USN

Internal Assessment Test 3 – May 2024

Sub:	Digital Image Processing			Sub Code:	21EC722	Branch:	ECE
Date:	16-10-2024	Duration:	90 min's	Max Marks: 50	Sem / Sec:	7 – A, B, C, D	OBE

	Answer any FIVE FULL Questions	MARKS	CO	RBT
1.	With the help of neat block diagram ,explain the components of digital image processing system.	[10]	CO1	L1
2.	Discuss Brightness adaptatioon and Discrimination and plot the typical weber ratio curves.	[10]	CO1	L1
3.	Let p and q are the two pixels at coordinates (120,140) and (150,170) respectively. Compute i) Euclidean distance ii) Chess Board distance iii)Manhattan distance.	[10]	CO1	L2
4.	Consider the image segment shown, Set V={0, 1}, compute the lengths of shortest 4,8 and m-path between p and q. If path does not exist between p and q, explain why? Repeat forV={1, 2}.	[10]	CO1	L2
5.	Predict the 2D – Discrete Cosine Transform matrix for N =2.	[10]	CO2	L2
6.	List out the properties of 2D – Discrete Fourier Transform. Explain any one property with suitable expressions.	[10]	CO2	L2
7.	Discuss about the Haar Transform with relevant mathematical expressions.	[10]	CO2	L3
8.	Predict the 2D -Haar Transformation matrx for N=2.	[10]	CO2	L3

Image segment for Question 4:

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

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Internal Assessment Test 3 – May 2024

Sub:	Network Security			Sub Code:	21EC722	Branch:	ECE
Date:	16-10-2024	Duration:	90 min's	Max Marks: 50	Sem / Sec:	7– A, B, C, D	OBE

	Answer any FIVE FULL Questions	MARKS	CO	RBT
1.	With the help of neat block diagram ,explain the components of digital image processing system.	[10]	CO1	L1
2.	Discuss Brightness adaptatioon and Discrimination and plot the typical weber ratio curves.	[10]	CO1	L1
3.	Let p and q are the two pixels at coordinates (100,120) and (130,160) respectively. Compute i) Euclidean distance ii) Chess Board distance iii)Manhattan distance.	[10]	CO1	L2
4.	Consider the image segment shown, Set V={0, 1}, compute the lengths of shortest 4,8 and m-path between p and q. If path does not exist between p and q, explain why? Repeat forV={1, 2}.	[10]	CO1	L2
5.	Predict the 2D – Discrete Cosine Transform matrix for N =4.	[10]	CO2	L2
6.	List out the properties of 2D – Discrete Fourier Transform. Explain any one property with suitable expressions.	[10]	CO2	L2
7.	Discuss about the Haar Transform with relevant mathematical expressions.	[10]	CO2	L3
8.	Predict the 2D -Haar Transformation matrx for N=2.	[10]	CO2	L3

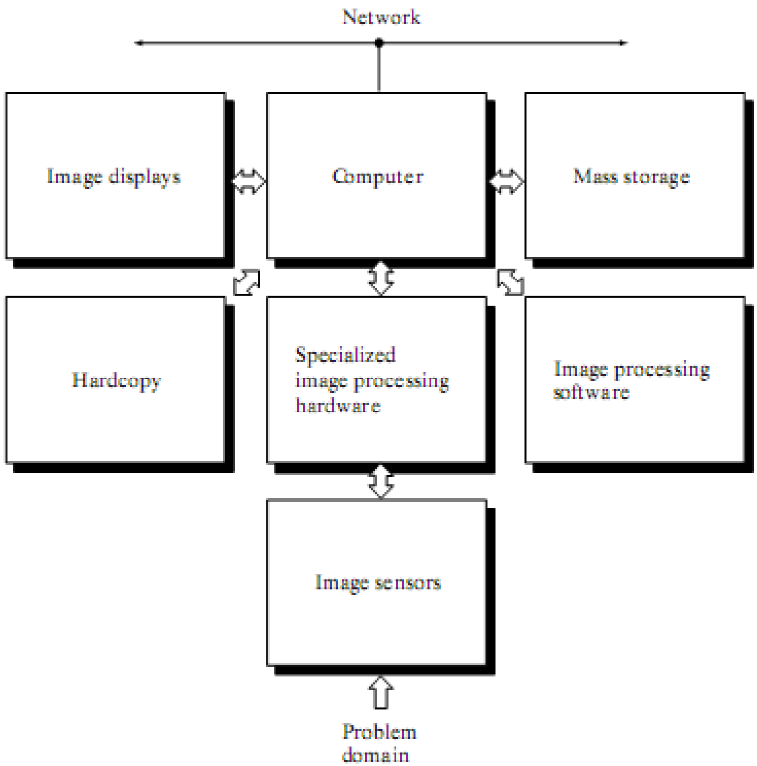
Image segment for Question 4:

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

Ques. 1: With the help of neat block diagram ,explain the components of digital image processingsystem.

Components of an Image Processing System:

As recently as the mid-1980s, numerous models of image processing systems being sold throughout the world were rather substantial peripheral devices that attached to equally substantial host computers. Late in the 1980s and early in the 1990s, the market shifted to image processing hardware in the form of single boards designed to be compatible with industry standard buses and to fit into engineering workstation cabinets and personal computers. In addition to lowering costs, this market shift also served as a catalyst for a significant number of new companies whose specialty is the development of software written specifically for image processing.



Although large-scale image processing systems still are being sold for massive imaging applications, such as processing of satellite images, the trend continues toward miniaturizing and blending of general-purpose small computers with specialized image processing hardware. Figure 3 shows the basic components comprising a typical general-purpose system used for digital image processing. The function of each component is discussed in the following paragraphs, starting with image sensing.

With reference to 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 intodigital form. For instance, in a digital video camera, the sensors produce an electrical output proportional to light intensity. The digitizer converts these outputs to digital data.

Specialized image processing hardware usually consists of the digitizer just mentioned, plushardware *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. In other words, this unit performs functions that require fast data throughputs (e.g., digitizing and averaging video images at 30 framess) that the typical main computer cannot handle. The computer in an image processing system is a general-purpose computer and can range froma PC to a supercomputer. In dedicated applications, some times specially designed computers are used to achieve a required level of performance, but our interest here is on general-purpose*

image processing systems. In these systems, almost any well-equipped PC-type machine is suitable for offline image processing tasks.

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.

*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.3.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.*

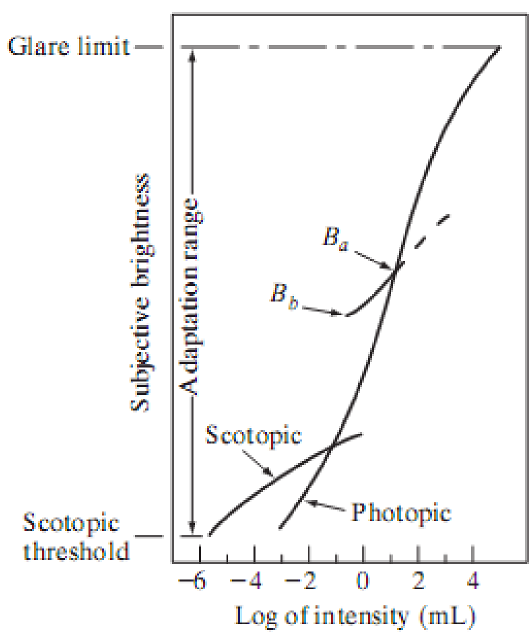
Image displays in use today are mainly color (preferably flat screen) TV monitors. Monitors are driven by the outputs of image and graphics display cards that are an integral part of the computer system. Seldom are there requirements for image display applications that cannot bemet by display cards available 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.

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.

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.*

2. Discuss Brightness adaptatioon and Discrimination and plot the typical weber ratio curves.

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 adapt is 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 theapproximate 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.



Range of Subjective brightness sensations showing a particular adaptation level

The essential point in interpreting the impressive dynamic range depicted in Fig.4.3 is that the visual system cannot operate over such a range simultaneously. Rather, it accomplishes this large variation by changes in its overall sensitivity, a phenomenon known as brightness adaptation. The total range of distinct intensity levels it can discriminate simultaneously is rather small when compared with the total adaptation range. For any given set of conditions, the current sensitivity level of the visual system is called the brightness adaptation level, which may correspond, for example, to brightness Ba in Fig. 4.3. The short intersecting curve represents the range of subjective brightness that the eye can perceive when adapted to this level. This range is rather restricted, having a level Bb at and below which all stimuli are perceived as indistinguishable blacks. The upper (dashed) portion of the curve is not actually restricted but, if extended too far, loses its meaning because much higher intensities would simply raise the adaptation level higher than Ba.

3.Let p and q are the two pixels at coordinates (120,140) and (150,170) respectively. Compute i) Euclidean distance ii) Chess Board distance iii)Manhattan distance.

Answer: Euclidean distance: $\sqrt{(150-120)^2+(170-140)^2} = 30\sqrt{2}$

Manhattan distance = $|150-120| + |170-140| = 60$

Chessboard distance= max(l150-120l,l170-140l) = 30.

4. Consider the image segment shown, Set V={0,1}, compute the lengths of shortest 4,8 and m-path between p and q. If path does not exist between p and q, explain why? Repeat forV={1,2}.

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

Answer:

(A) 2	(B) 3	(C) 2	1(q)
(D) 2	(E) 2	(F) 0	(G) 2
(H) 1	(I) 2	(J) 1	(K) 1
1(p)	(L)0	(M)1	(N)2

The 4-path between p and q does not exist of V={0,1}. The 8 path and m-path between p and q is given as pLJFq (length 4). For 8-path there is another path pLMJF1; however, it is not the shortest path.

One 8-path for V{1,2} is pHDEC1, another path (m-path) is pIEC2.

5. Predict the 2D – Discrete Cosine Transform matrix for N =2.

The DCT (discrete cosine transform) was first proposed by Ahmed et al. [3] in 1974. The discrete cosine transform is highly suitable for transform coding of images. The main reason is that the decorrelation property of the DCT is almost as good as for the optimal transform, the Karhunen–Loéve transform (1947), but the DCT is much simpler from a computational point of view, since it is independent of the signal.

There exist several types of DCTs: even, odd, symmetric, and the modified symmetric DCT. They possess slightly different properties which are of relevance for image coding applications. In fact, only the even DCT and modified symmetric DCT are suitable for image coding [27, 30, 34, 37].

3.19.1 EDCT (Even Discrete Cosine Transform)

The EDCT (even discrete cosine transform) is defined as

$$Xk \triangleq \sqrt{\frac{2}{N}} \sum_{n=0}^{N-1} c_k xn \cos\frac{\pi 2n+1k}{2N}, \quad k = 0, 1, \dots, N-1 \qquad (3.23)$$

Note that the denominator of the cosine term is an even number. This transform is also called DCT-II. The IEDCT (Inverse EDCT) is

$$xn = \sqrt{\frac{2}{N}} \sum_{k=0}^{N-1} c_k Xk \cos\frac{\pi 2n+1k}{2N}, n = 0, 1, \dots \mathrm{N}-1 \qquad (3.24)$$

where

Youtube Link: https://youtu.be/GB6Pxf2nvRI

Question 6; List out the properties of 2D – Discrete Fourier Transform. Explain any one property with suitable expressions.

Answer: The properties of 2D transform are enlisted in the next page. Among those, we prove the convolution theorem.

$$x(m,n) * y(m,n) = \sum_{s,t} x(s,t) y(m-s, n-t).$$

This leads to:

$F[x(m,n) * y(m,n)] = X(l,k)Y(l,k)$ *as*

$$\sum_{s,t} x(s,t)y(m-s,n-t)\exp\Big(-j*\frac{2\pi(m-s)l}{N} - j\frac{2\pi(n-t)k}{N}\Big)\exp\Big(-j*\frac{2\pi(s)l}{N} - j\frac{2\pi(t)k}{N}\Big)$$

Name	Expression(s)
1) Discrete Fourier transform (DFT) of $f(x,y)$	$F(u,v) = \sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)e^{-j2\pi(ux/M+vy/N)}$
2) Inverse discrete Fourier transform (IDFT) of $F(u,v)$	$f(x,y) = \frac{1}{MN}\sum_{u=0}^{M-1}\sum_{v=0}^{N-1} F(u,v)e^{j2\pi(ux/M+vy/N)}$
3) Spectrum	$\lvert F(u,v)\rvert = \left[R^2(u,v) + I^2(u,v)\right]^{1/2}$ $R = \text{Real}(F);\ I = \text{Imag}(F)$
4) Phase angle	$\phi(u,v) = \tan^{-1}\left[\frac{I(u,v)}{R(u,v)}\right]$
5) Polar representation	$F(u,v) = \lvert F(u,v)\rvert e^{j\phi(u,v)}$
6) Power spectrum	$P(u,v) = \lvert F(u,v)\rvert^2$
7) Average value	$\bar{f} = \frac{1}{MN}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y) = \frac{1}{MN}F(0,0)$
8) Periodicity (k_1 and k_2 are integers)	$F(u,v) = F(u+k_1M, v) = F(u, v+k_2N) = F(u+k_1, v+k_2N)$ $f(x,y) = f(x+k_1M, y) = f(x, y+k_2N) = f(x+k_1M, y+k_2N)$
9) Convolution	$(f \star h)(x,y) = \sum_{m=0}^{M-1}\sum_{n=0}^{N-1} f(m,n)h(x-m, y-n)$
10) Correlation	$(f \,☆\, h)(x,y) = \sum_{m=0}^{M-1}\sum_{n=0}^{N-1} f^*(m,n)h(x+m, y+n)$
11) Separability	The 2-D DFT can be computed by computing 1-D DFT transforms along the rows (columns) of the image, followed by 1-D transforms along the columns (rows) of the result. See Section 4.11.
12) Obtaining the IDFT using a DFT algorithm	$MNf^*(x,y) = \sum_{u=0}^{M-1}\sum_{v=0}^{N-1} F^*(u,v)e^{-j2\pi(ux/M+vy/N)}$ This equation indicates that inputting $F^*(u,v)$ into an algorithm that computes the forward transform (right side of above equation) yields $MNf^*(x,y)$. Taking the complex conjugate and dividing by MN gives the desired inverse. See

7. Discuss about the Haar Transform with relevant mathematical expressions.

The Haar Transform

The starting point for the definition of the Haar transform is the Haar functions $h_k(z)$, which are defined in the closed interval $[0,1]$. The order k of the function is uniquely decomposed into two integers p, q

$$k = 2^p = q - 1, \; k = 0,1......, L-1, \; and \; L = 2^n \quad (4.6.1)$$

where

$0 \le p \le n-1, 0 \le q \le 2^p$ for $p \ne 0$ and $q = 0$ or 1 for $p = 0$

Table (4.5.1) summarizes the respective values for $L = 8$. The Haar functions are

$$h_0(z) \equiv h_{00}(z) = \frac{1}{\sqrt{L}}, \; z \in [0,1]$$

$$h_k(z) \equiv h_{pq}(z) = \frac{1}{\sqrt{L}} \begin{cases} 2^{\frac{p}{2}} & \frac{q-1}{2^p} \le z < \frac{q-1}{2^p} \\ -2^{\frac{p}{2}} & \frac{q-1}{2^p} \le z < \frac{q}{2^p} \\ 0 & otherwise \, in \, [0,1] \end{cases} \quad (4.6.2)$$

Table (4.5.1): Parameters for the Haar functions

K	0	1	2	3	4	5	6	7
P	0	0	1	2	2	2	2	2
q	0	1	1	1	1	1	3	4

The Haar transform matrix of order L consists of rows resulting from the preceding functions computed at the points $z = m/L$, $m = 0,1,2,..., L-1$. For example, the 8 x 8 transform matrix is

$$H = \frac{1}{\sqrt{8}}\begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 \\ \sqrt{2} & \sqrt{2} & -\sqrt{2} & -\sqrt{2} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \sqrt{2} & \sqrt{2} & -\sqrt{2} & -\sqrt{2} \\ 2 & -2 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 2 & -2 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 2 & -2 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 2 & -2 \end{bmatrix} \quad (4.6.3)$$

t is not difficult to see that $H^{-1} = H^{T}$ that is H is orthogonal.

'he energy packing properties of the Haar transform are not very good. However, its importance for us lies beyond hat. We will use it as the vehicle to take us from the world of unitary transforms to that of multiresolution analysis. To his end, let us look carefully at the Haar transform matrix. We readily observe its sparse nature with a number of :eros, whose location reveals an underlying cyclic shift mechanism. To satisfy our curiosity as to why this happens, let is look at the haar transform from a different perspective

8. Predict the 2D -Haar Transformation matrx for N=2.

The Haar Transform Matrix

The N Haar functions can be sampled at $t = m/N$, where $m = 0, \cdots, N-1$ to form an N by N matrix for discrete Haar transform. For example, when $N = 2$, we have

$$\mathbf{H}_2 = \frac{1}{\sqrt{2}} \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

when $N = 4$, we have

$$\mathbf{H}_4 = \frac{1}{2} \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ \sqrt{2} & -\sqrt{2} & 0 & 0 \\ 0 & 0 & \sqrt{2} & -\sqrt{2} \end{bmatrix}$$

and when $N = 8$

$$\mathbf{H}_8 = \frac{1}{\sqrt{8}} \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 \\ \sqrt{2} & \sqrt{2} & -\sqrt{2} & -\sqrt{2} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \sqrt{2} & \sqrt{2} & -\sqrt{2} & -\sqrt{2} \\ 2 & -2 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 2 & -2 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 2 & -2 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 2 & -2 \end{bmatrix} \begin{matrix} \varphi_0(t) \\ \psi_0(t) \\ \psi_{1,0}(t) \\ \psi_{1,1}(t) \\ \psi_{2,0}(t) \\ \psi_{2,1}(t) \\ \psi_{2,2}(t) \\ \psi_{2,3}(t) \end{matrix}$$

Youtube Video link: https://youtu.be/QxTRYE4tGtk