Zewail City of Science and Technology

CIE-442

Project Part 2
FIR Filter Design Tool

1.1 Objectives

- Understand and implement the windowing, least squares (LS), and weighted LS methods for designing an FIR filter.
- Design practical digital filters using the windowing and LS methods based on standard requirements of a specific system, e.g., a communication system.
- Iterate the digital filter design procedure until the performance and complexity constraints are met.
- Develop an interactive GUI of a digital filter design toolbox

1.2 Introduction

The filter design part of the project will help you in understanding the design procedure of digital filters and how they affect signals. After you develop the filter design tool, you will use it to solve a practical problem of your choice in accordance with a specific standard requirement. Starting from the specifications of the digital filter and complexity constraints (in terms of the number of filter taps), you will design a digital FIR filter that solves your problem using the tool that you developed.

1.3 Project statement

It is first required to implement a filter design GUI tool. You will be required to implement the following FIR digital filter design methods in your tool:

1- **Windowed sinc method:**
   - You should give the user the option to enter the length of the filter impulse response.
   - Four different windows should be used which are the rectangular, Blackman, Chebyshev and Kaiser windows.
   - In Chebyshev window, try different values for γ, compare the results and indicate the effect.
   - In Kaiser window, try different values for β, compare the results and indicate the effect.
   - You should plot the magnitude spectrum of the designed filter and give the user the option to show the magnitude response in both linear and log scale.

2- **Least squares (LS) and weighted LS (WLS) methods:**
   - You should give the user the option to enter the length of the filter impulse response, as well as the number of points in the desired frequency response.
   - In the WLS method, the user should specify the weights of the passband, transition, and stopband frequencies.
   - You should plot the magnitude spectrum of the designed filter and give the user the option to show the magnitude response in both linear and log scale.

After implementing the filter design tool, you should use it to perform the following tasks:

1- First, define the digital filtering problem that you want to perform in accordance to a specific standard requirement, e.g., a channel selection filter in a communications receiver. You should search for a real problem to be solved in this step.
2- Determine the specifications of the digital filter to be designed based on the problem definition in part 1. The specifications should include at least the following: passband ripples, stopband attenuation, transition region width, and number of filter taps.
3- Start by designing an initial prototype filter using one of the different methods you implemented in the filter design tool under the complexity and specifications constraints defined in part 2.
4- Iterate your design by changing the filter design method and/or parameters until the specifications in part 2 are met.
5- The outcome of this design process should be the designed FIR filter coefficients, the filter frequency response, and a justification of this particular filter based on your iterative design process.

1.4 Requirements

- Implement the filter design tool including all the above tasks. Include all the MATLAB files in your online submission.
- Define a real digital filtering problem in accordance with a specific standard as explained above.
- Starting from the specifications, design an FIR filter using the filter design tool that you developed. Your design should be iterative. Start from a certain design, then iterate using different methods (windowing or LS, while trying different windows, filter lengths, weights, etc.) until you reach the desired performance/complexity defined in the specifications.
- Write a report that includes your code and documentation within your report. The report should also include a documentation of the iterative design process that you performed.

1.5 Important notes

- The code should be readable and all the variable names are meaningful.
- The code should be commented to explain the functionality of your code.
- The report should be formatted in an organized way.
- The pages should be numbered.
- The quality of your report will be assessed.
- Documentation should be clear in accordance with the above description.