Lab_4 Report

EECE 5554 Robotics Sensing and Navigation – Professor Singh

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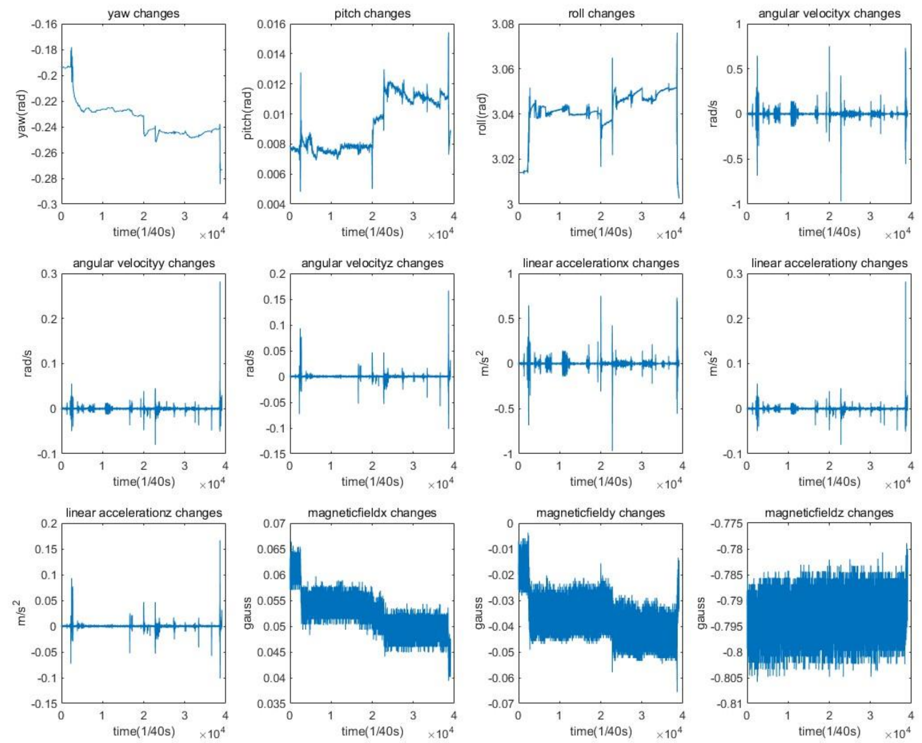
Part 1: Plot each time series in your report and figure out the noise characteristics of each of the values reported by the IMU.

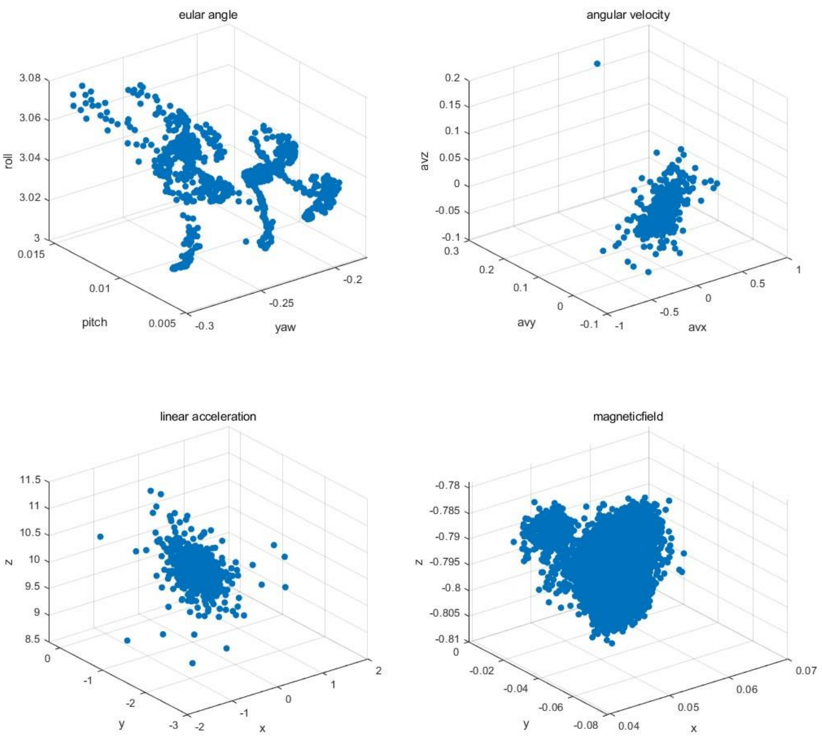
The data of the imu sensor output varies in time is plotted below. It shows that the 12 different outputs varies with the time(the frequency is 40Hz).

Description of the chart:

For yaw, pitch and roll, it is stable but changed for some time, it is because I put it on the bed and I sit on the other side of the bed for some time, so maybe that will be some changes in the chart. The same thing happens to the accel, gyro. One parameter change, other parameters also change at once. All in all, the stationary data is stable in total, although it changes sometimes, because it is very sensitive.

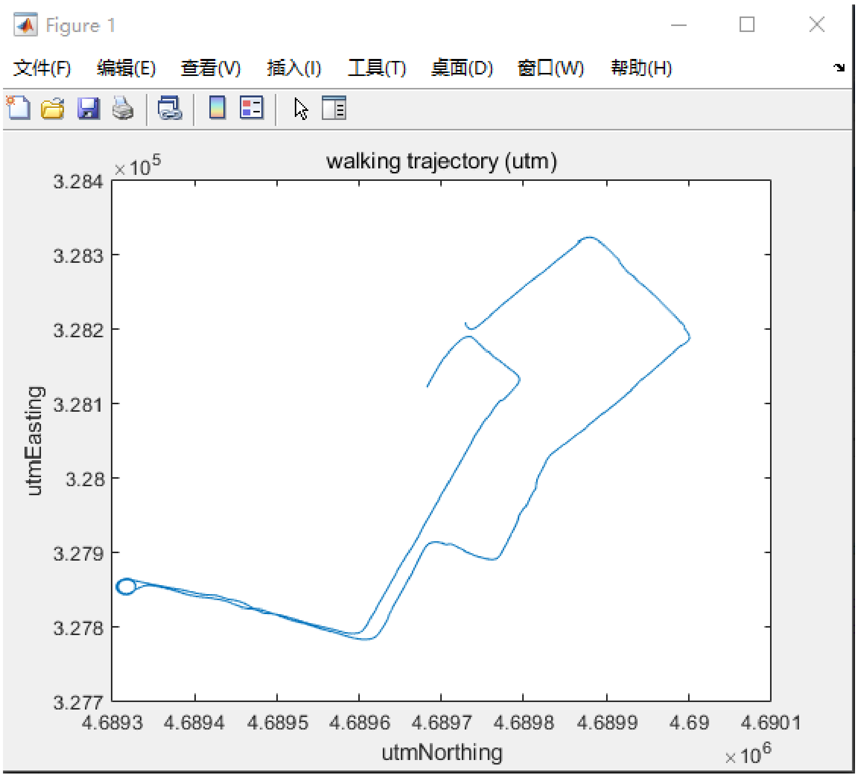


Here is the plot of the vectornav output in 3D:



Part 2: A

We collected the data using the 'NUANCE' car and professor Singh drive for us. We drive around the campus and get the plot:



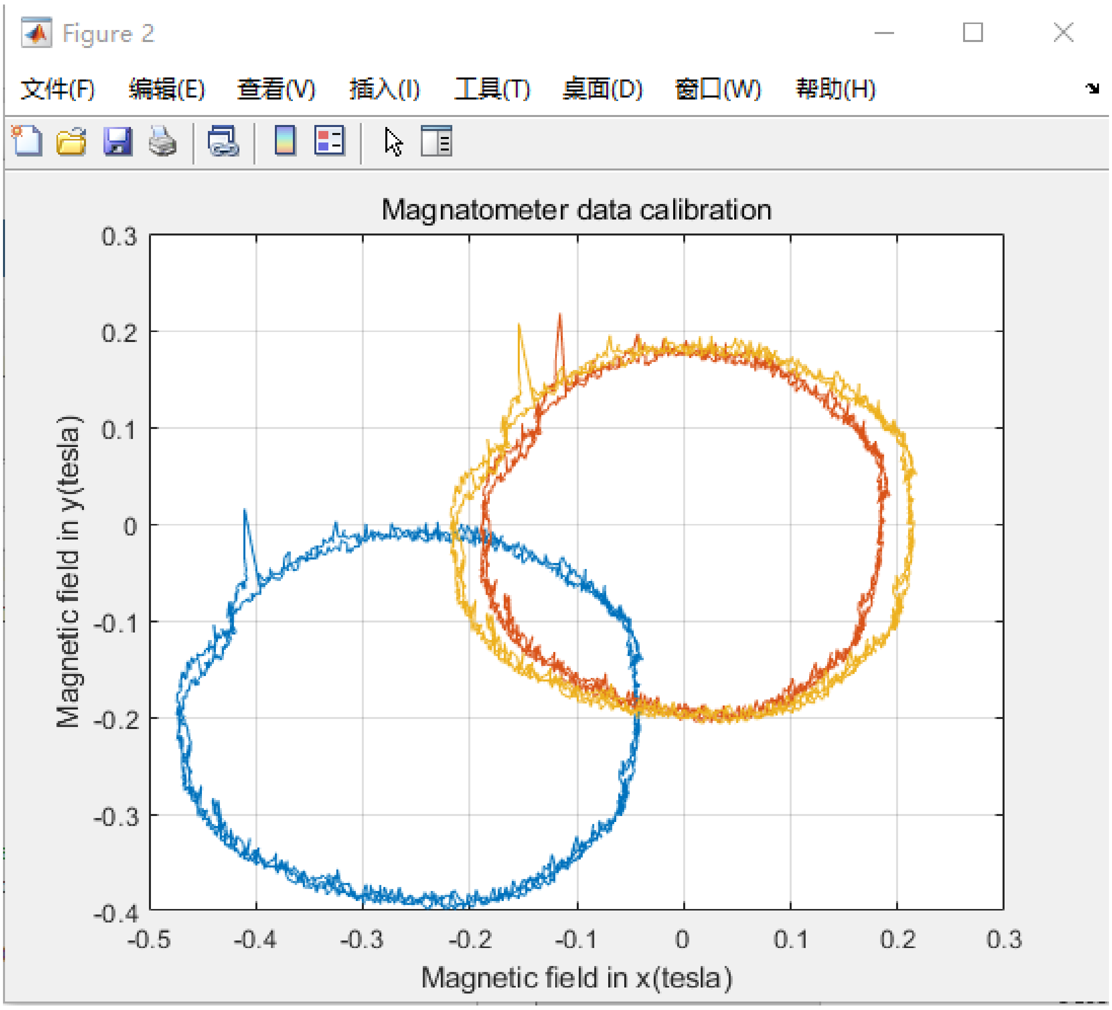
Part2: B1 estimate the heading

1. Correct magnetometer readings for "hard-iron" and "soft-iron" effects using the data collected when going around in circles.

   Answering the Question 1:

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

For hard-iron, I just need to choose the circle data and minus the offset data.
For soft-iron, I used the eclipse transform to make the correction. The detail is I attached an function matlab file for ellipse fit and then times rotation matrix and scaling to make the circle looks like the good circle. You can see that in the figure below:



2. Calculate the yaw angle from the corrected magnetometer readings.
   I choose the moving period After we going around the circle.
   And the yaw is calculated in

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yaw_corrected = unwrap(atan2(yy_corr2, xx_corr2));
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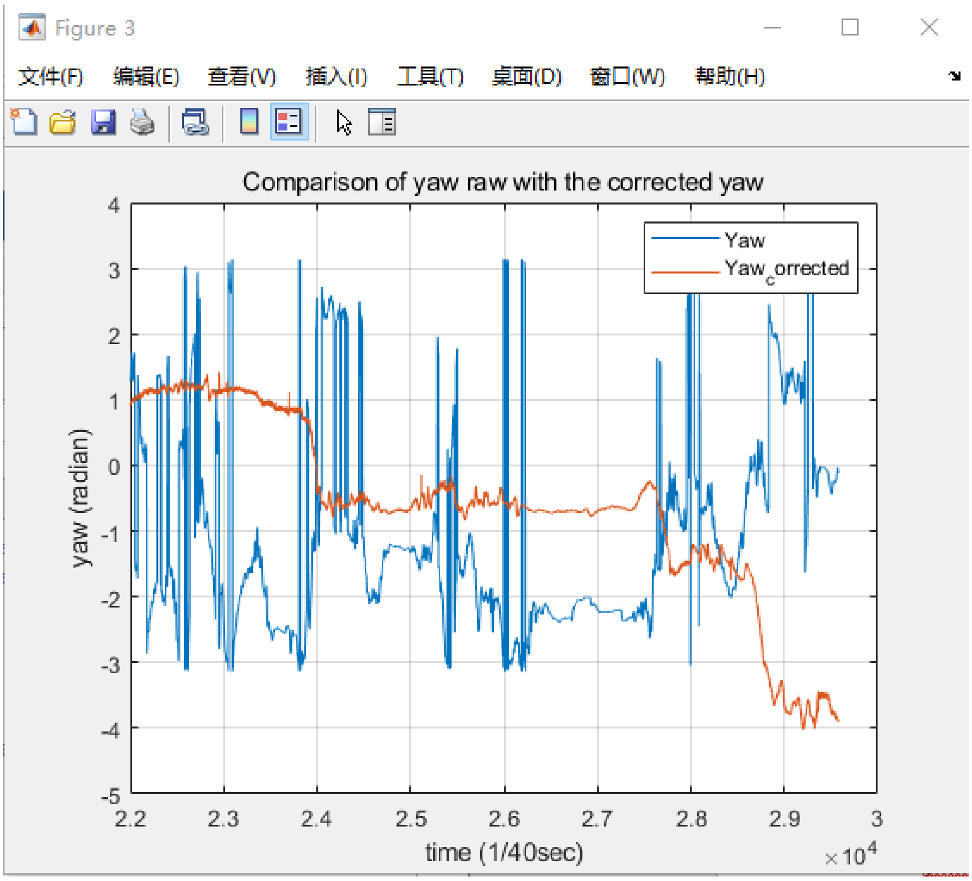
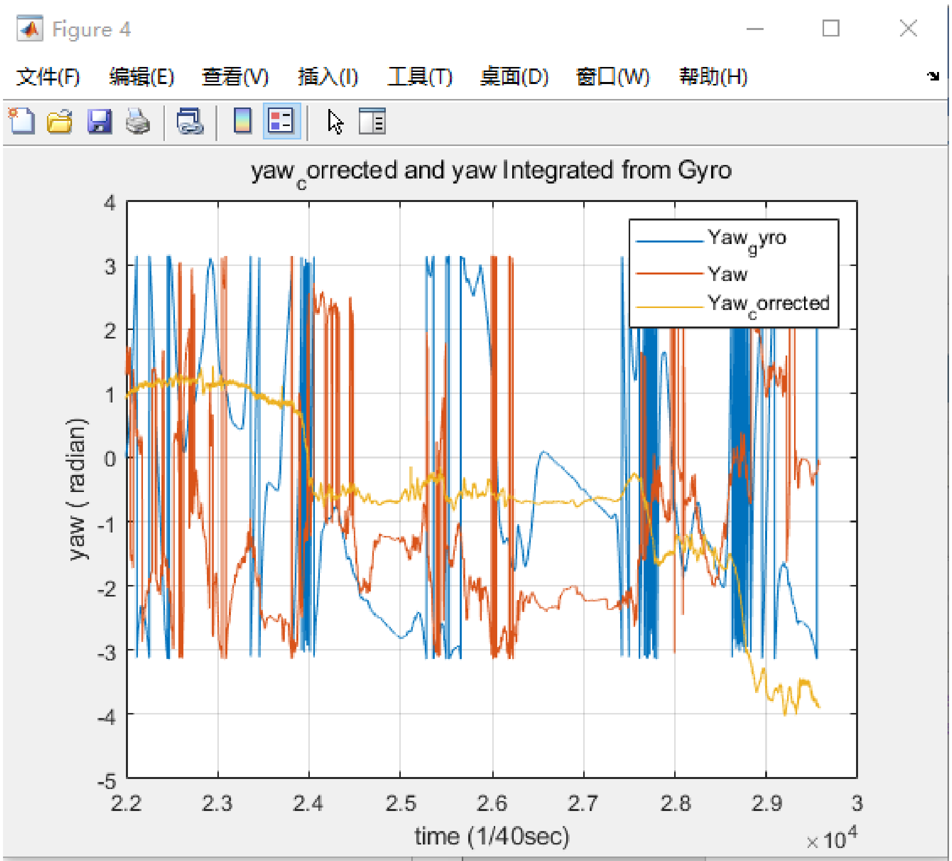
   this code.



3. Integrate the yaw rate sensor to get yaw angle.
   Compare the yaw angle from above two methods.



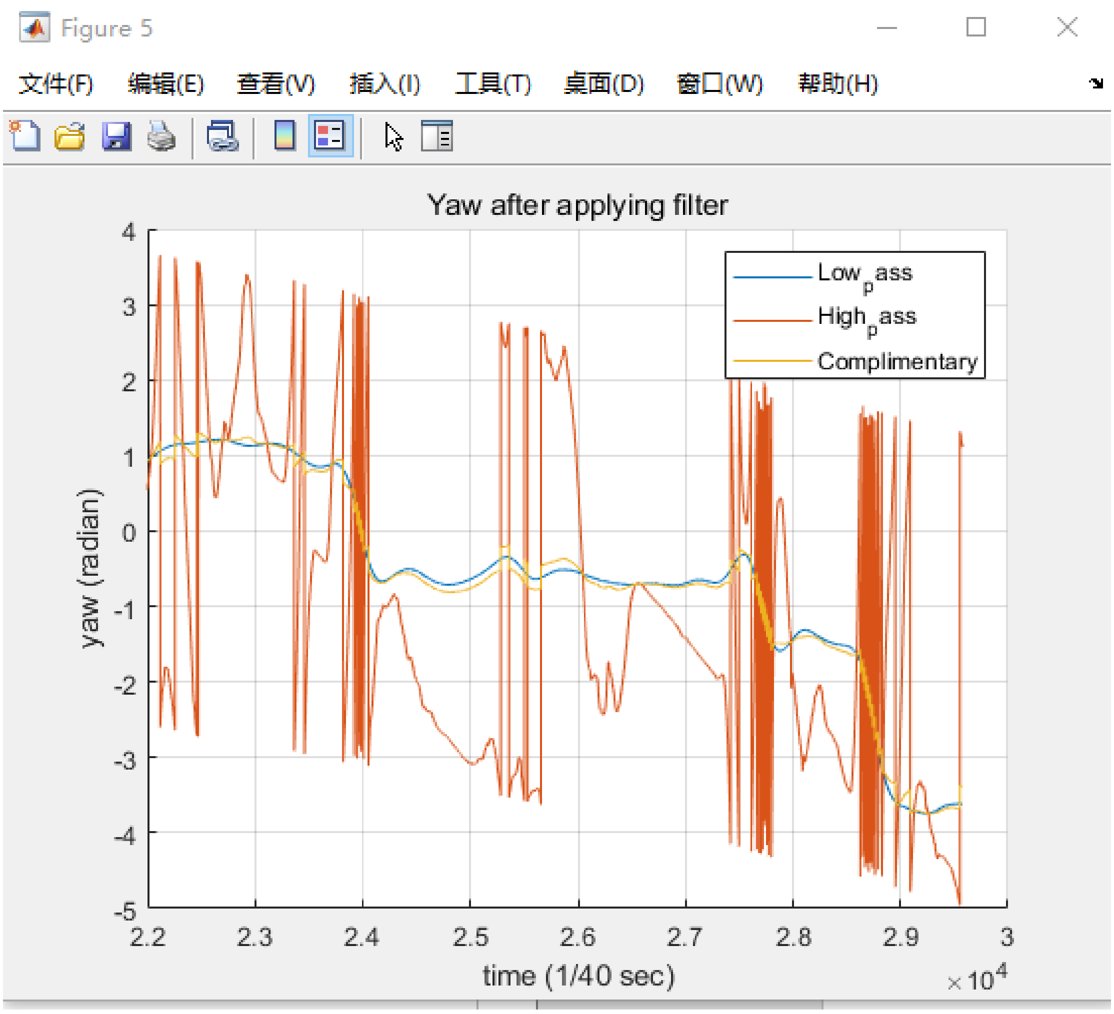
We can find that the yaw corrected is more stable and not change too much.

4. Use a complementary filter to combine the measurements from the magnetometer and yaw rate as described in class to get an improved estimate of yaw angle.

   Answer to Question 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?

I apply a high pass filter and a low pass filter, the frequencies I use is 0.05 for lowpass and 0.00015 for high pass filter. Then the complementary filter to make the two filters together.



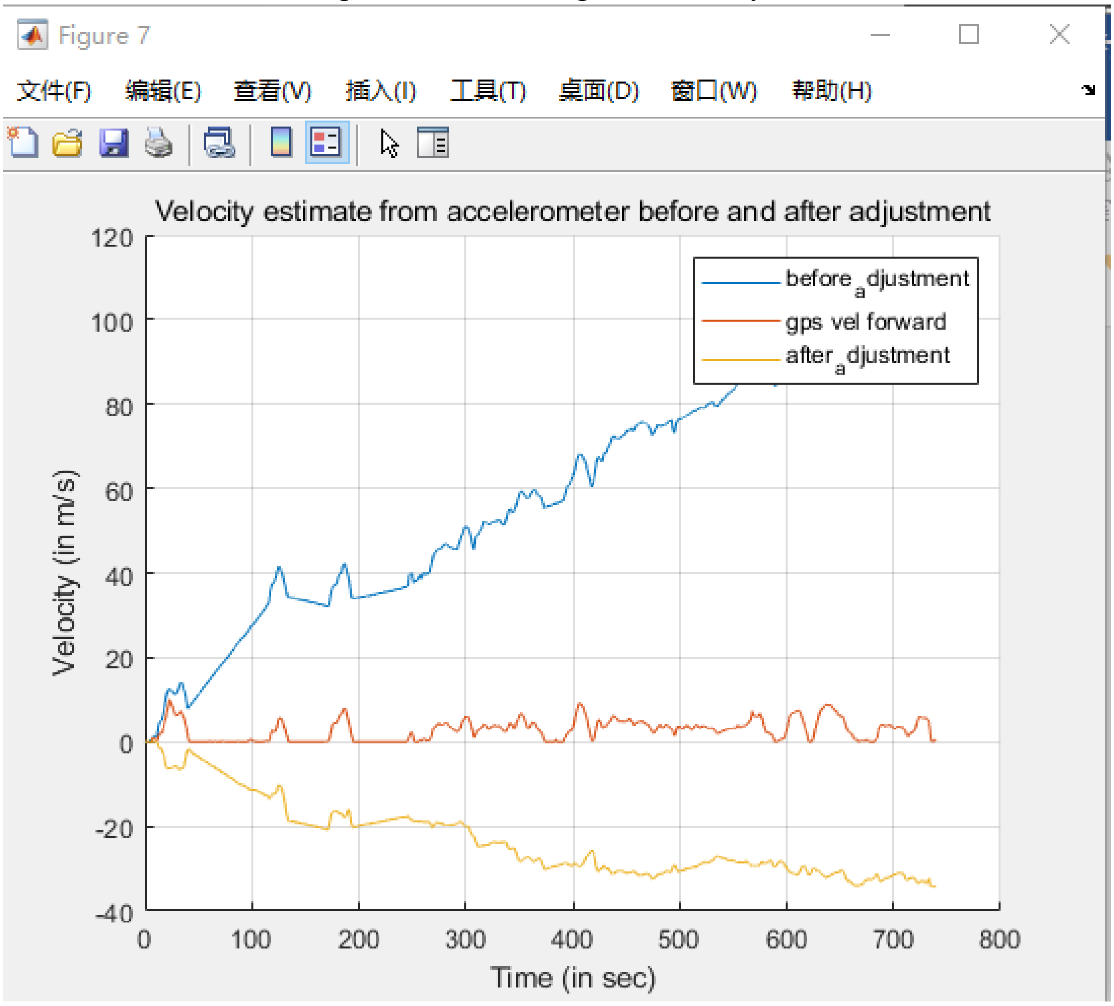
Q3: Which estimate or estimates of yaw would you trust for navigation? Why?

I will trust the yaw calculated after the complimentary because it removes the biases and is more trustworthy.

Part2: B2 estimate the forward velocity

1. Integrate the forward acceleration to estimate the forward velocity

Calculate an estimate of the velocity from your GPS measurements.
Plot both the velocity estimates.
Make observations on the plot. Does the integrated velocity estimate make sense?



The blue line is the row data of integration from forward acceleration, and the red line is the velocity from GPS, the velocity from GPS is more trustworthy, it shows

2. Make adjustments to the acceleration measurements to make the velocity plot more reasonable.
Provide the rationale you use for the adjustments and plot the adjusted velocity.
Q4: What adjustments did you make to the forward velocity estimate, and why?

I apply the high pass filter and the low pass filter to the velocity, and tried to make the velocity seems stable. You can observe from the chart that the peak of the curve is similar. And the trend is more stable than the raw data. Than may because another acceleration from the other axis will effect the integration and the error is also caused. I tried to do the correction by pitch and it shows better.

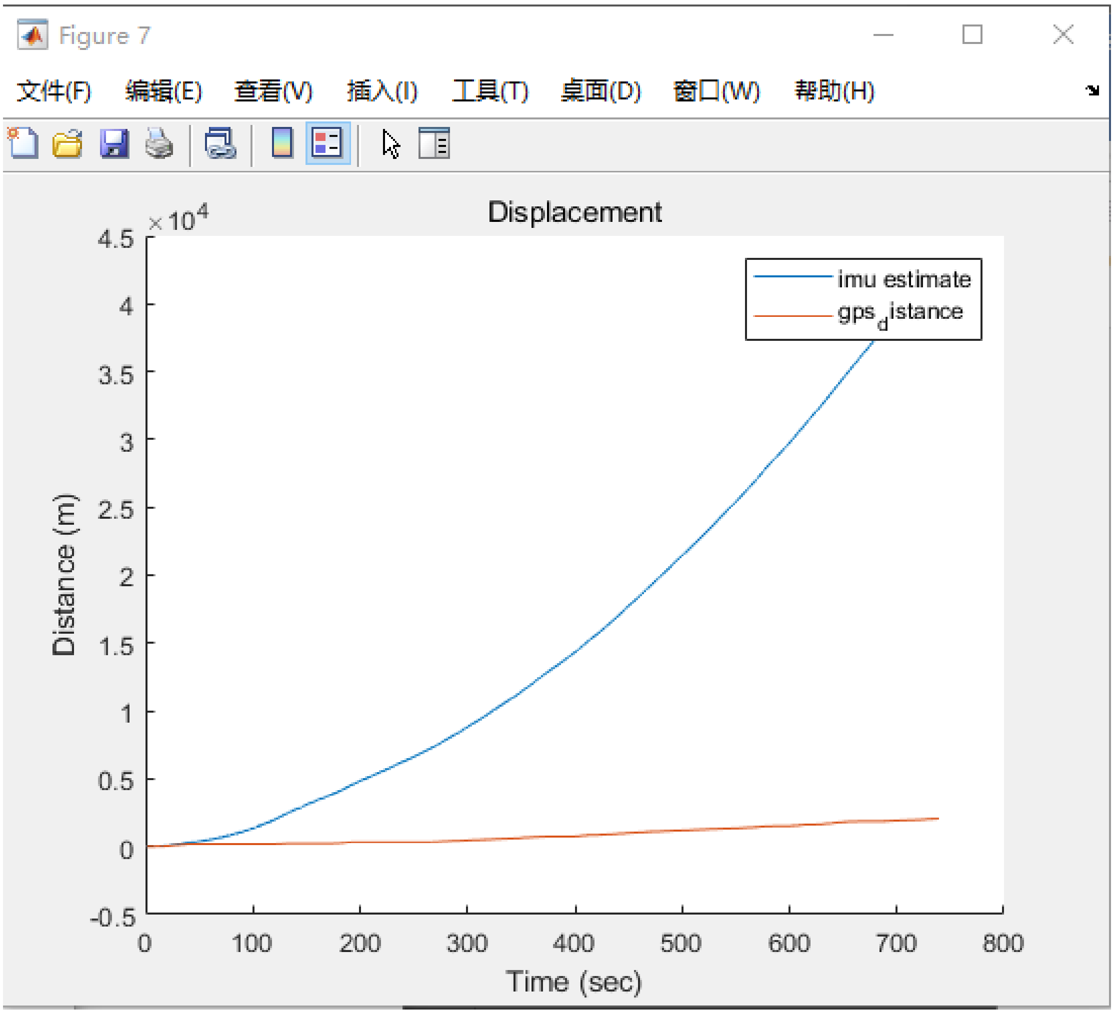
Q5: What discrepancies are present in the velocity estimate between accel and GPS.

Why?

In my opinion, the peaks of two plots seems appear at the same time but the acceleration velocity one will not shows more steady, than may because of the filters.

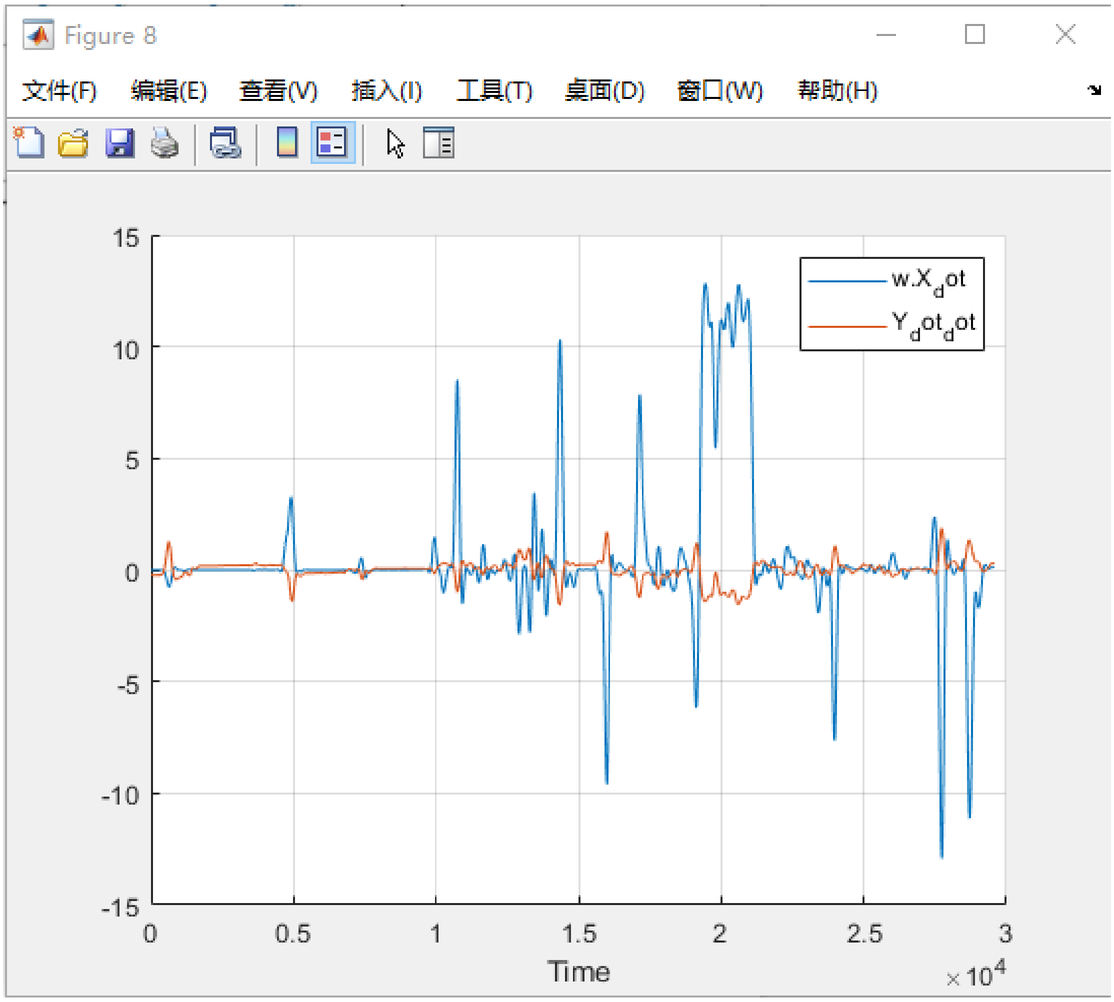
Part2: B3 dead reckoning with IMU

1. Integrate IMU data to obtain displacement and compare with GPS



The reason for this is that the velocity on the velocity figure shows the same trend: The velocity of imu grows higher.

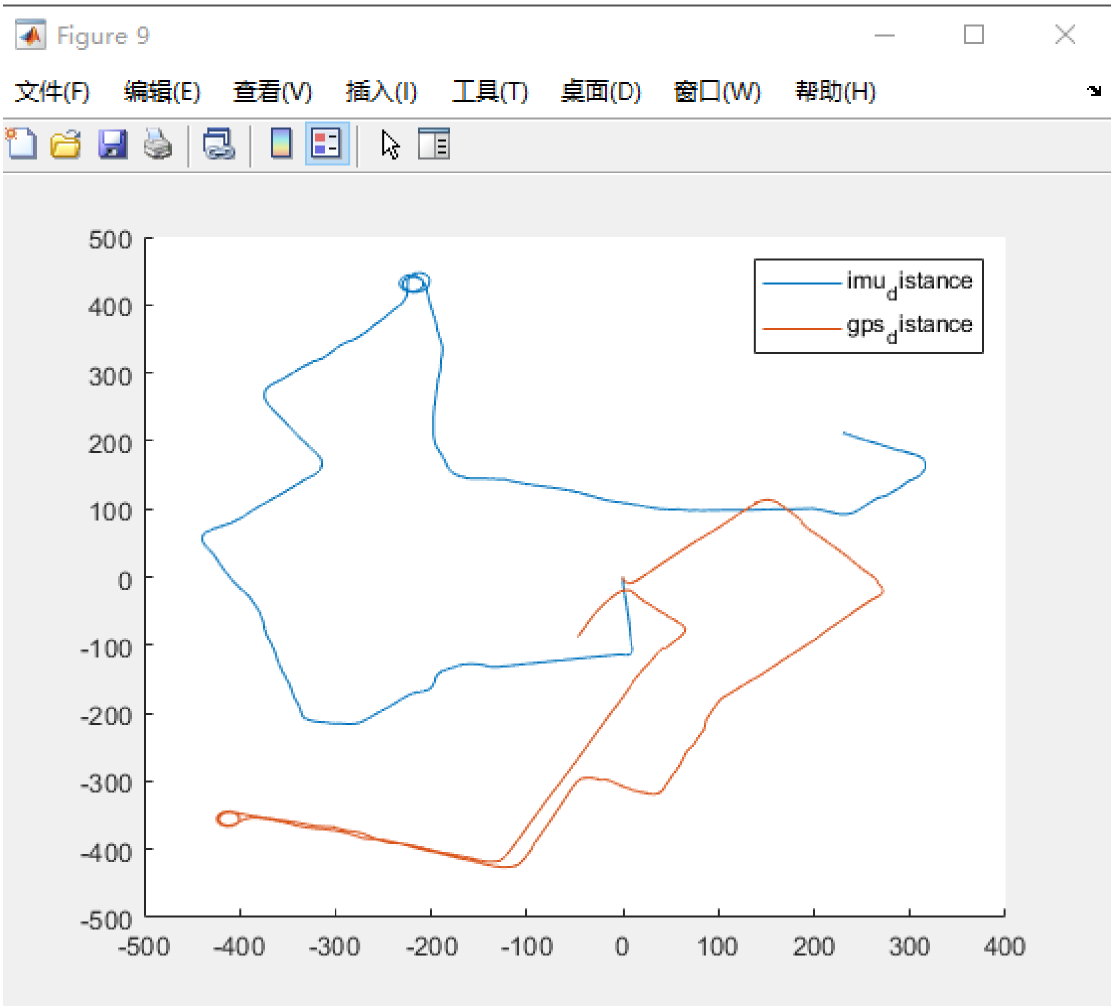
2. (Q6) Compute $\omega X'$ and compare it to y'_obs. How well do they agree? If there is a difference, what is it due to?



It’s easy to observe that the two plots are similar.

There is difference between them, the wX_dot is more unstable than the Y_dot_dot, that will be the error, the cause of the error my because of xc and the vibration when car is running.

3. Q7:Integrate it to estimate the trajectory of the vehicle (xe,xn). Compare the estimated trajectory with the GPS track by plotting them on the same plot.



We can find out that for the first few seconds the trajectory is right, but then the distance goes wrong, the angle of turning is right(almost 90 degree) but the actual distance estimate is not right.

4. Q8:Estimate xc

According to :

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

Y_dot_dot is known, wX_dot is known,

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w_dot = diff(angularz) ./ diff(time_imu);
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We can know that :

x_c 26.5762

Q9: 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?

I think the first few seconds it will do well, but In total the velocity of imu is not doing very well so it will not do so well in recording the distance. It's better to use the gps when doing navigation. So the IMU measurement doesn't match well with the gps measurement.