

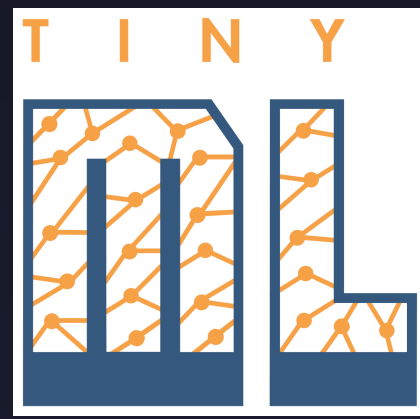
# tinyML<sup>®</sup> Summit

*Miniature dreams can come true...*

**March 28-30, 2022 | San Francisco Bay Area**



[www.tinyML.org](http://www.tinyML.org)



# Making Things Smarter

---

EON Tuner: AutoML for constrained devices



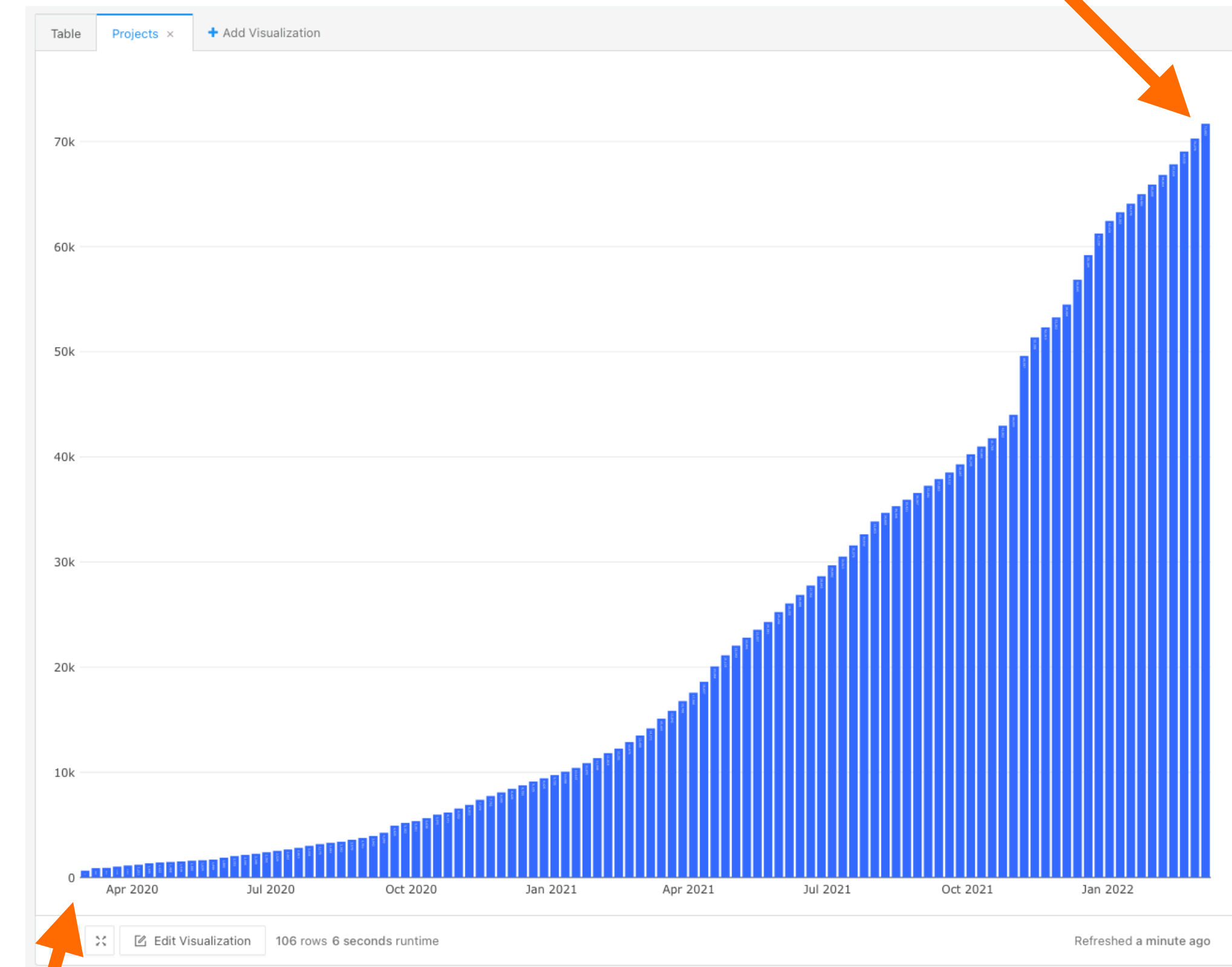
# Hi, I'm Jan!

Co-founder and CTO at **Edge Impulse**,  
leading development platform for machine  
learning on edge devices.

Launched just before TinyML summit 2020...  
Now 194 new projects daily (!)

TinyML Summit 2022

(71,682 projects)



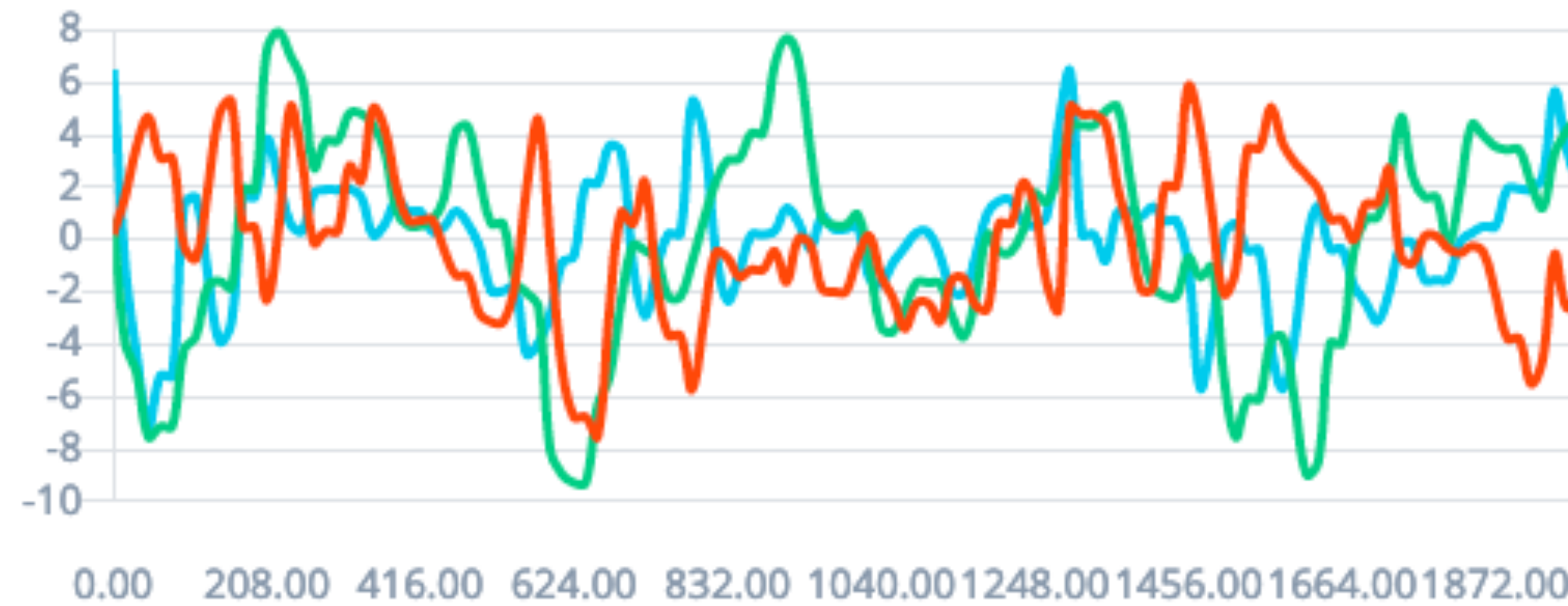
Edge Impulse project count

TinyML Summit 2020

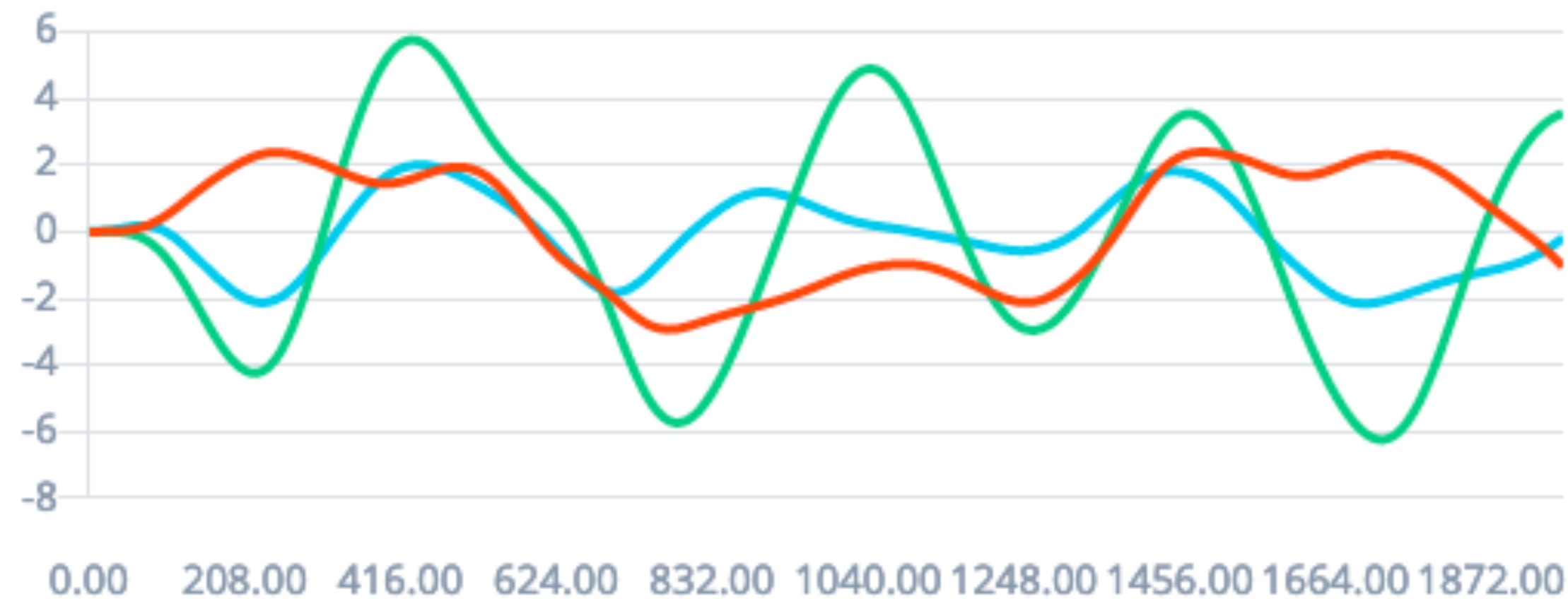
(643 projects)



# Signal processing + ML = ❤️



Apply low-pass filter...



= much easier job  
for the ML algo





# Leveraging signal processing

On-device intelligence is not new

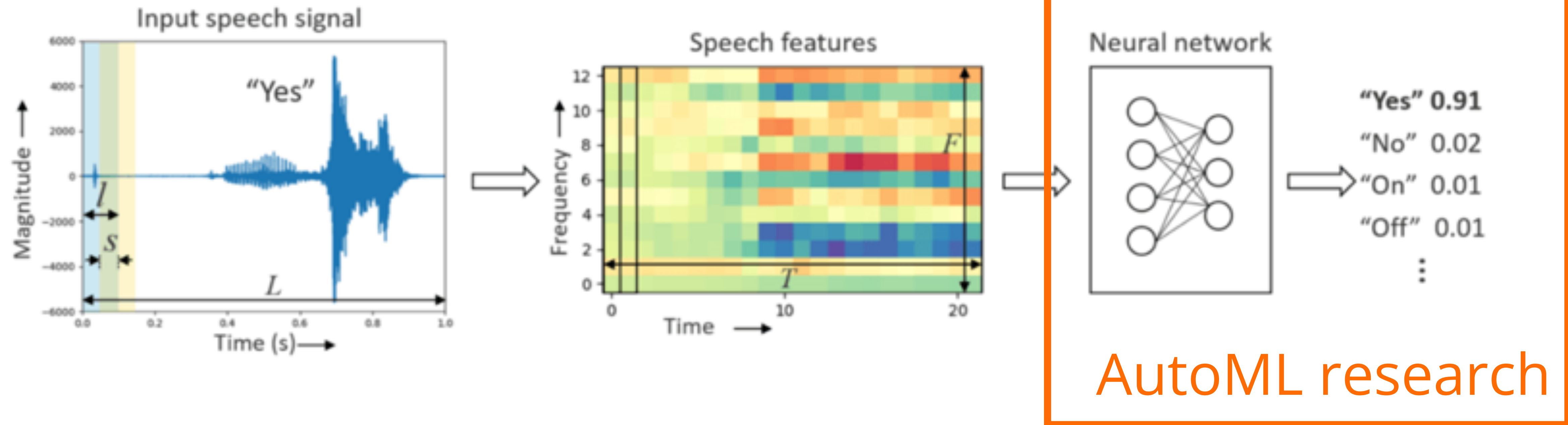
Neural networks are inefficient, if you can preprocess? Do so!

Significantly reduce input features, leading to smaller networks.

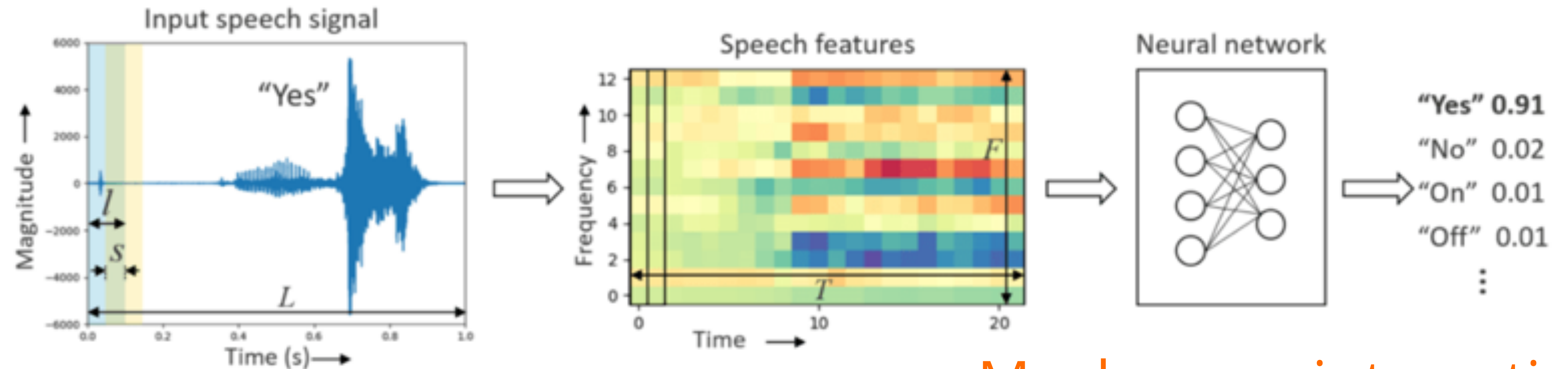
Cleans up input



# ML Sensor pipeline is often combination



# ML Sensor pipeline is often combination

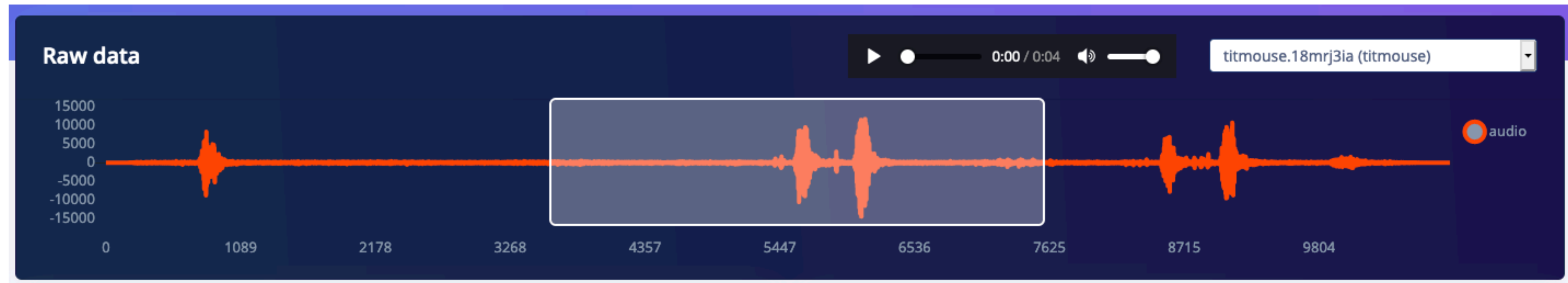


Much more interesting





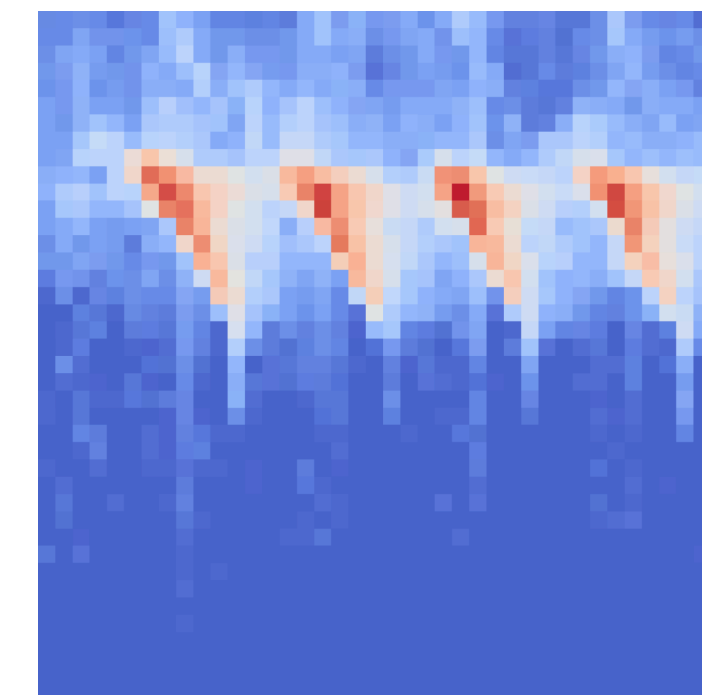
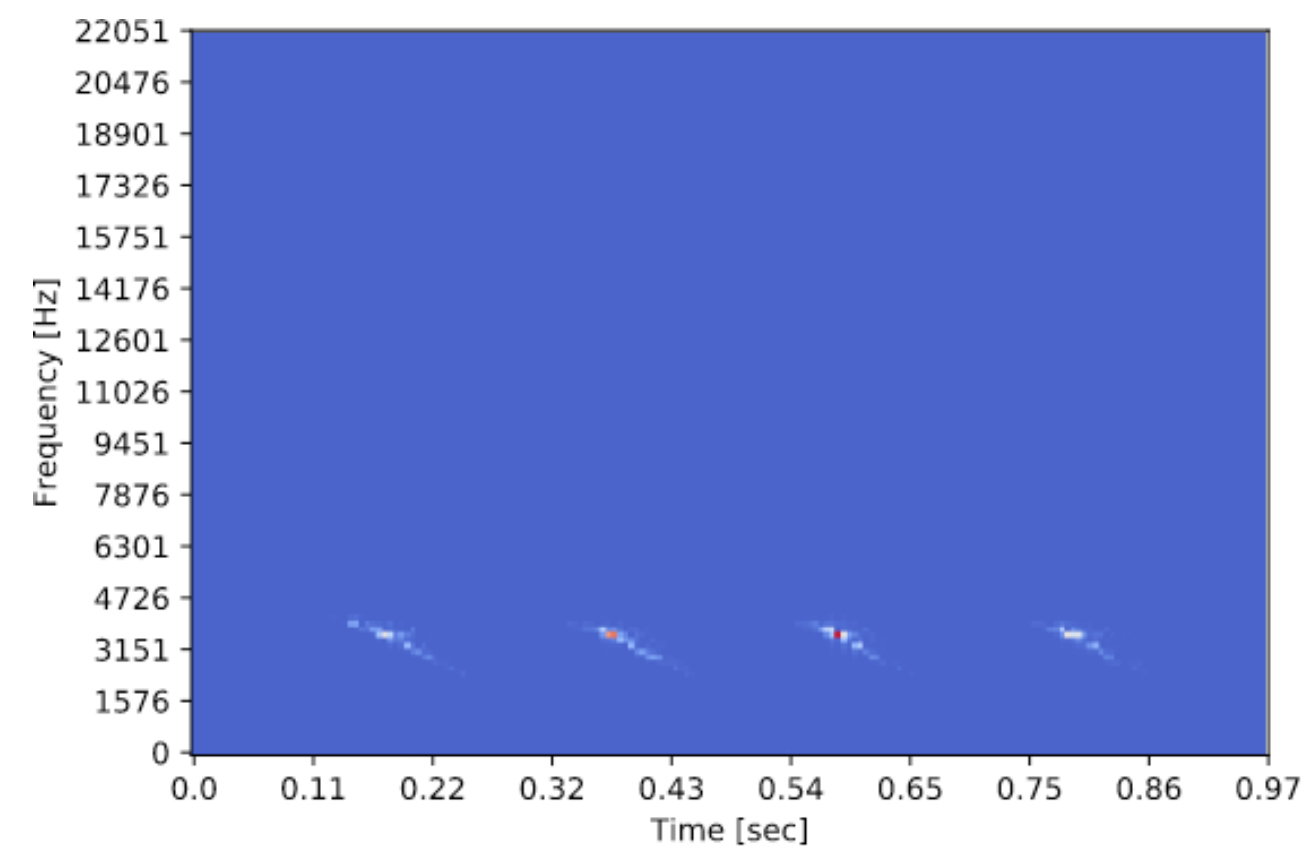
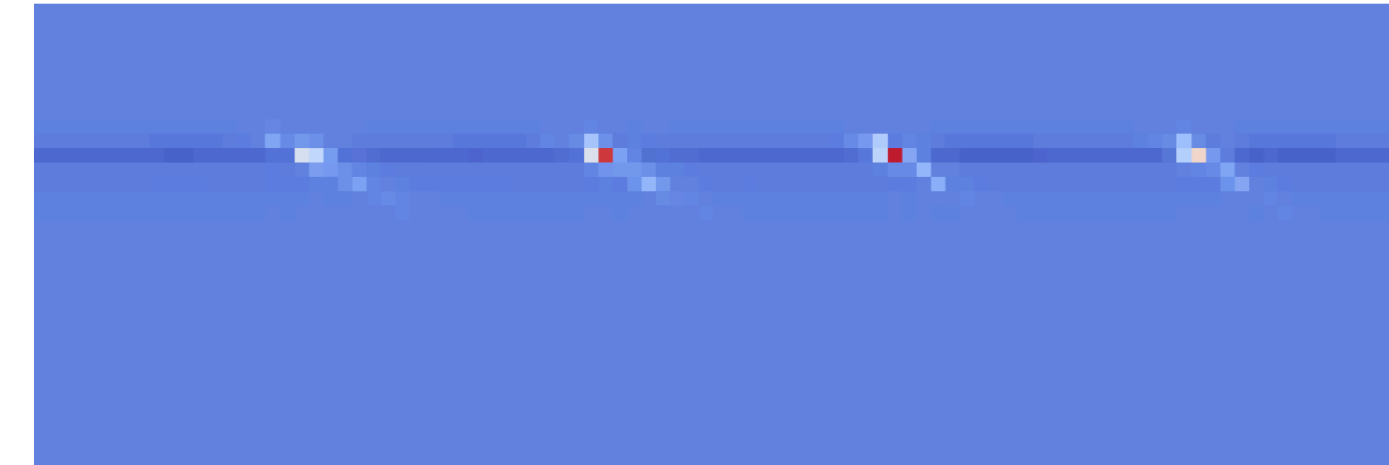
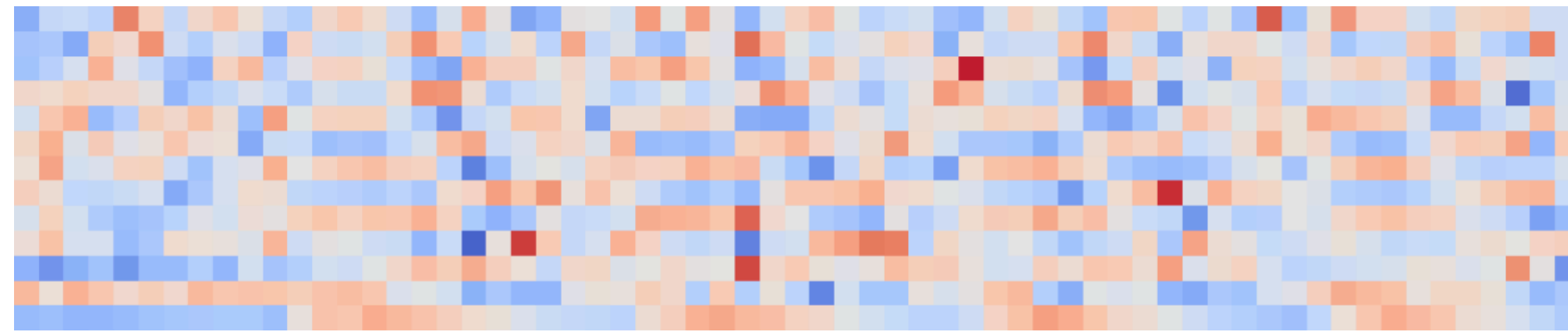
# Wide range of parameters



Window length, window step, downsample?



# Wide range of parameters



+ endless configuration options



# Constrained targets - what's worth it?

EDGE IMPULSE

Dashboard

Devices

Data acquisition

Impulse design

Create impulse

MFCC

Syntiant

Spectrogram

NN Classifier

Retrain model

Live classification

Model testing

Versioning

Deployment

GETTING STARTED

Documentation

Forums

SPECTROGRAM (BIRD SOUND CLASSIFIER)

Jan Jongboom

ParametersGenerate features

Raw data

0:00 / 0:01

titmouse16khz.wav.27gf72mg (titmouse16)

audio

20000

10000

0

-10000

-20000

0

295

591

887

1183

1479

1775

2071

2367

2663

Raw features

20, -41, -104, -32, -257, -137, 63, -54, -238, -220, -13, ...

Parameters

Spectrogram

Frame length0.02

Frame stride0.01

Frequency bands128

Graph options

Show axes☒

Save parameters

DSP result

Spectrogram

8000

7429

6858

6286

5715

5143

4572

4000

3429

2858

2286

1715

1143

572

0

0.0

0.11

0.22

0.32

0.43

0.54

0.65

0.75

0.86

0.97

Time [sec]

Processed features

0.0004, 0.0002, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0...

On-device performance

PROCESSING TIME

77 ms.

PEAK RAM USAGE

27 KB

EDGE IMPULSE

Dashboard

Devices

Data acquisition

Impulse design

Create impulse

MFCC

Syntiant

Spectrogram

NN Classifier

Retrain model

Live classification

Model testing

Versioning

Deployment

GETTING STARTED

Documentation

Forums

SPECTROGRAM (BIRD SOUND CLASSIFIER)

Jan Jongboom

ParametersGenerate features

Raw data

0:00 / 0:01

titmouse16khz.wav.27gf72mg (titmouse16)

audio

20000

10000

0

-10000

-20000

0

295

591

887

1183

1479

1775

2071

2367

2663

Raw features

20, -41, -104, -32, -257, -137, 63, -54, -238, -220, -13, ...

Parameters

Spectrogram

Frame length0.02

Frame stride0.01

Frequency bands256

Graph options

Show axes☒

Save parameters

DSP result

Spectrogram

8000

7429

6858

6286

5715

5143

4572

4000

3429

2858

2286

1715

1143

572

0

0.0

0.110

0.220

0.320

0.430

0.540

0.650

0.750

0.860

0.97

Time [sec]

Processed features

0.0001, 0.0002, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0...

On-device performance

PROCESSING TIME

159 ms.

PEAK RAM USAGE

51 KB





# Introducing the EON Tuner!

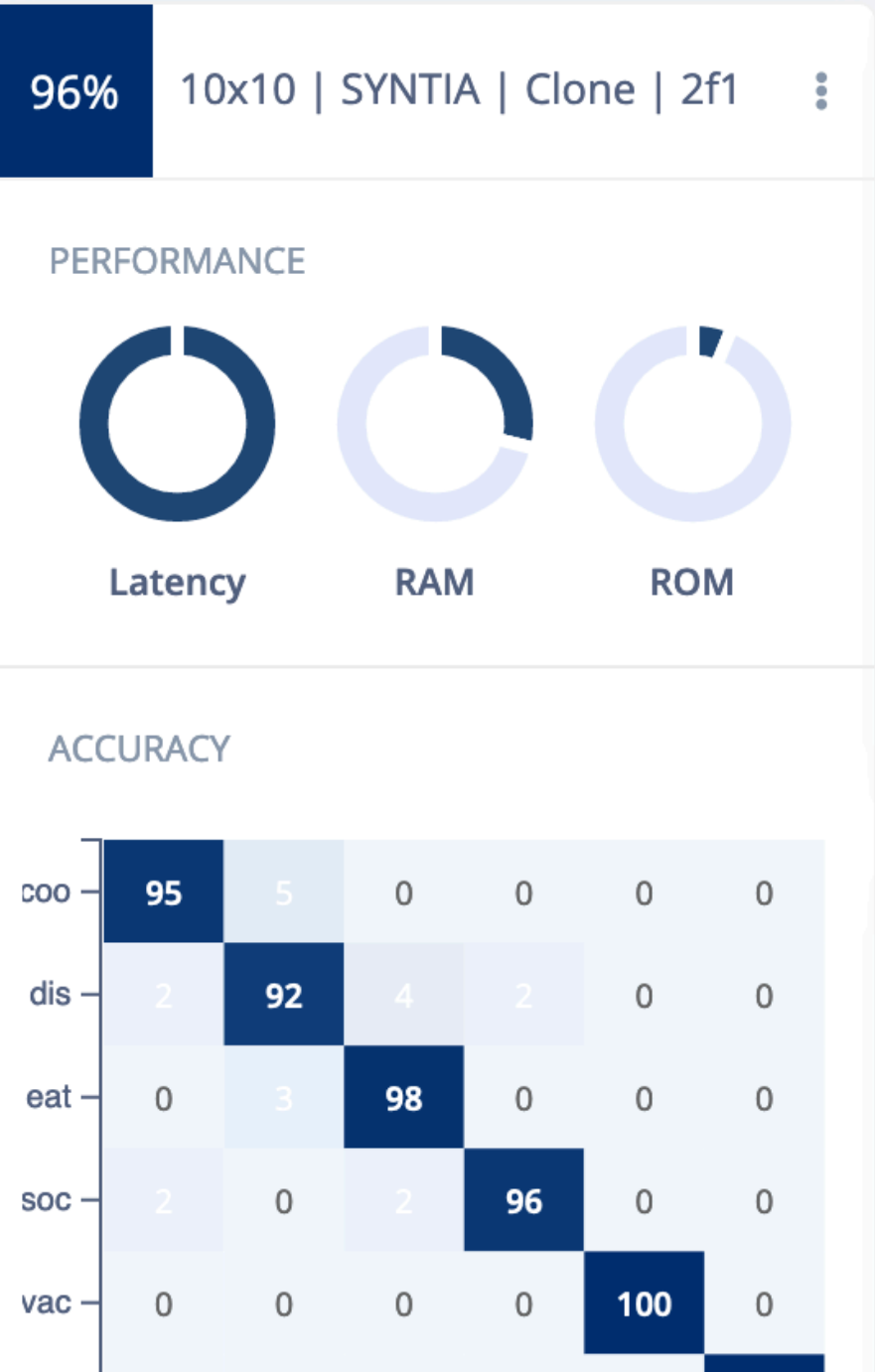
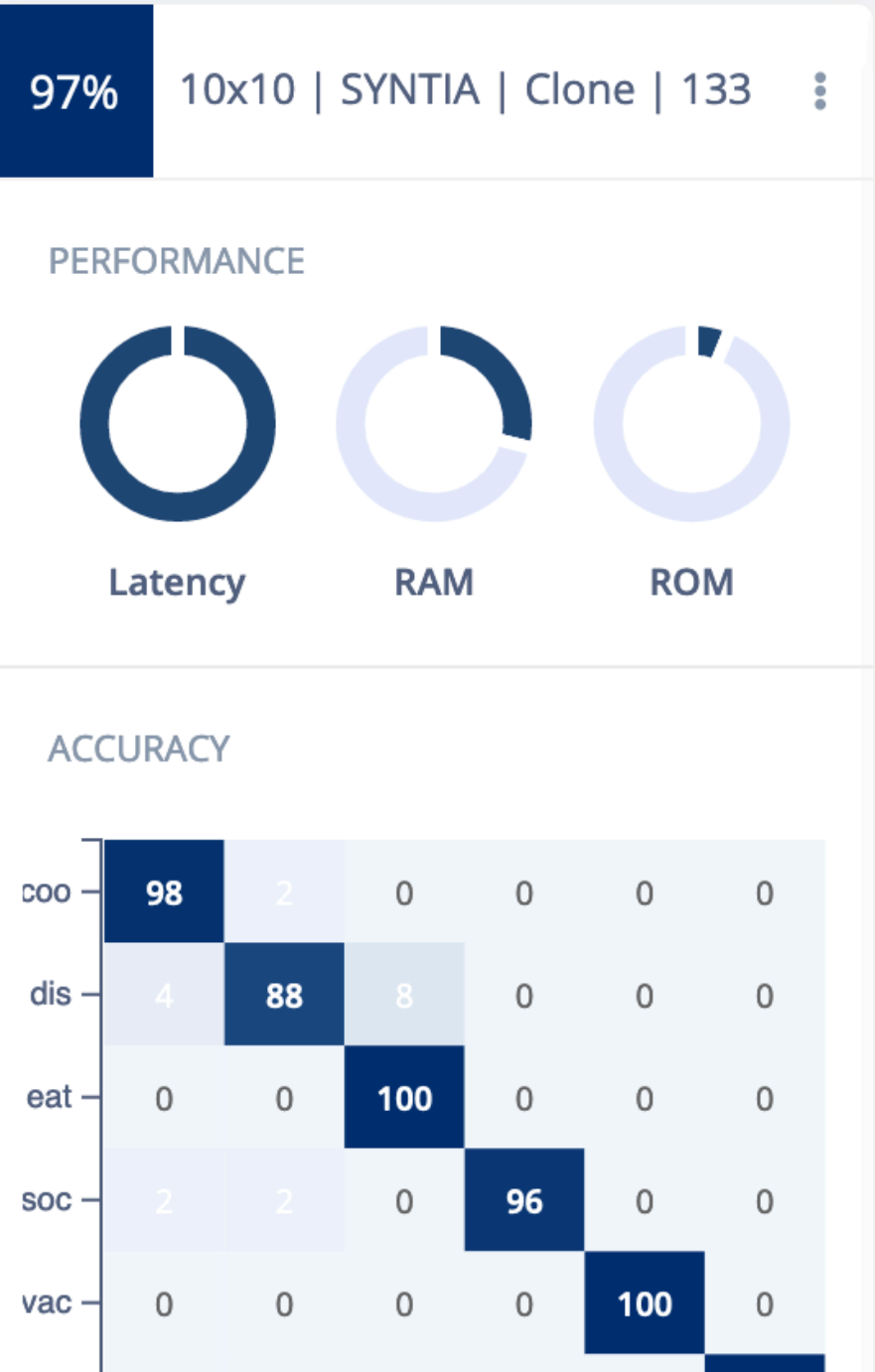
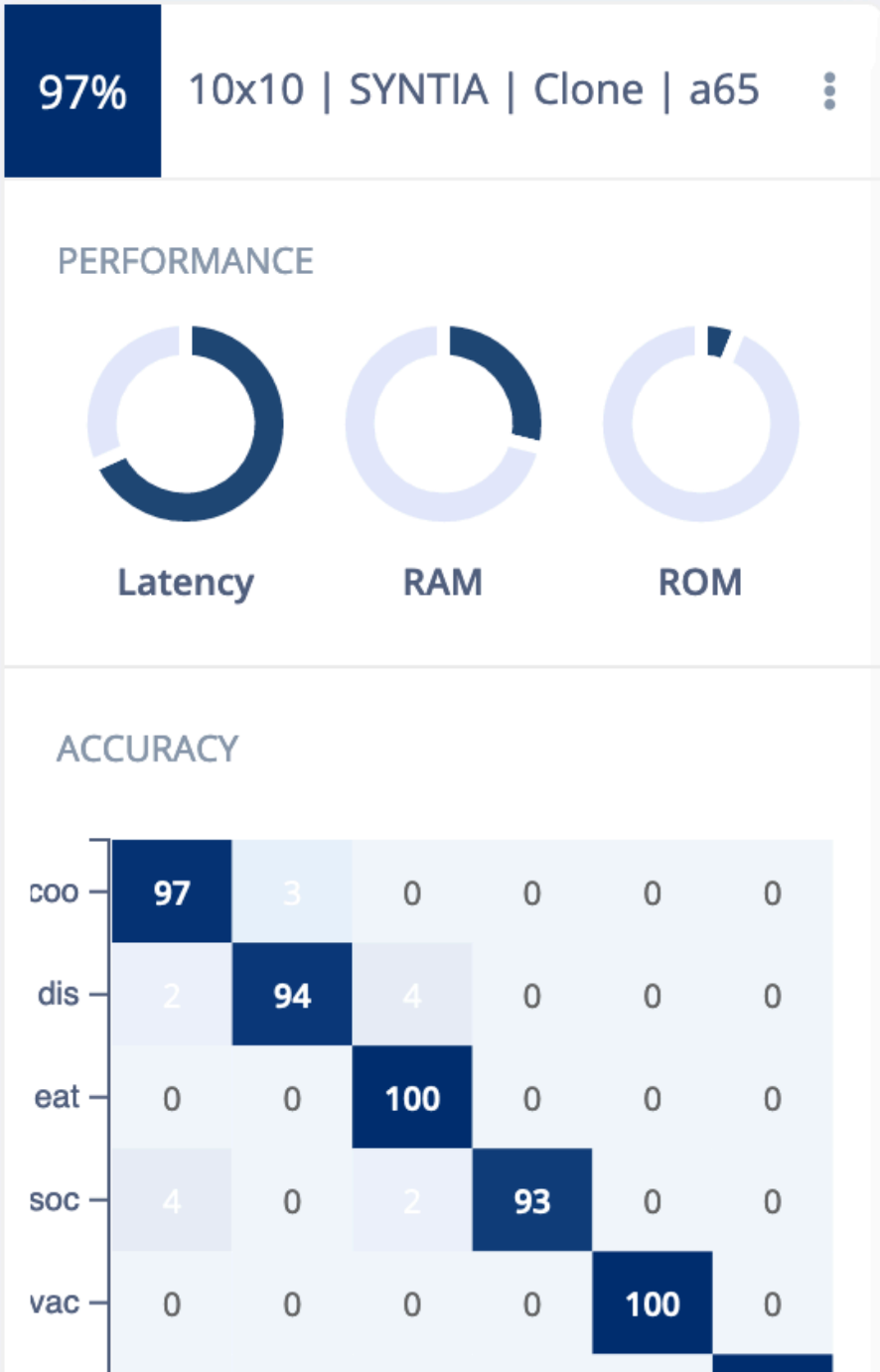
## EON Tuner

Config

Logs

Finding the most optimal architecture for your model (17 model variants evaluated / 50 variants total)

cortex-m7-216mhz 1000 ms RAM: 128kB • ROM: 1024kB



## Filters

### Status

- ☒ Pending
- ☒ Running
- ☒ Completed
- ☒ Failed

## View

### Data set

- ☐ Validation
- ☐ Train

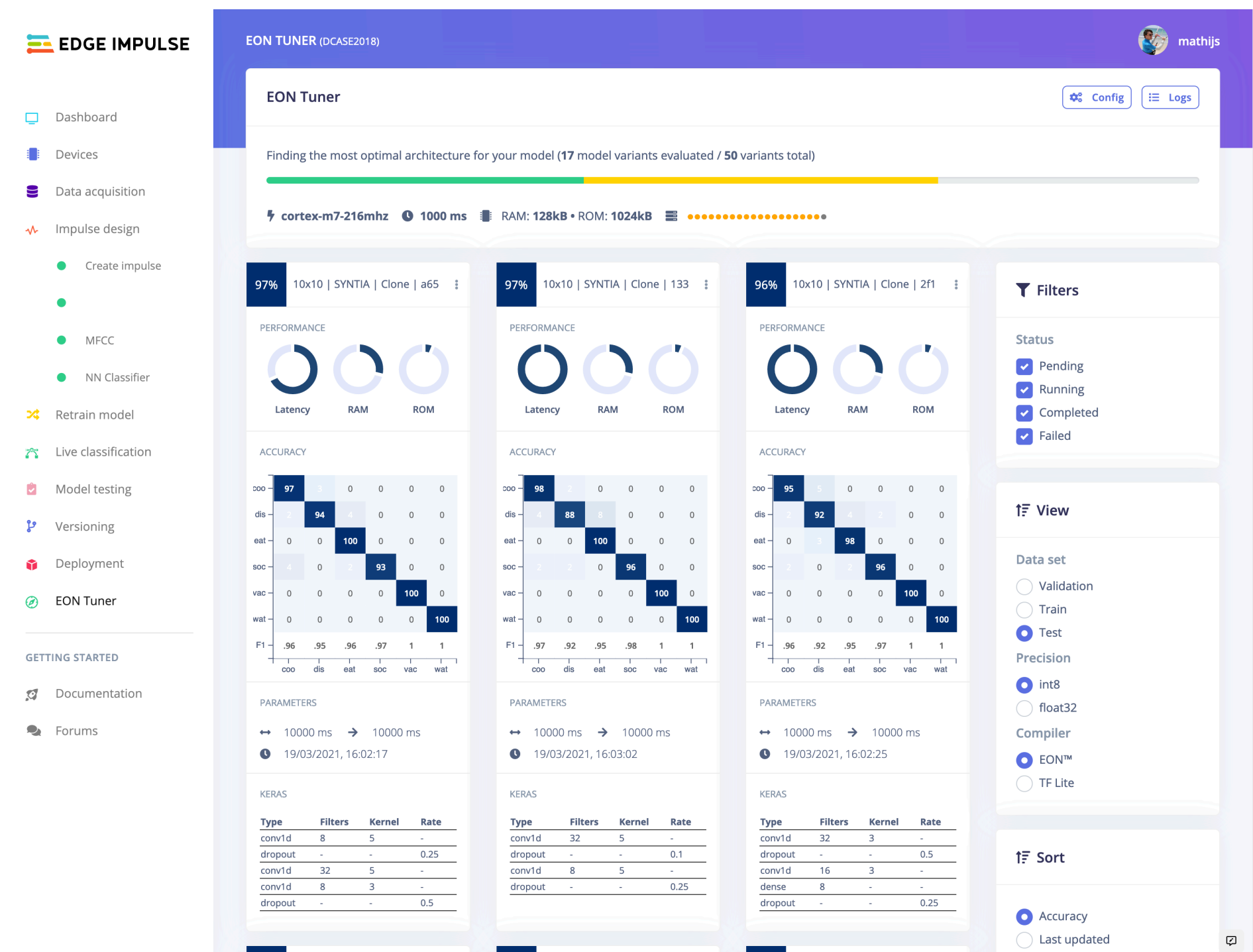
# EON Tuner

Find best model for sensor data over mix of input blocks, DSP blocks and ML blocks

Specify device constraints

Extensible with your own DSP and ML blocks

Biggest win: "we found DSP configuration that works so well, we no longer need ML"



# That sounds too easy...



# 1. Understand the problem

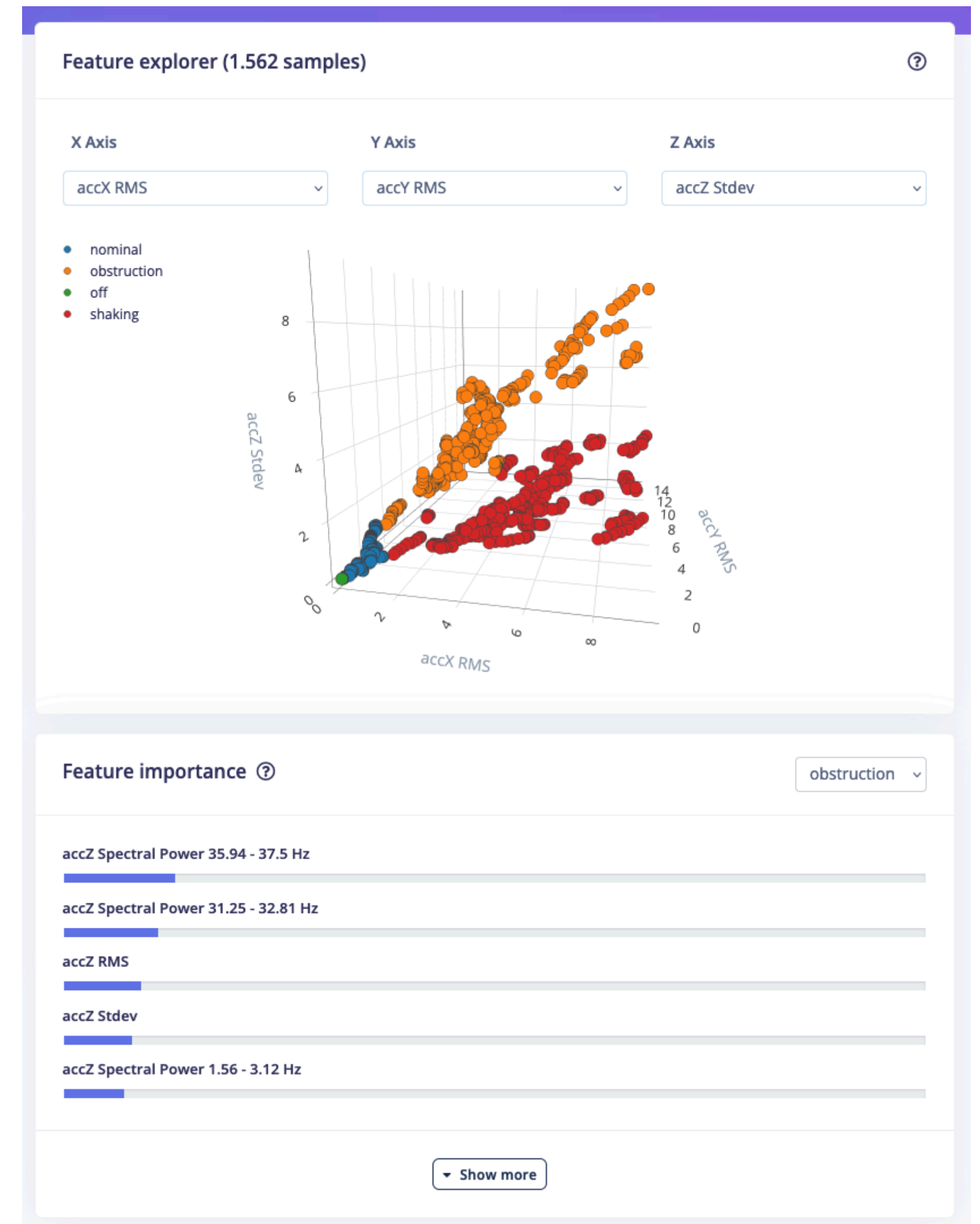
Understand the business constraints  
(response time = sampling time + inference)

See interesting frequencies?

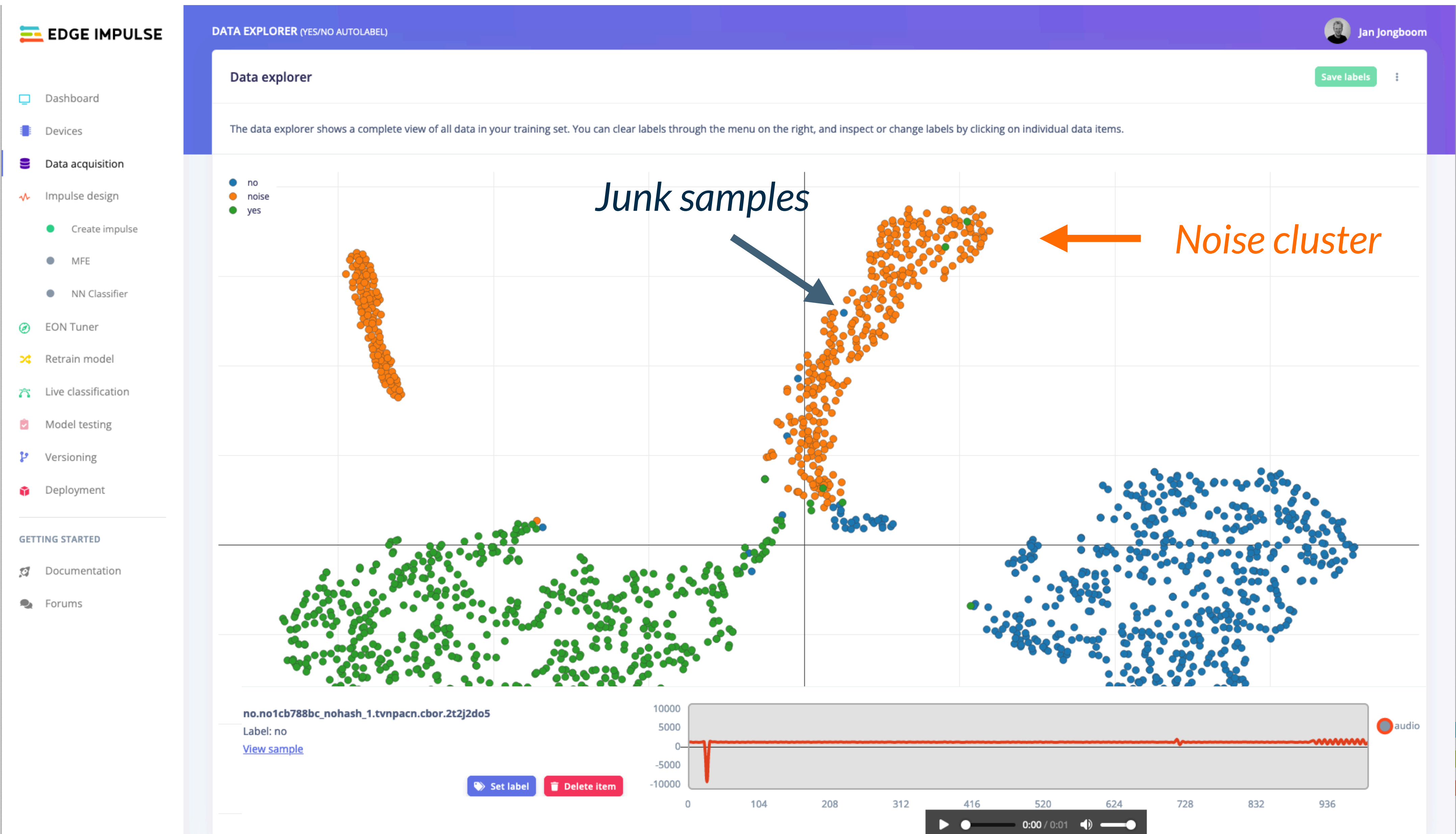
Need custom DSP code?

Classification, regression or anomaly detection?

**Still an engineering tool!**



# 2. Dataset quality



### 3. Custom search space

Tuner comes with basic scenarios (keyword spotting, continuous audio, image classification, motion, etc.)

Customize search space (parameters, which preprocessing blocks, ML configuration)

Tied to performance APIs, to drop parts of the space that don't fit constraints

```
dspBlock: {  
    type: 'spectrogram',  
    noise_floor: [ -62, -52, -42 ],  
    fft_length: [ 64, 128, 256 ]  
}
```





# Examples

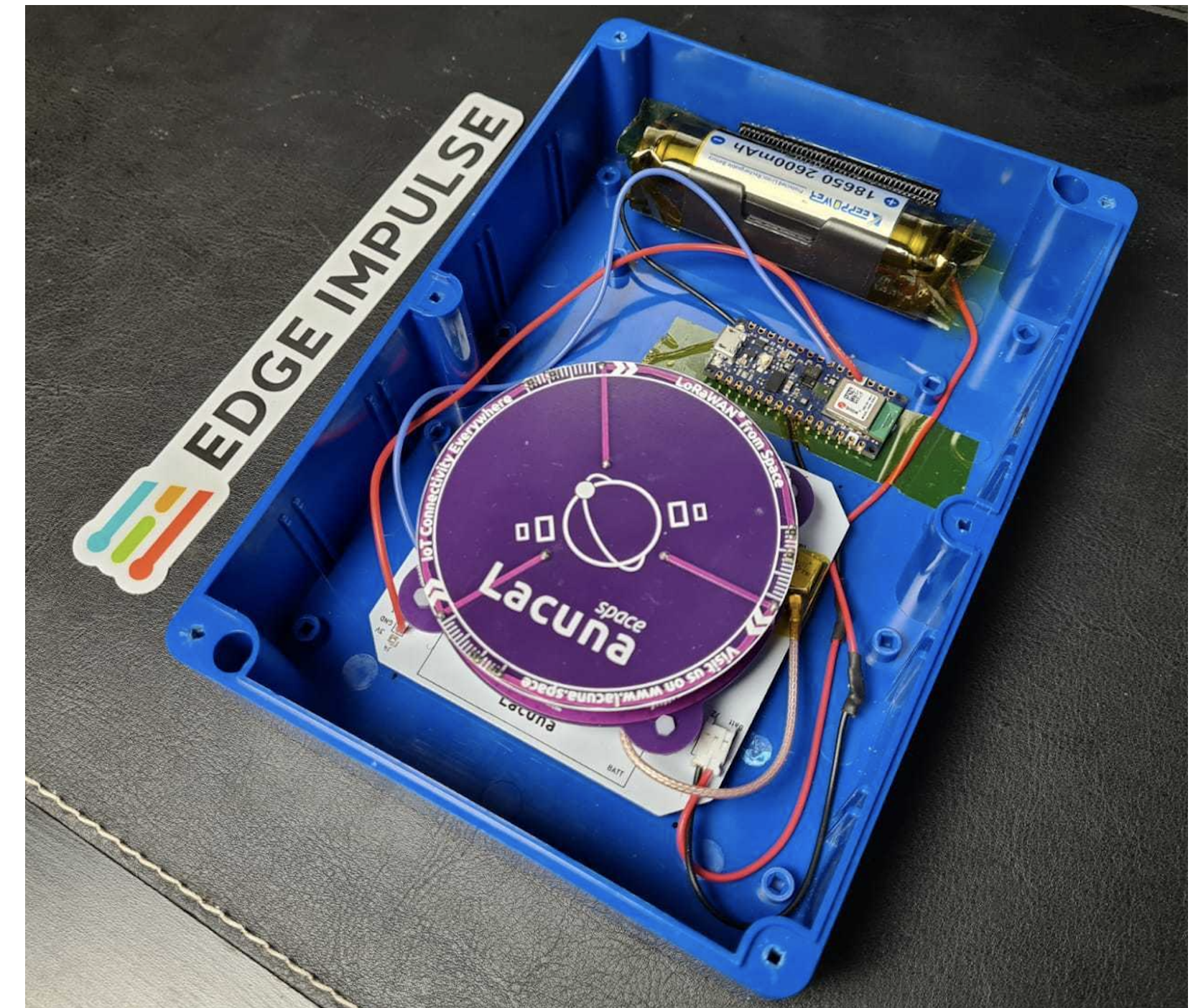


# Bird sound classifier

Built with Lacuna Space, counts birds locally and relays results back over satellite

Model built by Dan (hi Dan!) from our team:  
82.62% test set accuracy

EON Tuner found one w/ 92.66% test set accuracy  
(or even 95% if forego 1 sec. latency requirement)



<https://www.edgeimpulse.com/blog/introducing-the-eon-tuner-edge-impulses-new-automl-tool-for-embedded-machine-learning>





# Best models...



# Lots of DSP? Lots of NN?





# Getting started

# Getting started

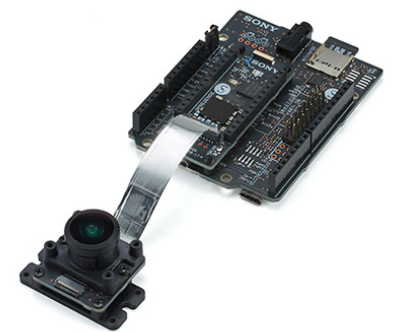
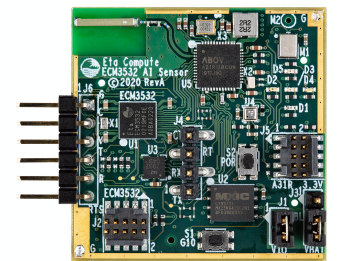
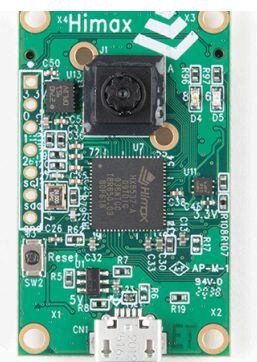
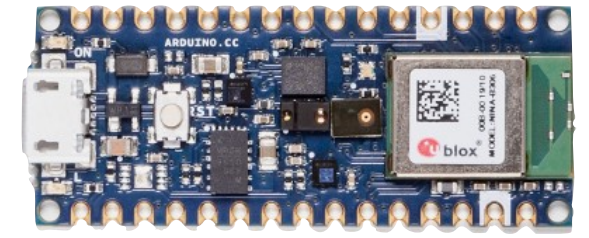
<https://docs.edgeimpulse.com/docs>

Very wide range of dev boards, from Cortex-M0+ to Jetson Nano

Deploy to any device that has a C++ compiler

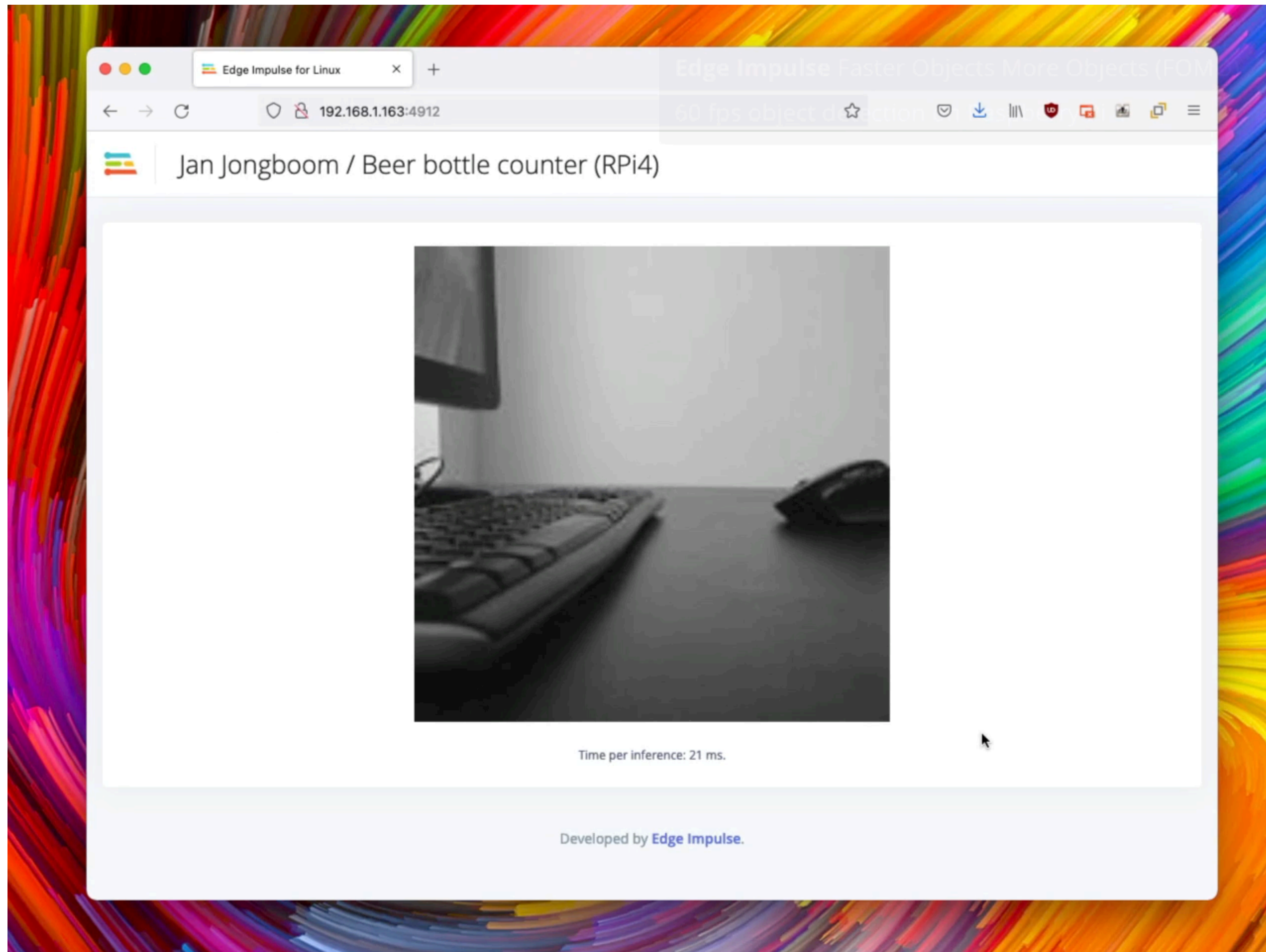
Or use your phone!

***Be one of today's 194 new projects!***





# FOMO - Object detection for MCUs



# Recap

We've come so far!

Domain knowledge is key.

It's the AutoML track, but it's still engineering.

[edgeimpulse.com](https://edgeimpulse.com)





# Questions?

Full docs:

<https://docs.edgeimpulse.com>

Tuner intro:

<https://docs.edgeimpulse.com/docs/eon-tuner>

FOMO

<https://docs.edgeimpulse.com/docs/fomo-object-detection-for-constrained-devices>

We're hiring!

<https://edgeimpulse.com/careers>

**More questions:**

[forum.edgeimpulse.com](https://forum.edgeimpulse.com) / [jan@edgeimpulse.com](mailto:jan@edgeimpulse.com)





AONdevices

arm

ASPINITY

brainchip  
The Neuromorphic Computing Company

CEVA®

Deeplite

EDGE IMPULSE

emza  
visual sense

FotaHub

GREENWAVES  
TECHNOLOGIES

Grovetly Inc.

Himax

HOTC

imagimob

infineon

itemis

KLIKA·TECH  
GLOBAL IOT SOLUTIONS

LatentAI

LATTICE  
SEMICONDUCTOR

Micro.ai

OmniML

NXP

POI

Plumerai

PROPHESSEE

Qeexo

Qualcomm

Rackner

RealityAI®  
Engineering Solutions for the Edge

REEXEN  
technology

RENESAS

SAP

seeed  
The IoT Hardware Enabler

SensiML

Sony Semiconductor  
Solutions  
Corporation

ST  
life.augmented

SA STREAM ANALYZE

synaptics®

SynSense

SYNTIANT

Tensil.ai

TensorFlow

XMOS



# Copyright Notice

The presentation(s) in this publication comprise the proceedings of tinyML® Summit 2021. The content reflects the opinion of the authors and their respective companies. This version of the presentation may differ from the version that was presented at the tinyML Summit. The inclusion of presentations in this publication does not constitute an endorsement by tinyML Foundation or the sponsors.

There is no copyright protection claimed by this publication. However, each presentation is the work of the authors and their respective companies and may contain copyrighted material. As such, it is strongly encouraged that any use reflect proper acknowledgement to the appropriate source. Any questions regarding the use of any materials presented should be directed to the author(s) or their companies.

tinyML is a registered trademark of the tinyML Foundation.

[www.tinyML.org](http://www.tinyML.org)