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 because they are position measurements in angle, not acceleration measurements. Rotational acceleration would be measured in units like deg/s2.

A comparison of gyroscope cumulative RMS error shows that errors grow much faster in the uncalibrated B1 run than the calibrated B2 run. Both runs tracked relatively similarly through 10 seconds, but a perturbation around 10 seconds (perhaps my phone buzzing on my desk or accidentally bumping it with my keyboard) resulted in a noticeable deviation. Because the B1 run was uncalibrated, that error grew rapidly and took longer to settle, nor did it get close to the calibrated B2 RMS error level again in the pitch axis. In comparison to the accelerometer pitch and roll data, the gyroscope showed much less jitter around zero. These plots put the RMS error of the gyroscope into perspective – orders of magnitude better than the noisy accelerometers. 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 responsivity lag.