Labs Part II

Infinite Impulse Response Filters Design

Where FIR digital filters are *finite* by definition, analogue filter know no such limitations. Infinite Impulse Response (IIR) filters try to mimic their behaviour by having a feedback loop in the convolution product of their digital implementation.
Whilst there is are dedicated `fir1` and `fir2` MATLABfunctions to design FIR filters, IIR filters have no equivalent. Instead there are individual functions for each filter type that come either in digital or simulated analogue flavours[1]. Said flavours are as follows:

- Bessel (analogue only): `bessel`
- Butterworth: `butter`
- Chebyshev Type I: `cheby1`
- Chebyshev Type II: `cheby2`
- Elliptic: `ellip`

Explore the documentations as to get a grip on how to design basic IIR filters.

From FIR to IIR

Re-take your FIR filters you have designed to clean up the audio in the previous part. Re-implement them using IIR filters and analyse the gain in filter order for similar performance.

Analogue vs FIR vs IIR

Consider a regular low-pass analogue fourth order filter with a cut-off frequency $\mathrm{f_c}$. Design an FIR filter that can reach the same attenuation as the Butterworth filter at $\mathrm{f} = 10 \cdot \mathrm{f_c}$, and no more than 3dB ripple in the bandpass. Also design an IIR filter with the same specifications. Do so for **Butterworth** and **Chebyshev** filters.
Once it's done, compare the performance of the three filters on the following criteria:

- Frequency response.
- Attenuation at $10 \cdot \mathrm{f_c}$.
- Ripple in the bandpass.

[1] To switch to an analogue filter, append `'s'` at the end of the function parameters.

- Ripple in the stopband.
- Filter order required[2].

Assignment

The assignment consist of:

1. Your filter from the previous part in IIR form.
2. The comparison between analogue, FIR and IIR filters as described in the previous section.

You should upload your code and a maximum 3 pages report to Claco by the due date indicated on the platform.
Evaluation criteria:

- The report is clear and well written. (2 points)
- The new IIR filter has similar performance compared to the old FIR filter and the analysis is sound. (3 points)
- The two times (Butterworth and Chebyshev) three filters (analogue, FIr and IIR) where successfully implemented. (3 points)
- A interesting analysis is derived from the comparison of the filters. (2 points)
- The report is in English. (1 bonus point)

Resource

- Filter design functions for MATLAB
- Octave signal processing functions

[2]Only the analogue filter needs to be a 4^{th} order. The digital FIR and IIR filters might be different.