Digital Filter Design

1. **Application of digital filters on simulated signals:**
    a. Write Matlab code to simulate a signal that contains two sinusoidal signals of frequencies 30 and 60 Hz sampled at a sampling frequency of 500 Sa/s and sampling duration of 1 s.
    b. Design and apply two different FIR digital filter to obtain only the signal of frequency 30 Hz and compare them.
    c. Design and apply two different IIR digital filter to obtain only the signal of frequency 30 Hz and compare them.
    d. Design and apply two different FIR digital filter to obtain only the signal of frequency 60 Hz and compare them.
    e. Design and apply two different IIR digital filter to obtain only the signal of frequency 60 Hz and compare them.

[Hint: different filters can be low-pass, highpass, bandpass, band-reject filters]

2. **Application of digital filters on real biosignals:**

In ECG, different noise sources can interfere with obtained signals in practice. The three main noise sources are baseline wander (in record 'bw'), muscle (EMG) artifact (in record 'ma'), and electrode motion artifact (in record 'em'). Electrode motion artifact is generally considered the most troublesome, since it can mimic the appearance of ectopic beats and also cannot be removed easily by simple filters, as can noise of other types. An active area of research in ECG is related to the design of filters that can improve the ECG recordings by removing such noise while keeping the ECG information intact. In this part of the project, you will design digital filters that address one of these artifacts.

Consider the ECG data in the variables “s118bw12”, “s118em12”, or “s118ma12” stored in the matlab data file “ECGdata.mat”. The ECG samples in these variables represent samples from 2 channels of patient s118 from MIT-BIH Arrhythmia Database [1] and each was obtained using a sampling rate of 360 Sa/s. You should consider one of these signals to be your target for noise removal

    a. Design and apply an optimized FIR digital filter to remove the artifact in one of the above signals. Show the magnitude response, phase response, and group delay for the filter you designed and signals before and after its application.
    b. Design and apply an optimized IIR digital filter to remove the artifact in one of the above signals. Show the magnitude response, phase response, and group delay for the filter you designed and signals before and after its application.
    c. Compare FIR and IIR filters and justify which is better in your opinion.

References

[1] MIT-BIH Arrhythmia Database: http://www.physionet.org/physiobank/database/mitdb/