Question Paper

Exam Date & Time: 02-May-2024 (02:30 PM - 05:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

VI SEMESTER B.TECH. END SEMESTER EXAMINATION, APRIL-MAY 2024

DIGITAL IMAGE PROCESSING [BME 3252]

Marks: 50 **Duration: 180 mins.**

Descriptive

Answer all the questions.

* Read the questions carefully.
* Answer all questions.
* Assume the missing data suitably.
* Write neatly and legibly.
* Give suitable examples and draw graphs wherever necessary.

1) **A 256-level (8-bit) grayscale image is presented in Fig. 1 below.** If it were to be reduced to a 64-level (4-bit) representation, analyze the type of quantization error that would be introduced. Examine how this reduction in bit-depth impacts the image quality. (4)

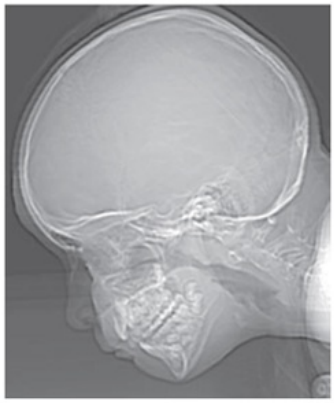

Fig. 1.

2) **A 2x2, 8-bit grayscale image is represented below in Fig. 2A.** Apply piece-wise linear transformation comprising of three segments to the given image using the following schema and enter the updated values of the pixels in the grid provided in Fig. 2B. Further, sketch the graph of the overall transformation function. (3)

Segment 1: For values in the range [0, 70], use the transformation: y=0.6x

Segment 2: For values in the range [70, 160], use the transformation: y=1.8(x−70)+42

Segment 3: For values in the range [160, 255], use the transformation: y=1.2(x−160)+180

75	110
180	240

Fig. 2A.

Fig. 2B.

3) **Plot the transformation function for a power law transformation.** Briefly explain how this transformation can be used to darken a gray-scale image. (3)

4) An image taken by the Hubble Telescope is presented in Fig. 3 below, containing four predominantly bright regions marked by white arrows **Apply a combination of appropriate image processing techniques to design an algorithm to extract only the bright regions from Fig. 3.** Post processing, the bright regions should be represented by 255 and the dark regions with 1. (3)

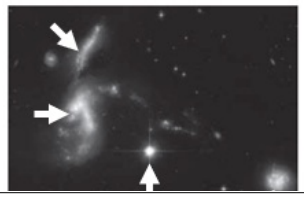

Fig. 3.

5) **A grayscale image was thresholded to produce a binary image.** This binary image has 4 distinct and connected regions in it. Apply your knowledge of connected component labelling to design an algorithm to represent these distinct regions with unique colours. (3)

6) **A single scan line (i.e. a row of pixels) from the 2d coordinate space of an image is shown below in Fig. 4.** (4)

i. Compute the values of its 1st and 2nd derivatives at each pixel.

ii. How can you use the values of the second derivative to find an edge in the given scan line?

Values of scan line	6	6	6	6	5	4	3	2	1	1	1	1	1	1	6	6	6	6	6	→ x

Fig. 4.

7) **The edge points of a straight line are shown using black dots in Fig. 5A.** What will these points look like in the parameter space? Plot your answer in Fig. 5B and briefly explain the rationale behind the plot drawn by you. Mention appropriate equations wherever applicable. (3)

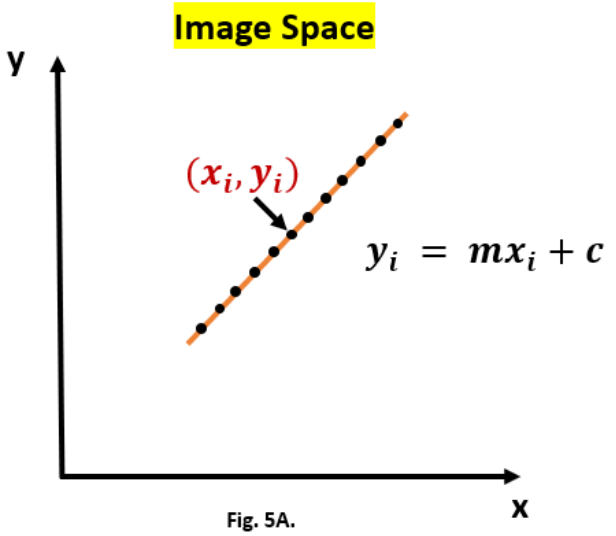

Fig. 5A.

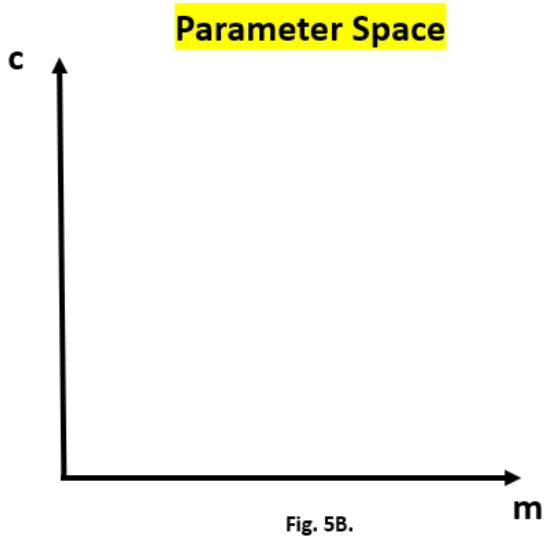

Fig. 5B.

8) **Design a line detection algorithm to detect straight lines in an image.** How can this algorithm be optimised to detect **(i)** significant lines only; **(ii)** to detect maximum number of lines in a given image? (4)

9) **A graphics studio wishes to process a batch of images** A sample input image is shown below in Fig. 6A, and the corresponding output image desired by the studio is represented in Fig. 6B. Analyse the given input and output images and design an algorithm using morphological image processing techniques (only) to obtain the desired output**.** (3)

Fig. 6A.

Fig. 6B.

10) **The following equation represents the 2D Discrete Fourier Transform (DFT).** Examine each of the variables in the given equation and write down what they represent. (2)

$$F(u,v) = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y) \cdot e^{-j2\pi\left(\frac{ux}{M} + \frac{vy}{N}\right)}$$

11) **Explain how the 2D Discrete Fourier Transform decomposes an image from the spatial domain to the frequency domain.** (3)

12) **A camera placed in a region of high seismic activity captures an image of a car driving by, as shown in Fig. 7** However, this image is corrupted by the (5)

presence of periodic noise resulting from vibrations. Apply your knowledge of frequency domain analysis and frequency domain filters to design an algorithm to remove the noise from the captured image.

Fig. 7.

13) **Design an algorithm to obtain a high-pass filtered image using the 2D Discrete Fourier Transform (DFT).** (4)

14) **A mobile app called "Reducto" employs the Discrete Cosine Transform (DCT) to share photos under constrained (slow) network conditions**Explain the key steps of how the DCT can be utilized to optimise (compress) image file sizes for faster upload speeds without significantly degrading visual quality. (4)

15) **Differentiate between the 2D DFT and 2D DCT**(any two points). (2)

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