Indian Institute of Space Science and Technology
AV336 - Digital Signal Processing Lab
Department of Avionics

Labsheet 2

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1. Suppose x_1 and x_2 are two finite sequences defined as

$$\begin{aligned} x_1[n] &= [4, 2, 6, 3, 8, 1, 5] \\ x_2[n] &= [3, 8, 6, 9, 6, 7] \end{aligned}$$

   Let the starting index of $x_1[n]$ be -1 (i.e. $x_1[-1] = 4, x_1[0] = 2 \dots$) and the starting index of $x_2[n]$ be -2. Obtain the convolution of $x_1[n]$ and $x_2[n]$.

2. Find out what is meant by auto-correlation of a discrete time signal $x[n]$. Find out the auto-correlation of $x_1[n]$ and $x_2[n]$ defined above using your own code. Find out whether there is a builtin Matlab function for finding out the auto-correlation. Find out the auto-correlation of $x_1[n]$ and $x_2[n]$ using the builtin function(s). Find out whether auto-correlation can be implemented using convolution.

3. Find out what is meant by cross-correlation between two discrete time signals $x_1[n]$ and $x_2[n]$. Find out whether cross-correlation is implemented as a builtin function in Matlab. Find the cross-correlation between $x_1[n]$ and $x_2[n]$ using your own code as well as builtin functions. Find out whether cross-correlation can be implemented using convolution.

4. Define what odd and even signals are. Write Matlab code to find out the odd and even parts of the following signals:

   (a) $x_1[n] = [4, 3, 5, 6, 7, 2]$; starting index is -2
   (b) $x_2[n] = sin(2\pi 100n) + cos(\pi 100n)$ for all n

5. Suppose x_1 and x_2 are two finite sequences defined as

$$\begin{aligned} x_1[n] &= [4, 2, 6, 3, 8, 1] \\ x_2[n] &= [3, 8, 6, 9, 6, 7] \end{aligned}$$

   Write a Matlab program to compute the circular convolution of $x_1[n]$ and $x_2[n]$. Modify your Matlab program such that it can compute the circular convolution of any x_1 and x_2 given as input - include in your program logic to check whether the circular convolution can be computed and return appropriate error messages.

6. Consider the following difference equation describing a single-input single-output system

$$y[n] - 1.8y[n-1] + 0.81y[n-2] = x[n] + 0.5x[n-1].$$

   Obtain the state space representation of the above system. Implement the state space representation (i.e., the nextstate and output functions) using Matlab. Find out what the output of the system using your Matlab implementation for an input

$$x[n] = u[n-1] - u[n-10],$$

   where $u[n]$ is the standard step function.

7. Let $x_1[n]$ and $x_2[n]$ be two signals defined as

$$\begin{aligned} x_1[n] &= u[n] - u[n-10], \\ x_2[n] &= \begin{cases} n, & \text{for } n \in 0, 1, \ldots, 10, \\ 0, & \text{otherwise.} \end{cases} \end{aligned}$$

   Here $u[n]$ is the standard step function. State whether the following systems (the input output relationship are given) are linear and time invariant. Using Matlab check whether the systems satisfy the linearity and time invariance property for the above candidate input signals and time delays of -1 and 1.

   (a) $y[n] = x[n-3] \times x[n-2]$

   (b) $y[n] = x[n+2]$

   (c) $y[n] = sin(x[n])$

   (d) $y[n] = x[2n]$

8. Find out what "audiorecorder" and "audioplayer" functions of MATLAB do. Use these functions to record and play the audio activity of your surroundings.

9. Generate and play the following signals as audio

   (a) sine wave of length 2 seconds with 500 Hz frequency and sampled at 22100 Hz.

   (b) chirp signal using Matlab's chirp function - find out what effect various parameters of the chirp function has

   (c) dual tone signal - consisting of two sine waves of two different frequencies - you are free to choose the different frequencies, but comment on what you hear as a function of the two frequencies.