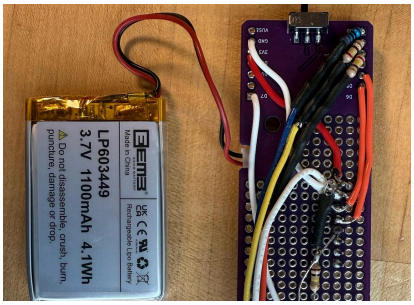
TECHIN 515 – Lab 4 Report: Magic Wand Gesture Recognition

1. Pictures of Hardware Setup



2. Data Collection Process & Results

Hardware Used:
- ESP32 XIAO
- MPU6050 (I^2C)
- Common cathode RGB LED (GPIO 6, 7, 8)
- SPDT switch (C → GND, NO → GPIO 3)
- LiPo battery (3.7V 1100mAh)
- Solderable breadboard

The ESP32 samples accelerometer data at 100Hz using the MPU6050. A gesture is triggered when the SPDT switch connects to ground. Each gesture recording lasts 1 second.
Captured Gestures:
- “Z” – Fire Bolt
- “O” – Reflect Shield
- “V” – Healing Spell

3. Edge Impulse Model Architecture & Optimization

Impulse Design:
- Input: 3-axis accelerometer (X, Y, Z)
- Processing block: Flatten
- Learning block: Dense Neural Network

Parameters:
- Window size: 1000 ms
- Window stride: 500 ms
- Sampling rate: 100Hz
- NN: 1 hidden layer, 20 neurons

4. Performance Metrics

Gesture	Samples	Accuracy	LED Color
Z – Fire Bolt	100	99%	Red
O – Reflect Shield	100	95%	Green
V – Healing Spell	100	98%	Blue

5. Challenges & Solutions

Challenge	Solution
PlatformIO upload issues	Specified upload port manually in .ini file
Serial collision with LED timing	Added delays + debounce logic in code
V and O gesture confusion	Recorded more data and slowed gesture motion

8. Discussion Questions

Q1: Why should you use training data collected by multiple students rather than your own only?

Using data from multiple people increases generalization and robustness of the model. It avoids overfitting to one person's motion patterns, making the wand more reliable for all users.

Q2: Discuss the effect of window size.

Larger window sizes capture more motion detail but slow down response and increase model size. Smaller windows respond faster but might miss slower gestures. A 1-second window was optimal for capturing complete gestures while maintaining responsiveness.

Q3: Why did you choose your learning block?

Given the input (100 time steps × 3 axes), a dense network can learn temporal-spatial relationships across the signal without the overhead of convolutional or recurrent layers.

Q4: Why did you choose your DSP block?

The Flatten DSP block to keep the feature extraction minimal and preserve raw signal structure. This allowed the neural network to directly learn patterns from the 3-axis accelerometer data over time

Q5: Give at least two strategies to enhance model performance.

- Collect data from more users to improve generalization.
- Tune hyperparameters and test alternative DSP blocks.