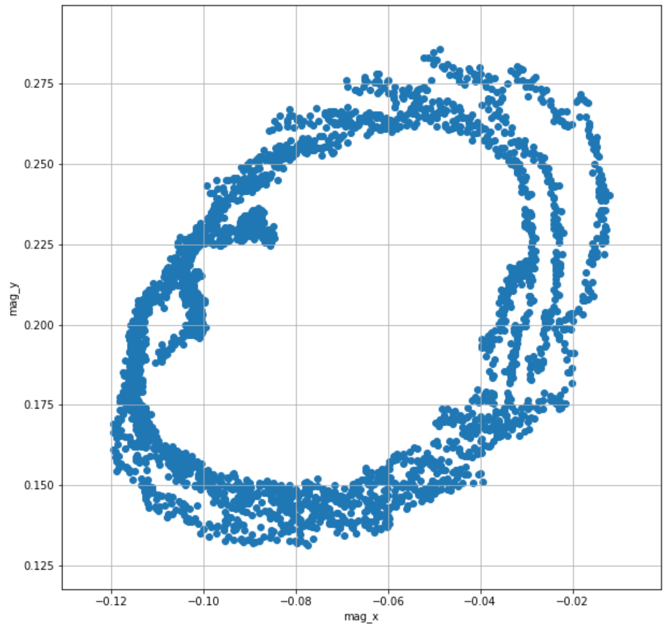
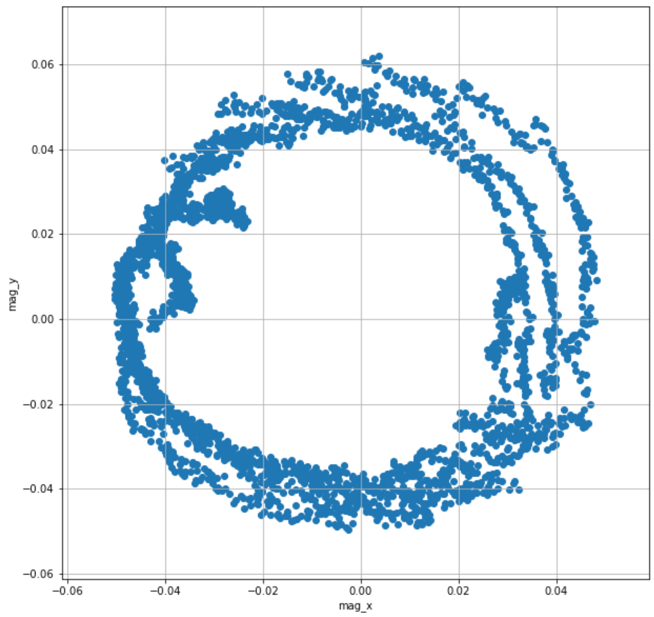
LAB4
Stationary data is plotted in the end
Analysis on circular path for calibration

<u>Yaw from Magnetometer</u>

<u>Before corrections</u>



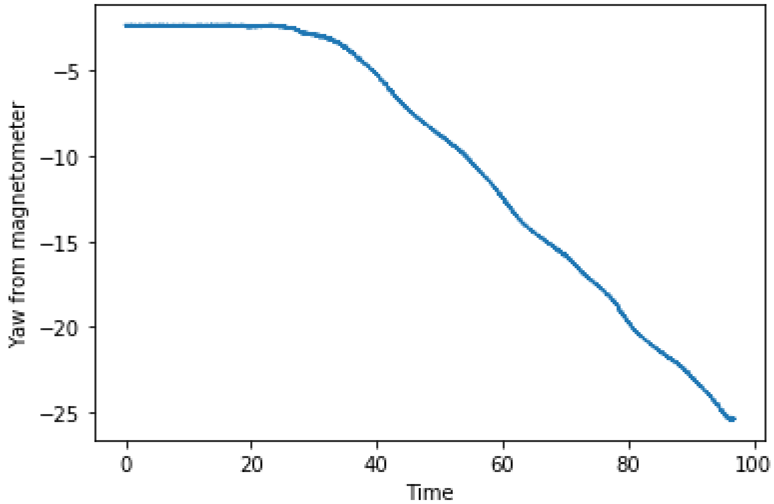
It can be seen that it needs both hard iron and soft iron corrections, for this we must use the formula given in the pdf. We have had to adjust the values to make it a proper circle.
<u>After corrections:</u>



Since we went in a circle multiple times we have multiple circular plots in the graph. The corrected matrix is mentioned in the analysis script.

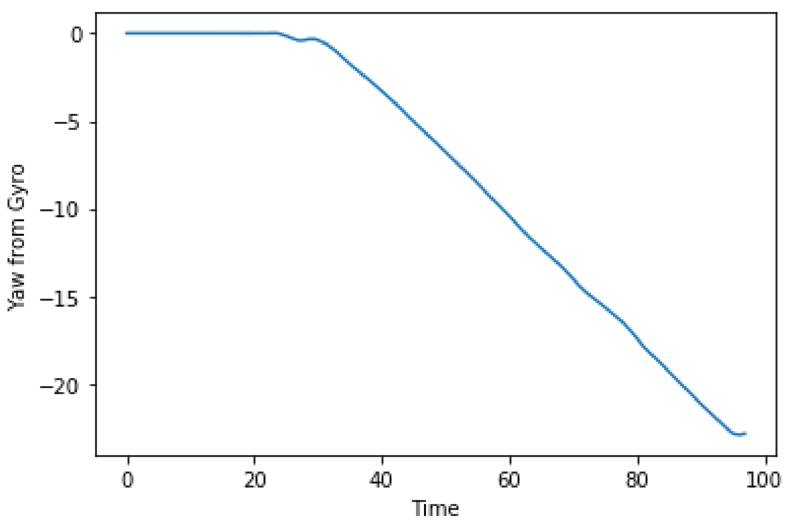
For the calibration we used the matrix from the graph and changed a few values to fix the ellipse, basically a trial and error method. These errors (hard and soft iron) have come up surely because of the presence of magnetic field around the IMU like phones and laptops.

Yaw from Magnetometer



This is the yaw from the magnetometer. Since we go in a circle the yaw is expected to keep decreasing so I believe that this yaw is correctly calculated.

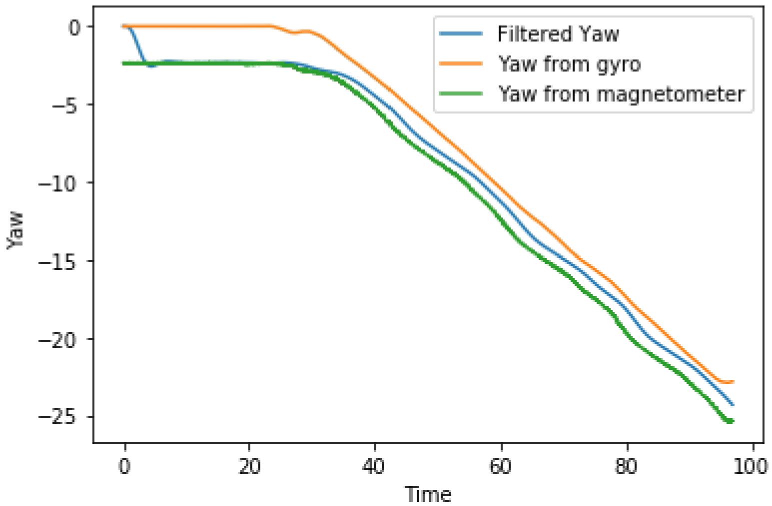
Yaw from Gyro



After integrating the yaw rate wrt time we get this graph.

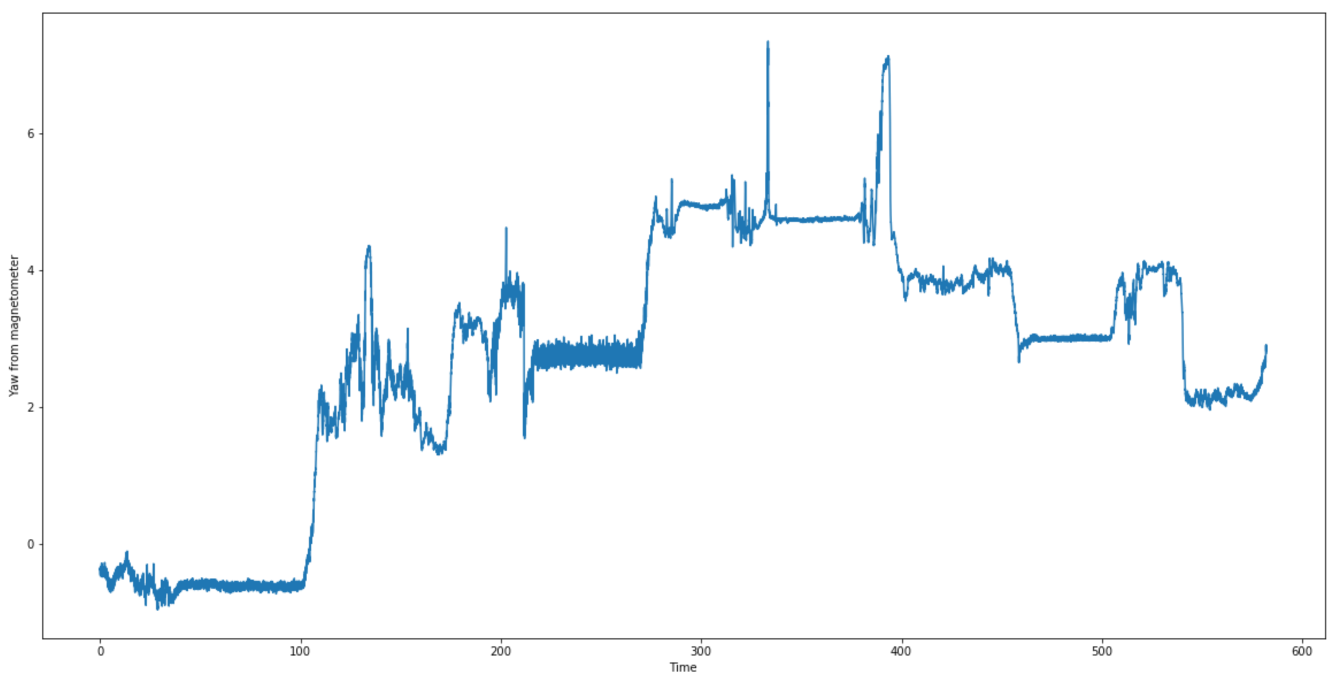
Comparison: The two graphs are quite similar in pattern however the gyroscope yaw gives a better and smoother yaw in comparison to the magnetometer

Yaw (filtered)



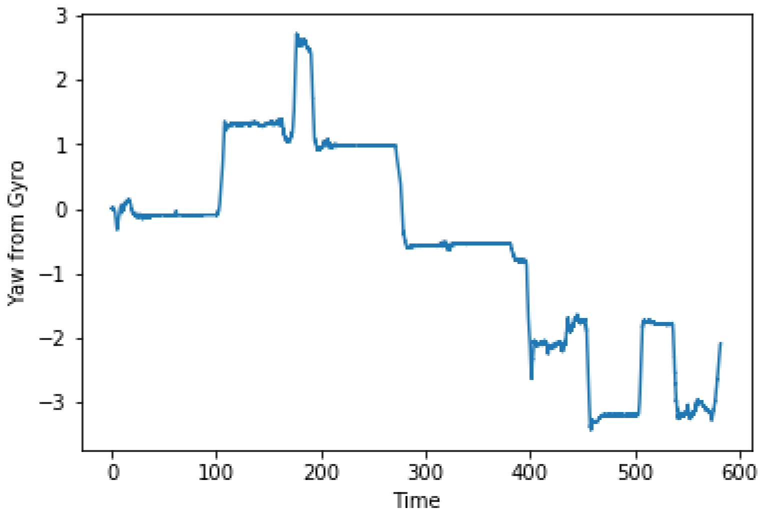
Analysis on normal path

Yaw from magnetometer

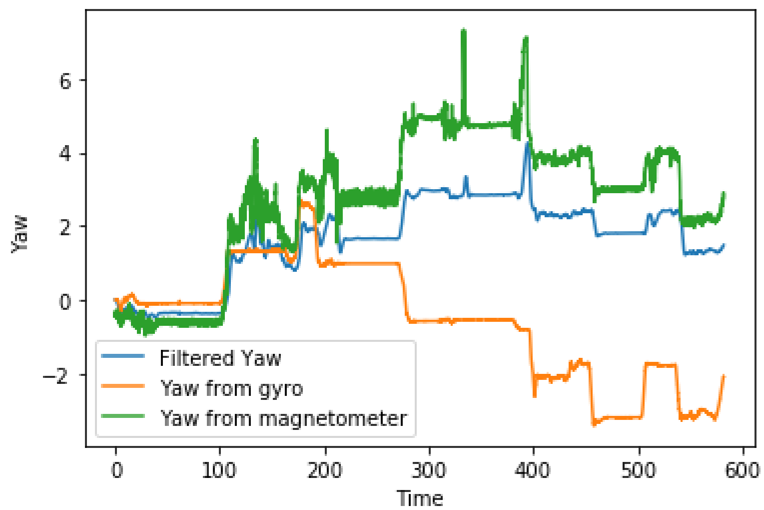


Before unwrapping this yaw from the magnetometer had a a lot of discontinuities so an unwrap function was needed.

Yaw from gyroscope



Yaw (filtered)



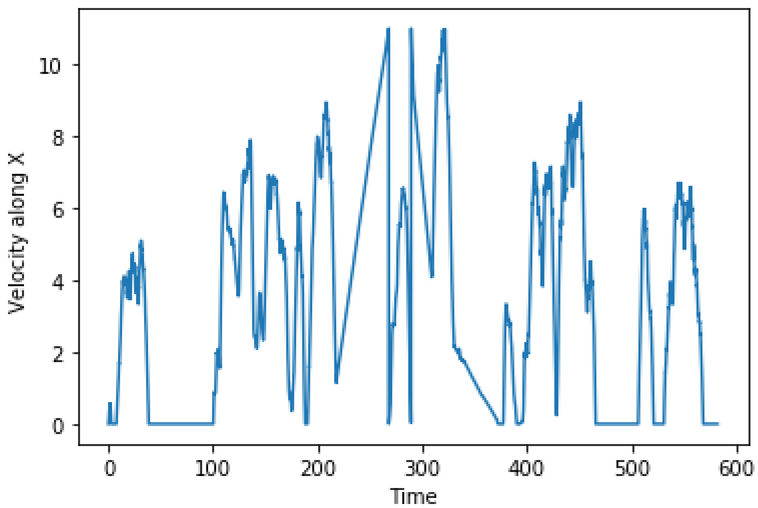
Specifications:
Cut off freq: 0.01 Hz
alpha: 0.7
used ‘butter’ to obtain filter parameters,and to initialize low pass and high pass paramters
used ‘lfilter’ for the filtering process
We assume that most of the magnetometer data is correct and hence alpha is the weight for the magnetometer and 1 – alpha is the weight of the gyroscope.

<u>Comparison</u>:
The yaws for this are pretty similar in pattern but there’s a lot of difference in the values of each, but they atleast follow the same ups and downs. The yaw from gyro is a very neat graph which would make me assume that it’s not very sensitive to changes. Another point to note out that the values for gyro are distributed evenly which should be the case since we followed the same path to and fro, but the magnetometer path doesn't show any kind of pattern. The yaw from the magnetometer varies a lot from time to time which shouldn’t be the case ideally but that's why we are filtering it to get an approximate of both yaws.
To answer the question of which yaw I would use for navigation it would definitely be the yaw from the gyroscope as a lot of corrections were needed to be made like hard iron, soft iron plus we had to

unwrap the inverse tangent to deal with data loss, all these sources add up to make the yaw from the magnetometer a tiring datset.

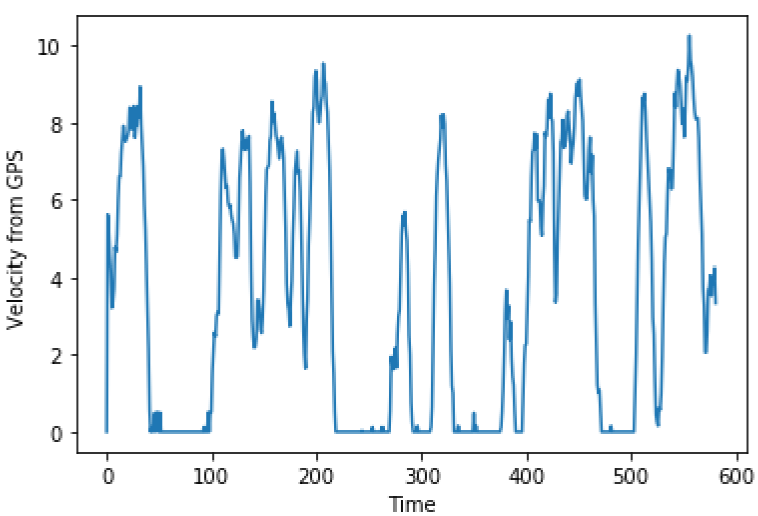
Velocities

Velocity from linear acceleration



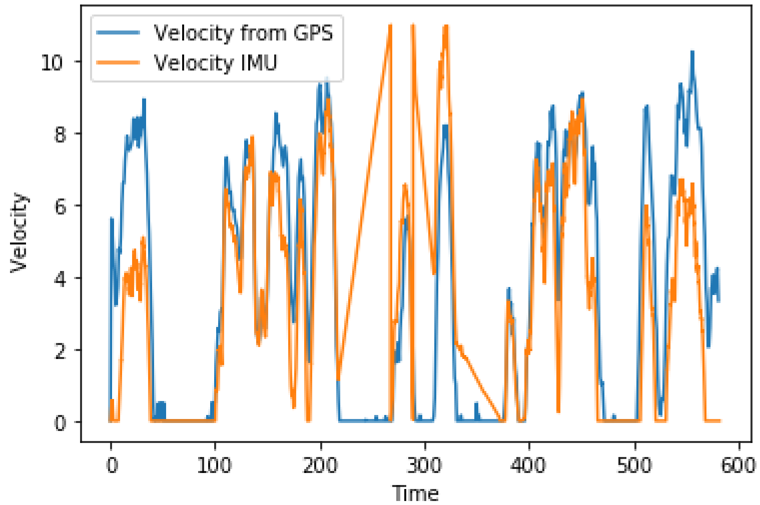
The graph had to be corrected for bias and this was the best correction that could be made. I observed the rolling deviation for most periods and took the mean of those and found that out to be -0.55. Initially I was getting a straight line graph but subtracting this offset made the graph look like this. There were periods of negative velocity in this which dont really make sense, so I had to make them 0 and this was the closest to the gps velocity plot.

Velocity from GPS



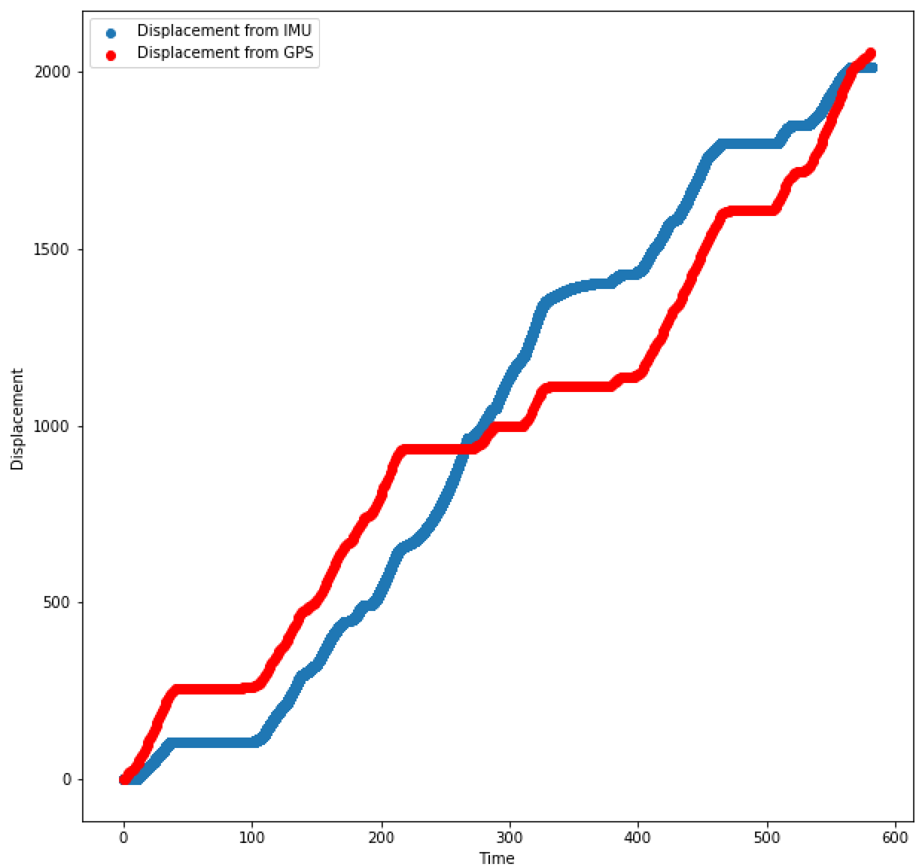
This graph is formed by differentiating the easting and northing w.r.t. time

Comparison:



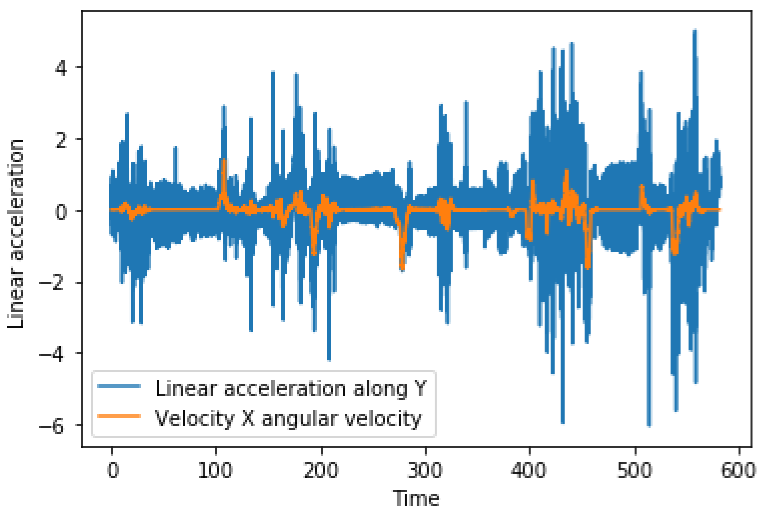
I filtered out some negative values obtained from the velocity obtained from the IMU bu adding a fixed bias to those points. However, still some kind of bias needs to be added to some parts of the data to actually coincide with the GPS velocity. The shapes of the graphs are almost similar in that sense. There are bursts of time where we really good velocity measurements but after that it gets completely offtrack and ruins the data. Also, integrating the accelerometer errors make it larger in the velocities so it is very nicely visible in this data.

Displacement



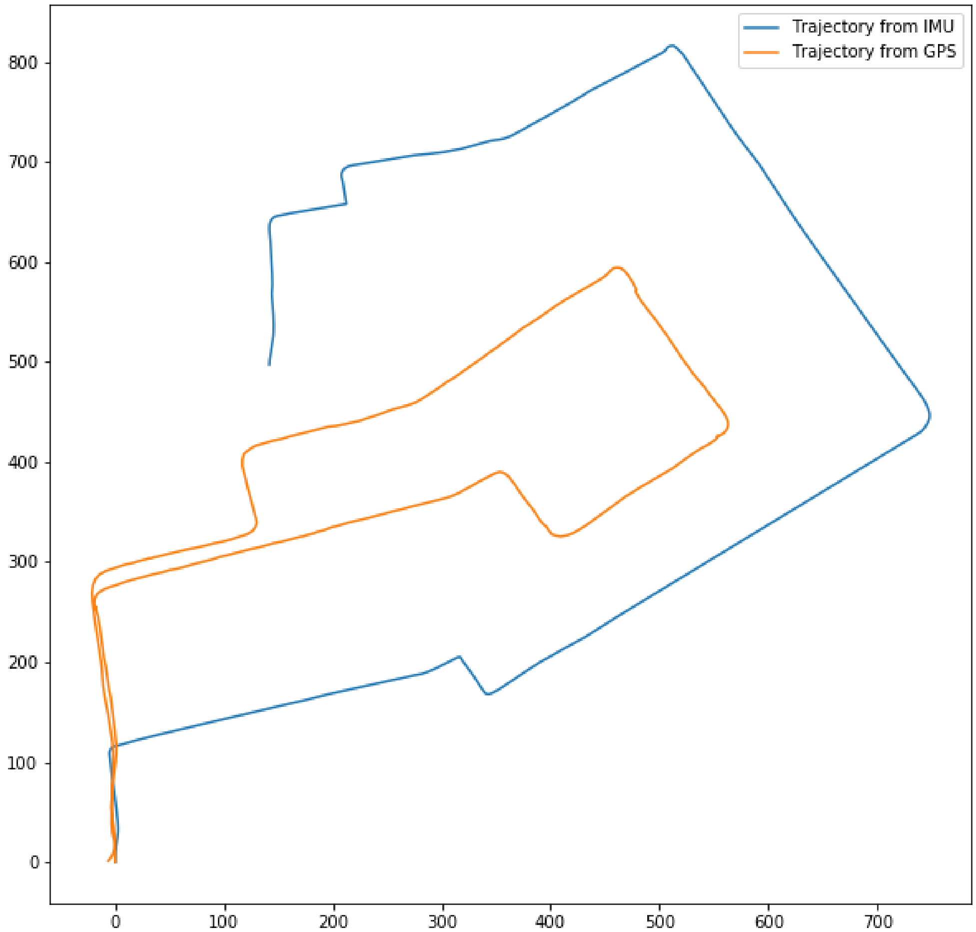
Comparison:
Due to the constantly changing bias of the accelerometer we have had some discrepancies between the two displacements. Adding even a small bias overall makes a massive change to the plots and hence we need a changing bias for every reading to get an accurate graph. The plots are almost similar but some fine tuning is required to make them absolutely coincide.

Dead reckoning with IMU



The calculated linear acceleration varies significantly and mostly remains close to 0 which should ideally be the case as our car is not drifting (I'm sure)., however the accelerometer still captures a lot of points of acceleration and is almost never 0. This might be because of the bias present in the accelerometer, we are sure because we sure had bias in the x direction (done for velocity). Also, external noise and vibrations also might effect the output of the accelerometer. The pattern is almost identical at some points which might also tell us that maybe our calculations have some errors present due to biases.

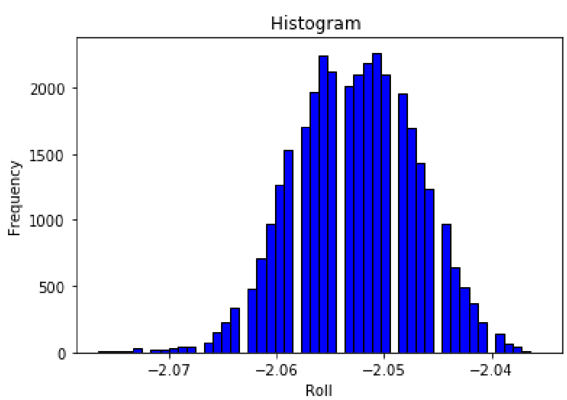
Trajectory

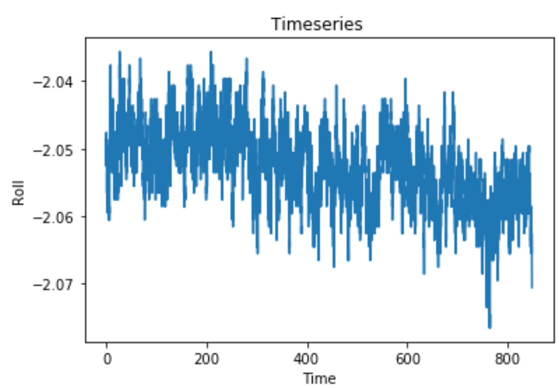


On integrating twice the errors have seemed to magnify, however we can make out that the path is atleast similar to that of the GPS. I have rotated the GPS trajectory by 11.5 degrees in the anticlockwise direction to coincide with the IMU data.

Stationary data

Orientation(in Euler)
ROLL

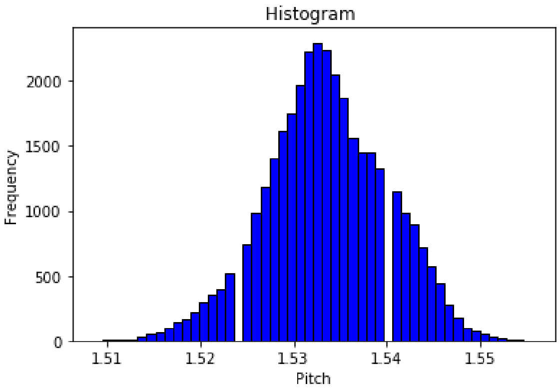


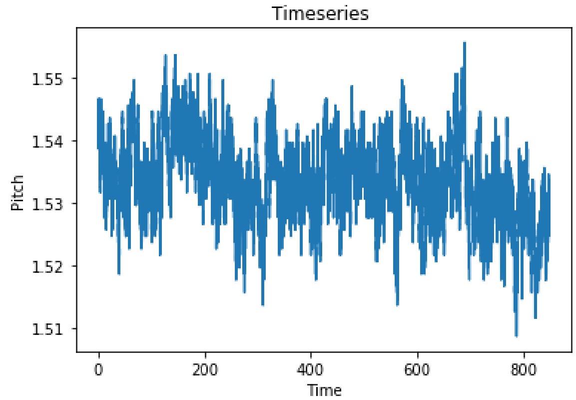


Mean: -2.0527107928232144

Standard deviation: 0.005631931611313559

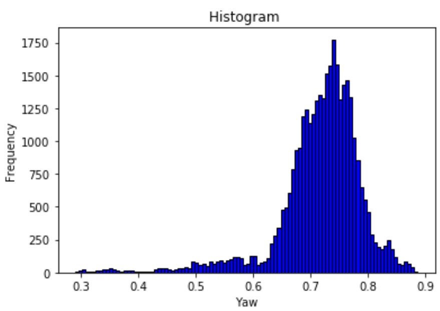
PITCH

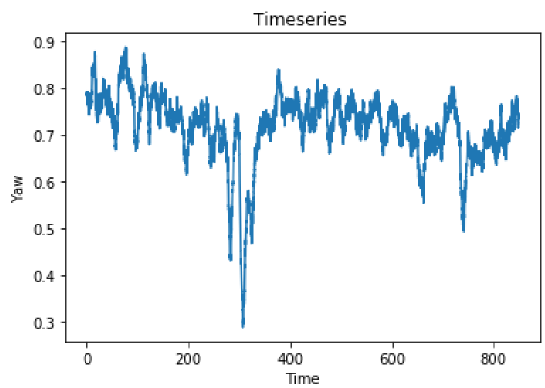




Mean: 1.5334600489290415
Standard deviation:0.006489009394327021

YAW



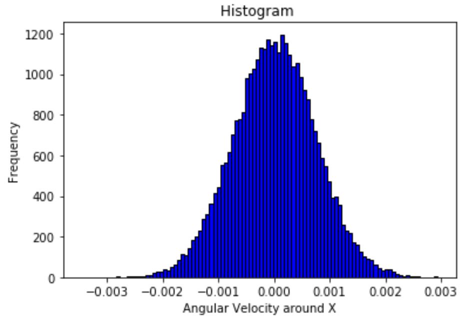


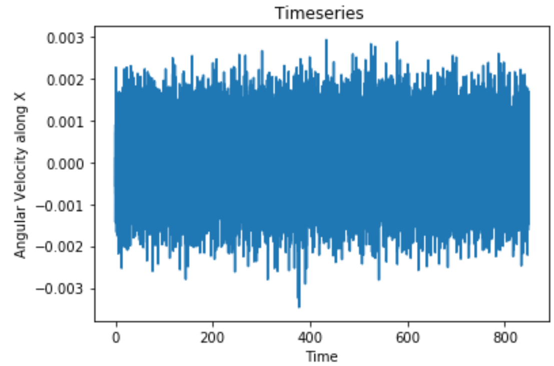
Mean:0.7164081782991557
Standard deviation:0.07408497149274834

Analysis of orientation:
If we take an overall look at the histograms of each we can say that the distributions are mostly gaussians. A negative roll mean implies that maybe the floor(basement) where I took the readings was tilted(most of the houses in Huntington are tilted unfortunately). As the IMU was taped to the floor so we can expect it to have really low standard deviation also owing to its high sensitivity. Also, there is an anomaly in the data for yaw where a slight disturbance has been seen for a very short duration this could possibly be because of the wire moved a little because of some possible vibration, hence this might also have impacted the standard deviation of yaw and hence is less than pitch and roll.

3 Axis angular gyros(angular velocity)

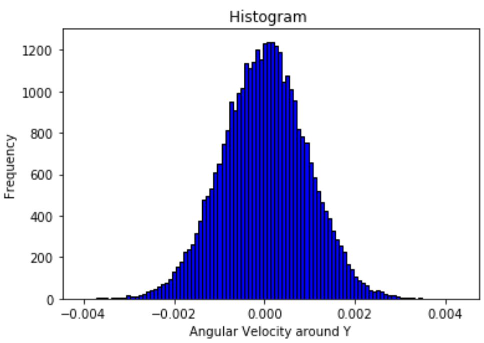
X Axis

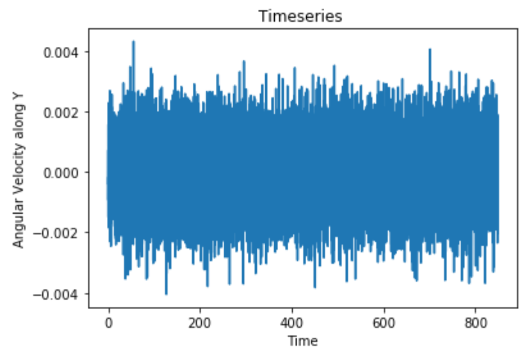




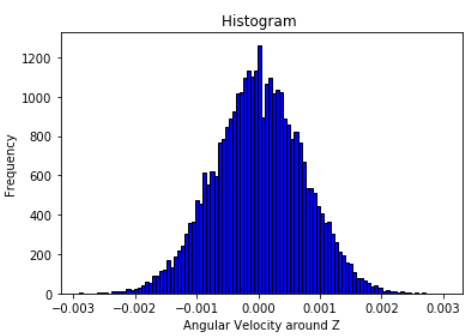
Mean:5.516262078717889e-06
Standard deviation:0.0007448542406968123

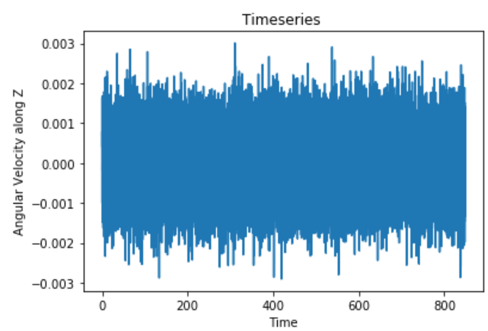
Y Axis





Mean:-3.428617723308979e-06
Standard deviation:0.000941141035379478
Z Axis



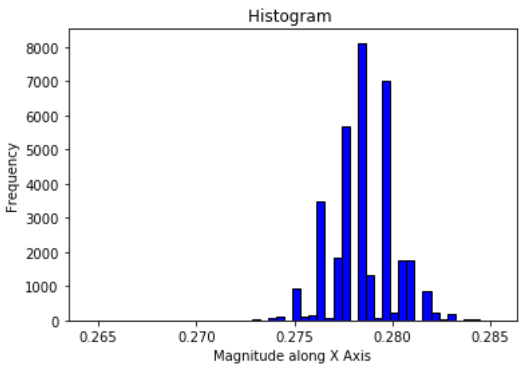


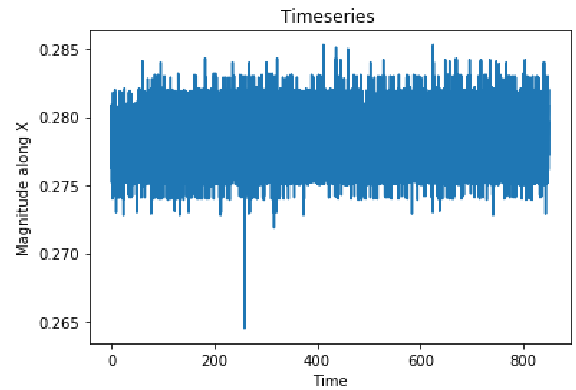
Mean:5.385635163799197e-06
Standard deviation:0.0007263771967508148

Analysis on angular gyros:
The values of each of these appear to be very close to an ideal gaussian distribution. The means are really low as the IMU was stuck to a table and was in a stationary place so obviously the angular velocity wouldnt change. The high sensitivity and precision of the device still managed to get some values but ideally the mean along all axis should be 0.

3 Axis magnetometer

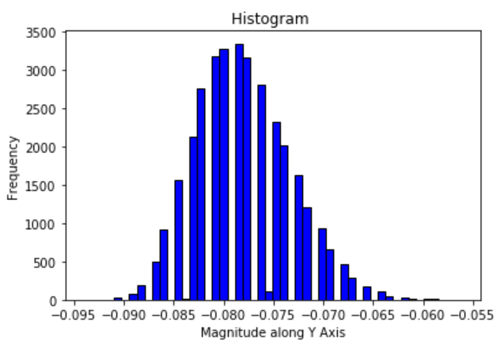
X Axis

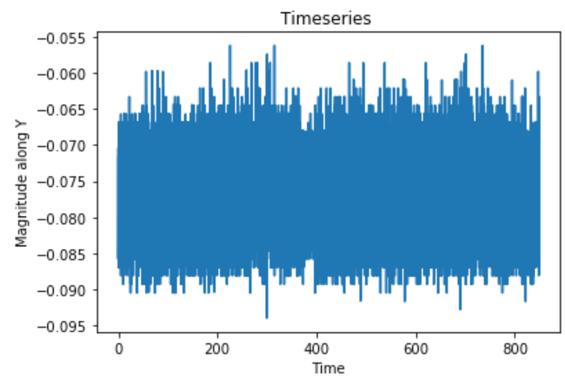




Mean:0.2785227610181475
Standard deviation:0.0015959525133468O5

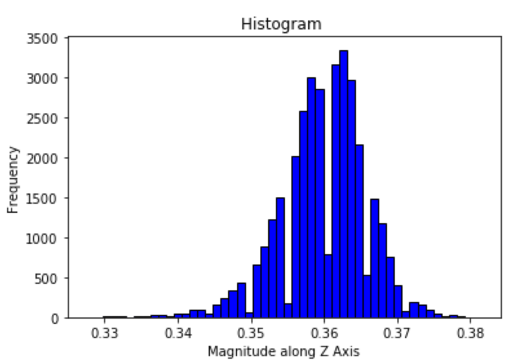
Y Axis

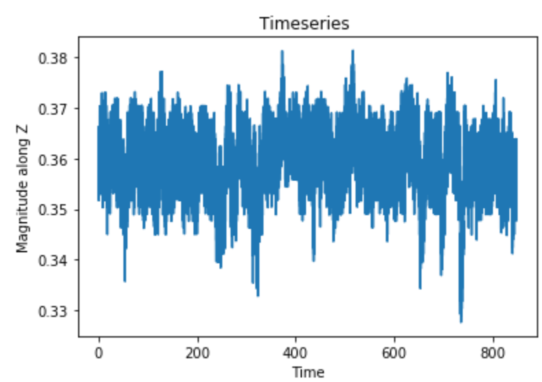




Mean:-0.07805647537119963
Standard deviation:0.004760813190172163

Z Axis





Mean:0.359950132571294
Standard deviation:0.005839520930356432

Analysis on magnetometer:

1. These are the only graphs which cant be called gaussian. The magnetic field that it would experience in a basement would be from the earth's magnetic field or from the magnetic waves produced by our devices. A magnetic spike along the X Axis is experienced almost at the same time when Yaw had a similar spike, this makes an interesting observation which can lead us to believe that it was because of some human or man made vibration(like a phone call?)