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

Raw Sensor Data
- Time-series
- Digital or ADC sources
- <1Hz thru 1MHz
- 1 to many channels
- Mixed sensor types

Signal Pre-Processing
- Filtering
- Downsampling
- Averaging
- Vector Magnitude
- Scaling
- Normalization
- ...

Event Triggering
- Sliding window
- Energy Based
- Key based
- Template based

Feature Transformation
- Fully automated selection
- Library of 80+ feature transforms
- Option for manual definition / tuning

Classification
- Classic ML (SVM, distance, trees)
- Hierarchical models
- Neural Network (TensorFlow Lite)
- Fully automated or manual tuning

Inference Result
- Ordinal class value
- Interim feature vector
- Associated raw data buffer

Runtime On-Device Sensor Processing
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

9-DOF IMU

Activity Detection

Butterfly
Breaststroke
Backstroke
Freestyle
Walking
Running
Resting

Breaststroke
Backstroke
Butterfly
Freestyle
Walking
Running
Resting
Virtual Coaching Wearable Heterogenous Model

Activity Detection

9-DOF IMU

Swimming
- Walking
- Breaststroke
- Backstroke
- Butterfly
- Freestyle

Resting

Walking

Running

Swimming Detection

Stroke Detection

Lap Detection

Turn
No Turn

Freestyle
Backstroke
Breaststroke
Butterfly

Gait Analysis

Good Form
Dysfunction
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.

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

Inset: Spectrogram of single pump audio sample from Hitachi MIMII dataset
An Example: Mixed Sensor/Sample Rate
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:

```json
{
  "Parent 1": {
    "source": "<CAPTURE CONFIG UUID>",
    "uuid": "Model UUID1",
    "results": {
      "1": "Child 1",
      "2": "Child 2"
    }
  },
  "Parent 2": {
    "source": "<CAPTURE CONFIG UUID>",
    "uuid": "Model UUID2",
    "Child 1": {
      "uuid": "Model UUID1",
      "parent": "Parent 1",
      "results": {
        "1": "Child 4"
      },
      "segmenter_frame": "parent"
    },
    "Child 2": {
      "uuid": "Model UUID1",
      "parent": "Parent 1",
      "segmenter_frame": "parent"
    },
    "Child 3": {
      "uuid": "Model UUID1",
      "parent": "Parent 1",
      "segmenter_frame": "parent"
    },
    "Child 4": {
      "uuid": "Model UUID1",
      "parent": "Parent 1",
      "segmenter_frame": "parent"
    }
  }
}
```

Automatic firmware generation:

Knowledge Pack:
- Model A
- Model B
- Model N
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

Knowledge Pack

Model 1

Model 2

Model 3
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

Knowledge Pack

- Model 1
- Model 2
- Model 3
To Learn More...

Please contact:

Chris Knorowski at chris.knorowski@sensiml.com

https://sensiml.com/contact

Please sign up for a FREE Community Edition account:

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Automated TinyML

Zero-code SaaS solution

Create tiny models, ready for embedding, in just a few clicks!

Compare the benchmarks of our compact models to those of TensorFlow and other leading neural network frameworks.

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Arm: The Software and Hardware Foundation for tinyML

1. Connect to high-level frameworks
2. Supported by end-to-end tooling
3. Connect to Runtime

Profiling and debugging tooling such as Arm Keil MDK

Application

Optimized models for embedded

Runtime (e.g. TensorFlow Lite Micro)

Optimized low-level NN libraries (i.e. CMSIS-NN)

RTOS such as Mbed OS

Arm Cortex-M CPUs and microNPUs

AI Ecosystem Partners

Stay Connected

@ArmSoftwareDevelopers

@ArmSoftwareDev

Resources: developer.arm.com/solutions/machine-learning-on-arm
TinyML for all developers

Edge Device
- Real sensors in real time
- Open source SDK

Embedded and edge compute deployment options

Dataset
- Acquire valuable training data securely

Enrich data and train ML algorithms

Impulse
- Test impulse with real-time device data flows

Test

www.edgeimpulse.com
Advancing AI research to make efficient AI ubiquitous

Power efficiency
- Model design, compression, quantization, algorithms, efficient hardware, software tool

Personalization
- Continuous learning, contextual, always-on, privacy-preserved, distributed learning

Efficient learning
- Robust learning through minimal data, unsupervised learning, on-device learning

Perception
- Object detection, speech recognition, contextual fusion

Reasoning
- Scene understanding, language understanding, behavior prediction

Action
- Reinforcement learning for decision making

A platform to scale AI across the industry

Qualcomm AI Research is an initiative of Qualcomm Technologies, Inc.
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.

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- Pre-built automotive solution that lets cars "see with sound"

Reality AI Tools® software
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- Optimize the hardware, including sensor selection and placement

https://reality.ai  info@reality.ai  @SensorAI  Reality AI
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Adaptive AI for the Intelligent Edge

LatentAI.com
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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