Electrical and Computer Engineering
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CE6302: Microprocessor and Embedded Systems

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TinyML Lab 1- Continuous Motion Recognition

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TinyML - Continuous Motion Recognition

1. Project Objective

• Understand about the concept of TinyML
• A brief understanding about ML algorithms
• A brief understanding about TI Launchpad (CC1352P) and Booster Sensors

1.1 Introduction

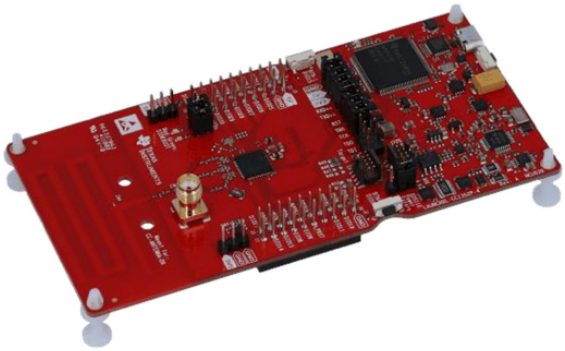
Machine learning is a subfield of artificial intelligence, which is broadly defined as the capability of a machine to imitate intelligent human behavior. Artificial intelligence systems are used to perform complex tasks in a way that is similar to how humans solve problems.

Tiny machine learning, or TinyML, is an emerging field that is at the intersection of machine learning and embedded systems. An embedded system is a computing device that usually is small, or tiny, that operates with low power, extremely low power. So much so that some of these devices can run for days, weeks, months, sometimes even years on something like a coin cell battery. TinyML is a type of machine learning that shrinks deep learning networks to fit on tiny hardware. It brings together Artificial Intelligence and intelligent devices.

Edge computing brings computation and data storage closer to the origin of data. Majority of the edge devices that are integrated with IoT-based ecosystems are initially designed to collect sensor data and transmission of the data to neighborhood or remote cloud.

1.2 Texas Instruments CC1352P LaunchPad

This LaunchPad speeds development on devices with integrated power amplifier and multi-band radio support for concurrent Sub-1Ghz and 2.4-GHz operation. Protocols supported include Bluetooth Low Energy, Sub-1 GHz, Thread, Zigbee, 802.15.4, and proprietary RF with the compatible CC13x2-CC26x2 SDK. It has Broad band antenna support for Sub-1 GHz (868 MHz / 915 MHz / 433 MHz) and 2.4 GHz frequency bands.



2. Edge Impulse

It is a cloud service for developing machine learning models in the TinyML targeted edge devices. This supports AutoML processing for edge platforms. It also supports several boards including smart phones to deploy learning models in such devices. The impulse can be run in a local machine by the help of the in-built C++, Node.js, Python, and Go SDKs. Impulses are also deployable as a WebAssembly library

2.1 Sampling New Data

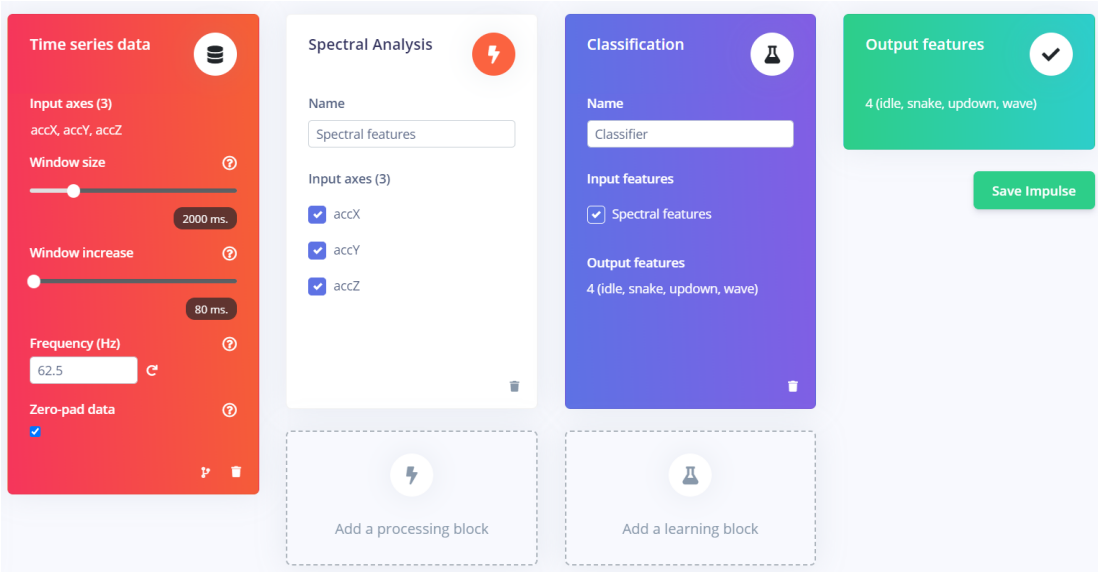
Machine learning works best with lots of data, so a single sample won't cut it. Now is the time to start building your own dataset. The following four classes, record around 3 minutes of data:

Idle - just sitting on your desk while you're working
Snake - moving the device over your desk as a snake
Wave - waving the device from left to right
Updown - moving the device up and down

2.2 Designing an Impulse

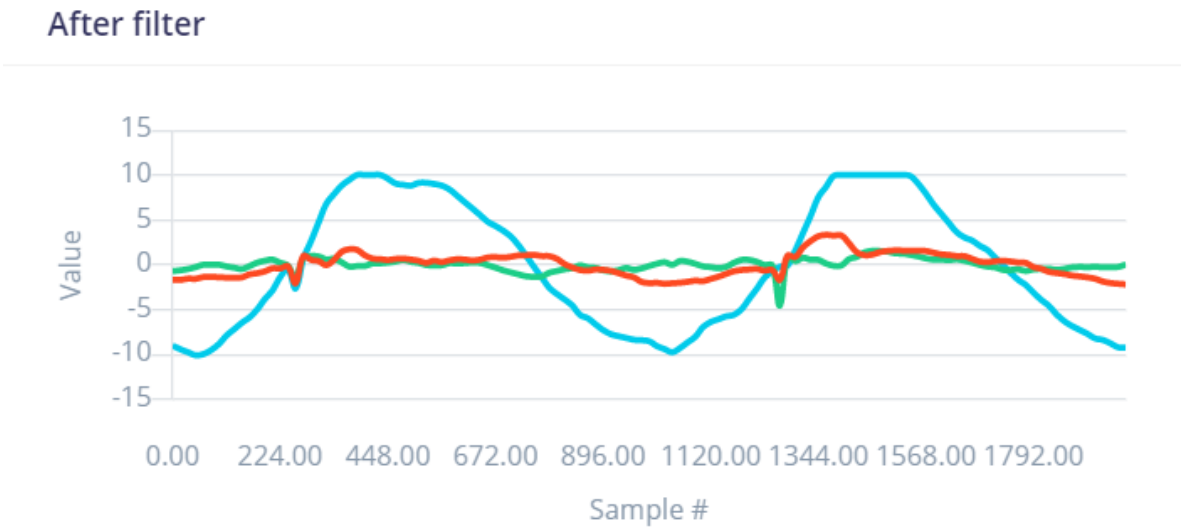
With the training set in place, an impulse is designed. An impulse takes the raw data, slices it up in smaller windows, uses signal processing blocks to extract features, and then uses a learning block to classify new data. Signal processing blocks always return the same values for the same input and are used to make raw data easier to process, while learning blocks learn from past experiences.

For this project we'll use the 'Spectral analysis' signal processing block. This block applies a filter, performs spectral analysis on the signal, and extracts frequency and spectral power data. Then we'll use a 'Neural Network' learning block, that takes these spectral features and learns to distinguish between the four (idle, snake, wave, updown) classes.

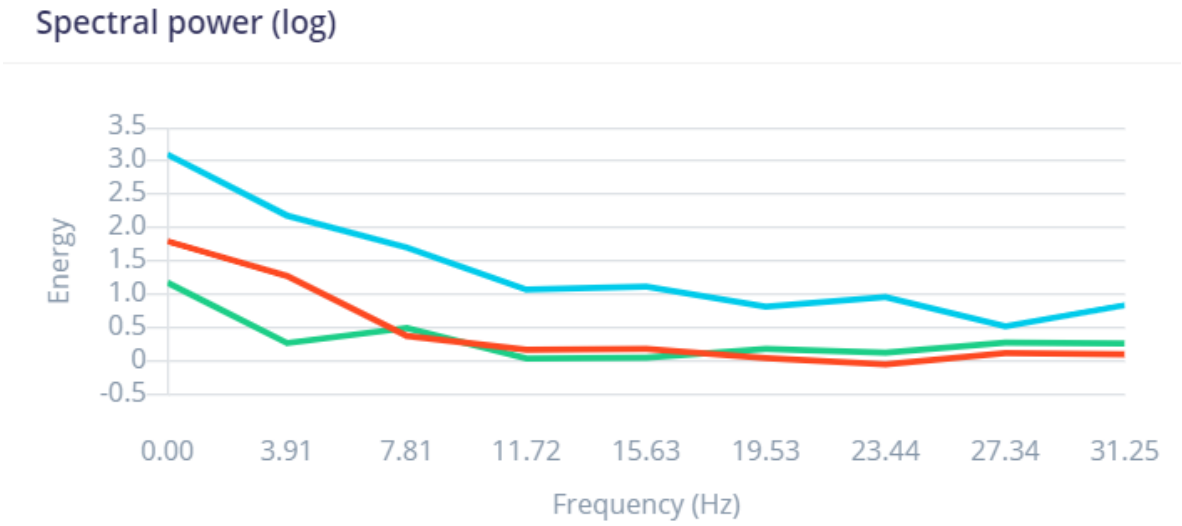


2.3 Spectral Analysis Block

The spectral features block contains the following graphs:



After filter – the signal after applying a low-pass filter. This will remove noise



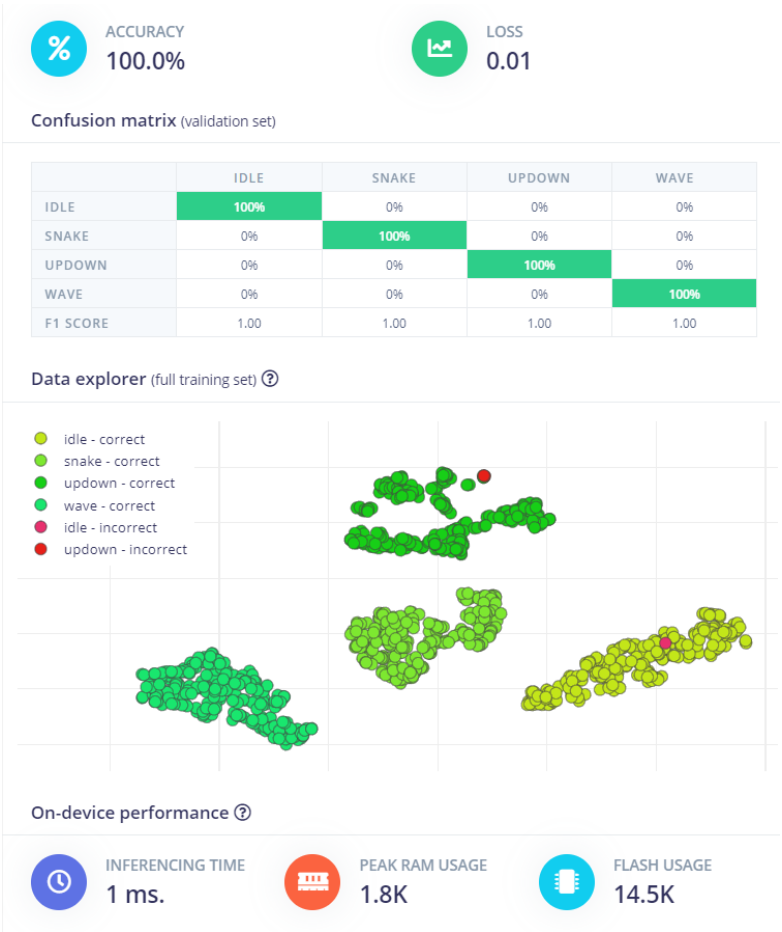
Spectral power – the amount of power that went into the signal at each frequency

2.4 Configuring the Neural Network

Neural networks are a set of algorithms, modeled loosely after the human brain, that are designed to recognize patterns. The network that we're training here will take the signal processing data as an input, and try to map this to one of the four classes.

A neural network consists of layers of neurons, all interconnected, and each connection has a weight. One such neuron in the input layer would be the height of the first peak of the X-axis (from the signal processing block); and one such neuron in the output layer would be wave (one the classes). When defining the neural network all these connections are initialized randomly, and thus the neural network will make random predictions.

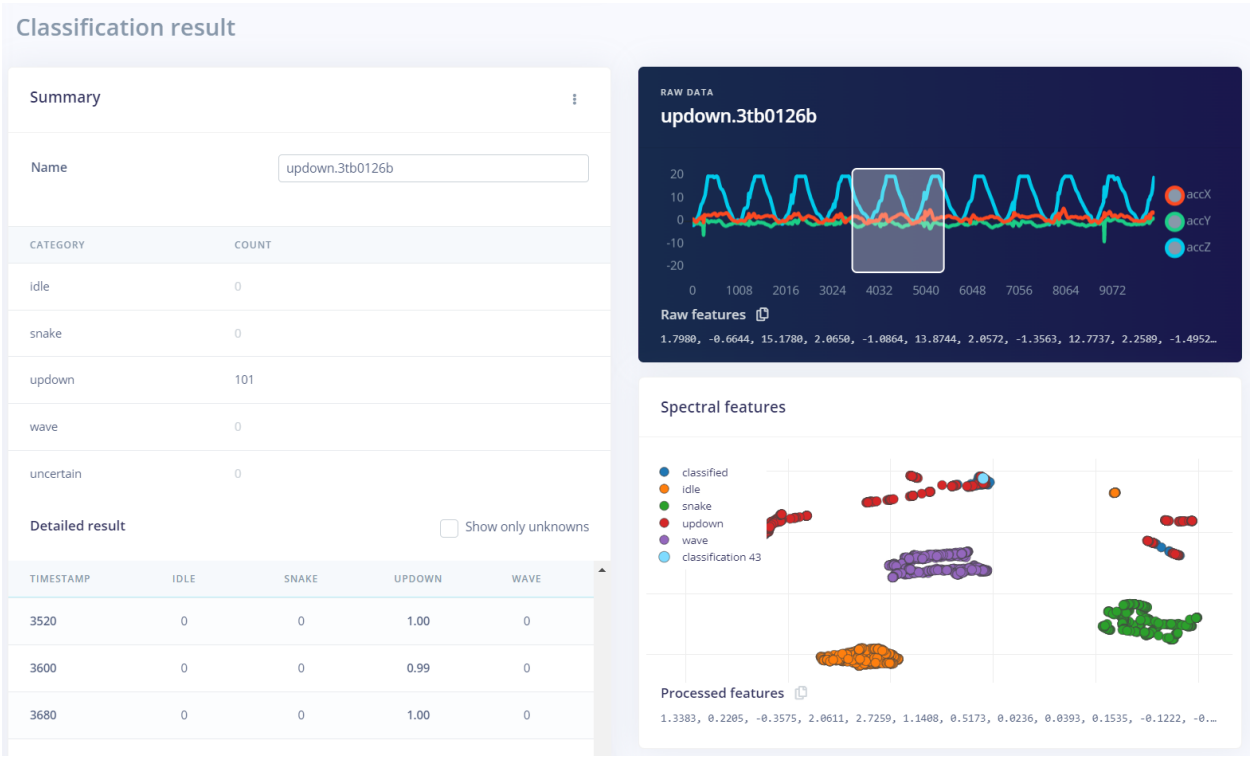
During training we then take all the raw data, ask the network to make a prediction, and then make tiny alterations to the weights depending on the outcome (this is why labeling raw data is important). This way, after a lot of iterations, the neural network learns; and will eventually become much better at predicting new data.



Full Training Set

2.5 Classifying New Data

By giving neural networks more data to learn patterns in data sets by classifying the data properly, classifying new data is fairly simple by increasing the testing data to train neural networks.



2.6 Deploying Back to Device

With the impulse designed, trained, and verified we can deploy this model back to your device. This makes the model run without an internet connection, minimizes latency, and runs with minimum power consumption. Edge Impulse can package up the complete impulse - including the signal processing code, neural network weights, and classification code - up in a single C++ library that you can include in embedded software.

```
Starting inferencing in 2 seconds...
Sampling...
Predictions (DSP: 71 ms., Classification: 0 ms., Anomaly: 0 ms.):
    idle:       0.000000
    snake:      0.980469
    updown:     0.019531
    wave:       0.000000
```

The output shows the prediction of the sample as the 98% probability being snake by using already neural networks which are trained by classified data that are labeled earlier.