**DIP-CSE340 ASSIGNMENT 2**
**Deadline : 26/9/2024, Time : 11 : 50 PM**

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**Total Marks : 40 Marks** | **Total Days : 14 Days**

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**Instructions:**

- Standard institute plagiarism policy holds.State any assumptions you have made clearly.
- Even a second late will be considered late, so do submit your assignments at least before 11:50 PM on the date of the deadline to avoid any unexpected issues.
- Viva 5 marks will be taken during the demos. (written)
- Submit a single Jupiter notebook with all results. (Python/Matlab)

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## Section A
6 marks

Consider the following matrix $f$ and convolution kernel $w$:

$$f = \begin{bmatrix} 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 1 \\ 1 & 1 & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \end{bmatrix}, w1 = \begin{bmatrix} 3 & 5 & 4 & 7 & 8 \end{bmatrix} \text{ and } w2 = \begin{bmatrix} 1 & 3 \\ 2 & 4 \end{bmatrix}$$

1. Implement Correlation and Convolution from scratch.
2. Compute and compare results of correlation and convolution using your implementation, taking input $f$ with weight matrices/filter $w1$ and $w2$ given above. Display the result at each stride. (3 mark)
3. Padding is a method of adding boundaries (e.g., $x$-padding of size 2 means adding two pixels with same value $x$ at boundary). To the matrix $f$, add a 2-padding of size 3. Now with a stride of 2, repeat section A question (2) . How does the answer change? Display the result at each stride. (3 marks)

Note: In this section, correlation and convolution should be applied from scratch. No marks will be awarded for using inbuilt functions. You can use basic packages like NumPy.

## Section B
14 marks

Consider the flower dataset with 102 classes, and choose the class that matches the number in the demo sheet 2. The instances that have this label are your data for the following experiment:

1. Load and display 10 images of the class. Grayscale and Resize an image to $400 \times 400$ (One random image of the class. We will call it $f(x, y)$).
2. Apply the following low pass filters to $f(x, y)$. (we will call the output ($\hat{f}(x, y)$): (5 marks)
   (a) Box filter of kernel size $6 \times 6$ and $10 \times 10$
   (b) Gaussian filter of the kernel with standard deviations ($\sigma = 1, 3, 7$).
   (c) Display the kernels (as a heat map) alongside the images.
3. Perform unsharp masking (see DIP text book chapter 3) using the outputs $\hat{f}(x, y)$ in section B (2). Choose three different values for $k$, i.e., $k < 1, k = 1, k > 1$. (3 marks)

4. Consider the following equation:

$$\nabla^2 f(x,y) = f(x+1,y) + f(x-1,y) + f(x,y+1) + f(x,y-1) - 4f(x,y)$$

Implement the above equation as a filter with/without diagonal entries. Repeat section B (3) with the new $\hat{f}(x,y) = \nabla^2 f$ and display the images. Comment what changes you observe in this case. (For reference, see the DIP textbook) (3 marks)

5. Consider the given image (img_filter.png) and perform the following filters: lowpass, highpass, band-reject, and bandpass filters. Explain the results. (3 marks)

## Section C

15 marks

Let the grayscale of the image chosen in section B from your designated class be $f_1(x,y)$ and let the grayscale of another image from another class in the same dataset be $f_2(x,y)$. Resize the images to a suitable value of your choice.

1. Find and visualize the DFTs of rotations of $f_1(x,y)$ and $f_2(x,y)$ at angles $0°$, $60°$, $120°$, $180°$, and $240°$ using contour plots. (2 marks)

2. Reconstruct the images $f_1(x,y)$ and $f_2(x,y)$ using : (3 marks)

   (a) Phase

   (b) Magnitude

   (c) Phase and Magnitude

   (d) Visualize the phase and magnitude using contour plots

3. Find the DFT after the filtering transformation in section B (5) for the images (img_filter.png) and $f(x,y)$. Comment on the results. ( 2 marks)

4. Demonstrate the importance of phase through reconstruction of $f_1(x,y)$ and $f_2(x,y)$ after interchanging the phase of their DFT. (Ref : Lecture slide page 25-26) (2 marks)

5. Demonstrate the importance of convolution theorem by applying inverse Fourier transform on the new DFT given by $DFT(f_i(x,y)) * DFT(\hat{f}_i(x,y))$ (Ref : Lecture slide page 35-36) where $*$ is multiplication, $i = 1,2$ and $\hat{f}_i(x,y)$ is the new image after applying a: (3 marks)

   (a) Gaussian filter of standard deviation $\sigma = 4$ on $f_i(x,y)$.

   (b) Bandpass filter on $f_i(x,y)$.

   (c) Unsharp masking on $f_i(x,y)$ using $\nabla^2 f$ (see section B question 4) with $k < 1$.

6. Using the images (img_filter.png) and $f(x,y)$ (you can resize/grayscale the images into suitable dimensions as required), demonstrate whether the Fourier Transform is distributive over multiplication. (3 marks)

Unless specified, you are free to add your own value to constants, variables, or parameters of the equation or kernel size. In section B and C you can use inbuilt functions, unless specified to perform a particular mathematical operation such as +,-*,/. If specified in the question a particular type of plot, no other plot will be accepted in its place.

**Reference :**
The DIP textbook referred to in the classroom and the Lecture slides. Viva will also be from these sections and from what is done in the Assignment.

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