Unit IV

CHAPTER

8

Digital Image Processing

8.1 Introduction

The digital image processing generally refers to processing of a two - dimensional picture (digital images) by a digital computer. The image processing operation is fundamentally different from the operation of the computer graphics. In computer graphics computer is used to create a picture where in image processing techniques used to modify and interpret an existing picture. Image processing is a form of information processing in which we provide an image as input for ex. Photographs or frames of video and the output may be an image or a set of features of the image. Most image-processing techniques involve treating the image as a two-dimensional signal. Signals can be either analog or digital and may come from different sources for different types of signals. There are various sets of signal processing depending on the nature of the signal. For analog signals, signal processing may involve the amplification and filtering of audio signals for audio equipment or the modulation and demodulation of signals for telecommunications. For digital signals, signal processing may involve the compression, error checking and error detection of digital signals. Digital image processing has many advantages over analog image processing. 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 signal distortion during processing.

Image processing generally involves three steps:

1. Import an image with an optical scanner or directly through digital photography.
2. Manipulate or analyze the image by image enhancement and data compression or the image may be analyzed to find those patters that are not visible to the human eye.
3. Output the result. The result might be the image altered in some way or it might be a report based on analysis of the image.

a digitally stored image by manipulating the image with software. Manipulation can be like making the image light or dark, zooming a particular portion of the image or increase or decrease the contrast colors of the image. Data compression enables devices to transmit or store same amount of data in fewer bits.

The image processing manipulation can be divided into three categories-

1. Image processing : image in- image out

   Image Analysis : measurement out

   Image under standing : image in - high level description out

Image processing techniques are used extensively in commercial art applications that involve the retouching and rearranging of sections of photographs similar methods are used to analyze satellite photos of earth and photos of another galaxies with the fast computers and signal processor available in the 2000 as digital image processing has become the most common form of image processing, and is generally used because it is not only the most versatile method but also the cheapest.

8.2 Difference between computer graphics and image processing :

Both computer graphics and image processing combined used by many application packages. Although methods used in computer graphics and image processing overlap there are differences in them.

1. In computer graphics, computer is used to create a picture. Scenes, images etc. To create picture we use methods that are involved in computer graphics such as line drawing, circle drawing, polygon drawing, different types of transformation, clipping, curve generation. Color filling projection of object, visible surface detection and surface rendering etc.

   When ever image processing applies techniques to modify or interpret existing pictures, such as photographic and tv scans.
2. Image processing is improving picture quality whenever computer graphics only creates a picture it does not improve a picture quality.
3. In computer graphics, we use the bar chart and pie chart whenever image processing doesn't use chart.
4. In computer graphics, we use to color models whenever image processing does not use color models.
5. In computer graphics, we use to define many algorithms whenever image processing does not use algorithm.
6. In computer graphics, we use two dimension and three dimensions whenever image processing is used to only improve the picture quality.

8.3 Digital Image Definition

A Digital image is composed of pixels which can be thought of as small dots on the screen.

An image may be defined as a two-dimensional function, f(x,y), where x and y are spatial (plane) coordinates and the amplitude of f (brightness) at any pair of coordinates

(x,y) is called the intensity or gray level of image at that point. When x, y and the amplitude values of f are all finite discrete quantities, we call the image a digital image.

The field of digital image processing refers to processing digital images by means of a digital computer.

A digital image is represented by a matrix of numeric values each representing a quantized intensity value. When I is a two dimensional matrix then I (r,c) is the intensity value at the position corresponding to row r and column c of the matrix.

The point at which an image sampled is known as picture elements, also known as pixels. The pixel values of intensity images are called gray scale levels. The intensity at each pixel is represented by an integer. If there are just two intensity values. For ex. black & white they are represented by the numbers 0 and 1 such images are called binary valued images. When 8-bit are used to store each pixel value. The gray levels range from 0 (black) to 255 (white) .

Each pixel has a particular value which determines its appearing color. This value is quantified by three numbers giving the decomposition of the color in the three primary colors red, green, and blue. Any color visible to human eye can be represented this way. The decomposition of a color in the three primary colors is quantified by a number between 0 and 255.

For ex. White will be coded as R=255, G=255,B=255, Black will be known as (R, G, B)=(0,0,0).

It is common to use a square sampling grid with pixels equally spaced along the two sides of the grid. The distance between grid points obviously affects the accuracy with which the original image is represented, and it determines how many details can be resourced. The resolution depends on the imaging system as well.

8.4 The storage and capture of digital image

The first step is capturing an images It is important to remember that the image that we view on our monitors and in print are not normally digital images. But it is analoge representation of the source digital images.

Digital computers process binary data if we want to process images within computers we have to extract information from the original analogue image and deliver it to a computer in binary form. This process is called digitization. Digitization of any analogue original is performed by a digital camera or scanner, these are both called ' capture' or 'input' devices of capturing images.

When we store an image, we are storing a 2 D array of values, where each value represents the data associated with a pixel in the image. For a bitmap, this value is a binary digit. For color images, the value may be a collection of :

- three number representing the intensities of the red, green and blue components of the colour at that pixel.
- three numbers that are indices to tables of red, green and blue intensities
- A single number that is an index to a table of color triples.
- An index to any number of other data structures that can represent a color including XYZ color system.

All the digital imaging systems have one or more components (media) in or on which the digital image is stored. It is called "storage media" writing and reading refers to the process of transferring image data to and from the storage media.

Storage for digital image may be categorized (depending on how the image data is recorded)

- Electronic (Short term storage)
- Magnetic
- Optical

1.Electronic Media.

All computers and digital imaging system have some form of electronic storage that is referred to as temporary This is in form of RAM (Random Access memory). It facilitates fast writing/recording and reading of data. But it has relatively limited capacity in comparison to the other storage media. It requires electrical power to maintain the stored data. Memory based storage is fast but it is normally volatile and memory is most expensive form of storage.

2. Magnetic storage Media

Image data and other form of information (Such as analog audio and Tv.) can be recorded on surfaced that can be magnetised. The recording and reading is done as the surface moves close to a device called a head. The magnetic

surface is usually on a spinning disk or on a moving tap for ex, VCR and audio cassettes. As an electrical pulse represents each digital bit is applied to the write head. It produces a small magnetic pulse when the magnetised bits pass under the read head they produce electrical pulse that pass on the processor.

3. Optical Storage Media

In this type of storage media, writing or recording operation to done by a laser. This laser produces a relatively intense beam of light that is directed to the bit positions as the disk rotates. The laser beam is turned on and off by the series of pulse representing the bits to be recorded. By this process each bit position is now marked by leaving either reflecting or non-reflecting. When the bit positions pass under the read laser (it is less intense than the write laser) they either reflect or do not reflect the light to a detector that converts the light pulses into electrical pulse. Ex. of such media are CD's DVD's etc.

8.5 File formats for image storage

Image file formats are standardized means of organizing and storing images, image files are composed of pixels that are ordered as a grid (rows & column) , each pixel consists of numbers representing magnitude of brightness and color. Storing an image in a file required compression of the image data which can be lossless and loosy.

Lossless compression do not lose any of the image information during compression and decompression

Loosy compression removes some of the original photographic detail. It can reduce the size of image files to a far a greater extent than lossless compression. At the highest compression level, image deterioration is noticeable.

The major file formats in which digital images are stored are

- JPEG Format
- GIF Format
- TIFF File format
- PNG file format

1. JPEG format (Joint Photographic Experts Group)

JPEG files are suitable for email and web posting as well as for printing at non-professional quality. JPEG compression is loosy technique. A useful property of JPEG is that the degree of loosiness can be varied by adjusing compression parameters. This means that the file size can be reduced against output image quality. JPEG images have small distortion especially around

the sharp edges such as edges of text characters.

2. GIF (Graphics Interchange Format) File format :

GIF file format allow high quality high resolution graphics to be displayed on a variety of graphics hardware and was intended as an exchange and display mechanism for graphics images.

For drawing and artwork created on a computer (including clipart, icons, screen captures)

and text) use GIF file format. Specially when image consists of uniformly colored piece (color line & shape). GIF is the best format for getting smaller, faster downloading files without loosing image quality. GIF also gives the best quality for scanned photographs and artwork. GIF is also the only choice if we want special effects such as animation and image with transparent area. GIF is useful on those areas where JPEG is poor and where the file size should be small.

3. TIFF file format (Tagged images file format)

It was designed for raster data interchange. The goal of TIFF specification on are extensibility, portability and revisability. Its main strengths are highly flexible and platform independent format which is supported by numerous image processing applications. TIFF can contain multiple kind of picture formats. It is not read only format, the software system should be able to edit, process and change TIFF files. The image files format refers to the files basic image storage stucture. It provides information about the image such as its width, length and no of pixels. Because of flexibility, very different levels of image quality can be produced with TIFF. You can obtain TIFF images by using desktop scanners, digital camera and you own photographs. Color photos work reasonably well but black and white photos are better. The biggest problem is file size. The scanner can scan 300 dots per inch (DPI) so a 3X5 inch photo at 300 DPI provides 900X1500 pixel. At eight bit/pixel 256 color the Image file comes to over 1350,000 bytes.

This is not practical for many applications.

4.PNG file Format (Portable Nature Graphics)

It is a newer format , it is designed to replace the GIF format and to some extent the more complex TIFF format.

For image editing PNG provides a useful format for the storage of intermediate stages of editing. PNG's compression is fully lossless and since it supports up to 48-bit true color or 16 bit grayscale.

Saving, restoring and re-saving an image will not degrade its quality. But unlike TIFF, in PNG specification the user cannot choose any features, the result is that a PNG image saved in one application is readable in any other PNG supporting applications.

8.6 Application Area of Digital Image Processing

Digital image processing has a broad spectrum of applications, such as remote sensing via satellites and other space crafts. Image transmission and storage for business application, medical, processing, radar, soear and acoustic images processing, robotics and automated inspection of industrial parts.

Images acquired by satellites are useful in tracking of earth's resources, geographical mapping, prediction of agricultural crops, urban growth and weather,flood and fire control and many other environmental application.

(1) Space Research center

Space image application includes recognition and analysis of objects contained in images obtained from deep space probe missions.

Image transmission and storage applications occur in broadcast television, taleconferencing, transmission of facsimile images (printed documents and graphics) for office automation.

Communication over computer networks, closed-circuit television based security, monitoring system and in military communications.

(2) In Medical Application

Image processing technique used in medical to make extensive use of picture. Enhancements, in tomography and simulations of operations.

Tomography is techniques of X-ray photography that allows cross sectional view of physiological systems to be displayed. Both computed X-ray tomography and position emission tomography use to reconstruct cross sections from digital data.

These techniques are also used to monitor to show cross section view during surgery.

Another medical image technique ultrasonic and nuclear medicine scanner is ultrasonic high frequency sound wave to generate digital data. In medical applications one is concerned with processing of chest X-rays, projection images of transexial tomography and other medical images that occur in radiology and ultrasonic scanning. There images may be used for patient screening and monitoring or for detection of tumors or other disease in patients.

(3) Photo Editing Application

Image processing methods used in many commercial photo-editing packages. Using image processing method, photo editing applications change the actual photo and apply many effects. As ex Photoshop, which mainly used photo-editing application.

There are many applications ranging from robot vision for industrial automation to image synthesis for cartoon making or fashion designs.

There are some applications of image processing which are given below:-

1 Image Representing and Modelling.
2 Image Restoration
3 Image Analysis
4 Image Reconstruction
5 Image Data Compression
6 Intensity Transformations and Spatial Filtering
7 Color Image Processing
8 Wavelets
9 Morphological Image Processing
10 Image Segmentation

1. Image Representing & Modeling

It Image representation is concerned with characterization of the quality that each picture element represents. An images could represent luminances of object in a scene, the absorption charactersitics of the body tissue. The radar cross section of a target, the temperature profile of a region (infrared imaging) or the gravitational field in an area (in geographical imaging).In general any two dimensional function that contains information can be considered an image.

2. Image Restoration :

Image restoration is used for removal or minimization of known degradations in an image. This includes deblurring of images degraded by the limitations a sensor or its environment, noise filtering and correlation of geometric distortion or non-linearities due to sensors.

3. Image Analysis

Image analysis is concerd with making quantitative measurements from an image to produce a description of it. More advanced image analysis systems measure quantitative information and use it to make a sophisticated decisions, such as controlling the arm of a robot to move an object after identifying it or navigating an aircraft. Image analysis technique requires extraction of certain features that aid in the identification of the object. Segmentation techniques are used to isolate the desired object from the scene so that measurements can be made on it subsequently.

4. Image reconstruction form projections

Image reconstruction from projection is a special class of image restoration problems where a two-dimensional object is reconstructed from several one -dimensional projections. Each projection is obtained by projecting a parallel X-ray beam through the object. Planar projections are thus obtained by viewing the object from many different angles. Such techniques are important in medical imaging, astronomy, radar imaging, geological exploration and non-destructive testing of assemblies.

5. Images Data Compression

The amount of data associated with visual information is so large that it storage would require enormous storage capacity. Although the capacities of several storage media are subtantial, their access speeds are usually inversely proportional to their capacity. Storage or transmission of such data require large capacity or bandwidth, which could be very expensive.

Image data compression techniques are concerned with reduction of the number of bits required to store or transit images without any appreciable loss of information.

6. Intensity Transformations and Spatial Filtering

The term spatial domain refers to the image plane itself and methods in this category are based on direct manipulation of pixels in an images. There are two important categories of spatial domain processing Intensity (Or Gray level) transformations and spatial filtering.

7. Color Image Processing

Colour image processing using the image processing toolbox and extend some of its functionality by developing additional colour generation and transformation functions. The image processing toolbox handles colour images either as indexed images or RGB(red, green, blue) images. An RGB image may be viewed as a "stack" of three gray scale images that , when fed into the red, green and blue inputs of colour monitor, produce a colour image on the screen. By conversion the three images forming an RGB colour images are referred to as the red, Green and blue component images. The data class of the components images, determines their range of values.

8. Wavelets

Like the Fourier transform, wavelet transforms can be used in tasks ranging form edge detection to image smoothing because they provide significant insight into both an image's spatial and frequency characteristics wavelets can also be used in applications in which Fourier methods are not well-suited, like progressive image reconstruction.

9. Morphological Image Processing

The work morphology commonly denotes a branch of biology that deals with the from and structure of animals and plants. We use the same word here in the context of mathematical morphology as a tool for extrating image components that are useful in the representation and description of region shape, such as boundaries, skeletons and the convex hull. These also include morphological filtering, thinning and pruning. The morphlogical concepts and techniques introduced constitute a powerful set of tools for extracting features from an image. The basic operators of erosion, dilation and reconstruction can be used in combination to perform a wide variety a tasks.

10. Images Segmentation.

Segmentation is another major step of image processing. Segmentation subdividers an image into its constituent regions or objects. The level to which the subdivision is carried depends as the problem being solved. That is segmentation should stop when the objects of interest in an application have beer isolated. For example, in the automated inspection of electronic assemblies interest lies in analyzing image of the products with the objective of determining the presence or absence of specific anomalies, such as missing components or broken connection paths. There it no point in carrying segmentation past the level of detail required to identify those elements.

8.7 Basic Image Processing Techniques

The image processing techniques include many types of operations but here we study some techniques such as antialiasing, covolution, thresholding and image enhancement.

8.7.1. Antialising

One of the most important techniques in making graphics and text easy to read is antialiasing. In line generating algorithm for drawing a line the jagged or stair step appearance of a line can be seen because tho sampling process digitizes coordinate points on an objects to discrete integer pixel position. This distortion of an image due to low frequency Sampling (undersampling) is called aliasing. We can improve the appearance of displaying image or lines by applying technique antialiased that compensate for the under sampling process.

Anti-aliasing is done by specific calcuation to determine which pixels are drawn extra, and in what shade to achieve the desired result. The graphics card perform this task when anti-aliasing is done the amount of pixels that the graphics card can render will lower by a degree and therefore cuts the frame rates. Without losing information from object we need to set the sampling frequency to at least twice that of the highest frequency occurring in the object in referred to as the Nyquist sampling frequency as

= 2 f max

We can apply antialiasing methods to mollify pixel intensty. By appropri... varying frequency the intensities of pixel along the boundaries of primitives we can smooth the edges in appearance. Antialiasing method increase sampling rate by treating the screen as if it were covered with finer grid than is actually available. This technique of sampling object characteristics at a high resolution and displaying the result at a lower resolution is called super sampling. By super sampling we obtain intensity information from multiple points that contributes to the overall intensity of a pixel

Super sampling or port filtering : The general methods of computing intensities at sub pixel grid position then combining the result to obtain the pixel intensity.

Area sampling or prefiltering : The pixel intensity calculated by the area of overlap of each pixel with the objects to be displayed. This is referred to as area sampling or prefiltering the intensity of the pixel whole is determined without calculating sub-pixel intensities.

Pixel phasing:

The raster scan objects can also be antialised by shifting the display location of pixel areas. This technique is called pixel phasing. Fittering techniques a more accurate method for antialiasing lines is to use filtering techniques.

8.7.2 Convolution :

Convolution is a mathematical way of combining two signals to form a third signal. It is a single most important technique in digital signal processing using the strategy of impulse decomposition, system is described by a signal called the impulse response. Convolution is important because it relates the three signals of interest : The input signals, the output signals, and the impulse response.

Convolution operations are commutative, associative and distributive. Convolution is central to modern image processing. The basic idea is that a window of some finite size and shape the support is scanned across the image. The output pixels value is weighted sum of the input pixels within the window where the weights are the values of the filter assigned to every pixel of the window itself. The window with its weights is called the convolution kernel. The window is translated across a digital image pixel by pixel. An image is defined over the entire cartesian grid and the convolution double sum can computed for all window.

Position over the image in practice the image exists within a finite frame. Now how to define C[M,N,] if the translated window extends outside the frame. There are various way of handling it. These include defining the

By appropri
es of primitives
rease sampling
than is actual

be to be zero outside the frame, extending the boundary values out ward into the complement of the frame and extending the image periodically. We shall take the mathematically straight forward approach of defining the image to be zero outside its frames.

According to the equation of 2D discrete convolution, if a[m,n] ≥ 0 for all (m,n) and the value a[m,n] sum to 1 then C[M,N] is weighted average of the image values in the window centered at (m,n). Consequently C is called a moving average. A moving average acts as a smoothing filter and can be used to suppress random additive pixel noise. Suppose F is the ideal image, n is the noise image and the observed noisy image is F+n. Since convolution is a linear operator.

$g*(F+n) = g* f+g*n$

If the noise is random with mean zero then g * n is close to zero. So that noise is suppressed in the output image.

There are several possible rotations to indicate the convolutions of 2-D singles to produce an output signal. The most common are $c = a \otimes b = a*b$

In 2D discrete space

$$C[M,N] = a[M,N] \otimes b[M,N]$$

$$\sum_{j=-\infty}^{\infty} \sum_{k=-\infty}^{\infty} a[j, k]\, b[m-j, n-k]$$

Convolution and related operations are found in many applications of engineering and mathematics.

- In statistics, a weighted moving average is a convolution.
- In probability theory, the probability distribution of the sum of the independent random variables is the convolution of their individual distributions.
- In digital image processing, convolutional filtering plays an important role in many important algorithm in edge detection and related processes.
- In digital signal processing, frequency filtering can be simplified by convolving two functions (data with a filter) in the time domain, which is analogous to multiplying data with a filter in the frequency domain.

8.7.3 Thresholding Techniques :

In many applications of image processing, the gray levels of pixels belonging to the object are substantially different from the gray levels of the pixels belonging to the background. Thresholding then becomes a simple but effective tool to separate objects from the background.

Suppose that the gray-level histogram corresponds to an image f(x,y), composed of light objects on a dark background, in such a way that object and backgroung pixels have gray levels grouped into two dominant modes. One way to extract the objects from the background is to select a threshold T that seperat these modes. Then any point (x,y) for which f(x,y) > T is called an object point. Otherwise, the point is called background point.

Image thresholding enjoy a central position in applications of image segmentation. Segmentation use two of the most common technique.

Thresholding and edge Finding.

- There is no universally applicable sementation technique that will work for all image.
- No segmentation technique is perfect.

The thresholding is based upon a simple concept A paramenter θ called the brightness threshold is selected and applied to the image a [M, N] as :

if a [M, N] $\geq \theta$

else a [M, N] = background = 0

The above procedure assum that we are interested in light object on a dark background.

For dark object on light backgrounds we use

if a [M, N] $< \theta$

a [M, N] = object =1

else

a [M, N] = background = 0

The output is labelled is "object" or "background" Now main thing is that how we choose threshold θ. There are same way :

- **Fixed threshold :** First choise is to use a threshold that is choosen independtly of the image data.
- **Historgram derived threshold :** In most cases the threshold is choosen from the brightness histogram of the region.

8.8 Image enhancement

Image enhancement processed consist of a collection of technique that seeks to improve the visual appearance of an image or the converts the image to a form better suited for analysis by human or a machine or we can say that image enhancement is the improvement of digital image quality wihout knowledge about the source of degradation. If the source of degradation is known, one calls the process image restoration. In image enhancement sharp. Ending of image features such as edges, boundaries or contrast to make a

graphic display more useful for analysis and display. The enhancement process does not increase the inherent information content in the data, but it does increase the dynamic range of the chosen features so that they can be datected easily. The technique of image enhancement includes grey level and contrast manipulation, noise reduction edge, crispening and sharpening, filtering, interpolation and magnification, pseudo colouring and so on. The greatest difficulty in image enhancement is quantifying the criterion for enhancement. Therefore, a large number of image enhancement techniques are empirical and require interactive procedures to obtain satisfactory results.

There are some most used capabilities of the better manipulation programs.

- **Image Size Alteration :**

Image editors can resize images in a process often called image scaling, make them larger or smaller.

- **Cropping an Image:**

Cropping used to create a new image by selecting a desired rectangular area from the image being cropped. The unwanted part of image is discarded. Image cropping doesn't reduce the resolution of the area cropped. The cropping improves the image composition in the new image.

- **Noise Removal :**

Image editors has a no. of algorithm which can add or remove noise in an image. JPEG artifacts can be removed, dust and scratches can be removed and an image can be de speckled.

Excessive noise reduction leads to loss of detail. Noise enters in image when pictures are taken in low light settings.

- **Removal of Unwanted Elements :**

Most images editors can be used to remove unwanted branches etc. Using a "clone" tool. Removing unwanted elements the overall composition is improved.

- **Selective Color Change:**

Image editor provided the facility of color swapping and selectively change the color of specific item in an image.

- **Perspective Correction and Distortion :**

Image editor allows the user to distort (or transfrom) the shape of an image. It is the preferred method of correcting the physical perspective distortion which results from photographs being taken at an oblique angle to a rectilinear subject, care is needed while performing this task.

- **Sharpening & Softening Images :**

Graphics programs can be used to both sharpens and blur images in a number of way such as unsharp mashing or de-convolution. Edge enhancement is an extremely common technique used to make image appear sharper.

- **Contrast Change and Brightening :**

Image editor having provision to change contrast of images and brighteness or darken the image. Recently advanced tool have allowed more intelligent exposure correction. Where only one or more pixels below a particular luminosity threshold are brightened without affording the rest of the image.

- **Special effect :**

Image editors usually have a list of special effects that can create unused results. Image may be skewed, distorted, artistic effects, geometric and texture effects and combinations of these.

OBJECTIVE TYPE QUESTIONS

1. Subdividing the total area and determining the number of sub pixels inside the area boundary is called (B.C.A. Part-III, R.U. 2006)
   (a) Pixel phasing (b) Pixel weighting
   (c) Filtering (d) Super sampling ( )
2. An image scanner can be used for storing:
   (a) Test material (b) Engineering drawing
   (c) Pictures (d) All of the above ( )
3. The meaning of the PNG is :
   (a) Portable Network Graphics (b) Printable Network Graphics
   (c) Passive Node Graphics (d) Pannable Network Graphics ( )
4. The format for string digital audio in multimedia application is: (B.C.A. Part-III, R.U. 2007)
   (a) JPEG (b) TIFF
   (c) WAV (d) BMP ( )
5. To store good utility sound the audio signal in a multimedia PC is sampled at the rate of (B.C.A. Part-III, R.U. 2007)
   (a) 44.1 Hz (b) 4.41 KHz
   (c) 44 KHz (d) 4.41 Mhz ( )
6. Which of the following is not an image file format ? (B.C.A. Part-III, R.U. 2006)
   (a) TIFF (b) .PAD
   (c) .ICO (d) .IMG ( )