Assignment 3: Reading Sensor Data

For this assignment you will need a BeagleBone Black, a Robotics Cape, and you are to have completed the previous assignment “Hello BeagleBone.” Please create a single PDF document containing the answers to all questions in this assignment. Also include your source code on the last page. For this assignment you will submit a single PDF file to submissions@renaissance-press.com instead of just your source code.

You may work together with a partner and may even share a BeagleBone. However, all source code, answers, and figures must be your own. Copying is another’s work is a violation of the academic honesty policy.

Setup

SSH into your BeagleBone Black with Robotics Cape attached. Run the test_imu example from the command line to confirm the IMU is working. Then run the calibrate_gyro and calibrate_mag programs so you are calibrated for the remainder of this exercise. Read thoroughly the API documentation for the IMU here:

http://strawsondesign.com/#!manual-imu

Part 1 (5 pts)

Note the X, Y, and Z axis directions printed on the Robotics Cape which indicate the IMU’s coordinate system. Rotate the BeagleBone about each of these axis and observe the gyro measurements while running the test_imu program. Do these measurements adhere to the right-hand rule?

What are the units of the gyroscope and accelerometer readings displayed with the test_imu program? Now run test_imu with the “-r” command line option to print raw ADC readings. Referencing the API documentation, what are the available full scale ranges of the gyroscope and accelerometer. For the default full scale ranges used by test_imu, calculate the conversion rates from raw ADC to m/s^2 and degrees/s for the accelerometer and gyroscope respectively.

Part 2 (8 pts)

Use the project template from the RoboticsCape Github page to make a new project for this assignment. Rename it the template to my_read_sensors. Using the API documentation, write a simple program that uses the DMP mode to print the accelerometer data to the console at 10hz. You may use the test_imu and test_dmp example programs for reference, however all you need is described in the API documentation.

The math.h library in already included in useful_includes.h and contains the atan2 function documented here http://www.cplusplus.com/reference/cmath/atan2/. Modify your program to print an angle in radians of the BeagleBone relative to the direction of gravity about its X axis. It should read close to 0 radians when Y axis points straight up, and close to -pi/2 radians while sitting flat on a table with the Z axis pointing upwards. Your angle estimate may only use two accelerometer axis.

Since the gyroscope reads an angular rate, you can integrate the rate in rad/s to get an angle in radians relative to the starting angle. Use the Euler integration method to integrate the X-axis gyroscope to get a second angle estimate.

Once you are confident that the values are correct, set the IMU sample rate to 20hz. Use Matlab or any other software of your choosing to plot the two angle estimates as you move the BeagleBone through the motion listed below.

- Hold upright with the Y-axis pointing upwards
- Lean forwards pi/4 radians
- Lean backwards pi/4 radians
- Return to starting position

Part 3 (2 pts)

Describe the accuracies and inaccuracies in both estimates using the concept of the frequency domain.