tinyML® EMEA

Enabling Ultra-low Power Machine Learning at the Edge

tinyML EMEA Technical Forum 2021 Proceedings

June 7 – 10, 2021

Virtual Event

www.tinyML.org

tinyML® Talks

Enabling Ultra-low Power Machine Learning at the Edge

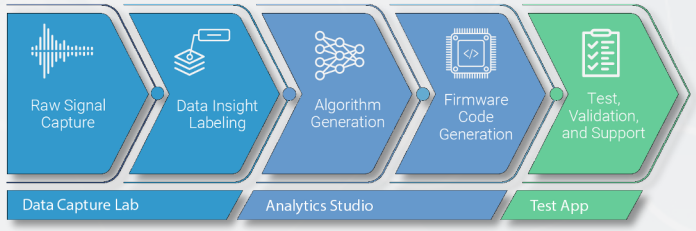
"Building Heterogeneous TinyML Pipelines"

Chris Knorowski – SensiML Corporation

June 7, 2021

www.tinyML.org

Introduction to SensiML



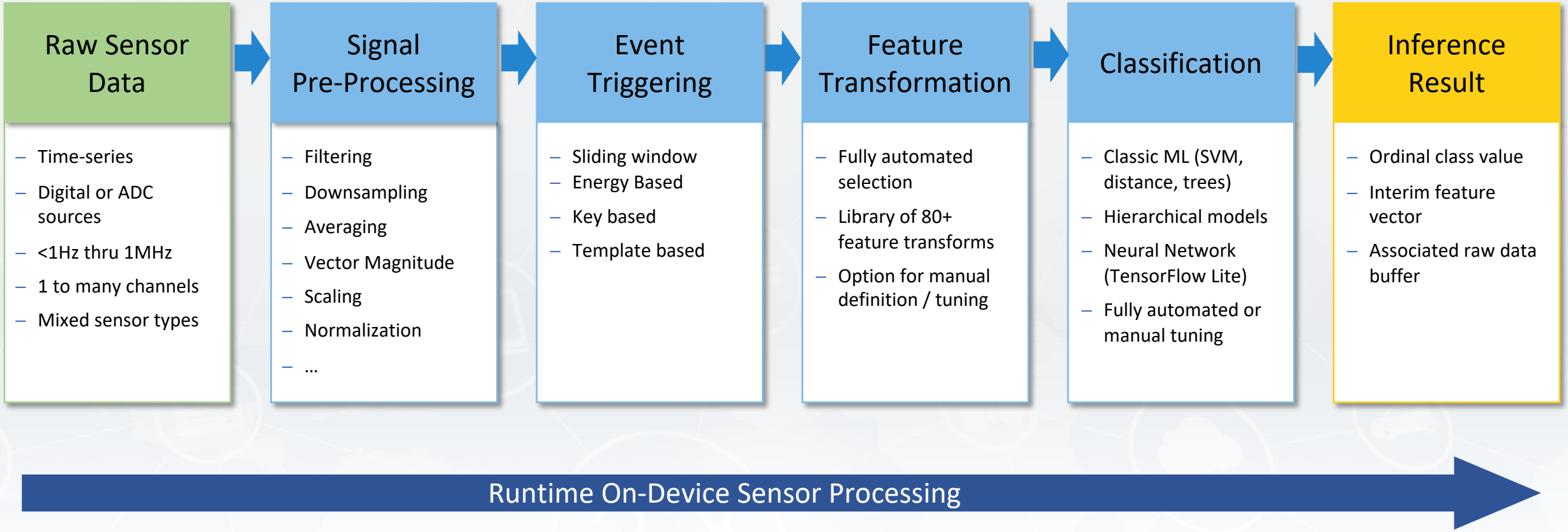
We Sell: TinyML toolkit for Smart Sensors

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

SensiML Embedded SDK – Easily build edge optimized ML pipelines



Why Heterogeneous models are good for TinyML

Single Model

- Computes all features at once
- Single Large model to identify all classes at once
- Difficulty dealing with imbalanced data

Heterogeneous Model

- Computes features as needed for classification
- Has smaller classifiers solving simpler problems
- Can help when you have imbalanced data sets
- ***More complex to deploy***

Example Use Cases

- Activity Recognition + Detailed Analysis (IMU)
- Mixed Sample Rate (Audio + IMU)

An Example: Virtual Coaching Wearable

9-DOF IMU

Walking

Running

Resting

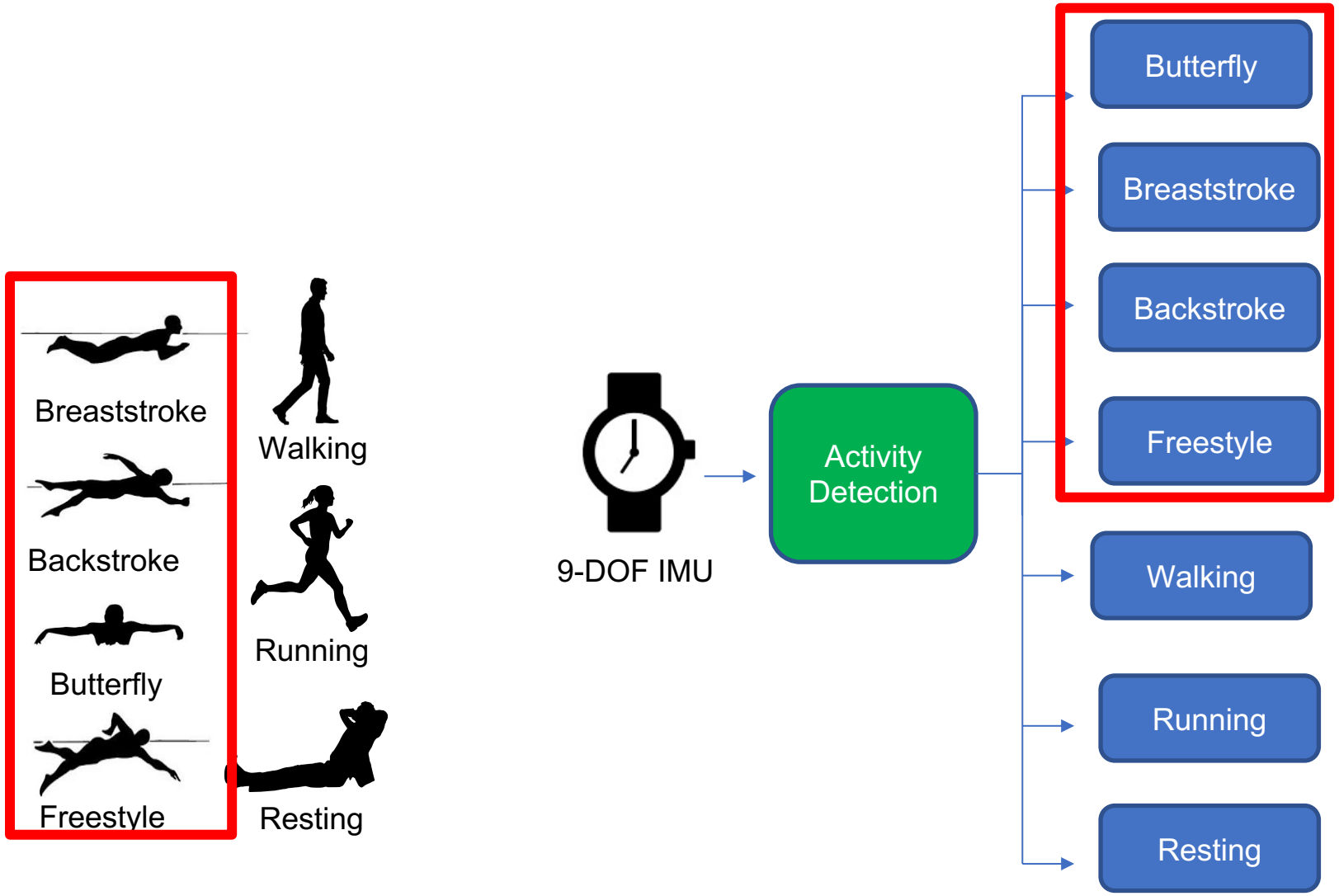
Breaststroke

Backstroke

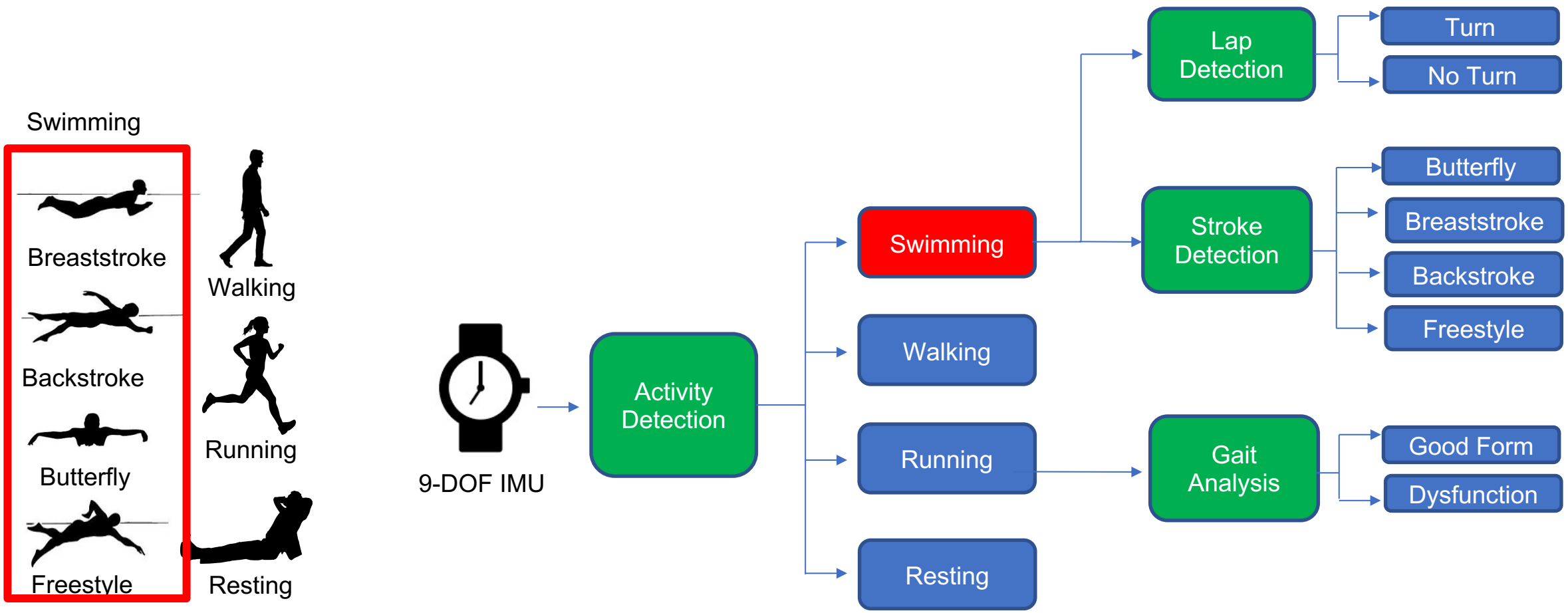
Butterfly

Free Style

Virtual Coaching Wearable Single Model



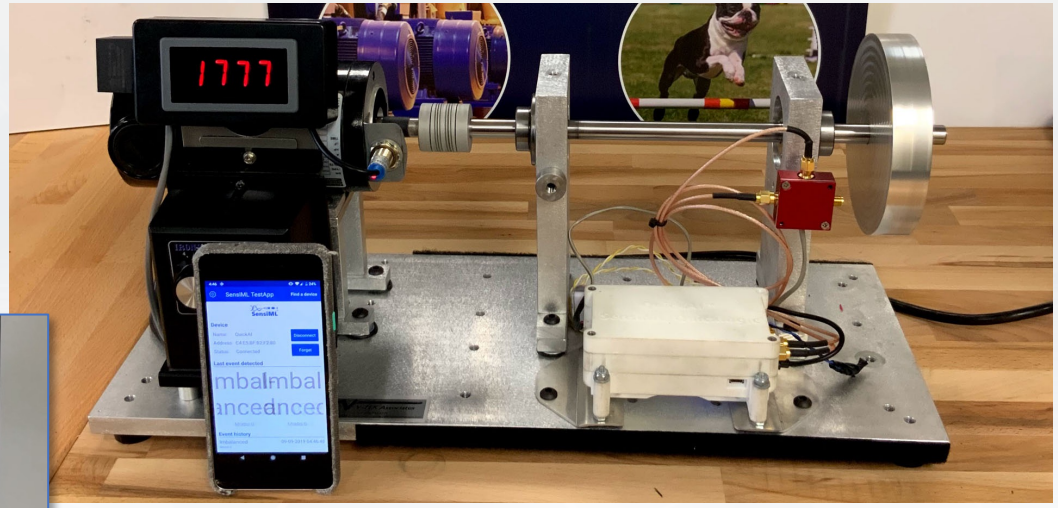
Virtual Coaching Wearable Heterogenous Model

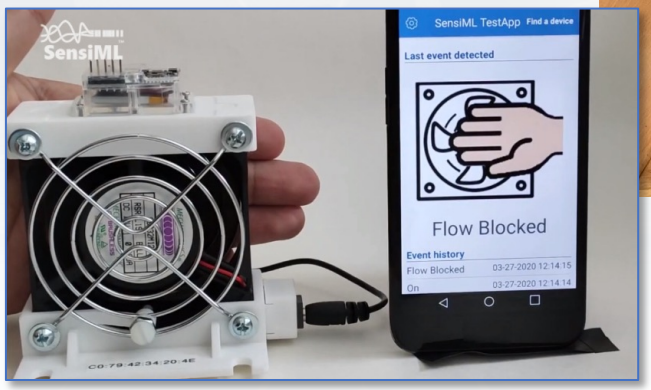


Predictive Maintenance and Anomaly Detection From Audio and Vibration

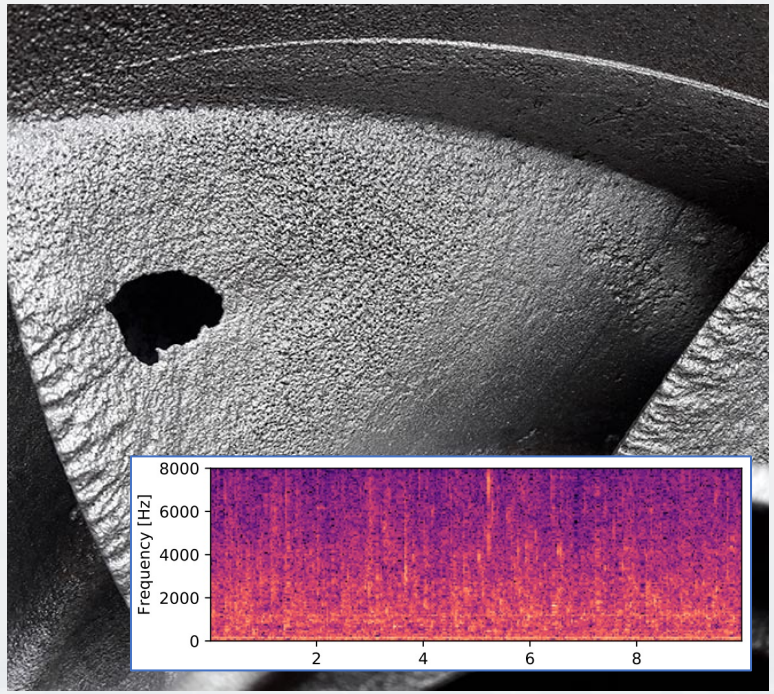
Skilled equipment operators are taught to detect and react to machine faults learned through years of experience. With SensiML AI algorithms, this same trained ear wisdom can be applied to 24/7 automated sensor endpoints as well. By detecting subtle changes in acoustics, AI-driven smart sensors can alert anywhere, anytime anomalous activity is found. With efficient edge algorithms that can run in low-power microcontrollers, SensiML has proven its edge AI tools can quickly generate algorithms with performance surpassing cloud AI analytics across a variety of models:

- Rotating pumps
- Fan and blowers
- Slide rails and linear bearings
- Conveyors and belt/pulley
- Hydraulic / pneumatic valves
- Custom processes and equipment





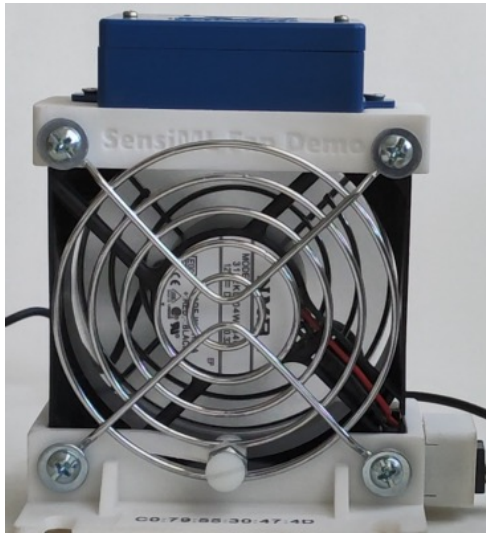
High sample rate vibration and microphone sensor streams serve as inputs to the SensiML Knowledge Pack machine learning firmware. ML recognition model provides real-time locally processed classification of machine state, faults, and undefined anomaly events.

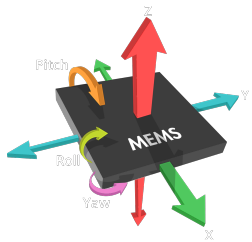


Mining operation slurry pressure pump defect enlarged
Inset: Spectrogram of single pump audio sample from Hitachi MIMII dataset
(Source: https://arxiv.org/pdf/1909.09347.pdf)

https://datadepot.sensiml.com/datasets/category/industrial/pdm

An Example: Mixed Sensor/Sample Rate



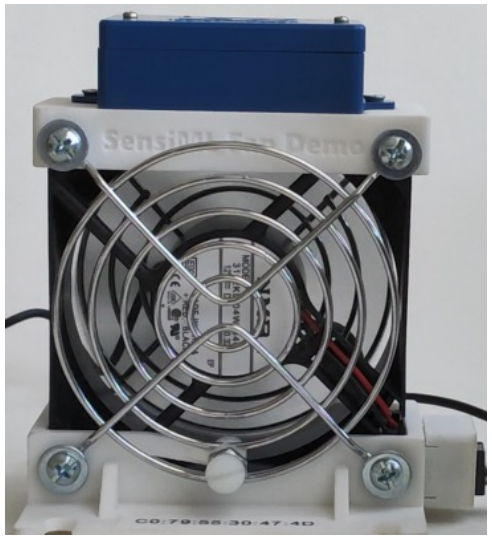


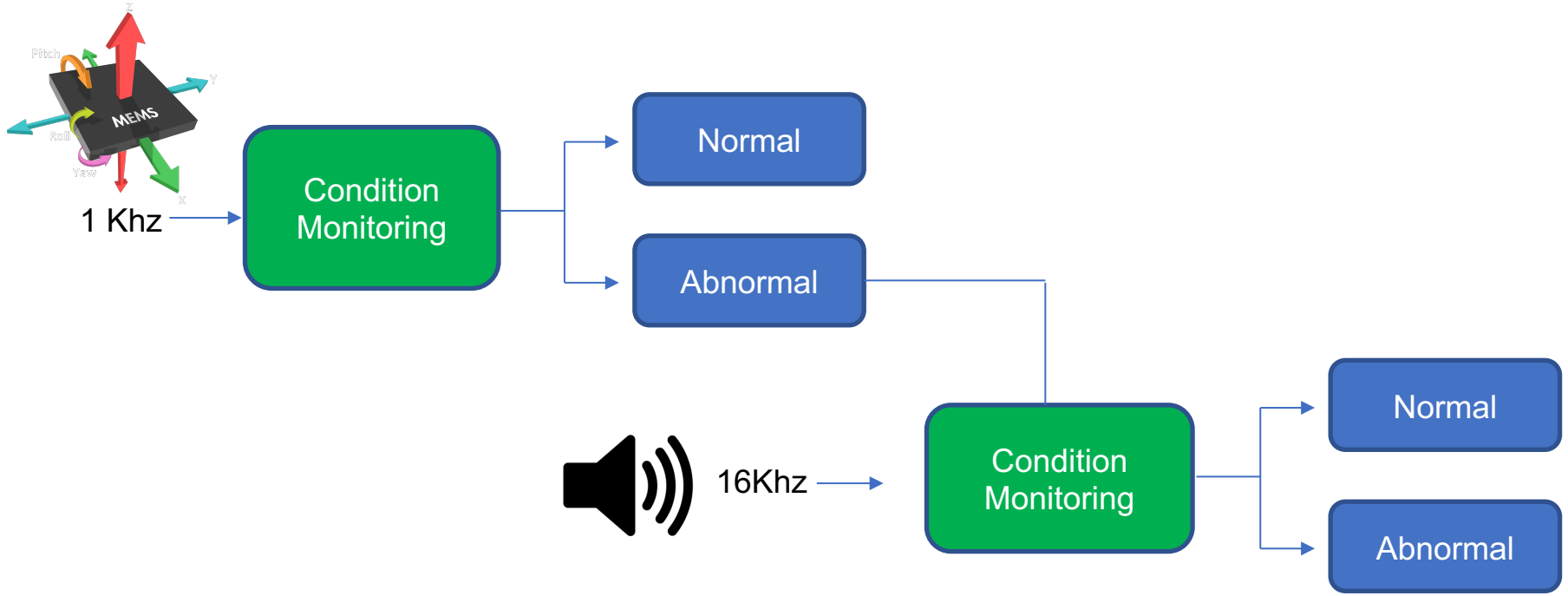
16Khz → Condition Monitoring → Normal / Abnormal

1 Khz → Condition Monitoring → Normal / Abnormal

Normal / Abnormal → Heuristics → Normal / Abnormal

An Example: Mixed Sensor Triggered Models





Building Heterogenous Models with SensiML

Train Individual Model Nodes

Train Model A

Train Model B

Train Model N

Describe Model Relationships

```
{
   "Parent 1": {
      "source": "<CAPTURE CONFIG UUID>",
      "uuid": "<Model UUID>",
      "results": {
            "1": "Child 1",
            "2": "Child 2"
      }
   },
   "Parent 2": {
      "source": "<CAPTURE CONFIG UUID>",
      "uuid": "<Model UUID>",
   },
   "Child 1": {
      "uuid": "<Model UUID>",
      "parent": "Parent 1",
      "results": {
            "1": "Child 4",
      },
      "segmenter_from": "parent"
   },
   "Child 2": {
      "uuid": "<Model UUID>",
      "parent": "Parent 1",
      "segmenter_from": "parent"
   },
   "Child 3": {
      "uuid": "<Model UUID>",
      "parent": "Parent 1",
      "segmenter_from": "parent"
   },
   "Child 4": {
      "uuid": "<Model UUID>",
      "parent": "Parent 1",
      "segmenter_from": "parent"
   }
}
```

Automatic firmware generation

Knowledge Pack

Model A

Model B

Model N

Automated Hierarchical Model Optimization with SensiML

Specify Input Data Classes

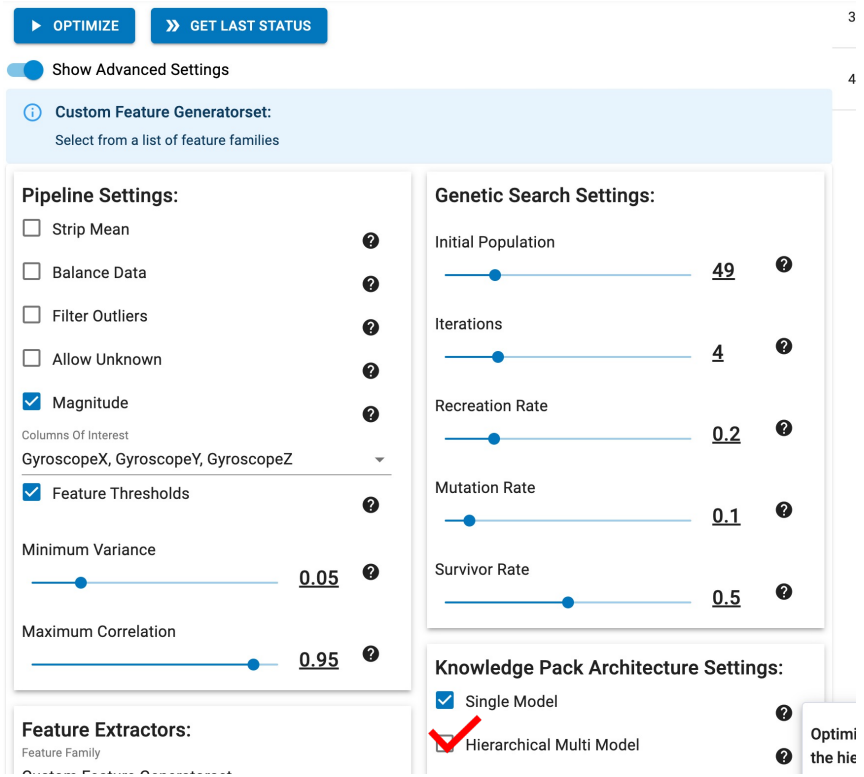
A

B

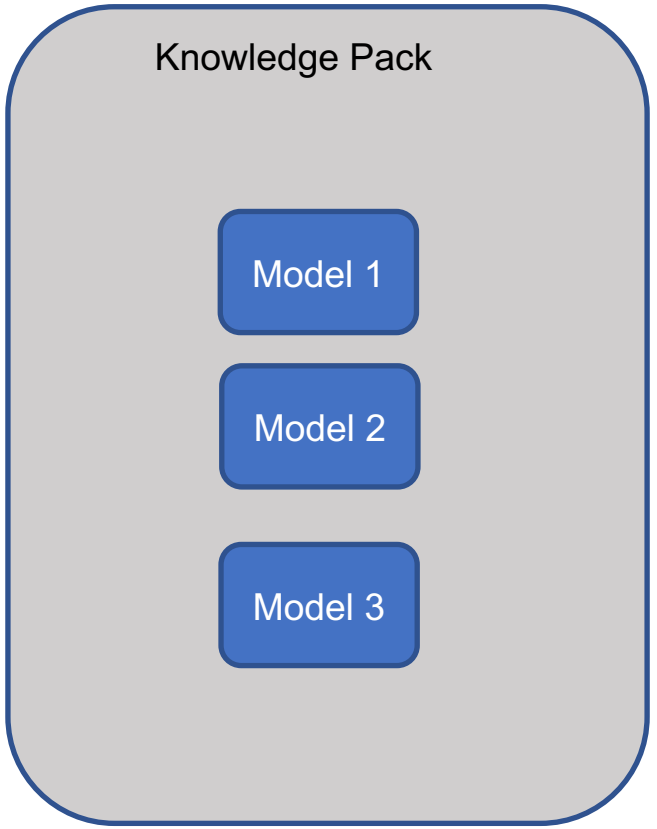
C

D

AutoML searches for the optimal hierarchical model by grouping data into the most easily separable classes



Automatic firmware generation

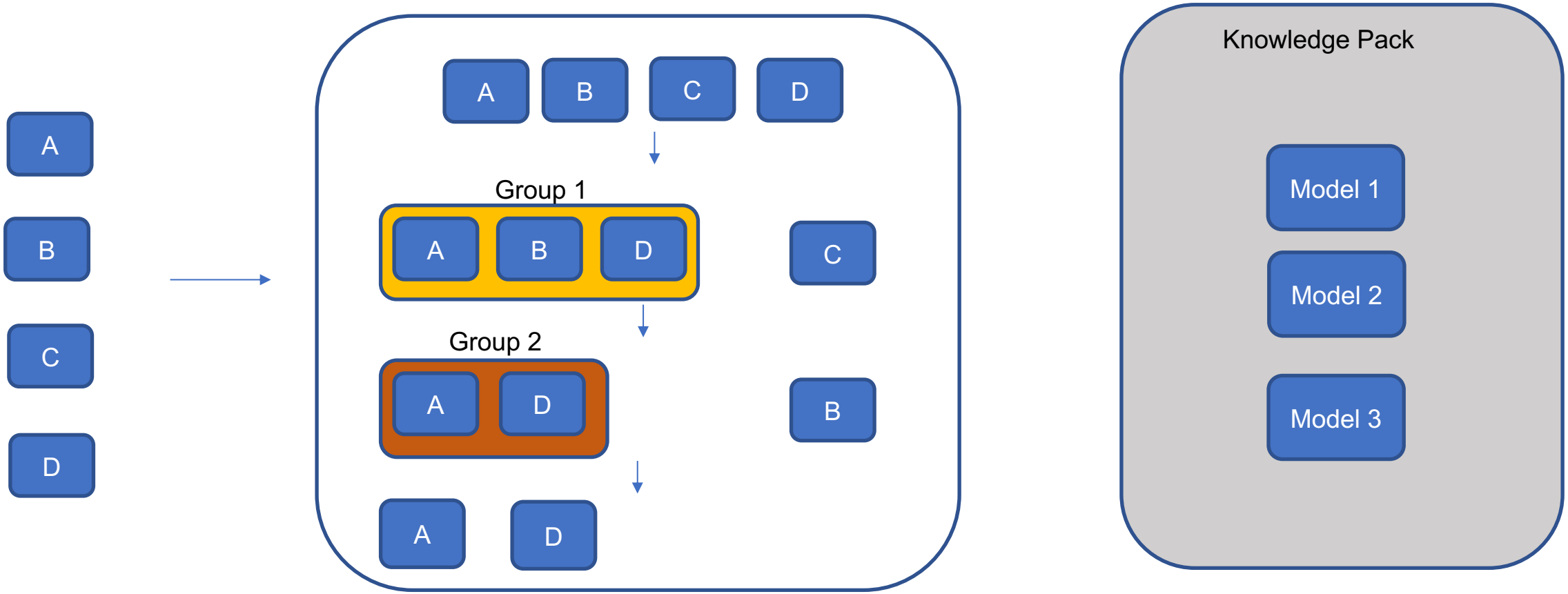


Automated Hierarchical Model Optimization with SensiML

Specify Input Data Classes

AutoML searches for the optimal hierarchical model by grouping data into the most easily separable classes

Automatic firmware generation



To Learn More…

Please contact:

Chris Knorowski at chris.knorowski@sensiml.com

https://sensiml.com/contact

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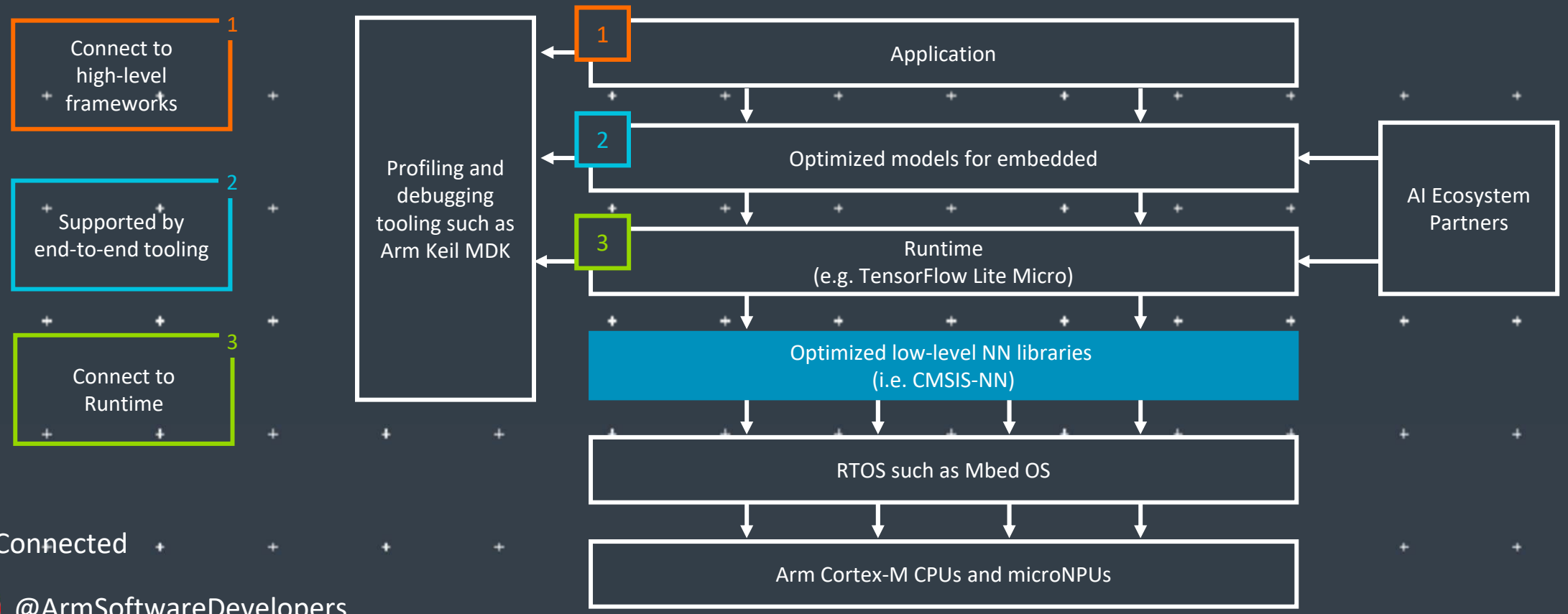
Arm: The Software and Hardware Foundation for tinyML



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Resources: developer.arm.com/solutions/machine-learning-on-arm

arm

TinyML for all developers

C++ library

Arduino library

WebAssembly

Dataset

Acquire valuable training data securely

Enrich data and train ML algorithms

Edge Device

Real sensors in real time

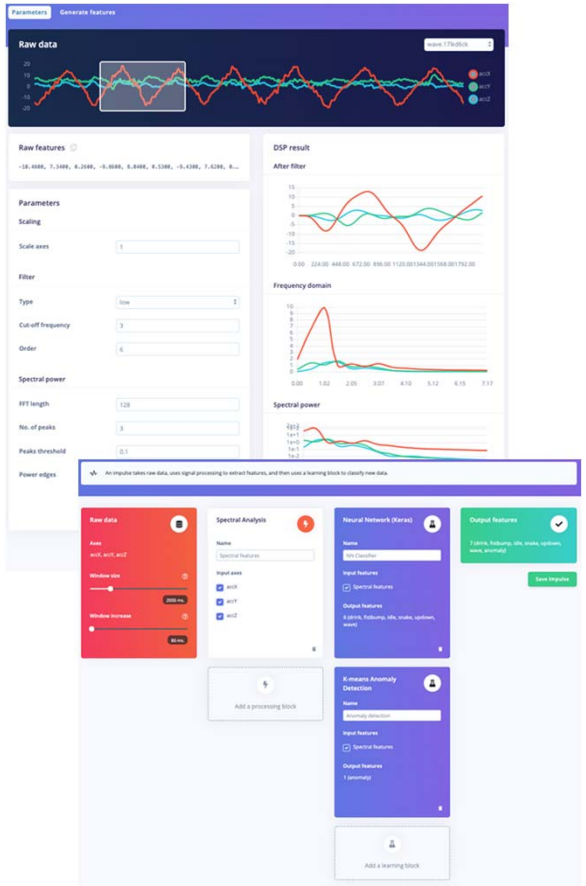
Open source SDK

Impulse

Embedded and edge compute deployment options

Test impulse with real-time device data flows

Test



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Perception

Object detection, speech recognition, contextual fusion

Reasoning

Scene understanding, language understanding, behavior prediction

Action

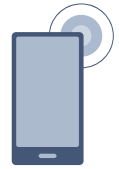
Reinforcement learning for decision making

Edge cloud

Cloud

IoT/IIoT

Automotive



Mobile

SYNTIANT

Syntiant Corp. is moving artificial intelligence and machine learning from the cloud to edge devices. Syntiant's chip solutions merge deep learning with semiconductor design to produce ultra-low-power, high performance, deep neural network processors. These network processors enable always-on applications in battery-powered devices, such as smartphones, smart speakers, earbuds, hearing aids, and laptops. Syntiant's Neural Decision Processors™ offer wake word, command word, and event detection in a chip for always-on voice and sensor applications.

Founded in 2017 and headquartered in Irvine, California, the company is backed by Amazon, Applied Materials, Atlantic Bridge Capital, Bosch, Intel Capital, Microsoft, Motorola, and others. Syntiant was recently named a CES® 2021 Best of Innovation Awards Honoree, shipped over 10M units worldwide, and unveiled the NDP120 part of the NDP10x family of inference engines for low-power applications.

www.syntiant.com

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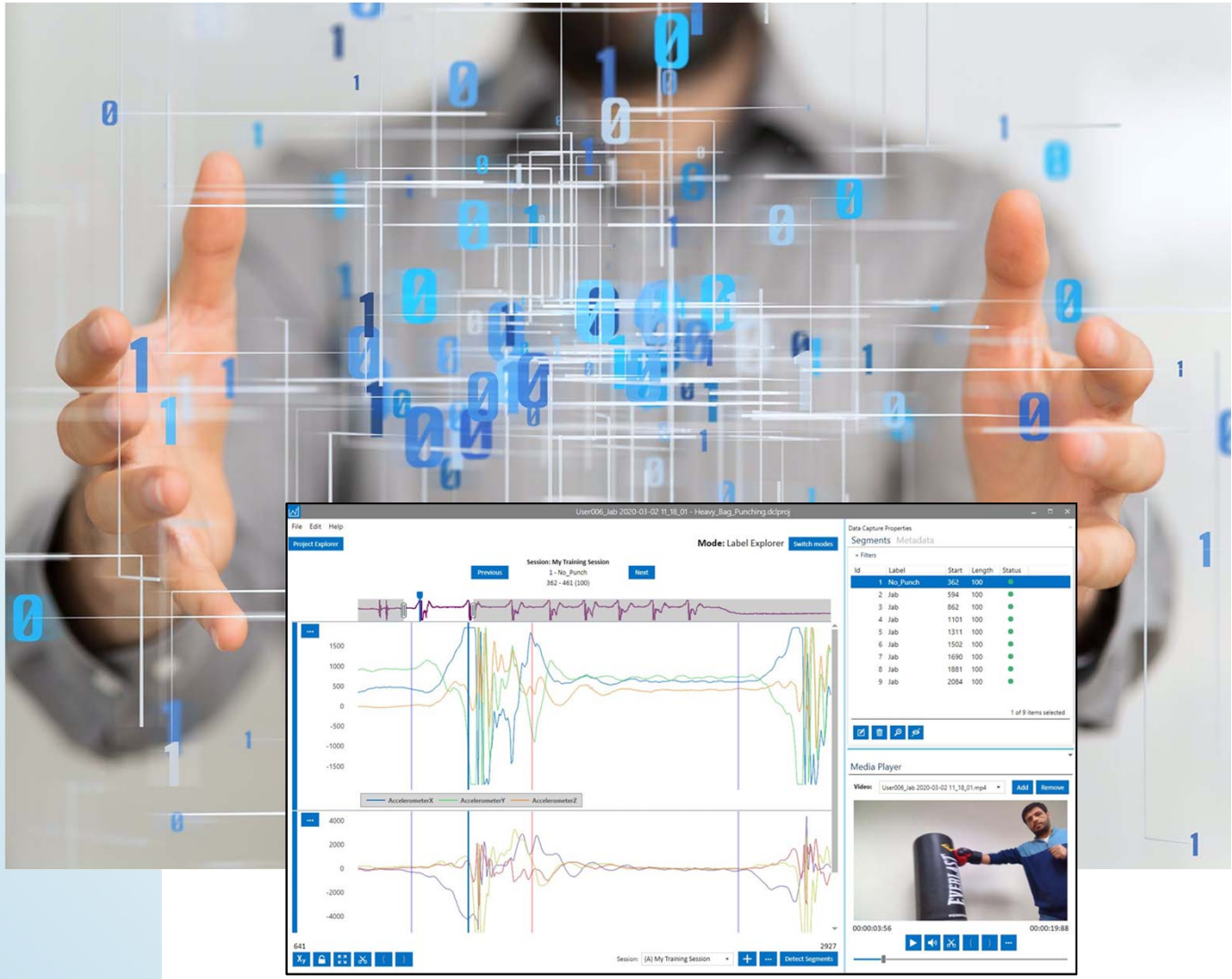
SensiML™

Build Smart IoT Sensor Devices From Data

SensiML pioneered TinyML software tools that auto generate AI code for the intelligent edge.

- End-to-end AI workflow
- Multi-user auto-labeling of time-series data
- Code transparency and customization at each step in the pipeline

We enable the creation of production-grade smart sensor devices.



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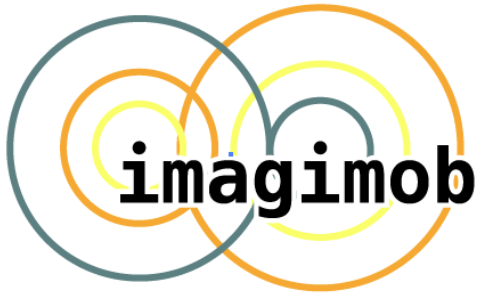

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