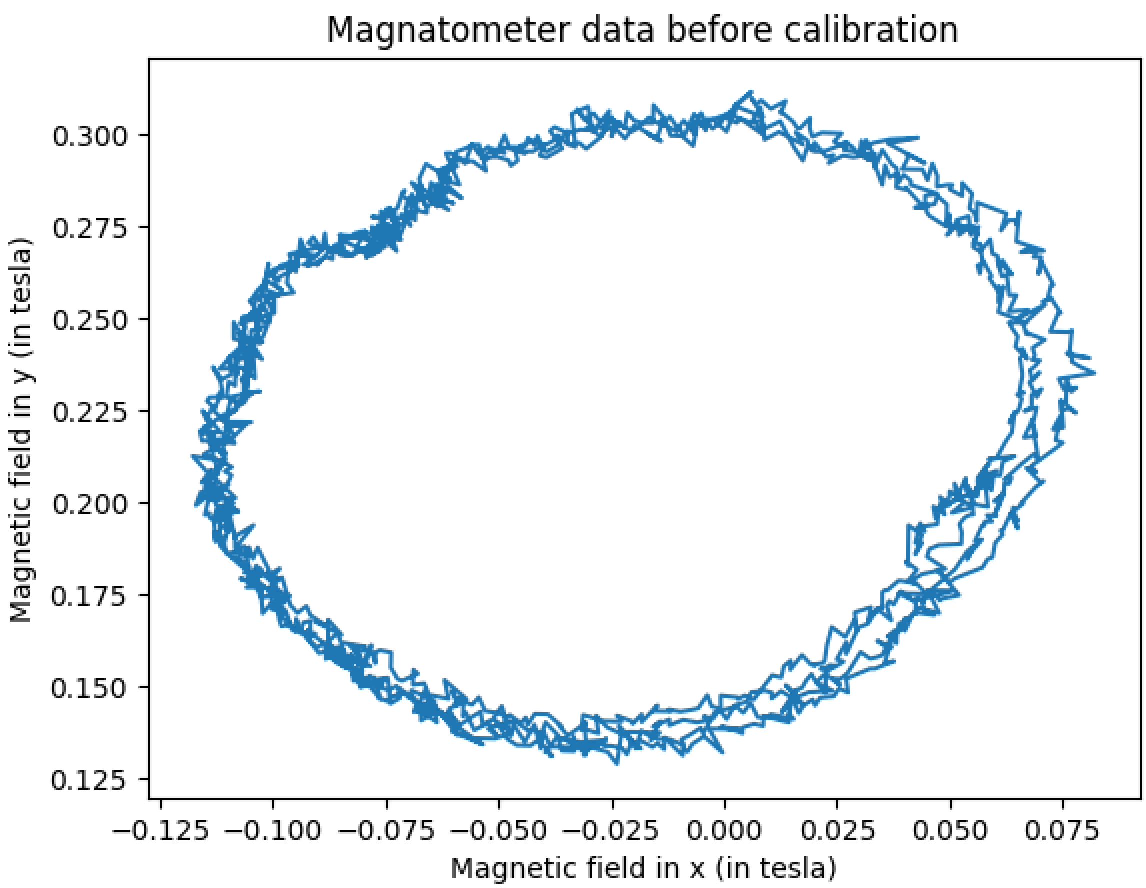
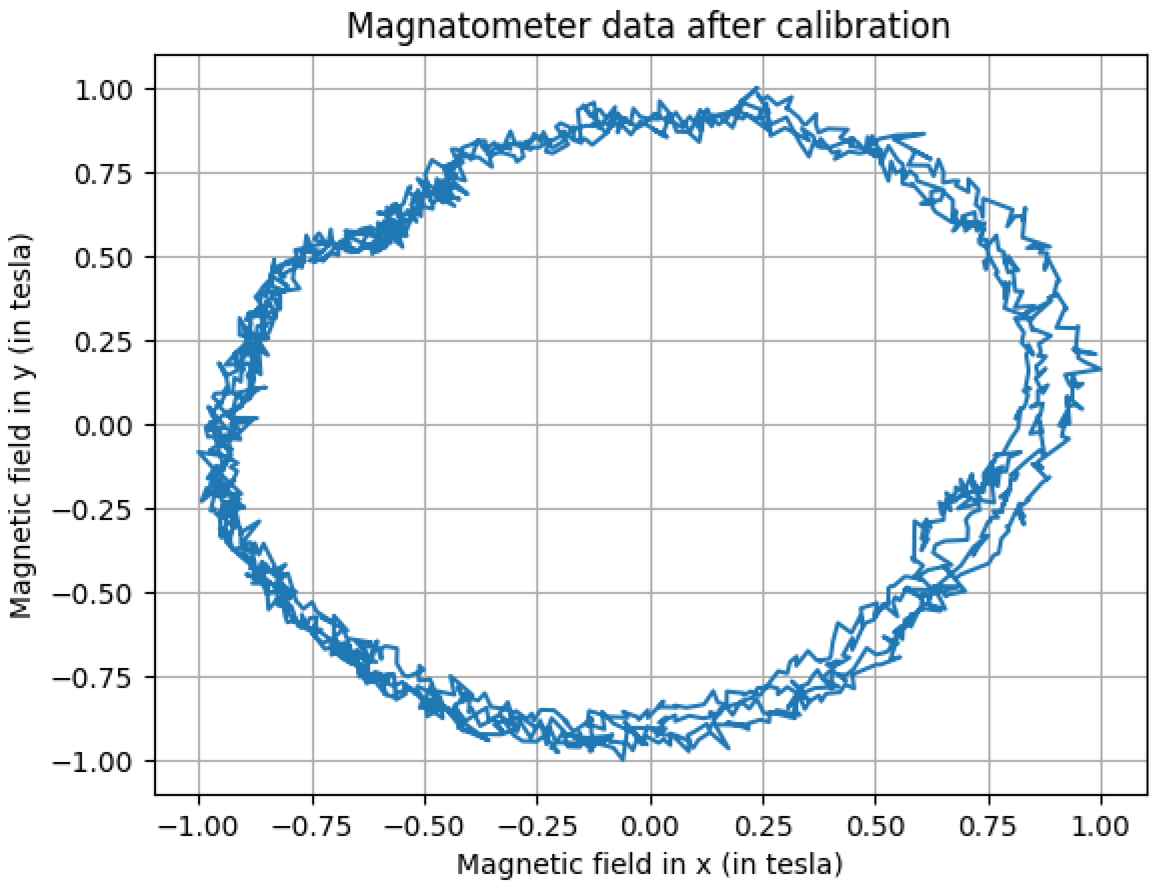
# LAB4- Report

## 1. How did you calibrate the magnetometer from the data you collected? What were the sources of distortion present, and how do you know?

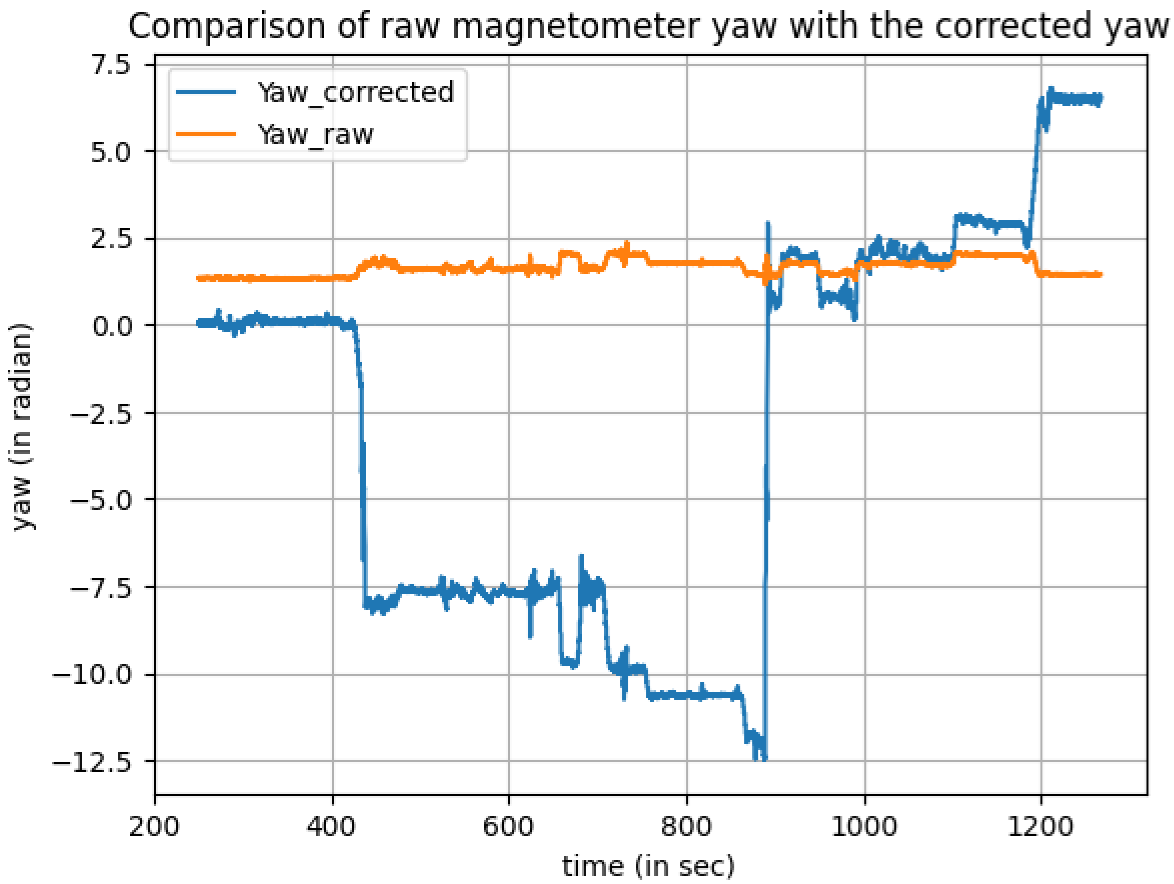
Firstly I isolated the data corresponding to driving in a circle, then I plotted the magnetic field in x and y for the same. Upon observing the data I came to the conclusion that there is hard iron and soft iron distortion as Hard iron distortion is caused by the presence of permanent magnetic materials near the magnetometer. This type of distortion can result in a constant offset in the magnetometer readings. Soft iron distortion is caused by the presence of ferromagnetic materials that can distort the Earth's magnetic field. This type of distortion can result in a change in the shape of the magnetic field, leading to inaccuracies in the magnetometer readings. To calibrate the magnetometer I did the ellipsoid fitting and shifted the circle to the origin.

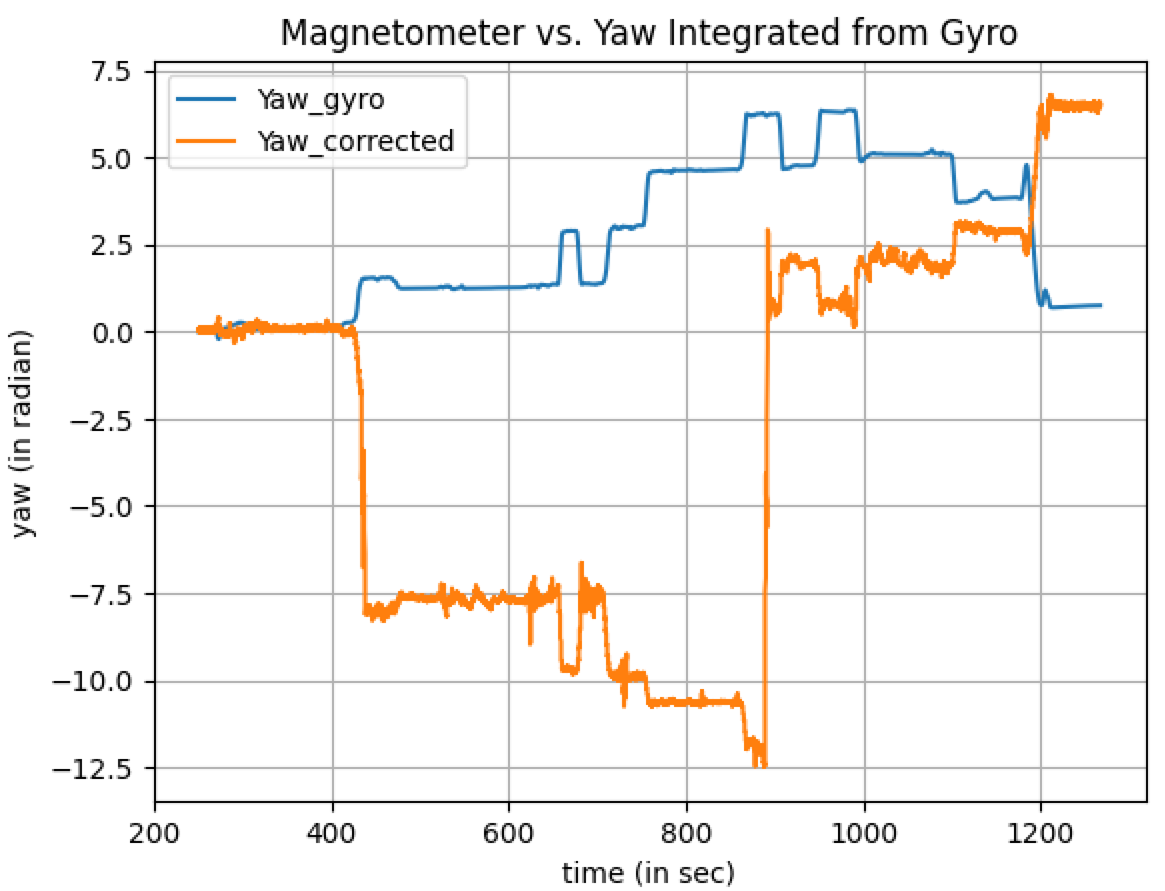


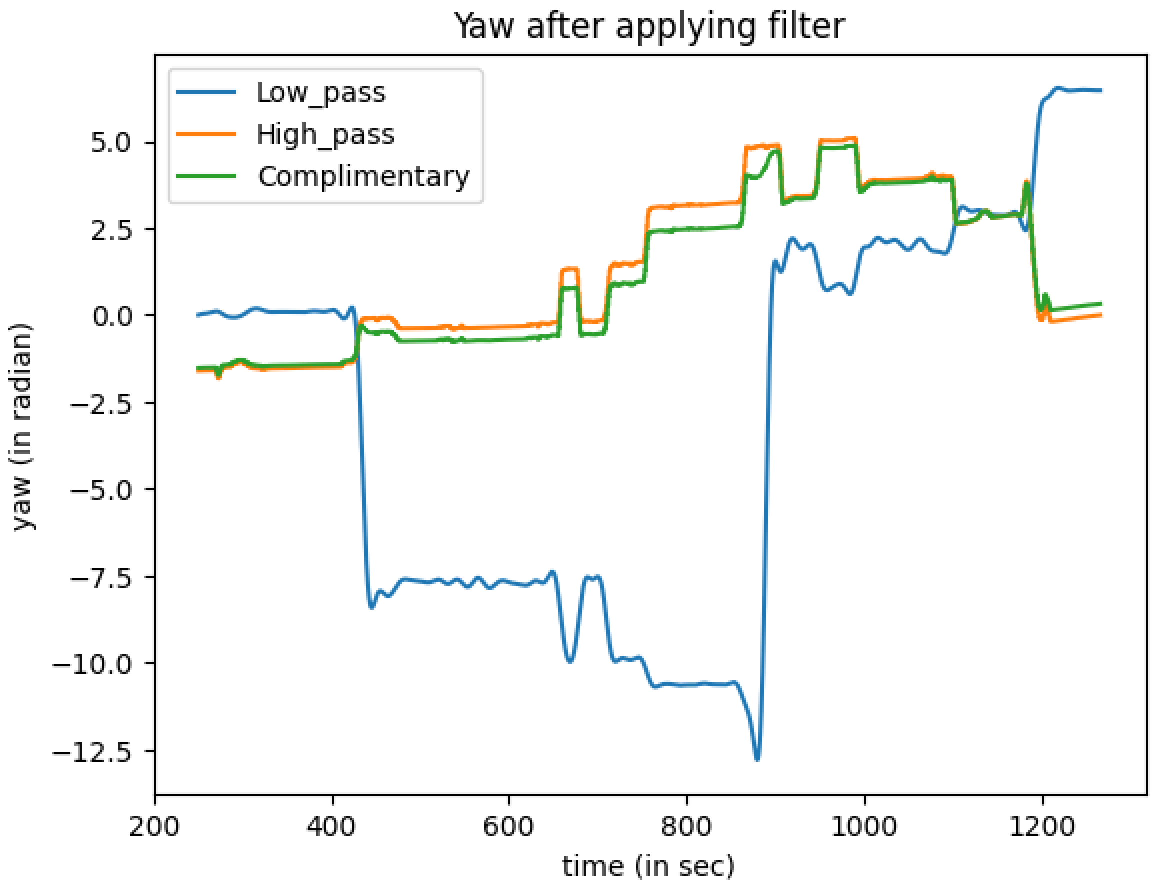



## 2. How did you use a complementary filter to develop a combined estimate of yaw? What components of the filter were present, and what cutoff frequency(ies) did you use?

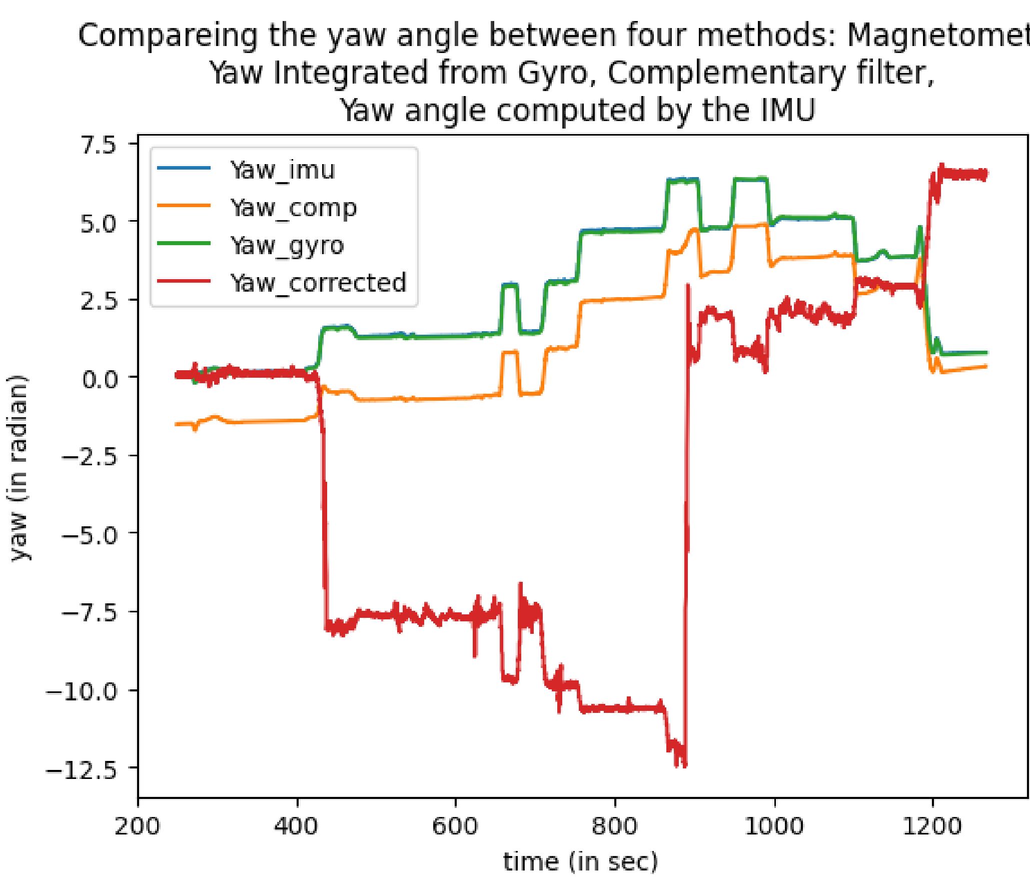
Firstly I used a low-pass filter on the yaw that was calculated from the corrected magnetometer data with a cutoff frequency of 0.05 Hz and then I used a high-pass filter on the yaw calculated from the gyro with a cutoff frequency of 0.000105 Hz. After that, I used a complementary filter to fuse the data together with the value of alpha = 0.95.


Comparison of raw magnetometer yaw with the corrected yaw
Yaw_corrected
Yaw_raw
yaw (in radian)
time (in sec)
7.5
5.0
2.5
0.0
−2.5
−5.0
−7.5
−10.0
−12.5
200
400
600
800
1000
1200


Magnetometer vs. Yaw Integrated from Gyro
Yaw_gyro
Yaw_corrected
yaw (in radian)
time (in sec)
7.5
5.0
2.5
0.0
−2.5
−5.0
−7.5
−10.0
−12.5
200
400
600
800
1000
1200

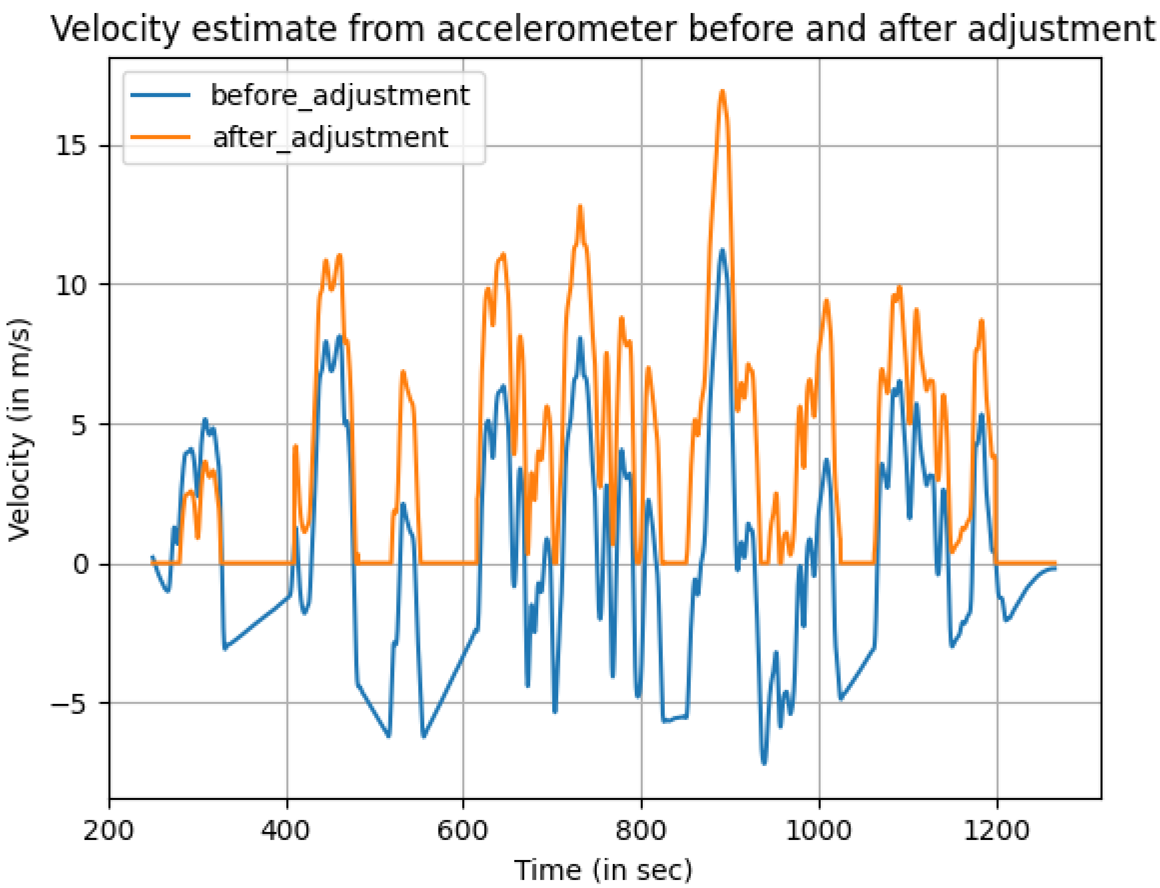



**3. Which estimate or estimates for yaw would you trust for navigation? Why?**



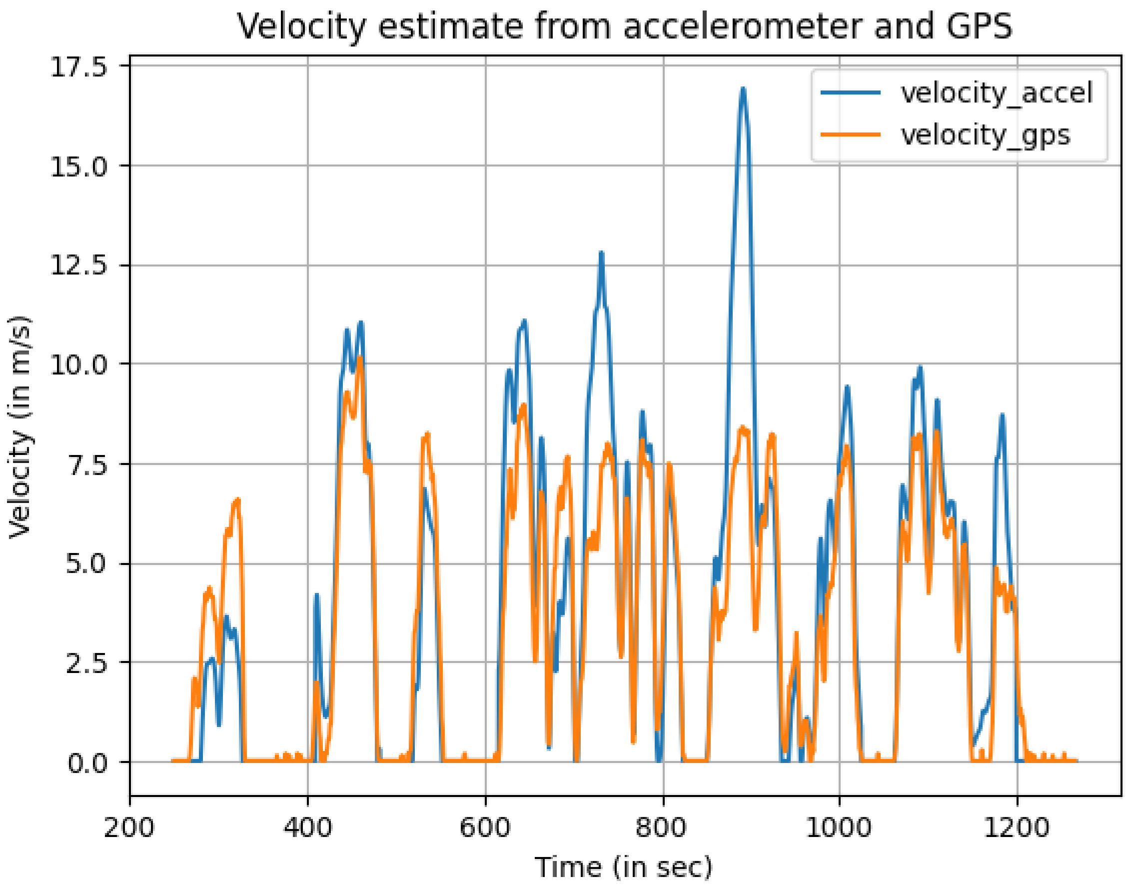
I would trust the yaw from the complementary filter as this is the one that I got after removing biases from the data and fusion between two different sensors for the most appropriate result and thus is the most suitable estimate of yaw that I can trust for navigation.

## **4. What adjustments did you make to the forward velocity estimate, and why?**



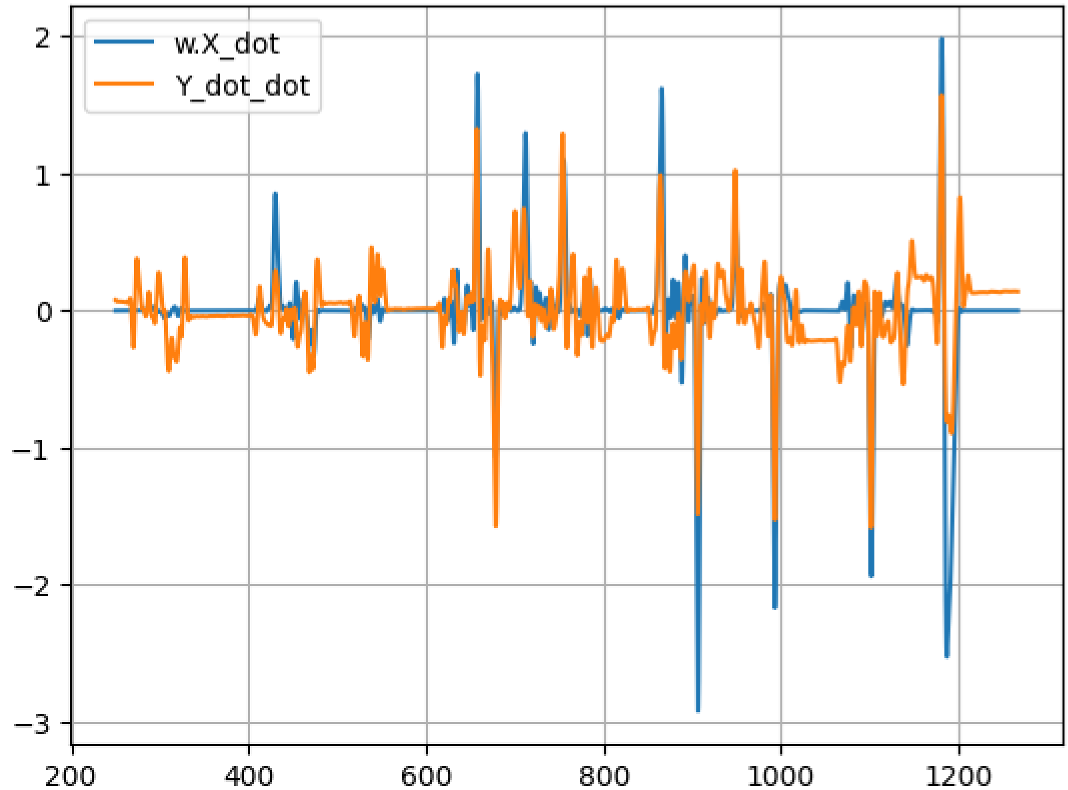

As acceleration is calculated most precisely when the sensor is stationary so, I located all the windows in which the car was stationary and took the mean of the acceleration in that window, and subtracted it from the present as well as all the future values.

## 5. What discrepancies are present in the velocity estimate between accel and GPS. Why?



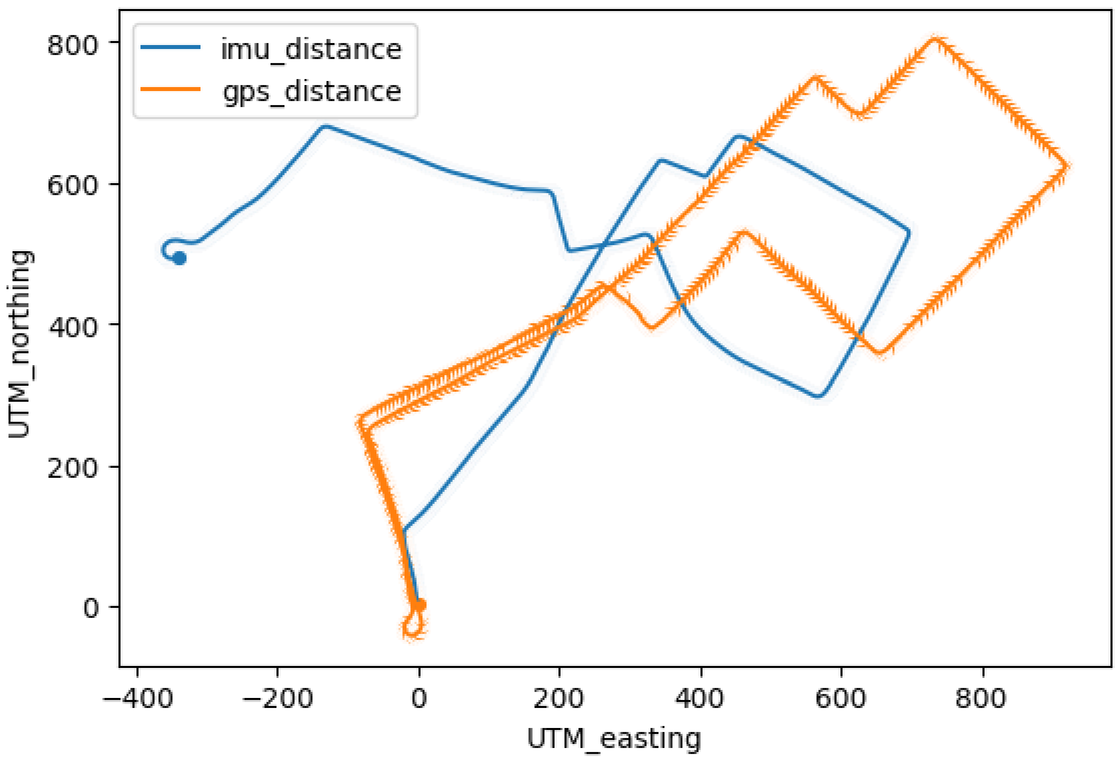

As we can see that most of the velocities are aligned and but the velocity estimated from the accelerometer is bloated. The reason for this could be that the sensor was not correctly oriented during data collection if the orientation is not correct then acceleration from the other axis might have an effect on forward acceleration which in turn will show an error in velocity as it is the integration of the acceleration the error is also magnified.

## 6. Compute $\omega\omega XX$ and compare it to $y\ddot{y}$ $oooooo$. How well do they agree? If there is a difference, what is it due to?




As we can see that the general trend is being followed but w.X has a lot of errors that are high frequency we can use a low pass filter to get rid of them and get a more accurate correlation between w.X. and Y.. , this difference is because xc is not zero and also it can be due to the vibrations in the car as well as having the orientation of the sensor slightly off.

## 7. Estimate the trajectory of the vehicle (xe,xn) from inertial data and compare with GPS. (adjust heading so that the first straight line from both are oriented in the same direction). Report any scaling factor used for comparing the tracks.




The initial position is set to (0,0) and then the heading is matched after that the distance is calculated based on the two sensors.

## 8. Given the specifications of the VectorNav, how long would you expect that it is able to navigate without a position fix? For what period of time did your GPS and IMU estimates of position match closely? (within 2 m) Did the stated performance for dead reckoning match actual measurements? Why or why not?

Given the specifications, I don't expect it to perform that well as there is no feedback to get it back on track once an error is generated. Even though GPS and IMU estimates of position match closely for just a few seconds under a minute we can see that if position fix is applied we would have got almost identical results as the general trend is followed throughout the trajectory.

## 9. Estimate xc and explain your calculations (bonus up to 100%)

$\ddot{y}_{obs} = \ddot{Y} + \omega X + \dot{\omega} x_c$

$X_c = (\ddot{y}_{obs} - \omega X)\dot{\omega}$

Based on our data, I got

Xc = 0.5891492207064902