IET Winter 2016
Semester-6
Digital Signal Processing

LAB 3

Objectives:

Understand different concepts of linear and circular convolution along with its applications.

Prerequisites:

- Linear Convolution
- 2D - Convolution
- Circular Convolution

Problems

1. Explore command **conv2** in Matlab. Take input of 2 Matrix from user and Find 2D convolution of the same. Also explore the properties of **conv2** command and analyze the result.

   For an example

$$A = \begin{bmatrix} 17 & 24 & 1 & 8 & 15 \\ 23 & 5 & 7 & 14 & 16 \\ 4 & 6 & 13 & 20 & 22 \\ 10 & 12 & 19 & 21 & 3 \\ 11 & 18 & 25 & 2 & 9 \end{bmatrix} \qquad B = \begin{bmatrix} 1 & 3 & 1 \\ 0 & 5 & 0 \\ 2 & 1 & 2 \end{bmatrix}$$

2. Application of 2D convolution on image processing applications

   a) Take a standard test image “Lenna.png” from shared folder. Explore following commands and apply for given image.
      - **imread**
      - **rgb2gray**
      - **imshow**

   b) Now in order to perform 2D convolution, Given image becomes first input as matrix and second input will be a sets of kernel matrix performing different operations on image which are mentioned below:

List of different kernels:

In image processing, a kernel, convolution matrix, or mask is a small matrix useful for averaging, sharpening, embossing, edge-detection, and more. This is accomplished by means of convolution between a kernel and an image.

- Average (blur, smooth) 3x3 convolution kernel

$$A = \begin{bmatrix} 1/9 & 1/9 & 1/9 \\ 1/9 & 1/9 & 1/9 \\ 1/9 & 1/9 & 1/9 \end{bmatrix}$$

- Sharpen 3x3 convolution kernel

$$S = \begin{bmatrix} 0 & -1 & 0 \\ -1 & 5 & -1 \\ 0 & -1 & 0 \end{bmatrix}$$

- Edge detection 3x3 convolution kernel

$$E = \begin{bmatrix} 0 & -1 & 0 \\ -1 & 4 & -1 \\ 0 & -1 & 0 \end{bmatrix} \qquad E_H = \begin{bmatrix} 0 & 0 & 0 \\ -1 & 2 & -1 \\ 0 & 0 & 0 \end{bmatrix} \qquad E_V = \begin{bmatrix} 0 & -1 & 0 \\ 0 & 2 & 0 \\ 0 & -1 & 0 \end{bmatrix}$$

- Gradient detection 3x3 convolution kernel

$$G_H = \begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix} \qquad G_V = \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

- Sobel Operator 3x3 convolution kernel

$$S_H = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} \qquad S_V = \begin{bmatrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{bmatrix}$$

3. Develop a MATLAB function to obtain circular convolution of two sequences. Use definition of circular convolution to obtain the output sequence. Verify the function for following sequence. Write a script file to use the developed function.

    1. $x_1(n) = \{1,-1,-2,3,-1\}$ and $x_2(n) = \{1,2,3\}$
    2. $x_1(n) = \{1, 2, 1, 2\}$ and $x_2(n) = \{3,2,1,4\}$
    3. $x_1(n)=\cos\left(\frac{2\pi n}{N}\right)$ and $x_2(n)=\sin\left(\frac{2\pi n}{N}\right)$, $0 \leq n \leq N-1$.for N=8

4. Write a MATLAB program to find circular convolution of two sequences using Matrix Multiplication method.

    4. $x_1(n) = \{1,-1,-2,3,-1\}$ and $x_2(n) = \{1,2,3\}$
    5. $x_1(n) = \{1, 2, 1, 2\}$ and $x_2(n) = \{3,2,1,4\}$
    6. $x_1(n)=\cos\left(\frac{2\pi n}{N}\right)$ and $x_2(n)=\sin\left(\frac{2\pi n}{N}\right)$, $0 \leq n \leq N-1$.for N=8