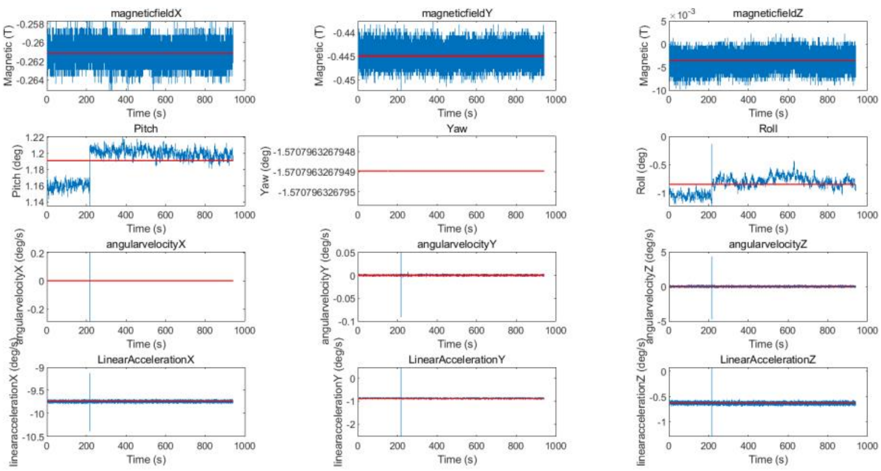
EECE5554 Lab 3 Report

In this lab, wo collected two separate data collections were needed to take statistics on the error of our VN-100 IMU device. The first data we set covers about 10 minutes and collected about 24,000 Ros messages. The second data set, my teammate placed sensor into his restroom bathtub for about 5 hours, and we finally get about 720,000 Ros message. The larger datasets were collected for long term drift done by computing the Allan Variance of the sensor data and the smaller dataset which help us to figure out the short-term errors of the sensors.

1. Stationary noise analysis

The table below shows an overview of the noise characteristics of each variable.

	MagX	MagY	MagZ	Pitch	Yaw	Roll
Mean	-0.261	-0.445	-0.00362	-1.57	1.20	-0.839
Standard Deviation	0.000973	0.00174	0.00161	0.00000931	0.0179	0.132
	GyroX	GyroY	GyroZ	LinearAccX	LinearAccY	LinearAccZ
Mean	0.0000127	-0.000000568	0.000155	-0.632	-0.884	-9.841
Standard Deviation	0.00197	0.00109	0.0765	0.0194	0.0173	0.0162



The standard deviation and mean of Gyro are quite small, the main problem is drifting and random noise, because we put the sensor on table and used tape to hold it firmly. The linear acceleration which has the highest standard deviation, the sensor is sensitive to mechanical noise (car engine running, people talking, etc.) in the environment would affect the result. The magnetometer error most caused by surrounded with metals and electronic devices, the magnetic field or merely the existence of these things can easily affect the magnetometer reading.

Besides, from the figure we can easily notice that the noise density of orientation (Pitch, yaw and roll) is much smaller than others, and the average value of pitch remain close to zero, indicating that the sensor is stable enough when measured data.

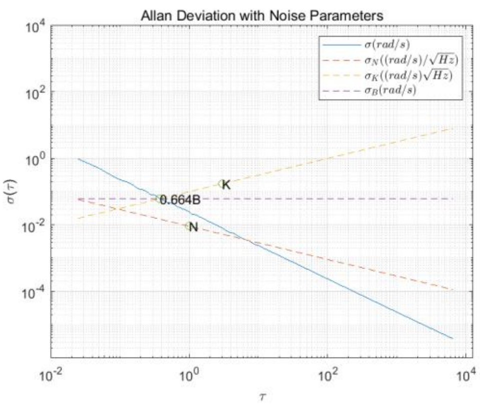
2. Allan Variance Data Analysis

Allan Variance is a method of analysis in a time domain. It describes variance of a signal as a function of averaging time. My teammate placed sensor into his restroom for about 5 hours, and we finally get about 720,000 Ros message.

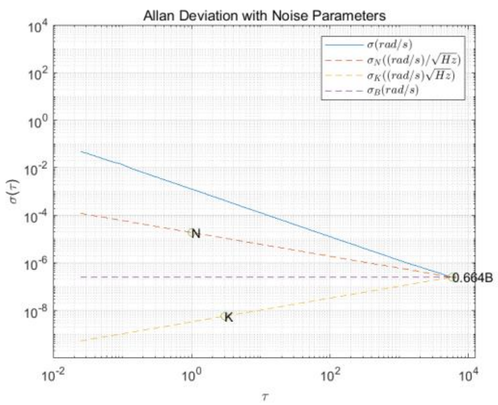
The angle random walk is characterized by the white noise spectrum of the gyroscope output where N represents the coefficient of that. The rate random walk is characterized by the red noise (Brownian noise) spectrum of the gyroscope output where K is rate random walk coefficient. And B means bias instability coefficient which characterized by the pink noise (flicker noise) spectrum of the output.

The table and figure below describe the Allan variance of different parameter of the IMU, Data were collected for the interval of 5 hours to achieve a reliable estimate of the bias instability. It is obvious that the level of ARW for Gyro X is much smaller than others which means the angular velocity X has the best performance in this test. On the other hand, the worst is Gyro Y which output contains bigger amount of high frequency noise. The noise demonstrated by this result is also known and solved by the manufacturer of the VN100, in datasheet they mentioned that VN-100 uses the accelerometer and magnetometer measurements to continuously estimate the gyro bias, such that the reported angular rates are compensated for this drift. And in the book *INERTIAL NAVIGATION PRIMER from VECOTRNAV* also have examples on noise calculation which shows different way to convert each of these different noise characteristics to standard deviation.

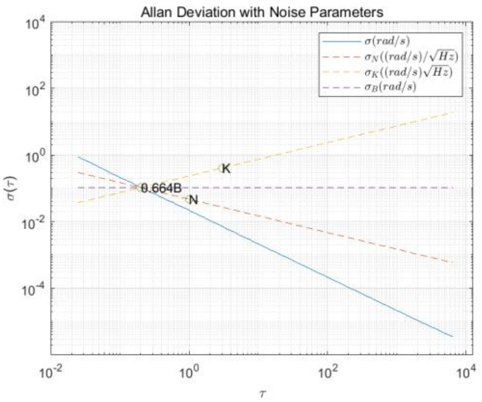
	GyroX	**GyroY**	**GyroZ**
N	6.39353596858234e-05	0.00292902124946164	0.0017011859232309
K	4.47567106703192e-07	0.0184480495291507	0.00785744120575168
B	6.11880385012893e-06	0.00840820677788028	0.0041819935103213
	Linear AccX	**Linear AccY**	**Linear AccZ**
N	0.000370139876038513	0.00199409566866428	0.000442003685257362
K	1.10037516899616e-07	3.37210155067569e-05	1.32507068678765e-07
B	7.26944236660857e-06	0.000296613020774598	8.75385528562293e-06



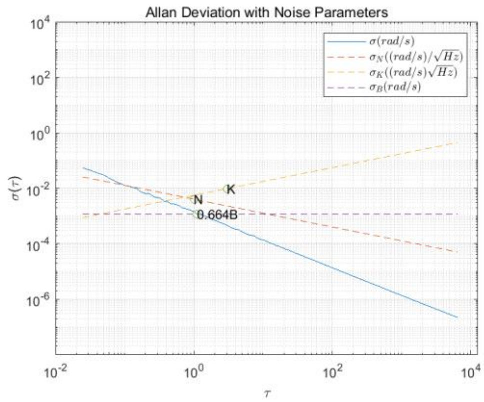
Angular Velocity X



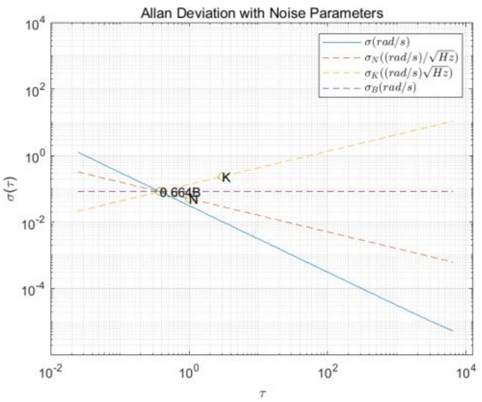
Linear Acceleration X



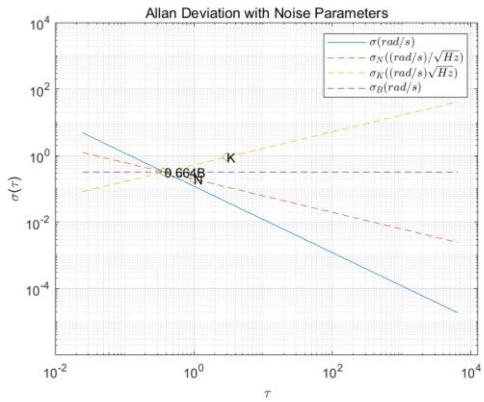
Angular Velocity Y



Linear Acceleration Y



Angular Velocity Z



Linear Acceleration Y