Assignment 3

Handin solutions to these problems within two weeks, using the Canvas system

1. Analysis of IMU performance

There are many different sources of accelerometer and gyro imperfections, in this problem we will focus on measurement noise modeled as a white noise. A consumer IMU can in data sheets give the following values on performance

$$\text{accelerometer: velocity random walk} = 0.1\frac{m}{s\sqrt{h}}$$
$$\text{gyro: angular random walk} = 0.1\frac{\text{deg}}{\sqrt{h}}$$

To understand the units used, you might want to have a look at equations (7)-(8) in [Woodman p.11] linked on the home page.

We will model the impact of gyro and accelerometer noise on IMU position estimation accuracy by these equations

$$dx = vdt$$
$$dv = g\phi dt + dw_1$$
$$d\phi = dw_2$$

where x is position error in meter, v velocity in meter/s and ϕ is gyro error in radians. The incremental variance of noise is $E(dw_1^2) = r_1\,dt$ and $E(dw_2^2) = r_2\,dt$.

a. Calculate r_1 and r_2 corresponding to the consumer IMU mentioned above. (Use units with meter, second, and radians.)

b. Calculate the position error variance ($E(x^2(t))$ as a function of time. Analyse the impact of each noise source w_1 and w_2 separately. What is the error variance after 1 second? After 100 seconds ?

2. Simulation of bandlimited white noise

Write simulation code that generates a voltage signal $v(t)$ sampled with sample rate h, i.e. at $t = 0, h, 2h, \ldots, T$. The signal should have a flat single-sided spectral density $= c$ Volt^2/Hz within the bandwidth f_B Hz. (You can choose yourself how to define 'bandwidth'). You can use a discrete time first order with random input

$$v(kh + h) = \gamma v(kh) + e_k$$

to generate the signal. Show results for $T = 1$, $h = 10^{-5}s$, $c = 10^{-9}$Volt^2/Hz and $f_B = 10^3$ Hz and verify that the result is correct.