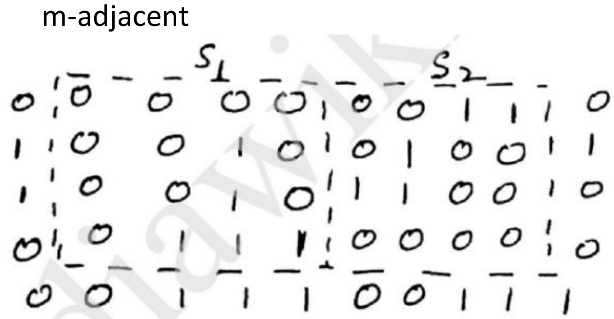
INTERNAL ASSESSMENT TEST I

Sub:	DIGITAL IMAGE PROCESSING							Code:	17EC72/15EC72
Date:	11/11/2021	Duration:	90 mins	Max Marks:	50	Sem:	VII	Branch:	ECE

<u>Answer any five full questions.</u>

	Questions	Marks	CO	RBT
1	With the help of a neat diagram, explain the components of general-purpose image processing system	[10]	CO1	L1
2	Explain how image is formed in human eye. Suppose a camera is focused at a tree of height 4 meters and situated at a distance of 20 meters. What will be the image height produced if the focal length of the camera is 20 cm.	[10]	CO1	L2
3(a)	Consider the two image subsets S_1 and S_2 as shown below. For $V = \{1\}$ determine whether these subsets are: (i) 4-adjacent (ii) 8-adjacent (iii) m-adjacent 	[02]	CO1	L3
3(b)	Explain the following terms: (i) Neighbors of pixels (ii) Distance metric (iii) Manhattan distance (iv) False contouring	[8]	CO1	L1
4(a)	Define m-adjacency. Compute the shortest 4, 8 and m-path between p and q for V={1,2,3,4}	[7]	CO1	L2

<table>
<tr><td></td><td><table><tr><td>5</td><td>1</td><td>3</td><td>1</td><td>(q)</td></tr><tr><td>2</td><td>3</td><td>0</td><td>2</td><td></td></tr><tr><td>1</td><td>2</td><td>1</td><td>3</td><td></td></tr><tr><td>1</td><td>0</td><td>1</td><td>2</td><td></td></tr></table>(p)</td><td></td><td></td><td></td></tr>
<tr><td>4(b)</td><td>Find the time required (in seconds) to send an image of size 2.5``X 3`` scanned at 75 dpi sent at 64 kilobits per second.</td><td>[3]</td><td>CO1</td><td>L2</td></tr>
<tr><td>5(a)</td><td>Let p and q be two pixels at coordinates (90,82) and (100, 40). Find the Euclidean distance, City block distance and D_8 distance</td><td>[6]</td><td>CO1</td><td>L3</td></tr>
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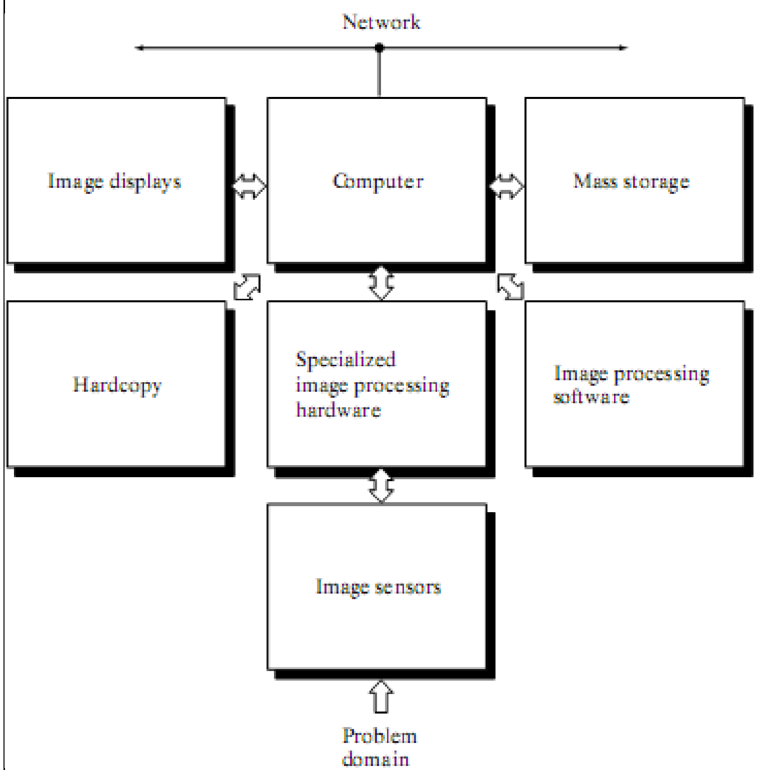
<tr><td>6</td><td>Explain any three of the following terms as applicable to image processing using proper graphs:
i) Brightness adaptation
ii) Weber ratio
iii) Mach bands
iv) Bicubic interpolation</td><td>[10]</td><td>CO1</td><td>L1</td></tr>
</table>

Solution and Scheme for INTERNAL ASSESSMENT TEST I

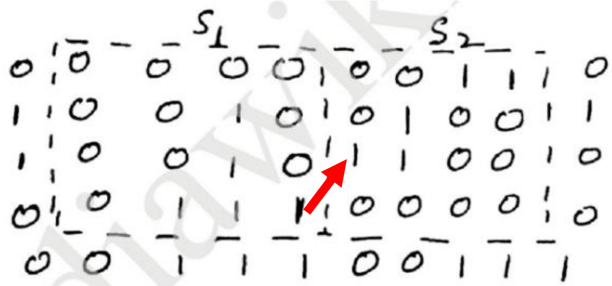
Digital Image Processing 18EC533

	Questions and Answers		Marks
1	With the help of a neat diagram, explain the components of general-purpose image processing system Figure 1 shows the basic components of a general-purpose image processing system. The function of each component is discussed in the following paragraphs, starting with image sensing.		[10]

	 	2	
	1. **Image sensing**: Two elements are required to acquire digital images, the first is a physical device that is sensitive to the energy radiated by the object we wish to image. The second, called a digitizer, is a device for converting the output of the physical sensing device into digital form.	1	
	2. **Specialized image processing hardware**: Specialized image processing hardware usually consists of the digitizer just mentioned, plus hardware that performs other primitive operations, such as an arithmetic logic unit (ALU), which performs arithmetic and logical operations in parallel on entire images. One example of how an ALU is used is in averaging images as quickly as they are digitized, for the purpose of noise reduction. This type of hardware sometimes is called a front-end subsystem, and its most distinguishing characteristic is speed.	1	
	3. **Computer:** The computer in an image processing system is a general-purpose computer and can range from a PC to a supercomputer. In dedicated applications, sometimes specially designed computers are used to achieve a required level of performance.	1	
	4. **Image processing software:** Software for image processing consists of specialized modules that perform specific tasks. A well-designed package also includes the capability for the user to write code that, as a minimum, utilizes the specialized modules. More sophisticated software packages allow the integration of those modules and general-purpose software commands from at least one computer language.	1	

	5. Mass storage: Mass storage capability is a must in image processing applications. An image of size 1024*1024 pixels, in which the intensity of each pixel is an 8-bit quantity, requires one megabyte of storage space if the image is not compressed. When dealing with thousands, or even millions, of images, providing adequate storage in an image processing system can be a challenge. Digital storage for image processing applications falls into three principal categories: (1) short-term storage for use during processing, (2) on-line storage for relatively fast re-call, and (3) archival storage, characterized by infrequent access. Storage is measured in bytes (eight bits), Kbytes (one thousand bytes), Mbytes (one million bytes), Gbytes (meaning giga, or one billion, bytes), and Tbytes (meaning tera, or one trillion, bytes). One method of providing short-term storage is computer memory. Another is by specialized boards, called frame buffers, that store one or more images and can be accessed rapidly, usually at video rates (e.g., at 30 complete images per second). The latter method allows virtually instantaneous image zoom, as well as scroll (vertical shifts) and pan (horizontal shifts). Frame buffers usually are housed in the specialized image processing hardware unit shown in Fig.1. Online storage generally takes the form of magnetic disks or optical-media storage. The key factor characterizing on-line storage is frequent access to the stored data. Finally, archival storage is characterized by massive storage requirements but infrequent need for access. Magnetic tapes and optical disks housed in –jukeboxes are the usual media for archival applications. 6. **Image Display:** Image displays in use today are mainly color (preferably flat screen) TV monitors. Monitors are driven by the outputs of image and graphics display cards that are an integral part of the computer system. Seldom are there requirements for image display applications that cannot be met by display cards available commercially as part of the computer system. In some cases, it is necessary to have stereo displays, and these are implemented in the form of headgear containing two small displays embedded in goggles worn by the user. 7. **Hardcopy:** Hardcopy devices for recording images include laser printers, film cameras, heat-sensitive devices, inkjet units, and digital units, such as optical and CD-ROM disks. Film provides the highest possible resolution, but paper is the obvious medium of choice for written material. For presentations, images are displayed on film transparencies or in a digital medium if image projection equipment is used. The latter approach is gaining acceptance as the standard for image presentations.	1 1 1	

	8. **Networking:** Networking is almost a default function in any computer system in use today. Because of the large amount of data inherent in image processing applications, the key consideration in image transmission is bandwidth. In dedicated networks, this typically is not a problem, but communications with remote sites via the Internet are not always as efficient. Fortunately, this situation is improving quickly as a result of optical fiber and other broadband technologies.	1	
2	Explain how image is formed in human eye. Suppose a camera is focused at a tree of height 4 meters and situated at a distance of 20 meters. What will be the image height produced if the focal length of the camera is 20 cm. The principal difference between the lens of the eye and an ordinary optical lens is that the former is flexible. The radius of curvature of the anterior surface of the lens is greater than the radius of its posterior surface. The shape of the lens is controlled by tension in the fibers of the ciliary body. To focus on distant objects, the controlling muscles cause the lens to be relatively flattened. Similarly, these muscles allow the lens to become thicker in order to focus on objects near the eye. The distance between the center of the lens and the retina (called the focal length) varies from approximately 17 mm to about 14 mm, as the refractive power of the lens increases from its minimum to its maximum. When the eye focuses on an object farther away than about 3 m, the lens exhibits its lowest refractive power. When the eye focuses on a nearby object, the lens is most strongly refractive. This information makes it easy to calculate the size of the retinal image of any object. The retinal image is reflected primarily in the area of the fovea. Perception then takes place by the relative excitation of light receptors, which transform radiant energy into electrical impulses that are ultimately decoded by the brain. Height of the image /focal length of the camera=height of the object/ distance of the object from the camera h/20=4/20 h=4cm therefore, the height of the image will be 4 cm.	8 2	[10]
3(a)	Consider the two image subsets $S_1$and S_2 as shown below. For $V = \{1\}$ determine whether these subsets are: (iv) 4-adjacent (v) 8-adjacent (vi) m-adjacent	[02]	[02]

<table>
<tr><td></td><td>
S1 and S2 are 8-adjacent with V={1}
</td><td></td><td></td></tr>
<tr><td>3(b)</td><td>Explain the following terms:
(v) Neighbors of pixels
(vi) Distance metric
(vii) Manhattan distance
(viii) False contouring

1) Neighbors of pixels: A pixel p at coordinates (x, y) has four horizontal and vertical neighbors whose coordinates are given by (x+1, y), (x-1, y), (x, y+1), (x, y-1). This set of pixels, called the 4-neighbors of p, is denoted by N_4 (p). Each pixel is a unit distance from (x, y), and some of the neighbors of p lie outside the digital image if (x, y) is on the border of the image.

The four diagonal neighbors of p have coordinates (x+1, y+1), (x+1, y-1), (x-1, y+1), (x-1, y-1) and are denoted by N_D (p). These points, together with the 4-neighbors, are called the 8- neighbors of p, denoted by N_8 (p). As before, some of the points in N_D (p) and N_8 (p) fall outside the image if (x, y) is on the border of the image.
2) Distance metric: For pixels p, q, and z, with coordinates (x, y), (s, t), and (v, w), respectively, D is a distance function or metric if

$$\begin{aligned}&\textbf{(a)}\ D(p,q) \geq 0 \quad (D(p,q) = 0 \quad \text{iff} \quad p = q),\\ &\textbf{(b)}\ D(p,q) = D(q,p), \text{ and}\\ &\textbf{(c)}\ D(p,z) \leq D(p,q) + D(q,z).\end{aligned}$$

3) Manhattan Distance: The D_4 distance (also called city-block distance or Manhattan distance) between p and q is defined as

$$D_4(p,q) = |x - s| + |y - t|.$$</td><td>2

2

2</td><td>[8]</td></tr>
</table>

In this case, the pixels having a D_4 distance from (x, y) less than or equal to some value r form a diamond centered at (x, y). For example, the pixels with D_4 distance ≤ 2 from (x, y) (the center point) form the following contours of constant distance:

		2		
	2	1	2	
2	1	0	1	2
	2	1	2	
		2		

The pixels with D_4 =1 are the 4-neighbors of (x, y).

4) **False Contouring:** Decreasing the gray-level resolution of a digital image may result in what is known as false contouring. This effect is caused by the use of an insufficient number of gray levels in smooth areas of a digital image.

2

4(a) Define m-adjacency. Compute the shortest 4, 8 and m-path between p and q for V={1,2,3,4} [7]

	5	1	3	1	(q)
	2	3	0	2	
	1	2	1	3	
(p)	1	0	1	2	

m-adjacency: Let V be the set of gray-level values used to define adjacency. In a binary image, V={1} if we are referring to adjacency of pixels with value 1. In a grayscale image, the idea is the same, but set V typically contains more elements. For example, in the adjacency of pixels with a range of possible gray-level values 0 to 255, set V could be any subset of these 256 values. There are three types of adjacencies: 4-adjacency, 8-adjacency, and m-adjacency or mixed adjacency. M-adjacency is defined as follows:

Two pixels p and q with values from V are m-adjacent if

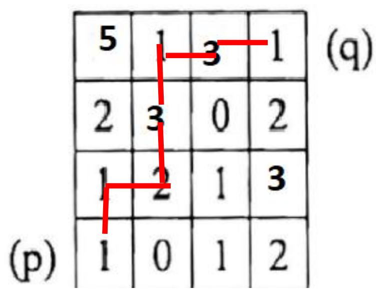
1

(i) q is in N_4 (p), or

(ii) q is in N_D (p) and the set has no pixels whose values are from V.

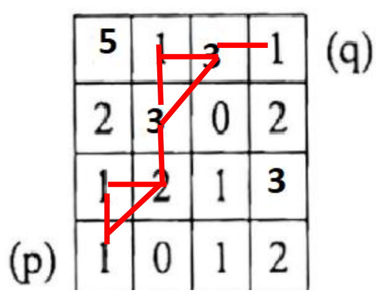
Mixed adjacency is a modification of 8-adjacency. It is introduced to eliminate the ambiguities that often arise when 8-adjacency is used.

Shortest 4-path between p and q is : p,(4,1),(3,1),(3,2),(2,2),(1,2),(1,3),(1,4),q



2

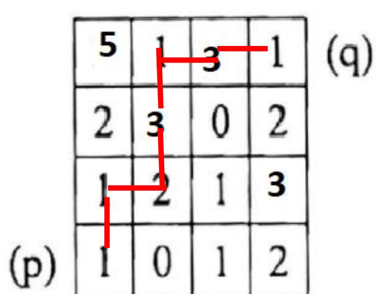
Shortest 8-path between p and q is :



2

Shortest m-path between p and q is : p,(4,1),(3,1),(3,2),(2,2),(1,2),(1,3),(1,4),q

2



Q. No.			
4(b)	Find the time required (in seconds) to send an image of size 2.5``X 3`` scanned at 75 dpi sent at 64 kilobits per second. Size of the image is: (2.5*3)*75*75*1 bits (Assuming the image to be binary) =42187.5 bits Time required to send thi image at a rate of 64kB/s= 0.6592sec	[3]	[3]

5(a) [6]

Let p and q be two pixels at coordinates (90,82) and (100, 40). Find the Euclidean distance, City block distance and D_8 distance

Euclidean Distance between pixel (x,y) and (s,t) is: — 2

$$D_e(p,q) = [(x-s)^2 + (y-t)^2]^{\frac{1}{2}}$$

For x=90, y=82, s=100 and t=40

$$D_e(p,q) = [(90-100)^2 + (82-40)^2]^{\{\frac{1}{2}\}} = 43.174$$

City Block Distance between pixel (x,y) and (s,t) is: — 2

$$D_4(p,q) = |x-s| + |y-t| = 52$$

D_8 Distance between pixel (x,y) and (s,t) is: — 2

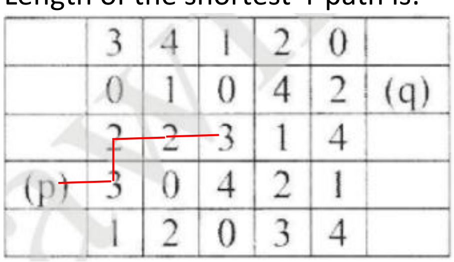
$$D_8(p,q) = \max(|x-s|, |y-t|) = 42$$

5(b) [4] [4]

Consider the image given below, let V={2,3,4} compute the length of shortest 4,8 and m path between ‘p’ and ‘q’. If path does not exists explain why?

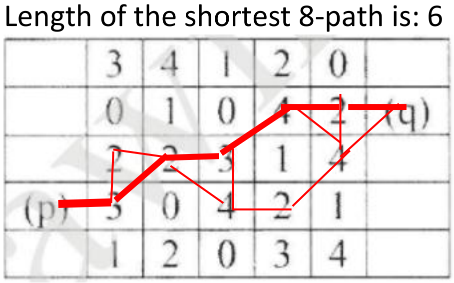
	3	4	1	2	0	
	0	1	0	4	2	(q)
	2	2	3	1	4	
(p)	3	0	4	2	1	
	1	2	0	3	4	

Length of the shortest 4-path is:



4-path does not exist because $N_4(3) \cap N_{4(2)} = \emptyset$

Length of the shortest 8-path is: 6



Length of the shortest m-path is: 7

	3	4	1	2	0	
	0	1	0	4	2	(q)
	2	2	3	1	4	
(p)	3	0	4	2	1	
	1	2	0	3	4	

[10]

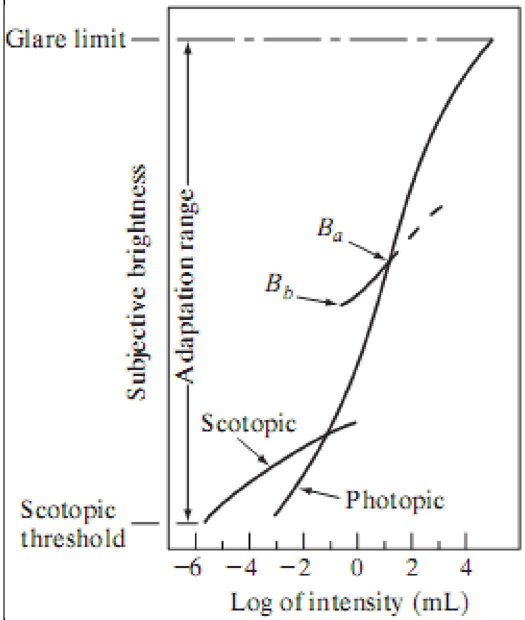
6

Explain any three of the following terms as applicable to image processing using proper graphs:

v) Brightness adaptation
vi) Weber ratio
vii) Mach bands
viii) Bicubic interpolation

2.5

Brightness adaptation: Because digital images are displayed as a discrete set of intensities, the eye's ability to discriminate between different intensity levels is an important consideration in presenting image- processing results. The range of light intensity levels to which the human visual system can adaptis enormous—on the order of 10^{10}—from the scotopic threshold to the glare limit. Experimental evidence indicates that subjective brightness (intensity as perceived by the human visual system)is a logarithmic function of the light intensity incident on the eye. Figure 4.3, a plot of light intensity versus subjective brightness, illustrates this characteristic. The long solid curve represents the range of intensities to which the visual system can adapt. In photopic vision alone, the range is about 10^6. The transition from scotopic to photopic vision is gradual over the approximate range from 0.001 to 0.1 millilambert (–3 to –1 mL in the log scale), as the double branches of the adaptation curve in this range show.



2.5

Weber Ratio:

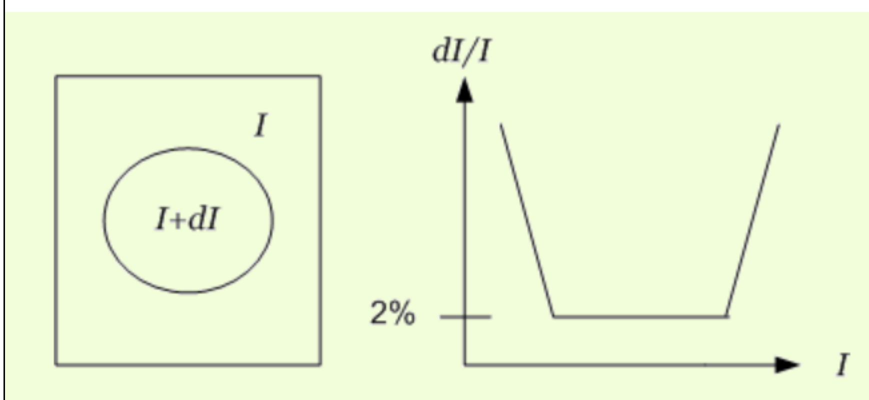


Fig.3

2.5

Consider a spot of intensity I+dI in a background intensity I, as shown I Fig. 3. dI is increased from 0 until it becomes noticeable. The ratio dI/I is called the Weber ratio, which is nearly constant of about 2% over a wide range of illumination levels, except for very high and low levels.

Mach bands: The brightness of a region, as perceived by the eye, depends on factors other than simply the light reflected by the region. For example, intensity variations (Mach bands) can be perceived in an area of constant intensity. Such phenomena result from the fact that the eye does not respond with equal sensitivity to all visual information. Certain information simply has less relative importance than other information in normal visual processing. Two phenomena clearly demonstrate that the perceived brightness is not simply a function of intensity. The first is based on the fact that the visual system tends to overshoot or undershoot around the boundary of region of different intensities. Fig. 4 shows a striking example of this phenomenon. Although the intensity of stripes is constant, we actually perceive a brightness pattern that is strongly scalloped near the boundaries. These seemingly scalloped bands are called

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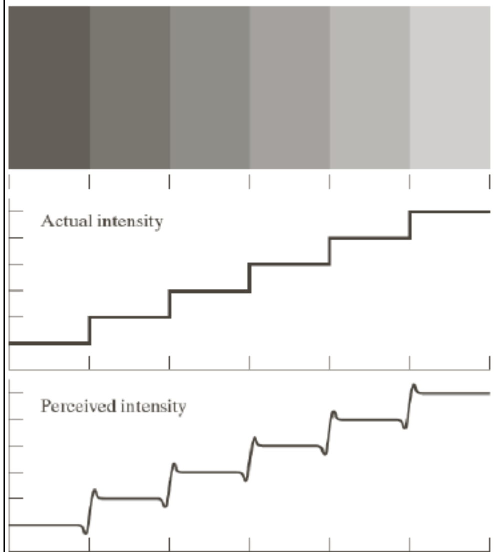
Mach bands after Ernst Mach, which first described the phenomenon in 1865.



Bicubic interpolation:

Image interpolation is a basic tool used extensively in tasks such as zooming, shrinking, rotating, and geometric corrections. Fundamentally, interpolation is the process of using known data to estimate values at unknown locations. Bicubic interpolation use the sixteen nearest neighbors of a point to estimate the unknown value. The intensity level assigned to point (x,y) is obtained using the following equation:

$$v(x,y) = \sum_{i=0}^{3}\sum_{j=0}^{3} a_{ij}x^{i}y^{j}$$

Where the sixteen coefficients are determined from the 16 equations in 16 unknowns that can be formed using 16 nearest neighbors of (x,y).

Bicubic interpolation is used in commercial image editing programs such as Adobe Photoshop and Corel Photopaint.
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