EECE5554 Robotic Sensing & Navigation

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**Lab 3: IMU Noise & Performance Calibration**

**Part I: Stationary Data**

Stationary data was recorded from the IMU over the course of 6 minutes, providing 15000 data samples at a 40hz sampling rate. Among the information recorded was gyroscopic data, acceleration data, orientation data, and magnetometer data. Each of these parameters were recorded for x, y, and z axes, and plotted Figure 1 below.

A graph with numbers and lines

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A graph of a graph

AI-generated content may be incorrect.A graph with numbers and lines

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**Figure 1: IMU data in X, Y, Z.**

Overall, noise was minimal. The device was not in ideal isolation from nearby devices, which may cause more visible variation in the magnetometer data. Additionally, each parameter recorded a single data sample containing zeroes across every axis, shown in each Figure 1 plot as an outlier yellow “x”. It is unclear what caused this hiccup in data values, especially given that each data point contains this outlier at a different time during the sampling period. Notably, the accelerometer data never rests at zero, despite the IMU having been Velcro-strapped to a nearby couch. This later impacts the motion data.

The mean and medians for the orientation axes, or Euler angle data, were as follows:

A math equations with numbers

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Given the low noise present in the stationary datasets, the histogram distributions for roll, pitch, and yaw were grouped tightly. Plotted in Figure 2 below, the histogram distributions are compared to the median values recorded for each corresponding axis.

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**Figure 2: Euler angle histograms with median line**

The VN-100 datasheet reports a 0.5 degree pitch/roll accuracy, which is well represented by the corresponding histograms (note the x10-3 scale in the stationary horizontal axis), with the roll accuracy being within the margins of ±0.01 degrees.

**Part II: Moving Data**

During the data collection process, the IMU motion is recorded via video to cross reference with the resulting data plots. For example, the accelerometer motion data is shown in the figure below.

**A graph of a sound wave

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Figure 3: Accelerometer motion data along X, Y, and Z axes.**

Ideally, the coordinate axes printed on the IMU face can be used to identify which axis the IMU is moving or rotating about, which would appear on a corresponding axis plot. However, the movements recorded in the video were not enough to appear prominently on the data plot.

That is, all but the middle portion of the video, where our IMU is shaken vigorously, both indicated by the spikes at the center of the data plot and the extremely blurry video footage shown below.

A blurry hand holding a red object

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**Figure 4: Video footage of IMU vibration**

**Part III: Allan Variance**

Provided with four separate bag files of unknown locations, labeled A, B, C, and D, the corresponding Allan Variance plots are generated using the bag data. The Allan Variance plots for each location’s accelerometer and gyroscope data are listed below.

**Location A:**

A graph of a line

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AI-generated content may be incorrect.A graph of a line graph

AI-generated content may be incorrect.A graph with colored lines and dots

AI-generated content may be incorrect.

**Location B:**

A graph with numbers and lines

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AI-generated content may be incorrect.A graph with numbers and lines

AI-generated content may be incorrect.A graph with numbers and lines

AI-generated content may be incorrect.A graph with numbers and lines

AI-generated content may be incorrect.A graph with numbers and lines

AI-generated content may be incorrect.

**Location C:**

A graph with lines and numbers

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AI-generated content may be incorrect.A graph with lines and numbers

AI-generated content may be incorrect.A graph with lines and text

AI-generated content may be incorrect.A graph with lines and words

AI-generated content may be incorrect.A graph of a graph showing the difference between a number of numbers

AI-generated content may be incorrect.

**Location D:**

A graph with lines and dots

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AI-generated content may be incorrect.A graph with lines and numbers

AI-generated content may be incorrect.A graph with a red line

AI-generated content may be incorrect.A graph of a graph showing a line

AI-generated content may be incorrect.A graph with lines and numbers

AI-generated content may be incorrect.

From this data, we begin assigning locations to these unknown markers. Location C is believed to be the Snell basement, as the low frequency noise region oscillates more than any other data set, likely caused by the orange line and commuter trains making frequent passes. On the other hand, Location B appears to have a smoother line indicating a more consistent “improvement from averaging” when compared to the other locations. The 5th floor of ISEC is selected to be Location B, further and more stable compared to the ISEC basement (near the commuter line) and Wooden house (I do not know what this is). The plot trend at Location D is more similar to that of Location C, which may indicate proximity to the commuter rail.

I do not know what wooden house is.

The ideal conditions for measuring Allan Variance would be an isolated location, where a lack of external factors such as vibrations and/or electromagnetic noise would increase the repeatability of sensor measurements.

To characterize a new sensor, measurements should be taken in a stable, controlled environment to isolate sensor noise. Raw, high-frequency data should be collected while the sensor remains stationary to analyze noise sources like bias instability and random walk using Allan variance. Tests in varying temperatures, vibrations, and electromagnetic conditions help identify environmental effects. Comparing these results to expected operating conditions provides insight into real-world performance and necessary calibrations.