SYSEN 5411 Fall 2025

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Lab 7 Report – IMU and Signal Processing

Accelerometer measurements are taken in milli Gs because they are linear acceleration measurements (m/s2) taken in the x, y, and z Cartesian axes. By contrast, gyroscope measurements are taken in degrees/second because they are velocity measurements in angle, not acceleration measurements. Rotational acceleration would be measured in units like deg/s2. The combination of acceleration and velocity measurements allows for more precise computation of true position.

A comparison of gyroscope cumulative RMS error shows that errors grow much faster in the uncalibrated B1 run than the calibrated B2 run. Uncalibrated B1 run showed very large and steady linear divergence in the gyro, reading over 10 degrees in roll by the end of the run. After calibration, the B2 run showed some gyro drift (still larger in roll than pitch) but much tighter around zero. In comparison to the accelerometer pitch and roll data, the gyroscope showed much less jitter around zero – even though it drifted, it was much steadier. Comparing the cumulative RMS error of pitch and roll between the B1 and B2 gyro runs, the increased magnitude of error is validated in roll vs pitch. See B1B2figures Folder for plots.

See C1figures Folder for plots of the LPF values for the three alphas. As expected, increasing alpha values were much less noisy. Lag is hard to observe in the α=0.9 plot, but the α=0.1 plot shows very little variability between the raw data and the filtered data as the filtered data tracks very closely with little lag. The α=0.5 plot is smoother – some peaks are seen to lag briefly, while other peaks track closely.

See D1figures Folder for plots of the complementary filter results. I collected data at 200 Hz reusing code from the previous sections. At that refresh rate, I found that α=0.98 seems to be the best. It offers better noise attenuation compared to α=0.9, but α=0.995 took too long settle and was overdamped while showing some steady state error. The figure D1\_combined\_comp\_roll.PNG shows this relationship best. The α=0.98 curve is a good balance of noise attenuation and responsiveness lag.