The American University in Cairo
Computer Science and Engineering Department
Fall 2022

THE AMERICAN UNIVERSITY IN CAIRO

CSCE 363/3611 – Digital Signal Processing

Assignment #3

(Due on: November 22, 2022 at mid-night)

(The assignment is individual – Submit on Blackboard as one .zip file)

Problem 1

Sketch the spectrum of the following periodic signals:

a) $x(n)=3\sin\left(\frac{2\pi}{5}n\right)$

b) $x(n)=3\sin\left(\frac{4\pi}{5}n\right)+\cos\left(\frac{2\pi}{3}n\right)$

c) $x(n)=\{\ldots,1,0,1,0,1,0,\ldots\}$, with the arrow ($\uparrow$) at the sample $n=0$

Problem 2

Find the Fourier Transform of the following signals:

a) $x(n)=\{0,1,5,6\}$, with the arrow ($\uparrow$) at the sample $n=1$

b) $x(n)=4^{-n}u(n-5)$

c) $x(n)=\begin{cases}\frac{1}{2}\sin\left(\frac{2\pi}{5}n\right), & 0\le n\le 6\\ 0, & \textit{Otherwise}\end{cases}$

Problem 3

Using MATLAB or Python, if the Fourier Transform is complex, plot the magnitude and phase of the Fourier Transform of the signals given in Problem 2. If the Fourier Transform is real, plot the Fourier Transform. In this problem, you do not need to use the Fourier Transform function. You are supposed to plot the expression you get in Problem 2.

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Problem 4

Implement the following functions using MATLAB or Python:

- ApplyDFT: A function that takes as input the file name of an input audio file, the length N of DFT, the length M of Inverse DFT, and the file name of the output audio file. This function should compute the *N*-point DFT of the input audio and then the M-point Inverse DFT of the obtained DFT. If the output of the Inverse DFT is complex, replace it with its magnitude.
- DropFrequencyRange: A function that takes as input the file name of an input audio file, the length N of DFT, the range of frequencies to drop (given as samples of the output DFT), and the file name of the output filtered audio file. This function should compute the *N*-point DFT of the input audio, replace the coefficients of the dropped frequencies by 0, then compute the N-point Inverse DFT and save the output file. The function can use the function above ApplyDFT.

Deliverables:

i- Your code (either MATLAB .m files or Python .py or Jupyter notebook files).

ii- Apply the function ApplyDFT to the audio file provided "Audio.wav" (N = 441000, M = 441000), (N = 220500, M = 220500), (N = 441000, M = 220500), and (N = 220500, M = 441000). Name the output audio files "Inverse_X_Y.wav", where X = N and Y = M.

iii- For each case in (ii), plot the original signal and the signal obtained after applying the Inverse DFT on the same plot. Name the output images as "Inverse_X_Y.jpg", where X = N and Y = M.

iv- Based on the outcomes in (ii) and (iii), comment on the output when $M = N$ and less than the length of the original signal, when $M < N$, and when $M > N$.

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v- Apply the function DropFrequencyRange to the audio file provided "Audio.wav" with $N = 441000$ and the following range of frequencies given as samples of the DFT as follows (1000, 30000), (100, 30000), and (30000, 40000). Name the output audio files "Drop_1000_30000.wav", "Drop_100_30000.wav", and "Drop_30000_40000.wav", respectively.

vi- For each case in (v), plot the original signal and the signal obtained after applying the function on the same plot. Name the output images as "Drop_1000_30000.jpg", "Drop_100_30000.jpg", and "Drop_30000_40000.jpg".

vii- Based on the outcomes in (v) and (vi), comment on the output based on the change in the range.

Important Notes:

- All deliverables should be included in one .zip file.
- For Problems 1 and 2, a scanned version of handwritten solutions is acceptable.
- For Problem 3, include the plots in a report.
- For Problem 4, you can use the DFT, Inverse DFT and any necessary functions available in MATLAB or Python.
- Include the plots of Problem 4 in the report along with the comments required in parts (iv) and (vii).
- This is an individual assignment.