

SEAS Winter 2020
Semester-6
Digital Signal Processing

LAB 3

Objectives:

Understand different concepts of 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

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

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

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

- Gradient detection 3x3 convolution kernel

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

- Sobel Operator 3x3 convolution kernel

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

3. Develop a MATLAB function to obtain circular convolution of two sequences. 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.

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 $N=8$