EE 570: Project 2

Project 1 involved the development of a MATLAB program to generate consistent, synthetic "ground truth data." This data was then utilized to test our ECEF INS mechanization implementation assuming perfect sensors. In this project we will use our code from project 1. Now we will simulate an IMU and generate more realistic specific force and angular velocity measurements (i.e. sensors with errors) to then "drive" our mechanizations.

1 Ground Truth Generation

Exactly the same as before. Use a 100Hz update rate.

2 ECEF Frame Mechanization

Use a "high-fidelity" version of your ECEF mechanization.

3 IMU Implementation

Develop a function to perform the IMU implementation (code skeleton is provided as imu.m and an updated load_constants.m file). The IMU takes the error free version of the specific force $\vec{f}^{\,b}_{ib}$ and angular velocity $\vec{\omega}^{\,b}_{ib}$ as inputs and outputs measured versions of the same, namely,

$$\tilde{\vec{f}}^{\,b}_{ib} = \vec{f}^{\,b}_{ib} + \delta\vec{f}^{\,b}_{ib} = \vec{b}_a + (\mathcal{I} + M_a)\vec{f}^{\,b}_{ib} + \vec{w}_a$$

and

$$\tilde{\vec{\omega}}^{\,b}_{ib} = \vec{\omega}^{\,b}_{ib} + \delta\vec{\omega}^{\,b}_{ib} = \vec{b}_g + (\mathcal{I} + M_g)\vec{\omega}^{\,b}_{ib} + G_g\vec{f}^{\,b}_{ib} + \vec{w}_g$$

For this project we will consider a commertially available kvh 1750 IMU. For the questions below you will need to plot the errors between the ground truth PVA and the PVA derived from the output of your ECEF-frame INS mechanization, now using measurements provided by a simulated (imperfect) IMU.

1. Develop a simple expression for the position error due to an uncompensated fixed accelerometer bias ($b_{a,FB}$).
   (a) Use the accel "bias offset" from the datasheet for $b_{a,FB}$ (for all three accels) as your **only** IMU error source and compare (i.e., plot) the resulting ECEF position error with that of an "error free" IMU.
2. Develop a simple expression for the error due to an uncompensated fixed gyro bias ($b_{g,FB}$) on the derived orientation (i.e., integrate). Also, if the IMU is perfectly aligned with the NAV frame (i.e., level) what is the position error as a function of time due to the above orientation error?
   (a) Use the gyro "bias offset" from the datasheet for $b_{g,FB}$ (for all three gyros) as your only IMU error source and compare (i.e., plot) the resulting ECEF PVA error with that of an "error free" IMU.
3. Use the datasheet to obtain all of the relevant IMU error characteristics:

Gyroscope Bias stability ($b_{g,BS}$), bias instability ($b_{g,BI}$), assume that fixed bias has been calibrated and is zero ($b_{g,FB} = 0$), ARW ($\vec{w}_g$), scale factor stability (s_g). Also, assume that the gyro g-sensitivity (G_g) is 0.5°/hr/g and the misalignment terms (e.g., $m_{g,xy}$) are as given in the code skeleton (see `imu.m`).

Accelerometers Bias stability ($b_{a,BS}$), bias instability ($b_{a,BI}$), assume that fixed bias has been calibrated and is zero ($b_{a,FB} = 0$), VRW ($\vec{w}_a$), scale factor stability (s_a). Also, assume that the accel offset error is zero and that misalignment terms (e.g., $m_{a,xy}$) are as given in the code skeleton (see `imu.m`).

(a) Plot the error free IMU measurements vs the 1750 IMU derived measurements and difference between the two (you may want to use the `plot_IMU.m` function).

(b) Plot the ECEF PVA errors resulting from your IMU device and compare with the error free IMU case.