

# W

AIML-102

## Machine Health and Condition Monitoring Using the Edge Impulse Platform

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# Benefits of edge ML



## Innovation

Add new differentiating features, become a market leader by standing out from your competition



## Privacy

Data stays on the device, gets processed locally and drives remote alerts, notifications, and actions



## Power

Stay operational for longer periods of time



## Cost

Save on storage and compute costs by not sending raw data constantly to the cloud



## Reliability

Be operational in low connectivity environments



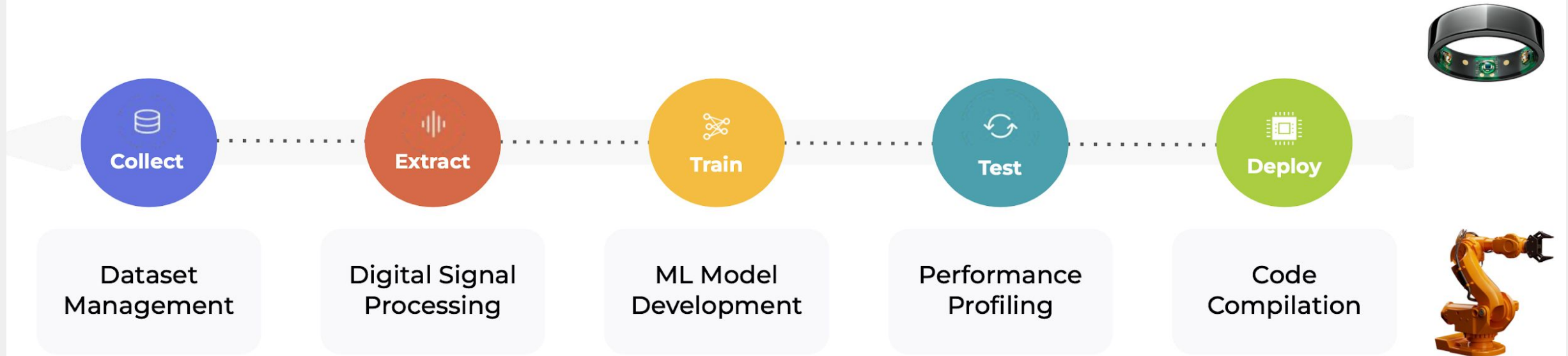
## Bandwidth & Latency

Process data real-time on the edge device, without having to wait for a response back from the cloud

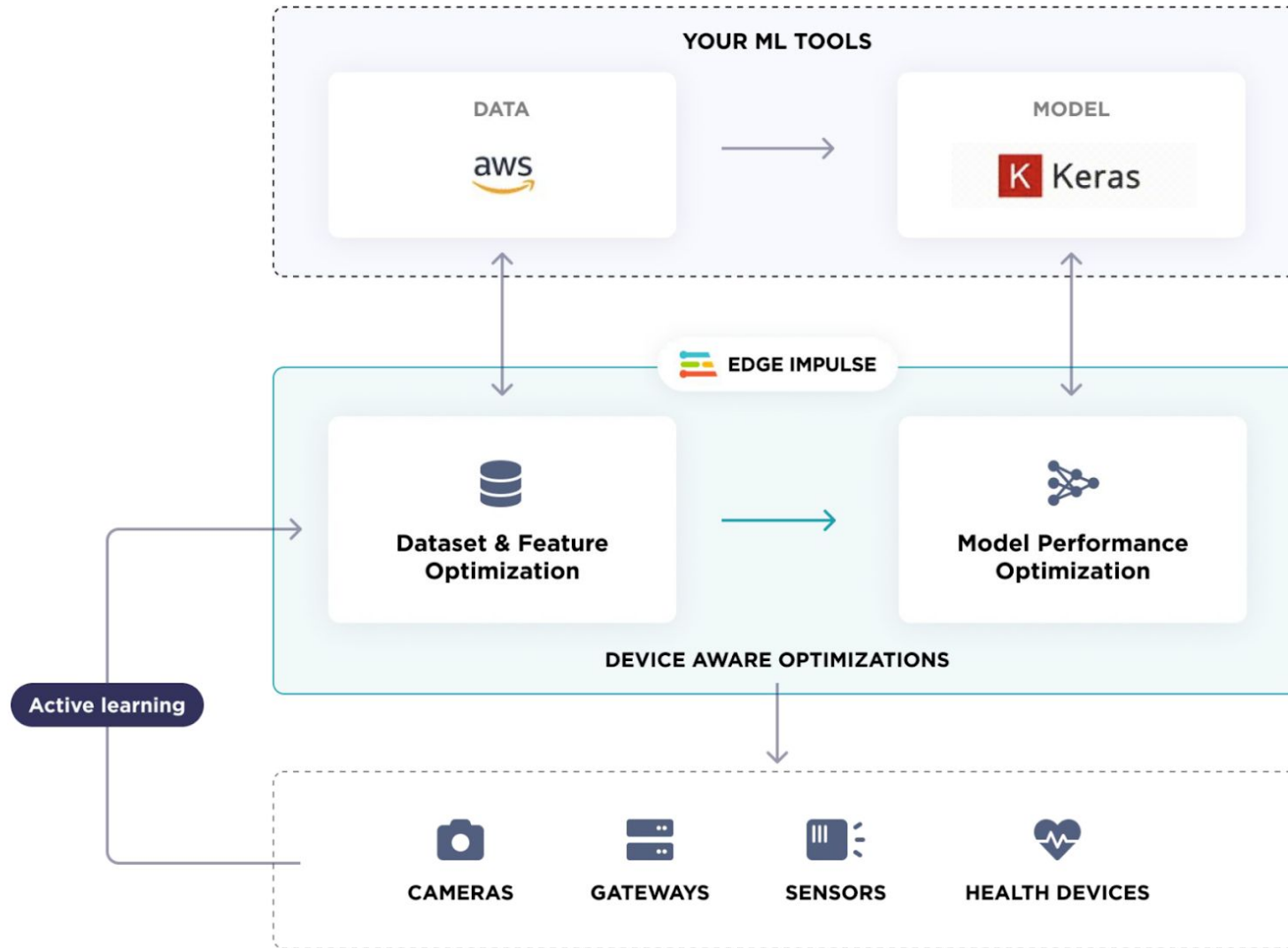
A large, bold, blue lowercase letter 'w' is positioned on the left side of the slide. It is partially overlaid by a thick, blue diagonal line that runs from the top left towards the bottom right. The background features several parallel, semi-transparent blue diagonal lines that create a sense of depth and movement.

# Edge AI with Edge Impulse

# The complete toolkit for embedded ML

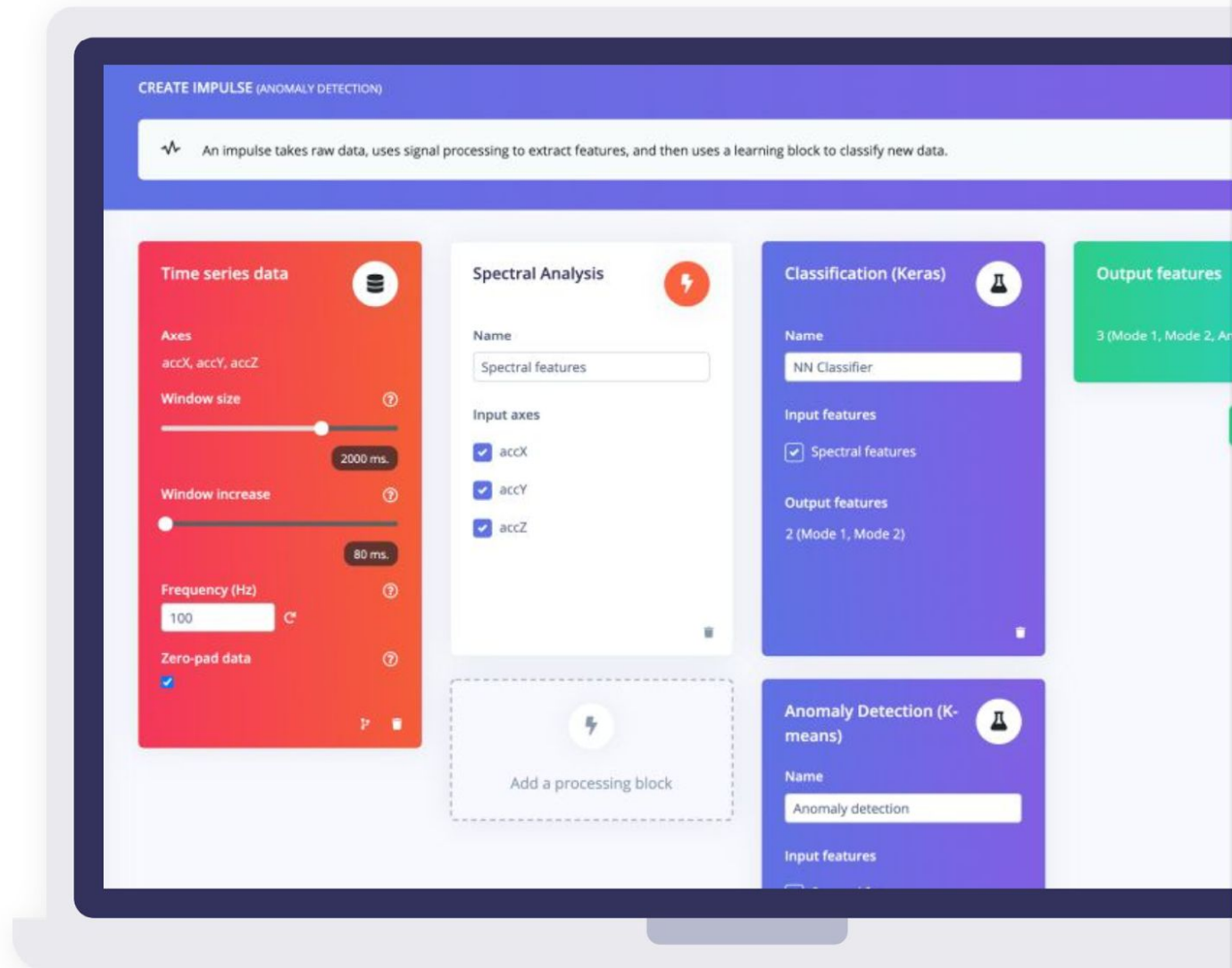


# Enable edge AI for any platform



# Optimize AI for the edge

- Royalty-free business model, therefore no impact on BOM cost
- Your IP, stays your IP
- Total explainability, no black boxes



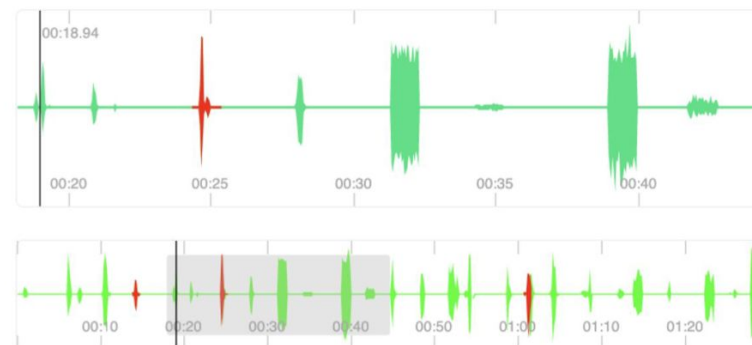
R&D FOCUS

## Active learning & continual improvement

- Simulate on-device behavior before deployment
- Assisted labelling and active learning workflows
- Model versioning and change management over time

### Generated audio

Below you can see and play with the generated audio file, which also shows where false positives and negatives appear in the audio.



Zoom in Zoom out



ID	LABEL	START TIME	END TIME	
9	yes => no	13.914	14.914	<a href="#">Play</a>
27	yes => no	60.807	61.807	<a href="#">Play</a>
15	unknown => yes	24.329	25.329	<a href="#">Play</a>

# Powering the largest edge ecosystem with MLOps

**80,000+**

Developers

**185,000+**

Projects

**5,000+**

Enterprises

TRUSTED BY LEADING ENTERPRISES

ŌURA

ADVANTECH

 poly



SONY



# Any sensor, any data, any use case

	Ultra low power	Low-end MCU	High-end MCU	NPU	MPU	GPU
Memory	Anomaly detection 10kB	Sensor fusion classification 18kB	Audio classification 50kB	Image classification 256kB	Complex image or voice 1MB+	Video classification 1GB+
Sensor	✓	✓	✓	✓	✓	✓
Audio	✓	✓	✓	✓	✓	✓
Image			✓	✓	✓	✓
Video					✓	✓

# A paradigm shift

## Traditional programming

Data

+

Rules

Adapt the rules

```
Blink §
This example code is in the public domain.
http://www.arduino.cc/en/Tutorial/Blink

// the setup function runs once when you press reset or power the board
void setup() {
  // initialize digital pin LED_BUILTIN as an output.
  pinMode(LED_BUILTIN, OUTPUT);
}

// the loop function runs over and over again forever
void loop() {
  digitalWrite(LED_BUILTIN, HIGH); // turn the LED on (HIGH is the voltage level)
  delay(1000); // wait for a second
  digitalWrite(LED_BUILTIN, LOW); // turn the LED off by making the voltage LOW
  delay(1000); // wait for a second
}
```

Outcomes

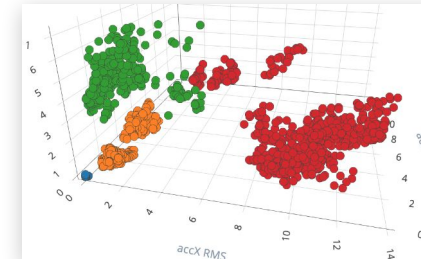
## Machine learning

Data

+

Outcomes

Collect more data



Rules

# Machine Learning

## Supervised learning

Task-driven

- Regression
- Classification
- Object detection

## Unsupervised learning

Data-driven

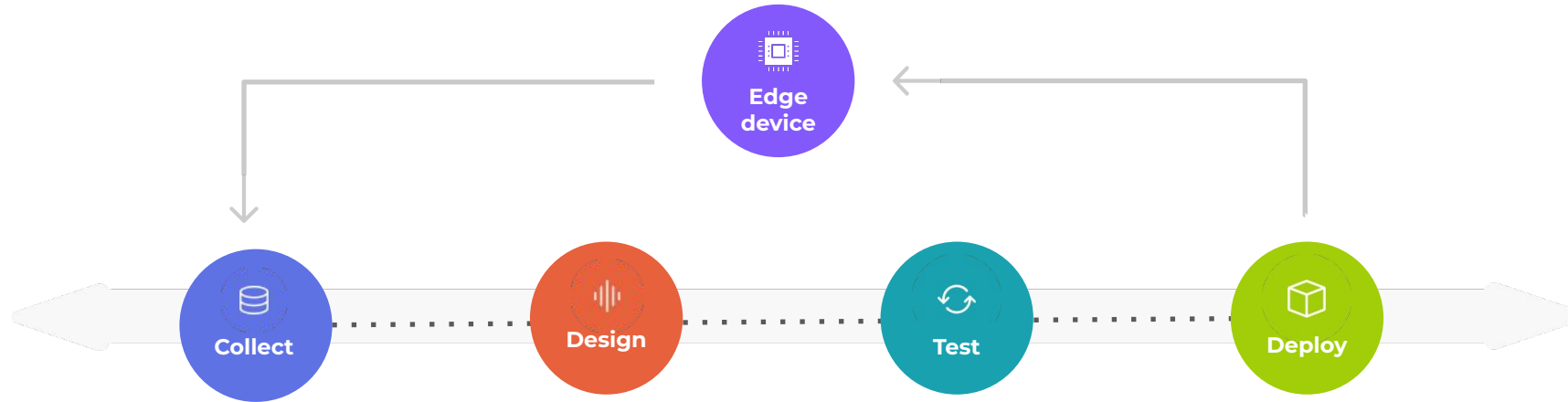
- Clustering
- Segmentation
- Anomaly detection

## Reinforcement learning

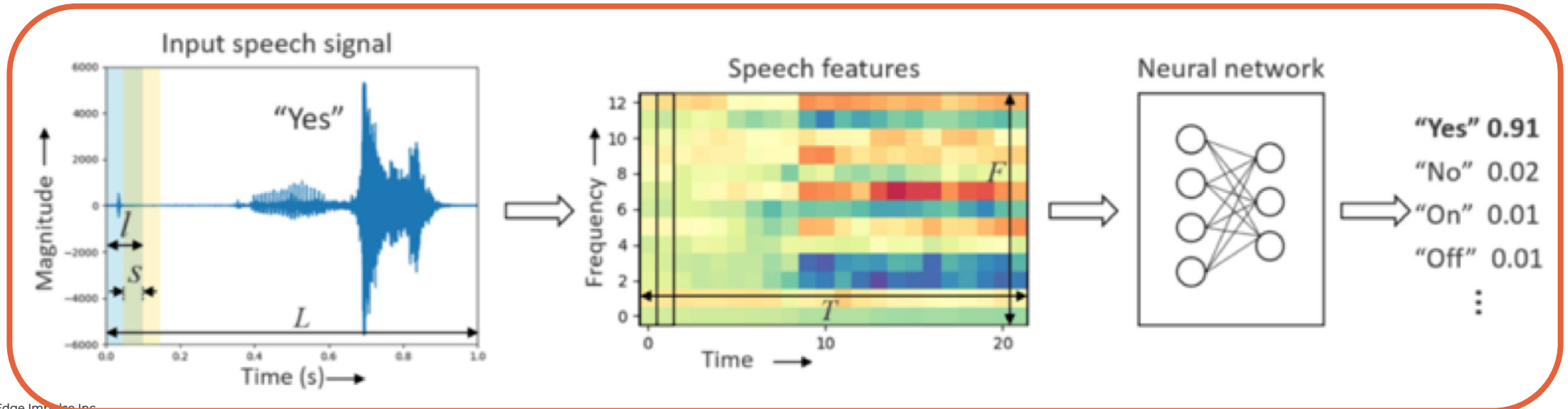
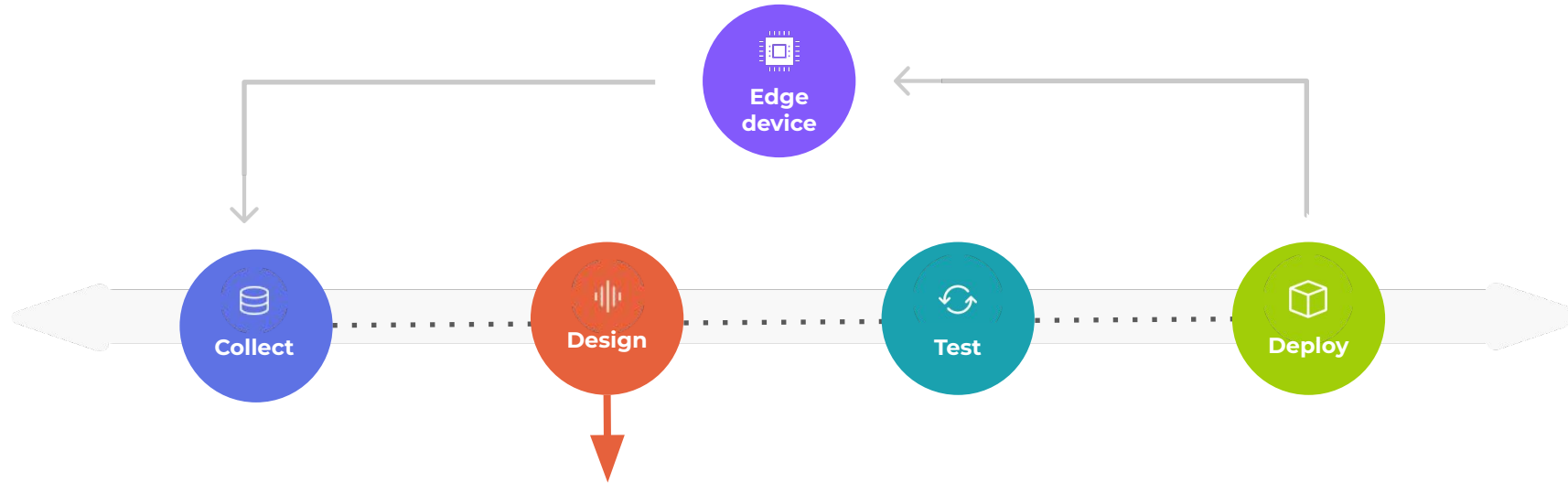
Learn from experience

- Robotics
- Games
- Recommender systems

# Embedded machine learning



# Embedded machine learning

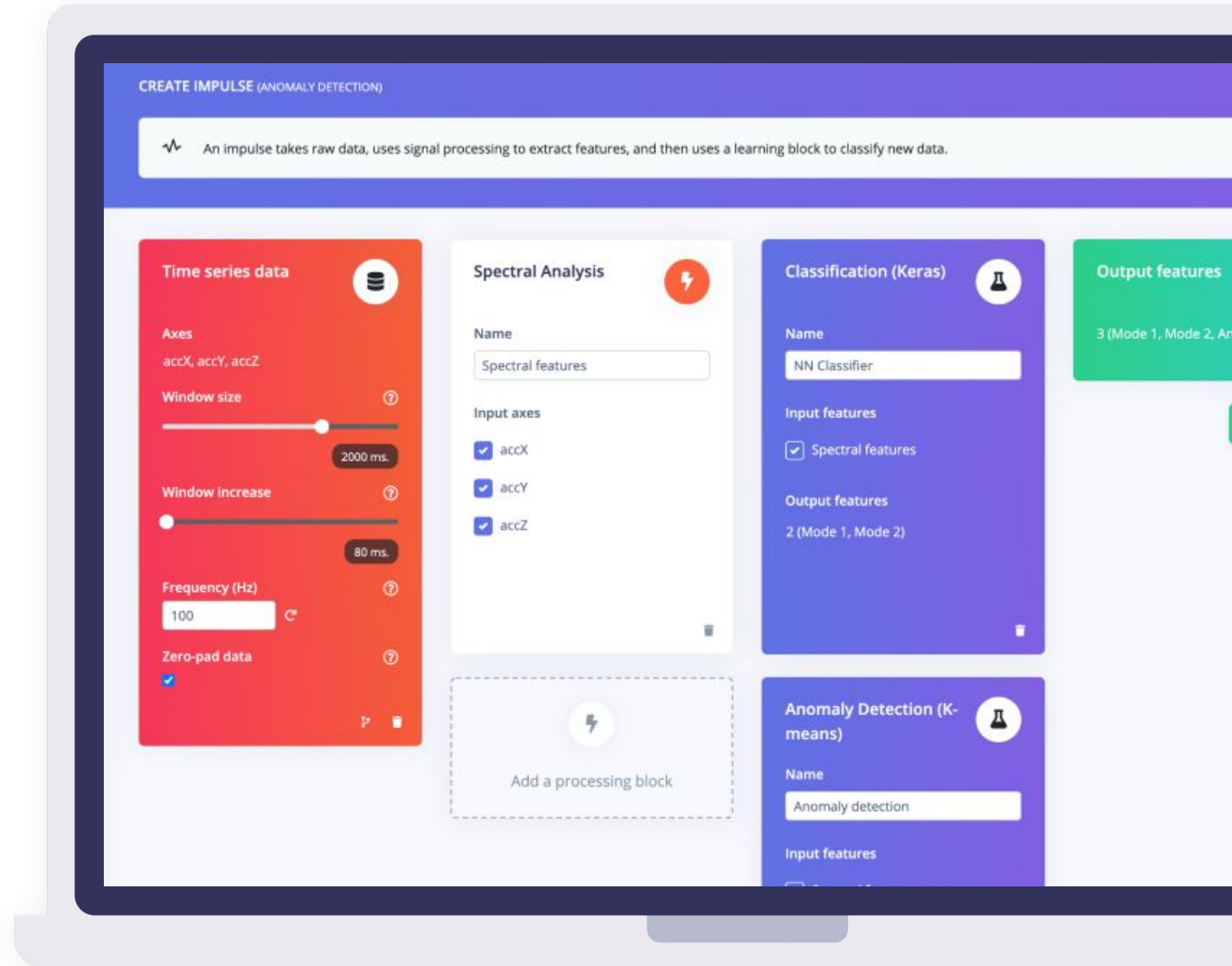


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# Studio Overview

# Developer-first integrated ML platform

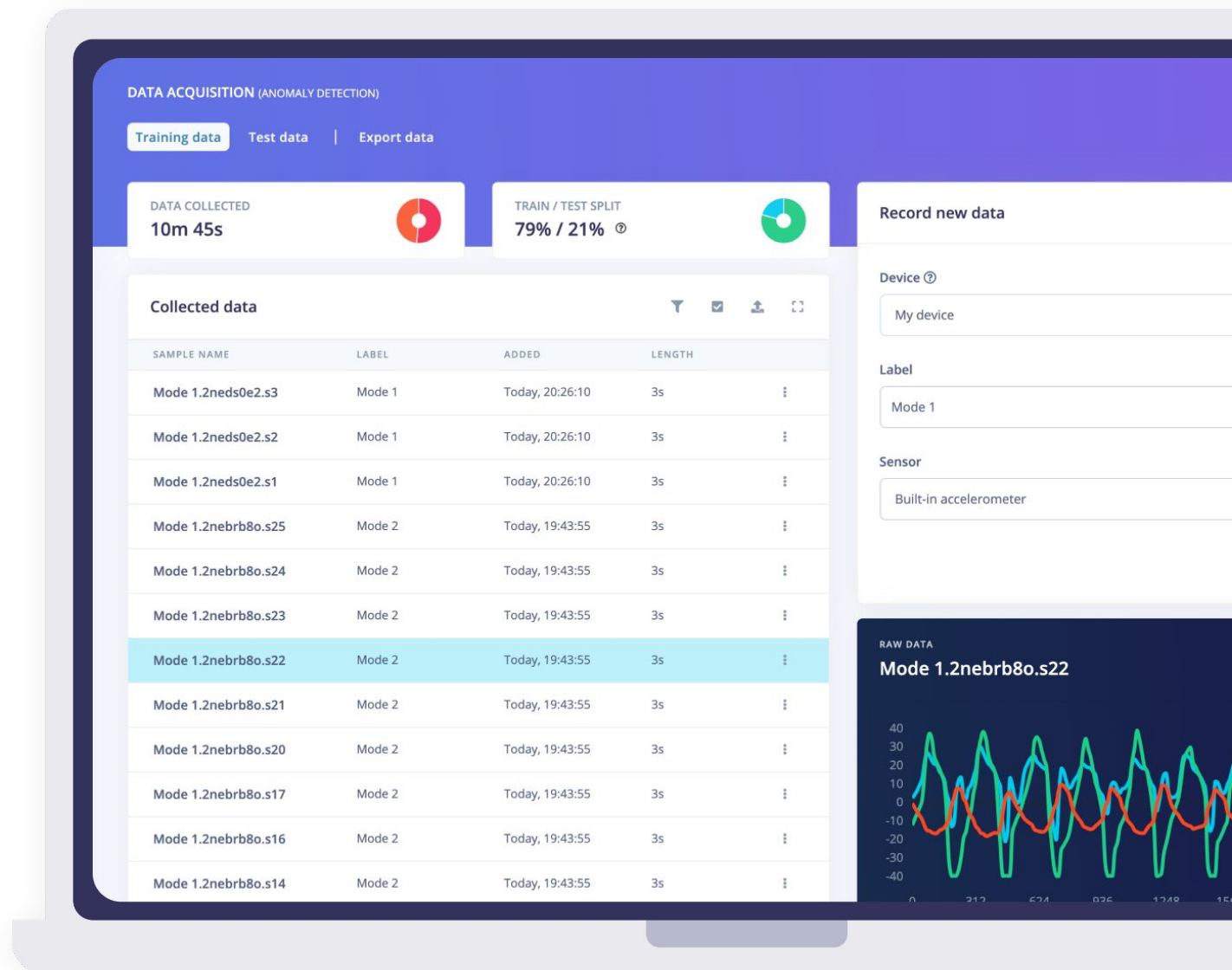
- Royalty-free business model, therefore no impact on BOM cost
- Your IP, stays your IP
- Total explainability, no black boxes



Collect

# Build valuable datasets at scale

- The infrastructure ML teams need
- Auto-labeling tools
- Integrations with most widely used data science tools
- Strong data traceability and quality control
- Secure data exchange portal

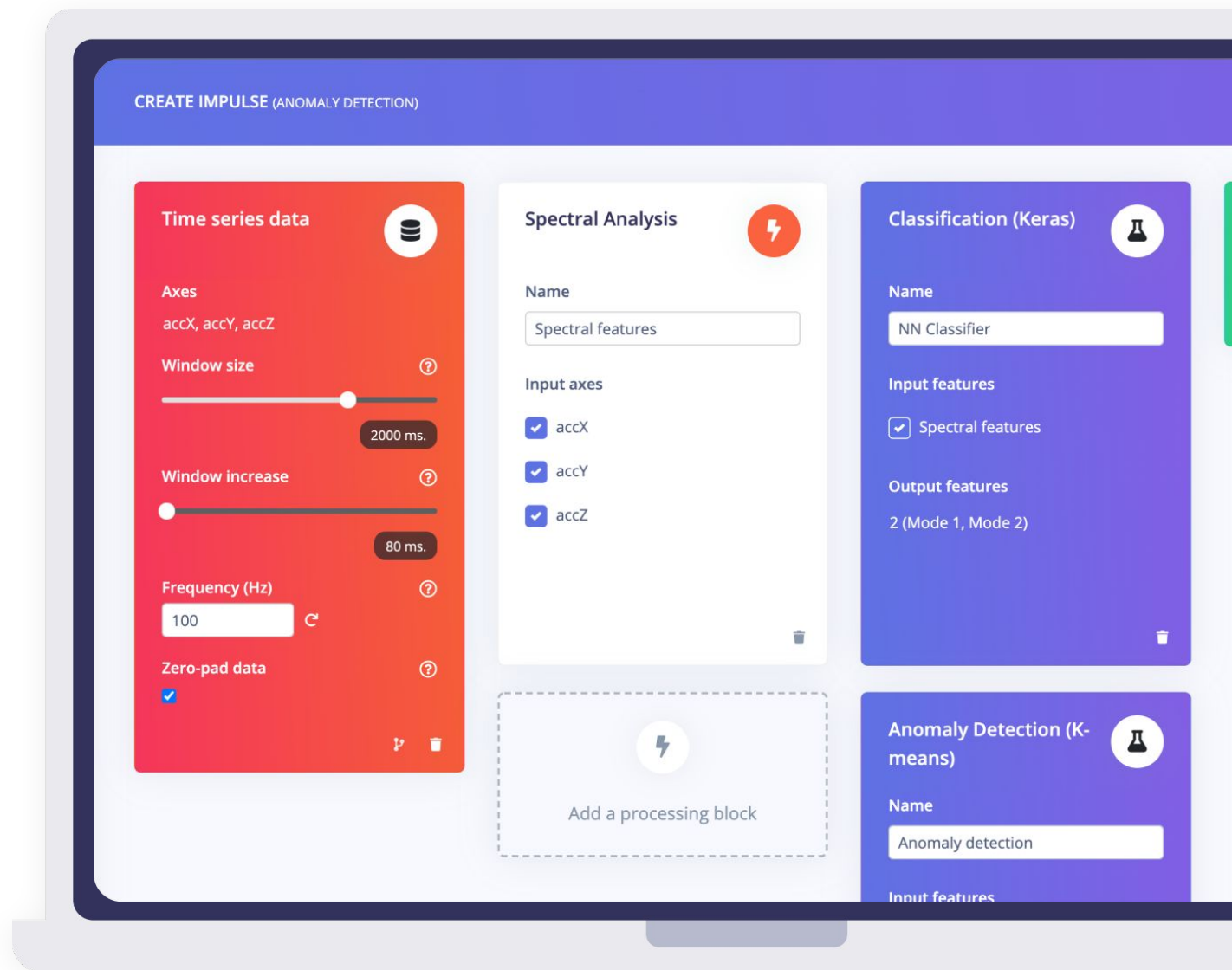




## Design

# Advanced algorithm and ML expertise

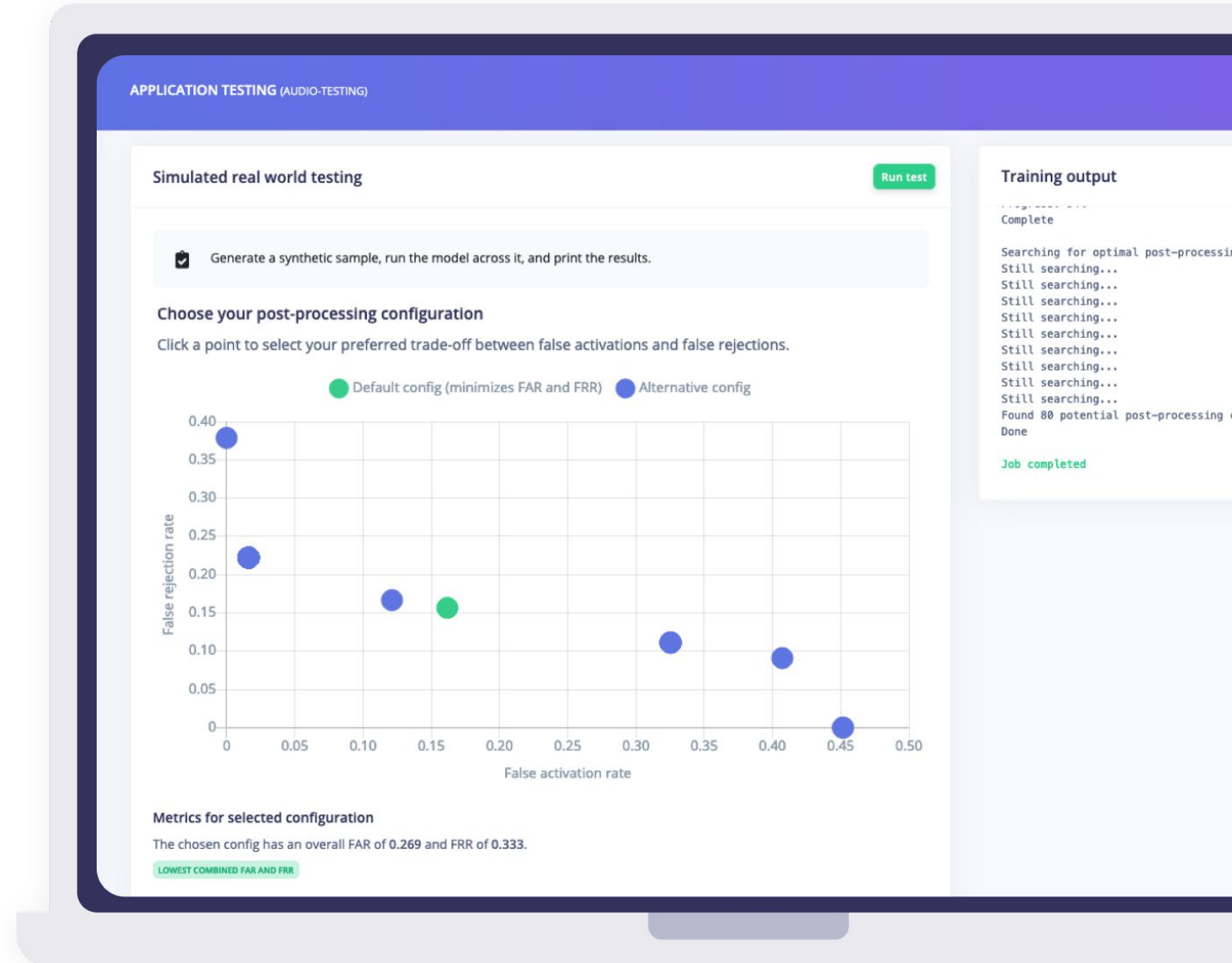
- Advanced algorithm and DSP expertise
- No black boxes
- Explainable AutoML
- Knowledge sharing and collaboration between teams



Test

# Go to market faster, with confidence

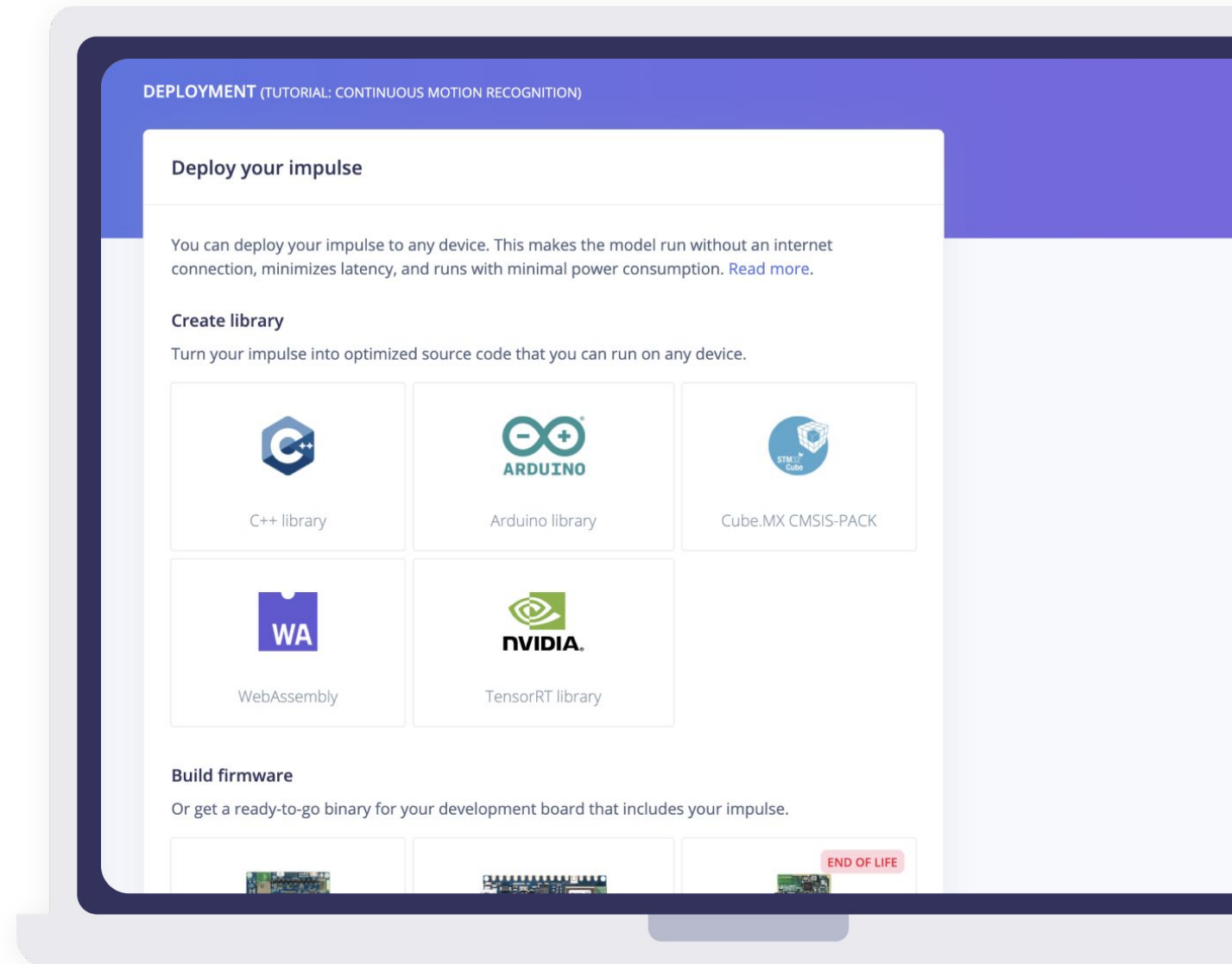
- Hardware-aware development
- Full visibility across the whole ML pipeline
- Test your development against 24hrs of real world data
- Tune the post-processing algorithm to perform optimally



## Deploy

# Deploy to any edge device with ease

- The largest silicon ecosystem
- Award-winning compiler
- Get access to full source code
- Full firmware integration for a number of devices
- Digital twin for performance profiling and analysis
- Enable brownfield and future greenfield



- Getting Started
- Getting Started: Next Steps
- API and SDK references
- What is embedded ML, anyway?
- Frequently asked questions

#### EDGE IMPULSE STUDIO

- Dashboard
- Devices
- Data sources
- Data acquisition >
- Data explorer
- Impulse design
- Bring your own model (BYOM)
- Processing blocks >
- Learning blocks >
- EON Tuner >
- Retrain model
- Live classification
- Model testing
- Performance calibration

## SiLabs xG24 Dev Kit

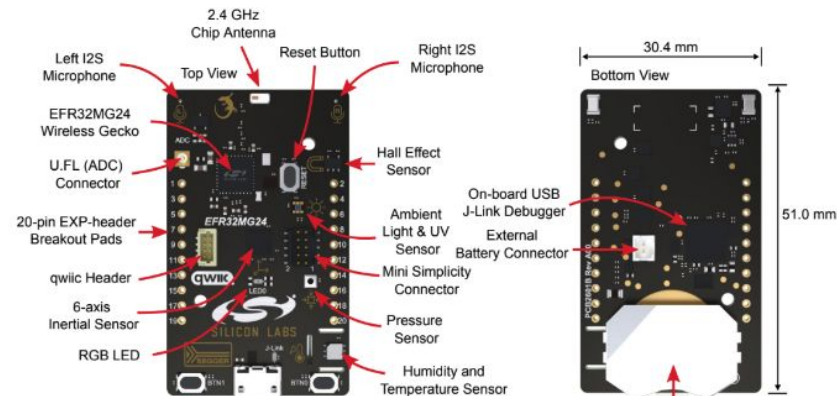
The Silicon Labs xG24 Dev Kit (xG24-DK2601B) is a compact, feature-packed development platform built for the EFR32MG24 Cortex-M33 microcontroller. It provides the fastest path to develop and prototype wireless IoT products. This development platform supports up to +10 dBm output power and includes support for the 20-bit ADC as well as the xG24's AI/ML hardware accelerator. The platform also features a wide variety of sensors, a microphone, Bluetooth Low Energy and a battery holder - and it's fully supported by Edge Impulse! You'll be able to sample raw data as well as build and deploy trained machine learning models directly from the Edge Impulse Studio - and even stream your machine learning results over BLE to a phone.

The Edge Impulse firmware for this development board is open source and hosted on GitHub: [edgeimpulse/firmware-silabs-xg24](https://github.com/edgeimpulse/firmware-silabs-xg24).

[Export as PDF](#)[Copy link](#)

#### ON THIS PAGE

- Installing dependencies**
- Updating the firmware
- Connecting to Edge Impulse
- Bluetooth Demo
- Next steps: Build a machine lear...



<https://docs.edgeimpulse.com/docs/development-platforms/officially-supported-mcu-targets/silabs-xg24-devkit>

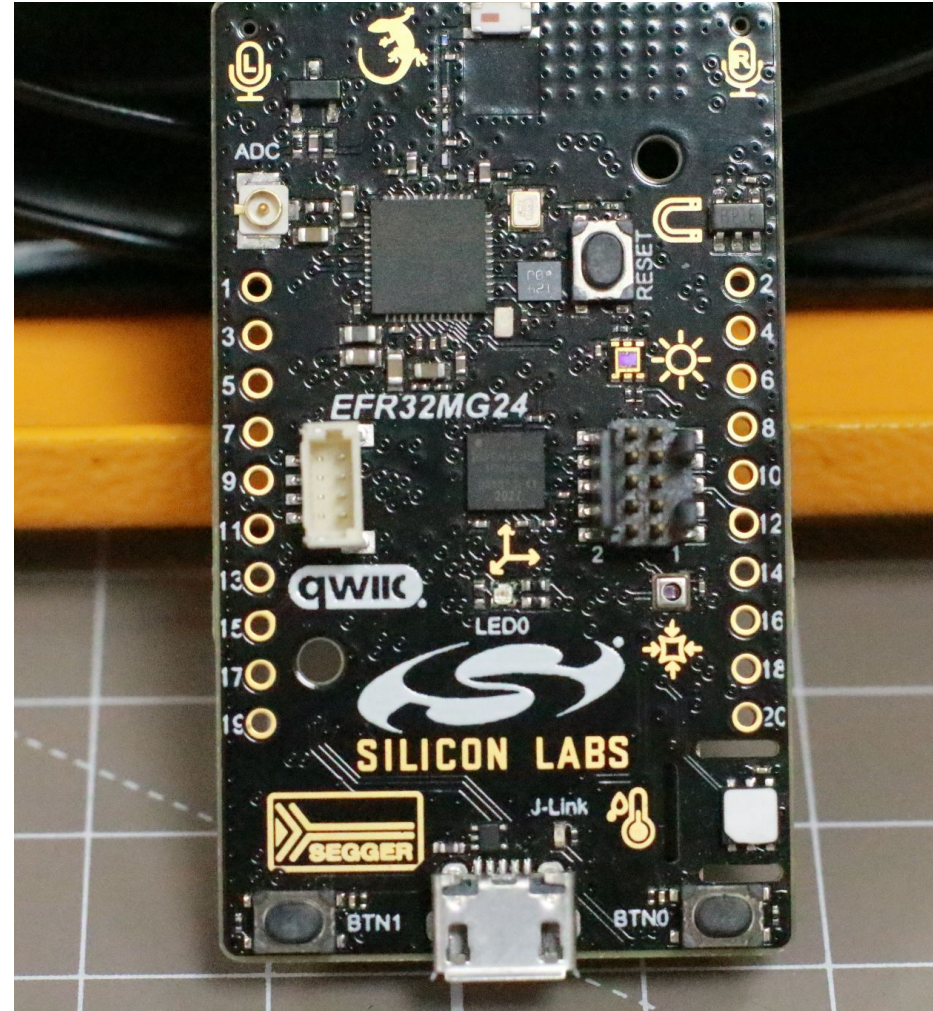
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# Condition Monitoring vs Predictive Maintenance



# Condition Monitoring vs Predictive Maintenance

- **Condition monitoring** is the process of continuously monitoring the condition of assets in real-time to identify existing or emerging faults
- **Predictive maintenance** is a strategy that uses data analysis and modeling to predict when maintenance should be performed.



Silicon Labs xG24 placed beside a Solder Extractor Fan

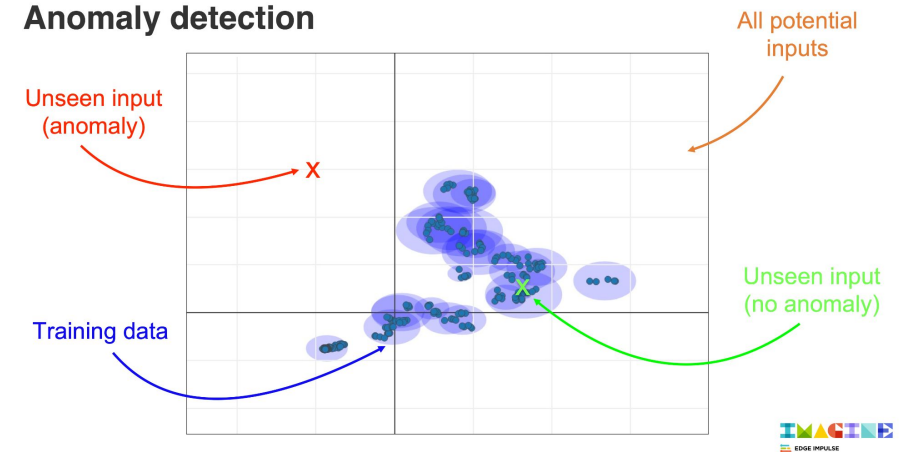
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# Condition Monitoring - Anomaly detection

# Anomaly Detection

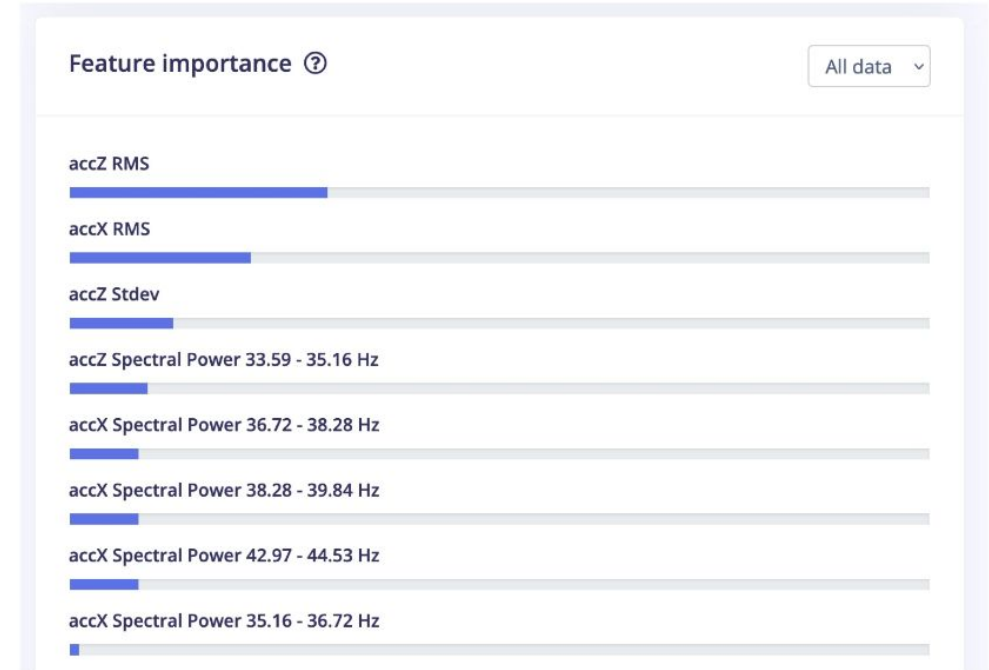
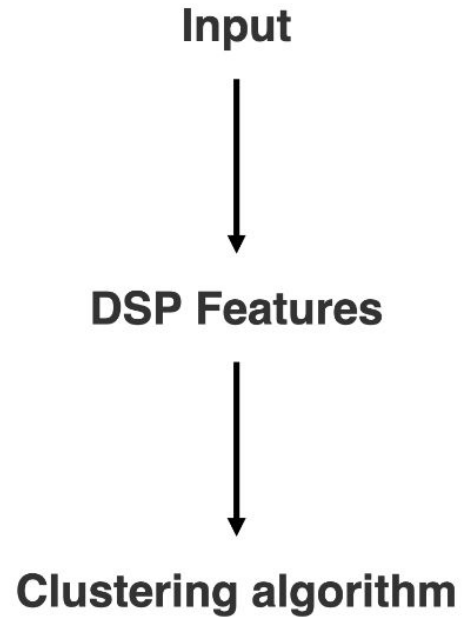
- Predictive maintenance can be aided by anomaly detection algorithms.
- Training classification models for classes where examples captured of idle states, nominal and introduced faults can build a strong base.

## Anomaly detection





# Anomaly detection today



*Great for basic sensor data  
for which you can reason about features*

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

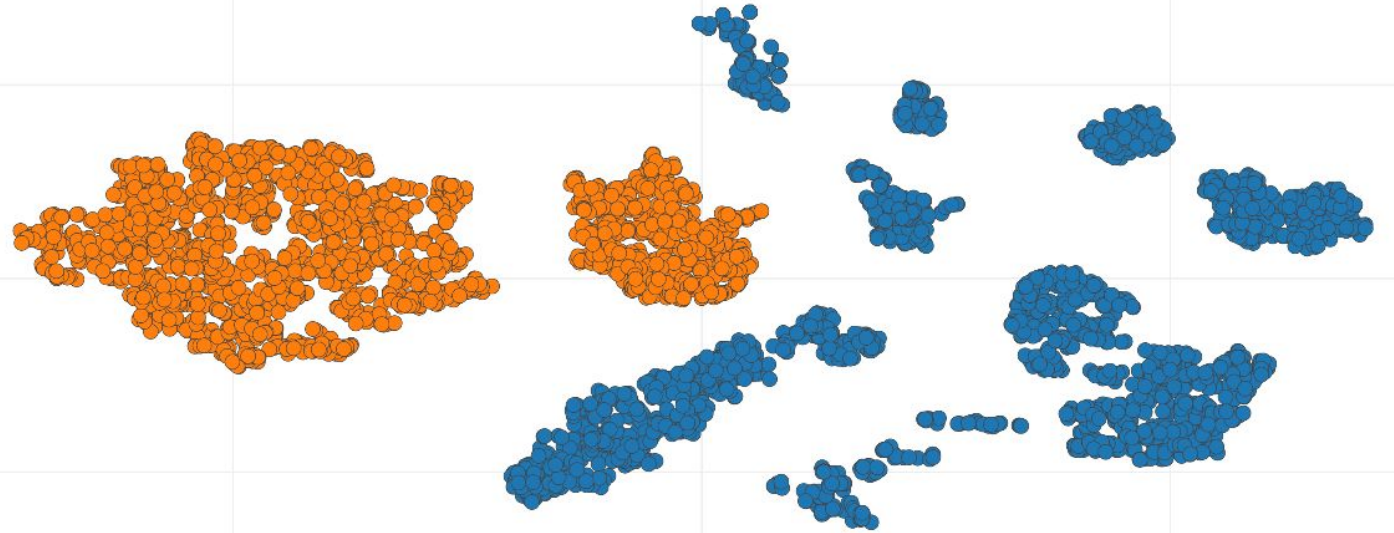
### Data explorer

The data explorer shows a complete view of all data in your project. You can clear labels through the menu on the right, and inspect or change labels by clicking on individual data items. [Learn more.](#)

Label colors:  Data labels  Predictions

- 00\_idle
- 01\_nominal

Save changes (0 pending)



- Dashboard
- Devices
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  - Create impulse
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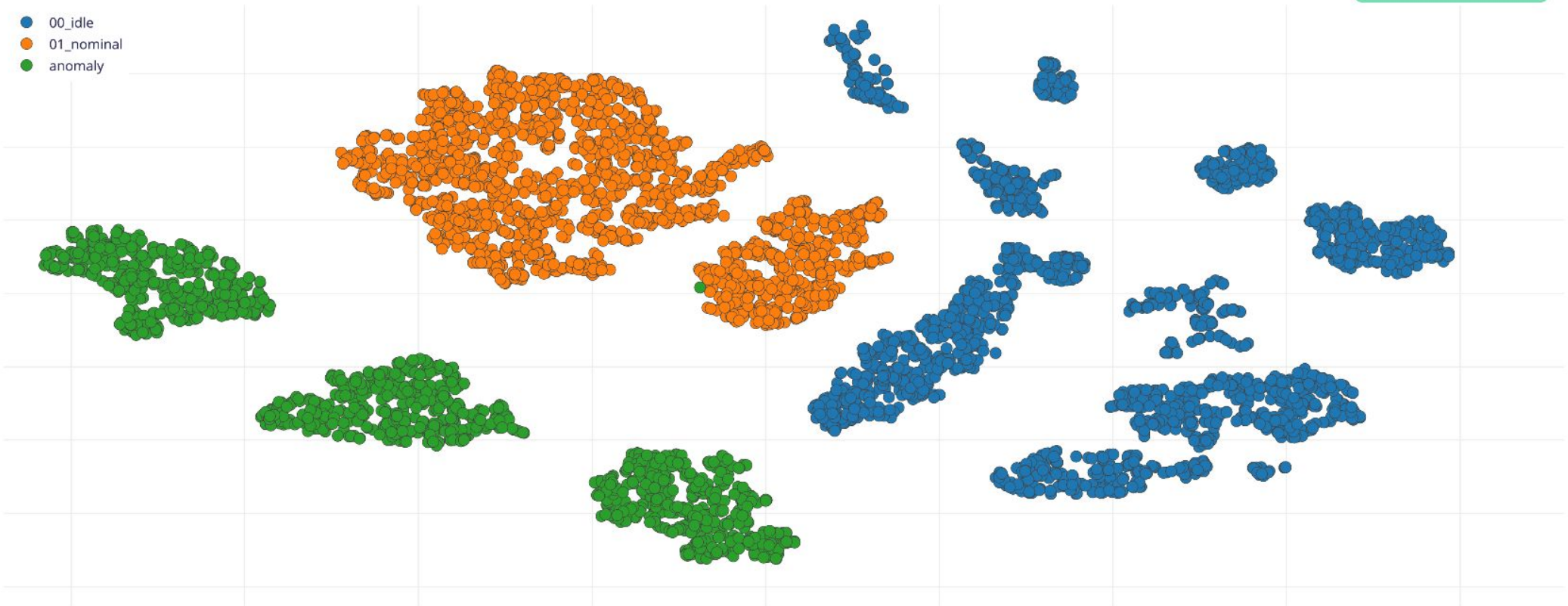
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Label colors:  Data labels  Predictions

- 00\_idle
- 01\_nominal
- anomaly

Save changes (0 pending)



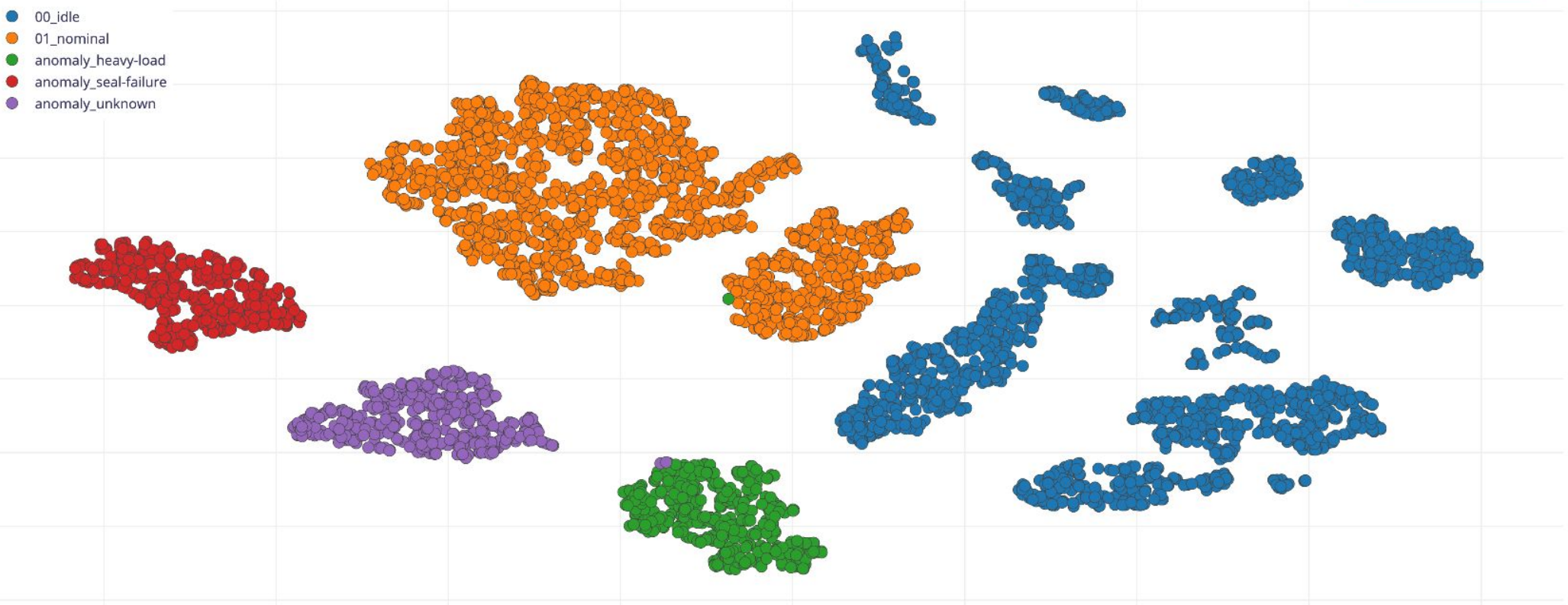
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# Predictive Maintenance - Transfer Learning

# Audio Event Detection

- **Audio events** detected in other models can help identify similar types in another e.g. engine sounds used in the type of engine may help identify our idling one.

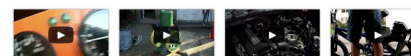
{ |||| } AudioSet

Ontology > Sounds of things >

## ↩ Engine

The sound of a machine designed to produce mechanical energy. Combustion engines burn a fuel to create heat, which then creates a force. Electric motors convert electrical energy into mechanical motion. Other classes of engines include pneumatic motors and clockwork motors.

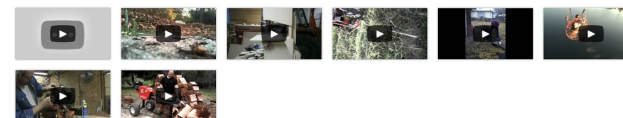
[16,245 annotations in dataset](#)



### Light engine (high frequency)

The sound of a small engine such as a toy car, sewing machine, or moped.

[433 annotations in dataset](#)



### Medium engine (mid frequency)

The sound of a moderately-sized engine such as that which powers a motorcycle, sedan, or small truck.

[6,132 annotations in dataset](#)



# Public Project: Machine Health and Condition Monitoring

 **EDGE IMPULSE**

 Dashboard

 Devices

 Data acquisition

 Impulse design

 Create impulse

 MFE

 Classifier

 EON Tuner

 Retrain model

 Live classification

 Model testing

 Performance calibration

 Versioning

 Deployment

GETTING STARTED

 Documentation

 Forums

Launchpad

Eoin /

## Machine health and condition monitoring using Edge Impulse platform.

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

 KEYWORD SPOTTING

 + New tag

### Getting started

Start building your dataset or validate your model's on-device performance:



Add existing data



Collect new data



Upload your model

### Start with a tutorial

Not sure where to start? Follow a tutorial to build your first model in just minutes!



### Sharing

Your project is private.

 Make this project public

### Collaborators (1/4)



Eoin **OWNER**

### Summary



DEVICES CONNECTED

# W/

AIML-102

## Q&A

Eoin Jordan





# W/

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## Thank you!

Eoin Jordan | [eoin@edgeimpulse.com](mailto:eoin@edgeimpulse.com)



# References

## Documentation:

- WW23 Condition Monitoring Public Project:  
<https://studio.edgeimpulse.com/studio/267189>
- SiLabs xG24 Dev Kit:  
<https://docs.edgeimpulse.com/docs/development-platforms/officially-supported-mcu-targets/silabs-xg24-devkit>
- Feature Importance:  
<https://docs.edgeimpulse.com/docs/edge-impulse-studio/learning-blocks/anomaly-detection#features-importance-optional>
- Anomaly Detection:  
<https://docs.edgeimpulse.com/docs/edge-impulse-studio/learning-blocks/anomaly-detection>
- xG24 Firmware:  
<https://github.com/edgeimpulse/firmware-silabs-xg24>
- xG24 Workshop Notes:  
<https://github.com/edgeimpulse/workshop-silabs-xg24-dev-kit>

## Tutorials:

- Advanced Anomaly Detection with Edge Impulse (Custom DSP Blocks, Feature Importance):  
[https://www.youtube.com/watch?v=7vr4D\\_zlQTE](https://www.youtube.com/watch?v=7vr4D_zlQTE)
- Edge Impulse Imagine 2022: Silicon Labs MG24 Wireless SoC Demo:  
<https://www.youtube.com/watch?v=ujMR84vLLvk>
- Edge Impulse Imagine 2022: Silicon Labs Tech Talk:  
<https://www.youtube.com/watch?v=bg9CRnWP6Co>
- Silicon Labs Works With 2021: Industrial Predictive Maintenance with Embedded Machine Learning:  
<https://www.youtube.com/watch?v=hhJN1r-sAgg>