Internal Assessment Test 1 – Nov2021

Solution

Sub:	**Digital Image Processing(Professional Elective)**				**Sub Code:**	**18CS741**	**Branch :**	**CSE**
Date:		**Duration:**	**90 mins**	**Max Marks :**	**50**	**Sem / Sec:**	**7(A,B,C)**	**OBE**

Q1(A) Let p and q be two pixels at coordinates (100, 120) and(130, 160) respectively Compute i) Euclidean distance ii) Chess board distance, iii) Manhattan distance (2 marks each -2+2+2)

Solution: 2 marks each part
(i) Euclidean Distance:= ((x-s)^2 + (y-t)^2)^1/2
Euclidean distance =((100-130)^2+(120-100)^2)^1/2
=50
Chessboard Distance= max(|x-s|,|y-t|)
=40
Manhattan distance =|x-s|+|y-t|
=70

Q1(B) Explain the data structures of representing digital images. (4 marks- Pixels,adjacency,connectivity,boundary and region)

Digital Image representation:

Digital image is a finite collection of discrete samples (*pixels*) of any observable object. The pixels represent a two- or higher dimensional "view" of the object, each pixel having its own discrete value in a finite range. The pixel values may represent the amount of visible light, infra red light, absortation of x-rays, electrons, or any other measurable value such as ultrasound wave impulses. The image does not need to have any visual sense; it is sufficient that the samples form a two-dimensional spatial structure that may be illustrated as an image. The images may be obtained by a digital camera, scanner, electron microscope, ultrasound stethoscope, or any other optical or non-optical sensor. Examples of digital image are:

- digital photographs
- satellite images
- radiological images (x-rays, mammograms)
- binary images, fax images, engineering drawings

Computer graphics, CAD drawings, and vector graphics in general are not considered in this course even though their reproduction is a possible source of an image. In fact, one goal of intermediate level image processing may be to reconstruct a model (e.g. vector representation) for a given digital image.

RELATIONSHIP BETWEEN PIXELS:

We consider several important relationships between pixels in a digital image.

NEIGHBORS OF A PIXEL

- 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* or *p*, is denoted by $N_4(p)$. Each pixel is one 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 and are denoted by N_D (*p*).

(x+1, y+1), (x+1, y-1), (x-1, y+1), (x-1, y-1)

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.

ADJACENCY AND CONNECTIVITY

Let v be the set of gray –level values used to define adjacency, in a binary image, v={1}. In a gray-scale image, the idea is the same, but *V* typically contains more elements, for example, *V* = {180, 181, 182, …, 200}.

If the possible intensity values 0 – 255, *V* set can be any subset of these 256 values. if we are reference to adjacency of pixel with value.

Three types of adjacency

- 4- Adjacency – two pixel P and Q with value from V are 4 –adjacency if A is in the set N_4(P)
- 8- Adjacency – two pixel P and Q with value from V are 8 –adjacency if A is in the set N_8(P)
- M-adjacency –two pixel P and Q with value from V are m – adjacency if (i) Q is in N_4(p) or (ii) Q is in N_D(q) and the set $N_4(p) \cap N_4(q)$ has no pixel 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.

Types of Adjacency: In this example, we can note that to connect between two pixels (finding a path between two pixels):

- In 8-adjacency way, you can find multiple paths between two pixels
- While, in m-adjacency, you can find only one path between two pixels
- So, m-adjacency has eliminated the multiple path connection that has been generated by the 8-adjacency.
- Two subsets S_1 and S_2 are adjacent, if some pixel in S_1 is adjacent to some pixel in S_2. Adjacent means, either 4-, 8- or m-adjacency.

A Digital Path: A digital path (or curve) from pixel *p* with coordinate (x,y) to pixel *q* with coordinate (s,t) is a sequence of distinct pixels with coordinates (x_0,y_0), (x_1,y_1), …, (x_n, y_n) where $(x_0,y_0) = (x,y)$ and $(x_n, y_n) = (s,t)$ and pixels (x_i, y_i) and (x_{i-1}, y_{i-1}) are adjacent for $1 \le i \le n$

- n is the length of the path
- If $(x_0,y_0) = (x_n, y_n)$, the path is closed.

We can specify 4-, 8- or m-paths depending on the type of adjacency specified.

Connectivity: Let *S* represent a subset of pixels in an image, two pixels *p* and *q* are said to be connected in *S* if there exists a path between them consisting entirely of pixels in *S*.

For any pixel *p* in *S*, the set of pixels that are connected to it in *S* is called a *connected component* of *S*. If it only has one connected component, then set *S* is called a *connected set*.

Region and Boundary:

- REGION: Let *R* be a subset of pixels in an image, we call *R* a region of the image if *R* is a connected set.
- BOUNDARY: The *boundary* (also called *border* or *contour*) of a region *R* is the set of pixels in the region that have one or more neighbors that are not in *R*.

If *R* happens to be an entire image, then its boundary is defined as the set of pixels in the first and last rows and columns in the image. This extra definition is required because an image has no neighbors beyond its borders. Normally, when we refer to a region, we are referring to subset of an image, and any pixels in the boundary of the region that happen to coincide with the border of the image are included implicitly as part of the region boundary.

Mention any 5 fields that use digital image processing.(3 marks)

There are several applications under medical field which depends on the functioning of digital image processing.

- Gamma-ray imaging.
- PET scan.
- X-Ray Imaging.
- Medical CT scan.
- UV imaging.

Explain the concept of sampling and quantization using a single example.(4 marks explanation+ 3 marks theory= 7 marks)

Image Sampling and Quantization

Sampling and quantization are the two important processes used to convert continuous analog image into digital image. Image sampling refers to discretization of spatial coordinates (along x axis) whereas quantization refers to discretization of gray level values (amplitude (along y axis)).

(Given a continuous image, f(x,y), digitizing the coordinate values is called sampling and digitizing the amplitude (intensity) values is called quantization.)

The one dimensional function shown in fig 2.16(b) is a plot of amplitude (gray level) values of the continuous image along the line segment AB in fig 2.16(a). The random variation is due to the image noise. To sample this function, we take equally spaced samples along line AB as shown in fig 2.16 (c).In order to form a digital function, the gray level values also must be converted(quantizes) into discrete quantities. The right side of fig 2.16 (c) shows the gray level scale divided into eight discrete levels, ranging from black to white. The result of both sampling and quantization are shown in fig.

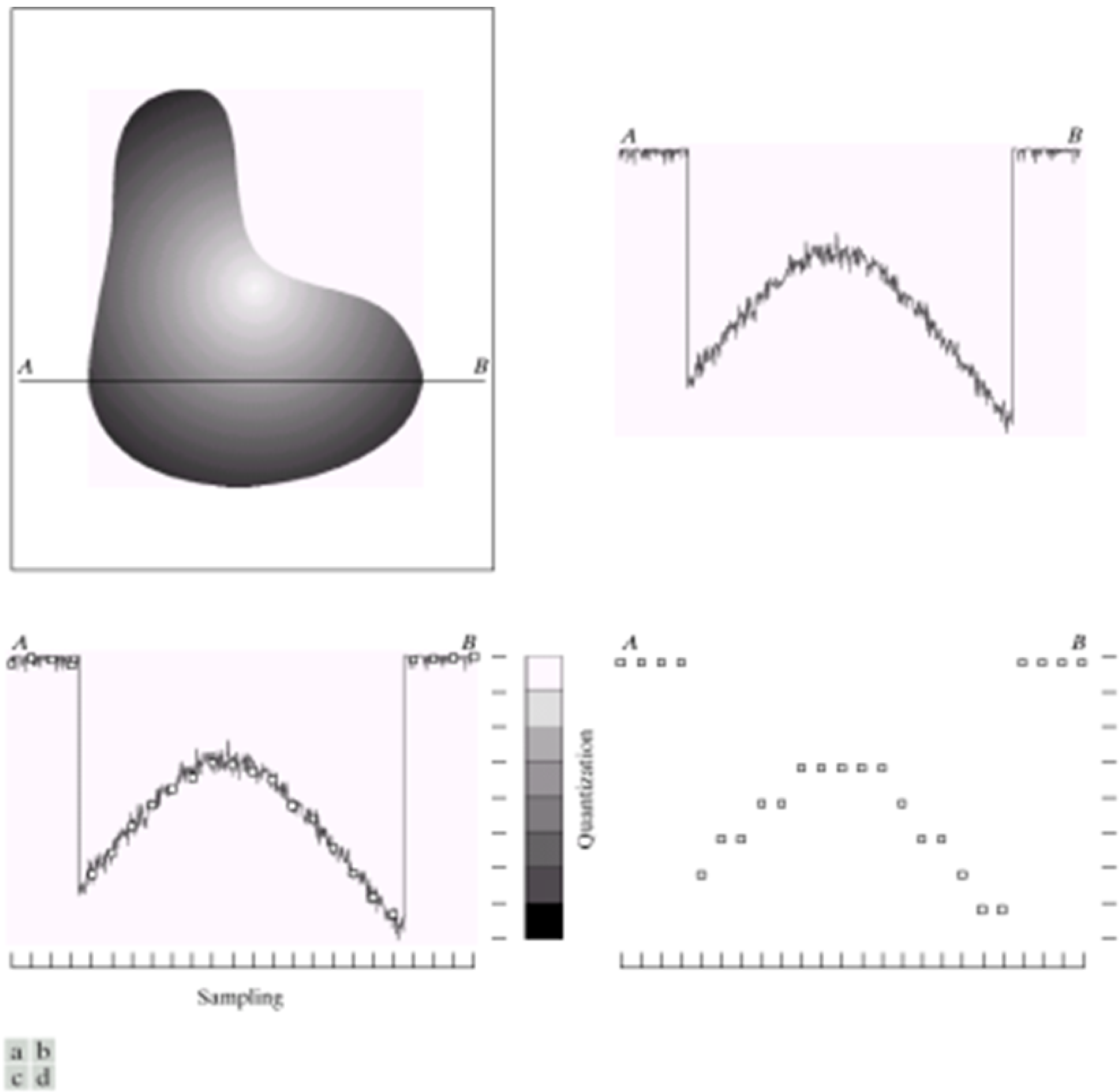
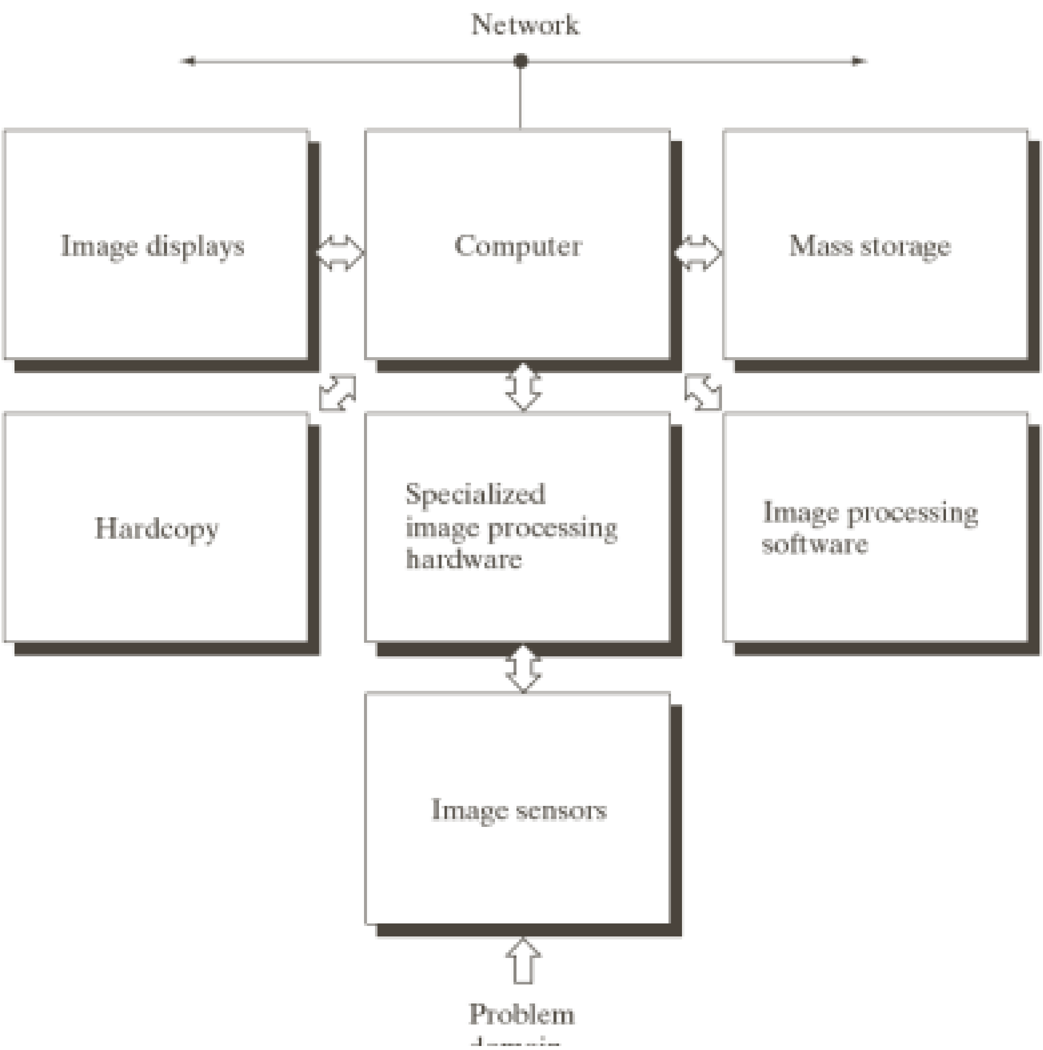


FIGURE 2.16 Generating a digital image. (a) Continuous image. (b) A scan line from A to B in the continuous image, used to illustrate the concepts of sampling and quantization. (c) Sampling and quantization. (d) Digital scan line.

Explain about fundamental steps in digital image processing? Explain the components of an Image Processing system?(7 maks fundamental steps+ 3 marks component)

Components of Image processing System:



u Image Sensors: With reference to sensing, two elements are required to acquire digital image. The first is a physical device that is sensitive to the energy radiated by the object we wish to image and second is specialized image processing hardware.

u Specialize image processing hardware: It consists of the digitizer just mentioned, plus hardware that performs other primitive operations such as an arithmetic logic unit, which performs arithmetic such addition and subtraction and logical operations in parallel on images.

u Computer: It is a general purpose computer and can range from a PC to a supercomputer depending on the application. In dedicated applications, sometimes specially designed computer are used to achieve a required level of performance

u Software: It consists of specialized modules that perform specific tasks a well designed package also includes capability for the user to write code, as a minimum, utilizes the specialized module. More sophisticated software packages allow the integration of these modules

u Mass storage: This capability is a must in image processing applications. An image of size 1024 x1024 pixels, in which the intensity of each pixel is an 8-bit quantity requires one Megabytes of storage space if the image is not compressed .Image processing applications falls into three principal categories of storage

i)Short term storage for use during processing

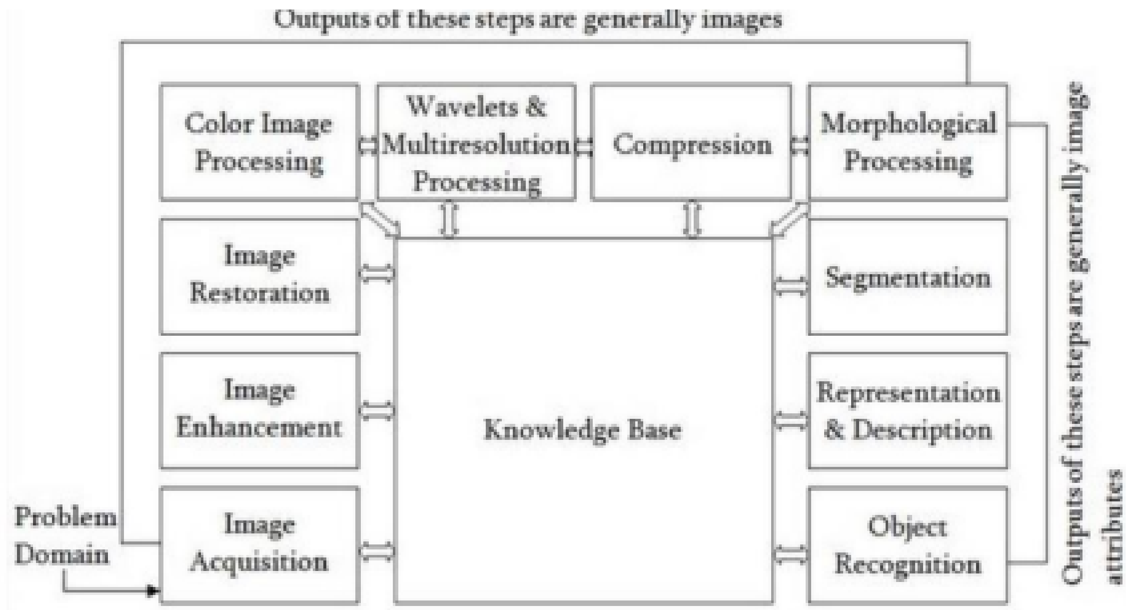
ii)On line storage for relatively fast retrieval

iii)Archival storage such as magnetic tapes and disks u Image display: Image displays in use today are mainly color TV monitors. These monitors are driven by the outputs of image and graphics displays cards that are an integral part of computer system.

u Hardcopy devices: The devices for recording image includes laser printers, film cameras, heat sensitive devices inkjet units and digital units such as optical and CD ROM disk. Films provide the highest possible resolution, but paper is the obvious medium of choice for written applications

u Networking: It 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 bandwidth.

Fundamental Steps in Digital Image Processing



u There are two categories of the steps involved in the image processing – 1.Methods whose outputs are input are images.

2.Methods whose outputs are attributes extracted from those images.

u Image acquisition: It could be as simple as being given an image that is already in digital form. Generally the image acquisition stage involves processing such scaling.

Image Enhancement: It is among the simplest and most appealing areas of digital image processing. The idea behind this is to bring out details that are obscured or simply to highlight certain features of interest in image. Image enhancement is a very subjective area of image processing.

u Image Restoration: It deals with improving the appearance of an image. It is an objective approach, in the sense that restoration techniques tend to be based on mathematical or probabilistic models of image processing. Enhancement, on the other hand is based on human subjective preferences regarding what constitutes a “good” enhancement result.

u Color image processing: It is an area that is been gaining importance because of the use of digital images over the internet. Color image processing deals with basically color models and their implementation in image processing applications.

u Wavelets and Multiresolution Processing: These are the foundation for representing image in various degrees of resolution.

u Compression: It deals with techniques reducing the storage required to save an image, or the bandwidth required to transmit it over the network. It has to major approaches a) Lossless Compression b) Lossy Compression

u Morphological processing: It deals with tools for extracting image components that areuseful in the representation and description of shape and boundary of objects. It is majorly used in automated inspection applications.

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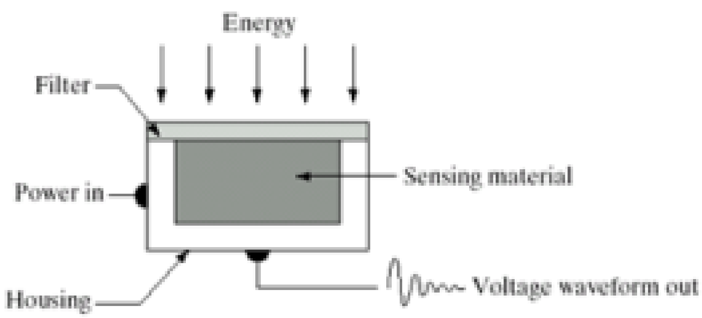
u Representation and Description: It always follows the output of segmentation step that is, raw pixel data, constituting either the boundary of an image or points in the region itself. In either case converting the data to a form suitable for computer processing is necessary.

u Recognition: It is the process that assigns label to an object based on its descriptors. It isthe last step of image processing which use artificial intelligence of software.

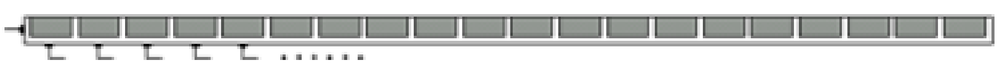
Explain the process of image acquisition using single sensor with motion to generate a 2-D image.(6 marks)

Image Sensing and Acquisition

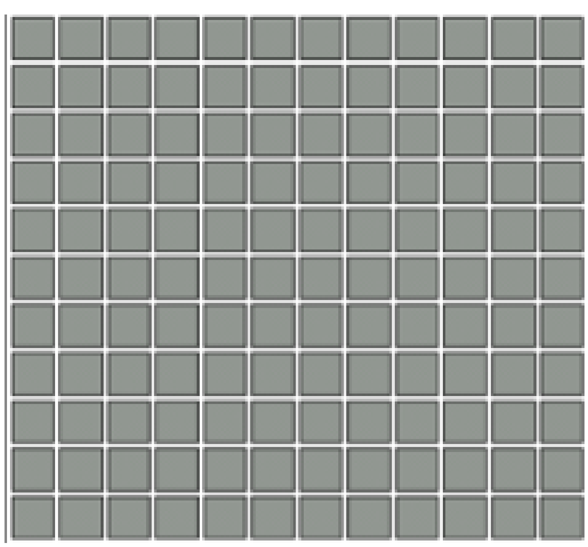
There are 3 principal sensor arrangements (produce an electrical output proportional to light intensity).
(i)Single imaging Sensor (ii)Line sensor (iii)Array sensor



(i)



(ii)



(iii)

Fig: (i)Single image (ii)Sensor line sensor (iii)Array sensor
Image Acquisition using a single sensor

The most common sensor of this type is the photodiode, whichbe imaged. One-dimensional imaging sensor strips that respond to various bands of the electro is constructed of silicon materials and whose output voltage waveform is proportional to light. The use of a filter in front of a sensor improves selectivity. For example, a green (pass) filter in front of a light sensor favours light in the green band of the color spectrum. As a consequence, the sensor output will be stronger for green light than for other components in the visible spectrum.

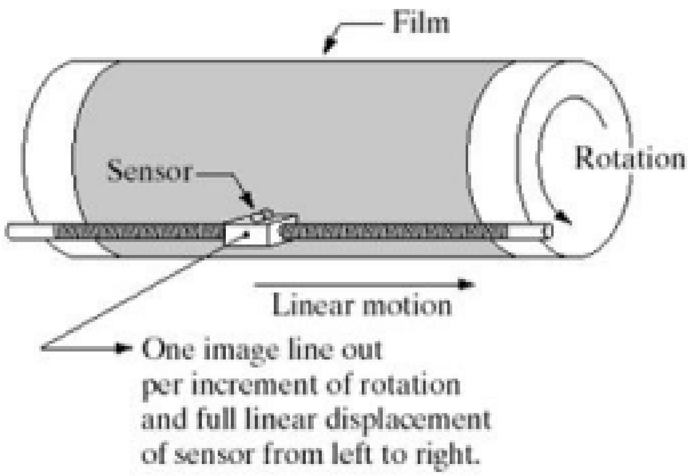


Fig: Combining a single sensor with motion to generate a 2-D image

In order to generate a 2-D image using a single sensor, there have to be relative displacements in both the x- and y-directions between the sensor and the area to be imaged. An arrangement used in high precision scanning, where a film negative is mounted onto a drum whose mechanical rotation provides displacement in one dimension. The single sensor is mounted on a lead screw that provides motion in the perpendicular direction. Since mechanical motion can be controlled with high precision, this method is an inexpensive (but slow) way to obtain high-resolution images.

Explain the following intensity transformation functions: (1) Image Negatives (2) Power law transformation(2marks each=2 +2=4)

IMAGE NEGATIVE: The image negative with gray level value in the range of [0, L-1] is obtained by negative transformation given by S = T(r) or

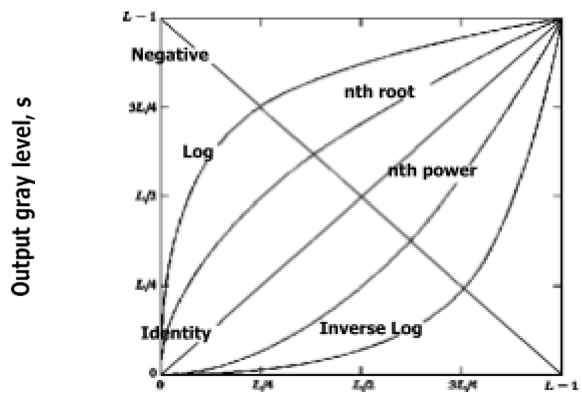
S = L -1 – r

Where r= gray level value at pixel (x,y)

L is the largest gray level consists in the image

It results in getting photograph negative. It is useful when for enhancing white details embedded in dark regions of the image.

The overall graph of these transitions has been shown below.



Input gray level, r

Fig. Some basic gray-level transformation functions used for image enhancement.

In this case the following transition has been done.

s = (L – 1) – r

since the input image of Einstein is an 8 bpp image, so the number of levels in this image are

256. Putting 256 in the equation, we get this

s = 255 – r

So each value is subtracted by 255 and the result image has been shown above. So what happens is that, the lighter pixels become dark and the darker picture becomes light. And it results in image negative.

It has been shown in the graph below.

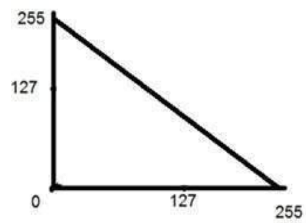


Fig. Negative transformations.

POWER – LAW TRANSFORMATIONS:

There are further two transformation is power law transformations, that include nth power and nth root transformation. These transformations can be given by the expression:

$s=cr^{\gamma}$

This symbol γ is called gamma, due to which this transformation is also known as gamma transformation.

Variation in the value of γ varies the enhancement of the images. Different display devices / monitors have their own gamma correction, that"s why they display their image at different intensity.

where c and g are positive constants. Sometimes Eq. (6) is written as $S = C(r+\varepsilon)^{\gamma}$ to account for an offset (that is, a measurable output when the input is zero). Plots of s versus r for various values of γ are shown in Fig. 2.10. As in the case of the log transformation, 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. Unlike the log function, however, we notice here a family of possible transformation curves obtained simply by varying γ.

In Fig that curves generated with values of γ>1 have exactly The opposite effect as those generated with values of γ<1. Finally, we Note that Eq. (6) reduces to the identity transformation when c=γ=1.

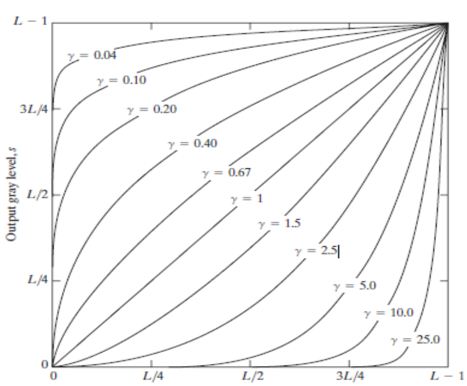


Fig. 2.13 Plot of the equation $S = cr^{\gamma}$ for various values of γ (c =1 in all cases).

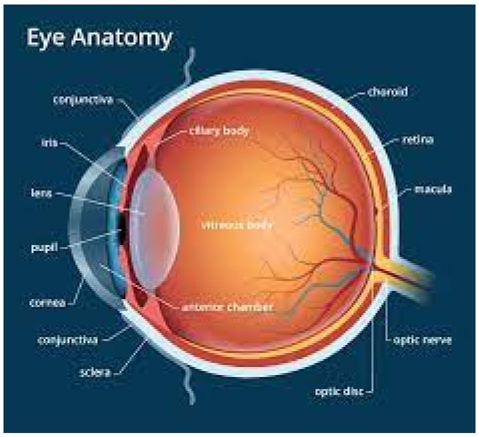
This type of transformation is used for enhancing images for different type of display devices. The gamma of different display devices is different. For example Gamma of CRT lies in between of 1.8 to 2.5, that means the image displayed on CRT is dark.

Varying gamma (γ) obtains family of possible transformation curves $S = C^* r^{\gamma}$

Here C and γ are positive constants. Plot of S versus r for various values of γ is $\gamma > 1$ compresses dark values

Draw a neat diagram of human eye, Explain its various parts(5 marks diagram+ 3 marks explanation=7)

The eye is a sensory organ. It collects light from the visible world around us and converts it into nerve impulses. The optic nerve transmits these signals to the brain, which forms an image so thereby providing sight.



Visible parts of the eye

Eyelid: Your eyelid covers your eye to protect it from dust, grit, and perspiration that could cause damage. It opens and closes both voluntarily and involuntarily, and facilitates blinking to help keep the eye hydrated and well-lubricated.

Pupil: The pupil is the part of the eye which we see through, and changes size depending on light levels. If you are in a particularly bright environment, the pupil contracts to let less light in, while if you're in a darker setting, it will expand to let more light in. This helps us to see well in different light levels, making sure that the correct amount of light reaches the retina at the back of the eye.

Sclera: The sclera is the white part of your eye, providing a protective outer layer. It covers the optic nerve and its can also be a good indication of your eye health. For example, a red sclera might suggest that your eyes and tired or dry, while a yellow-tinted sclera could indicate liver problems.

Iris: The iris is the coloured part of your eye and is what actually controls the size of the pupil. This means that it regulates how much light gets into the eye. This iris is made from connective tissue and muscle surrounding the pupil, and its structure, pattern and colour are just as unique as your fingerprint!

Internal parts of the eye

Cornea: The cornea is the clear surface at the front of your eye, allowing light to enter the eye. It directly covers your iris and pupil, providing a layer of protection. The cornea is what we operate on for laser eye surgery procedures, as it is imperfections in the curve of your cornea that create an eye prescription, requiring you to need glasses. The smoother the surface of your cornea is, the better your vision will be.

Lens: The lens is located behind your iris and is the part of the eye which provides focus. The lens can change shape to alter the focal distance of the eye, focusing light rays that pass through it to hit the retina at the right angle. As you get older, a build-up of protein in the eye can mean that the lens becomes cloudy. This is called a cataract. Thankfully, your lens is easily removable and can be replaced with an artificial clear lens to provide good vision again.

Aqueous humour: The aqueous humour is a watery fluid that your eyes constantly produce in order to maintain good eye pressure and nourish your cornea. This keeps your eyes healthy and, in turn, contributes to good vision. It is drained from the eye at the same rate that it is produced (when this rate isn't constant, it leads to glaucoma) and its presence is vital for good vision.

Ciliary muscle: The ciliary muscle is the part of the eye that actually changes the shape of the lens, allowing it to focus on different distances. It also holds the lens in the correct position in the eye's middle layer and regulates the flow of the aqueous humour within the eye.

Medial rectus muscle: There are six extraocular movement muscles in your eye (medial rectus, lateral rectus, superior oblique, superior rectus, inferior rectus, and the inferior oblique) and the medical rectus is the largest of them. It moves the pupil closer to the midline of your body (towards your nose) and makes sure that the eye is aligned correctly. If there are problems with the medial rectus, it can lead to strabismus.

Lateral rectus muscle: This is the muscle which is responsible for lateral – or sideways – movement of the eye, particularly movements away from the midline. Again, if there are issues with the lateral rectus muscle, you may experience esotropia. This is a form of strabismus where the eye turns inwards because the muscle is either too weak, or isn't working properly to move it away from the midline.

Retina: The retina is a layer of tissue at the back of the eye. The primary purpose of the retina is to receive light from the lens and send signals to the brain to process it into a visual image. The retina contains two types of photoreceptor cells: rods and cones. Rods are responsible for picking up on motion, dark and light, while cones detect colour vision. Problems with the retina can lead to loss of vision, so preserving your retinal health is crucial.

Choroid: This is a major blood vessel which sits between the retina and the sclera at the back of the eye. It nourishes the outer layers of the retina and keeps the eye at the right temperature. It also provides the right amount of oxygen and blood flow to the retina, helping the eye to function well.

Macula: The macula is the central part of your retina and is around 5mm in diameter. A healthy macula means we will have clear vision and be able to see fine details. When the macula becomes diseased, such as with macular degeneration, your central vision is affected. This obviously has a huge impact on your day to day life, and can keep worsening until all vision is lost.

Optic nerve: The optic nerve is the part of your eye which transmits visual signals from the retina to the brain, to be processed into images. It contains over a million nerve fibres and is actually considered to be part of the central nervous system. One of the most common ways the optic nerve can be damaged is by glaucoma. Eye pressure builds up, compressing the optic nerve, meaning visual signals can't be transmitted effectively anymore.

Vitreous humour: The vitreous humour is a liquid in your eye with the consistency of gel, and sits behind your lens but in front of your retina. If any substances enter the vitreous humour, they are referred to as floaters. They can be small flecks of blood or clusters of cells and, while they can be annoying to see in your line of vision, they are typically harmless. With age, your vitreous thins and can separate from the retina, causing "posterior vitreous detachment". This causes even more floaters but isn't sight-threatening.

Explain image smoothing in spatial domain (3marks)

Spatial Filtering technique is used directly on pixels of an image. Mask is usually considered to be added in size so that it has specific center pixel. This mask is moved on the image such that the center of the mask traverses all image pixels.

Classification on the basis of linearity:

There are two types:

1. Linear Spatial Filter
2. Non-linear Spatial Filter

smoothing Spatial Filter: Smoothing filter is **used for blurring and noise reduction in the image**. Blurring is pre-processing steps for removal of small details and Noise Reduction is accomplished by blurring.

6 **Let the gray levels used to define connectivity be {94, 95, 96, 97} and compute shortest D4 and D8 distances between pixels p and q for the image segment shown in below. Indicate the shortest path by double lines (10 marks)**

(p)96 97 94 97

98 98 100 96

99 97 98 95

(q)97 96 97 96