tinyML® Summit

Miniature dreams can come true...

March 28-30, 2022 | San Francisco Bay Area

TINY
ML
www.tinyML.org

ADAPDIX

SensiML™

Suitability of TinyML for predictive maintenance in high-tech manufacturing

Prepared for TinyML Summit
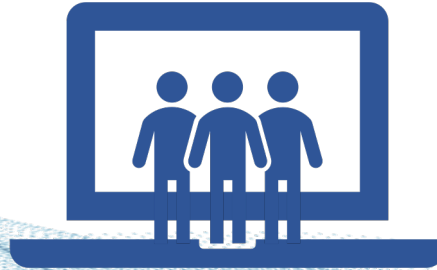
March 29th , 2022

Chris Knorowski, SensiML CTO

Steven Hauser, Adapdix Director of Product Management
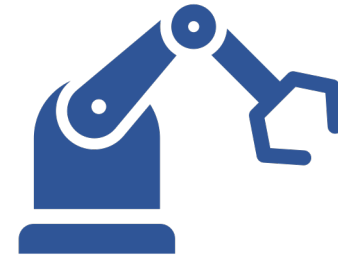
Introduction to SensiML

We Sell: TinyML toolkit for Smart Sensors

To: Application developers and system integrators

To enable: rapid development of novel applications for edge devices

SensiML Analytics Toolkit - Market Leading AutoML Technology for IoT Endpoint Algorithms

Introduction to Adapdix

We Enable
Next-level Operational
Efficiency & Cost Savings

45% Avg. Maintenance Savings

50% Avg. UDT Reduction

33% Avg. Cycle Time Savings

20% Avg. UPH Increase

Software For
Autonomous Operations

100's Exabytes of Data Ingested

2000+ Models Deployed

100,000+ Anomalies Resolved

100's of Machines Optimized

Benefitting
Global Leaders

2 of the largest, global
Semiconductor Manufacturers

Top 10 Semiconductor OEMs

Fortune 500 Communication
Companies

Adapdix Enables Autonomous Systems

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High-Tech Manufacturing Predictive Maintenance

Case Study

- A leading semiconductor manufacture to add predictive maintenance to a photonic optical alignment manufacturing process

The Challenge

- Unplanned downtime through unexpected equipment or process failure drives high cost and low OEE
- Identifying failure root causes in complex system is challenging without high visibility into all the processes

Implemented multistep process to prevent downtime and improve yield

- Identify issues with the current process leading to low yield

- Identify indications of equipment failure to prevent downtime

- Improved yield by increasing the throughput units/hour

- Once the manufacturing process is finalized, identify deviations/anomalies in behavior

The final solution was successfully deployed on over 100 machines in the factory

Successfully Increased throughput by over 50%

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SensiML™

Industrial AI: Advanced Analytics at Scale

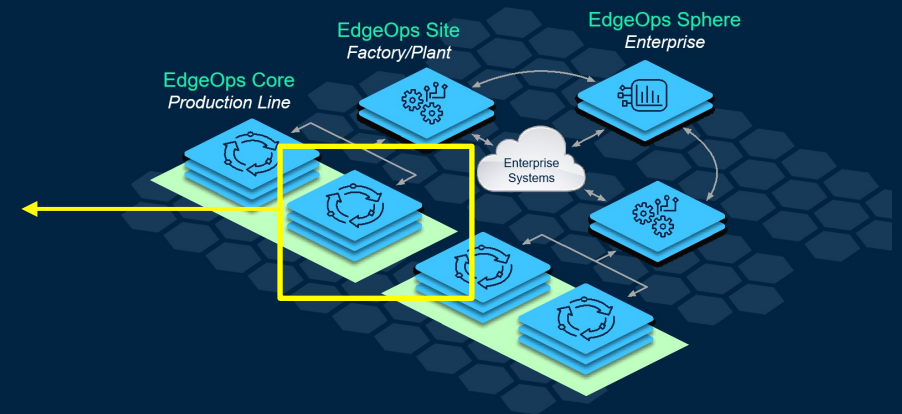Complex Integration, Data and Communications
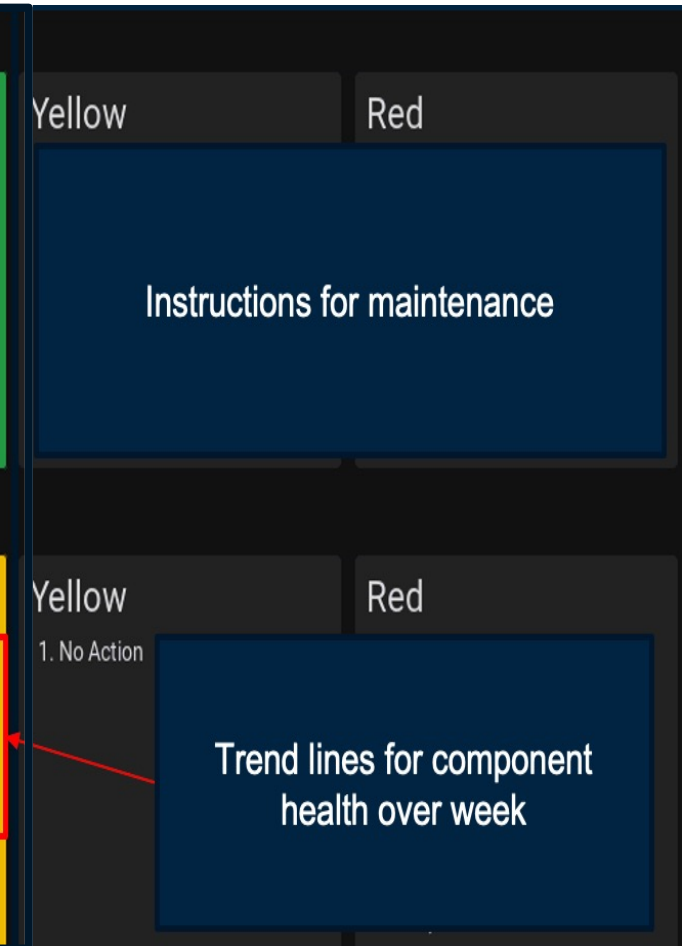
Where Does TinyML Fits into the Solution?

- Using **Adapdix EdgeOps Autonomous Systems Platform** to orchestrate data flow, analytics, monitoring and automate the tool workflow

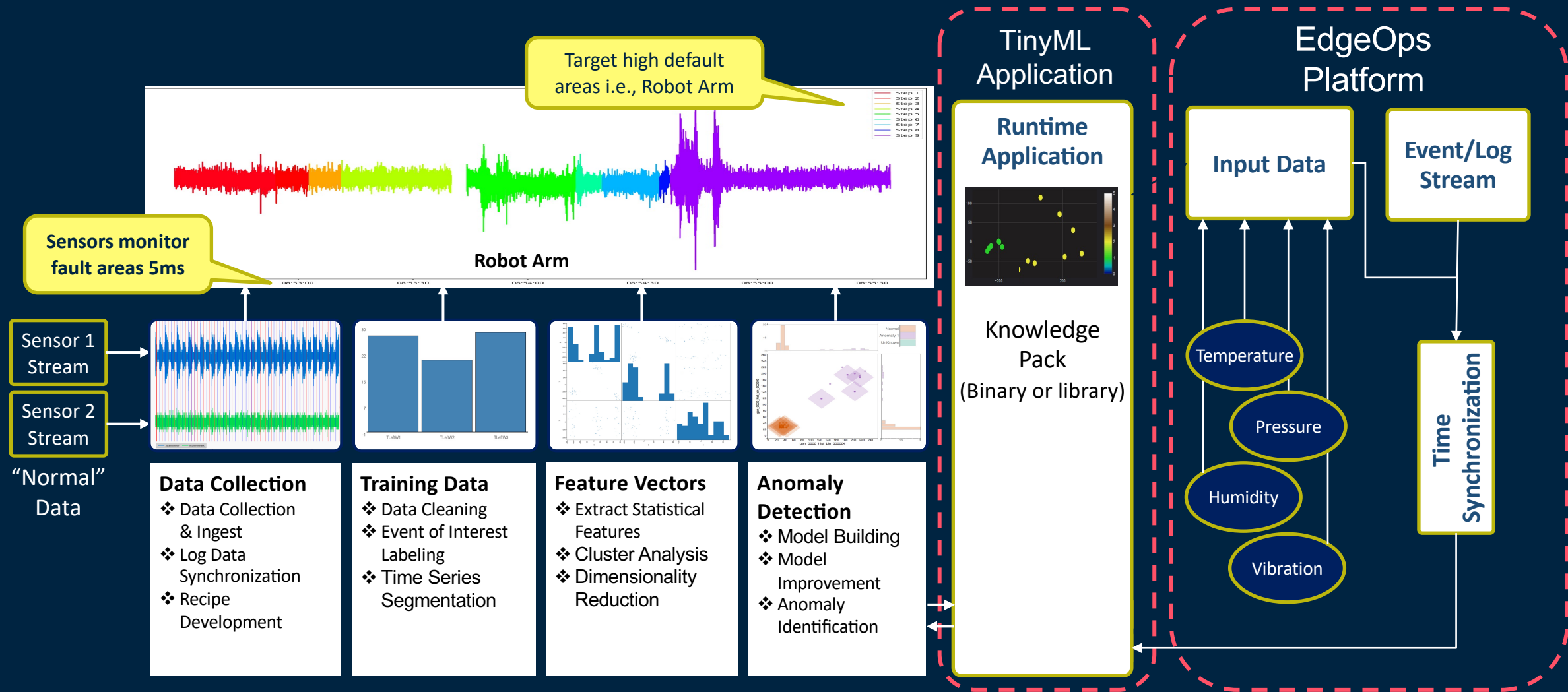- Used **SensiML** to build **TinyML** models for real-time time-series classification and anomaly identification

TinyML is only a part of the solution

Makes deploying models easier and provides flexibility in how close ML models can run to the sensor data

Allows you to run multiple models in commodity hardware in real-time

EdgeOps Site
Factory/Plant

EdgeOps Sphere
Enterprise

EdgeOps Core
Production Line

Enterprise
Systems

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SensiML

Architecture & TinyML Integration

SensiML Data Capture Lab: Data Curation Made Simple

Time-Series
Mark segment
others based o

Project Explorer
Lists all available data
collected and its status

Metadata Labeling
t classifications and
extual metadata

notation Window
ed visual cues about
ensor data waveforms

SensiML Analytics Studio: Efficient AutoML for Edge Sensing

Query Labeled Data
Easily Filter based on metadata

AutoML for Edge AI
Select Feature, algorithm parameters, Tune max model size

Model Visualization
Explore model parameters, visualize features, and model metrics

Test Model
Test Model and validate offline

Download Model
Download Library, Binary or Source code optimized for target device

SensiML Python SDK

- Programmatic access to model building
- Python API for data visualization and manipulation

Robot Arm Gestures

Model 1
Model 2
Model 3
• • • •
Model 9
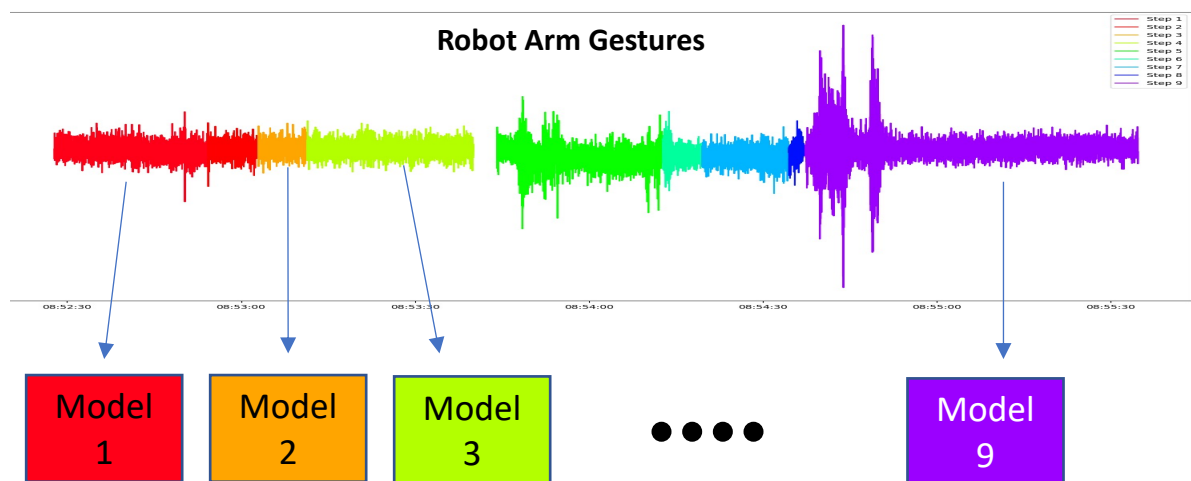
Pipelines 🔗

A pipeline is a container for a series of data processing steps. The pipeline object allows you to get an existing pipeline or create a new one with a given name. With this object, you can set input data sources, add transforms, feature generators, feature selectors, feature transforms and classifiers. An example pipeline is shown below.

Examples:

```
client.pipeline = 'my_pipeline'

client.pipeline.set_input_query('ExampleQuery')

client.pipeline.add_transform('Windowing')

# Feature Generation
client.pipeline.add_feature_generator(
    [
        {'subtype_call':'Time', 'params':{'sample_rate':100}},
        {'subtype_call':'Rate of Change'},
        {'subtype_call':'Statistical'},
        {'subtype_call':'Energy'},
        {'subtype_call':'Amplitude', 'params':{'smoothing_factor':9}}
```
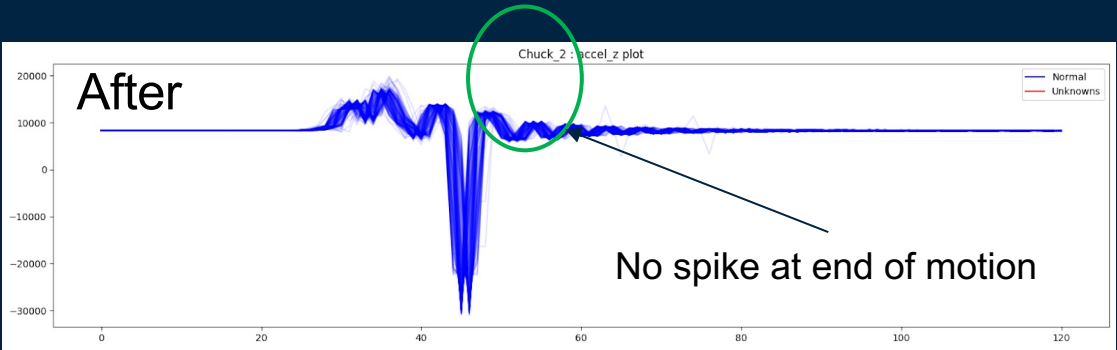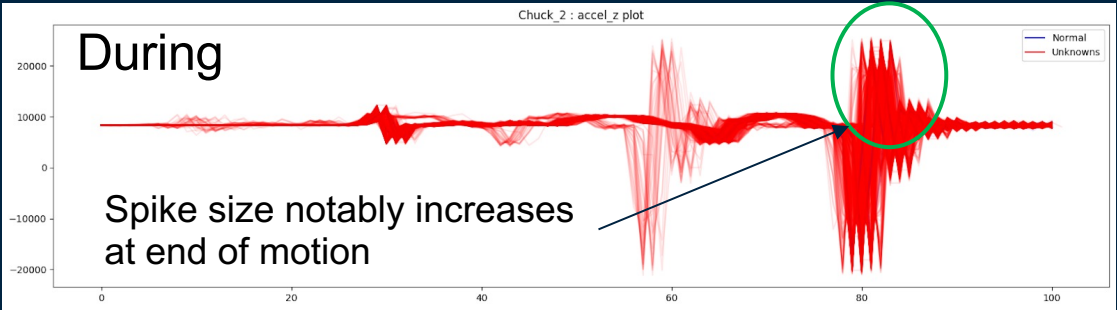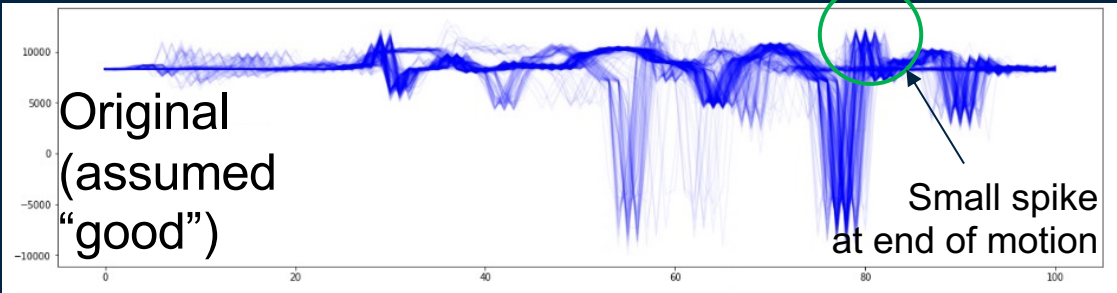
Multi Model Knowledge Pack

If you want to download multiple Knowledge Packs at once you will need to use the programmatic interface. Models can either be Parent or Children Models. Parent models require a **source**. Children models require a **segmenter_from** and **parent** flag. Optional flags are **results** which allows a **Child** model to be called depending on the output of a Parent model.

The model graphs are defined in the kb_description. The format for multiple parent models is as follows:

```
{
    "MODEL_1": {
        "source": "<CAPTURE CONFIG UUID>",
        "uuid": "<Model UUID>"
    },
    "MODEL_2": {
        "source": "<CAPTURE CONFIG UUID>",
        "uuid": "<Model UUID>"
    },
    "MODEL_3": {
        "source": "<CAPTURE CONFIG UUID>",
        "uuid": "<Model UUID>"
    }
}
```
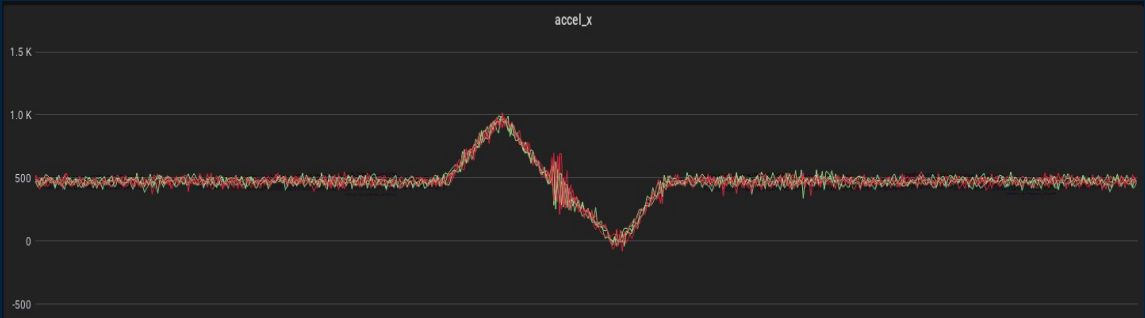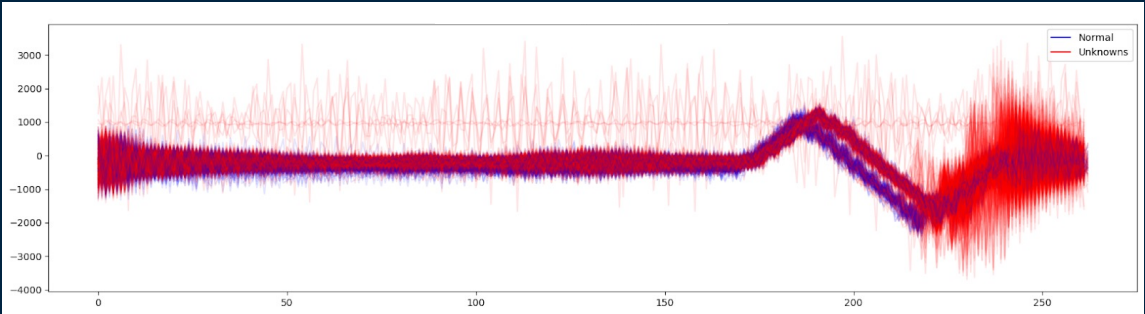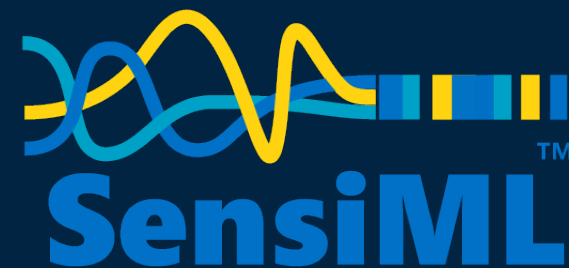
Preventative Maintenance Around Equipment Motion

Pneumatic Actuators

Original (assumed "good")

Small spike at end of motion

During

Spike size notably increases at end of motion

After

No spike at end of motion

Linear Motor Stage

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Additional Detail

Unit-level Fault Traceability

Parameter: Pressure

Parameter: Electrical Current

Tag, correlate, monitor and trace unit-level faults/anomalies for any parameter(s)

Parameter: Absolute Positions
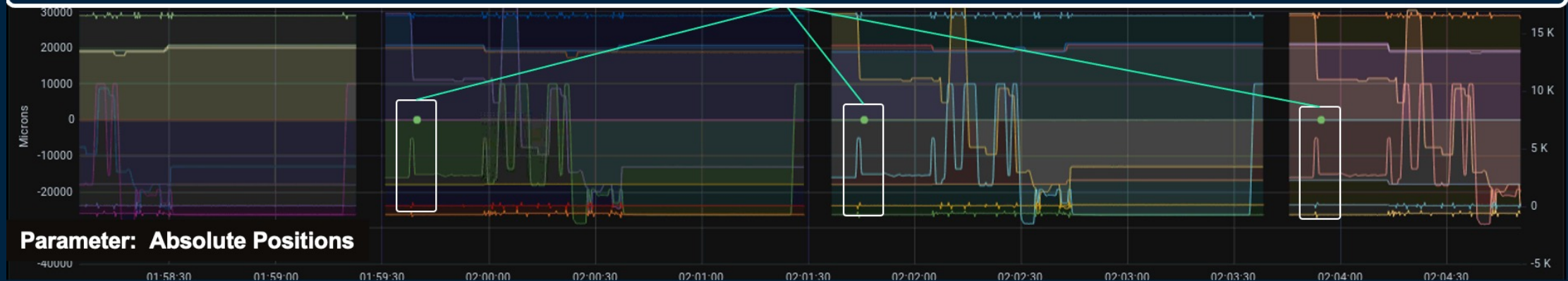
Vibration Use Cases

SensiML Data Capture Lab: Data Collection and Validation

- Capture Sensor Data:
    - WiFi/TCP/IP
    - BLE
    - USB Serial Port
    - Import CSV, WAV
- Easily Collect Metadata
- Programmable File Naming
- Live Labeling
- Real Time Model Validation
- Video Capture/Syncrhonization
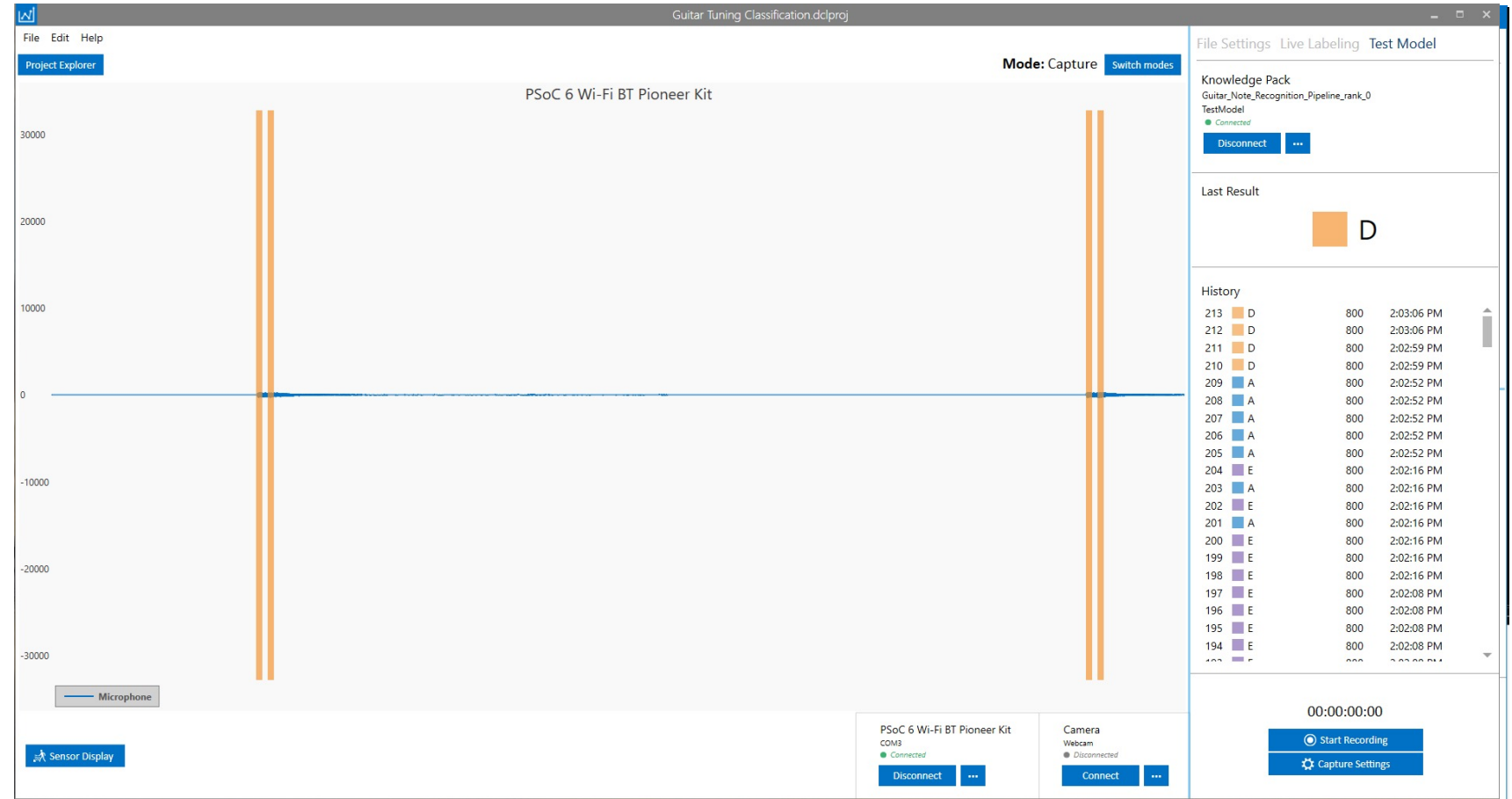
EdgeOps Platform: Key Features & Benefits

Features

Millisecond Synchronization and Stitching of IT and OT Data

No-Code Configuration, Reporting, Alerts, and Analytics

Separated, but Integrated Computing and Storage

Optimized Data Routing across Edge and Cloud Endpoints

Benefits

Autonomous systems control minimizes waste, improves throughput

Easy to use, up to the second visibility saves time and money.

Optimizes your Hybrid Cloud environment to reduce costs while increasing visibility

Reduces costs of infrastructure and storage

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SensiML

Equipment Improvement Area

Improvement approach:
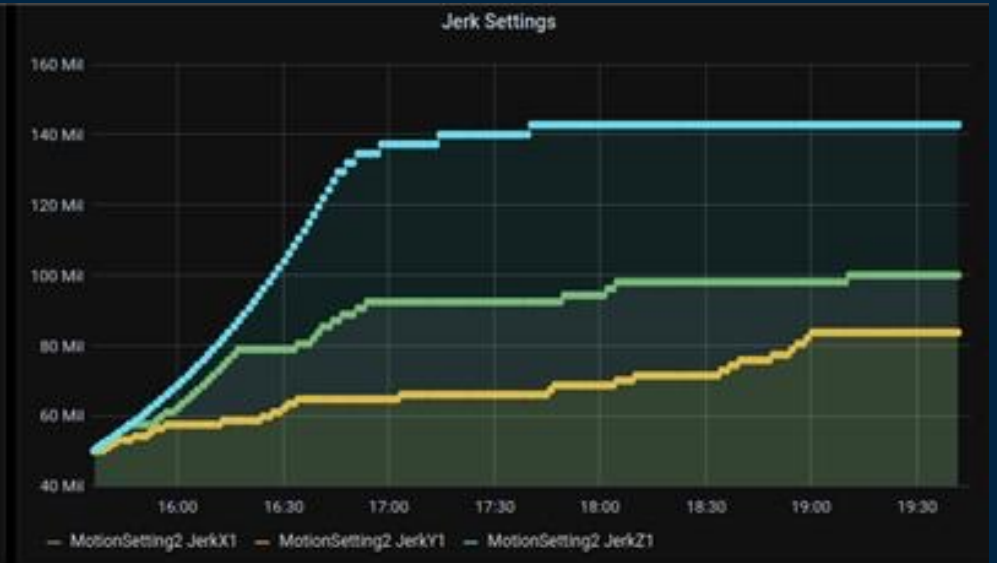
- Model Power readings
- Alert if anomalies exceed 15%

Benefit:

- Decrease downtime due to Low Power

Adaptive Controls

EdgeOps Feedback

Equipment Changes

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