In the Name of God

University of Tehran

School of Electrical and
Computer Engineering

Digital Signal Processing

Final Project

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Abstract

Goal of the computer assignment is to get familiar with additive watermarking. We will hide a signal inside an audio file which listener cannot recognize there is something within the file.

Question One

As N increases, main vector divides into bigger frames and as size of frames increases number of frames decreases. We know that in each frame one bit is hidden so decreasing number of frames means decreasing amount of information that we can hide.

Question Two

If we compare PN_w with $(-1)^n = e^{j\pi n}$, it can be guessed that it has high frequency components and it is changing a lot, but if we want to proof it mathematically:

Firstly we calculate autocorrelation of signal:

$$R\,[n+m,n] = E\{key[n+m]key[n]\} \rightarrow E\{n\} = 0 \rightarrow R[n+m,n] = \delta[m]$$
$$S_{key} = Fourier\,\{\,R[m]\,\} \rightarrow S_{key} = 1$$

This signal has all of frequency componenet, but our signal which is a voice signal has value in lower frequency (<3khz) since this additive signal has lower value versus main signal, it effects higher frequencies.

Question Three

Watermarked audio has been saved in name of "watermark.wov" and it has been attached with code.

Question Four

After running "main.m" and giving reasonable arguments to embedding and extrancting function we can extract student number easily.

Question Five

We know that increasing α and N will cause more stability to our system, and we can reconstruct hidden information easier so we need to increase N as much as it is possible, for finding maximum N we first have to count number of audio samples, from audio read function it is observable that length of samples is 2×669935[1] $= 1339870$.

[1] We have to channels of music and both of them has been for watermarking

We need 36 frames in order to hide 36 bits in each frame, for maximum stability, maximum N is required, so N is $\frac{1339870}{36} = 37{,}219$. It is obvious that bigger N is not acceptable since length of frames times number of bits will be bigger than original signal.

α in other hand cannot increase without consideration, increasing α will cause distortion in our signal which is not favorable. Finding minimum value of α is desirable since higher value of alpha will be acceptable either.

With my algorithm $\alpha = 0.004$ is value which we can rely on, lower value stability is not guaranteed (N is given its maximum value).

Question 6

As we can see by increasing α, MSE increases either. MSE can be indicator of distortion in signal; higher MSE more distortion.

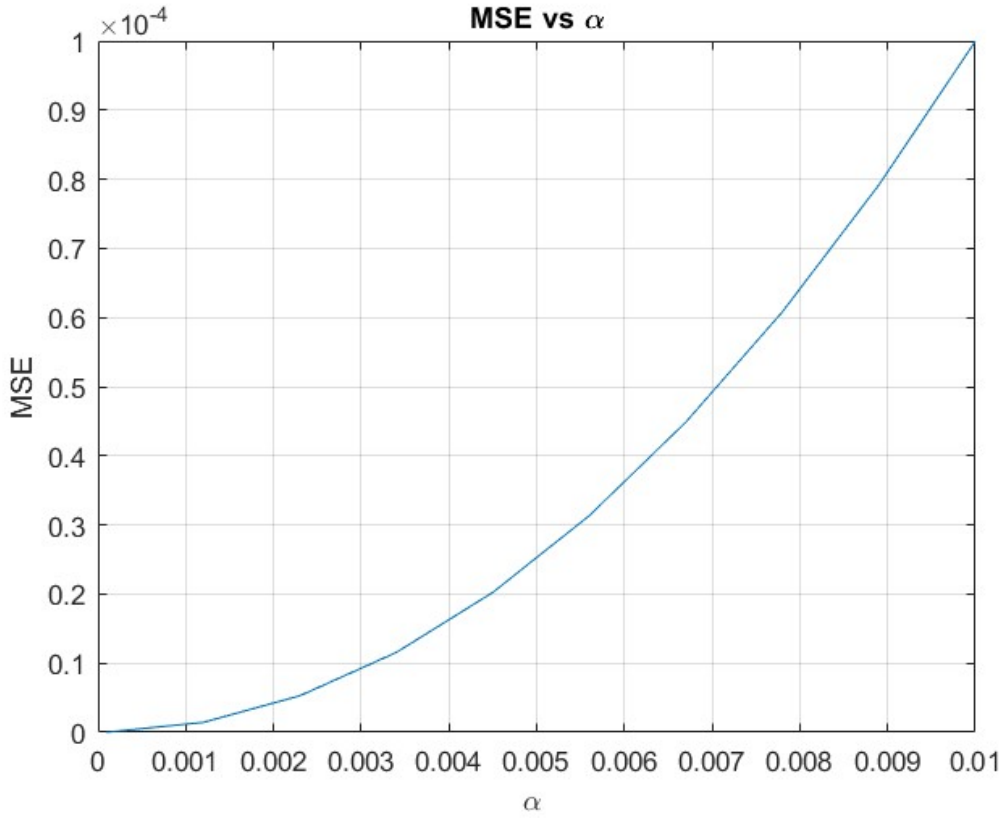

Figure 1

Question 7:

Same as previous part increasing N will lead to increasing MSE.

Since N indicate size of frames, bigger frames cover more samples so error increases. For i.e., if N be 15000, we have 15000×36 samples and if N be 20000, we have 36×20000 samples respectively in first one 540000 audio sample will be watermarked and in second one 720000 audio samples will be watermarked so in second one additive part is much more.

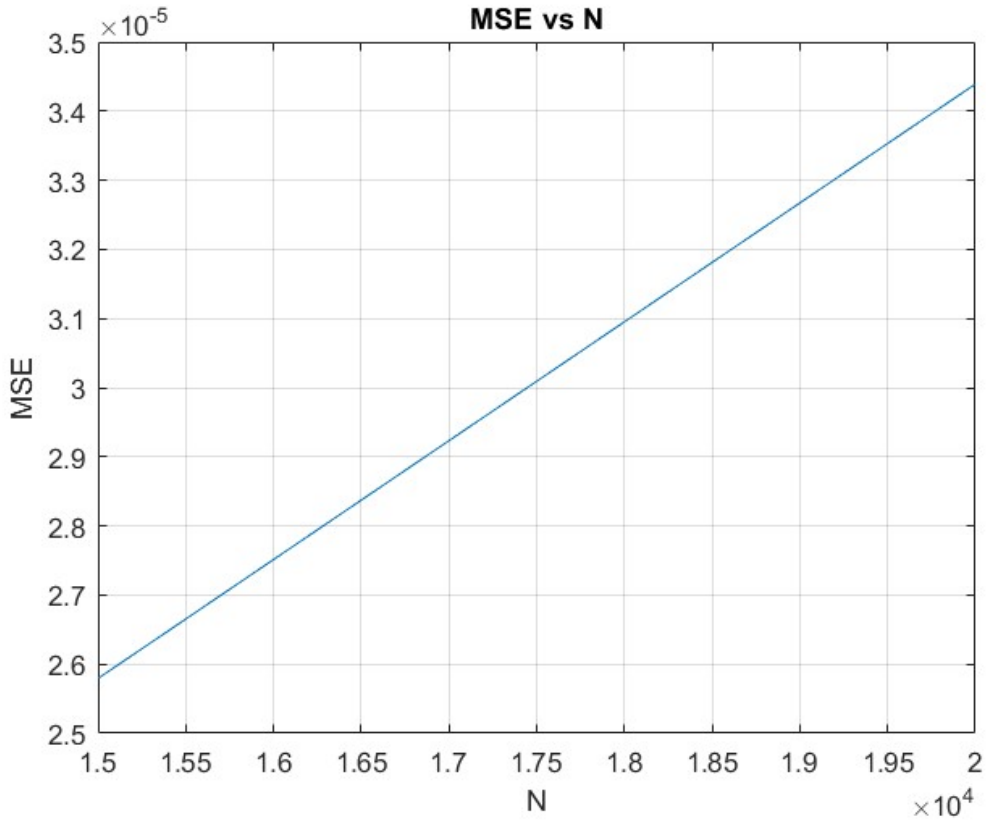

Figure 2

Question 8

From FilterDesigner tool five FIR Kaiser filter has been designed, filtering increases quality of sound but it make watermarking system unstable, since our information has high frequency components, a low pass filter corrupts our hidden data.

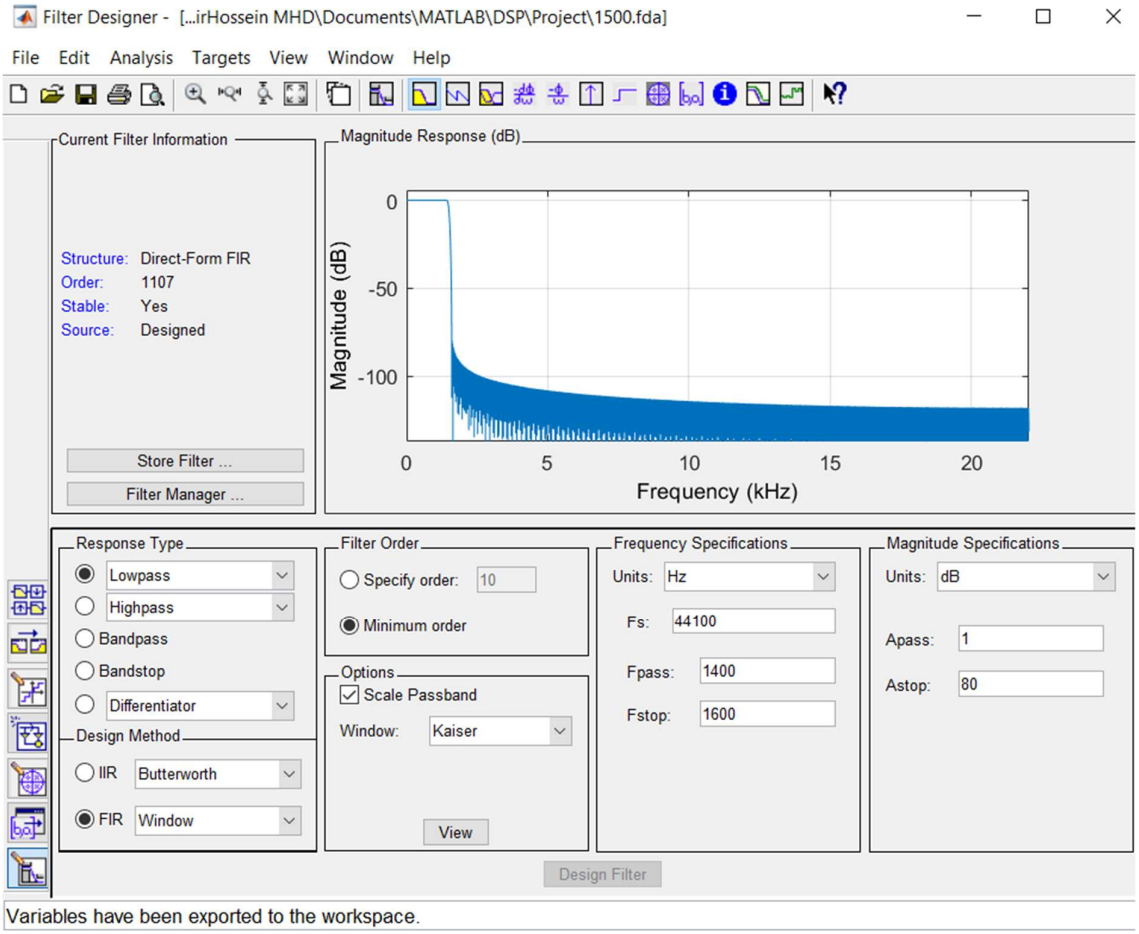

Figure 3, Example of FIR filter

Appendix

Two main function embedding and extrancting has been written as requested, in order to run files up to fifth section open main.m for two next section, there are two separate files. And for last part .fda files should be opened and exported to workspace as an object. Last part is at bottom of main.m file.