set)



On-device performance

INFERENCING TIME
1 ms.

PEAK RAM USAGE
1.8K

FLASH USAGE
19.1K

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Training the Model

EDGE IMPULSE

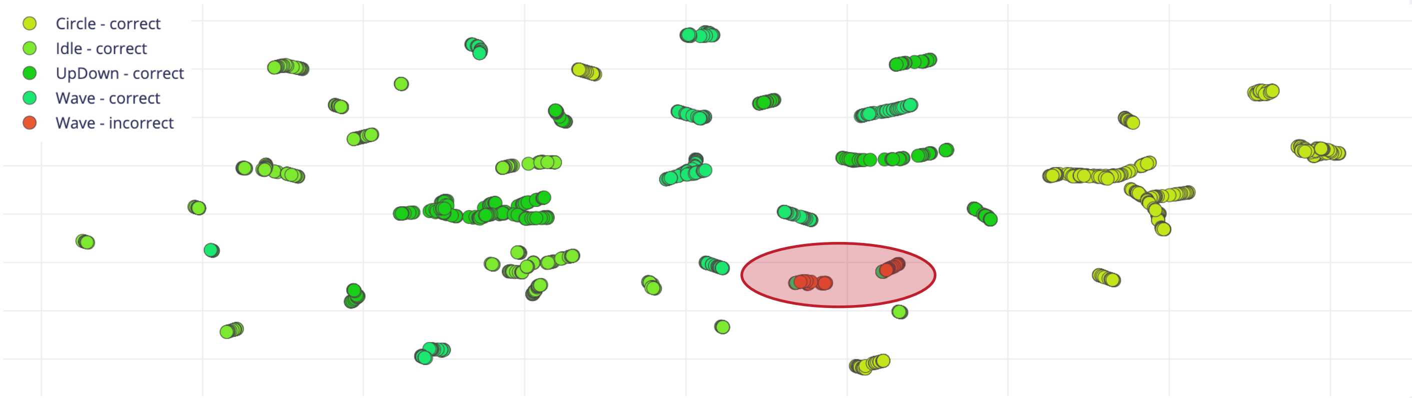
- Dashboard
- Devices
- Data sources
- Data acquisition
- Impulse design
  - Create impulse
  - Spectral features
  - NN Classifier
- EON Tuner
- Retrain model
- Live classification
- Model testing
- Performance calibration
- Versioning
- Deployment

Model testing results

ACCURACY
96.88%

	CIRCLE	IDLE	UPDOWN	WAVE	UNCERTAIN
CIRCLE	100%	0%	0%	0%	0%
IDLE	0%	100%	0%	0%	0%
UPDOWN	0%	0%	100%	0%	0%
WAVE	0.7%	0%	9.0%	87.5%	2.9%
F1 SCORE	1.00	1.00	0.96	0.93	

Feature explorer



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What can we do to improve our model?
- Use the IMU analysis instead of spectral features
- Gather more data or throw away “bad” data
- Adjust the training parameters
- Change the features looked at
- All the above and more

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4 Going Further

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From www.beningo.com under

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

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