RSN Lab 3 report

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1 Introduction

This report discusses the process of extracting data from an **Inertial Measurement Unit**(IMU) and analyse the data received. IMU is a sensor which outputs the acceleration by measuring the inertial forces experienced by a proof body. The IMU used in this experiment is a *VectorNav VN-100*. The report also discusses the extraction of natural noise of the IMU from a collection of data sets.

2 Setup

The experiment is carried out in three segments. The first segment is the analysis of the stationary IMU readings. This is done by attaching the sensor to a stable surface firmly. Data is collected for a duration of 5 minutes. Care was taken as to not have any sources of disturbances near the sensor. This is to reduce any chances of artificial noise. The second segment is the analysis of data while the IMU sensor is in motion. Readings from the IMU is collected for a duration of 5 minutes while the sensor is in motion. The IMU was constantly is motion throughout and a video was recorded so that it can later be associated with the data.

The third segment is a bit different in the sense that the data was not recorded first-hand. Four different data sets of IMU data of 6 hours each in different locations were made available. The data was then analysed and noise parameters were extracted.

3 Analysis of data set

The data set consists of a rosbag file which contains message in *std_msg/String* format in the '*/imu*' topic. The data is then extracted, parsed and stored in appropriate variables that make it convenient to analyse. The data is analysed by determining the Allan variance, the rate random walk, the angle random walk and the instability bias of the sensor using the data set.

4 Results

4.1 Stationary data

$$Mean\ accleration\ about\ X-axis = 0.0576\ m/s^2$$
$$Mean\ accleration\ aboutY-axis = 0.0048\ m/s^2$$
$$Mean\ accleration\ aboutZ-axis = -9.619\ m/s^2$$
$$Mean\ Rotation\ aboutX-axis = -0.0329\ rad/sec$$
$$Mean\ Rotation\ aboutY-axis = 0.3610\ rad/sec$$
$$Mean\ Rotation\ aboutZ-axis = 172.628\ rad/sec$$

$$Median\ accleration\ about\ X-axis = 0.058\ m/s^2$$
$$Median\ accleration\ aboutY-axis = 0.005\ m/s^2$$

$$Median\ accleration\ about Z - axis = -9.62\ m/s^2$$
$$Median\ Rotation\ about X - axis = -0.0329\ rad/sec$$
$$Median\ Rotation\ about Y - axis = 0.3610\ rad/sec$$
$$Median\ Rotation\ about Z - axis = 172.628\ rad/sec$$

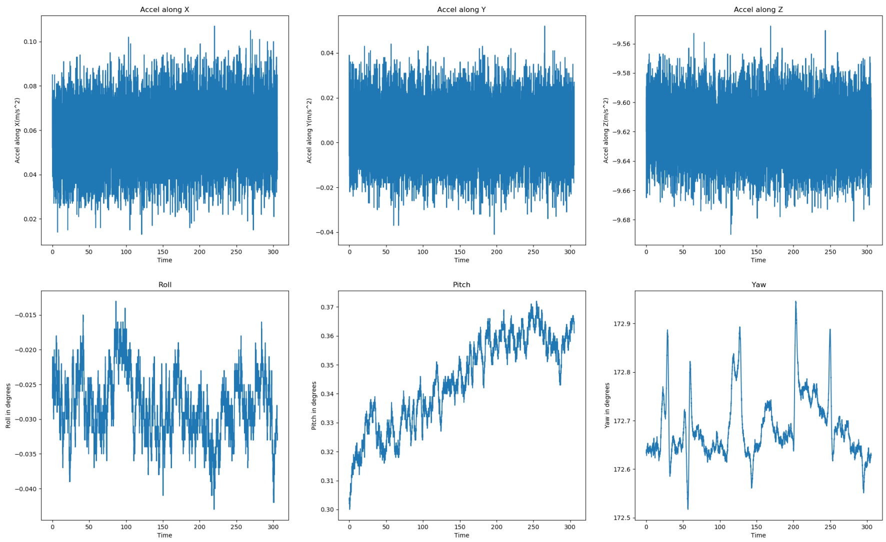


Figure 1: Raw readings from the IMU

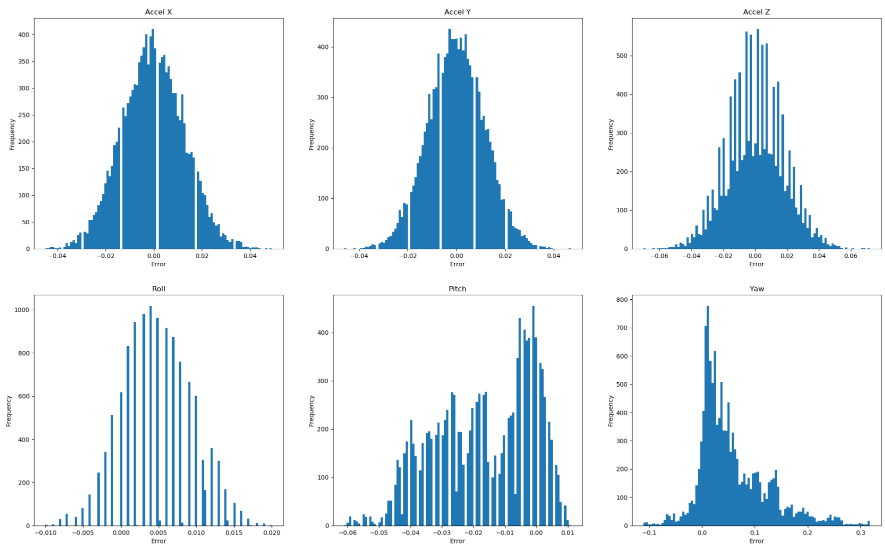
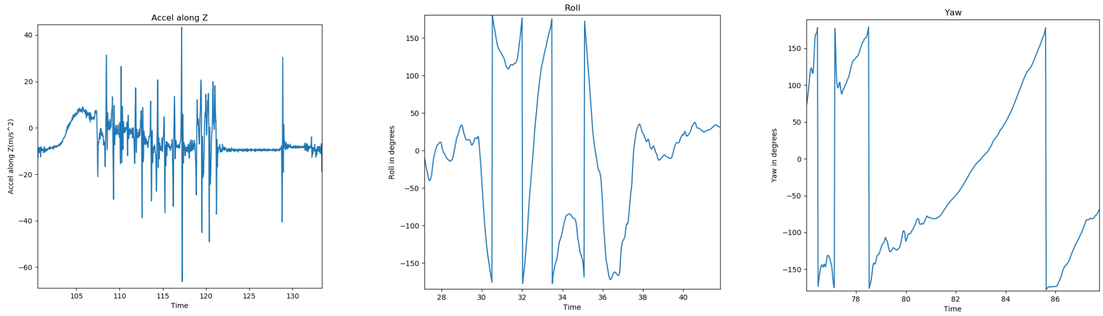


Figure 2: Histogram about the median

4.2 Moving data

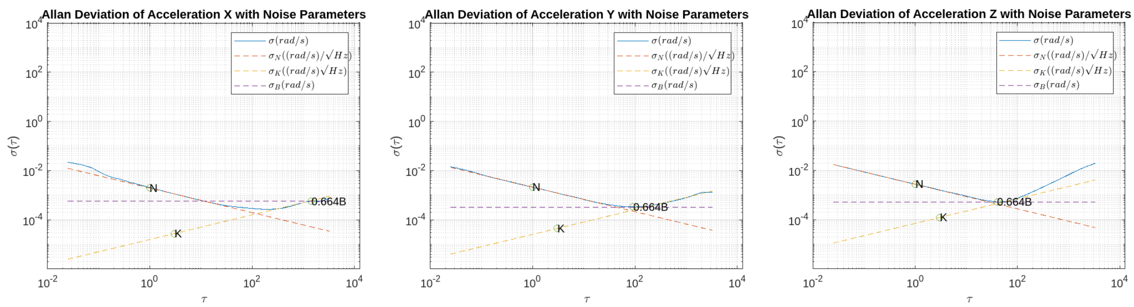


(a) Found at 1:45 (b) Found at 0:30 (c) Found at 1:26

Figure 3: Visualizing moving data set

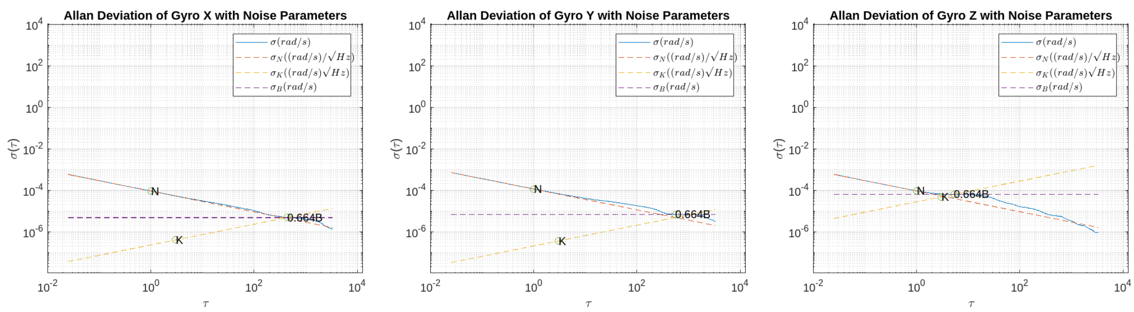
4.3 Data sets

4.3.1 Location A



(a) X - axis (b) Y - axis (c) Z - axis

Figure 4: Noise parameters along with Allan variance of accelerometer

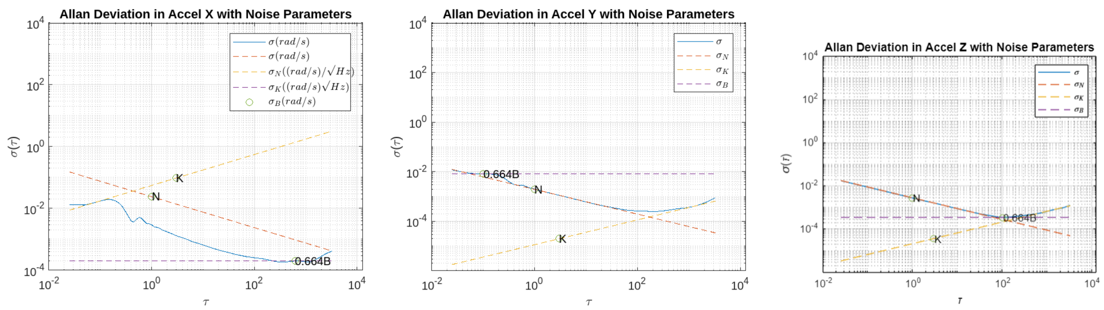


(a) X - axis (b) Y - axis (c) Z - axis

Figure 5: Noise parameters along with Allan variance of gyroscope

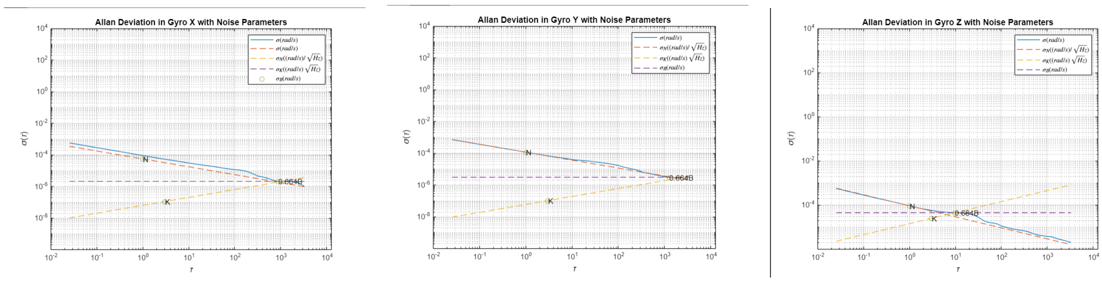
Parameters of Accelerometer:
Along X:
N = 0.0020; K = 2.7509e-05; B = 8.5466e-04
Along Y:
N = 0.0021; K = 4.4462e-05; B = 5.0139e-04
Along Z:
N = 0.0027; K = 1.2282e-04; B = 7.9223e-04
Parameters of Gyroscope:
About X:
N = 9.0084e-05; K = 3.9555e-07; B = 7.1553e-06
About Y:
N = 1.1251e-04; K = 3.5289e-07; B = 1.0239e-05
About Z:
N = 9.1164e-05; K = 4.7209e-05; B = 9.4461e-05

4.3.2 Location B



(a) X - axis (b) Y - axis (c) Z - axis

Figure 6: Noise parameters along with Allan variance of accelerometer

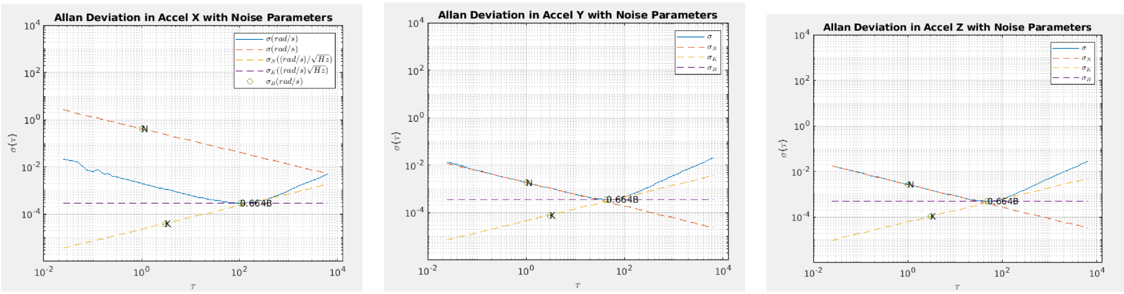


(a) X - axis (b) Y - axis (c) Z - axis

Figure 7: Noise parameters along with Allan variance of gyroscope

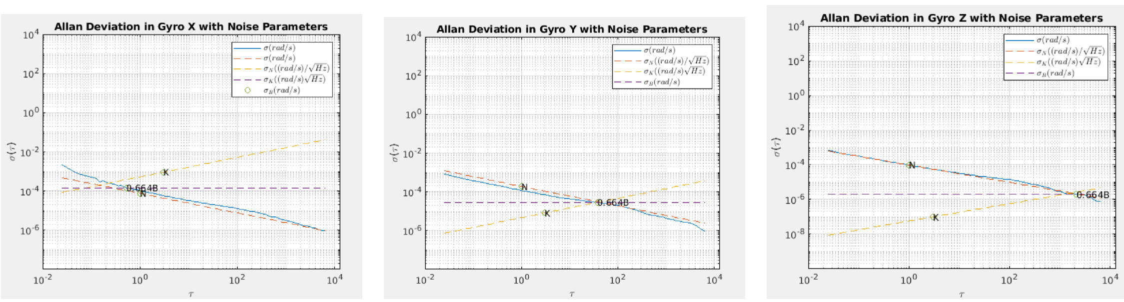
Parameters of Accelerometer:
Along X:
N = 0.0240; K = 0.0962; B = 3.0139e-04
Along Y:
N = 0.0019; K = 1.9716e-05; B = 0.0122
Along Z:
N = 0.0027 K = 3.5605e-05; B = 5.0781e-04
Parameters of Gyroscope:
About X:
N = 5.3858e-05; K = 1.0811e-07; B = 3.1026e-06
About Y:
N = 1.1353e-04; K = 1.0157e-07; B = 4.5021e-06
About Z:
N = 9.0601e-05; K = 2.4620e-05; B = 6.6385e-05

4.3.3 Location C



(a) X - axis (b) Y - axis (c) Z - axis

Figure 8: Noise parameters along with Allan variance of accelerometer

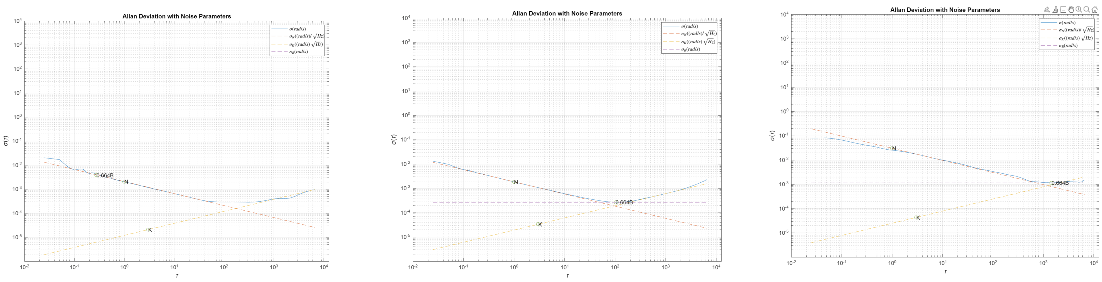


(a) X - axis (b) Y - axis (c) Z - axis

Figure 9: Noise parameters along with Allan variance of gyroscope

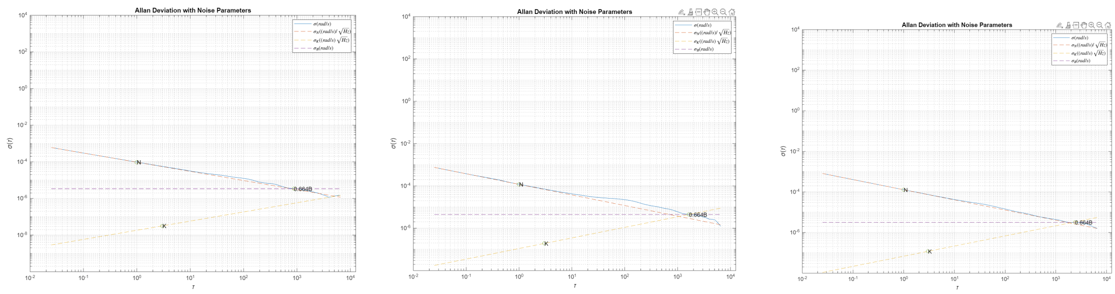
Parameters of Accelerometer:
Along X:
  N = 0.4162; K = 3.9045e-05; B = 4.3992e-04
Along Y:
  N = 0.0019; K = 7.6865e-05; B = 5.3425e-04
Along Z:
  N = 0.0027 K = 1.0507e-04; B = 7.5436e-04
Parameters of Gyroscope:
About X:
  N = 7.4822e-05; K = 9.0026e-04; B = 2.1290e-04
About Y:
  N = 1.9149e-04; K = 7.9209e-06; B = 4.2087e-05
About Z:
  N = 9.8138e-05; K = 9.7200e-08; B = 2.9252e-06

4.3.4 Location D



(a) X - axis (b) Y - axis (c) Z - axis

Figure 10: Noise parameters along with Allan variance of accelerometer



(a) X - axis (b) Y - axis (c) Z - axis

Figure 11: Noise parameters along with Allan variance of gyroscope

Parameters of Accelerometer:
Along X:
N = 0.0021; K = 2.0842e-05; B = 0.0058
Along Y:
N = 0.0019; K = 3.3554e-05; B = 4.0730e-04
Along Z:
N = 0.0309 K = 4.3375e-05; B = 0.0017
Parameters of Gyroscope:
About X:
N = 1.2796e-04; K = 1.1802e-07; B = 4.7675e-06
About Y:
N = 1.1811e-04; K = 1.9097e-07; B = 6.7183e-06
About Z:
N = 1.2796e-04; K = 1.1802e-07; B = 4.7675e-06

4.4 Conclusion

From the above analysis, the following conclusions can be drawn to answer the questions:

1. The stationary data distribution about its median resembles a Gaussian distribution
2. The data collected from the IMU was visualized using Rviz which was quite helpful to associate the video to the data collected
3. The measurements more or less reflects the specifications mentioned in the data-sheet
4. The lower performance may be caused to due incorrect calibration of the IMU. It could also stem from an increased sources of external noise in the testing area
5. Seeing as how the instability bias along both X and Y axis is the highest with Location C, it is likely to be the most unstable location, the 3^{rd} Floor of a wooden house. The location with 2^{nd} highest instability bias is Location D which can be guessed to be the 5^{th} Floor of ISEC. The value with the 3^{rd} highest instability bias is Location A, since it is much closer to the Ruggles green line, the Snell Library basement is likely to have an increased variance and can thus be matched with Location A. Location B, having the smallest value of instability bias is most likely to be the ISEC building's basement
6. Best results can be achieved with large data set and by eliminating any source of external noise
7. To best test the performance of an unknown sensor, a large data set spanning between 5 to 8 hours should be collected in a stable environment without any sources of external noise. The Allan variance of such a data set would best represent the performance of the unknown sensor.