Lab 2 Report

1, Stationary spot data

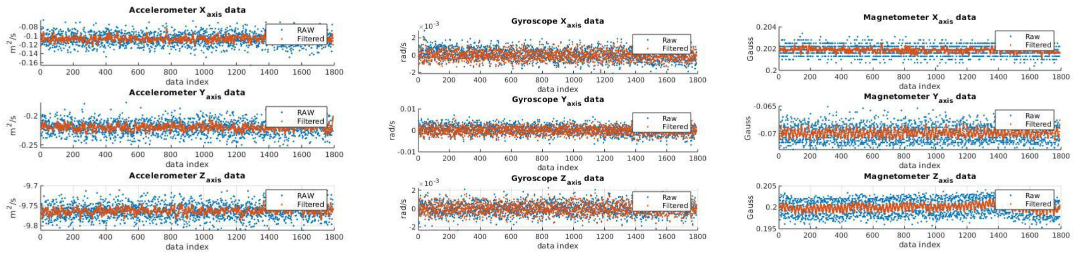

Figure 1: Stationary spot data plotting

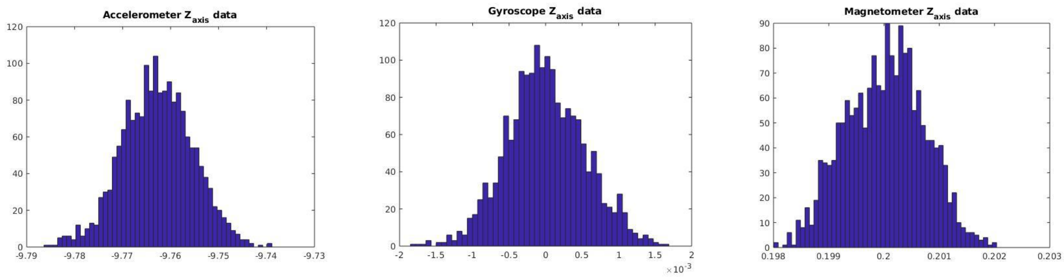

Figure 2: Stationary spot data histogram

Magnetometer analysis

	X_Axis	Y_Axis	Z_Axis
range	0.0014	0.0037	0.0040
mean	0.2019	-0.0699	0.2000
median	0.2019	-0.0700	0.2000
var	3.5451e-08	3.9903e-07	5.0157e-07

Gyro analysis

	X_Axis	Y_Axis	Z_Axis
range	0.0042	0.0104	0.0035
mean	-5.9486e-07	2.2605e-07	2.0505e-07
median	-1.0324e-06	6.0555e-11	-2.9611e-05
var	2.7827e-07	2.6853e-06	2.8625e-07

Accelerometer analysis

	X_Axis	Y_Axis	Z_Axis
range	0.0385	0.0320	0.0475
mean	-0.1070	-0.2200	-9.7628
median	-0.1072	-0.2200	-9.7629
var	3.0400e-05	2.3272e-05	5.3166e-05

Distribution type: Gaussian Distribution
Accuracy: All of the ranges and variance are pretty small, which means the IMU is quite accurate. The Accelerometer has larger variance and range compared to other measurement because it has higher frequency.

I summed the square of Accelerometer of XYZ axis to get the gravity factor of our location -- 9.7659 m^2/s

2, Estimate the heading (yaw)

- **Magnetometer Calibration**

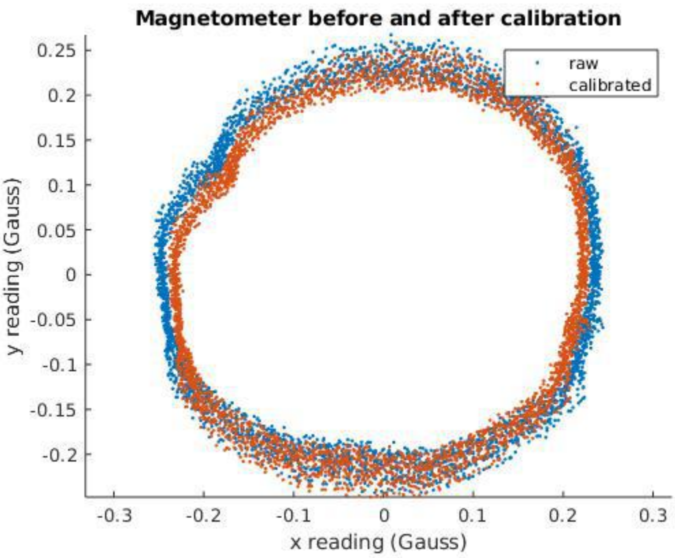

Figure 3: Magnetometer data during circling

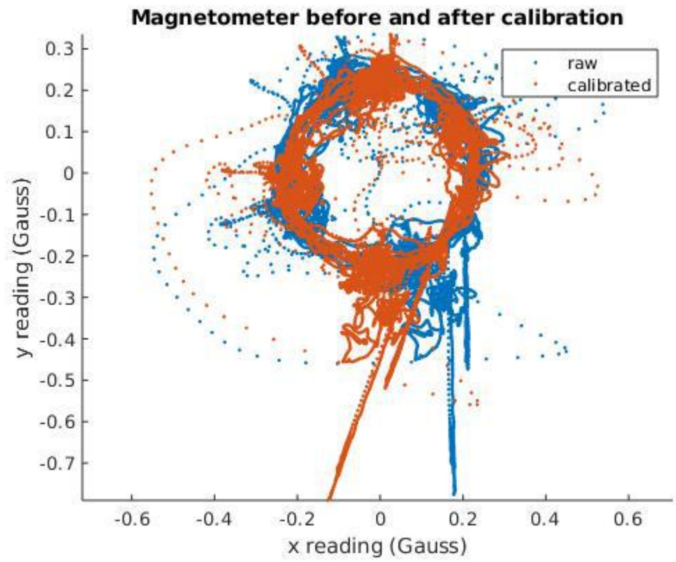

Figure 4: Magnetometer data of driving

- **Yaw comparison**

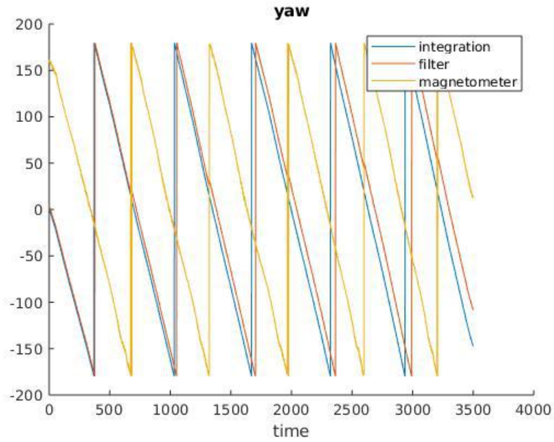

Figure 5: Circling data by Yaw

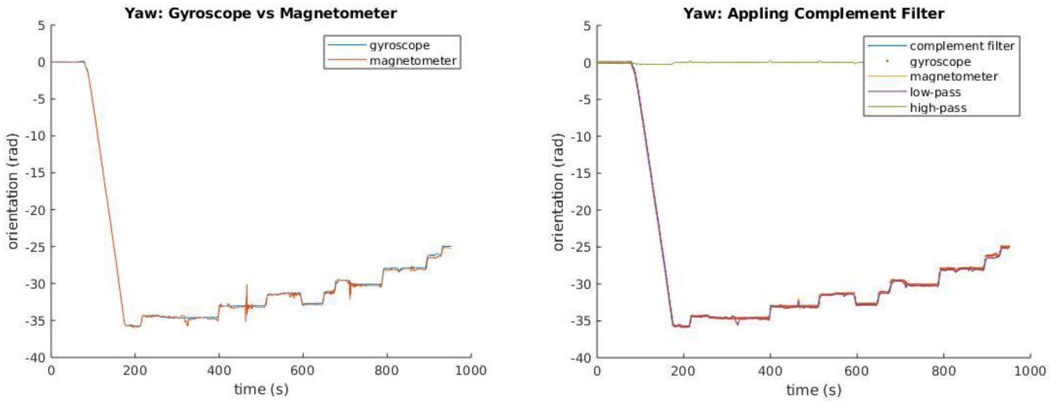

Figure 6: Circling data by Yaw

Analysis: From Figure 5 and Figure 6 we can see, yaw-integration obtained from gyroscope, which is the integration of Z axis of gyro, is more smooth than yaw-mag and less noise influenced.

3, Estimate the forward velocity

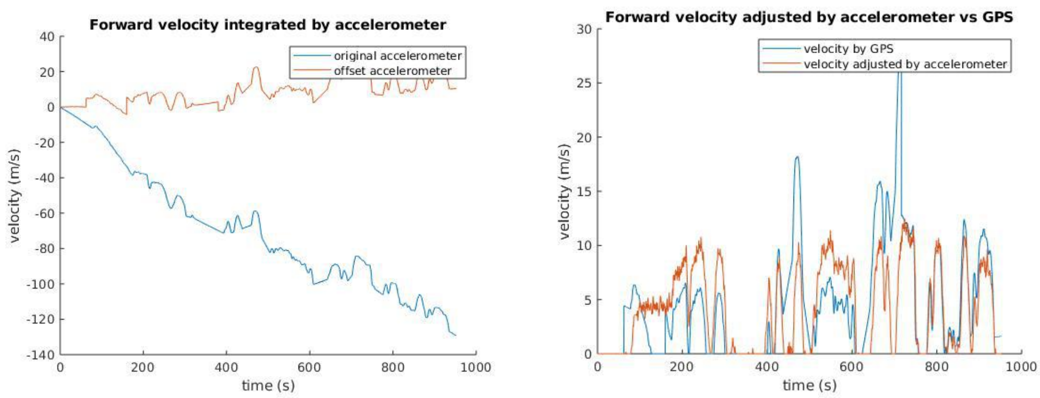

Figure 7: Velocity data from Accelerometer and GPS

Analysis:

Comparing the velocity derived from GPS and Accelerometer, we can see they change simultaneously and their trend matches.
However, the IMU velocity integrate too much error during our driving process due to factors like road gradient and car condition.
To eliminate the integrated error and make IMU velocity more reasonable, I take the particular gradient offset for each road. After taking the offset to the accelerometer, the velocity integrated from accelerometer matches the GPS velocity much better.

4, Dead Reckoning with IMU

- **Y acceleration**

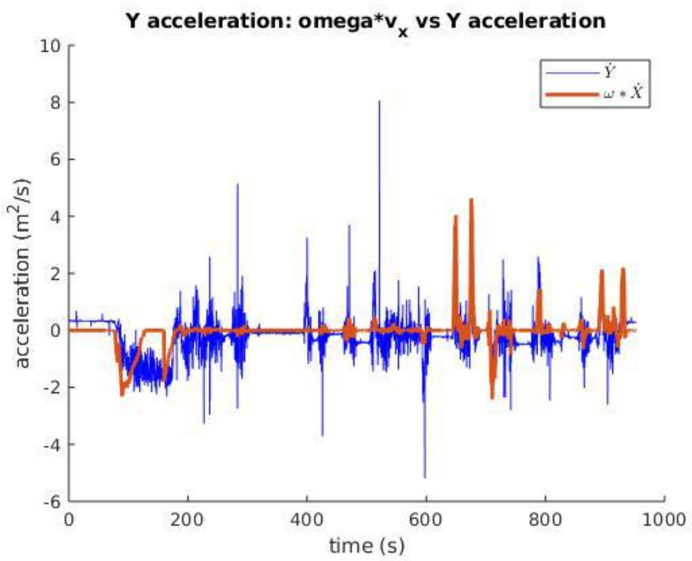

Figure 8: Y acceleration data comparison

Analysis: According to Figure 8, we can see there is difference between Y acceleration and ωX. I think it’s because the velocity of X axis is integrated by X acceleration, which included a lot of error.

- **Compare the estimated trajectory with GPS track**

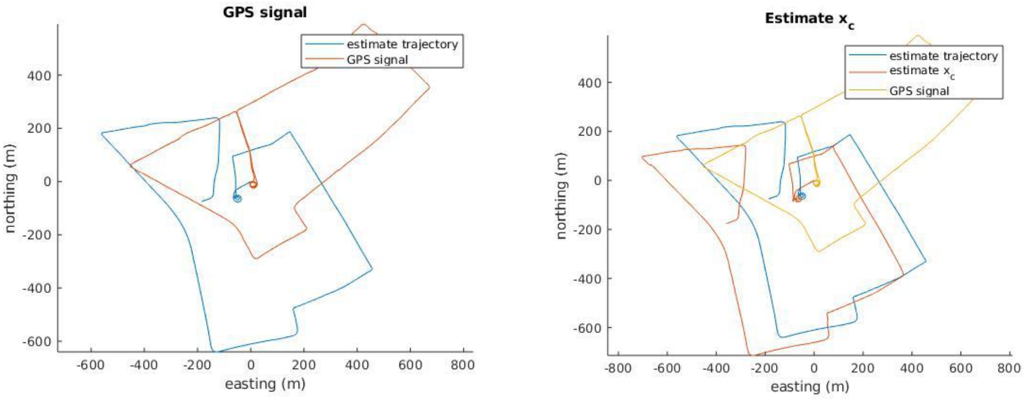

Figure 9: Trajectory comparison

Analysis:
By multiplying real-time Yaw angle to forward velocity, I get the X and Y direction velocities. Then I integrated them with time and get the displacement of X and Y axis. Referring to estimate Xc, I set Xc to be 0.3 in my code, then integrated X and Y direction velocities by following the equation of: $v = V + \omega \times r$.
As we see in Figure 9, all the trajectories follow a similar shape. In conclusion, IMU and GPS both have pros and cons. IMU can collect accurate data of Gyroscope, Magnetometer and Accelerometer to reflect the real world dynamics. But it will come with too many noise and errors when we integrate its data to get displacement, while GPS can provide precise location and displacement information.
Therefore, we should take advantages of both GPS and IMU, fusing their data to get more accurate estimation.