Tutorial 3

Fourier Transform

CS2108

Due date: 14th Feb 2023 (Tuesday) 2359 hrs

Semester 2, AY22/23, School of Computing, National University of Singapore

IMPORTANT:

For this tutorial, you are supposed to submit your project file to CANVAS.

Instruction for submission:

- *Create a folder using the following naming convention:*

  StudentNumber_yourName_Tut3

- *Put your Matlab .m file and also the results (i.e. the figures and the diary file) in this folder.*

- *Zip your folder. Name your zip file using the following convention:*

  StudentNumber_yourName_Tut3.zip

  For example, if your student number is A1234567B, and your name is Chow Yuen Fatt, for this tutorial, your file name should be A1234567B_ChowYuenFatt_Tut3.zip

- *Submit the zip file in the "Tutorial-3 Submit Here" folder in CANVAS.*

Note:

- ***Do the following questions using Matlab. Put all commands in a .m file.***
- ***You may use Matlab "disp" command to display your answers.***
- ***You can create a log file to keep all your results when running the matlab .m file. Use the "diary" command.***

Create a Matlab file and answer all questions using Matlab.

Question 1

(a)

$$y(t) = 2 + 5\sin(4\pi t) + 10\cos(8\pi t) + 15\sin\left(10\pi t + \frac{\pi}{4}\right) + 10\cos(14\pi t)$$

Plot the signal $y(t)$ from 0 to 0.999 seconds using a sampling interval of 0.001sec.

(b)

Define the following set of basis functions:

$\sin(2\pi f_i t)$ where $f_i = i \quad for\ i = 0, 1, 2, 3, \ldots, 9$

$\cos(2\pi f_i t)$ where $f_i = i \quad for\ i = 0, 1, 2, 3, \ldots, 9$

Project $y(t)$ onto each of the sine basis functions $\sin(2\pi f_i t)$ and store the result as p_i.

Project $y(t)$ onto each of the cosine basis functions $\cos(2\pi f_i t)$ and store the result as q_i.

Compute $m_i = \sqrt{p_i^2 + q_i^2}$

Create a figure, use subplot to show 4 graphs (note: for $y(t)$, use the plot command. For p_i , q_i , and m_i , use the stem command):

$y(t)$, p_i , q_i , and $m_i \quad for \quad i = 0,1,2,3, \ldots 9$

(c) Comment on the values of m_i w.r.t. the terms in $y(t)$.

Question 2

2.1 Use the Matlab built-in command *fft* to compute the 1000-point Discrete Fourier Transform of y defined in Question-1 and store the result in a vector called *Y*. Do a "*help fft*" at Matlab command prompt if you are not sure how to use *fft.*

2.2 Create a figure, use subplot and stem to graph the real part of *Y*, the imaginary part of *Y*, and the magnitude of *Y*,

2.3 Compare your plots in 2.2 with the plots in Question-1(b). What do you observe?

Question 3

Define the vector `yq3`:

```
yq3 = [1 zeros(1,7)];
```

Create a figure, use subplot and stem to plot `yq3` and the magnitude of fft of `yq3.`

Question 4

Define the vector `yq4`:

```
yq4 = ones(1,8);
```

Create a figure, use subplot and stem to plot `yq4` and the magnitude of fft of `yq4.`

Question 5

Define a time vector t starting from 0 and ending at 0.9999 at a time step of 0.0001sec.

Define `yq5 as` one second of a cosine signal of frequency 300Hz, sampled using the time instances given by the vector t.

Create a figure, use subplot and stem to plot `yq5` and the magnitude of fft of `yq5.`

Locate the position/s in fft of yq5 where the magnitude is highest. Give the location in terms of its index in the array, as well as in terms of Hz.

Note: The first item in the array returned by fft represents 0Hz. To compute the frequency in Hz, you will need to use the following formula

$$frequency = (position\ of\ first\ peak\ in\ fft\ result\ array - 1) * frequency\_resolution$$

where $frequency\_resolution = 1 \quad in\ this\ case.$

Question 6

Define a time vector t starting from 0 and ending at 0.9999 at a time step of 0.0001sec.

Define yq6 as one second of a sine signal of frequency 400Hz, sampled using the time instances given by the vector t.

Create a figure, use subplot and stem to plot yq6 and the magnitude of fft of yq6.

Locate the position/s in fft of yq6 where the magnitude is highest. Give the location in terms of its index in the array, as well as in terms of Hz.

Note: use the same formula given in Question 5.