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NATIONAL INSTITUTE TECHNOLOGY, TIRUCHIRAPPALLI

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

Cycle Test 1, dated 21.08.2024

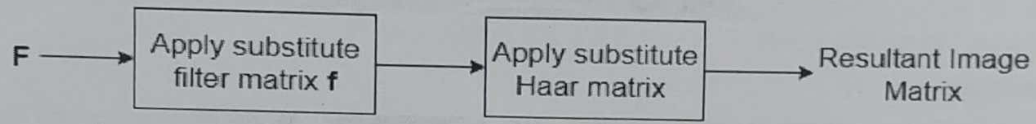
CSPE 74 Image Processing and Applications

Attend all questions

PART-A (5x3=15 marks)

1. Apply Discrete Fourier Transform, for the following image matrix: $\begin{bmatrix} 0.3 & 1.8 & 3 & 4.5 \\ 0.5 & 0.3 & 3 & 4.5 \\ 0.2 & 1.2 & 0.3 & 4.5 \\ 0.6 & 1.4 & 3 & 0.3 \end{bmatrix}$

2. For the following image matrix, perform the operation is given figure:



where, $F = \begin{bmatrix} 0.5 & 0.8 & 0.3 & 4.8 \\ 0.5 & 0.5 & 0.3 & 4.8 \\ 0.1 & 0.4 & 0.3 & 4.8 \\ 0.4 & 2.4 & 0.3 & 3.8 \end{bmatrix}, f = \begin{bmatrix} 1.3 & 1.7 \\ 2.5 & 0.6 \\ 4.2 & 1.2 \\ 5.6 & 1.5 \end{bmatrix}$

3. Perform Histogram Equalization for the following data points:

Pixel Intensities	1	2	3	4	5	6	7	8	9	10
No. of pixels	1	3	3	2	2	1	3	1	0	0

PART-B (5x1=5 marks)

1. You're given two photographs of the same old building:

   - **Photo A** is taken with a vintage film camera from the 1970s.
   - **Photo B** is taken with a modern smartphone camera in 2025.

   The task is to prepare both images for analysis in a digital image processing pipeline. Before you can run algorithms like edge detection or object recognition on Photo A, you're told it must go through a process that Photo B does not need.

   Question

   - What is this process,
   - Why is it necessary for Photo A but not Photo B
   - And what does this tell you about the nature of the data in Photo A?

2. You are restoring a historic painting by scanning it into a computer so art experts can study it remotely.

   - First, you decide how many points on the painting you'll measure for color — fewer points make the file smaller but might miss fine details.
   - Then, for each measured point, you decide how many distinct color levels you'll store - fewer levels make the file smaller but might cause visible color banding.

   Question

   Identify and explain the two separate decisions you are making in this process, and describe how each one affects the quality and file size of the digital image.

3. A photography lab notices that certain repetitive patterns (like brick walls or striped shirts) in digital photos often cause strange interference effects when resized, while random textures like clouds look fine.
   One technician proposes:

   "Instead of working with the picture as tiny colored dots, let's describe it as a combination of waves of different sizes and directions. Then we can remove or adjust the waves causing the problem before turning it back into a picture."

   Question

   What is the principle behind the technician's idea, and why would describing the image in this "wave-based" way help in detecting and fixing the interference patterns?

4. You are given an aerial photograph of a city taken in the early morning. The image looks hazy and uneven: some parts are very bright because of sunlight, while other areas are in deep shadow. Details like building edges are barely visible in darker areas.
   An engineer says:
   "Let's assume what we see is caused by two independent factors: the lighting that falls on the scene, and the way objects in the scene reflect that light. The lighting changes slowly across the image, but the reflectance changes rapidly in places where fine details exist. If we can somehow separate these two factors, we can reduce the lighting variations and enhance the details."

   Question

   - Propose a mathematical model for the image based on the engineer's description.
   - Show how to transform the model so that the multiplicative components become additive.
   - Derive the form of a filter in the frequency domain that would reduce the low-frequency lighting component while emphasizing the high-frequency detail component.
   - Explain the effect of filter parameters on the final processed image.

5. A crime scene photo was taken in a dimly lit alley at night.
   When viewed on a computer:

   - Most of the scene appears too dark - details in the shadows are almost invisible.
   - A few bright spots from a streetlamp appear very bright, but they don't contain useful detail.

The forensic analyst says:

"We need to apply a transformation that spreads out the values in the darker range to reveal hidden details, but at the same time compresses the values in the bright range so that the intense light from the streetlamp doesn't dominate the image. The transformation should be nonlinear and mimic how the human eye perceives brightness."

Question

- Propose a mathematical transformation $g = T(f)$ that meets the analyst's requirements, assuming pixel values f are in the range $[0, L-1]$.
- Explain briefly why this transformation is effective for scenes with very low-light details and a few bright highlights.