Lab 3

ECE 167

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All parts checked off
by **Cris Vasquez**
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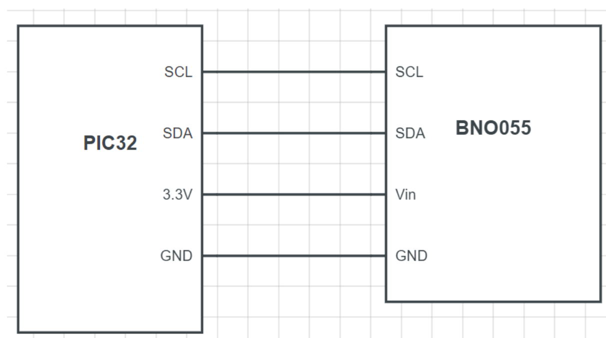
1 Overview

For this project, we responsible for calibrating and using the data from the provided IMU. This involved calibrating the data for each of the three separate types of sensors onboard. That is the accelerometer, the gyroscope, and the magnetometer.

Each of these required slightly different methods of calibration but each of these processes involved comparing raw data to expected output that we want, and mapping the raw to what we know as real.

I did the whole lab with the following circuit setup:



(a) Calibrated

Parts Required:

- BNO055 IMU Chip
- Jumper wires
- chipKIT32 (with jumpers JP6 and JP8 set closest to labels RG3 and RG2)

2 Accelerometer

For the accelerometer, I recreated the process I have done in previous labs for mapping sensor output values to known values. For calibrating our flex angle sensor in the past, I took down data points for the raw potentiometer value and the angle it corresponded to.

For this part, for each of the axis I only had two known data points. $\pm 1G$ corresponding to gravity which is the only acceleration force the sensor should read when placed level and stationary on a desk. I set in the code for the microcontroller to output 1000 values at $50Hz$ which would collect data for a total of 20 seconds. This data was exported to Matlab and I plotted the X-Axis as the raw data and the Y-Axis was the stationary target value of $1000mG = 9.8m/s^2$. The line of best fit was then calculated in MatLab and the scaling factor and offset were given.

Accelerometer X-Axis:

Scaling Factor = 1.0051 $\longrightarrow$ Offset = 16.0869

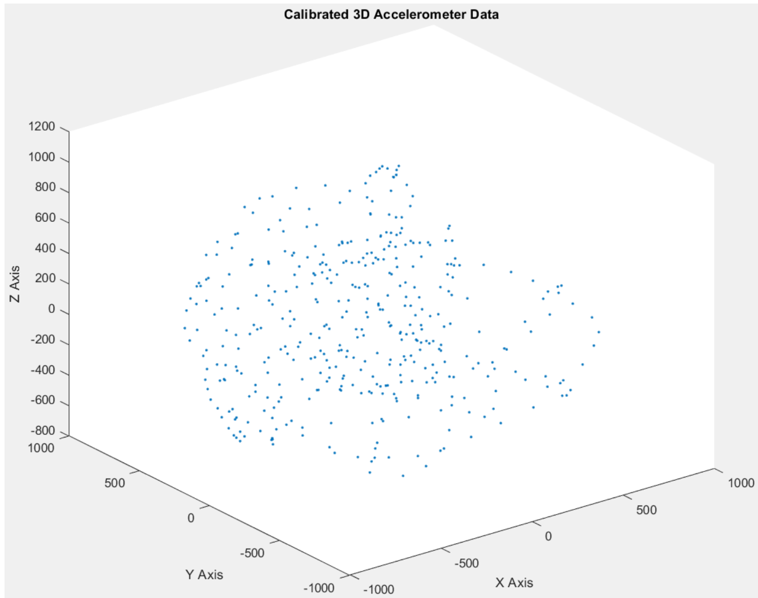
Accelerometer Y-Axis:

Scaling Factor = 1.0058 $\longrightarrow$ Offset = 29.7377

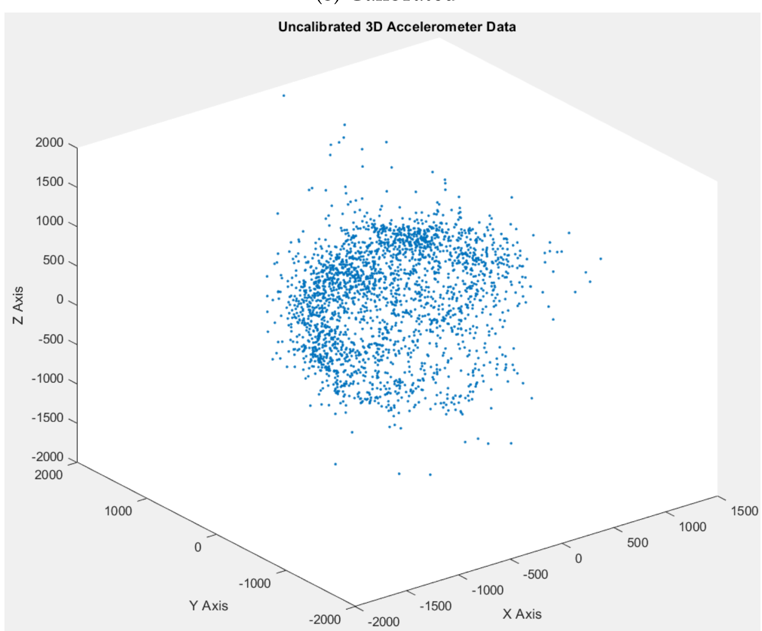
Accelerometer Z-Axis:

Scaling Factor = 1.0016 $\longrightarrow$ Offset = 13.5053

This was then applied to the raw data as well as an average taken over time for additional smoothing. With these two measures taken, I then set the MCU to output raw and calibrated X, Y, and Z data points to a .csv file and charted the following 3D charts in Matlab.



(b) Calibrated



(c) Uncalibrated

3 Magnetometer

Calibrating the Magnetometer was by far the most annoying of the whole lab. It really just felt like I was never sure how we were supposed to be calibrating it. It also felt like absolutely anything around me produced a stronger magnetic field than the earth so it did not even necessarily feel useful. This could just be the environment I was in though.

For this section, I started off by finding the average over 100 samples in order to smooth out the data and be able to pinpoint when the values were where I wanted them. I then found each axis by moving the IMU until the other two axes equaled close to 0. At this point 1000 samples were taken just like in the last section and all the data was plotted. Using Matlab, I was able to find the average of each of my target axis and use this to find the desired offset.

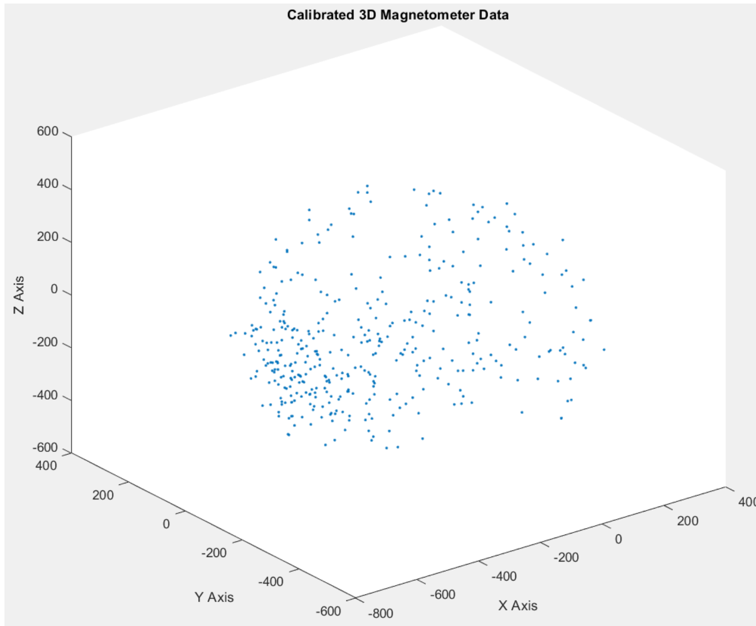
As an example, when the X and Y axes equaled around 0, I would store 1000 Z values and find the median of all of them. This median then gave the offset from what the Z was supposed to be which would be the horizontal intensity in Santa Cruz. I calculated the offsets as

Magnetometer X-Axis:
    Offset $= -139.5479$

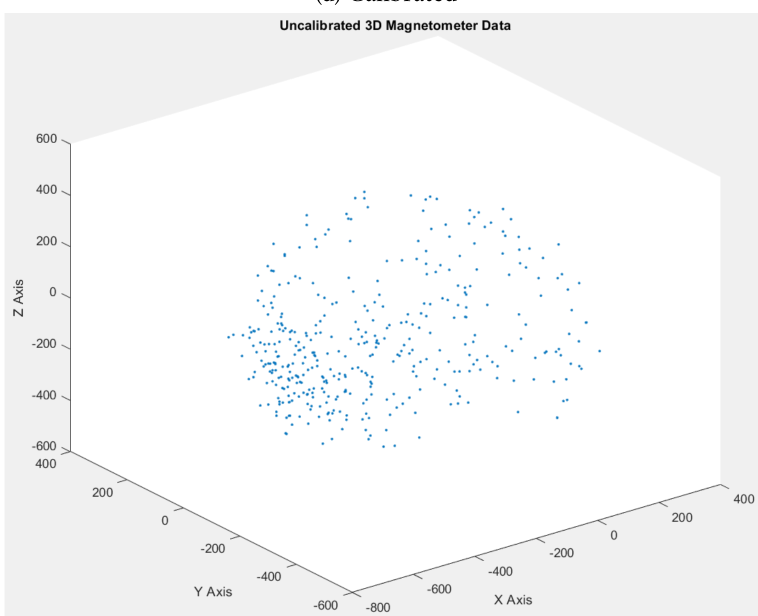
Magnetometer Y-Axis:
    Offset $= 185.5479$

Magnetometer Z-Axis:
    Offset $= -365.6390$

The following calibrated and uncalibrated 3D charts were plotted just as with the accelerometer:



(d) Calibrated



(e) Uncalibrated

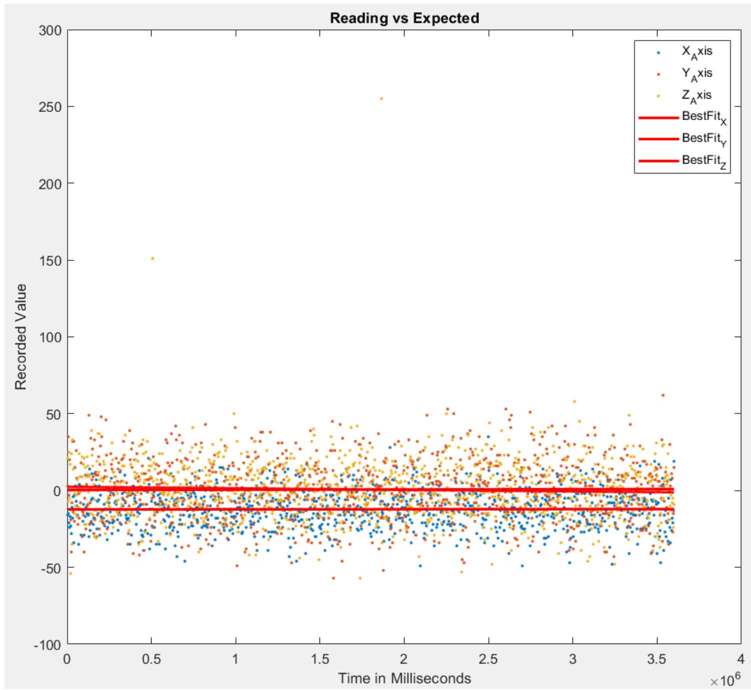
4 Gyroscope

The Gyroscope was honestly not too bad. There was one main step with the calibration and then a different method to implementing its data. In order to calibrate it, 1000 samples over 20 seconds was taken again with it not moving. This is because the gyroscope does not always read 0 despite it not moving. The average of these values was then found for X, Y, and Z all at once and used as the offset, knowing that we wanted it to be 0. The following was gotten:
Gyroscope X-Axis:
    Offset = 7.1240

Gyroscope Y-Axis:
    Offset = 7.1064

Gyroscope Z-Axis:
    Offset = 8.0019

The value gyroscope value also needed to be divided by 131 in order to convert the sensor output into degrees/sec. After these two conversions were made, I then set up the MCU to take 1000 samples every 3.6seconds in order to automatically end after 1 hour of data collection. These measurements over time were then exported to Matlab and a line of best fit was applied. This resulted in the following graph:



(f) Calibrated

The offset and scaling factor of the best fit line was 2.4372 and 0 respectively. The slope of the line was 0 which showed that, despite the lines being all over the place, there was no bias in the drift. The values were all over the place a little extra because I was not also averaging them and calculating that.

Finally, the data was used in order to calculate with a running integration, the current angle. After taking the average and applying the bias, the angle was actually very accurate. It might have been even more accurate than with the flex sensor.

5 Conclusion

This lab was probably the most tedious yet. If I'm being honest, the previous lab probably took slightly longer, but this one was a monumental pain. It felt like a lot of work for little progress and overall, I feel like not much was achieved. Despite this, I am excited to use the newly calibrated IMU. It was just keeping track of all the numbers and output data this lab that proved difficult and tedious. I also got a lot of conflicting information on how to do each part and the best methods of calibration

so I can only hope that I chose the correct methods each time.
Est. Hours: 16