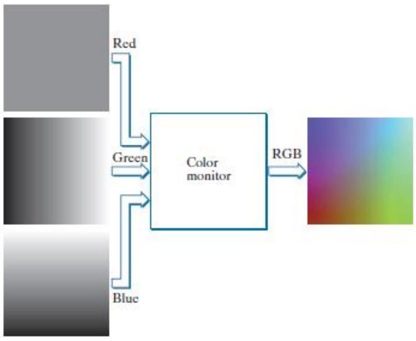
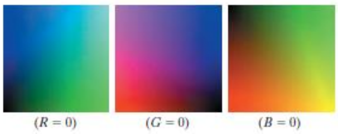
Assignment 1

1. Explain CMY and CMYK color models.

Cyan, magenta, and yellow are the secondary colors of light or, alternatively, they are the primary colors of pigments. For example, when a surface coated with cyan pigment is illuminated with white light, no red light is reflected from the surface. That is, cyan subtracts red light from reflected white light, which itself is composed of equal amounts of red, green, and blue light.Most devices that deposit colored pigments on paper, such as color printers and copiers, require CMY data input or perform an RGB to CMY conversion internally.This conversion is performed using the simple operation where the assumption is that all RGB color values have been normalized to the range [0, 1].





$$\begin{bmatrix} C \\ M \\ Y \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} - \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

Equation (6-5) demonstrates that light reflected from a surface coated with pure cyan does not contain red (that is, $C = 1 - R$ in the equation). Similarly, pure magenta does not reflect green, and pure yellow does not reflect blue. Equation (6-5) also reveals that RGB values can be obtained easily from a set of CMY values by subtracting the individual CMY values from 1. According to Fig. 6.4, equal amounts of the pigment primaries, cyan, magenta, and yellow, should produce black. In practice, because C, M, and Y inks seldom are pure colors, combining these colors for printing black produces instead a muddy-looking brown. So, in order to produce true black (which is the predominant color in printing), a fourth color, *black*, denoted by *K*, is added, giving rise to the CMYK color

model. The black is added in just the proportions needed to produce true black. Thus, when publishers talk about “four-color printing,” they are referring to the three CMY colors, plus a portion of black. The conversion from CMY to CMYK begins by letting

$$K = \min(C,M,Y) \quad (6\text{-}6)$$

If $K = 1$, then we have pure black, with no color contributions, from which it follows that

$$C = 0 \quad (6\text{-}7)$$
$$M = 0 \quad (6\text{-}8)$$
$$Y = 0 \quad (6\text{-}9)$$

Otherwise,

$$C = (C - K)\,(1 - K) \quad (6\text{-}10)$$
$$M = (M - K)\,(1 - K) \quad (6\text{-}11)$$
$$Y = (Y - K)\,(1 - K) \quad (6\text{-}12)$$

where all values are assumed to be in the range [0, 1]. The conversions from CMYK back to CMY are:

$$C = C * (1 - K) + K \quad (6\text{-}13)$$
$$M = M * (1 - K) + K \quad (6\text{-}14)$$
$$Y = Y * (1 - Y) + K \quad (6\text{-}15)$$

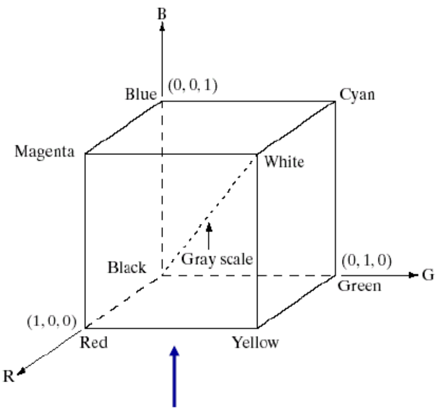
As noted at the beginning of this section, all operations in the preceding equations are performed on a pixel-by-pixel basis. Because we can use Eq. (6-5) to convert both ways between CMY and RGB, we can use that equation as a “bridge” to convert between RGB and CMYK, and vice versa. It is important to keep in mind that all the conversions just presented to go between RGB, CMY, and CMYK are based on the preceding relationships as a group. There are many other ways to convert between these color models, so you cannot mix approaches and expect to get meaningful results. Also, colors seen on monitors generally appear much different when printed, unless these devices are calibrated (see the discussion of a device-independent color model later in this section). The same holds true in general for colors converted from one model to another. However, our interest in this chapter is not on color fidelity; rather, we are interested in using the properties of color models to facilitate image processing tasks,such as region detection.

2. **Interpret in detail about:**

i.RGB model

RGB color model stores individual values for red, green, and blue. With a color space based on the RGB color model, the three primaries are added together to create colors from completely white to completely black.The RGB color space is associated with the device. Thus, different scanners get different color image data when scanning the same image; different monitors have different color display results when rendering the same image.There are many different RGB color spaces derived from this color model, standard RGB (sRGB) is a popular example.

FIGURE 6.7 Schematic of the RGB color cube. Points along the main diagonal have gray values, from black at the origin to white at point (1, 1, 1).



Images represented with the RGB color model have 3 component images:

Red component
Green component
Blue component

If 8 bits are used for each pixel, we have a 24-bit RGB image.

Each color is represented by a point in or on the unit cube.

ii.Hsi model

RBG and CMY are suitable for hardware implementations.

- Unfortunately, they are not good for describing colors for human interpretation.
- One does not refer to the color of a car by giving the % of each of the primaries!
- Humans describe a color object by its hue, saturation, and brightness.
- Hue: a color attribute that describes a pure color.
- Saturation: gives a measure of the degree to which pure color is diluted by white light.
- Brightness: a subjective descriptor that is practically impossible to measure.
- The HSI model decouples the intensity component from the color-carrying information (hue & saturation).

The RBG values have been normalized to the range [0,1].

HUE AND SATURATION IN THE HSI MODEL

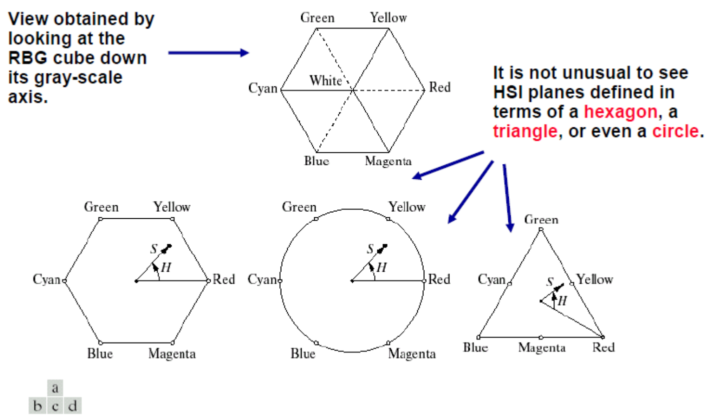


FIGURE 6.13 Hue and saturation in the HSI color model. The dot is an arbitrary color point. The angle from the red axis gives the hue, and the length of the vector is the saturation. The intensity of all colors in any of these planes is given by the position of the plane on the vertical intensity axis.

CONCEPTUAL RELATIONSHIP BETWEEN RGB AND HSI COLOR MODELS

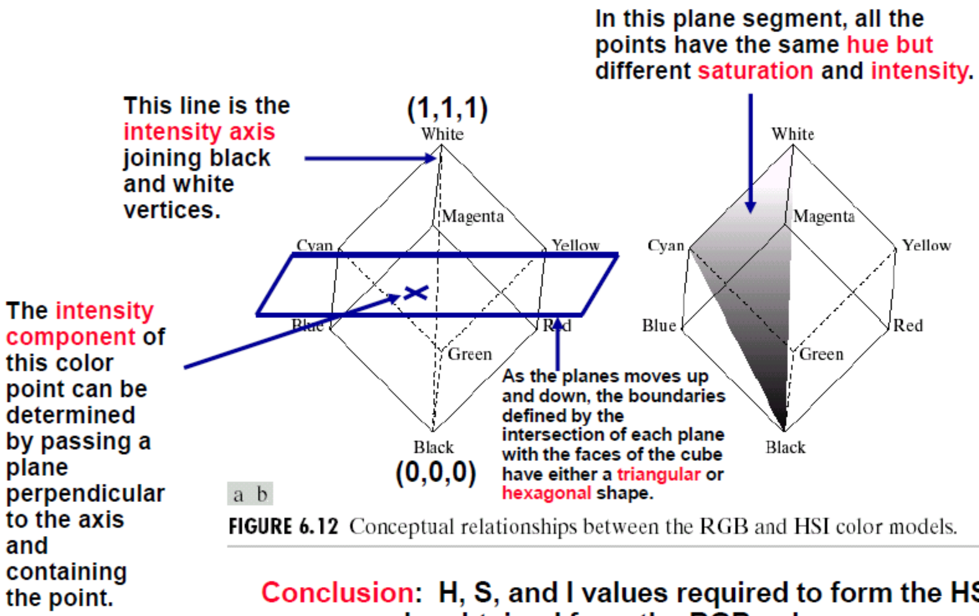


FIGURE 6.12 Conceptual relationships between the RGB and HSI color models.

Conclusion: H, S, and I values required to form the HSI space can be obtained from the RGB cube.

CONVERTING COLORS FROM RGB TO HSI

The RBG values have been normalized to the range [0,1].

$$H = \begin{cases} \theta & \text{if } B \leq G \\ 360 - \theta & \text{if } B > G \end{cases} \quad \text{with} \quad \theta = \cos^{-1}\left\{ \frac{\frac{1}{2}[(R-G)+(R-B)]}{\left[(R-G)^2+(R-B)(G-B)\right]^{1/2}} \right\}$$

Can be normalized to the range [0,1] by diving all the values by 360.

$$S = 1 - \frac{3}{(R+G+B)}[\min(R,G,B)]$$

$$I = \frac{1}{3}(R+G+B)$$

CONVERTING COLORS FROM HSI TO RGB

The HSI values are given in the interval [0,1].

The applicable equations depend on the values of *H*.

***RG* sector ($0^0 \leq H < 120^0$):**

$$B = I(1-S) \qquad R = I\left[1 + \frac{S\cos H}{\cos(60^0 - H)}\right] \qquad G = 3I - (R+B)$$

***GB* sector ($120^0 \leq H < 240^0$): first subtract 120^0 from it.**

$$R = I(1-S) \qquad G = I\left[1 + \frac{S\cos H}{\cos(60^0 - H)}\right] \qquad B = 3I - (R+G)$$

***BR* sector ($240^0 \leq H \leq 360^0$): first subtract 240^0 from it.**

$$G = I(1-S) \qquad B = I\left[1 + \frac{S\cos H}{\cos(60^0 - H)}\right] \qquad R = 3I - (G+B)$$

3. What is Pseudo color image processing?

Pseudo-color image processing: assignment of colors to gray values based on a specified criterion.

- The principal use of pseudo-color is for human visualizationand interpretationof gray-scale events in images.
- A principal motivation for using color is that humans can discern thousands of color shades and intensities!
- Intensity slicingand color coding is a simple example of pseudo-color image processing.
- The image is a 3-D function.
- Planes parallel to the coordinate plane are used.
- More general transformations achieve a wider range of pseudo-color enhancement results.

Assignment 2

1. **What is meant by Digital Image Processing? Explain how digital images can be represented?**

1.Digital image processing is the use of a digital computer to process digital images through an algorithm. As a subcategory or field of digital signal processing, digital image processing has many advantages over analog image processing.

2.It allows a much wider range of algorithms to be applied to the input data and can avoid problems such as the build-up of noise and distortion during processing.

3. Digital Image Processing (DIP) is a software which is used to manipulate the digital images by the use of computer system. It is also used to enhance the images, to get some important information from it.

4. It is the subfield of signal processing, which focuses primarily on images. Digital image processing allows the user to take the digital image as an input and perform the different algorithm on it to generate an output.

5. These algorithms may vary from image to image according to the desired output image. Adobe Photoshop is the most popular software that uses digital image processing to edit or manipulate images.

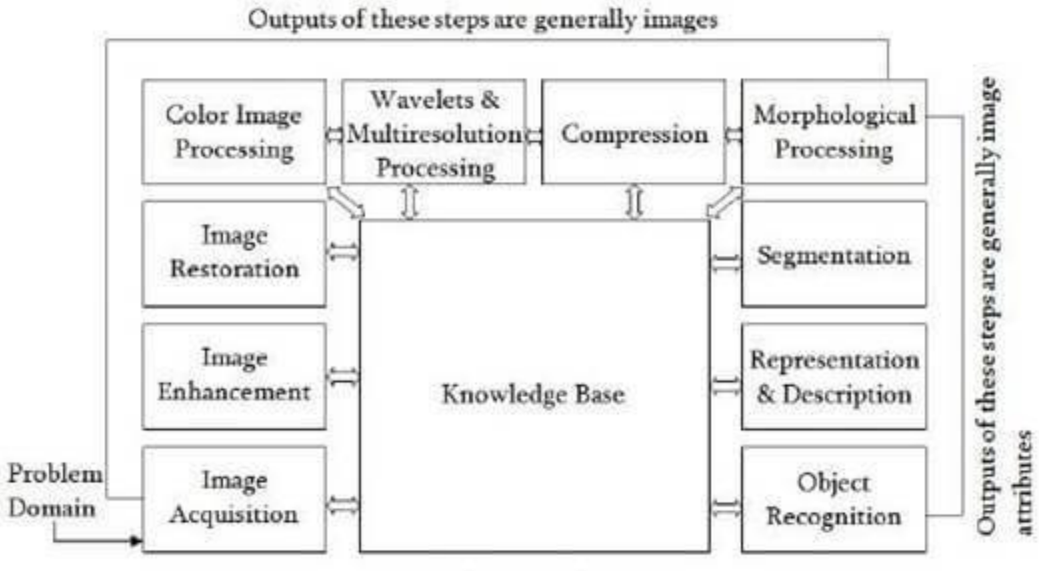
Representation:-

- An image can be defined as a 2D signal that varies over the spatial coordinates x and y and can be written mathematically a f(x,y). In general, the image can be written as a mathematical function f(x,y) as a matrix of values, comprising of rows and columns.The image f(x,y) is divided into X rows and Y columns. Thus, the coordinate ranges are x = {0, 1,......, X-1} and y = {0, 1,......, Y-1}.The value of the function f(x,y) at every point indexed by a row and a column is called the **gray value** or intensity of the image. Generally, the value of the pixel is the intensity value of the image at that point.The number of rows in the digital image is called **vertical resolution**. The number of columns in the digital image is called **horizontal resolution**. The number of rows and columns describes the dimensions of the image.The number of bits necessary to encode the pixel value is called **bit depth**. The set of all colors that can be represented by the bit depth is called the **gamut** or **palette**. So, the total number of bits necessary to represent the image is equal to Number of rows x Number of columns x Bit depth.

2. What are the fundamental steps in Digital Image Processing?

1. Image Acquisition: Image acquisition is the first step of the fundamental steps of DIP. In this stage, an image is given in the digital form. Generally, in this stage, pre-processing such as scaling is done.
2. Image Enhancement: Image enhancement is the simplest and most attractive area of DIP. In this stage details which are not known, or we can say that interesting features of an image is highlighted. Such as brightness, contrast, etc...
3. Image Restoration: Image restoration is the stage in which the appearance of an image is improved.

4. Color Image Processing: Color image processing is a famous area because it has increased the use of digital images on the internet. This includes color modeling, processing in a digital domain, etc....

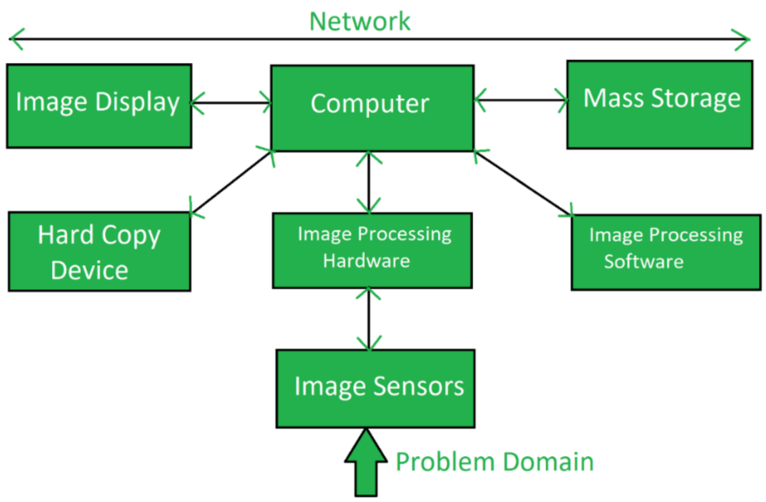


5. Wavelets and Multi-Resolution Processing: In this stage, an image is represented in various degrees of resolution. Image is divided into smaller regions for data compression and for the pyramidal representation.
6. Compression: Compression is a technique which is used for reducing the requirement of storing an image. It is a very important stage because it is very necessary to compress data for internet use.
7. Morphological Processing: This stage deals with tools which are used for extracting the components of the image, which is useful in the representation and description of shape.
8. Segmentation: In this stage, an image is a partitioned into its objects. Segmentation is the most difficult tasks in DIP. It is a process which takes a lot of time for the successful solution of imaging problems which requires objects to identify individually.
9. Representation and Description: Representation and description follow the output of the segmentation stage. The output is a raw pixel data which has all points of the region itself. To transform the raw data, representation is the only solution. Whereas description is used for extracting information's to differentiate one class of objects from another.
10. Object oriented: In this stage, the label is assigned to the object, which is based on descriptors.

11.Knowledge Base: Knowledge is the last stage in DIP. In this stage, important information of the image is located, which limits the searching processes. The knowledge base is very complex when the image database has a high-resolution satellite

3. **What are the components of an Image Processing System?**

Image Processing System is the combination of the different elements involved in the digital image processing. Digital image processing is the processing of an image by means of a digital computer. Digital image processing uses different computer algorithms to perform image processing on the digital images. It consists of following components:-



- **Image Sensors:**
  Image sensors senses the intensity, amplitude, co-ordinates and other features of the images and passes the result to the image processing hardware. It includes the problem domain.
- **Image Processing Hardware:**
  Image processing hardware is the dedicated hardware that is used to process the instructions obtained from the image sensors. It passes the result to general purpose computer.
- **Computer:**
  Computer used in the image processing system is the general purpose computer that is used by us in our daily life.
- **Image Processing Software:**
  Image processing software is the software that includes all the mechanisms and algorithms that are used in image processing system.
- **Mass Storage:**
  Mass storage stores the pixels of the images during the processing.
- **Hard Copy Device:**
  Once the image is processed then it is stored in the hard copy device. It can be a pen drive or any external ROM device.
- **Image Display:**
  It includes the monitor or display screen that displays the processed images.
- **Network:**
  Network is the connection of all the above elements of the image processing system.

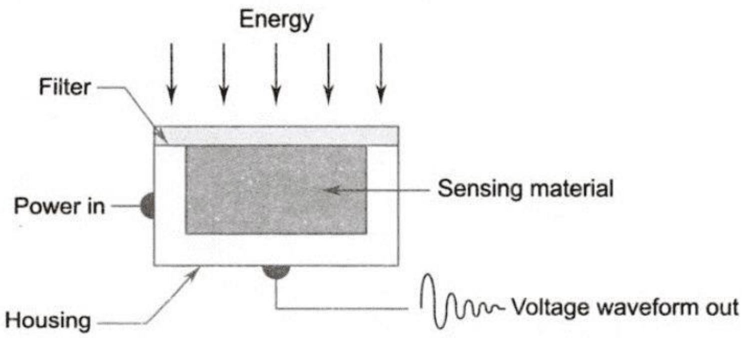
4. Explain the process of image acquisition.

In **image** processing, **image acquisition** is an action of retrieving **image** from an external source for further processing. It's always the foundation step in the workflow since no process is available before obtaining an **image**. The process of capturing an unprocessed **image** from an object or scene by an optical device into a manageable form for processing and analysis purposes.

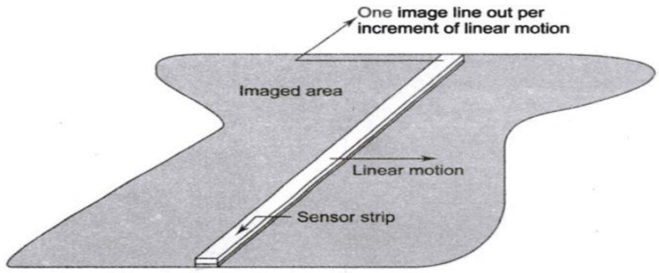
1. **Image acquisition using a single sensor:** Example of single sensor is a photodiode. Now to obtain a 2-Dimensional image using a single sensor, the motion should in both x & y direction.

- Rotation provides motion in one direction
- Linear motion provides motion in the perpendicular Direction.

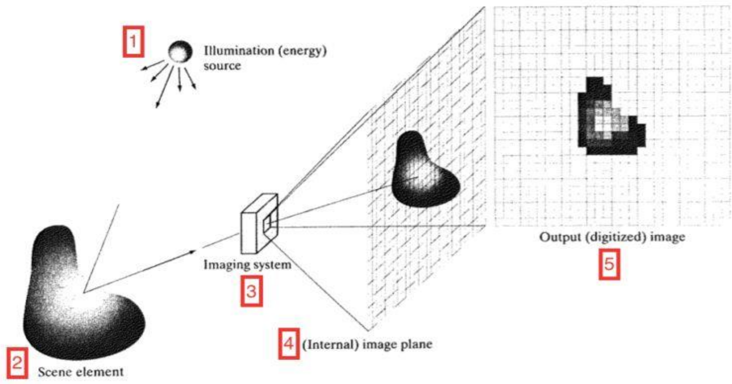
This is inexpensive method & as we can obtain high-resolution image with high precision control. But downside of this method is that it is slow.



2. **Image acquisition using a line sensor (Sensor strips):**
   - The Sensor strips provide imaging one direction.
   - Motion perpendicular to strip provides imaging in other direction.



3. **Image acquisition using an Array sensor: -** In this, individual sensors are arranged in the form of 2-D array. This type of arrangement is found in digital cameras. E.g. CCD array.
   In this, the response of each sensor is proportional to integral of the light energy projected onto the surface of the sensor. Noise reduction is achieved by letting the sensors integrate the i/p light signals over minutes or every hours.
   Since Sensor array is 2-D, a complete image can be obtained by focusing the energy pattern onto surface of the array.



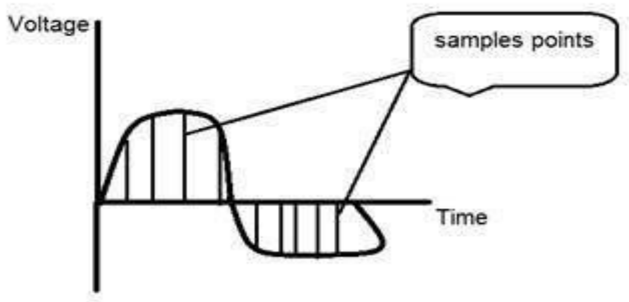
5. Explain about image sampling and quantization process

To create a digital image, we need to convert the continuous sensed data into digital form. This process includes 2 processes:

1. **Sampling:** Digitizing the co-ordinate value is called sampling.
2. **Quantization:** Digitizing the amplitude value is called quantization

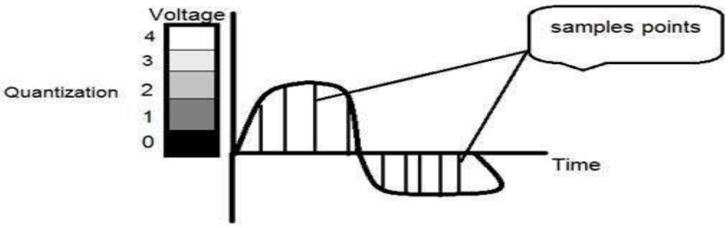
Sampling:

- Since an analogue image is continuous not just in its co-ordinates (x axis), but also in its amplitude (y axis), so the part that deals with the digitizing of co-ordinates is known as sampling.
- When looking at this image, we can see there are some random variations in the signal caused by noise. In sampling we reduce this noise by taking samples. It is obvious that more samples we take, the quality of the image would be more better, the noise would be more removed and same happens vice versa. However, if you take sampling on the x axis, the signal is not converted to digital format, unless you take sampling of the y-axis too which is known as quantization.
- Sampling has a relationship with image pixels. The total number of pixels in an image can be calculated as Pixels = total no of rows * total no of columns. For example, let’s say we have total of 36 pixels, that means we have a square image of 6X 6. As we know in sampling, that more samples eventually result in more pixels. So it means that of our continuous signal, we have taken 36 samples on x axis. That refers to 36 pixels of this image. Also the number sample is directly equal to the number of sensors on CCD array.



Quantization:

- Quantization is opposite to sampling because it is done on “y axis” while sampling is done on “x axis”. Quantization is a process of transforming a real valued sampled image to one taking only a finite number of distinct values. Under quantization process the amplitude values of the image are digitized. In simple words, when you are quantizing an image, you are actually dividing a signal into quanta(partitions).
- Now let’s see how quantization is done. Here we assign levels to the values generated by sampling process. In the image showed in sampling explanation, although the samples has been taken, but they were still spanning vertically to a continuous range of gray level values. In the image shown below, these vertically ranging values have been quantized into 5 different levels or partitions. Ranging from 0 black to 4 white. This level could vary according to the type of image you want.



- There is a relationship between Quantization with gray level resolution. The above quantized image represents 5 different levels of gray and that means the image formed from this signal, would only have 5 different colors. It would be a black and white image more or less with some colors of gray.
- When we want to improve the quality of image, we can increase the levels assign to the sampled image. If we increase this level to 256, it means we have a gray scale image. Whatever the level which we assign is called as the gray level.
- Most digital IP devices uses quantization into k equal intervals. If b-bits per pixel are used,

$$\text{No. of quantization levels} = k = 2^b$$

6. State and explain various applications of digital image processing.

1. **Face Detection** - In this method important facial features are detected and else are ignored. Face detection can be treated as a specific case of object class detection. The objective of face detection is to find the specified features such locations and sizes of a known number of faces.
2. **Remote Sensing** - Remote sensing is basically an acquisition of small or large scale information signals from an object or phenomenon, by the using various real-time sensing devices that are wireless in nature, or not in physical or direct contact with the object.
3. **Biomedical Image Enhancement & Analysis** - Biomedical image enhancement is very important issue for biomedical image diagnosis, the aim of this area is to enhance the biomedical images.
4. **Biometric Verification -** It refers to the automatic identification or recognition of humans by their behaviors or characteristics. Biometrics recognition is such an efficient type of identification and access control. It can also be used to recognize individuals in groups that are under observation.
5. **Signature Recognition -** Signature verification and recognition is also an important application, which is to decide, whether a signature belongs to a given signer based on the image of signature and a few sample images of the original signatures of the signer.
6. **Character recognition -**usually known as optical character recognition or abbreviated as OCR. It is mechanical or electronic translation of images of either handwritten or printed text into machine editable text.
7. **Digital Video Processing -** In different engineering and computing applications video processing is a particular and an important case of signal processing. Here the input and output signals are video files or video streams. Video processing techniques are used in television sets, VCRs, DVDs.

7. State and explain various applications of digital image processing.

Gamma rays:- Imaging with gamma rays is used in nuclear medicine, as well as in court medicine. This technique can be used for both diagnosis and prevention. Imaging with gamma rays has a wide range of functions, such as: Tumor imaging, Bones imaging.

a) X- Ray:- X-ray imaging creates pictures of the inside of your body. The images show the parts of your body in different shades of black and white. This is because different tissues absorb different amounts of radiation.
b) Ultra violet:- Images taken with ultraviolet light serve a number of scientific, medical or artistic purposes. Images may reveal deterioration of art works or structures not apparent under visible light. Diagnostic medical images may be used **to detect certain skin disorders** or as evidence of injury.
c) Visible & infra red band:- Imaging systems may be provided with image sensors for capturing information about incident light intensities in the visible and infrared bands of light. The means of capturing information about visible light may be unintentionally and undesirably influenced by infrared light.
d) Microwave Band:- Microwave imaging has been used in a variety of applications such as: **nondestructive testing and evaluation** (NDT&E, see below), medical imaging, concealed weapon detection at security check points, structural health monitoring, and through-the-wall imaging.
e) Radio Band:- Radio waves are very widely used in modern technology for **fixed and mobile radio communication, broadcasting, radar and radio navigation systems, communications satellites**, wireless computer networks and many other applications.

8. **Define spatial and gray level resolution. Explain about iso preference curves**

Spatial level: Spatial resolution states that the clarity of an image cannot be determined by the pixel resolution. The number of pixels in an image does not matter. Spatial resolution can be defined as the smallest discernible detail in an image.

Gray level: Gray level resolution refers to the predictable or deterministic change in the shades or levels of gray in an image. In short gray level resolution is equal to the number of bits per pixel.

ISO Prefrence:

A study conducted on this effect of gray level and contouring, and the results were shown in the graph in the form of curves, known as Iso preference curves. The phenomena of Isopreference curves shows, that the effect of contouring not only depends on the decreasing of gray level resolution but also on the image detail.

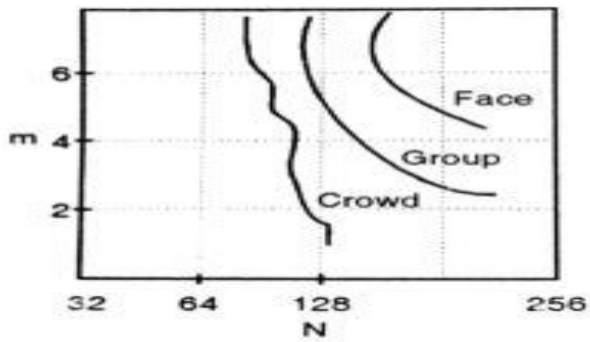


Fig no: 2

Observe that isopreference curves tend to become more vertical as the detail in the image increases. This result suggests that for images with a large amount of detail only a few intensity levels may be needed. For example, the isopreference curve in Fig. corresponding to the crowd is nearly vertical. This indicates that, for a fixed value of N, the perceived quality for this type of image is nearly independent of the number of intensity levels used for the range of intensity levels The perceived quality in the other two image categories remained the same in some intervals in which the number of samples was increased, but the number of intensity levels actually decreased. The most likely reason for this result is that a decrease in k tends to increase the apparent contrast, a visual effect often perceived as improved image quality.

9.Explain the principle of sampling and quantization. Discuss the effect of increasing the
a) Sampling frequency
b) Quantization levels on image

Principle of sampling:-

1. **Principle of 'Statastical Regularity'**: The principle of statistical regularity is derived from the theory of probability in mathematics. According to this principle, when a large number of items is selected at random from the universe, then it is likely to possess the same characteristics as that of the entire population.
2. **Principle of 'Inertia of Large Numbers'**: The principle of Inertia of large numbers states that the larger the size of the sample the more accurate the conclusion is likely to be.

Principle of quantization:- Quantization is **the process of replacing analog samples with approximate values taken from a finite set of allowed values**.

a) **Sampling frequency:-**

10. **Explain about the basic relationships and distance measures between pixels in a digital image.**

Assignment 3

1. **How to measure distance between two pixels in an image? Explain with the help of example.**

   If we have 3 pixels: p,q,z respectively

   p with (x,y)
   q with (s,t)
   z with (v,w)

   Then:

   A. D (p,q) ≥ 0 ,D(p,q) = 0 iff p = q
   B. D(p,q) = D(q,p)
   C. D(p,z) ≤ D(p,q) + D(q,z)

   - Euclidean distance between p and q:

     De(p,q) = [(x-s)2 + (y-t)2]1/2

   - D4 distance (also called city-block distance):

     D4(p,q) = |x-s| + |y-t|

   - D8 distance (also called chessboard distance) :

     D8(p,q) = max (|x-s| , |y-t|)

   E.g.Compute the distance between the two pixels using the three distances :
   q:(1,1)
   P: (2,2)

	1	2	3
1		d	
2	a	p	c
3		b	

   Euclidian distance : ((1-2)2+(1-2)2)1/2 = sqrt(2).
   D4(City Block distance): |1-2| +|1-2| =2
   D8(chessboard distance) : max(|1-2|,|1-2|)= 1
   (because it is one of the 8-neighbors)

2. **Explain with example**

   a) Neighbors of pixel -The neighbourhood of a pixel is the collection of pixels which surround it. The neighbourhood of a pixel is required for operations such as morphology, edge detection, median filter, etc. Many computer vision algorithms allow the programmer to choose an arbitrary neighborhood.

   b) Connectivity.: In image processing, pixel connectivity is the way in which pixels in 2-dimensional (or hypervoxels in n-dimensional) images relate to their neighbors. The notation of pixel connectivity describes a relation between two or more pixels. ... Or, in other words, two pixels q and p are connected if there is a path from p and q on which each pixel is 4-connected to the next one. A set of pixels in an image which are all connected to each other is called a connected component.

3. **What is m---connectivity among pixels? Give an example.**

   m---connectivity among pixels -Two or more pixels are said to be m-connected if they are m-adjacent with each others.

a. **Explain relationship amongst the pixel.**

Two pixels are connected if they are. neighbors and their gray levels satisfy some specified criterion of similarity. • For example, in a binary image two pixels. are connected if they are 4-neighbors and have same value (0/1). Two pixels are linked if they are neighbors and their gray levels satisfy few detailed pattern of similarity. For instance, in a binary image two pixels are connected if they are 4-neighbors and have same value (0/1).

b. **Explain type of connectivity in pixels using example.**

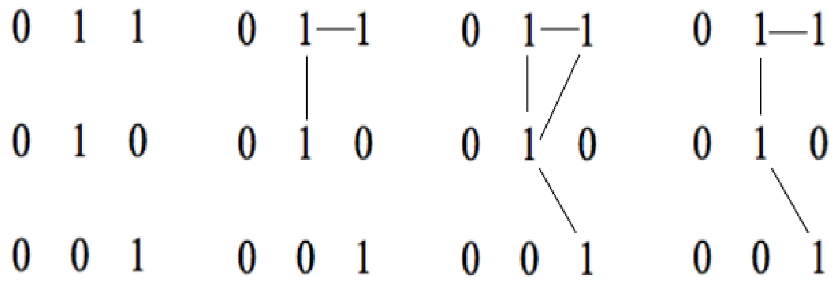


Fig: An arrangement of pixels | Fig: 4-connectivity of pixels | Fig: 8-connectivity of pixels | Fig: m-connectivity of pixels

a) 4-connectivity: Two or more pixels are said to be 4-connected if they are 4-adjacent with each others.
b) 8-connectivity: Two or more pixels are said to be 8-connected if they are 8-adjacent with each others.
c) m-connectivity: Two or more pixels are said to be m-connected if they are m-adjacent with each others.

c. **Explain types of path and distance with examples.**

The Euclidean distance is the straight-line distance between two pixels. The city block distance metric measures the path between the pixels based on a 4-connected neighborhood. Pixels whose edges touch are 1 unit apart; pixels diagonally touching are 2 units apart.
Depending on the type of adjacency, we can have 4-path, 8-path or m-path. 4. Connectivity – let S represent a subset of pixels in an image. Then, 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.

4. **Explain image arithmetic with example.**

Image arithmetic is the implementation of standard arithmetic operations, such as addition, subtraction, multiplication, and division, on images. Image arithmetic has many uses in image processing both as a preliminary step in more complex operations and by itself.

- addition: image + image (or constant)
- Subtraction - pointwise subtraction: image - image (or constant)
- Multiplication - pointwise multiplication: images * image (or constant)
- Division - pointwise division: images / image (or constant)
- Blending - pointwise linear combination of two images
- Logical AND/NAND - pointwise logical ANDing/NANDing of two binaryimages
- Logical OR/NOR - pointwise logical ORing/NORing of two binary images

- Logical XOR/XNOR - pointwise logical XORing/XNORing of two binary images
- Invert/Logical NOT - pointwise inversion of a binary image

5. Explain logical operation on images. Give its application.

Logical operators are often used to combine two (mostly binary) images. In the case of integer images, the logical operator is normally applied in a bitwise way. In this lecture we will talk about arithmetic operations such as subtraction and averaging as well as logic operations such as Not, And, and OR.

There are a lot of applications of arithmetic and logic operations such as motion detection, objects extraction and etc. ALOImagePro (Arithmetic Logical Operations for Images Processing) application is developed as Java plugin for the open-source software ImageJ. The proposed plugin has one main window which contains one or twelve images which are results of arithmetic and logic operations performed on two images, selected by the user.

6. Explain set operation on images.

Mathematical Morphology-Morphology is a tool for extracting information from images on the basis of spatial structure and relationships. Such spatial elements of region shape as boundaries, skeletons and the convex hull can be found. Morphology is useful for preprocessing images to fill in holes and remove noise.

Index Structure-The index of a pixel at location (x,y) is k=N*y+x where N is the number of columns in the image. The set indexes are relative to the position of the set in the base image.

The column and row indexes of all of the pixels in a set can be found

Image Reflection-A standard morphological operation is the reflection of all of the points in a set about the origin of the set. The origin of a set is not necessarily the origin of the base

Set Union-The union of two or sets includes all of the points that are in one or more of the sets.

This is illustrated at the right. In the first pane the set A1 (white) is overlaid with the set A2 (red).

Set Intersection-The intersection of sets includes the points that are in all of the sets. Use Intersection to find the common points.

The common area of sets A1 (white) and A2 (red) is highlighted in green.

Set Complement-The complement of a set is the set of pixels that are not in the set. The complement is always in reference to a global set.

The function COMPLEMENT finds the complement relative to all of the pixels in an image

Assignment 4

1. **Write note on following, also give its application:**

    a. **Image Negatives**

    The negative of an image is achieved by replacing the intensity 'i' in the original image by 'i-1', i.e. the darkest pixels will become the brightest and the brightest pixels will become the darkest. Image negative is produced by subtracting each pixel from the maximum intensity value.

    For example in an 8-bit grayscale image, the max intensity value is 255, thus each pixel is subtracted from 255 to produce the output image.

    The transformation function used in image negative is :

    $s = T(r) = (L – 1) – r$

    Where L - 1 is the max intensity value,
    s is the output pixel value and
    r is the input pixel value

    Application

    In photography,negatives are normally used to make positive prints on photographic paper by projecting the negative onto the paper with a photographic enlarger or making a contact print

    b. **Log Transformations**

    Logarithmic transformation of an image is one of the gray level image transformations. Log transformation of an image means replacing all pixel values, present in the image, with its logarithmic values. Log transformation is used for image enhancement as it expands dark pixels of the image as compared to higher pixel values.

    The formula for applying log transformation in an image is,

    $S = c * \log (1 + r)$

    where,
    R = input pixel value,
    C = scaling constant and
    S = output pixel value

    Application

    Log transformation is used for image enhancement as it expands dark pixels of the image as compared to higher pixel values. When we apply log transformation in an image and any pixel value is '0' then its log value will become infinite.

    c. **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.

    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.

Correcting gamma.

$s=cr^\gamma$

$s=cr^{(1/2.5)}$

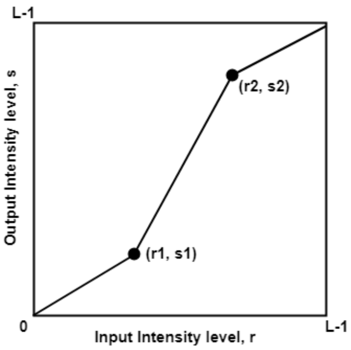
Application

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.

d. Contrast stretching

Contrast stretching as the name suggests is an image enhancement technique that tries to improve the contrast by stretching the intensity values of an image to fill the entire dynamic range. The transformation function used is always linear and monotonically increasing.

Below figure shows a typical transformation function used for Contrast Stretching.

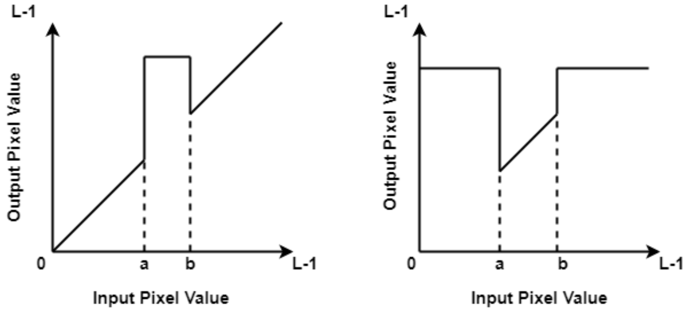


By changing the location of points (r1, s1) and (r2, s2), we can control the shape of the transformation function. For example,

1. When r1 =s1 and r2=s2, transformation becomes a **Linear function**.
2. When r1=r2, s1=0 and s2=L-1, transformation becomes a **thresholding function**.
3. When (r1, s1) = (r_{min}, 0) and (r2, s2) = (r_{max}, L-1), this is known as **Min-Max Stretching.**
4. When (r1, s1) = (r_{min} + c, 0) and (r2, s2) = (r_{max} – c, L-1), this is known as **Percentile Stretching**.

e. Intensity---level slicing

There are applications in which it is of interest to highlight a specific range of intensities in an image. Some of these applications include enhancing features in satellite imagery, such as masses of water, and enhancing flaws in X-ray images. The method,called intensity-level slicing, can be implemented in several ways, but most are variations of two basic themes. One approach is to display in one value (say, white) all the values in the range of interest and in another (say, black) all other intensities. This transformation, shown in Fig. 3.11(a), produces a binary image. The second approach, based on the transformation in Fig. 3.11(b), brightens (or darkens) the desired range of intensities, but leaves all other intensity levels in the image unchanged.



f. Bit---plane slicing

Instead of highlighting gray level images, highlighting the contribution made to total image appearance by specific bits might be desired. Suppose that each pixel in an image is represented by 8 bits. Imagine the image is composed of 8, 1-bit planes ranging from bit plane1-0 (LSB)to bit plane 7 (MSB).

In terms of 8-bits bytes, plane 0 contains all lowest order bits in the bytes comprising the pixels in the image and plane 7 contains all high order bits.

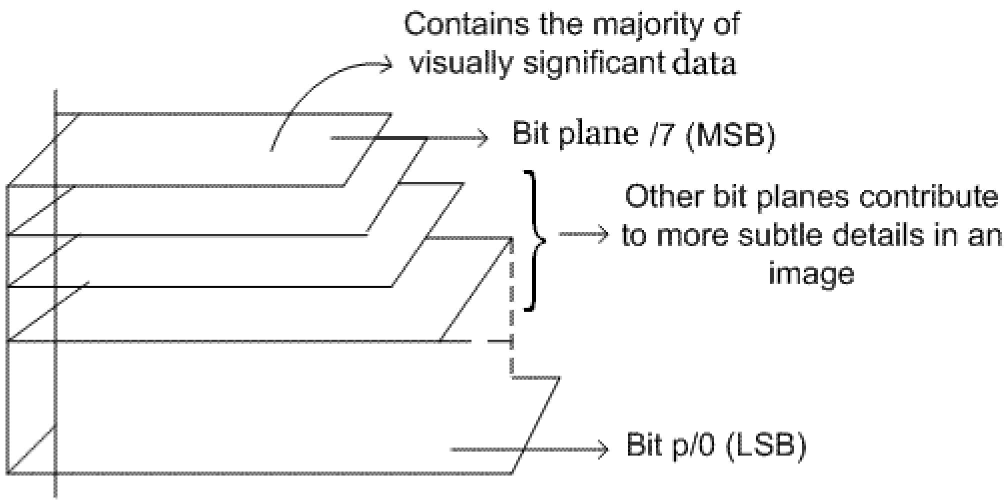


Figure (5.15)

Separating a digital image into its bit planes is useful for analyzing the relative importance played by each bit of the image, implying, it determines the adequacy of numbers of bits used to quantize each pixel , useful for image compression.

In terms of bit-plane extraction for a 8-bit image, it is seen that binary image for bit plane 7 is obtained by proceeding the input image with a thresholding gray-level transformation function that maps all levels between 0 and 127 to one level (e.g 0)and maps all levels from 129 to 253 to another (eg. 255).

As an exercise obtain gray-level transformation functions that would yield other bit planes.

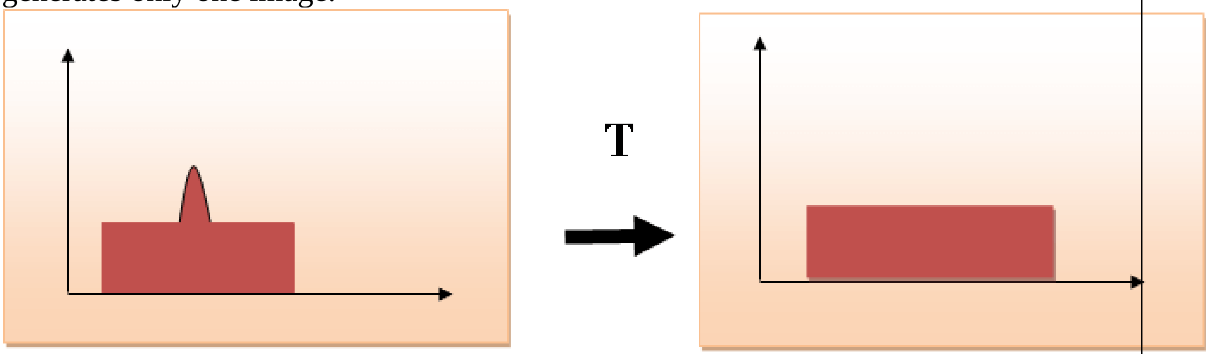
g. Histogram processing

In digital image processing, the histogram is used for graphical representation of a digital image. A graph is a plot by the number of pixels for each tonal value. Nowadays, image histogram is present in digital cameras. Photographers use them to see the distribution of tones captured.

Histogram equalization is used for equalizing all the pixel values of an image. Transformation is done in such a way that uniform flattened histogram is produced.

Histogram equalization increases the dynamic range of pixel values and makes an equal count of pixels at each level which produces a flat histogram with high contrast image.

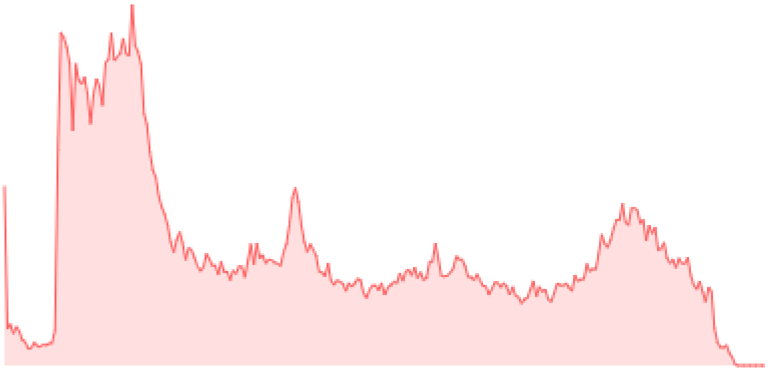
While stretching histogram, the shape of histogram remains the same whereas in Histogram equalization, the shape of histogram changes and it generates only one image.



2. **Explain the types of gray level transformation used for image enhancement**
   Linear
   Logarithmic
   Power – law
3. **What is meant by image enhancement by point processing? Discuss any two methods in it.**
   Image Negatives,Contrast Stretching, Log Transformations
4. **Define histogram of a digital image. Explain how histogram is useful in image enhancement?**

In digital image processing, the histogram is used for graphical representation of a digital image. A graph is a plot by the number of pixels for each tonal value. Nowadays, image histogram is present in digital cameras. Photographers use them to see the distribution of tones captured.

In a graph, the horizontal axis of the graph is used to represent tonal variations whereas the vertical axis is used to represent the number of pixels in that particular pixel. Black and dark areas are represented in the left side of the horizontal axis, medium grey color is represented in the middle, and the vertical axis represents the size of the area.



Histogram of the above scenery

Applications of Histograms

1. In digital image processing, histograms are used for simple calculations in software.
2. It is used to analyze an image. Properties of an image can be predicted by the detailed study of the histogram.
3. The brightness of the image can be adjusted by having the details of its histogram.
4. The contrast of the image can be adjusted according to the need by having details of the x-axis of a histogram.
5. It is used for image equalization. Gray level intensities are expanded along the x-axis to produce a high contrast image.
6. Histograms are used in thresholding as it improves the appearance of the image.

7. If we have input and output histogram of an image, we can determine which type of transformation is applied in the algorithm.

5. What is meant by image subtaction? Discuss various areas of application of image subtraction.

Image subtraction or pixel subtraction is a process whereby the digital numeric value of one pixel or whole image is subtracted from another image. This is primarily done for one of two reasons – levelling uneven sections of an image such as half an image having a shadow on it, or detecting changes between two images.

One of the more interesting applications of the image averaging (or image addition) operation is suppressing the noise component of images. In this case, the addition operation is used to take the average of several noisy images that are obtained from a given input image.

Image subtraction is used for analysis of the results, i.e. the identification of areas of the sample where particle movement occurs, the evolution of the locations where particles are removed and their corresponding transportation paths and the evolution of particle motion over the height of the sample.

Image subtraction is used widely in image processing to segment dynamic regions from static regions for higher level processing of images for motion detection, recognition and object tracking

6. What is meant by image avaraging? Discuss various areas of application of image avaraging.

Image averaging is a digital image processing technique that is often employed to enhance video images that have been corrupted by random noise. The algorithm operates by computing an average or arithmetic mean of the intensity values for each pixel position in a set of captured images from the same scene or viewfield.

For Portraits : at the time of shooting, it is necessary to use the multi-shot method like the HDR Photography. So the best result is obtained by clicking on the tripod and raising the mirror (mirror lockup function) to reduce vibration. You should also lock focus and exposure so that they are consistent across the various photos. Using Photoshop gives you a feature that allows you to align layers. Obviously you have to make sure that you have the same exposure and focus in all the shots and minimum movement between shots.

While image averaging is usually utilized for noise reduction, image subtraction can be employed to mitigate the effect of uneven illuminance. Moreover, we'll see that image subtraction allows us to compare images and detect changes.

Assignment 5

1. **What is meant by image segmentations? Give two applications of image segmentation**

   Image segmentation is the division of an image into regions or categories, which correspond to different objects or parts of objects. Every pixel in an image is allocated to one of a number of these categories. A good segmentation is typically one in which:
   • pixels in the same category have similar greyscale of multivariate values and form a connected region,
   • neighbouring pixels which are in different categories have dissimilar values.
   For example, in the muscle fibres image each cross-sectional fibre could be viewed as a distinct object, and a successful segmentation would form a separate group of pixels corresponding to each fibre. Similarly in the SAR image (Fig 1.8(g)), each field could be regarded as a separate category
   There are three general approaches to segmentation, termed thresholding, edge-based methods
   and region-based methods.
   • In thresholding, pixels are allocated to categories according to the range of values in which a pixel lies. Fig 4.1(a) shows boundaries which were obtained by thresholding the muscle fibres image. Pixels with values less than 128 have been placed in one category,and the rest have been placed in the other category. The boundaries between adjacent pixels in different categories has been superimposed in white on the original image. It can be seen that the threshold has successfully segmented the image into the two predominant fibre types.
   • In edge-based segmentation, an edge filter is applied to the image, pixels are classified as edge or non-edge depending on the filter output, and pixels which are not separated by an edge are allocated to the same category. Fig 4.1(b) shows the boundaries of connected regions after applying Prewitt's filter (§3.4.2) and eliminating all non-border segments containing fewer than 500 pixels. (More details will be given in §4.2.)
   • Finally, region-based segmentation algorithms operate iteratively by grouping together pixels which are neighbours and have similar values and splitting groups of pixels which are dissimilar in value

   Aplication-

   Some of the practical applications of image segmentation are:

   - Content-based image retrieval
   - Medical imaging
   - Object detection
   - Face detection
   - Locate objects in satellite images (roads, forests, crops, etc.)
   - Recognition Tasks o Face recognition
   - Fingerprint recognition
   - Traffic control systems
   - Video surveillance

2. **Classify the types of edges in the digital image.**

   Edges are significant local changes of intensity in a digital image. An edge can be defined as a set of connected pixels that forms a boundary between two disjoint regions. In Image Processing, an edge can be defined as a set of contiguous pixel positions where an abrupt change of intensity (gray or color) values occur. Edges represent boundaries between objects and background. Sometimes, the edge-pixel-sequence may be broken due to insufficient intensity difference. There are three types of edges:

Horizontal edges
To detect horizontal edges we first convolve with a Gaussian and then differentiate the resultant image in the y direction. But this is the same as convolving the image with the Derivative Of the Gaussian (DOG) in the y-direction.
Vertical edges-
Vertical edges can be detected by using a horizontal gradient operator followed by a threshold operation to detect the extreme values of the gradient. The gradient produces a doublet of extremes, positive-negative or negative-positive, depending on the direction of the transition.
Diagonal edges-
A diagonal edge is neither horizontal nor vertical. It will cause a partial response to both the horizontal and vertical edge detectors. An image that is a combination of the two processes can be created by combining the results of each gradient calculation.

3. List and explain the various methods of thresholding in image segmentation.

Thresholding is a very popular segmentation technique, used for separating an object from its background. In the article below, I have described various techniques used to threshold grayscale images(8-bit).

The process of thresholding involves, comparing each pixel value of the image (pixel intensity) to a specified threshold. This divides all the pixels of the input image into 2 groups:

- Pixels having intensity value lower than threshold.
- Pixels having intensity value greater than threshold.

These 2 groups are now given different values, depending on various segmentation types.

Thresholding Methods

Histogram shape-based methods, where, for example, the peaks, valleys and curvatures of the smoothed histogram are analyzed

Clustering-based methods, where the gray-level samples are clustered in two parts as background and foreground (object), or alternately are modeled as a mixture of two Gaussians

Entropy-based methods result in algorithms that use the entropy of the foreground and background regions, the cross-entropy between the original and binarized image, etc.[2]

Object Attribute-based methods search a measure of similarity between the gray-level and the binarized images, such as fuzzy shape similarity, edge coincidence, etc.

Spatial methods [that] use higher-order probability distribution and/or correlation between pixels

Local methods adapt the threshold value on each pixel to the local image characteristics. In these methods, a different T is selected for each pixel in the image. The T can be of many types like mean, gaussian, median, mode(not used generally).

4. **Differentiate between local and global thresholding technique for image segmentation.**

Local adaptive thresholding is used to convert an image consisting of gray scale pixels to just black and white scale pixels. ... Unlike the global thresholding technique, local adaptive thresholding chooses different threshold values for every pixel in the image based on an analysis of its neighboring pixels.

Global thresholding consists of setting an intensity value (threshold) such that all voxels having intensity value below the threshold belong to one phase, the remainer belong to the other. Global thresholding is as good as the degree of intensity separation between the two peaks in the image.

Unlike the global thresholding technique, local adaptive thresholding chooses different threshold values for every pixel in the image based on an analysis of its neighboring pixels. This is to allow images with varying contrast levels where a global thresholding technique will not work satisfactorily.

A global thresholding technique is one which makes use of a single threshold value for the whole image, whereas local thresholding technique makes use of unique threshold values for the partitioned subimages obtained from the whole image.

5. **Evaluate the advantages and disadvantages of using more than one seed in a region growing technique**

By using more than one seed, we expect a better segmentation of an image, since more seeds lead to more homogeneous regions. On the other hand, the probability of splitting a homogeneous region in two or more segments increases**.**

(ii) Explain region based segmentation technique.

The region-based segmentation method looks for similarities between adjacent pixels. That is, pixels that possess similar attributes are grouped into unique regions. ... Regions are grown by grouping adjacent pixels whose properties, such as intensity, differ by less than some specified amount.

(i)Illustrate region based segmentation and region growing with examples

Region growing is a simple region-based image segmentation method. It is also classified as a pixel-based image segmentation method since it involves the selection of initial seed points.

The main goal of segmentation is to partition an image into regions. Some segmentation methods such as thresholding achieve this goal by looking for the boundaries between regions based on discontinuities in grayscale or color properties. Region-based segmentation is a technique for determining the region directly.

6. **Explain the detection of isolated points in an image.**

The mask output or response at each pixel is computed by centering centering the mask on the pixel location. This is used to detect isolated spots in an image. The graylevel of an isolated point will be very different from its neighbours.

7. **Explain the basics of intensity thresholding in image segmentation.**

In simple implementations, the segmentation is determined by a single parameter known as the intensity threshold. In a single pass, each pixel in the image is compared with this threshold. If the pixel's intensity is higher than the threshold, the pixel is set to, say, white in the output.

Suppose that the intensity histogram in Fig. 10.32(a) corresponds to an image, $f(x, y)$, composed of light objects on a dark background, in such a way that object and background pixels have intensity values grouped into two dominant modes. One obvious way to extract the objects from the background is to select a threshold, *T*, that separates these modes. Then, any point (x, y) in the image at which $f(x, y) > T$ is called an *object point*. Otherwise, the point is called a *background* point.

8. **Explain point detection ,edge detection ,line detection in imge segmentation.**

In point-detection method, the point is detected at a location (x, y) in an image where the mask is centered. In line detection method, we have two masks so that the corresponding points are more likely to be associated with a line in the direction of the one mask as compare to the one.

Edge detection is a technique of image processing used to identify points in a digital image with discontinuities, simply to say, sharp changes in the image brightness. These points where the image brightness varies sharply are called the edges (or boundaries) of the image.

In image processing, line detection is an algorithm that takes a collection of n edge points and finds all the lines on which these edge points lie. The most popular line detectors are the Hough transform and convolution-based techniques.

Assignment 6

1] Explain the pattern and pattern classes in object recognition

A pattern is an arrangement of descriptors, The name feature is used often in the pattern recognition literature to denote a descriptor. A pattern class is a family of patterns that share some common properties. Pattern is everything around in this digital world. A pattern can either be seen physically or it can be observed mathematically by applying algorithms. Example: The colors on the clothes, speech pattern, etc. In computer science, a pattern is represented using vector feature values.

Classification is the task of assigning a class label to an input pattern. The class label indicates one of a given set of classes. The classification is carried out with the help of a model obtained using a learning procedure. A pattern class is a family of patterns that share some common properties. Pattern classes are denoted ω1,ω2,………….,ωW where W is the number of classes.

2] Explain Matching

: Template matching is a technique in digital image processing for finding small parts of an image which match a template image. ... It can be used in manufacturing as a part of quality control, a way to navigate a mobile robot, or as a way to detect edges in images. Template matching is a technique in computer vision used for finding a subimage of a target image which matches a template image. This technique is widely used in object detection fields such as surveillance [1], vehicle tracking [2], robotics [3], medical imaging [4], and manufacturing [5].

Pattern matching problem aims to search the most similar pattern or object by matching to an instance of that pattern in a scene image. ... The scene image is logically divided into a number of candidate windows which are then to be matched with the query pattern. Pattern matching is the process of checking whether a specific sequence of characters/tokens/data exists among the given data. ... It is also used to find and replace a matching pattern in a text or code with another text/code. Any application that supports search functionality uses pattern matching in one way or another.

3] Explain Optimum Statistical Classifiers

: Criterion Function

Make the decision that yields the lowest probability of committing an error.

p(wi |x) - Probability that pattern x comes from class wi .

Lij - The cost (loss) when putting x in wj when it belongs to wi .

These are combined to form the conditional average risk (or loss) rj (x) = X W k=1 Lkjp(wk|x). (1) Assign x to the class wj that gives the smallest risk. The classifier that minimises the total average loss is called the Bayes classifier. Thus the Bayes classifier assigns an unknown pattern x to class wi if ri(x) ≤ rj (x) for j = 1, 2, ..., W; j 6= i, where W is the number of classes.

Use of Bayes Rule

From statistics we have Bayes rule p(A|B) = p(A) · p(B|A) p(B) . (2) We use Equation 2 to rewrite Equation 1 as rj (x) = 1 p(x) X W k=1 Lkjp(x|wk)P(wk), (3) where p(x|wk) is the probability density function of class wk and P(wk) is the probability of class wk occurring. p(x) is the same for all classes and will thus not affect the order of the different loss values.

Simplification 1

: Assume Uncorrelated Patterns We can simplify the the discrimination process further by assuming that the patterns are uncorrelated. Example: When using a 2D pattern vector the covariance matrices will be on the form { HERE C1 AND C2 ARE MATRIX }

C1 = [A 0 |

| 0 B |

C2 = |C 0 |

| 0 D |

where A, B, C, and D are constants

Simplification 2

: Assume Same Covariance If we assume that all classes have the same covariance we get the discriminant function dj (x) = −(x − mj)^ T C^-1 (x − mj) which will result in linear decision functions with hyperplanes as decision boundaries. The discriminant function is also called the Mahalanobis distance.