Assignment 4: Complementary Filtering

For this assignment you will need a BeagleBone Black, a Robotics Cape, and must have completed the previous assignment “Reading Sensor Data.” Please create a single PDF document containing the answers to all questions and requested plots 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

Make a copy of the program you wrote in the previous assignment “Reading Sensor Data” and rename it to complementary_filter. Then read the RoboticsCape API documentation for discrete filters and ring buffers here:

http://strawsondesign.com/#!manual-discrete-siso

http://strawsondesign.com/#!manual-ring-buffer

Question 1 (5 pts)

Now you will combine the accelerometer and gyroscope derived angle estimates to make one which has the best qualities of both. In Matlab, design two first order continuous-time filters, one high pass and one low pass. Choose a rise time for your two filters and justify your choice. Make sure that the sum of the two transfer functions is 1. Plot the two filters and their sum on a single bode plot. Make sure to include a legend that clearly identifies what curve is.

Question 2 (5 pts)

Modify your existing sensor reading program to use 100hz for a smoother angle estimate. Use the discrete filter API to create a low and high pass filter with the same rise time as you used in question 1. Run the accelerometer angle estimate through the low pass filter and the gyroscope angle estimate through the high pass filter. Plot these two filtered values and their sum as you tilt the BeagleBone through the same motion you used in the last assignment.

Question 3 (2 pts)

Now experiment with the rise time until you find a value you are satisfied with. What is the new rise time you prefer and justify why it is better.

Question 4 (8 pts)

Modify your matlab code to have continuous time filters with the new preferred rise time. Use Tustin's approximation to generate discrete-time filter constants for a sample rate of 100hz. Now implement these discrete filters WITHOUT using the discrete filter API. When it performs the same as the discrete filter library results, plot again the filtered accelerometer angle, filtered gyroscope angle, and the sum through the same tilting sequence.

Bonus (3 pts)

Use the ring buffer API to implement your discrete filter. Explain why this is beneficial, particularly for higher order filters.