SIGNALS AND SYSTEMS

TERM PROJECT

Due: June 11, 2019

1 Objectives

You will study the concept of convolution, Fourier Series (FS) and Fourier Transform (FT), and the relationship among them. You can build ability to use Matlab and conduct convolution, FS, and FT by Matlab.

2 Generation of Signals

1. Please be familiar with Matlab commands, e.g., sin, cos and plot. Use "help" command as follows after the Matlab prompt >>.

   ```
   >> help sin
   >> help plot
   ```

   You may need to look at some tutorials on Matlab.
   For example, http://www.mathworks.com/academia/student_center/tutorials/intropage.html

2. Generate a continuous-time signal $x(t) = \cos(2\pi 10t + \frac{\pi}{4}) + \cos(2\pi 30t + \frac{\pi}{4})$. You may use the part of the followings.

   ```
   ...
   >> t = 0:0.001:1;
   ...
   >> plot(t, x_t)
   ```

3. Generate a discrete-time signal $x[n] = (1/4)(u[n] - u[n-4])$. You may use the part of the followings.

   ```
   >> a_n = ones(1, 4);
   >> b_n = zeros(1, 7);
   ...
   >> stem(n, x_n)
   ```

3 Continuous-Time Non-periodic Signal

1. Convolution and Fourier Transform (FT)

   (a) Generate a signal (sinc function) for $-10 \leq t \leq 10$.

   $$x_1(t) = \text{sinc}(t) = \frac{\sin(\pi t)}{\pi t}.$$

   Note: Use the sampling interval of 0.01 to generate the signal in $-10 \leq t \leq 10$.

(b) Generate a function $h_1(t)$ for $-10 \leq t \leq 10$.

$$h_1(t) = \begin{cases} 1, & -1 \leq t \leq 1 \\ 0, & \text{otherwise} \end{cases}$$

(c) Using the conv function in Matlab, compute the convolution $y_1(t) = x_1(t) * h_1(t)$.

(d) Using the fft function in Matlab, find the FT of $x_1(t)$ and $h_1(t)$.

(e) Multiply the FT of $x_1(t)$ by that of $h_1(t)$, that is $Y_1(jw) = X_1(jw)H_1(jw)$.

(f) Using ifft function in Matlab, find the inverse FT (IFT) of $Y_1(jw)$ to find $y_1(t)$.

(g) Compare the signal $y_1(t)$ found from the convolution in time domain and $y_1(t)$ found from the multiplication in frequency domain.

2. Plot

(a) Plot $x_1(t)$ and $h_1(t)$ using the plot function in Matlab for $-10 \leq t \leq 10$.

(b) Plot $y_1(t)$ from the convolution in time domain using the plot function in Matlab for $-10 \leq t \leq 10$.

(c) Plot FTs of $x_1(t)$ and $h_1(t)$ using the plot.

(d) Plot $Y_1(jw) = X_1(jw)H_1(jw)$ using the plot. (You may need to use fftshift() to shift the zero frequency to the center.)

(e) Plot $y_1(t)$ obtained from the multiplication $Y_1(jw) = X_1(jw)H_1(jw)$ in frequency domain and IFT using the plot function in Matlab for $-10 \leq t \leq 10$.

(f) Plot $y_1(t)$ in (b) and that in (e) together in a graph using subplot.

4 Discrete-Time Periodic Signal

1. Convolution and Discrete-Time Fourier Series (DTFS)

(a) Generate a periodic signal $x_2[n]$ with the fundamental period N.

$$x_2[n] = \sin(2\pi n/10) + \sin(2\pi n/20) + \sin(2\pi n/30), \text{for } 0 \leq n \leq N-1.$$

Find the fundamental frequency $\Omega_0 = 2\pi/N$ with the fundamental period N.

(b) Generate a periodic signal $h_2[n]$ with the fundamental period N.

$$h_2[n] = (1/2)^n, \text{for } 0 \leq n \leq N-1$$

(c) Using the conv function in Matlab, compute the convolution $y_2[n] = x_2[n] \circledast h_2[n]$.

(d) Using the fft function in Matlab, find the DTFS $X_2[k]$ of $x_2[n]$ and $H_2[k]$ of $h_2[n]$.

(e) Multiply the DTFSs of $x_2[n]$ and $h_2[n]$, that is $Y_2[k] = NX_2[k]H_2[k]$.

(f) Using the ifft function in Matlab, find the inverse DTFS (IDTFS) of $Y_2(k)$ to find $y_2[n]$.

(g) Compare the signal $y_2[n]$ found from the convolution in time domain and $y_2[n]$ found from the multiplication in frequency domain and IDTFS.

2. Plot

(a) Plot $x_2[n]$ and $h_2[n]$ for $0 \leq n \leq N-1$.

(b) Plot $y_2[n]$ from the convolution in time domain for $0 \leq n \leq N-1$.

(c) Plot DTFSs of $x_2[n]$ and $h_2[n]$.

(d) Plot $Y_2[k] = NX_2[k]H_2[k]$.

(e) Plot $y_2[n]$ obtained from the multiplication in frequency domain and IDTFS.

(f) Plot the signal $y_2[n]$ found from the convolution in time domain and $y_2[n]$ found from the multiplication $Y_2[k] = NX_2[k]H_2[k]$ in frequency domain and IDTFS in a single graph using subplot.

5 Real Audio Signal

1. Generate and Process Audio Signal

   (a) Follow the steps to collect your own voice signal. You have to have audio input device, e.g., microphone, Web camera.

```
recObj = audiorecorder

disp('Start speaking.')
recordblocking(recObj, 5); % 5 seconds
disp('End of Recording.');

play(recObj);

x = getaudiodata(recObj);

plot(x);
```

2. Filter the Voice Signal

   (a) Create a low pass filter $h[n]$ to process your voice signal $x[n]$. You can use a moving average FIR filter with the window size windowSize. You may change the window size.
   (b) Filter your voice signal $x[n]$ by the filter $h[n]$ to get $y[n]$. Use the filter function filter().
   (c) Plot the voice signals and filter, $x[n]$, $h[n]$, and $y[n]$ in a figure window.
   (d) Plot the frequency spectrums of the signals and the filter.
   (e) Listen to the original voice $x[n]$ and the filtered voice $y[n]$ and compare them. You can use the sound() function to listen to the voice signal.
   (f) Save the signals into .wav audio files. Use the function audiowrite().

6 Report

1. Write a report.

   - Describe the background and the objectives.
   - Describe the procedures.
   - Present the plots and write the results with the observations.
   - Write a conclusion.

2. Items to submit:

   - Final report
   - Matlab program source codes and other related files

3. Submission Instruction:

   (a) You have to zip all the files into one file (filename: term_studentname.zip, e.g., term_kimsungkyun.zip), and upload it to the term project box in i-campus(www.icampus.ac.kr).
   (b) You also have to submit the printed version of the report and the sources. You have to print out two pages per sheet if you can.
   (c) You may be required to demonstrate and explain your work in front of me or TA.

Good luck and enjoy the project !