SensiML Toolkit Technical Overview

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Please visit the SensiML website (https://www.sensiml.com) for contact information.

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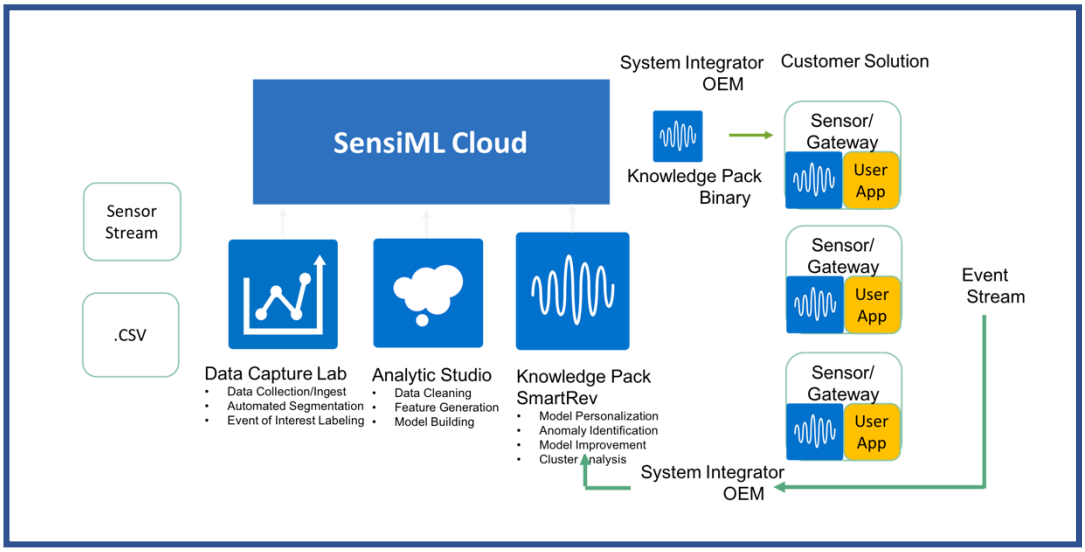
1 Toolkit Overview

SensiML brings real-time event detection to the sensor endpoint with a platform that is accessible to any application developer. Algorithms are created by feeding labeled sets into a cloud-based analytic engine, where SensiML's AI routines create an optimized device-ready predictive model that balances the desired accuracy with the resource constraints of the target hardware. These models are automatically compiled to optimized machine code that can run in real time on the target embedded platform. SensiML's platform brings the firmware and data science expertise so that you can go from PoC to production rapidly and with confidence.

Software Component Overview

The SensiML platform is a software suite that makes it easy for a software developer to take simple physical sensors and turn them into advanced event detectors. The platform consists of five main applications:

- **Data Capture Lab** – The DCL (Desktop and Mobile) is a tool that helps you capture, organize, and label raw data from the sensor and transform it into the events you want to detect.
- **SensiML Analytics Studio** – The Analytics Studio is a data-driven optimizing compiler that runs in SensiML Cloud and utilizes a GUI-based front-end interface for filtering and optimizing your labeled sensor data through machine learning algorithms.
- **SensiML Analytics Studio Notebook** – Analytics Studio Notebook is a an alternative Python-based interface for creating SensiML models. Intended for more advanced users, it provide full control over the model generation pipeline via a Python client API and leverages the familiar Jupyter Notebook IDE for self-documenting code execution for the model creation process.
- **SensiML Knowledge Pack -** Device optimized firmware intended for the target embedded device enabling sensor-driven, real-time event detection.
- **SensiML TestApp** – The SensiML TestApp is an application that allows you to validate and visualize the real-time event classifications from the SensiML Knowledge Pack running on your sensor-equipped embedded device.



Architectural Overview of the SensiML Platform

2 Data Capture Lab - Data Collection and Labeling

Capturing a high-quality data set is the first step in creating a smart sensor algorithm. This is often the first stumbling point in development of machine learning sensor algorithms as it is often difficult to fully anticipate upfront all the undesired sources of noise and variance the model must accommodate. The SensiML Data Capture Lab (DCL) provides the tools you need to be successful. DCL allows you to capture, organize, and label raw data from the sensor and transform it into the events you want to detect all in a single application. By syncing your projects to SensiML cloud you will have a single repository of data multiple users can access, label, and add additional data sets. This enables you and your team the flexibility to collect data and manage data between members with ease. The rich event and metadata labeling features allow you to fully annotate datasets with ease using the many productivity shortcuts geared towards productive dataset construction.

Desktop Data Capture Lab used to label and visualize raw accelerometer sensor data

Desktop Data Capture Lab	Mobile Data Capture Lab
• Record over BLE, serial, WiFi, USB or start/stop remote SD card collection • Upload/Download to SensiML cloud projects • Import CSV and WAV files for labeling • Playback of WAV files for audio labeling • View sensor data and recorded video side by side • Label sensor data with events of interest • Label captured files with metadata • Use Auto Segmentation to detect events	• Record over BLE or start/stop SD card collection • Record video synchronized to sensor data • Upload to SensiML cloud Project • Augment with phone sensors such as GPS/speed • Collect and upload on the go

3 SensiML Analytics Studio – Model Generation

SensiML Analytics Studio provides you with sophisticated machine learning tools to build a model that detects your events. We have an automated machine learning mode that provides users a user-friendly interface reducing or eliminating the need for data science expertise. If you want to dive deeper into the underlying algorithms that, we also give you the tools to create and modify them on your own. The Analytic Studio provides you with the ability to query, sub sample, apply transforms, generate features, perform feature selection and train algorithms using a variety of validation methods and classifiers. The Analytic Studio comes with a series of

tutorials to familiarize yourself with the model building process and get up in running in no time.

Analytic Studio GUI interface to AutoSense Pipeline

4 SensiML Knowledge Pack – Optimized Device Algorithm

The Knowledge Pack pipeline consists of preprocessing, feature extraction and classification algorithms. Using the SensiML Analytics Studio users can optimize their algorithm either through **AutoML** - an automated machine learning approach - or through an expert user interface of **plug and play** building blocks using Analytics Studio Notebook and our rich library of device optimized functions.

Algorithms Supported by SensiML Knowledge Pack

Preprocessing	Feature Extraction	Classification Methods
• Sensor Transforms • Sensor Filters • Segmentation • Data Augmentation • Segment Transforms • Segment Filters	• Statistical • Shape-based • Amplitude-based • Sensor Fusion • Area-based • Histogram • Rate of Change • Physical • Energy-based • Convolution • Frequency-based	• Pattern Matching with KNN • Neuron activation with RBF • Ensemble of Decision Trees • Hierarchical Modeling with Multiple Classifiers • Anomaly Detection with RBF • Deep Inference with Quantized NN*

For a complete list see supporting documentation at https://sensiml.com/documentation/pipeline-functions/index.html

Hardware Supported by SensiML Knowledge Pack

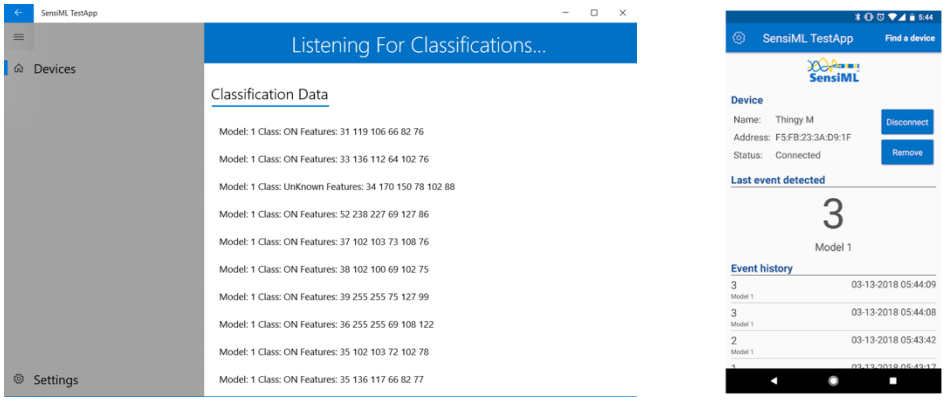
Hardware Vendor	Platforms
Arduino	Arduino Nano 33 BLE Sense
Arm	Cortex-M and Cortex-A Microcontrollers
Intel	X86 Microprocessors
Neurosense	ELA106 System in Package
Nordic Semiconductor	nRF52 and Thingy52 IoT Development Kit
NXP	i.MX RT Crossover MCUs and MIMXRT1050-EVK
QuickLogic	EOS S3 MCU/FPGA, QuickFeather Development Kit
Raspberry Pi	Raspberry Pi3
Silicon Labs	EFR32/EFM32 MCUs and Thunderboard Sense 2 IoT Kit
ST Microelectronics	STM32 and ST.SensorTile and SensorTile.Box Eval Kits

5 SensiML TestApp - Edge Model Validation

Validating model accuracy in real-time is vital to ensuring ML sensor models are performing as expected and this is fully supported using the SensiML TestApp. TestApp is available in both

* Quantized Neural Network supported through integrated support of Google TensorFlow Lite for Microcontrollers.

Windows 10 desktop and mobile (Android) versions. Using TestApp, you will be able to view the and log classification results in real time along with the feature vector that is generated by the preprocessing and feature extraction steps. Aside from online validation, it is also possible to validate models in the cloud and on the device using a predefined raw signal file.



Desktop(left) and Mobile(right) test apps for viewing real-time classifications over BLE

6 Additional Resources

This brief is intended to provide a basic overview of the SensiML software capabilities and features. For further details please visit http://www.sensiml.com. On the website the 'Resources' tab provides additional details on supported hardware platforms, case studies, videos, and additional documentations. To inquire about and sign up for trial access to the SensiML software email info@sensiml.com.