Experiment : 1

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1 Introduction

This lab experiment covers some basic practicality of Digital Signal Processing such as signal generation, various tone generation, convolution of signals and amplitude modulation. Along with Python, I have used libraries such as numpy, pandas, scipy etc. The code to my entire work in this lab experiment is here. And the input files and my output files can be viewed here. The GitHub repo link to my entire work regarding experiment 1 can be found here.

Please Note : I have used $\alpha = 3$ because my registration number is 191910.

Question 1 - Generating Signals

- The question asks to create a user defined function that exponentially decaying with α as it's time constant
- This has to be visualised by plotting 3 different variations i.e $x(t)$, $x(t - 1.5\alpha)$ and $x(2t)$ for t $\in$ [0,10]
- Also the magnitude and phase spectrum of $x(t)$ have to be plotted

Question 2 - Generating Tones

- The question asks to create two different sinusoids of 200α Hz and 220α Hz i.e 600 Hz and 640 Hz
- This has to be visualised by plotting using **plot** function as well as **stem**

Question 3 - Convolution

- In this question, we have to load the datastream from the corresponding .wav file and also from the corresponding .txt file and then convolute these two datastreams using different modes
- These differently convoluted signals have to be stored as .wav files and an observation to be made.

Question 4 - Amplitude Modulation

- We are expected to multiply two signals,in a specific way using the function given in the question. And one of the two signals isto be imported from a **wav** file.
- We should then compute the Fourier Transform and draw our observations

2 Algorithms / Methods

Question 1 - Generating Signals

- X(Ω) $= \frac{1}{(\alpha^2+j\Omega)} = \frac{1}{(3^2+j\Omega)} = \frac{1}{(9+j\Omega)}$
- Maginitude Spectrum $= |X(\Omega)| = \frac{1}{\sqrt{\alpha^2+\Omega^2}} = \frac{1}{\sqrt{3^2+\Omega^2}} = \frac{1}{\sqrt{9+\Omega^2}}$
- Phase Spectrum $= \arctan\frac{\Omega}{\alpha} = \arctan\frac{\Omega}{3}$
- $Fourier\ Transform\ of\ x(t-4.5) <=> Y(\Omega) = e^{-4.5j\Omega}X(\Omega)$
- $Fourier\ Transform\ of\ x(2t) <=> Z(\Omega) = \frac{X(\frac{\Omega}{2})}{2}$

Question 2 - Generating Tones

- I created 5000 samples from t $\in$ [0,5] for the sinusoids of 600 Hz and 660 Hz.
- Then I have appended both the sinusoids using the append() function available in numpy. Later I plotted the first 100 samples using plot function and stem function.

Question 3 - Convolution

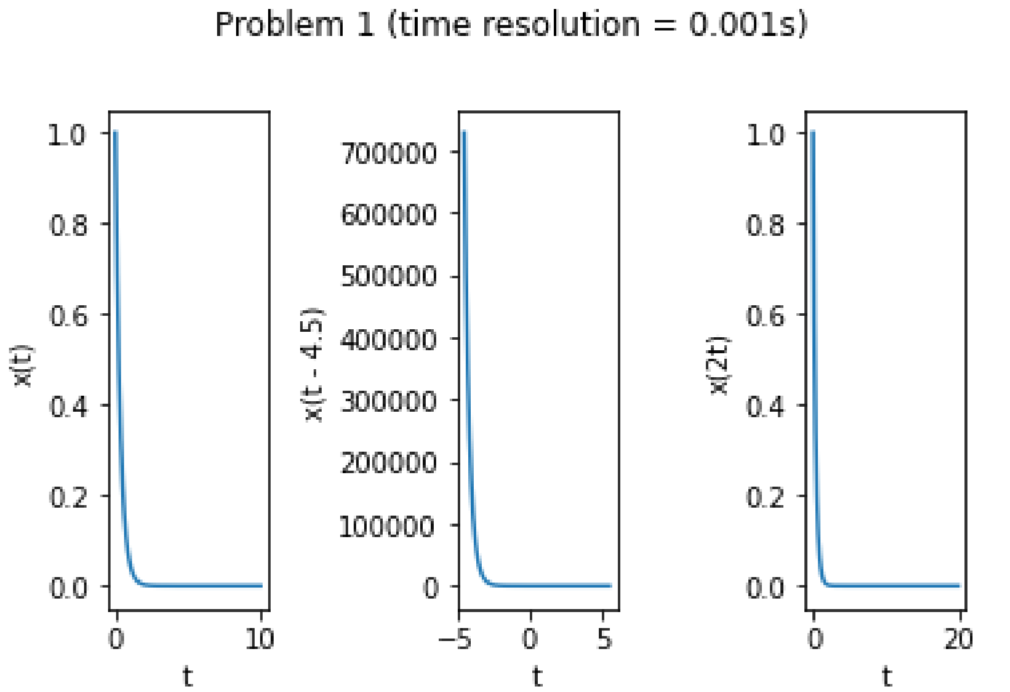
- I read the .wav file and then the text file had to be type casted to float32.
- Then I convoluted the two datastreams using numpy's convolve function. This was done in 3 modes i.e same, valid, full (for more on these modes, please refer here)
- These three convoluted outputs were then stored in 3 different output files which can be accessed refer here)

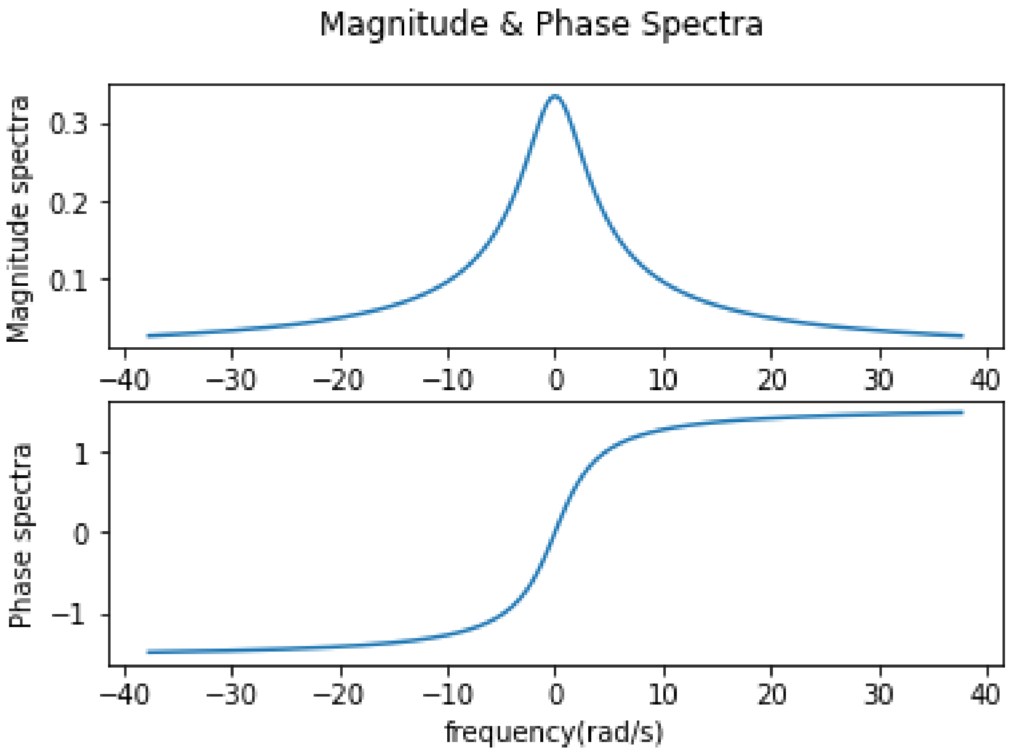
Question 4 - Amplitude Modulation

- The Fourier transform of x(t)cos(2π f_0 t) is 0.5(X(Ω + f_0) + X(Ω - f_0))

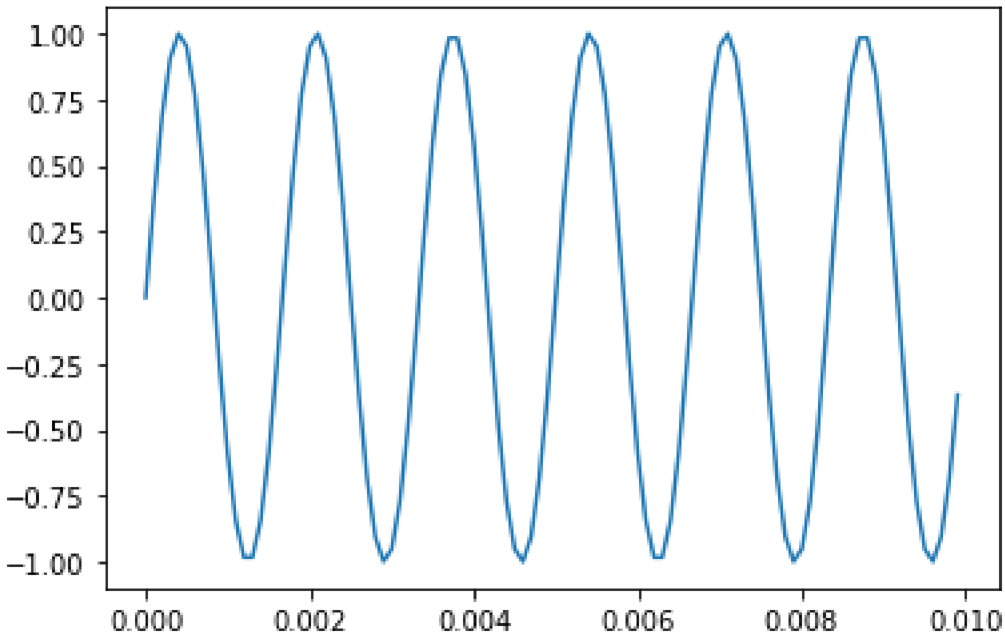
3 Results

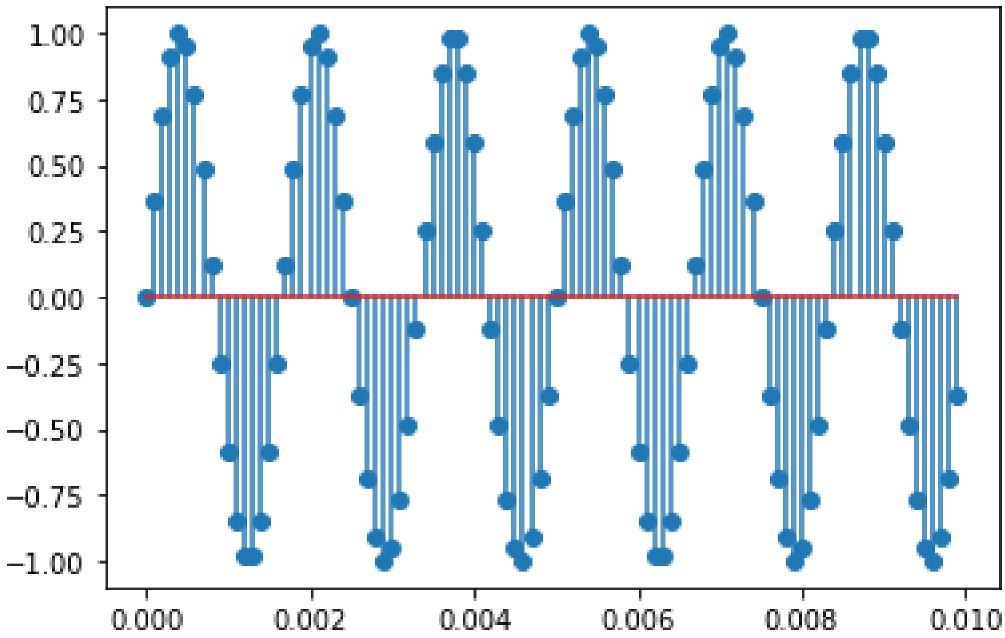
Question 1 - Generating Signals





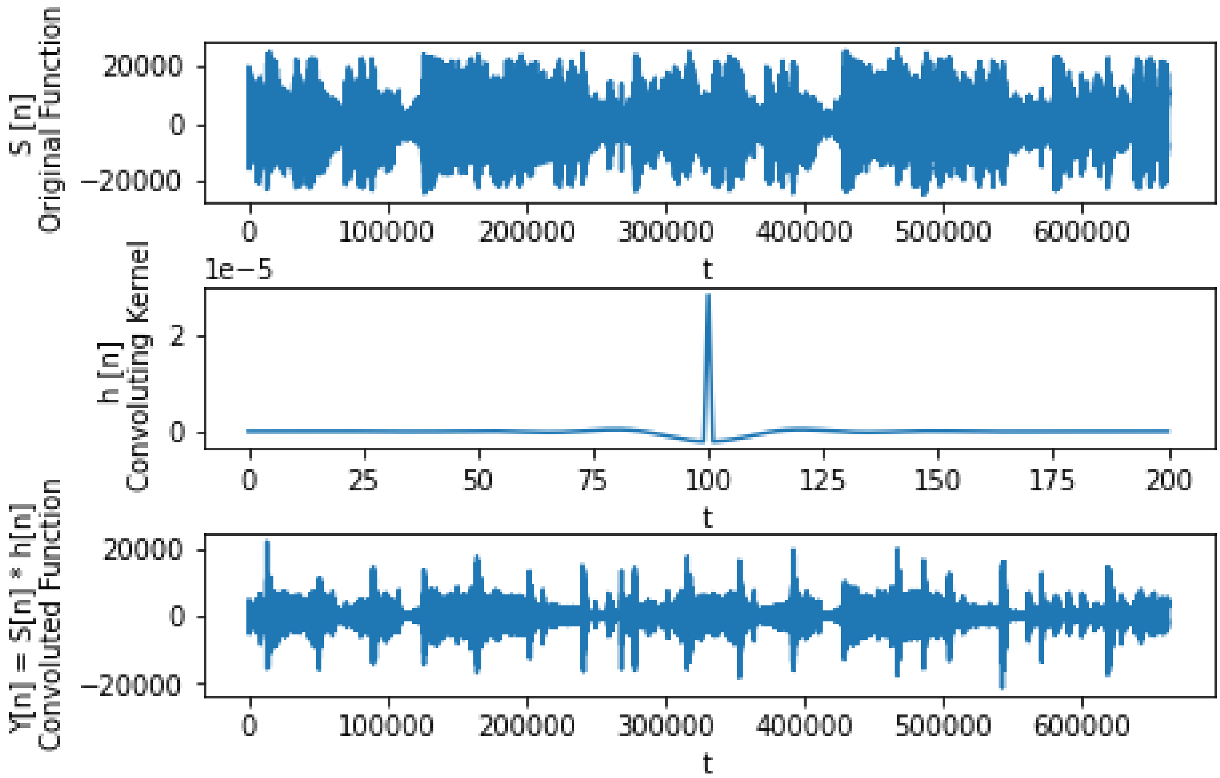
Question 2 - Generating Tones





- Plot function plots the samples and makes it look like it's a continuous signal whereas it is not because the computer is a digital device with discrete inputs and discrete outputs
- Stem plots vertical lines from a baseline to the y-coordinate and places a marker at the tip, also the position of the baseline can be adapted using bottom

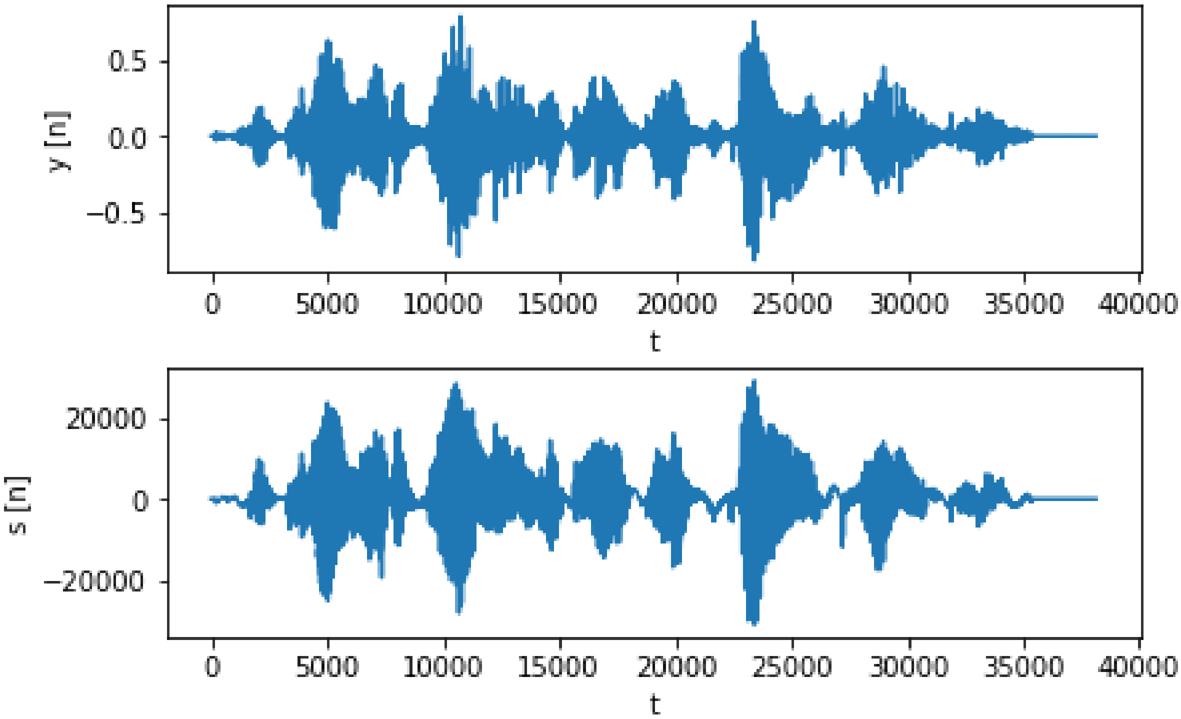
Question 3 - Convolution



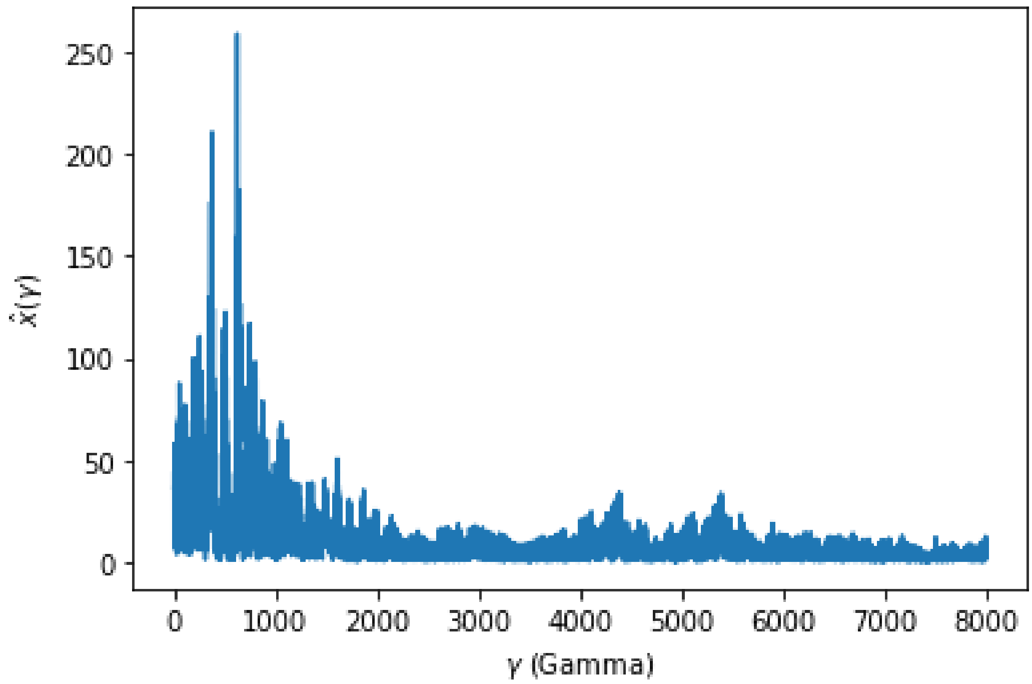
- It can be observed that the convoluted signal i.e **Y[n]** is **High pass filter**.
- This means that the slow changing values are removed and only the fast changing values remain.

Question 4 - Amplitude Modulation

Because of amplitude modulation, $y[n]$ seems to be enveloped by a cosine function. So when we try hearing this sound, it's higher pitched than the original audio.



The Spectrum of Amplitude Modulated signal is shifted upwards by 500Hz. This is because the Fourier transform of $y[n]$: $Y(\Omega) = \frac{[\hat{s(t)}(\Omega+f_0)+\hat{s(t)}(\Omega-f_0)]}{2}$



4 Appendix

- Note : I have used $\alpha = 3$ because my registration number is 191910. Since α = 1 + mod(910,4) = 1 + 3
- The link to all the code is here