SYDE 252

Matlab® Assignment 2

(Due date: Nov. 17, 6 pm)

Note:

You SHOULD NOT use any build-in signal processing commands or functions of Matlab, such as *fft*. You SHOULD NOT use any functions from any toolboxes of Matlab, such as symbolic toolbox, signal processing toolbox or digital signal processing toolbox. You CAN use any plotting functions you feel like to.

Problem 1: Numeric approximation of Fourier transform of continuous-time signals

With the experiences and results from Assignment One, write two functions that perform numeric approximation of analysis equation and synthesis equation of Continuous-time Fourier Transform, such as:

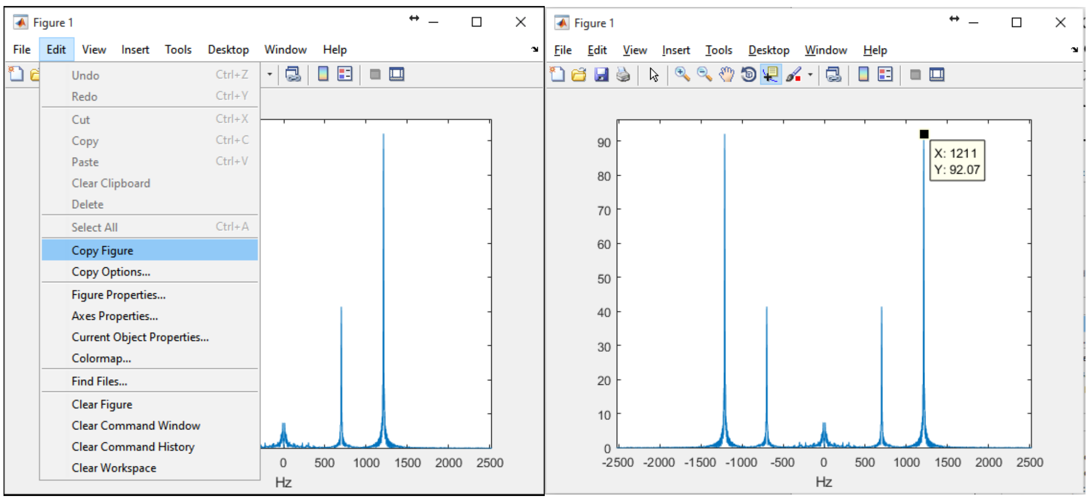
```
Xw = MyFT(Xt, t, w);
Xt = MyiFT(Wt, w, t);
```

Please provide the functions, as well as testing scripts that you used to validate your work.

Problem 2: Choose ONE of the two options bellow.

You need to provide a script detailing your analysis steps. If some actions or steps you would like to do is not possible or not convenient using commands, you should described it clearly in an accompany document. For example, if you manually zoom in a plot of signal to a region of interest, you should include a figure using 'copy figure' option in Matlab (see the left-hand side figure below), and paste the figure into Word. Or you can save the figure in .fig files, and submit them along with the main document(s). You CAN also use the build-in annotation functionalities of Matlab to perform analysis (see an example of

Datatip tool in the right-hand side figure below). In this case, a peak in the spectrum at 1211 Hz is identified by the Datatip tool. Allowing this type of manual analysis removes the need to develop fully automatic analysis. Although a fully automatic script or function will be considered as bonus.



Option 1: Identification of the dialed numbers from recordings of dual tone multi-frequency (DTMF) dialing.

When we press a number in the dialing pad of our phone, each key produces a distinct sound. The sound is consisted of two pure sinusoid tones. These tones and their responding dialing keys are presented in the following table (shaded entries are the keys, and frequencies are in Hz):

	1209	**1336**	**1477**
697	1	2	3
770	4	5	6
852	7	8	9
941	*	0	#

For example, when key '7' is pressed, a tone consists (by consist, it means the operation of addition) two sinusoids (852 Hz and 1209 Hz) will be generated:

$$x(t) = a\cos(2\pi 852 t) + b\cos(2\pi 1209 t)$$

where $x(t)$ is the tone one would hear when the key '7' is pressed, and the two efficients, a and b, are the weighting factors of the two sinusoid tones, respectively.

Another example, when key '#' is pressed, the tone will be:

$$x(t) = c\cos(2\pi 941 t) + d\cos(2\pi 1477 t)$$

You can find more detailed information on DTMF here.

Two recordings of DTMF dialing are stored in Matlab's .mat format attached (DTMF1.mat and DTMF2.mat). The data is sampled at 16k Hz. Please use the Fourier Transform code that you've developed in Assignment One to analysis these signals, and determine key sequence dialed. Please provide a script, and description of the analysis steps, the necessary plots/figures detailing your analysis, and your results.

Option 2 Identification of piano keys

The frequencies of the keys of a standard 88-key piano can be calculated with the following equation:

$$f_n = 440 \times 2^{\frac{n-49}{12}}$$

where *n* is the key number, from 1 (A0) to 88 (C8), and 440 is the frequency (in Hz) of key number 49 (the standard tuning reference note). The above equation is the result of the requirement that the frequencies of notes should double every 12 notes (12 notes per octave: C, C#, D, D#, E, F, F#, G, G#, A, A#, B). The table below are the frequencies of musical notes from C0 to B8 (nine Octaves). Piano starts from A0 to C8

	C	C#	D	Eb	E	F	F#	G	G#	A	Bb	B
0	16.35	17.32	18.35	19.45	20.60	21.83	23.12	24.50	25.96	27.50	29.14	30.87
1	32.70	34.65	36.71	38.89	41.20	43.65	46.25	49.00	51.91	55.00	58.27	61.74
2	65.41	69.30	73.42	77.78	82.41	87.31	92.50	98.00	103.8	110.0	116.5	123.5
3	130.8	138.6	146.8	155.6	164.8	174.6	185.0	196.0	207.7	220.0	233.1	246.9
4	261.6	277.2	293.7	311.1	329.6	349.2	370.0	392.0	415.3	440.0	466.2	493.9
5	523.3	554.4	587.3	622.3	659.3	698.5	740.0	784.0	830.6	880.0	932.3	987.8
6	1047	1109	1175	1245	1319	1397	1480	1568	1661	1760	1865	1976
7	2093	2217	2349	2489	2637	2794	2960	3136	3322	3520	3729	3951
8	4186	4435	4699	4978	5274	5588	5920	6272	6645	7040	7459	7902

More details on the frequencies of piano keys/notes can be found here.

The data file ‘pianoNotes.mat’ contains two variables: *noteFreqs* and *noteNamesFull*, containing the frequencies of the 88 notes (as calculated by the above equation), and the full name of the notes, respectively. The other two data files (*Music1.mat* and *Music2.mat*) contain recording of two series of simple piano key strokes. Use the Fourier Transform functions you developed in Assignment One to analyze these two data files, and determine the sequences of the piano key strokes, such as A3→C3→B3→….

Please provide a script, and description of the analysis steps, and necessary plots/figures detailing your analysis.