LAB4

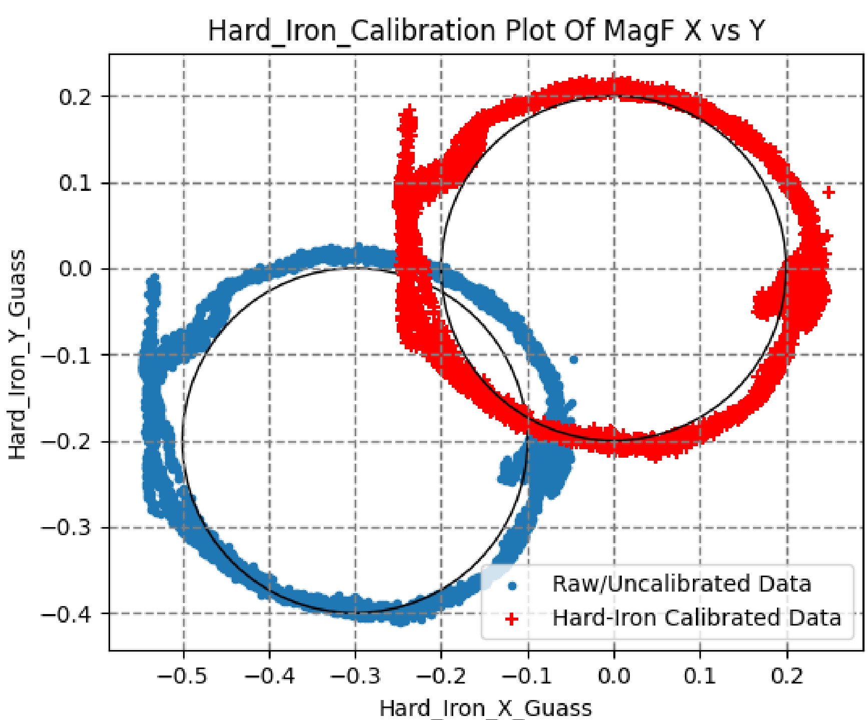
Navigation with IMU and Magnetometer sensor fusion

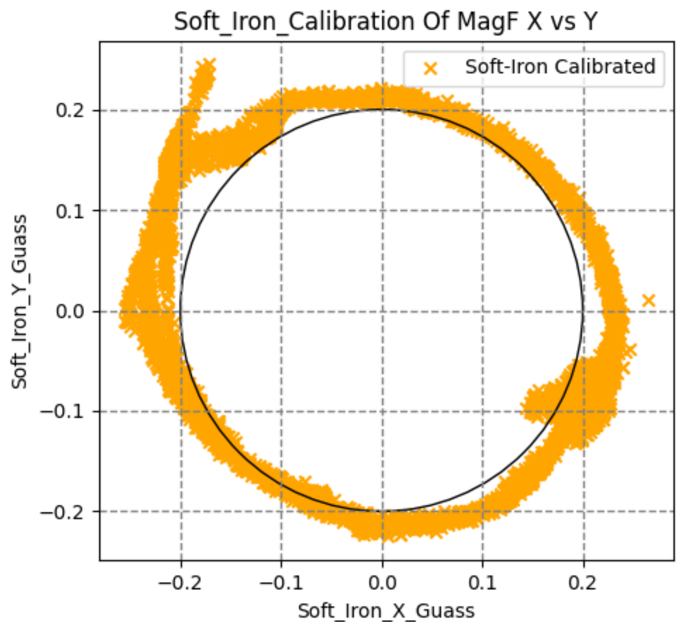
Magnetometer calibration for hard Iron and soft Iron

A magnetometer is a sensor used to measure the strength and direction of the local magnetic field surrounding a system. This magnetic field measurement can then be compared to models of Earth's magnetic field to determine the heading of a system with respect to magnetic North.

The purpose of this report is to analyze the hard iron calibration plot of mag X vs Y. The hard iron calibration plot is used to determine the offset of the magnetometer due to the presence of hard iron materials. Hard iron materials are magnetic materials that do not change their magnetization in the presence of an external magnetic field. the data for the hard iron calibration plot was collected by rotating the magnetometer around all axes in the presence of a known magnetic field. The X and Y components of the magnetic field were measured and recorded at each orientation of the magnetometer.

The hard iron calibration plot shows the difference between the raw and calibrated X and Y components of the magnetic field. The calibrated data is the raw data minus the hard iron offset. The hard iron offset is determined by fitting a plane to the calibrated data. The plane represents the ideal response of the magnetometer in the absence of hard iron materials. The offset of the plane from the origin represents the hard iron offset.

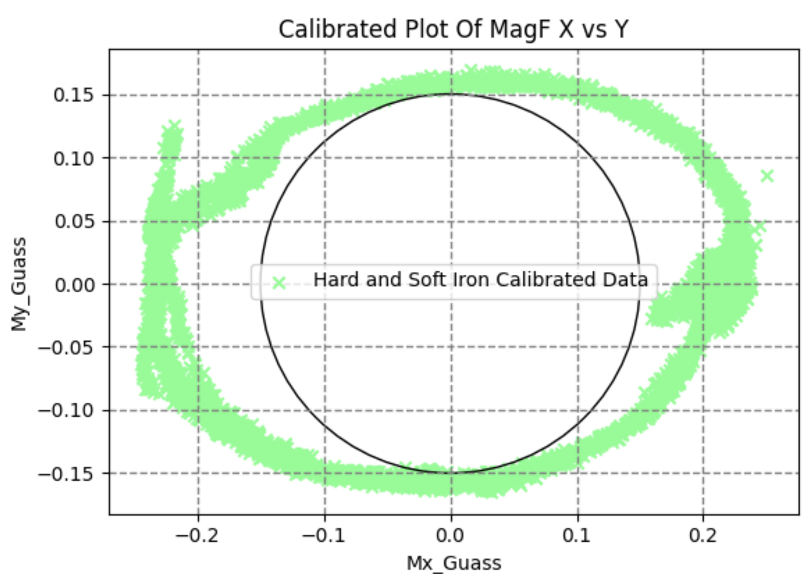




The soft iron calibration can be used to improve the accuracy of the magnetometer readings. To use the soft iron calibration, you need to measure the soft iron offset at different values of magF x and y. Once you have measured the soft iron offset, you can use it to correct the magnetometer readings.
The soft iron offset is largest at high values of magF x and y. This is because the magnetic field of the vehicle is strongest at high values of magF x and y.

•The soft iron offset is also larger in the y direction than in the x direction. This is because the magnetic field of the vehicle is stronger in the y direction than in the x direction.

•The soft iron offset is non-linear. This means that the soft iron offset at a given value of magF x and y cannot be predicted from the soft iron offset at other values of magF x and y.



The graph shows the **Y-observed acceleration** versus **wX(dot) acceleration**. The Y-observed acceleration is the acceleration of the vehicle in the Y direction, as measured by the IMU. The wX(dot) acceleration is the angular velocity of the vehicle in the X direction, multiplied by the vehicle's velocity in the X direction.The graph shows that the Y-observed acceleration and the wX(dot) acceleration are correlated. This means that the Y-observed acceleration is affected by the angular velocity of the vehicle in the X direction. This is because the IMU measures the acceleration of the vehicle in the IMU frame of reference, which is not the same as the vehicle's body frame of reference. The IMU frame of reference is rotated relative to the vehicle's body frame of reference by the vehicle's attitude.The correlation between the Y-observed acceleration and the wX(dot) acceleration can be used to improve the accuracy of the IMU measurements. For example, the wX(dot) acceleration can be used to compensate for the error in the Y-observed acceleration caused by the vehicle's rotation.

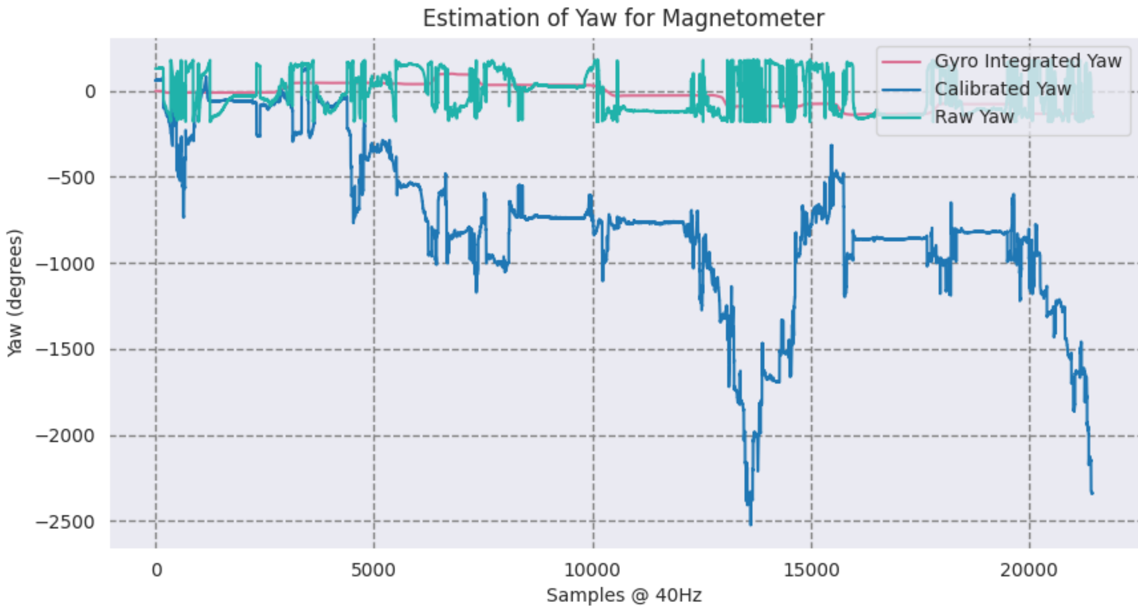
observations from the graph:

•The Y-observed acceleration and the wX(dot) acceleration are generally correlated. This means that the Y-observed acceleration is affected by the angular velocity of the vehicle in the X direction.

•The correlation between the Y-observed acceleration and the wX(dot) acceleration is strongest at high angular velocities. This is because the error in the Y-observed acceleration caused by the vehicle's rotation is greatest at high angular velocities.

•The correlation between the Y-observed acceleration and the wX(dot) acceleration is non-linear. This means that the correlation between the Y-observed acceleration and the wX(dot) acceleration cannot be predicted from the correlation between the Y-observed acceleration and the wX(dot) acceleration at other angular velocities.

Estimation of yaw angle



The graph shows the **estimated yaw from the magnetometer** versus **time**. The estimated yaw from the magnetometer is the yaw angle of the vehicle, as estimated from the magnetometer readings.

The graph shows that the estimated yaw from the magnetometer is generally accurate. However, there are some spikes in the graph, which indicate that the magnetometer readings are noisy. The noise in the magnetometer readings is caused by a number of factors, including the presence of magnetic fields from other sources, such as the vehicle's engine and electronics.

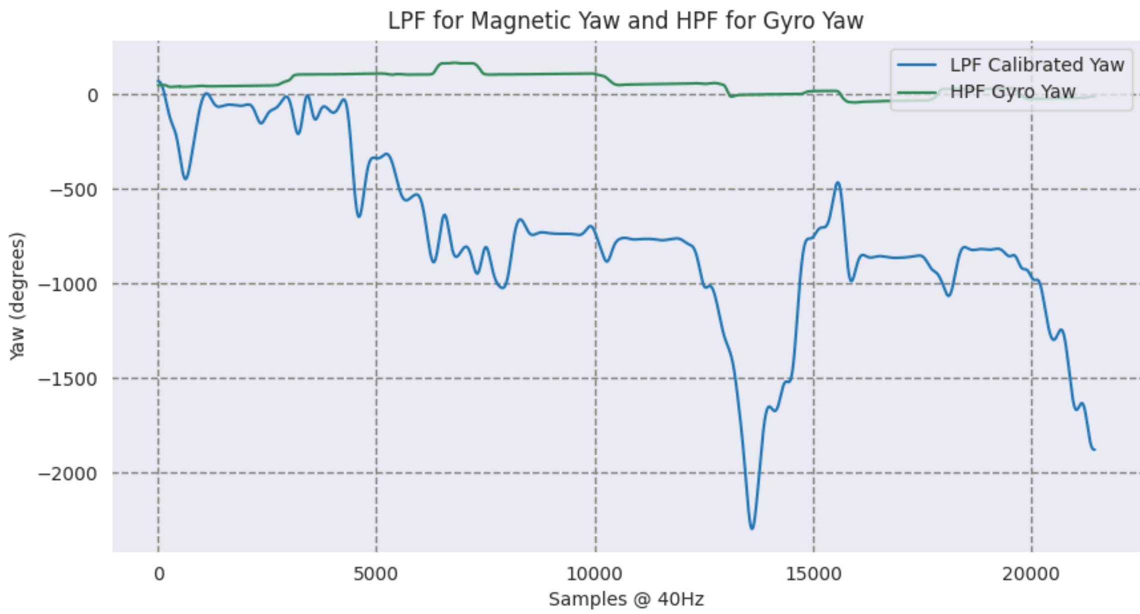
From the graph:

•The estimated yaw from the magnetometer increases over time. This is because the vehicle is turning.

•The estimated yaw from the magnetometer is generally smooth, with no sudden changes. However, there are some spikes in the graph, which indicate that the magnetometer readings are noisy.

•The estimated yaw from the magnetometer is close to the actual yaw angle of the vehicle. However, there are some errors in the estimated yaw angle, which are caused by the noise in the magnetometer readings.

Yaw angle is found after the calibration of hard and soft iron of the magnetometer. It can also be derived from integrating gyroscope data. Both calculated yaw closely matches the form of the yaw angle internally calculated in the IMU. The yaw calculated from the gyroscope data is relatively smoother and less sensitive (fewer peaks) compared to the IMU yaw, while the yaw derived from the magnetometer data is relatively less smooth.



The LPF for magnetic yaw is higher than the HPF for gyro yaw. This is because the magnetometer readings are more noisy than the gyroscope readings.

•The LPF for magnetic yaw and the HPF for gyro yaw are complementary. This means that they remove different types of noise from the magnetometer and gyroscope readings.

•The complementary filter is a weighted average of the LPF for magnetic yaw and the HPF for gyro yaw. The weights are chosen such that the complementary filter is more accurate than either the LPF for magnetic yaw or the HPF for gyro yaw on its own.