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Department of Electrical and Computer Engineering
EECE 491 – Discrete-time Signal Processing

MATLAB Assignment: Basic Signals and Systems

Overview:
One of the best ways to learn the material in this course is through using a computer. MATLAB is a powerful software package which is very useful for generating, processing, and plotting signals, and insight into many signal processing concepts can be gained through using it. This assignment is primarily designed to get you familiar with using MATLAB.

You may find the **`diary`** command useful for maintaining a history of your MATLAB session. Other commands you may find useful include **`subplot`**, **`orient tall`**, and **`orient landscape`**. To get information about a function and its usage, use the MATLAB help command, e.g. help subplot, help filter, etc.

Problem 1: Basic Signals

1. Generate and plot (using MATLAB's **`stem`** command) the sequence

$$x[n]=(0.95)^n \cos(\pi / 20\, n)$$

for $0 \le n \le 63$. Note that MATLAB's indexing for the first element starts with 1 and not 0, so you will have to adjust for this in your plot.

2. The following is a simple example of a MATLAB function **`framp`** which generates an N-point ramp $x[n] = n$ *for* $1 \le n \le N$. The input argument is N and the function generates the desired values.

```
function x=framp(N)
%  function x=framp(N)
%  Generates an N-point ramp sequence
n=l:N;
x=n' ;
```

Write a MATLAB function, **`fcosine`**, which will generate the values from a finite-length sinusoid $A \cos(\omega_0 n + \phi)$ for $n_I \le n \le n_f$. The function will need a total of five input arguments: A, ω_0, ϕ, n_I, and n_f. The function should return a column vector which contains only the desired values of the sinusoid. Test your function by plotting the results with $A = 4$, $\omega_0 = \pi/10$, $\phi = \pi/4$, $n_I = -20$, and $n_f = 20$.

Problem 2: Impulse Response and Step Response

Consider an LTI system where the input $x[n]$ and output $y[n]$ satisfy the following difference equation (assume initial rest conditions):

$$y[n]-1.85\cos(\tfrac{\pi}{18})y[n-1]+0.83y[n-2]=x[n]+\tfrac{1}{3}x[n-1]$$

1. Using **`filter`**, generate and plot the response $y[n]$ for $-10 \le n \le 100$ when the input is $x[n] = \delta[n]$, the unit impulse sequence.
2. Generate and plot the response $y[n]$ for $-10 \le n \le 100$ when the input is $x[n] = u[n]$, the unit step sequence.

<u>Problem 3</u>:

We have shown that if the input and output of a causal LTI system satisfy the difference equation

$$y[n] = ay[n-1] + x[n],$$

then the impulse response of the system is $h[n] = a^n u[n]$.

(a) For what values of a is this system stable?

(b) Consider a causal LTI system for which the input and output are related by the difference equation

$$y[n] = ay[n-1] + x[n] - a^N x[n-N],$$

where N is a positive integer. Determine and sketch a plot of the impulse response of this system. **Hint**: Use linearity and time-invariance to simplify the solution.

(c) Is the system in part (b) an FIR or an IIR system? Explain.

(d) For what values of a is the system in part (b) stable? Explain.

(e) Write two brief MATLAB programs (really just single statements) that implement the system in part (b) for a = 0.8. One program should use **`filter( )`** and the other should use **`conv( )`**. Test your programs with an impulse input to verify that they produce the same impulse response.

<u>Problem 4: System Functions, Frequency Response, and Pole/Zero Plots</u>

Consider an LTI system whose system function is given by:

$$H(z) = \frac{1 + \frac{1}{3} z^{-1}}{1 - 1.85 \cos\left(\frac{\pi}{18}\right) z^{-1} + 0.83 z^{-2}}$$

1. Using **`freqz`** with $N = 512$, generate plots of the magnitude and phase responses $|H(\omega)|$ and $\angle H(\omega)$ for $0 \le \omega \le \pi$. Specify what type of filter this system represents (i.e. lowpass, highpass, bandpass, etc.).

2. Use **`zplane`** to make a pole/zero plot of all finite poles and zeros of $H(z)$. (**Hint**: To determine all finite poles and zeros, express $H(z)$ in positive powers of z by multiplying the numerator and denominator by an appropriate power of z.)

<u>Problem 5</u>:

Use the built-in functions **`filter`**( ) and **`freqz`**( ) of MATLAB to compute 51 samples of the impulse response and frequency response of the system defined by the difference equation:

$$y[n] \;=\; 1.556y[n-1] - 1.272y[n-2] + 0.398y[n-3] + 0.0798x[n] + x[n-1] + x[n-2] + x[n-3]$$

Hint: To compute the impulse response, make an input vector for **`filter`**( ) consisting of one unit sample followed by 50 zero samples.)

Hand in a **`stem`**( ) plot of the impulse response. Use **`subplot`**( ) and **`plot`**( ) to make a two panel plot of the magnitude and phase of the frequency response.