Computer Engineering Dept.
Faculty of Engineering
Cairo University **Digital Image Processing Lab**

Lab 2

Convolution & Discrete Fourier Transform

Objective:

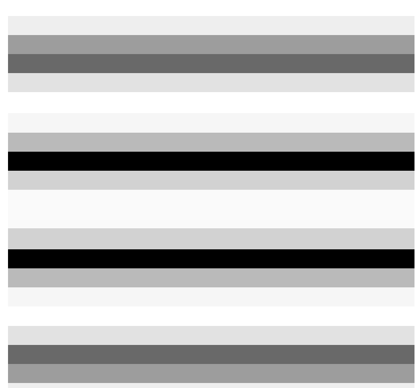
- Learn the concept of Convolution in space domain.
- Learn the concept of Inverse Fourier Transform.
- Learn the concept of Multiplication in frequency domain.

Example: Inverse Fourier Transform

In this example, we show the transformation for an image from frequency domain to spatial domain using inverse Fourier Transform.

- Create a zeros matrix of size 21x21, then change the following pixels to be ones:
  - Pixels (9,10) and (11,10)
- Get the inverse Fourier transform of the image using ***ifft2***.
- The result of ***ifft2*** contains complex and very small values that must be pre-processed before displaying.
- This is done by getting the ***abs*** of the image***.***
- Display each of the above images and its inverse.

- What image gives an inverse Fourier transformation to be something like this?



Example: Multiplication in frequency domain

In this exercise, we transfer the image and the filter to the frequency domain, hence we can perform a multiplication operation, then we inverse transfer the result.

- Read any image from your choice then convert it to gray level.
- Calculate the Fourier transform for it using ***fft2***, then shift it using ***fftshift***
- Generate the filter $\frac{1}{9}\begin{bmatrix}1 & 1 & 1\\ 1 & 1 & 1\\ 1 & 1 & 1\end{bmatrix}$.
- Calculate the Fourier transform of the filter using ***fft(filter , rows(image), columns(image))***.
- Perform a multiplication operation between the image and the filter in frequency domain using np.multiply**.**
- Display the result use the ***abs*** then ***log (image +1)*** before plotting the image.
- Then you apply inverse fourier transformation using ***ifft2.***
- To display the result use the ***abs*** then before the before plotting the image.

Experiment 1: Convolution in space domain (30minutes)

In this exercise we experiment convolution in space domain for 2d images and linear filters.

- Read any image from your choice then convert it to gray level.
- Generate another version of the image after adding salt and paper noise with density=0.05.
- Convolve in space domain using the function ***convolve2d*** the following filters with the images and write your comments about the results:
    - $\frac{1}{9}\begin{bmatrix}1 & 1 & 1\\ 1 & 1 & 1\\ 1 & 1 & 1\end{bmatrix}$ On the image after adding noise.

- $\begin{bmatrix} 1 & 1 & 1 \\ 1 & -8 & 1 \\ 1 & 1 & 1 \end{bmatrix}$ On the image without noise.
- $\begin{bmatrix} 1 & 1 & 1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix}$ On the image without noise.
- $\begin{bmatrix} 1 & 0 & -1 \\ 1 & 0 & -1 \\ 1 & 0 & -1 \end{bmatrix}$ On the image without noise.

- After applying each filter display
  1. gray scaled original image
  2. image after adding noise to it
  3. The four images after applying the four filters

  Images in **one single figure** using ***show_images*** function.
- What are the uses of these filters?
- For the second filter, how can we make the output more descriptive?

Useful New Functions and Attributes

Name	Attribute or Function	Usage
np.log	Function	to get log for matrix (element-wise)
np.abs	Function	to get absolute value for matrix (element-wise)
np.multiply	Function	to multiply two matrices (element-wise)
np.power	Function	to power a matrix (element-wise)

For Fourier Transform functions,
check: https://docs.scipy.org/doc/scipy/reference/fftpack.html