CMR INSTITUTE OF TECHNOLOGY

USN | | | | | | | | | |

Internal Assessment Test 1 –March 2018

Sub:	Image Processing							Code:	15TE655
Date:	/03/2017	Duration:	90 mins	Max Marks:	50	Sem:	6	Branch:	TCE

Answer Any Five Full Questions

		Marks	OBE CO	OBE RBT
1	With a neat block diagram, explain the fundamental steps in Digital Image Processing.	10	CO1	L4
2	With a neat block diagram, explain the components of an Image Processing System.	10	CO1	L4
3	Explain the following terms as applied to Image Processing with necessary graphs: Brightness adaptation, weber's ratio, Mach bands, distance measure.	10	CO1	L4
4	Consider the image segment in Fig.4: i) Let V= {0,1}. Calculate the length of shortest 4, 8 and m paths between p and q. ii) Repeat for V= {1,2}. 3 1 2 1 2 2 0 2 1 2 1 1 1 0 1 2 Fig. 4	10	CO1	L3
5	Explain Image acquisition using sensor using sensor arrays.	10	CO1	L4
6	Explain the Piecewise Linear transformations functions.	10	CO2	L4
7	Explain the following terms with reference to Image Processing: Image Negatives, Log Transformations, Power-Law Transformations and Histogram.	10	CO2	L4

1 With a neat block diagram, explain the fundamental steps in Digital Image Processing. 10 CO1 L4

Soln:

1.2 Fundamental Steps in Digital Image Processing

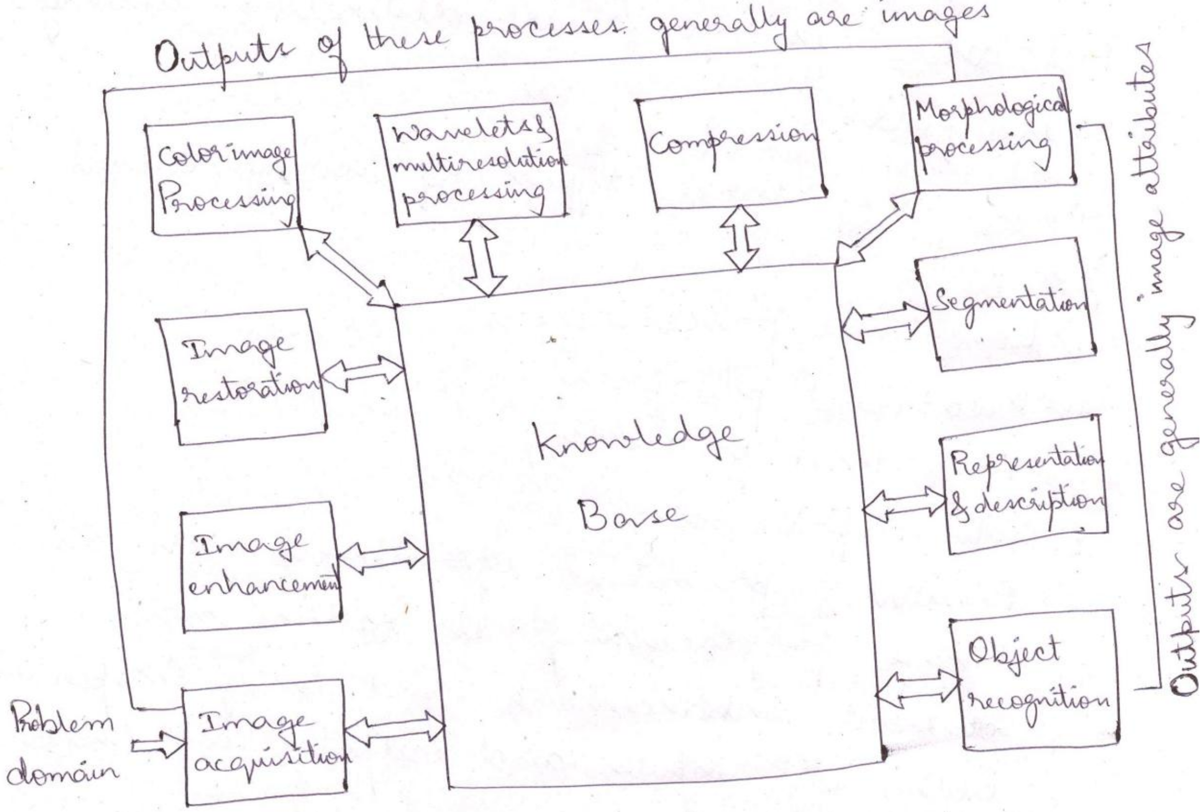


fig: Fundamental steps in DIP.

i) Image acquisition: The first process.

a) Acquisition can be as simple as being given an image that is already in digital form.

b) This stage involves preprocessing such as scaling.

ii) Image enhancement :

a) Simplest areas of DIP.

b) The idea behind enhancement techniques is to bring out detail that is obscured, or simply to highlight certain features of interest in an image.

c) eg: when we increase the contrast of an image "it looks better". This is enhancement.

d) Enhancement is a very subjective area of image processing.

iii) Image restoration :

a) Area that deals with improving the appearance of an image.

b) Image restoration is objective.

c) Restoration techniques are based on mathematical or probabilistic models of image degradation.

iv) Color image processing :

a) Basis for extracting features of interest in an image.

b) This area is of importance because of the usage of digital images over the internet.

v) Wavelets and Multiresolution processing:

a) Wavelets are the foundation for representing images in various degrees of resolution.

b) This is used for image data compression and for pyramidal representation, in which images are successively subdivided into smaller regions.

vi) Compression:

a) Deals with techniques for reducing the storage required to save an image or bandwidth required to transmit it.

b) eg: JPEG compression standard

vii) Morphological processing:

a) Deals with tools for extracting image components that are useful in the representation and description of shape.

viii) Segmentation:

a) Partitions an image into its constituent parts or objects.

b) Autonomous Segmentation is one of the most difficult tasks in DIP.

c) A rugged segmentation procedure brings the process a long way toward successfully solution of imaging problems that require objects to be identified individually

d) A weak or erratic segmentation algorithms almost always guarantee eventual failure.

e) More accurate the segmentation, the more likely recognition is to succeed.

ix) Representation and description:

a) Always follows the output of a segmentation stage, which is usually a raw pixel data, contituting either the boundary of the region or all the points in the region itself.

b) The first decision that must be made is whether the data should be represented as a boundary or as a complete region.

c) ~~Representation~~

c) Description is also called feature selection and deals with extracting attributes that result in some quantitative information of interest.

x) Recognition:

a) Process that assigns a label eg: "vehicle" to an object based on its description.

xi) Knowledge Base:

a) Guides the operation of each processing module and controls the interaction between modules.

b) Knowledge about a problem is coded into an image processing system in the form of a knowledge database.

2	With a neat block diagram, explain the components of an Image Processing System.	10	CO1	L4

Soln:

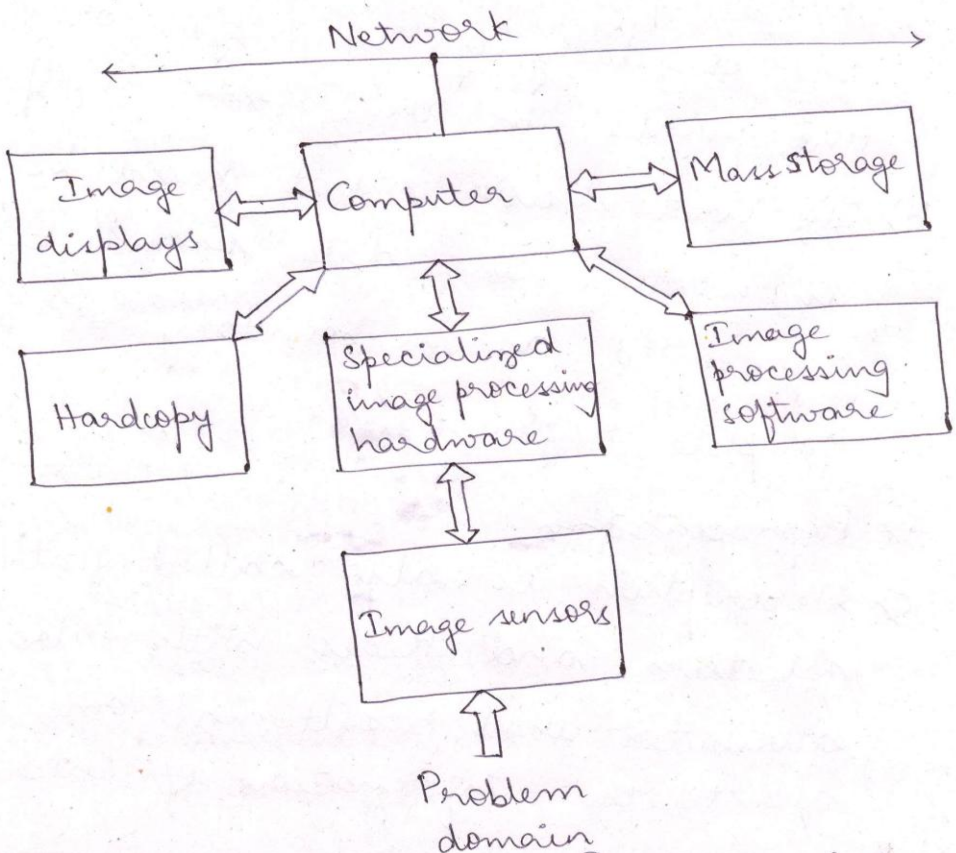


fig: Components of an Image Processing System

i) Image sensors:

a) Two elements are required to acquired digital images.

b) The first is a physical device that is sensitive to the energy radiated by the object we wish to image.

c) The second is a digitizer, a device for converting the output of the physical sensing device into digital form.

d) eg: In a digital video camera, the sensors produce an electrical output proportional to light intensity. The digitizer converts these outputs to digital data.

ii) Specialized image processing hardware:

a) Consists of the digitizer plus hardware that performs primitive operations such as an ALU, which performs arithmetic and logical operations in parallel on entire images.

iii) The Computer:

a) It is a general-purpose computer that can range from a PC to supercomputer suitable for off-line image processing tasks.

iv) Image processing Software:

a) It consists of specialized modules that perform specific tasks.

v) Mass storage:

a) This capability is a must in image processing applications.

b) eg: An image of size 1024X1024 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.

vi) Image displays:

a) Mainly used are color (preferably flat screen) TV monitors.

b) Monitors are driven by the outputs of images and graphics display cards that are an integral part of the computer system.

viii) Hardcopy:

a) These devices are for recording images. These include laser printers, film cameras, heat-sensitive devices etc.

ix) Networking:

a) A default function in any computer system.

3	Explain the following terms as applied to Image Processing with necessary graphs: Brightness adaptation, weber's ratio, Mach bands, distance measure.	10	CO1	L4

Soln:

3) Brightness Adaptation and Discrimination : ★★★

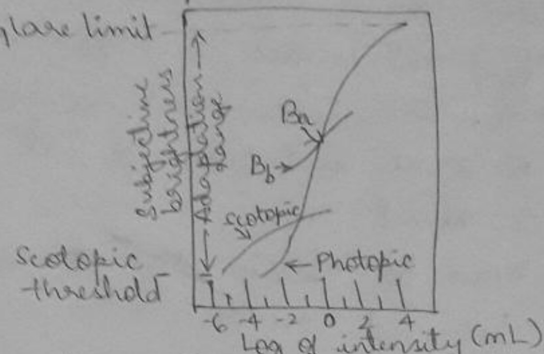


fig. 4: Range of subjective brightness sensations showing a particular adaptation level.

i) Digital images are displayed as a discrete set of intensities.

ii) The range of light intensity levels to which visual system can adapt is in the order of 10^{10} from scotopic threshold to glare limit.

iii) Experimental evidences indicate that subjective brightness (intensity as perceived by human visual system) is a logarthmic function of the light intensity incident on the eye.

iv) Fig. 4 shows the plot of light intensity versus subjective brightness.

a) The long solid curve represents the range of intensities to which the visual system can adapt.

b) The range in photopic region of vision is 10^6.

c) The transition from scotopic to photopic vision is gradual over the range from 0.001 to 0.1 mL (-3 to -1 mL in log scale).

d) The visual system cannot operate over such a dynamic range simultaneously.

e) The visual system accomplishes this large variation by changing its overall sensitivity known as brightness adaptation.

f) For any given set of conditions, the current sensitivity level of the visual system is called the brightness adaptation level. (Ba).

g) The range of subjective brightness having a level B_b at and below which all stimuli are perceived as indistinguishable blacks.

v) Weber ratio:

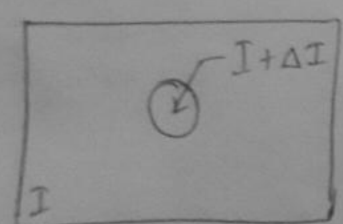


fig.5: Basic experimental setup used to charactaize brightness discrimination

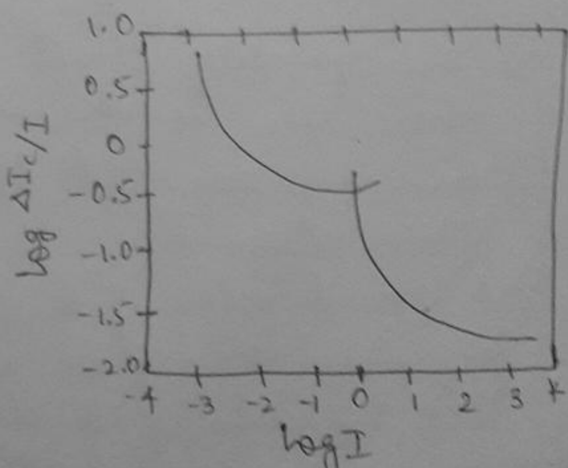


fig.6: Typical Weber ratio as a function of intensity.

v) Fig. 6 shows weber ratio. This curve shows that brightness discrimination is poor at low levels of illumination. It improves significantly as background illumination increases.

***
vi) Two phenomena demonstrates that perceived brightness is not a simple function of intensity.

a) The first is based on the fact that the visual system tends to undershoot or overshoot around the boundary of regions of different intensities. eg. is as in fig. 7.

b) In the fig. 7, although the intensity of the stripes is constant, perception of brightness pattern is strongly scalloped near the boundaries. These scalloped bands are called Mach bands.

c) The second phenomenon is called simultaneous contrast. It is related to the fact that a region's perceived brightness does not depend on its intensity as Fig. 8 demonstrates.

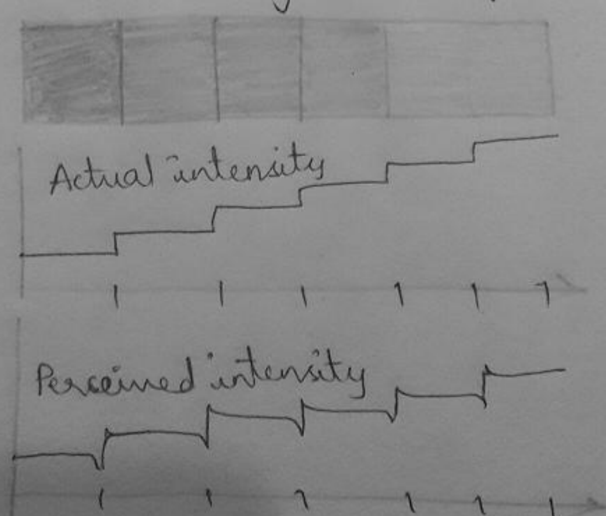


Fig. 7: Illustration of Mach band effect.

Distance Measures:

→ For pixels p, q & r with coordinates (x,y), (s,t) & (v,w), D is a distance metric if

a) $D(p,q) \geq 0$

b) $D(p,q) = D(q,p)$ &

c) $D(p,r) \leq D(p,q) + D(q,r)$

i) Euclidean distance b/n p & q

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

ii) City block distance b/n p & q

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

iii) Chessboard distance b/n p & q

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

4	Explain Image acquisition using sensor using sensor arrays.	10	CO1	L4

Soln:

4) b) Process of image acquisition using single sensor:

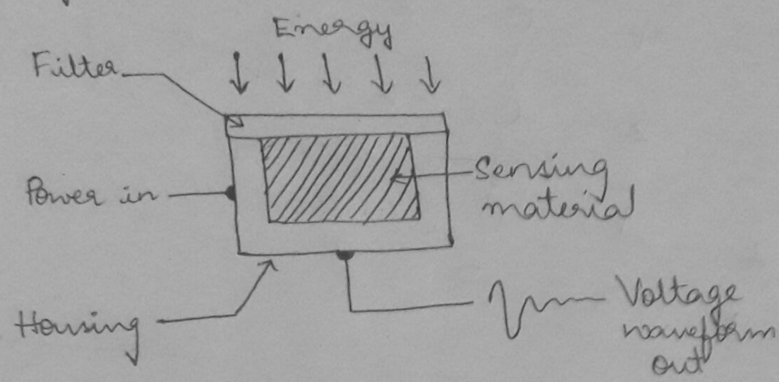


fig: 9: Single imaging sensor.

→ The most familiar sensor of this type is photodiode.
→ It is constructed of silicon materials and output voltage waveform is proportional to light.
→ Selectivity is improved by the use of a filter in front of a sensor.
→ eg: A green (pass) filter infront of a light sensor favors light in the green band of color spectrum. As a consequence, the sensor output will be stronger for green light than for other components in the visible spectrum.
→ To generate a 2-D image using a single sensor, there should be relative displacements in both the x- and y- directions between the sensor and the area to be imaged.

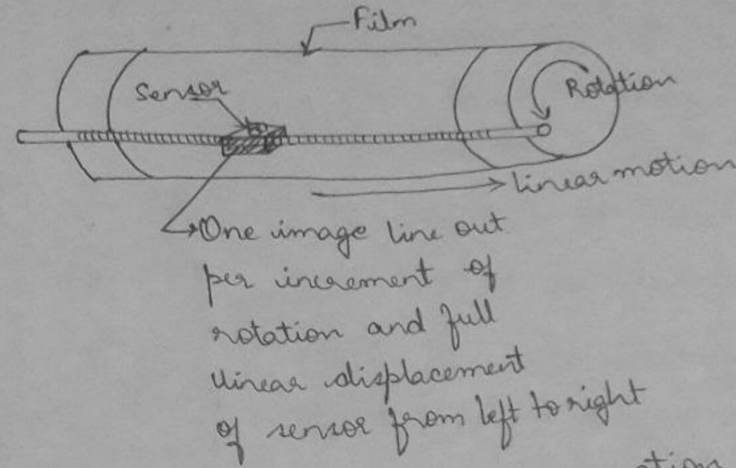


fig combining a single sensor with motion to generate a 2-D image

→ The above fig. shows an arrangement used in high-precision scanning [Microdensitometers]
→ A film negative is mounted onto a drum.
→ The drum's mechanical rotation provides displacement in one dimension.
→ The single sensor is mounted on a lead screw.
→ Lead screw provides motion in the perpendicular direction.
→ This is an inexpensive way to obtain high-resolution images because mechanical motion can be controlled with high precision.

5 Explain the Piecewise Linear transformations functions. 10 CO2 L4

Soln:

[PLTF]

Piecewise-Linear Transformation Functions.

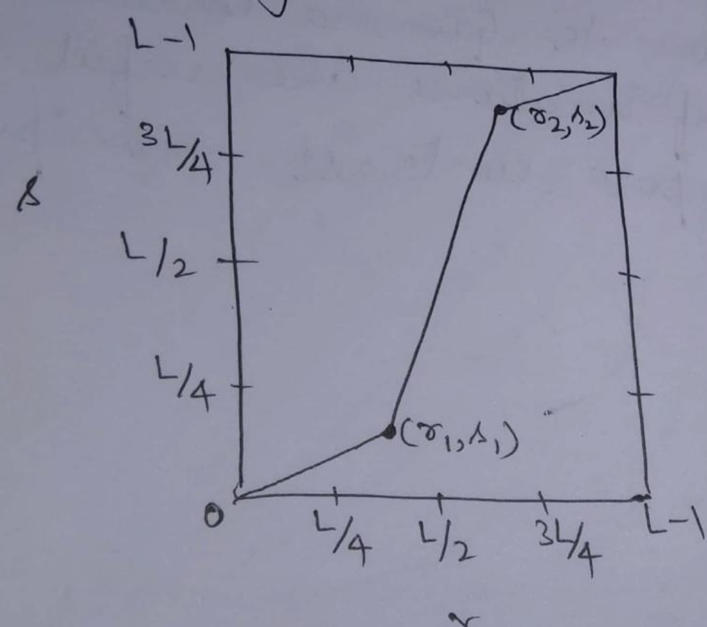
→ Advantage: The form of piecewise functions can be arbitrarily complex.

→ Disadvantage: Specification requires considerable more user input.

Contrast stretching:

→ Simplest PLTF

→ A process that expands the range of intensity levels in an image so that it spans the full intensity ~~the~~ range of the recording medium or display device.



→ Locations (r_1, s_1) & (r_2, s_2) control the shape of transformation functions.

→ If $r_1 = s_1$ and $r_2 = s_2$, transformation is a linear function that produces no changes in intensity levels.

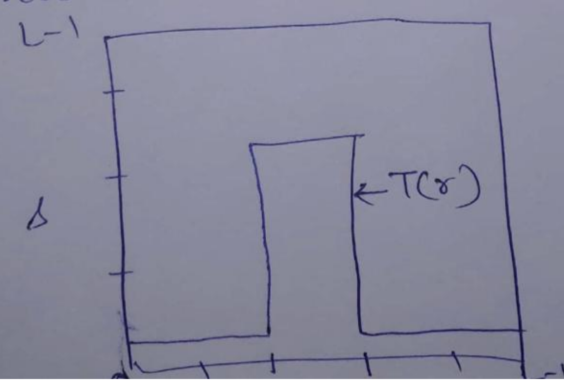
→ If $r_1 = r_2$, $s_1 = 0$ & $s_2 = L-1$, the trans. becomes a thresholding function that creates a binary image.

→ Intermediate values of (r_1, s_1) and (r_2, s_2) produce various degrees of spread in the intensity levels of s.

Intensity-level slicing

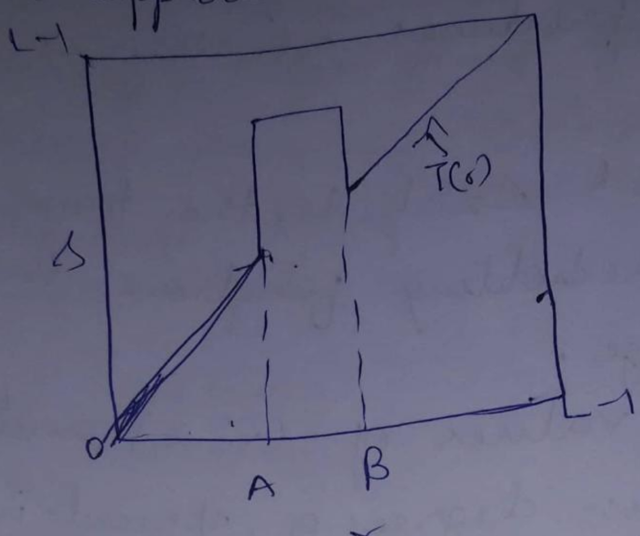
→ Deals with highlighting a specific range of intensities in an image.

→ One approach to do this is to display in one value (white) all the values in the range of interest and in another (black) all other intensities.



→ produces a binary image.

Second approach:-



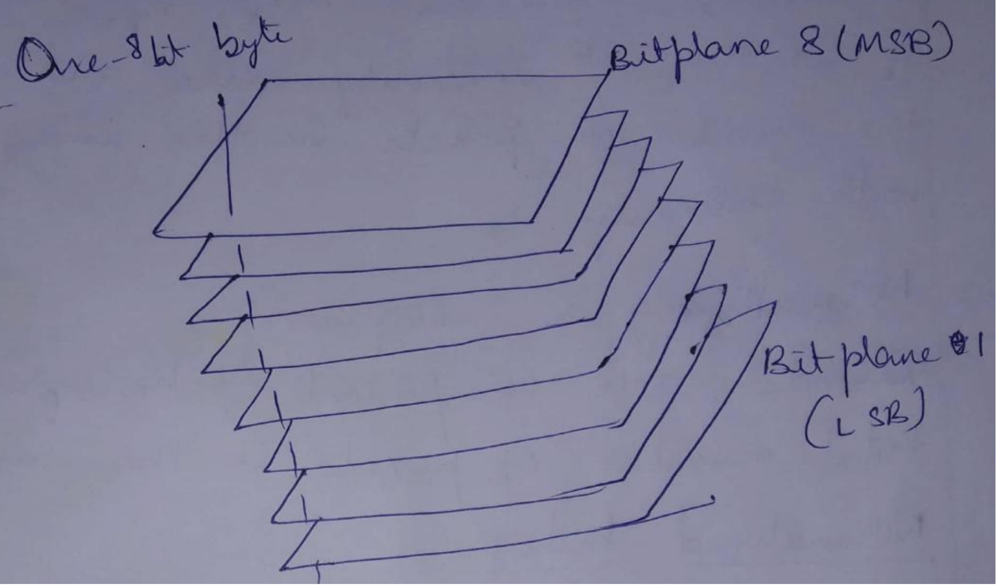
brightens the desired range of intensities but leaves all other intensity levels in the image unchanged.

→ Eg: Aortic angiogram near the kidney area

Bit-plane slicing:

→ Pixels are digital numbers composed of bits.

→ Here we concentrate on the contribution made to total image appearance by specific bits.



6 Consider the image segment in Fig.4: 10 CO1 L3

i) Let V= {0,1}. Calculate the length of shortest 4, 8 and m paths between p and q.

ii) Repeat for V= {1,2}.

3	1	2	1
2	2	0	2
1	2	1	1
1	0	1	2

Fig. 4

Soln: When V = f0; 1g, 4path does not exist between p and q because it is impossible to get from p to q by traveling along points that are both 4adjacent and also have values from V . Figure P2.15(a) shows this condition it is not possible to get to q. The shortest 8path is shown in Fig. P2.15(b) its length is 4. The length of shortest m path (shown dashed) is 5. Both of these shortest paths are unique in this case. (b) One possibility for the shortest 4path when V = f1; 2g is shown in Fig. P2.15(c) its length is 6. It is easily verified that another 4path of the same length exists between p and q. One possibility for the shortest 8path (it is not unique) is shown in Fig. P2.15(d) its length is 4. The length of a shortest *m* path (shown dashed) is 6. This path is not unique.

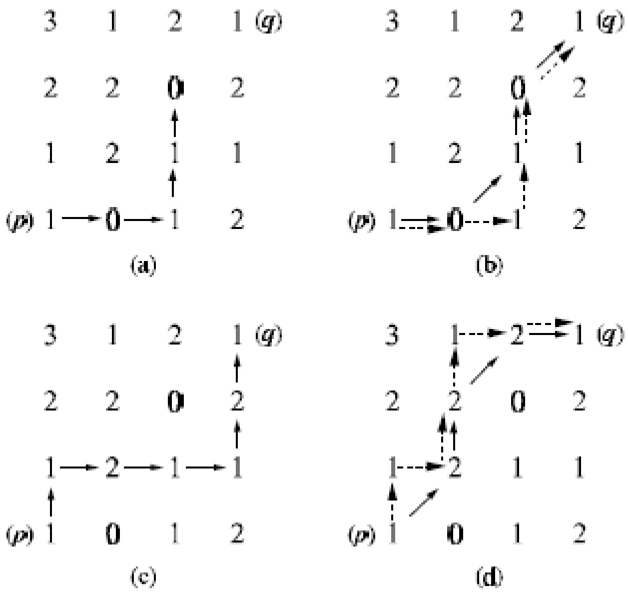


Figure P2.15

Likewise for 2nd case.

7 Explain the following terms with reference to Image Processing: Image Negatives, Log Transformations, Power-Law Transformations and Histogram. 10 CO2 L4

Soln:

Image negatives:-

Negative transformation is given by the expression

$$s = (L-1) - r$$

$L-1 \rightarrow$ max. range of intensity level

O/P is reversed intensity levels of an image which is equivalent to a photographic negative

This type of processing is suited for enhancing white or gray detail embedded in dark regions of an image, especially when black areas are dominant in size.

Log Transformations:

Log transformation is

$$s = c \log(1+r)$$

$c \rightarrow$ constant & $r \geq 0$

Shape of the log curve shows that this transformation maps a narrow range of low intensity values into ~~to~~ a wider range of output levels, and higher intensity ~~to~~ values into a narrow range of output levels.

This type of transformation is used to expand the values of dark pixels in an image while compressing the higher level values. The opposite is in Inverse log transformatio

Power-Law Transformations:

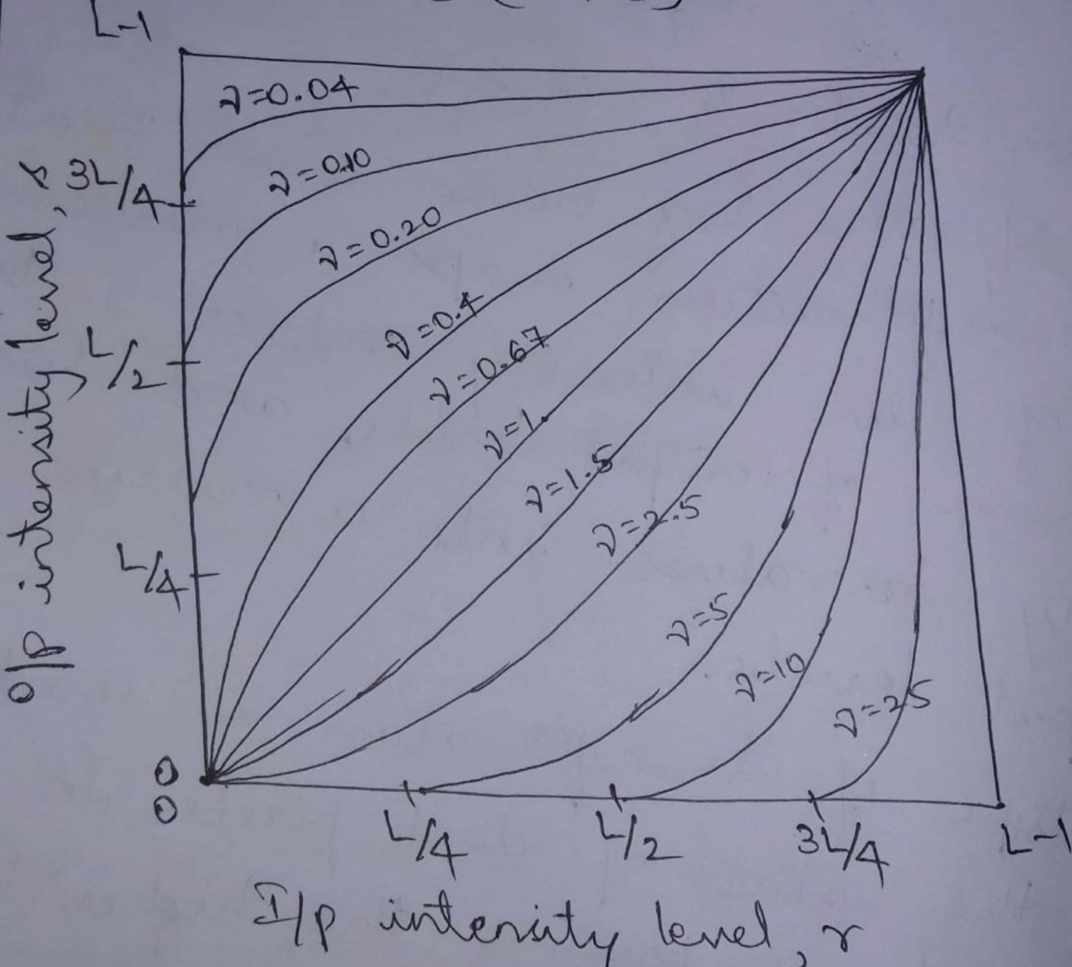
Power-law Transformations

$$s = c r^{\gamma} \quad \text{——— (1)}$$

c and γ are positive constants.

To account for an offset i.e. a measurable output when the i/p is zero (1) can be written

$$s = c(r+\varepsilon)^{\gamma}$$



→ Power-law curves with fractional values of γ map a narrow range of dark input values into a wider range of output values, with the opposite being true for higher values of input levels.

→ For $c = \gamma = 1$, the eqn. $s = cr^{\gamma}$ reduces to identity transformation.

→ By convention, the exponent in the Power-law equation is referred to as gamma.

→ The process used to correct these power law response phenomena is called Gamma correction.

→ In addition to Gamma Correction, power-law transformations are useful for general purpose contrast manipulation.

→ Histogram Processing:

Histogram:

The histogram of a digital image with intensity levels in the rang $[0, L-1]$ is a discrete function $h(r_k) = n_k$, where r_k is the k^{th} intensity value and n_k is the number of pixels in the image with intensity r_k.

→ N