Lab-3 Assessment

The data has been taken in two different scenarios: moving and stationary.

Question 4:

The three graphs for different sensors depict the moving scenario: in MFA and round circle.

Each sensor is being plotted against X, Y and Z axis'.

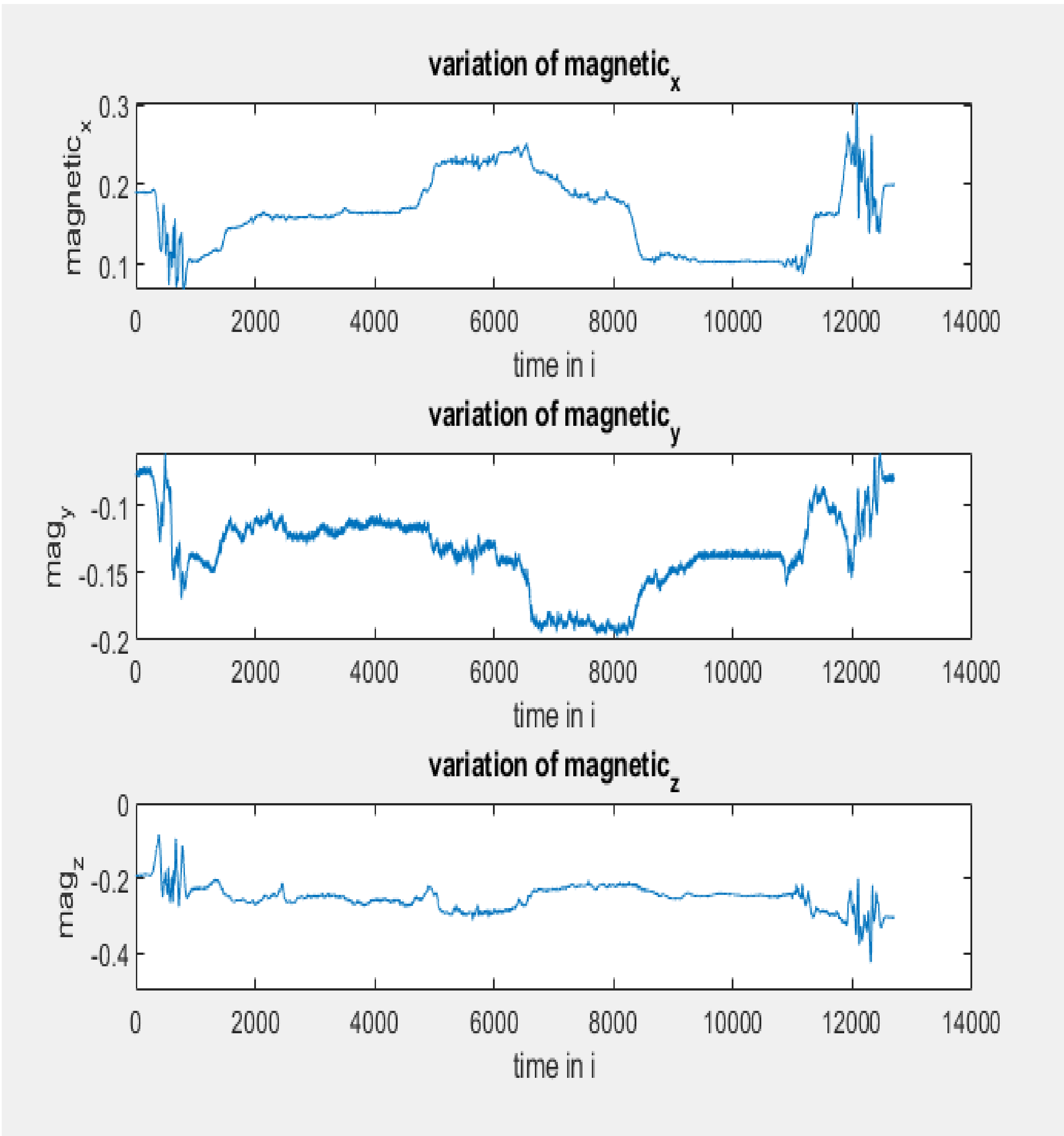


Fig 1: Variation of Magnetometer along X, Y and Z axis.

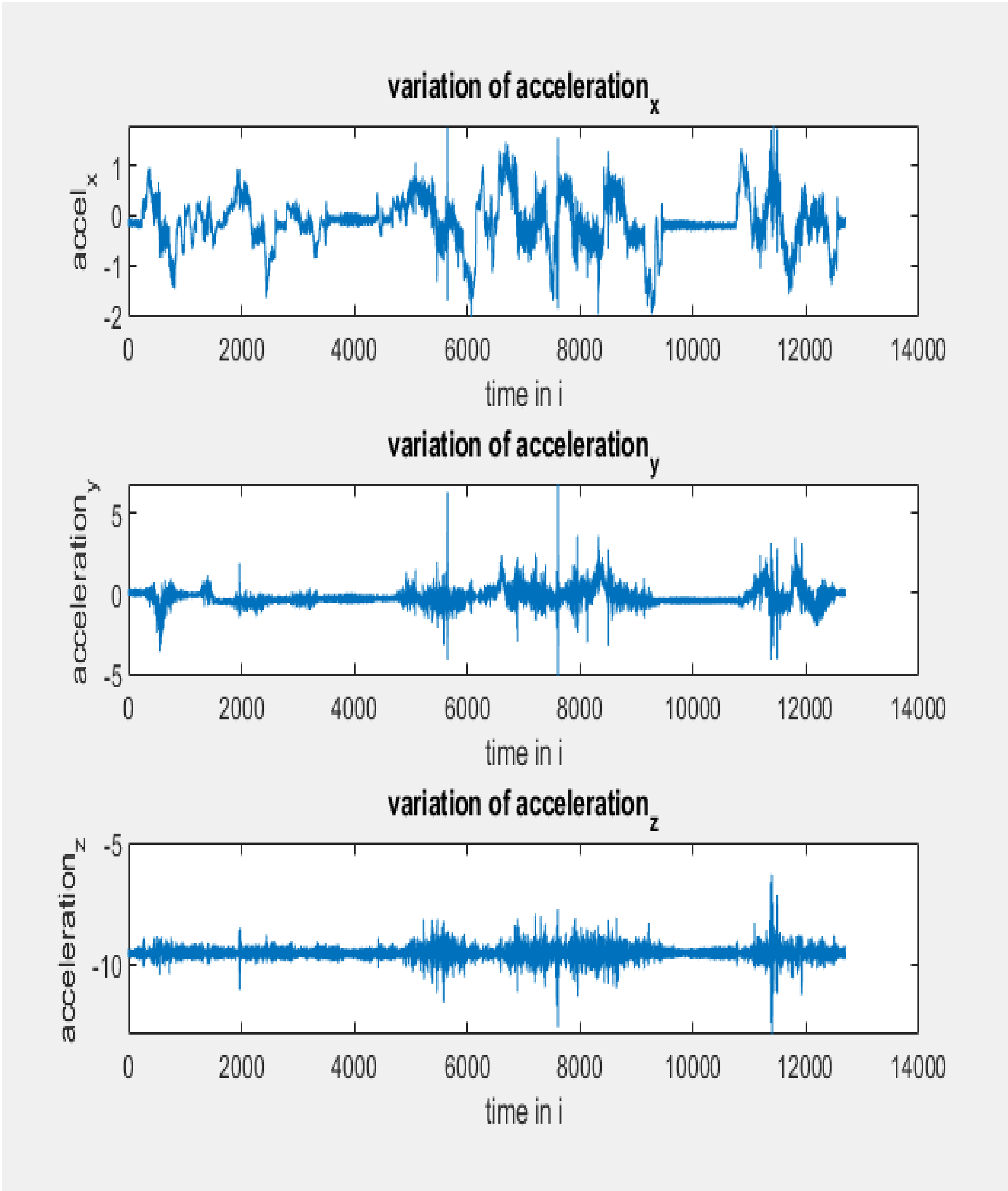


Fig 2: Variation of Accelerometer along X, Y and Z axis.

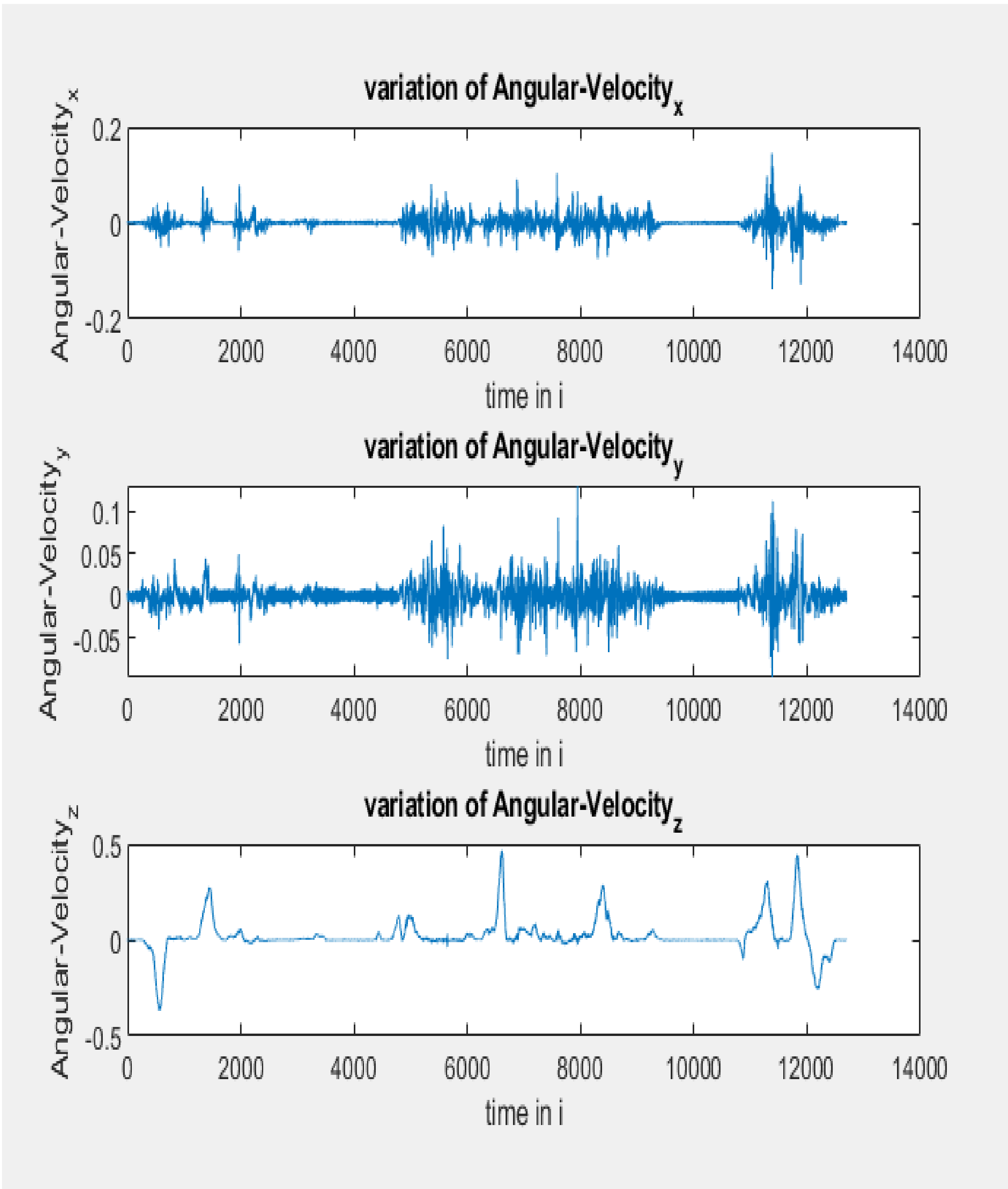


Fig 3: Variation of Gyroscope along X, Y and Z axis.

Now we take the graphs in a stationary case, where where the car is not moving, but the IMU is kept at a stationary point. The IMU is subject to some motion but a random motion, rather than a straight line or a circle.

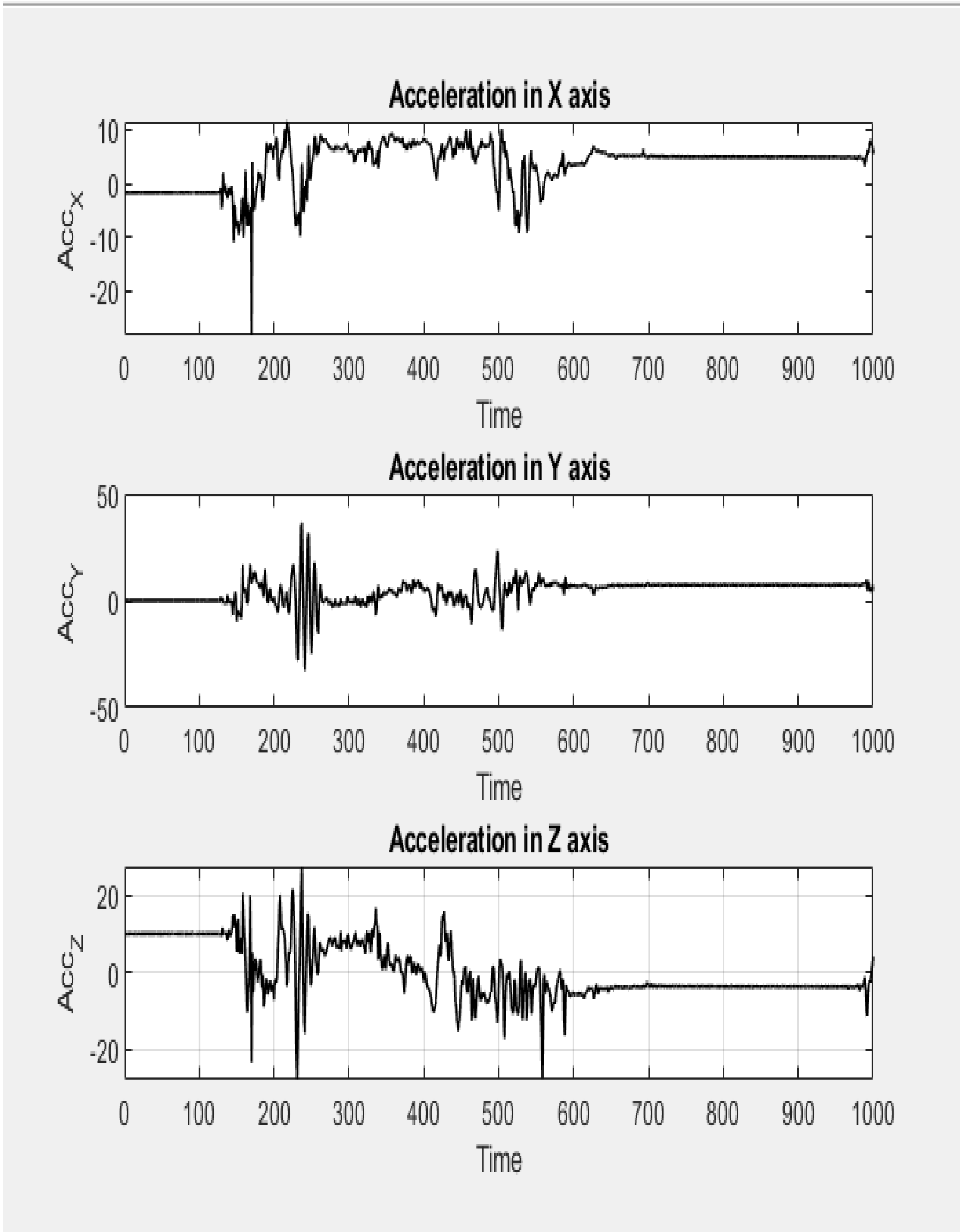


Fig 4: Variation of Accelerometer along X, Y and Z axis, with random movements.

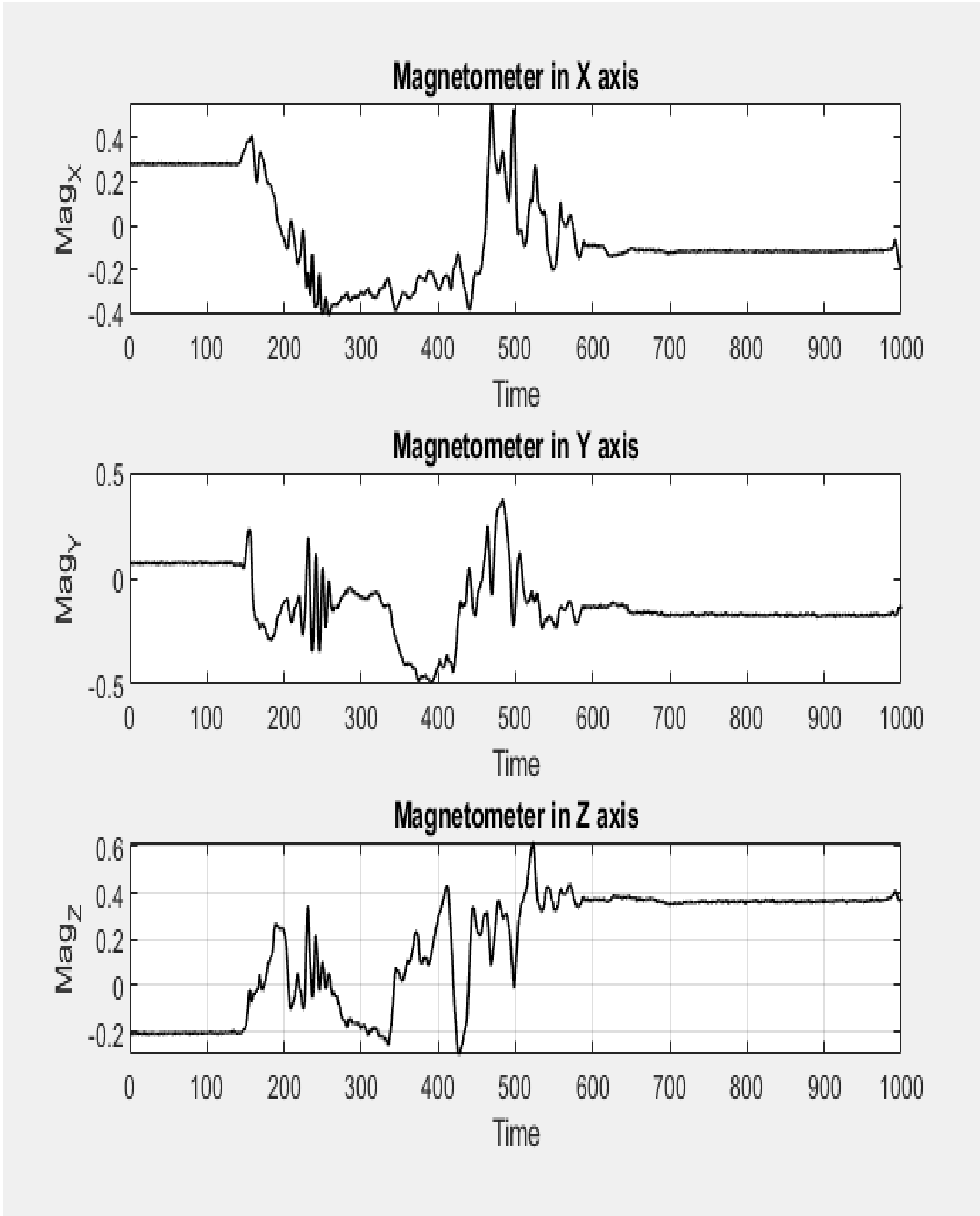


Fig 5: Variation of Magnetometer along X, Y and Z axis, with random movements.

During the random movements, the magnetic field in z direction has the highest positive magnitude. We usually measure the magnitude in terms of (x,y,z).

The unit to measure the magnetometer readings are in microtesla.

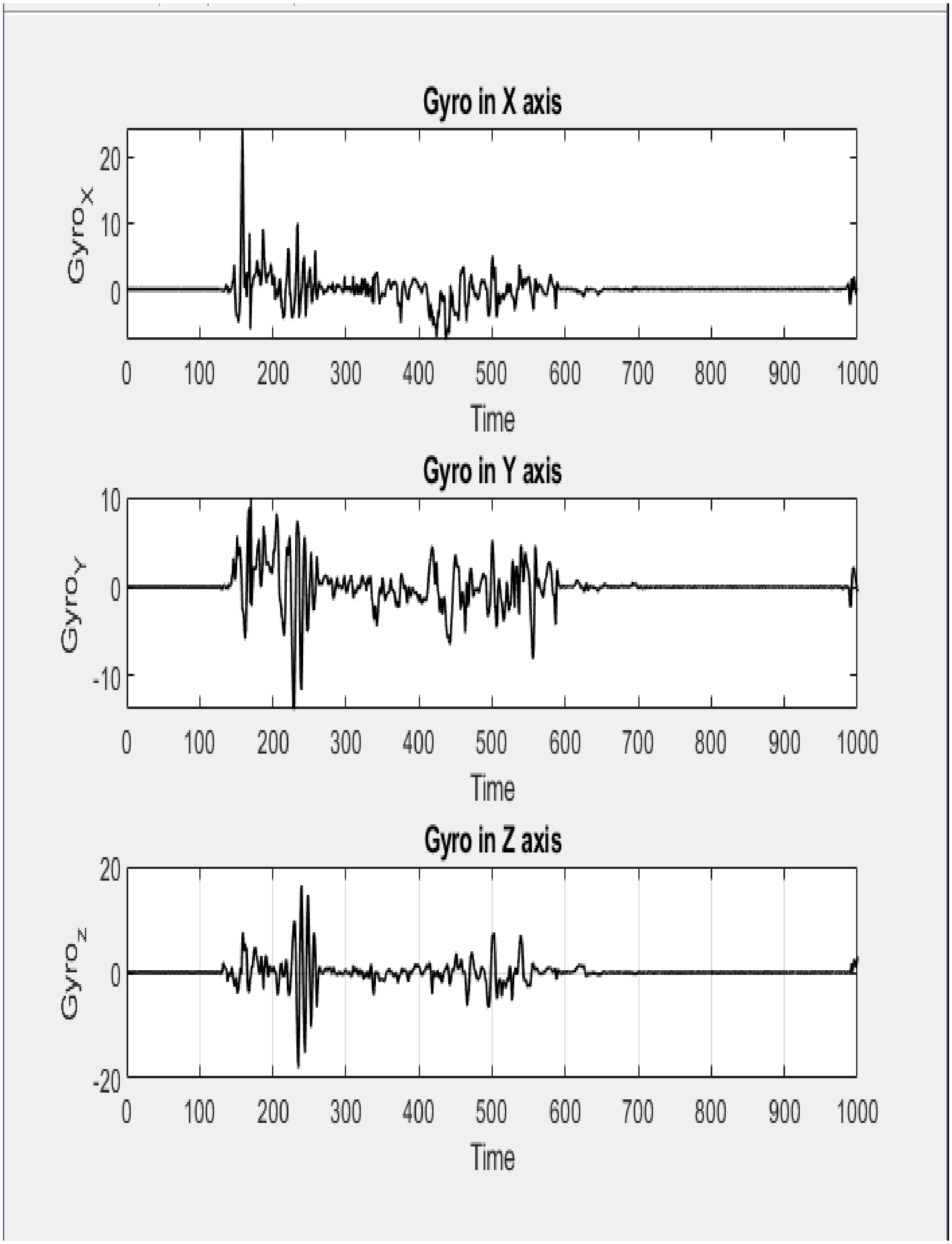


Fig 6: Variation of Gyroscope along X, Y and Z axis, with random movements.

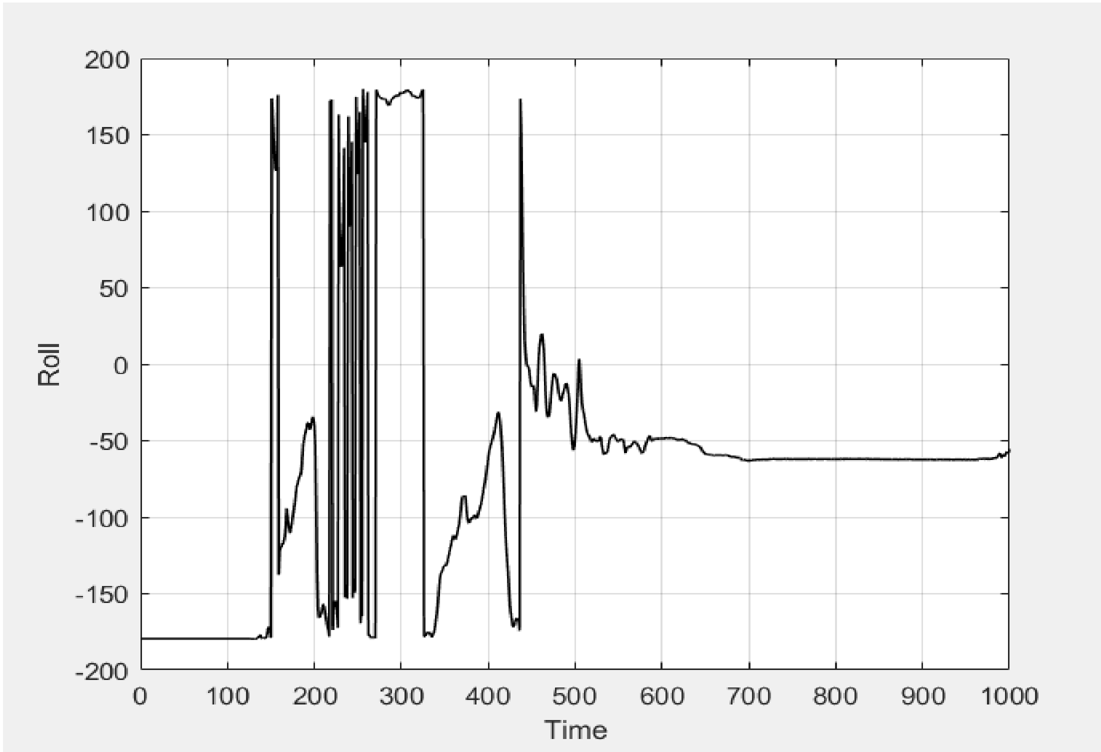


Fig 7: Yaw vs Time with random movements.

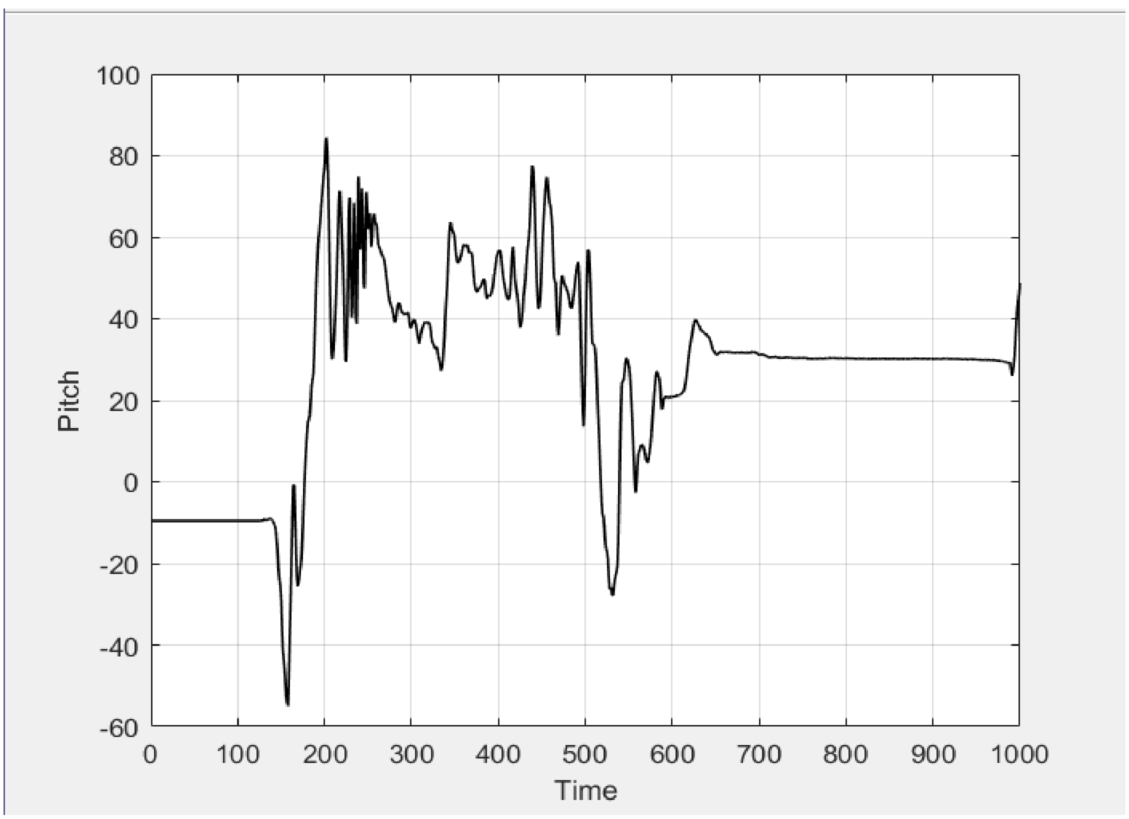


Fig 8: Pitch vs Time with random movements.

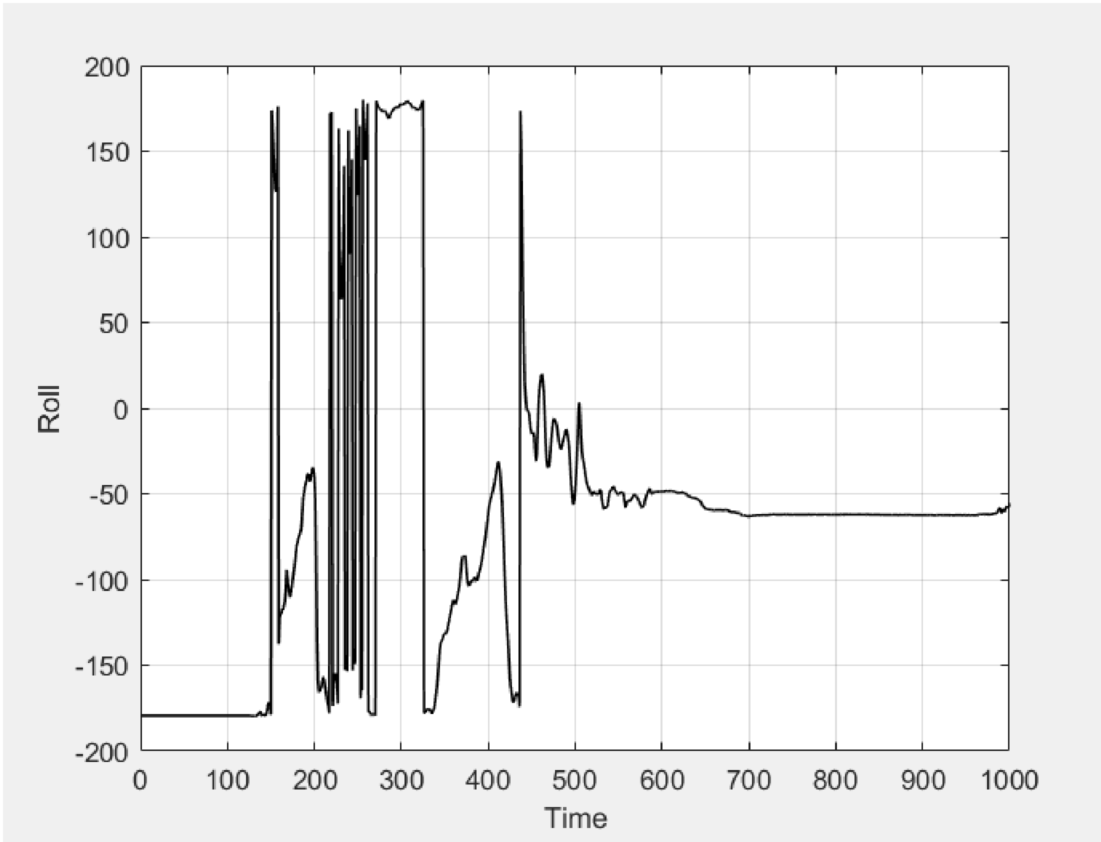


Fig 9: Roll vs Time with random movements.

Question 5:

Now, we know how the magnetometer data looks before correction, from the above graphs. We can see that the data has a lot of external noise, usually because of small bumps in the road, and human errors.

Successful implementation of magnetometers in an inertial system requires careful management of both the sensor and environmental behaviors. Even if a perfect magnetometer exists, it will still need to rely on the access to the earth's magnetic field, to produce accurate orientation estimates. Any condition which is responsible for influencing the magnitude or direction of earth's magnetic field.

Now, there are two types of static error sources. Hard Iron and Soft Iron errors. Hard Iron errors are representing magnetic field sources, which add or subtract to the earth's magnetic field. Examples of this type of errors can be: permanent magnets, power supply currents.

Soft Iron errors represent magnitude and direction change that the earth's magnetic field experiences near ferromagnetic objects.

Here we cannot calculate the Yaw angle vs Accelerometer because of the physics involved in it. Because, acceleration depends on earths gravity. Yaw is perpendicular to gravitational force. So, we can calculate the roll and pitch, but the yaw will be zero.

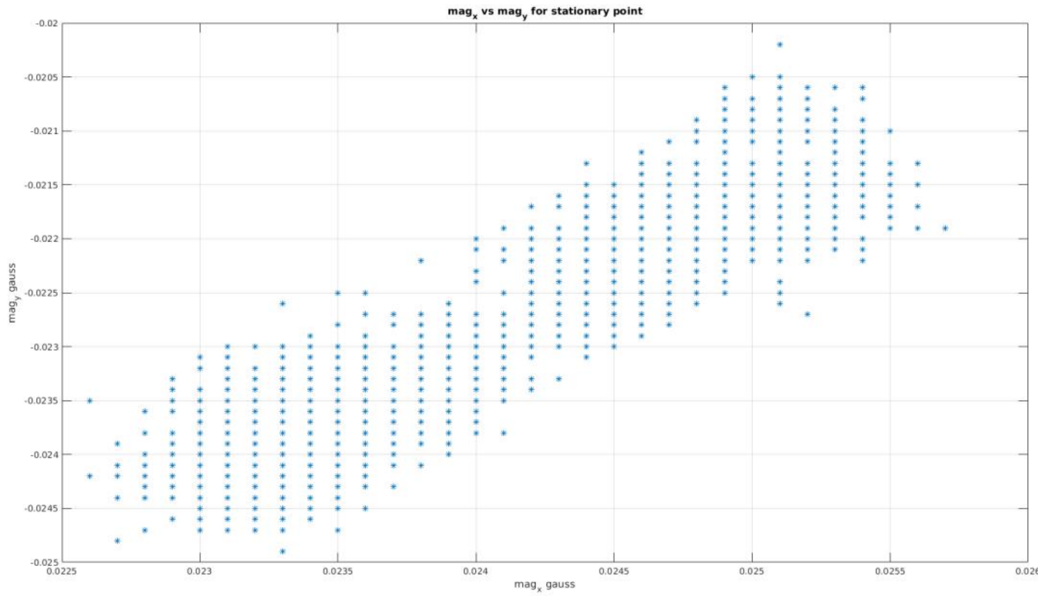
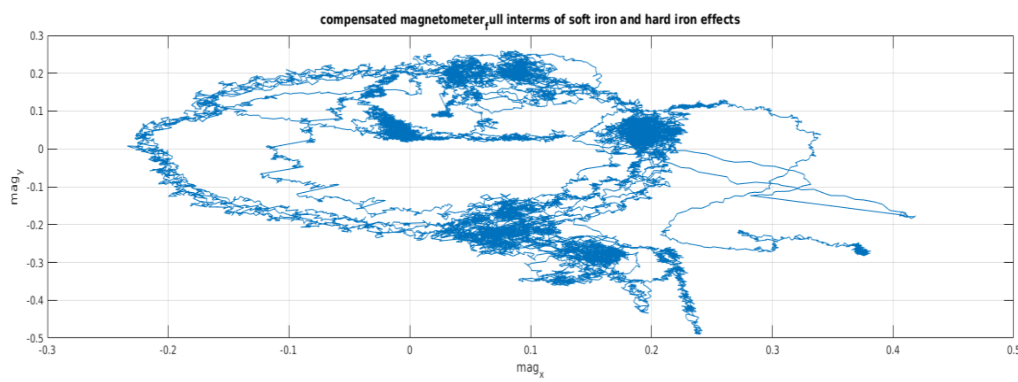


Fig 11: MagX vs Mag Y at Stationary point



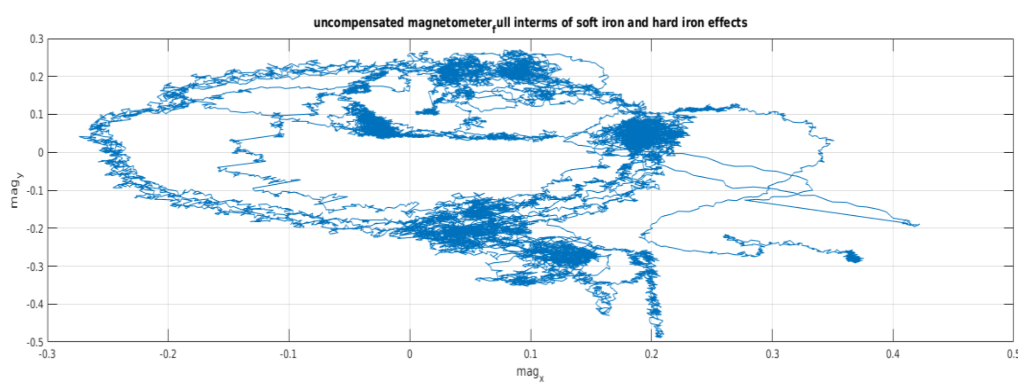


Fig 12: Uncalibrated vs Calibrated in 3D

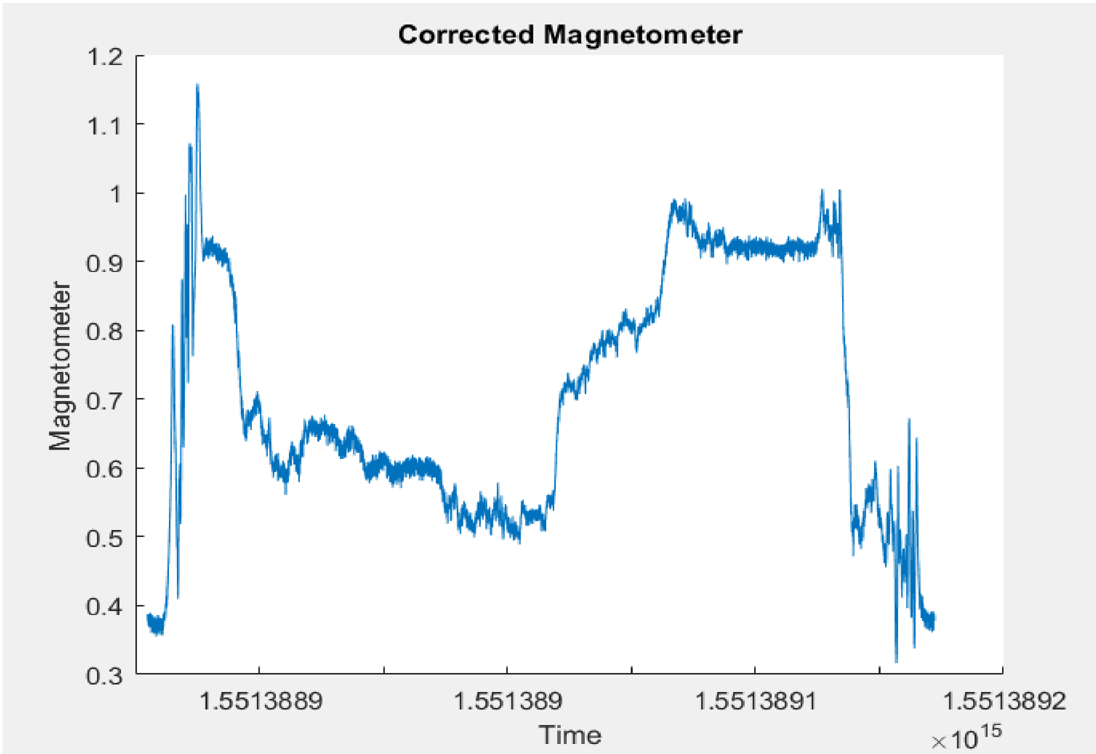


Fig 13: Calibrated Magnetometer in 2D

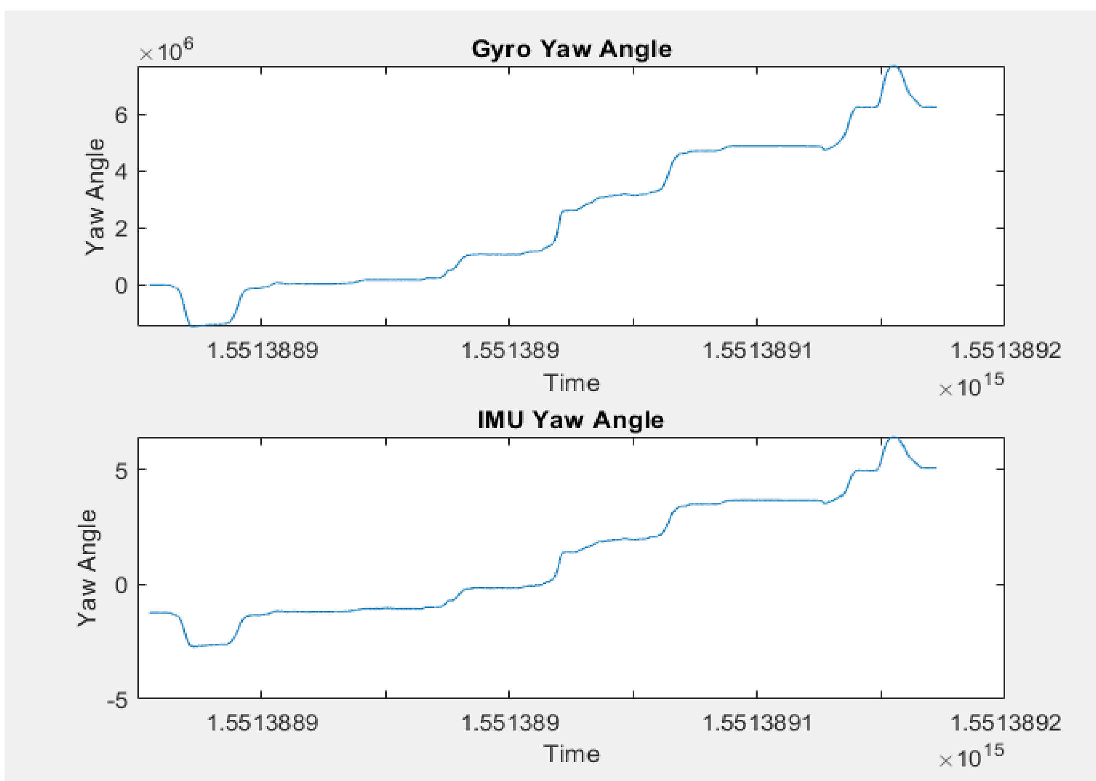


Fig 14: IMU angle vs Gyro Angle

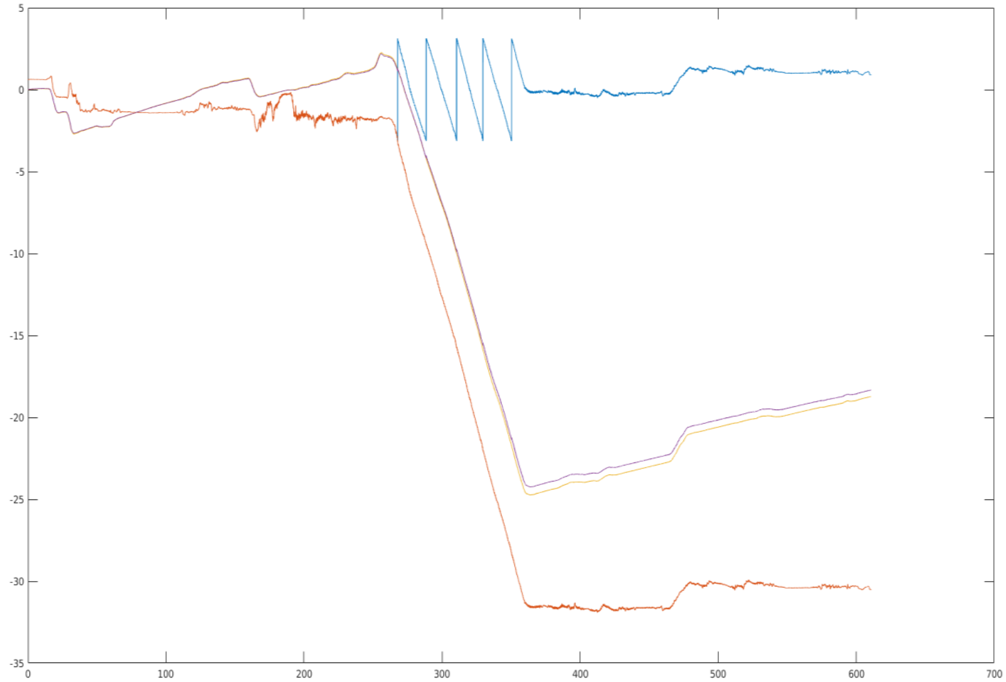


Fig 15: Magnetometer Yaw angle and Gyroscope Yaw angle Estimate with proposed Low Pass Filter

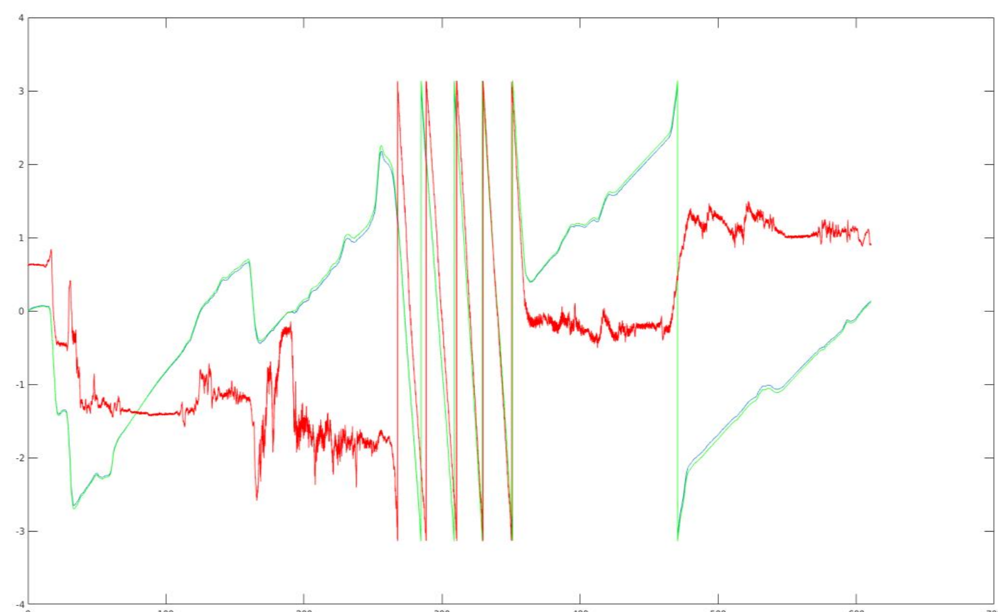


Fig 16: Gyroscope Yaw angle vs Magnetometer Yaw angle unwrapped with filter

Here in Figure 15, blue line corresponds to the mag yaw. The orange line is unwrapped mag yaw. Yellow line is the gyro_z yaw and the purple line is the complimentary low pass filter.

In figure 16, we plot the gyro yaw angle unwrapped, i.e. we do not integrate it with time. Here the Red line is the mag yaw, green line is the gyro yaw and dark green is the complimentary filter.

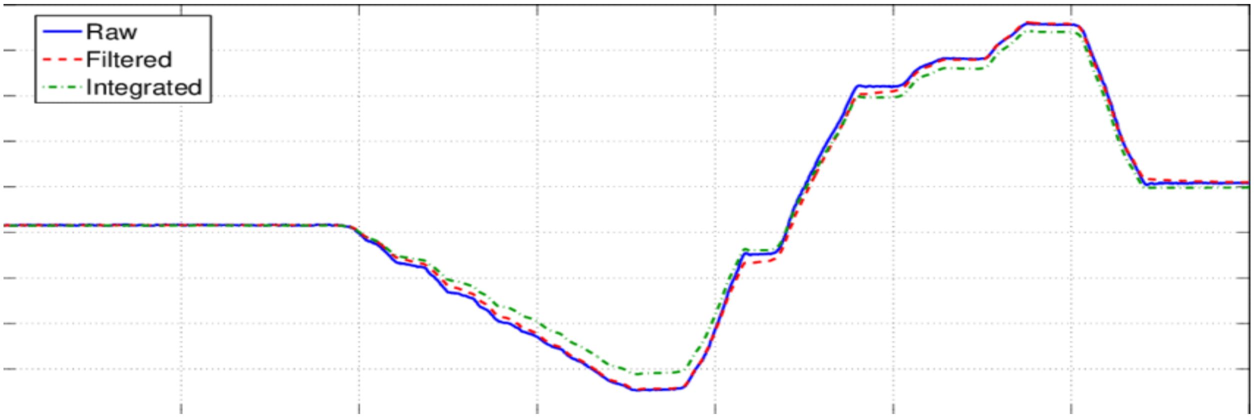


Fig 17: Gyroscope Yaw angle with complimentary filter

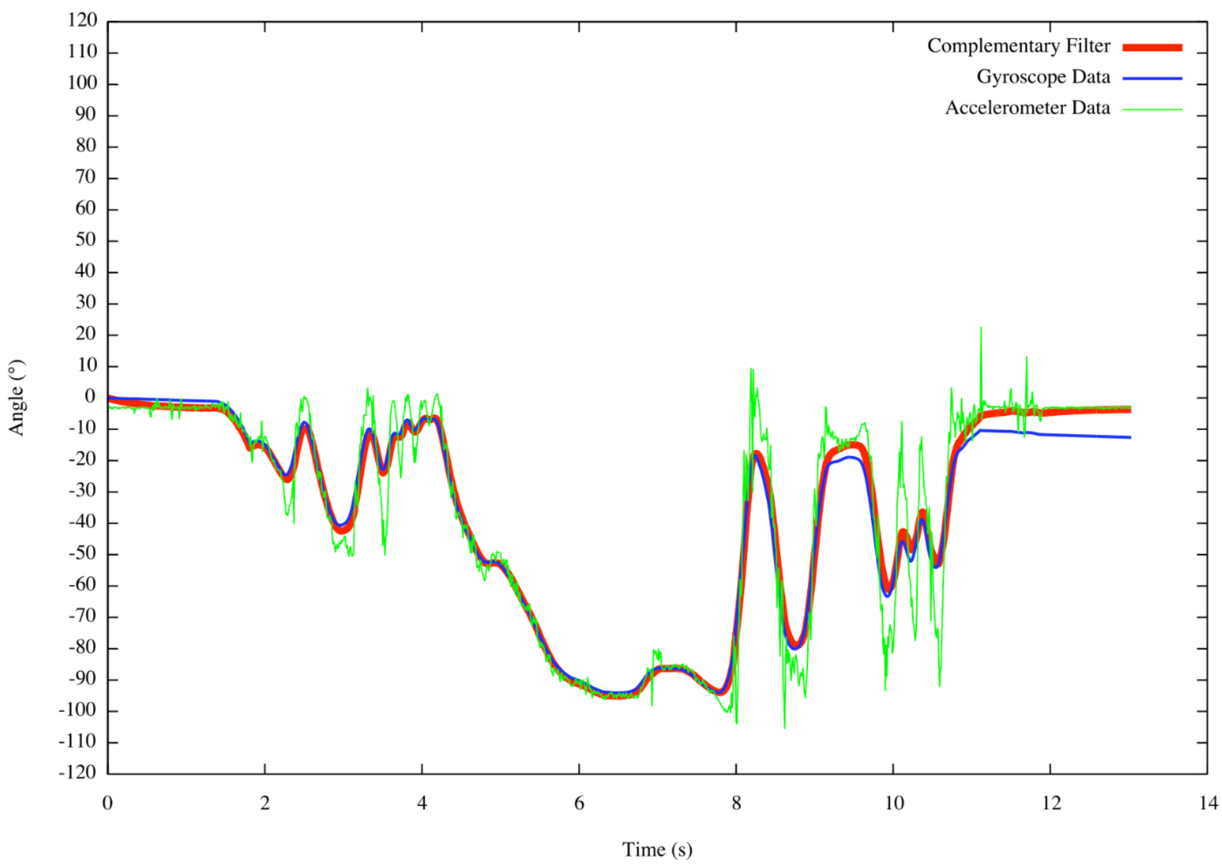


Fig 18: Gyroscope Yaw angle vs Acceleration with complimentary filter

Question 6:

Here what we experience with IMU sensors, because of the presence of accelerometer and gyroscope is that the readings are very small. We see the result of a drift. Once we integrate these values, we get the velocity, which is the error at each point multiplied with time t.

The initial plot of accelerometer samples directly from the IMU i.e. the figure 19. The sampling occurs approximately every 100^{th} of a second, and the X axis is the indexes of the time array, so they correspond to every $1/100^{th}$ of a second. The acceleration plot displays most of the area which is above the x axis.

If we shake the IMU back and forth, the mean acceleration data, and the velocity which we get from it should be zero.

In most of the GPS receivers, there is a lack of synchronization of a relatively low-quality GPS receiver clock. One of the factors needed for the calculation of accurate velocity estimate can be with the use of ADR or accumulated delta ranges. Another important factor can be the pseudoranges. Due to the lack of synchronization, both the ADR and pseudoranges contain significant components connected with the clock errors. These components contain additional variables of bias and drift, which must be calculated along the way.

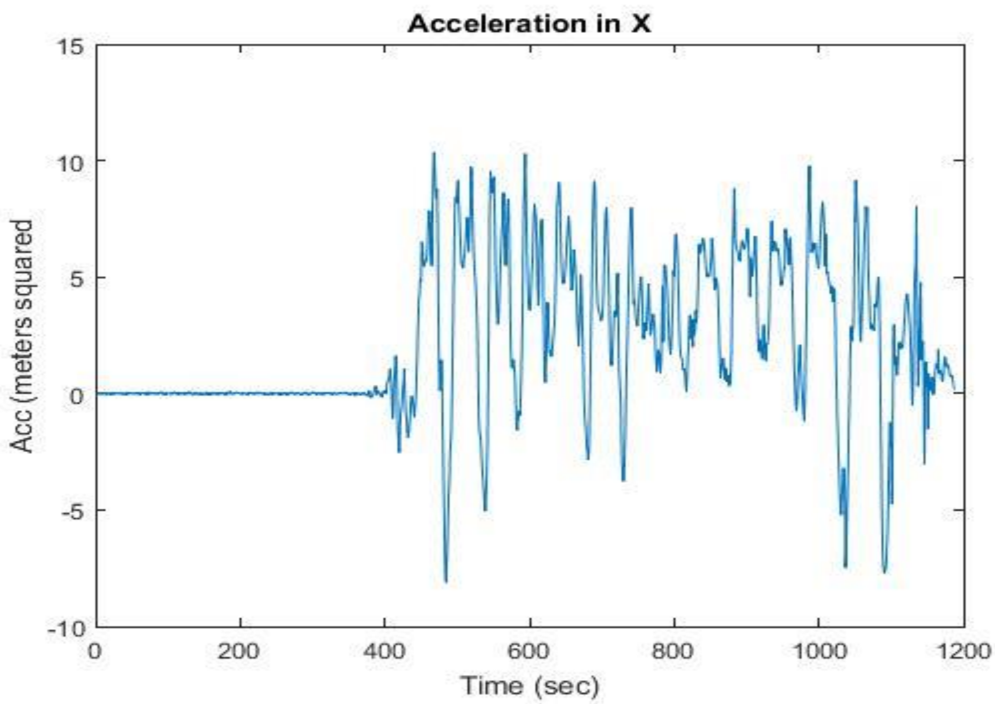


Fig 19: Accelerometer in X Axis

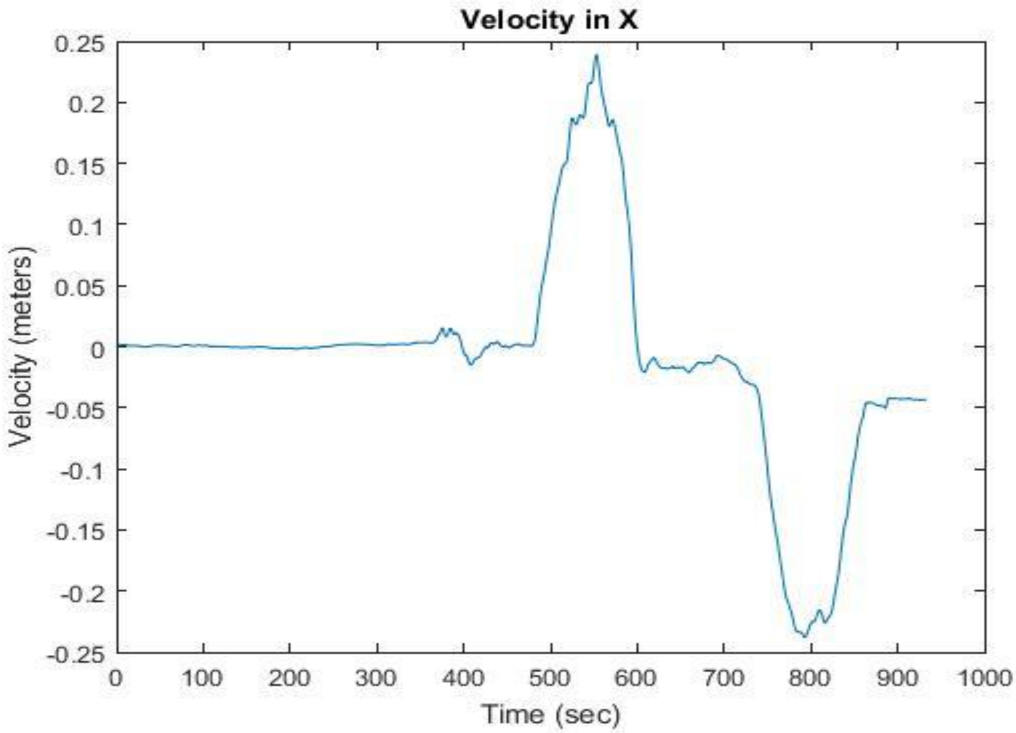


Fig 20: Velocity estimate of forward acceleration

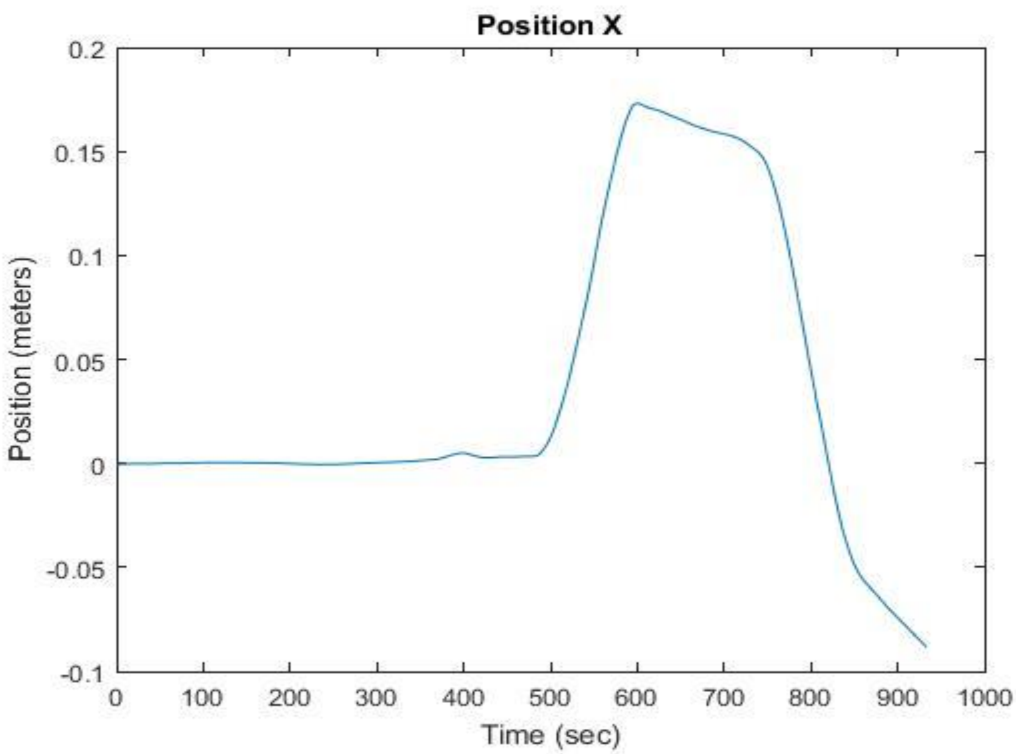


Fig 21: Position of Velocity Estimate

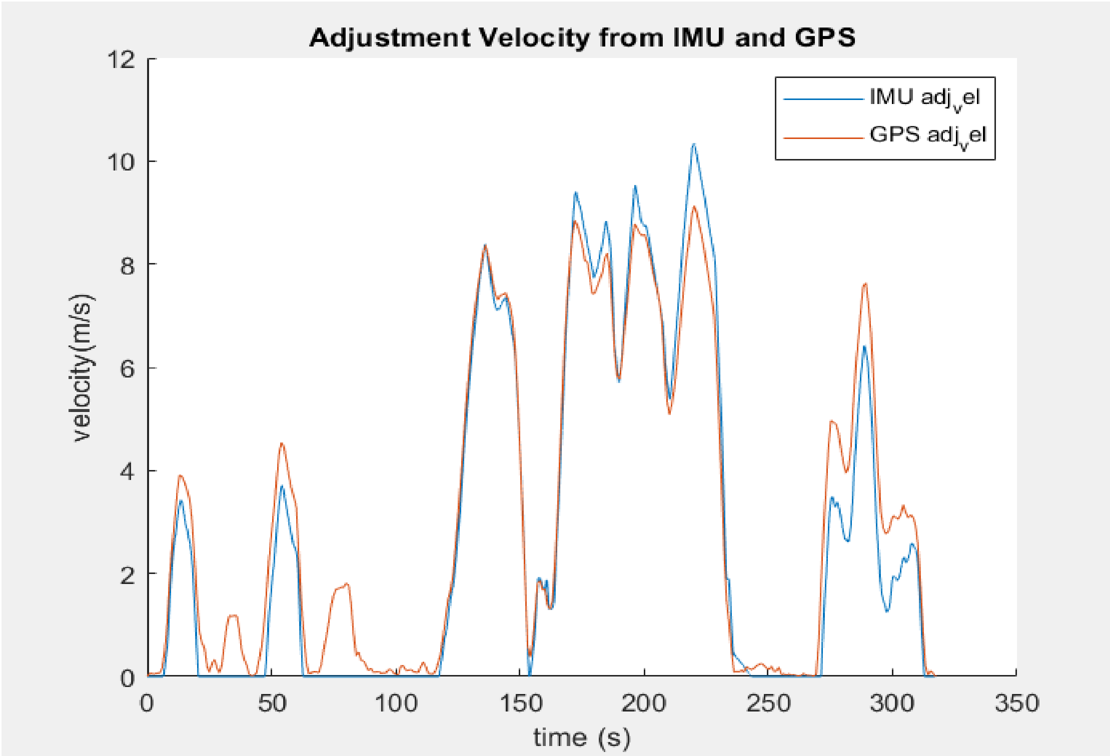


Fig 22: Adjustment Velocity from IMU and GPS

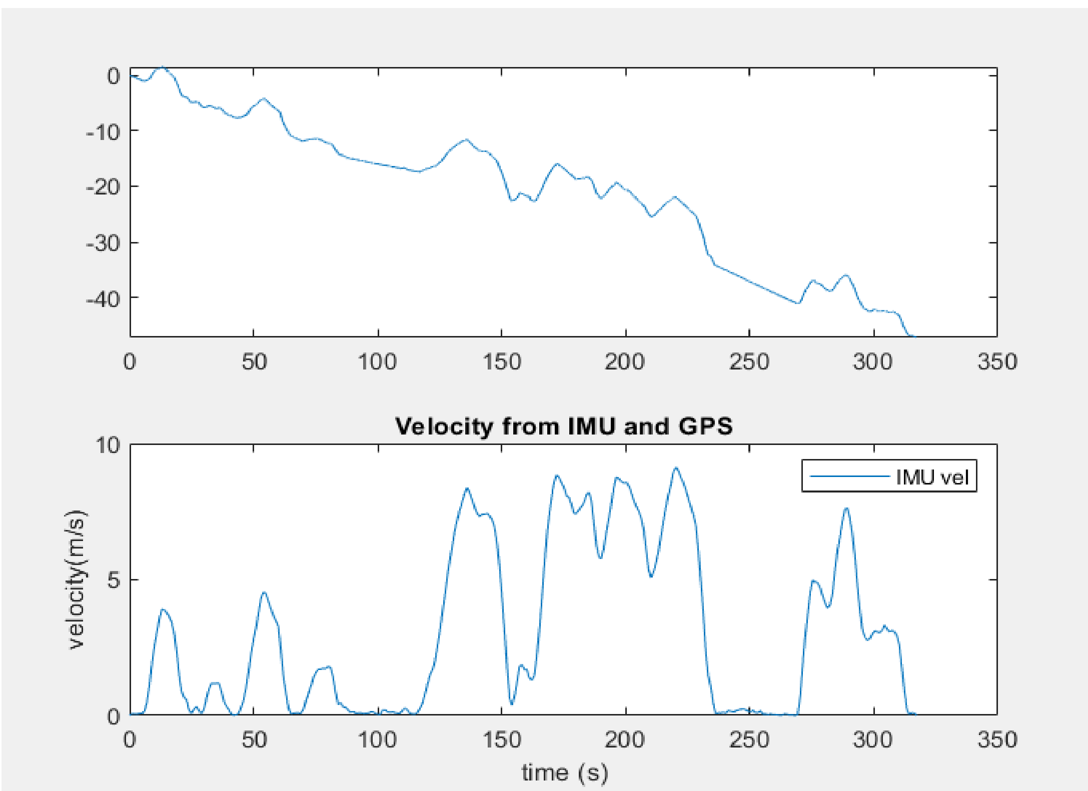


Fig 23: Separate graphs for IMU and GPS

Question 7:

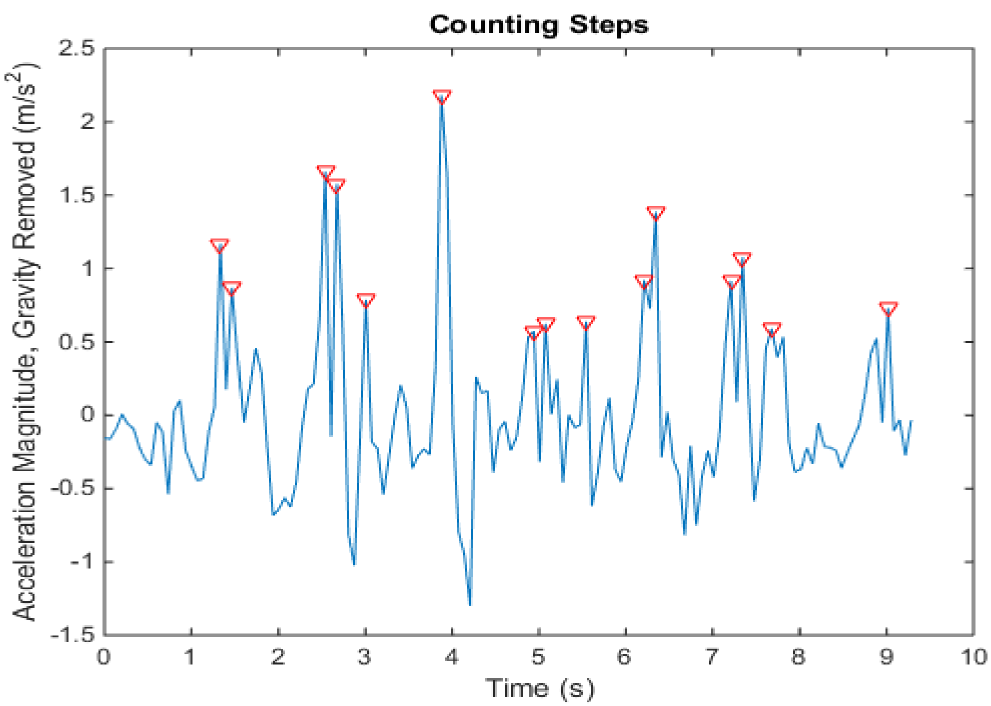


Fig 24: Displacement of IMU in terms of steps vs Time

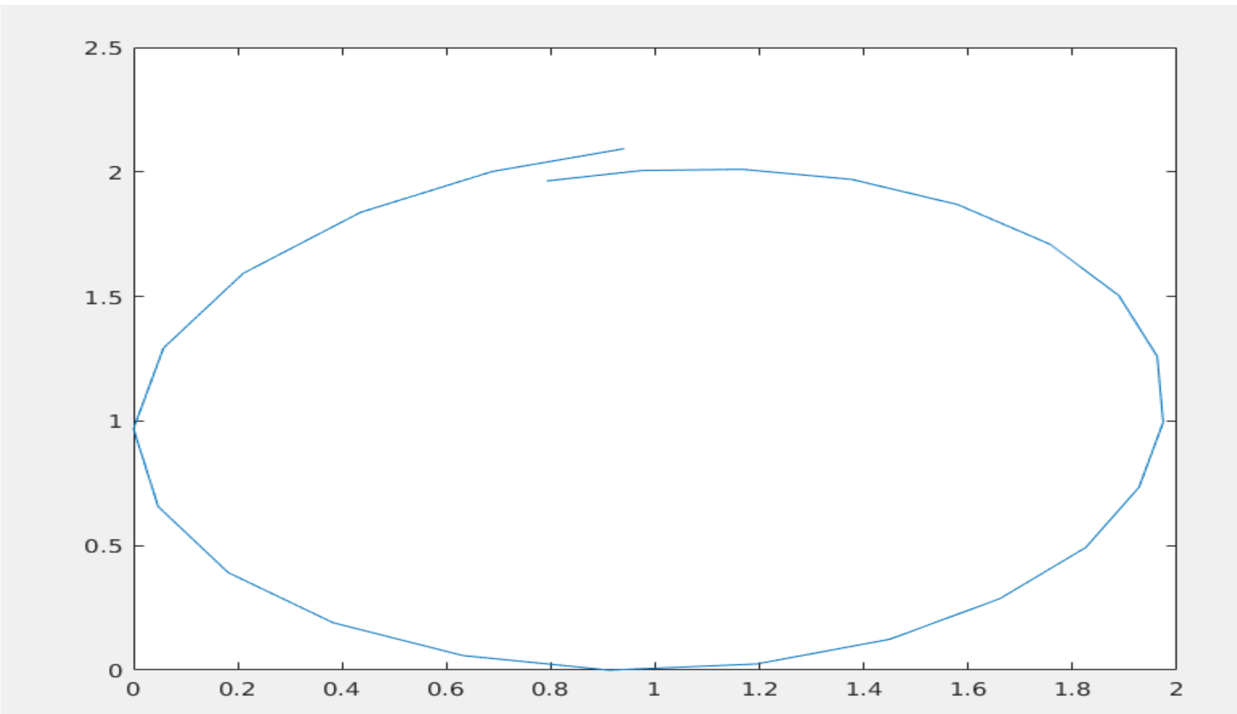


Fig 25: IMU displacement after estimating the trajectory of GPS

Using our calculation, the difference between the wX and Yobs comes out to be quite small, considering the offset is zero.

The starting point has been adjusted a little bit for the GPS data, to match with the IMU one. Installation error can cause a significant difference in terms of output readings, and this error is systematic. It can be removed using some of the equations.

We can take the inverse matrix of the IMU reference frame, and then write down the transformation matrix of the body reference. By this, we can also calculate the offset error.