# ASSIGNMENT 3


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## Motion Detection System Using Edge Impulse

## Introduction

This report details the process of building a motion recognition system using Edge Impulse. The system is designed to classify four types of movements: Idle, Snake, Wave, and Updown. This model is trained on data provided for these movements and is deployed for live classification using an Arduino nano 33 BLE board.

## Edge Impulse Workflow

Edge Impulse provides an end-to-end machine learning platform that simplifies the process of data collection, model training, and deployment for edge devices.

### 1. Project Creation

The dataset provided for the four movements (Idle, Snake, Wave, Updown) was uploaded to the Edge Impulse platform under the project name **A3_SKFnumber**.

Data set contains 95 training data and 15 test data.

### Data Acquisition

**Motion Modes**
We defined four motion modes:

- **Idle**: No motion or stationary position.
- **Snake**: moving the device over the desk as a snake
- **UpDown**: moving the device up and down. (with the device facing up/down)
- **Wave**: waving the device from left to right (with the device facing us)

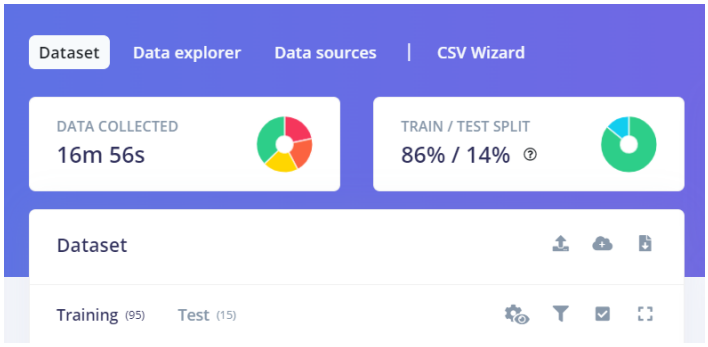
### 2. Signal viewing

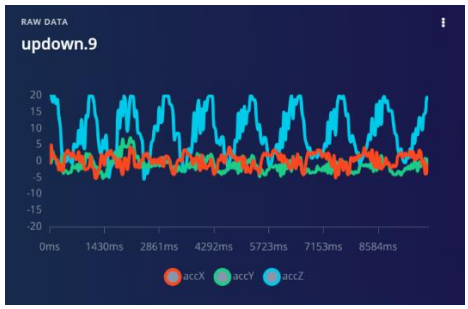
These graphs depict the raw sensor data from different movements (wave, updown, snake, idle) captured by accelerometers along three axes: X (red), Y (blue), and Z (green). Each movement creates a unique pattern based on how the device is moved in space.

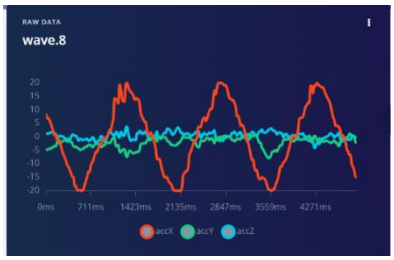
- Wave: The wave motion shows a clear oscillating pattern, particularly in the X-axis (red). This suggests a repeated back-and-forth motion along the X-axis, typical of a waving gesture. The Y-axis (blue) and Z-axis (green) have smaller variations, indicating minimal movement in those directions.
- Updown: The updown movement produces significant variation in the Z-axis (green). This shows that the device was moved predominantly in the vertical direction (up and

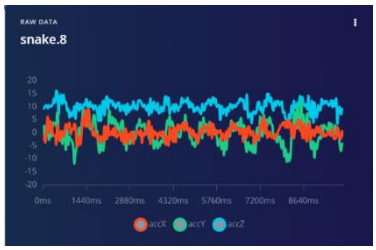
down). The X and Y axes remain relatively stable, reinforcing that the movement was mainly vertical.

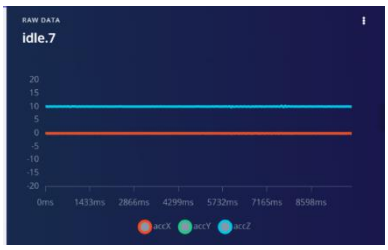
- Snake: The snake movement has a more complex pattern, with significant variations in both the X-axis (red) and Y-axis (blue). This indicates a lateral, serpentine motion in both horizontal directions (X and Y). The Z-axis (green) is relatively stable, indicating minimal vertical movement during this motion.
- Idle: The idle movement shows almost no variation in any axis. The accelerometer readings are flat across all three axes (X, Y, Z), suggesting that the device remained still during this phase.



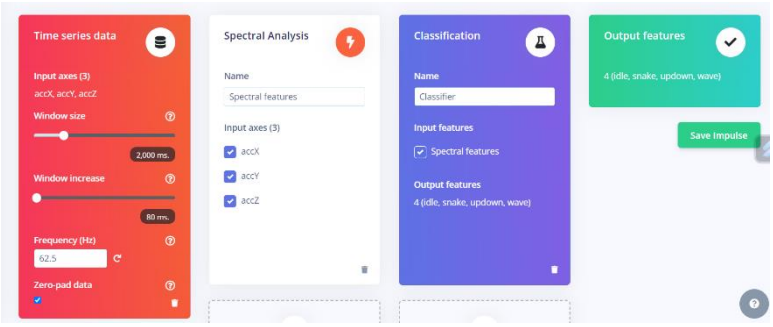




### 3. Creating an impulse

An impulse was created with the following input parameters:

- **Window size**: 2000 ms
- **Window increase**: 80 ms
- **Frequency**: 62.5 Hz

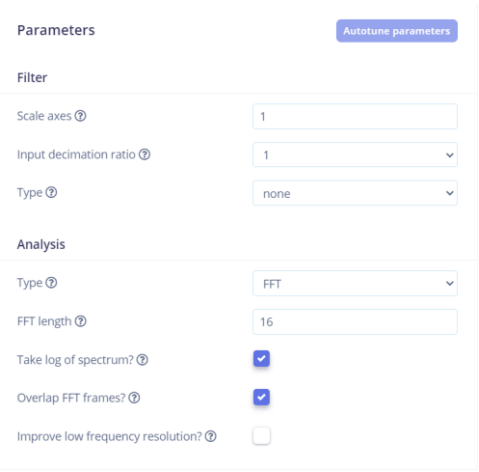


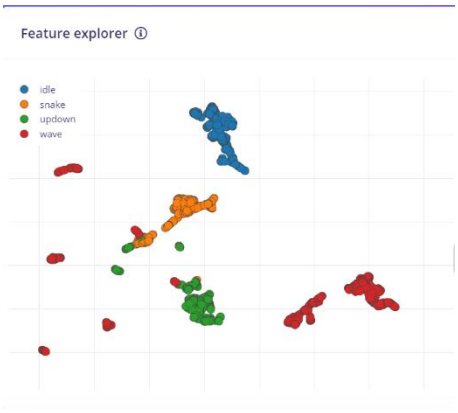

The impulse was designed to segment the sensor data into manageable chunks for feature extraction and classification.

### 4. Feature Extraction

The features were extracted using a signal processing block. Various parameters were tested to optimize the results. By sliding the window across the raw data and switching between files of the same label, similar graphs were observed, indicating consistent feature extraction.

The feature explorer showed distinct clusters for each movement class, helping to visualize the separability of the classes before training the model.



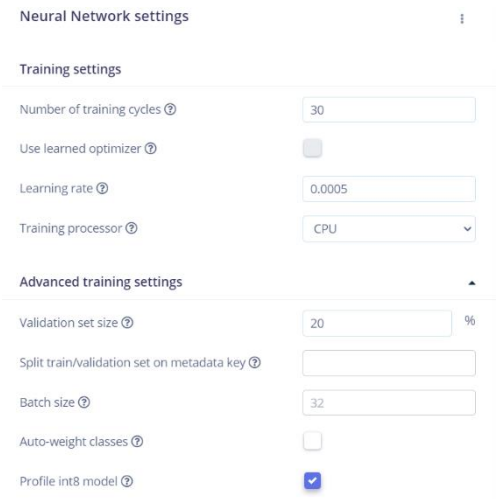



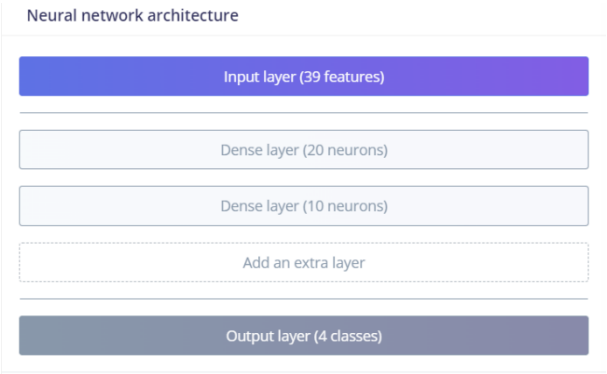

Raw sensor data is often noisy and too detailed for machine learning models to use directly. In this step, the raw data is processed to extract features that summarize important aspects of the signal.
The **distinct clustering** for most of the modes (especially idle and wave) suggests that these movements are well-represented in the feature space and are likely to be classified accurately. However, the **overlap between snake and up-down** might lead to some confusion for the model when classifying these motions. Overall, the feature map provides a good visualization of how well the extracted features separate the different motion modes and gives an idea of which motions might be more challenging to differentiate.

## 5. Model Training and Testing

### 5.1 Neural network architechture

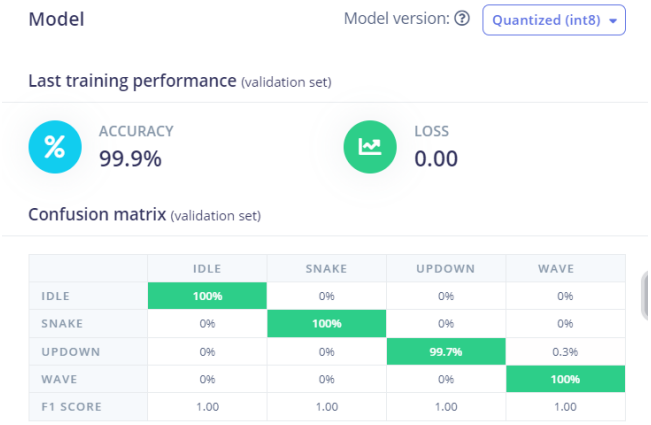
A simple neural network was designed for classification, ensuring that the model did not overfit.



5.2 Training performance

During training, the following performance metrics were observed




| | IDLE | SNAKE | UPDOWN | WAVE |
|---|---|---|---|---|
| IDLE | 100% | 0% | 0% | 0% |
| SNAKE | 0% | 100% | 0% | 0% |
| UPDOWN | 0% | 0% | 99.7% | 0.3% |
| WAVE | 0% | 0% | 0% | 100% |
| F1 SCORE | 1.00 | 1.00 | 1.00 | 1.00 |

5.3 Testing

The testing dataset was used to validate the model's performance, achieving the following results.


| | IDLE | SNAKE | UPDOWN | WAVE | UNCERTAIN |
|---|---|---|---|---|---|
| IDLE | 100% | 0% | 0% | 0% | 0% |
| SNAKE | 0% | 100% | 0% | 0% | 0% |
| UPDOWN | 0% | 0% | 99.3% | 0% | 0.7% |
| WAVE | 0% | 0% | 0% | 100% | 0% |
| F1 SCORE | 1.00 | 1.00 | 1.00 | 1.00 | |

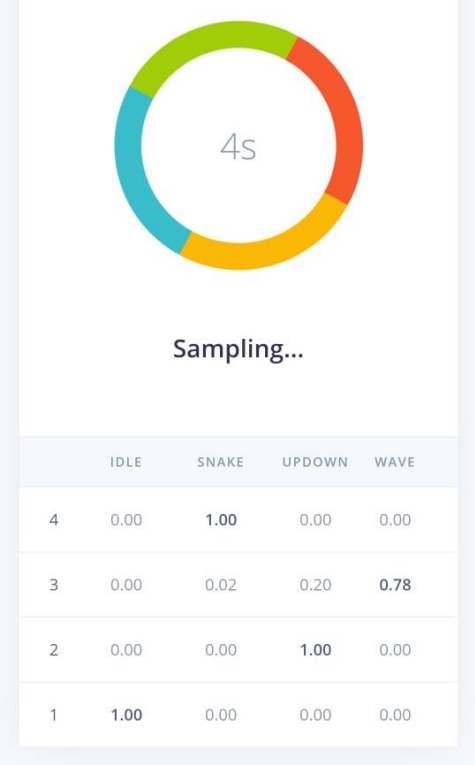
5.4 Reasoning for parameter choices

The learning rate was set to 0.005 to ensure that the model converged quickly without overshooting the minimum loss. The batch size was chosen to balance memory efficiency and training stability. The number of epochs was selected based on the performance observed during training.

## 6. Model Deployment

The model was deployed using the mobile phone interface for live classification. The mobile phone was connected to the Edge Impulse platform, and the model was tested with real-time classification of the four movements (Idle, Snake, Wave, and Updown).

Each movement was correctly classified when performed in real-time, showing the effectiveness of the trained model.




## 7. Conclusion

The motion recognition system successfully classifies the four types of movements: Idle, Snake, Wave, and Updown. The model was trained on pre-recorded datasets and deployed on a mobile device for live classification. The model achieved satisfactory accuracy during both the training and testing phases, with minimal confusion between classes.