Rock Climbing Route Counter

NDOF MODE

In 9DOF mode, the BNO055 combines data from its accelerometer, gyroscope, and magnetometer to provide a comprehensive and accurate representation of its orientation in space.

It leverages the sensor fusion algorithms to calculate the device's absolute orientation in space with respect to the Earth's surface.

The BNO055_LINEAR_ACCEL_DATA is used to output the acceleration data without the acceleration due to gravity generating noise when the device’s relative orientation changes slightly

Calibrating the Sensor

When first recording data the program goes into calibration mode.

To calibrate the sensor begins at rest and is rotated in each axis, the LEDS light up once it is calibrated

Once it is reprogrammed the offsets will be subtracted

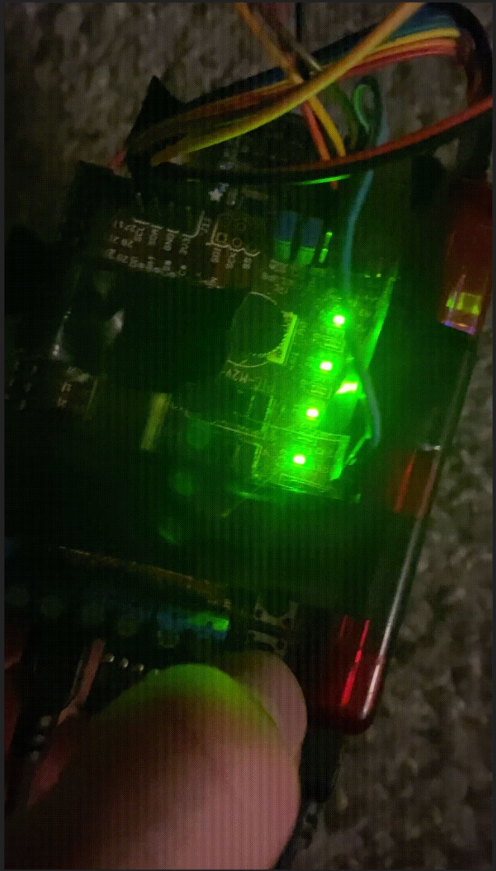
Recording the Data

```
11120142,-5,16,-29
11124995,-5,16,-20
11131005,8,67,-20
11136533,8,72,-14
```

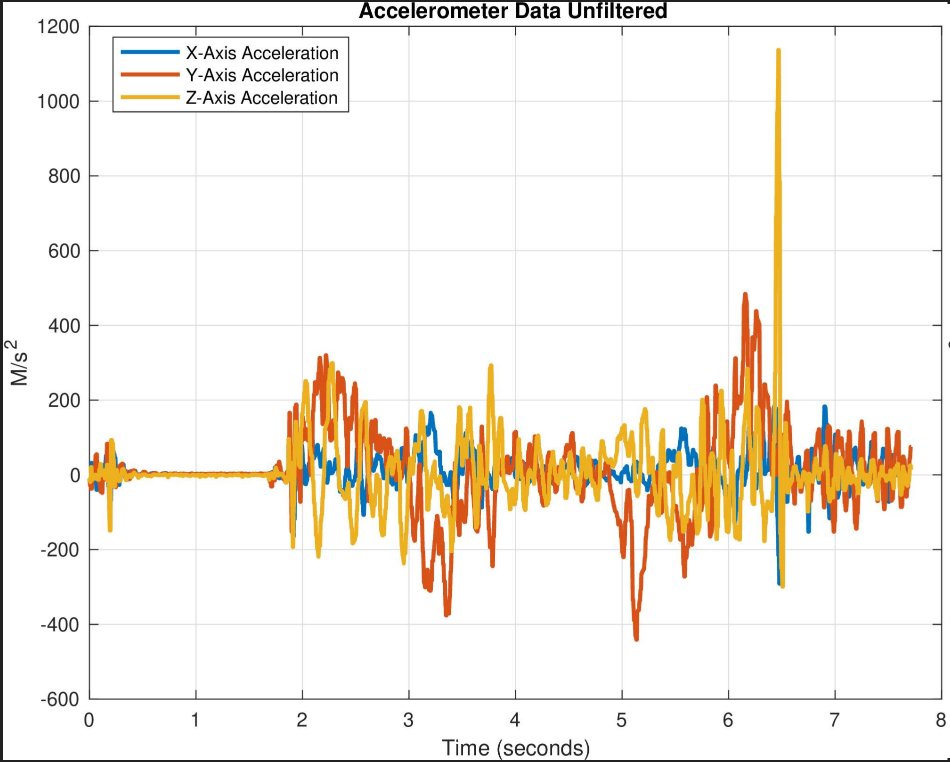
Example of data output, with the timestamp of the current data as well as the acceleration in every axis.

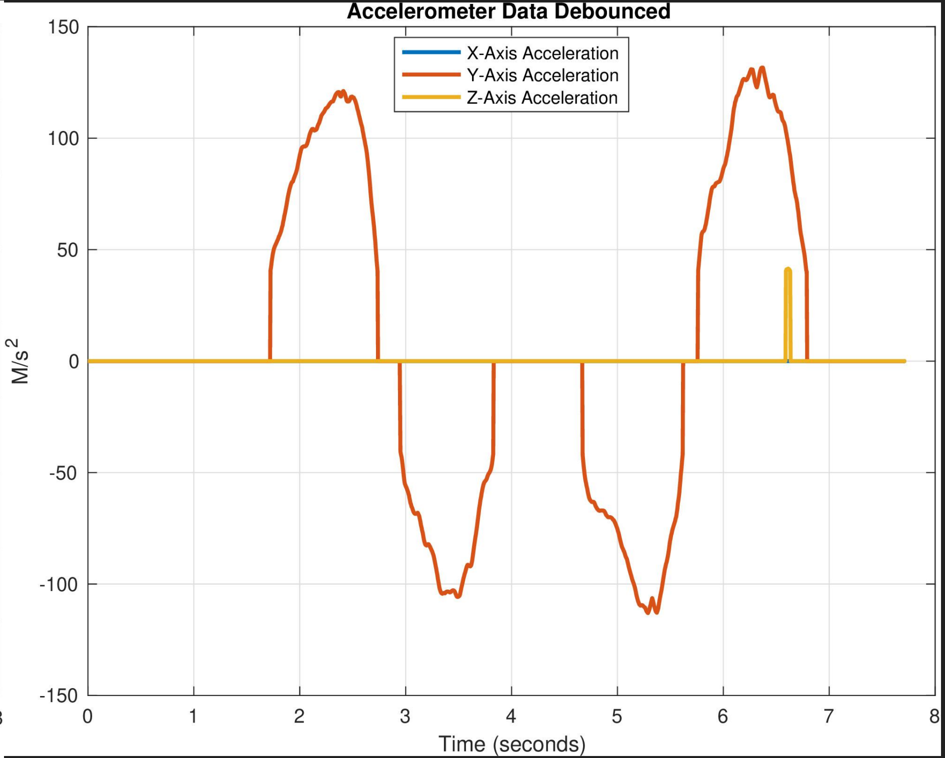
The time stamp was used to determine the timestep for the integration

Initial attempts were made at using 100Hz but the recorded data output was determined to be 230Hz

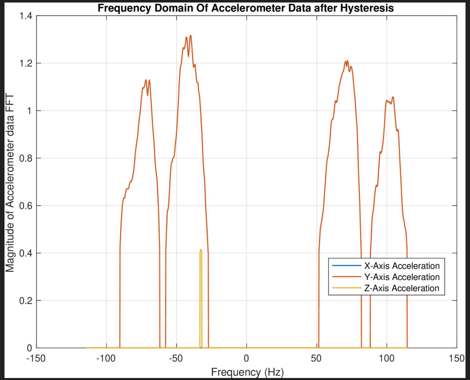


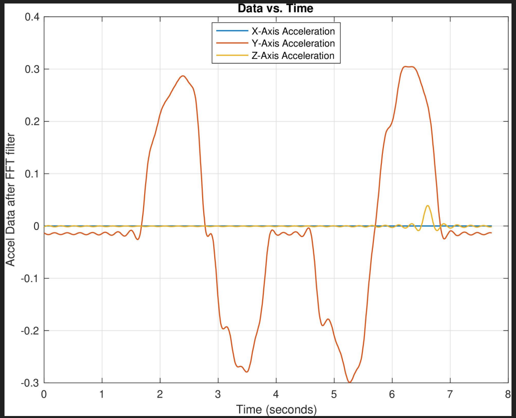
Debouncing Acceleration Data





Frequency Domain Filtering





The acceleration data was converted to the frequency domain

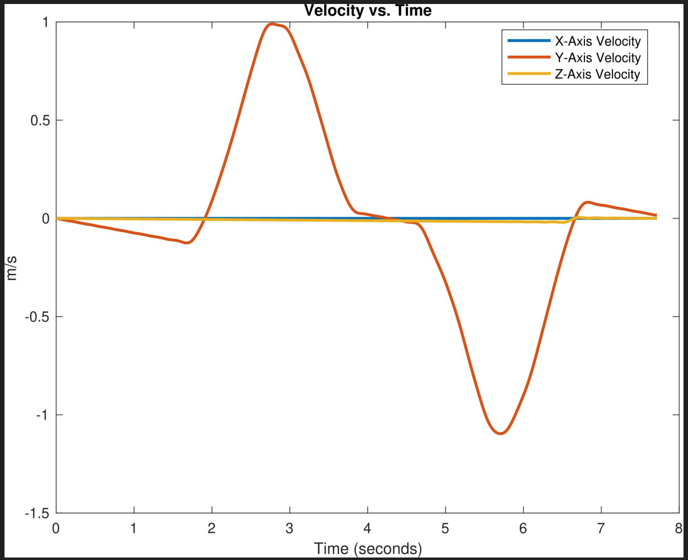
My initial approach was to find the frequency of my movements using an app to find the frequencies of interest

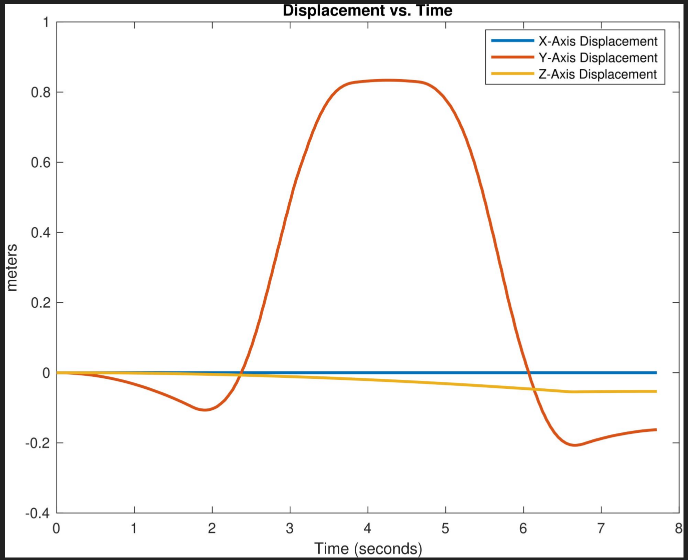
However after testing I manual adjusted the highpass and lowpass filters in order to get more accurate results

Integration

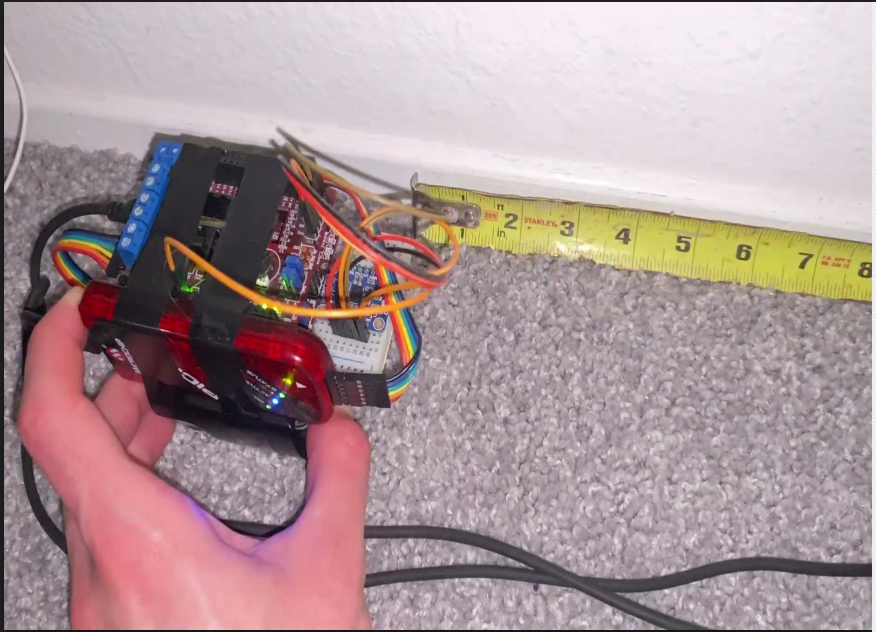
The time step found from the time difference between each readings used to perform the 2 integrations and determine the displacement over time

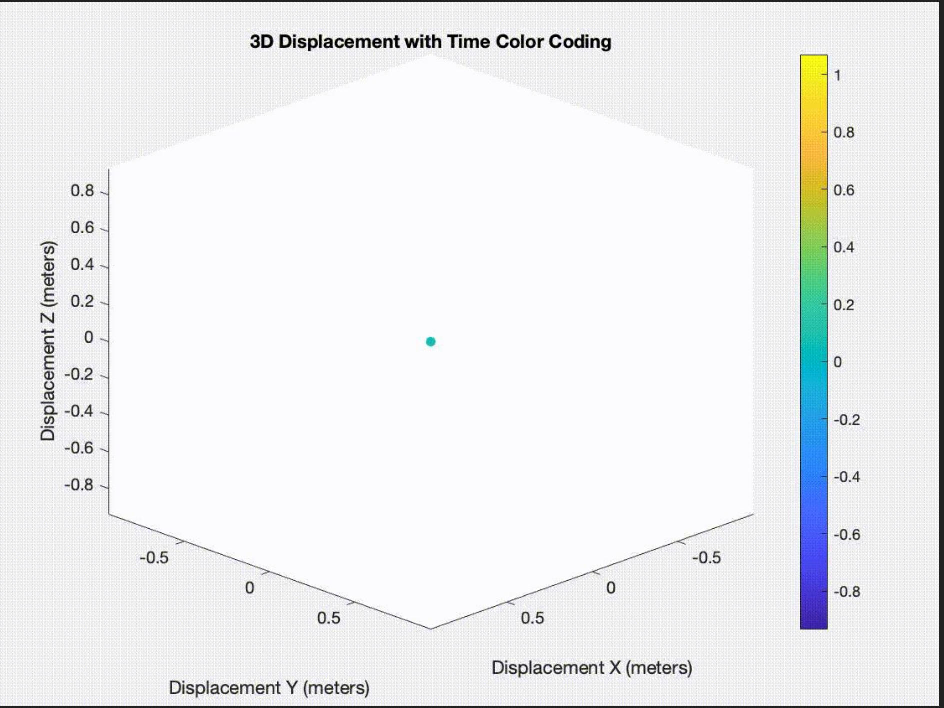
Because the double integration exaggerates errors, the data needs to be curated and extensively filtered in order to get useable results



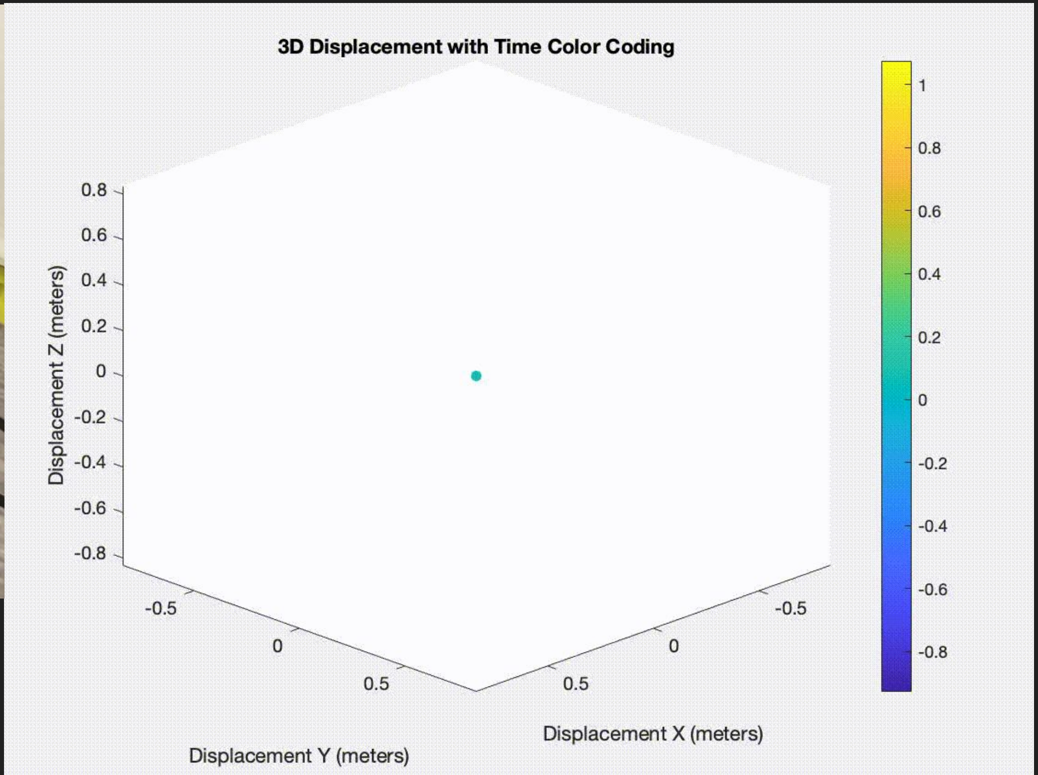


Collecting Data For X-Axis

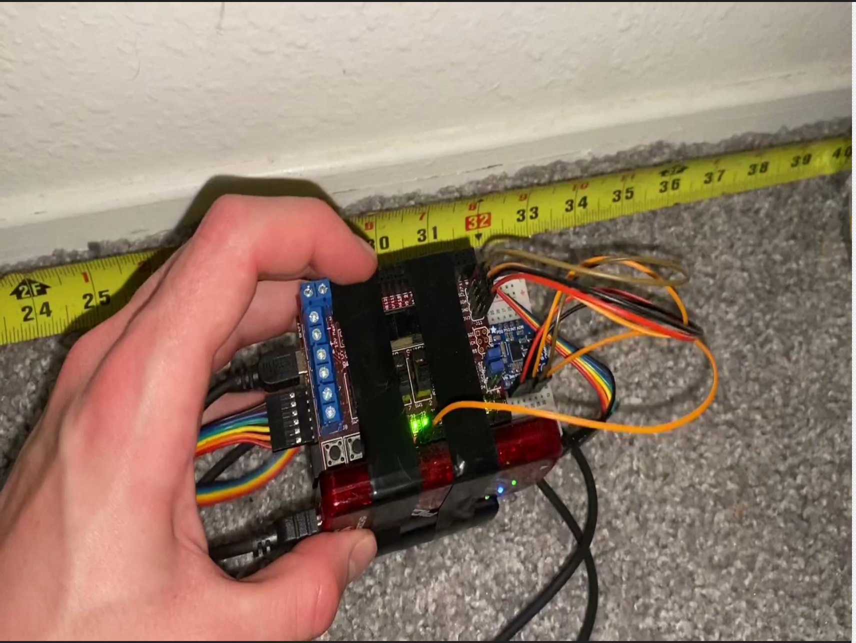


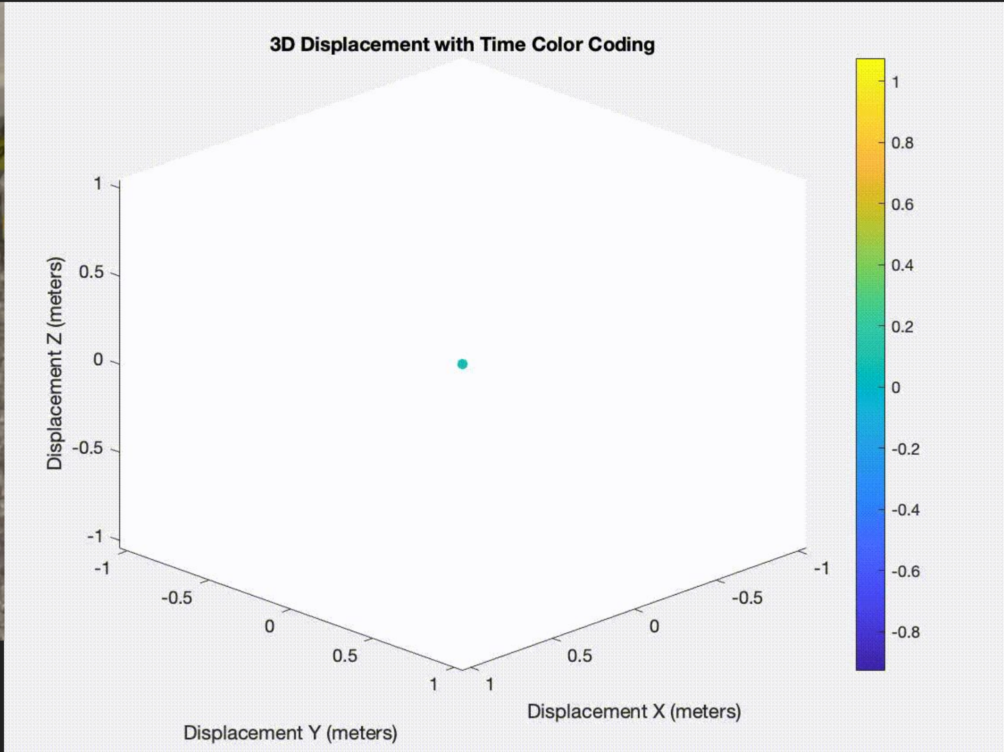


Collecting Data For Y-Axis



Collecting Data For Z-Axis





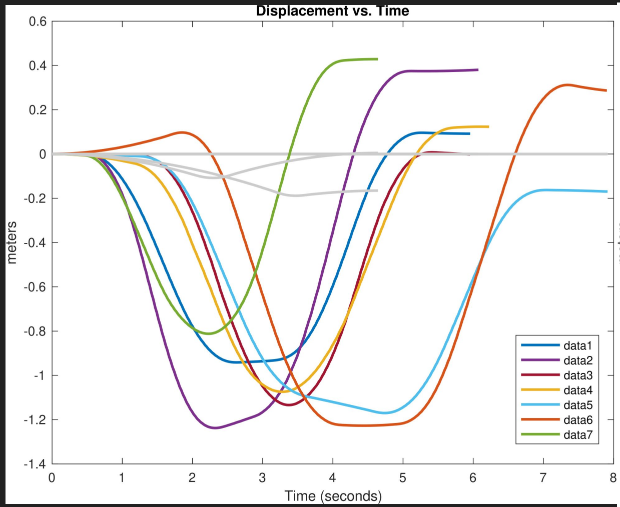
Error Rate

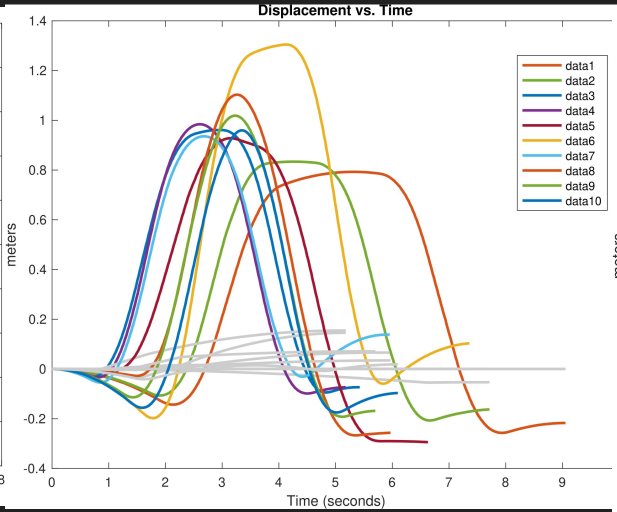
X-axis	Y-axis	Z-axis
0.1556m	0.1031m	0.1489m

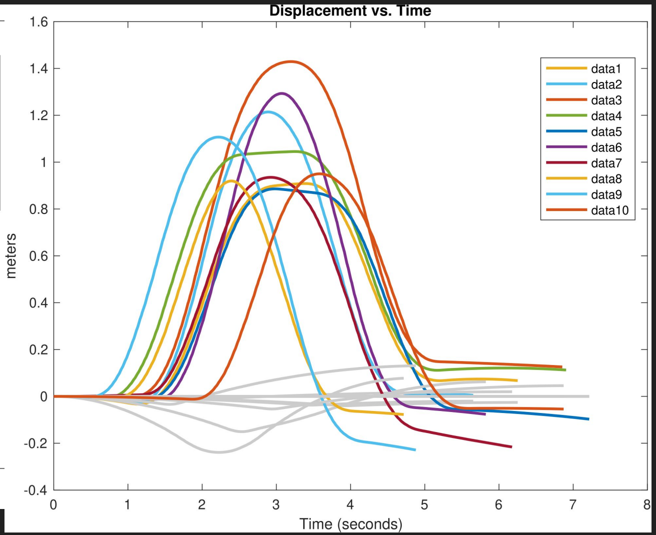
10 tests were performed in each axis and the results were plot for each trial in a different color

The error rate was found to be about +-0.2m

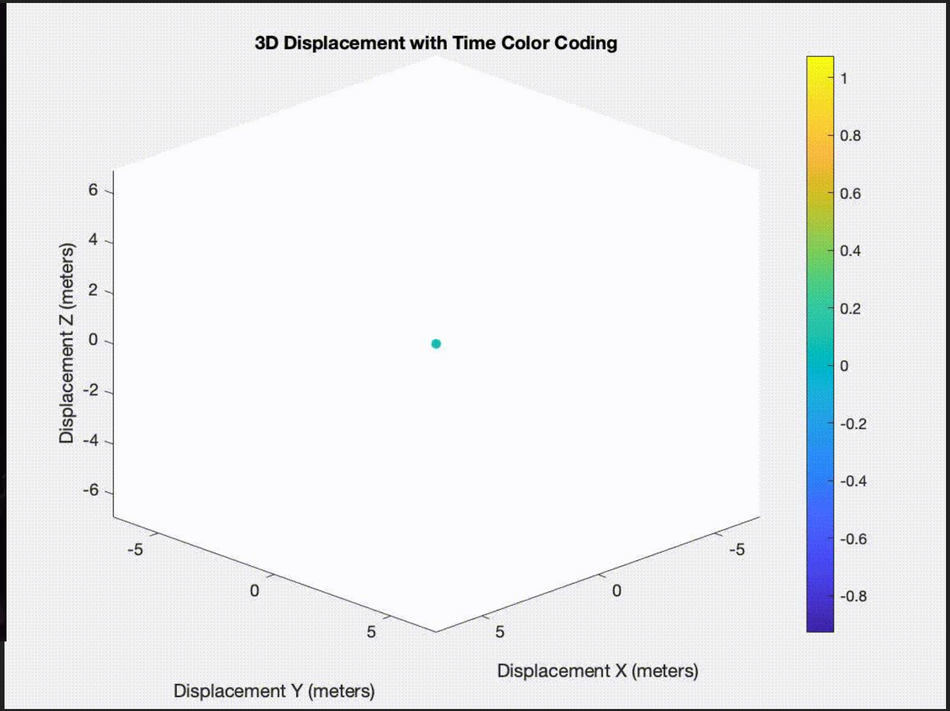
Noise in other axes are shown in grey, this is most likely due to the inaccuracies of movements while performing the tests



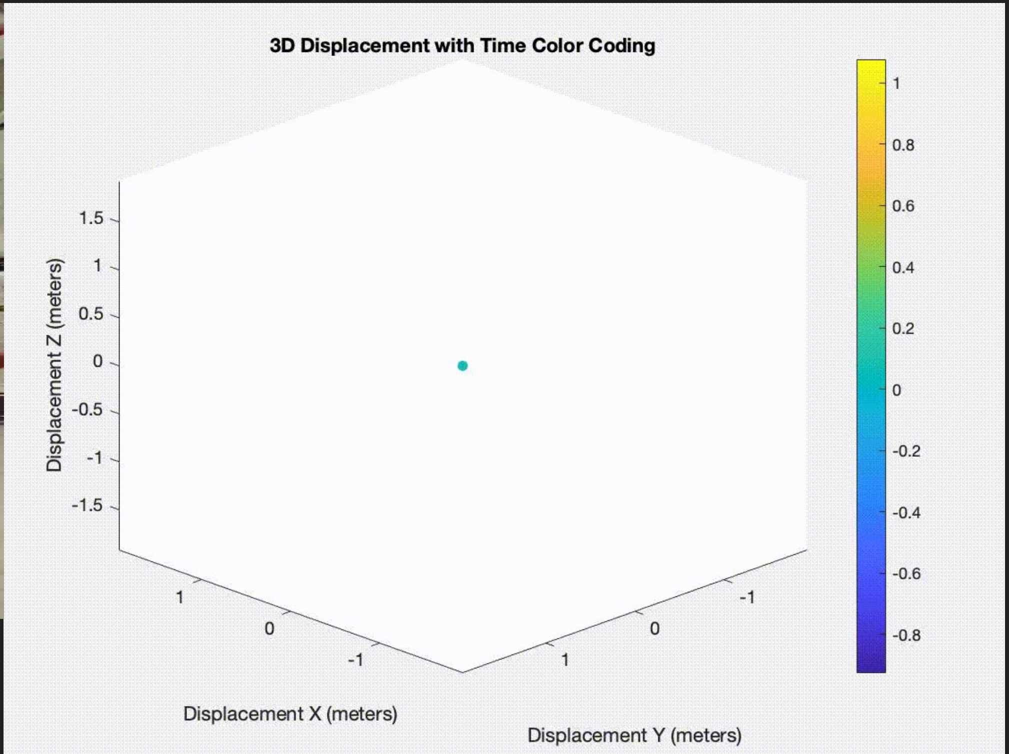




Traverse Wall on Campus



Gym Testing

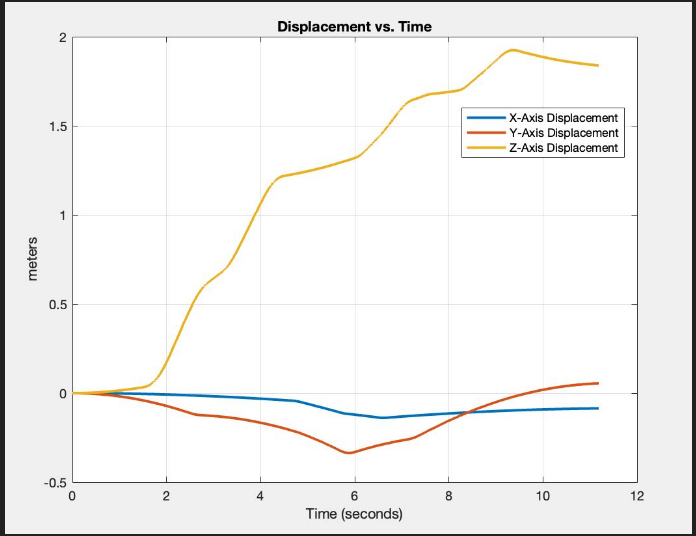


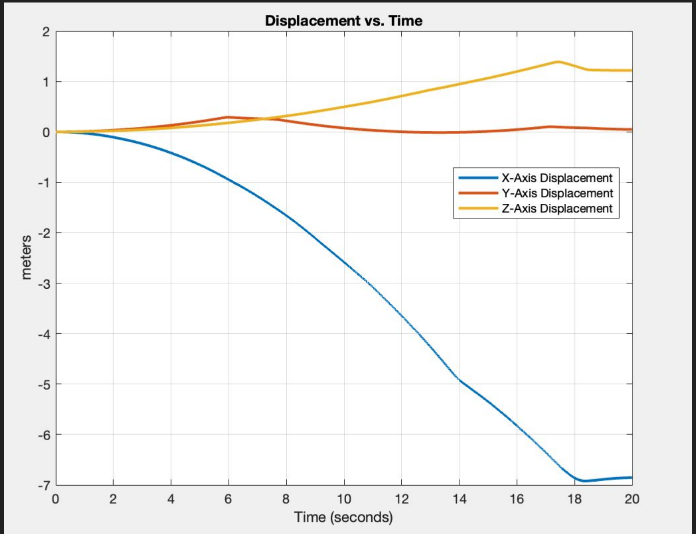
3D Displacement with Time Color Coding
Displacement Z (meters)
1.5
1
0.5
0
-0.5
-1
-1.5
1
0
-1
Displacement X (meters)
-1
0
1
Displacement Y (meters)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8

Real Results and Errors

The section of the traverse wall was measured to be 6m, and in the gym it was a height of 2m

Due to sporadic movements of climbing it was difficult to take good measurements, an improvement could be putting the imu on a gimbal in order to reduce the random acceleration of the sporadic movements





Future Improvements

-Adding a gimbal to reduce noise

-Making the device smaller and communicate wirelessly

-Taking more data

-Real time C program

-Better IMU with less noise

-More extensive complex filtering