HACETTEPE UNIVERSITY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

ELE 409: DIGITAL SIGNAL PROCESSING LABORATORY

EXPERIMENT 6 - DISCRETE-TIME FILTERING

I. PURPOSE

The main purpose of this experiment is to study filtering (linear convolution) using DFT and circular convolution. Another purpose of this experiment is to study overlap-add and overlap-save algorithms which are used in filtering.

- Learn how to implement filtering with DFT and circular convolution
- Learn how to filter a long signal with a limited filter buffer length.
- Frequency range should be $[-1, 1]$ in your frequency domain figures.

II. PRELIMINARY WORK

Design a 50th order FIR low-pass filter using Hamming window with cut-off frequency $f = 0.2\pi$ (you can use fir1.m). Throughout this experiment use the FIR filter above. Call this filter $\mathbf{h}1[n]$.

1. Write a MATLAB function y=dftfilt(x,h,N), that filters the signal $\mathbf{x}[n]$ with filter $\mathbf{h}[n]$ using N point DFT.
2. Write a MATLAB function y=convfilt(x,h,N), that filters the signal $\mathbf{x}[n]$ with filter $\mathbf{h}[n]$ using N point circular convolution.
3. Generate the signal,

$$\mathbf{x}_1[n] = \cos(0.1\pi n) + \cos(0.3\pi n) + \cos(0.5\pi n) + \cos(0.7\pi n) + \cos(0.9\pi n),\ n = 0, \ldots, 255$$

4. (a) Filter $\mathbf{x}1[n]$ using Matlab built-in *conv* function with $\mathbf{h}1[n]$. Name the filtered output $\mathbf{y}[n]$.
   (b) Filter $\mathbf{x}1[n]$ using 'dftfilt' where $h = \mathbf{h}1[n]$ and $N = 256$. Name the output of the filter as $\mathbf{y}1[n]$.
   (c) Filter $\mathbf{x}1[n]$ using 'convfilt' where $h = \mathbf{h}1[n]$ and $N = 256$. Name the output of the filter as $\mathbf{y}2[n]$.
   (d) Filter $\mathbf{x}1[n]$ using 'dftfilt' where $h = \mathbf{h}1[n]$ and $N = 512$. Name the output of the filter as $\mathbf{y}3[n]$.
   (e) Filter $\mathbf{x}1[n]$ using 'convfilt' where $h = \mathbf{h}1[n]$ and $N = 512$. Name the output of the filter as $\mathbf{y}4[n]$.
5. Compare $\mathbf{y}[n]$, $\mathbf{y}1[n]$, $\mathbf{y}2[n]$, $\mathbf{y}3[n]$ and $\mathbf{y}4[n]$ in terms of time waveform and magnitude spectra. Which are the same? Which are the true filtered outputs? Explain results clearly.
6. Load the signal 'sound.wav'. Filter this signal using function 'dftfilt' which you have written in part 1. Select an appropriate DFT length N for proper filtering.
7. Filter 'sound.wav' using overlap save method with circular convolution. You may write a MATLAB function y=convsave(x,h,L) to perform filtering. Where L is the signal length to use in each step. Choose an appropriate L.
8. Filter 'sound.wav' using overlap save method with DFT. You may write a MATLAB function y=dftsave(x,h,L) to perform filtering. Where L is the signal length to use in each step. Choose an appropriate L. And choose an appropriate DFT length N depending on your choice of L.
9. Compare the methods you used in parts 6, 7 and 8 in terms of complexity and operational load.
10. Repeat parts 7, 8 and 9 using overlap add method.