CHAPTER 6

Digital Image Processing

LEARNING OBJECTIVE

In this chapter, the students can

- Study the fundamental steps involved in Digital image processing
- Expose current applications of Digital image processing
- Study the importance of Image sensors (CCD, CMOS) in the digital camera technology
- Understand the basic functions of Digital camera
- Understand the Fundamental concepts of CCTV system

CONTENT

6.1 Introduction

'A picture is worth more than thousand words'. It refers that a single still image or an image of a subject conveys meaning of the subject matter effectively than a description. Seventy percent of human perception is only through vision. It will give much more meaningful information to the user.

An image is a pictorial representation of an object or scene. There are two types of images. They are

1. Analog
2. Digital

Analog is a continuously varying quantity. Analog images are captured by traditional photographic sensor portrays on paper based media or transparent media.

HISTORY

In the early 1920s, one of the first applications of digital imaging was in the newspaper industry. The pictures were sent by submarine cable between London to New York. This took several hours to send a picture. Then, Barlane cable picture transmission system was introduced. This system used a specialized printing equipment to code the picture before sending and reconstructing the same after receiving. The early Barlane systems were capable of coding the images in only five different gray levels.

In 1929, Barlane systems with 15 grays levels resulted in higher quality images. The new reproduction processes based on photographic techniques was evolved during this period. In 1960s, the improvements in computing technology and the onset of the space led to a surge of work in digital image processing. For example, computers used to improve the quality of images of the moon taken by the Ranger 7 probe.

In 1970s, Digital Image Processing (DIP) was used in medical applications. Especially, it was used in Computerized Axial Tomography (CAT) scanners. Thereafter, DIP techniques have exploded and they are now used for all kinds of tasks in all fields of science, technology, engineering and medicine. Figure 6.1 shows the first digital image taken.

Digital images are produced by electro-optical sensors and composed of elements of tiny equal areas, called picture elements, abbreviated as pixels or pels arranged in a rectangular array.

Digital image processing can be defined as the computer manipulation of digital values contained in an image for the purposes of image correction, image enhancement and feature extraction.

A digital image processing system consists of computer hardware (PCs) and dedicated image processing software necessary to analyse digital image data.

The application of image processing is important in several areas of science, engineering and technology. It can be realized through the following applications.

1. Improvement of pictorial information for human perception.
2. Image processing for autonomous machine application.
3. Efficient storage and transmission.

DO YOU KNOW?

Do you know the first photograph?

The world's first photograph made in a camera was taken in 1826 by Joseph Nicéphore Niépce. The photograph was taken from the upstairs' windows of Niépce's estate in the Burgundy region of France. This image was captured via a process known as heliography, which used Bitumen of Judea coated onto a piece of glass or metal; the Bitumen then hardened in proportion to the amount of light that hit it.

DO YOU KNOW?

The first digital photograph was taken all the way back in 1957; that is almost 20 years before Kodak's engineer invented the first digital camera. The photo is a digital scan of a shot initially taken on film. The picture depicts Russell Kirsch's son and has a resolution of 176×176 – a square photograph worthy of any Instagram profile.

FIGURE 6.1 First Digital Image

6.2 PIXELS

Pixel is the smallest element of an image. Each pixel correspond to anyone value. In an 8-bit grey scale image, the value of the pixel ranges between 0 and 255. The value of pixel at any point corresponds to the intensity of the light photons striking at that point. Each pixel stores a value proportional to the light intensity at that particular location. Figure 6.2 shows the pixel representation of an image. Pixel is also known as PEL. From the Figure 6.2, we can have more understanding of the pixel. In this picture thousands of pixels that together make up the image. If we zoom the image to the extent that we are able to see some pixels division, it looks like the one shown in the middle of Figure 6.2.

Calculation of total number of pixels

We have defined an image as a two dimensional signal or matrix. From this, the number of pixel is equal to number of rows multiplied with number of columns.

Total number of pixels
=
Number of rows x number of columns

In other words, the number of (x, y) coordinate pairs make up the total number of pixels.

Gray Level

The value of the pixel at any point denotes the intensity of image at that location, and that is also known as gray level.

Pixel value (0)

A pixel can have only one value and this value denotes the intensity of light at that point of image. Now, we can see the unique value of 0 (zero). The value 0

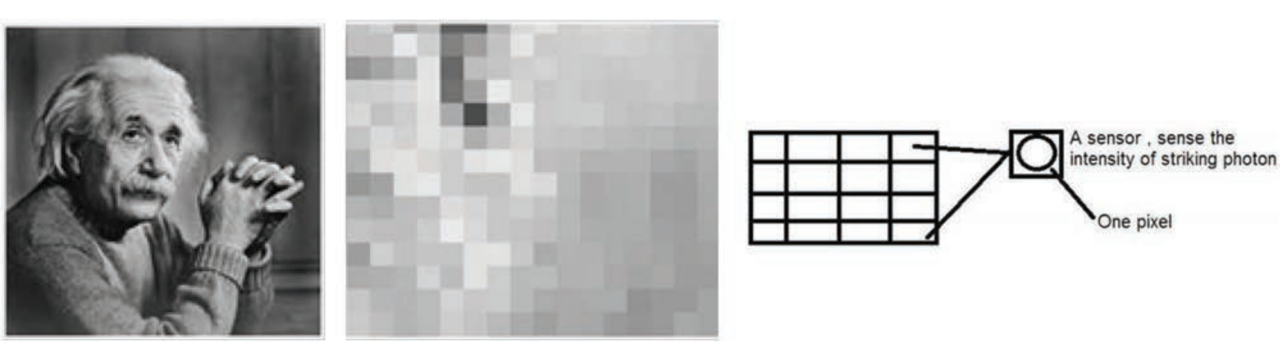

FIGURE 6.2 Pixel representation of an image

means absence of light and also denotes darkness. Further, it means that whenever a pixel has a value of 0, it means at that point, black color is formed. For example, the following matrix is filled with 0s.

$$\begin{matrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{matrix}$$

Total no. of pixels
=
total no. of rows x total no. of columns
= 3 x 3 = 9

It means that an image is formed with 9 pixels, and that image is having a dimension of 3 rows and 3 columns and most important that all the pixels in the image are black.

6.3 Light sensitivity

Light sensitivity or minimum illumination refers to the smallest amount of light needed or the camera to produce an image of useable quality. Minimum illumination is presented in lux (lx), which is a measure of illuminance. The image is better and more light is available in the scene, is not to be overexposed. Otherwise, the amount of light is insufficient; the image will be noisy or dark. The amount of light that is required to produce a good–quality image depends on the camera and how sensitive to light it is. To capture good quality images in low light or dark conditions, a day and night camera that takes advantage of near-infrared light, is required. For detection in complete darkness and difficult conditions such as smoke, haze and dust, a thermal network camera provides a best solution. Different light conditions offer different illumination. Many natural scenes have fairly complex illumination, with both shadows and high lights, which give different lux readings in different parts of a scene. We must understand that one lux reading does not indicate the light condition for a scene as a whole, nor does it say anything about the direction of the light. Table 6.3 lists the illuminance versus light condition.

TABLE 6.1 Illuminance and light conditions

Illuminance	Light condition
1,00,000 lux	Strong Sunlight
10,000 lux	Full day light
500 lux	Office light
100 lux	Poorly lit room

There are number of factors that influence the light sensitivity of a camera, which include:

- Exposure time
- F – stop
- Sensor quality and size
- Lens quality
- Color temperature

6.4 Image Processing

In the image processing technique, analog image is converted into digital image. Now we may raise one question, what is a Digital Image?

An image may be defined as a two-dimensional function, f (x, y), when x and y are spatial coordinates and the amplitude of ‘f’ at any pair of coordinates (x, y) is called the intensity of gray level of the image at that point. When x, y and the amplitude values f are all finite, discrete quantities, we call the image as a digital image. The term gray level is used often to refer to the intensity of monochrome images. Color images are formed by a combination of individual 2D images.

For example: In the RGB color system, a color image consists of three (red, green & blue) individual components.

DO YOU KNOW?

The first color photograph

The first color photograph was taken by the mathematical physicist, James Clerk Maxwell. The piece above is considered the first durable color photograph and was envied by Maxwell at a lecture in 1861. The inventor of the SLR, Thomas Sutton, was the man who pressed the shutter button, but Maxwell is credited with the scientific process that made it possible. For those having trouble identifying the image, it is a three-color bow.

For this reason, many of the techniques developed for monochrome images can be extended to color images by processing the three components, individually.

An image may be continuous with respect to the x and y coordinates and also in amplitude. Converting such an image to digital form requires that coordinates as well as the amplitude of the image to be digitized.

6.4.1 Electromagnetic energy spectrum

Figure 6.3 shows the electromagnetic spectrum, in which human eye can visualize and distinguish the visible region of the spectrum. If you want to see the images taken using the other regions of the spectrum such as X-ray, gamma ray, UV, Infrared, etc., you need to generate the images using specialized instruments and those images are processed using digital image processing methods.

Image processing is used everywhere in the world. The areas of application of image processing are classified according to the images generated from their energy source. The principal energy source for images is the electromagnetic energy spectrum. The other energy sources may be acoustic, ultrasonic and electronic.

Images generated using gamma rays are called gamma ray imaging. Similarly, using X - rays are called X-ray imaging. These types of images are widely used in the medical field. Figure 6.3 shows some of the medical images taken using X-ray and gamma ray.

6.4.2 Image Sampling and Quantization

There are many ways to acquire or get images. But, the output from most of the sensors is a continuous or analog waveform. In order

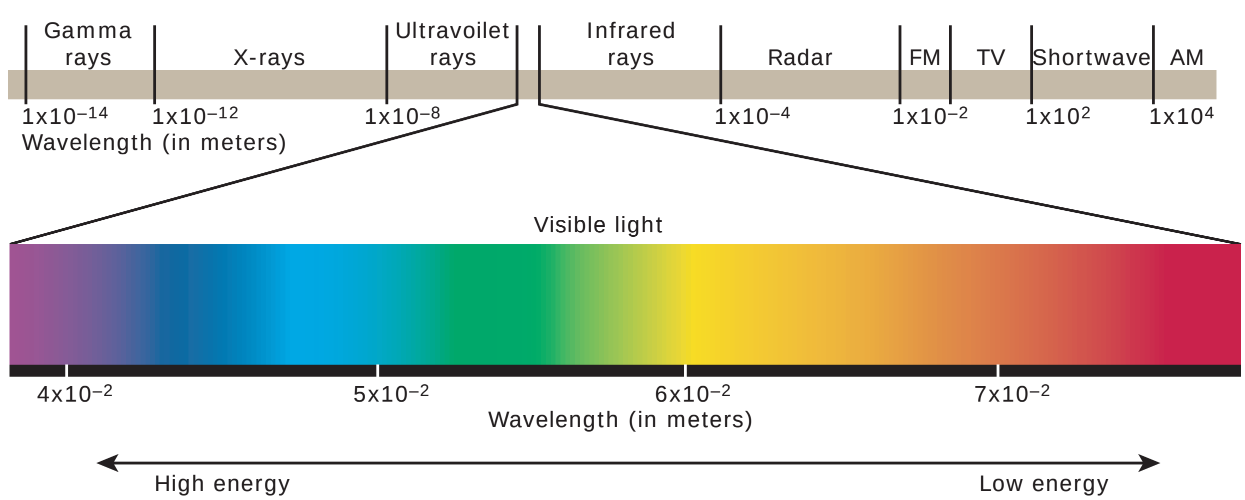

FIGURE 6.3 Electromagnetic Spectrum

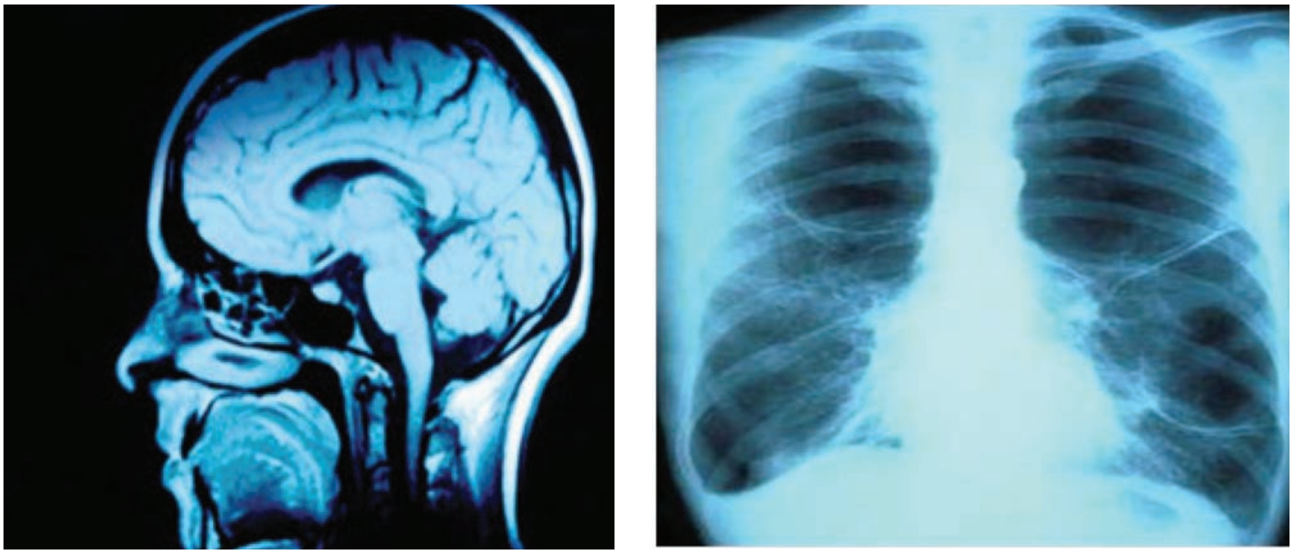

FIGURE 6.4 Gamma ray and X-ray images

to generate a digital image, this continuous sensor data is converted into digital form. This comprises of two processes.

1. Sampling: Digitization spatial coordinates (x, y) is called image sampling. To be suitable for computer processing, an image function f(x, y) must be digitized both in spatial and magnitude domains.
2. Quantization: Digitizing the amplitude values is called quantization. Quality of digital image is determined to a large degree by the number of samples and discrete gray levels used in sampling and quantization processes.

6.4.3 Types of Image processing

There are no specific boundaries in the image, i.e., image processing at one end and computer vision at the other end. Image processing is divided into three basic types.

Low – Level Image processing

This process involves basic operations such as noise reduction in the image, image enhancement in terms of contrast and image sharpening. Here, the input and output of these processes are images.

Medium – Level Image processing

This process involves operations such as image segmentation, description of the objects presented in the image and the classification of objects. The inputs of this process are images, but the outputs are features extracted from these images. i.e., edges, contours.

High-level Image processing

This process involves operations such as image analysis. The inputs of this process are features of images and the outputs are also the important features of images.

6.4.4 Fundamental steps of digital image processing

Figure 6.5 shows the steps involved in digital image processing. The important steps involved in image processing are described as follows.

Image Acquisition

It is the first step in any image processing application. Note that the acquisition could be as simple as being given an image that is already in digital form. Generally, the image acquisition stage involves preprocessing, such as sampling, scaling, coding, etc.

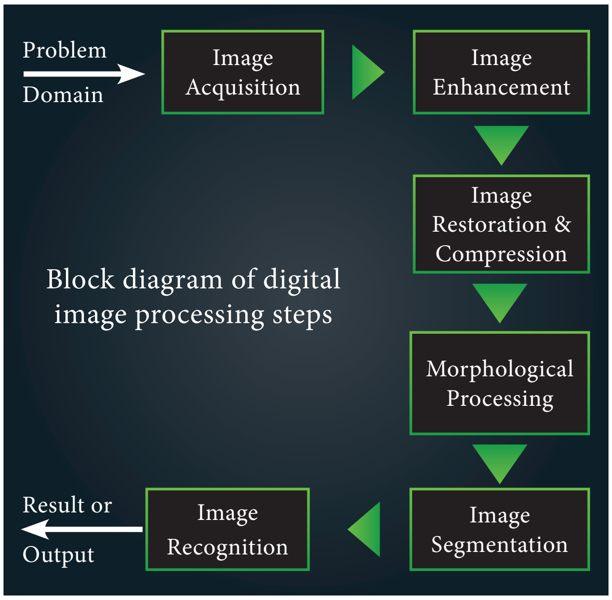

FIGURE 6.5 Block diagram of digital image processing steps

Image Enhancement

It is the process of improving the quality of a digitally stored image by manipulating the image with software. For example, removing noise, sharpening or brightening an image, this makes easier to identify key features. Figure 6.6 shows the image enhancement on a noisy input image, which exhibits improved features as well as complete removal of noise (salt and pepper noise).

Image Restoration

It is the process of recovering an image from a degraded version. The degradation may come in many forms like blurred, noisy image and camera out of focus problem. In order to restore the original image, we have to apply the inverse process to restore the degraded pixels. Figure 6.7shows image restoration in a still image.

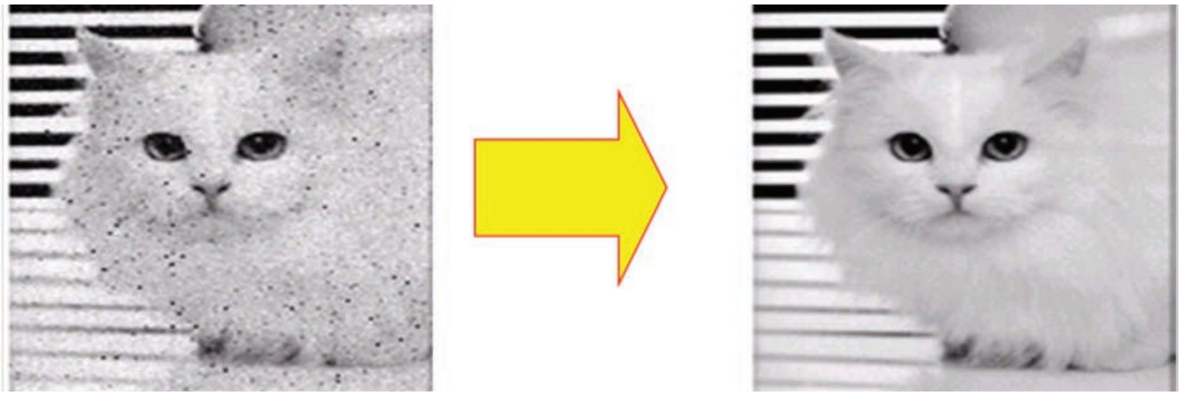

FIGURE 6.6 Image enhancement and noise removal applied on still image

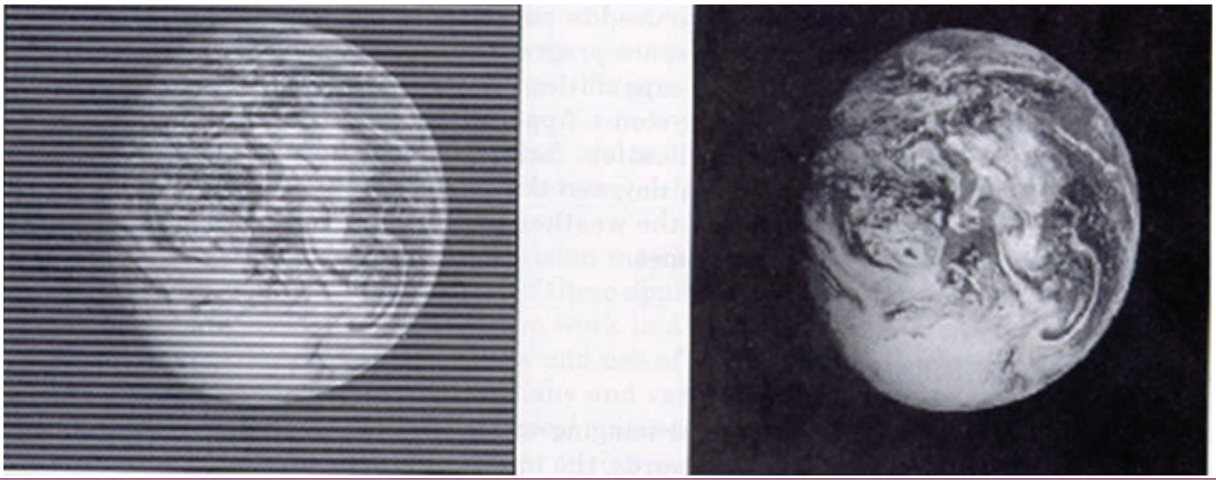

FIGURE 6.7 Image restoration correcting an out-off focus image

FIGURE 6.8 Compression of brain image, Original image (left), Compressed image (middle) and Reconstructed image from compressed image (right)

Image Compression

It is a process used to reduce the amount of data required to faithfully represent original file. This technique should not affect or degrade the quality of the image, but it will reduce the file sizes up to 60 -70% and hence many files can be combined into one compressed document, which makes the communication of image over internet at a faster transmission rate. Figure 6.8 shows the compression and decompression (reconstruction) of a brain image.

Morphological Processing

It is used to extract image components that are useful in the representation and description of region shape such as boundary extraction, skeletons, convex hull, morphological filtering, thinning and pruning. Figure 6.9 shows some of the morphological operations like binarization and thinning applied in a biometric fingerprint image.

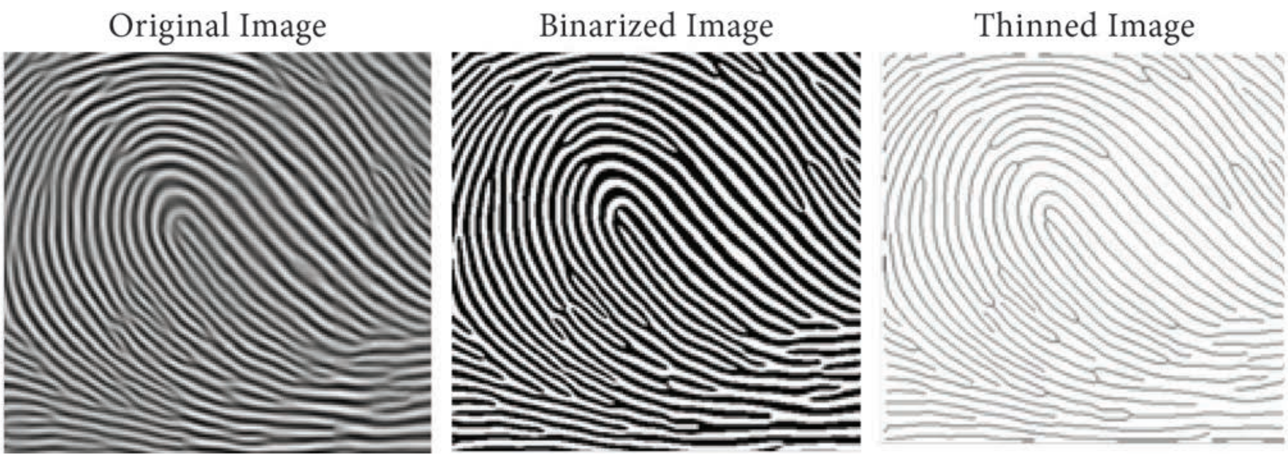

FIGURE 6.9 Morphological Operations in Fingerprint biometric image

Image Segmentation

It is a technique of dividing or partitioning an image into parts called segments. The ultimate goal of segmentation is to find meaning from an image such as identification of an object, understanding the interactions, etc. Figure 6.10 shows the segmentation of a Palm image.

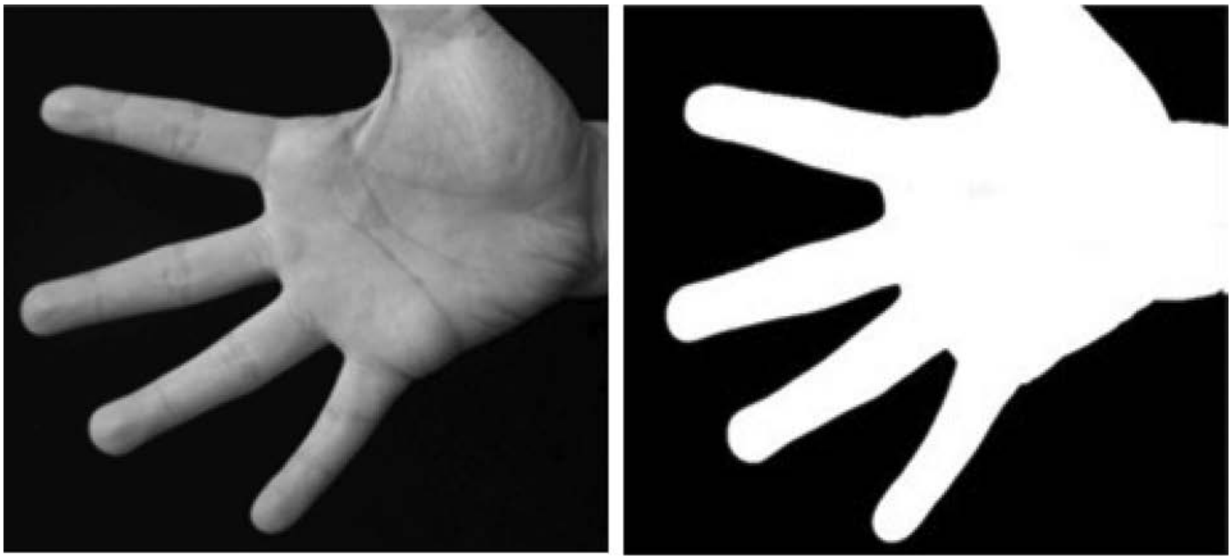

FIGURE 6.10 Segmentation of Palm Image

Image Recognition

It is the process of identifying and detecting an object or a feature in a digital image or video. For example, computers can use machine vision technologies in combination with a camera and artificial intelligence software to achieve image recognition. Figure 6.11 shows face recognition of a person for different expressions.

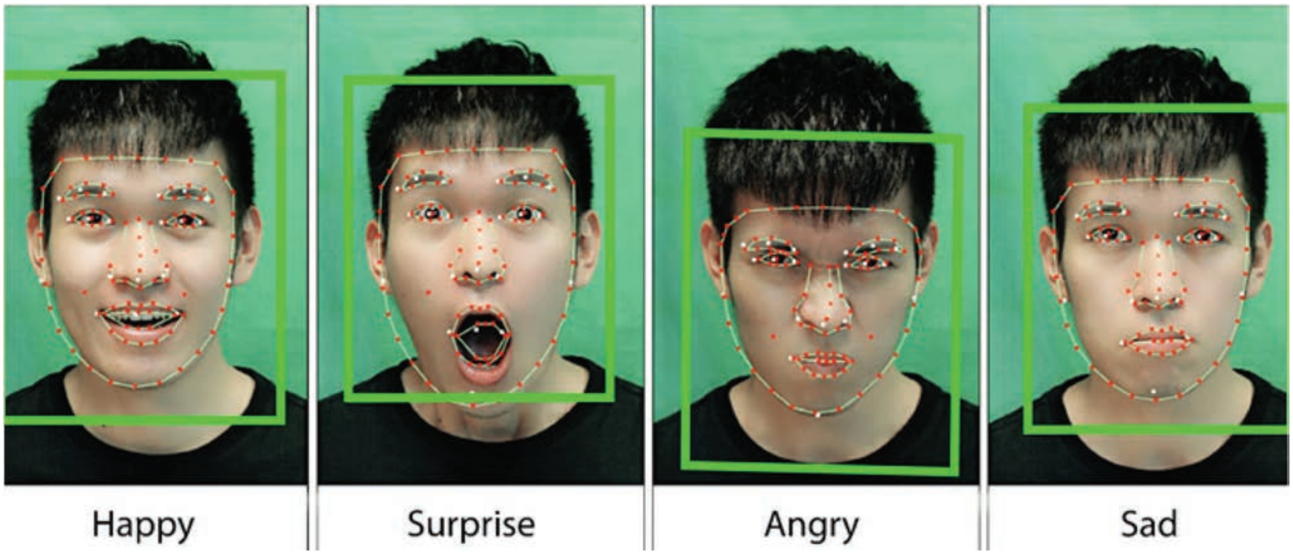

FIGURE 6.11 Face recognition of an individual based on the expression of a person

6.4.5 Applications of Digital Image Processing

The field of Digital Image Processing has experienced continuous and significant development in recent years. The usefulness of this technology is apparent in many different disciplines covering medicine through remote sensing. The availability of image processing hardware has further enhanced the usefulness of image processing.

The broad areas of digital image processing applications include.

- Medical field
- Remote sensing
- Intelligent transportation systems
- Automatic visual inspection system
- Moving object tracking
- Video processing
- Pattern recognition
- Transmission and encoding

1 **Medical field**

For medical diagnosis, different types of imaging modalities such as X-ray, Ultrasound, Computed aided tomography (CT), etc., are used.

2. **Remote sensing**

In this application, sensors mounted on a remote sensing satellite or multi-spectral scanners mounted on an aircraft capture the pictures of the earth's surface. These pictures are processed by transmitting to the earth station. Techniques used to interpret the objects and regions are employed in flood control, city planning, resource mobilization, agricultural production monitoring, etc.

3. **Intelligent transportation system**

This technique is used in Automatic number plate recognition and Traffic sign recognition.

4. **Automatic visual inspection system**

This application improves the quality and productivity of the product in the industries. For example, any faulty components in electronic or electromechanical systems can be identified by this application. Higher amount of thermal energy is generated by these faulty components. The infra-red images are taken to detect the distribution of thermal energies in the assembly. From this, the faulty components can be identified by analyzing the infra-red images.

5. **Moving object tracking**

This application enables to measure motion parameters and acquire visual record of the moving object. The different types of approach to track an object are

i Motion based tracking

ii Recognition based tracking

6. **Video processing**

A video is a very fast movement of pictures. The quality of a video depends on the number of frames/ seconds and the resolution of each frame being used. Video processing involves noise reduction, detail enhancement, motion detection, frame rate conversion, aspect ratio conversion, color space conversion, etc.

7. **Pattern recognition**

In pattern recognition, image processing is used to identifying the objects from the images and then machine learning is used to train the system for the change in pattern. Pattern recognition is used in computer aided diagnosis, recognition of handwriting, recognition of image, etc.

8. **Transmission and encoding**

The very first image that has been transmitted from London to Newyork via a submarine cable. The picture that was sent took three hours to reach from one place to another

Nowadays, we are able to see live video feed, or live CCTV footage from one continent to another with just a delay of second. It means that lot of techniques have been developed in this field for transmission and encoding. Many different file formats have been developed to meet the requirements of high or low bandwidth to encode photos and then streaming over the internet.

6.5 Image Sensors

Image sensor is an electronic device that converts an optical image into an electronic signal. It is widely used in digital cameras and imaging devices to produce digital image from the received light energy.

There are two types of digital camera sensors . They are,

1. Charge Coupled Device (CCD) sensor
2. Complementary Metal Oxide Semiconductor (CMOS) sensor

Both these sensors consist of millions of photosites called pixels. These photosites converts the incoming light into the charge or electron. The CCD and CMOS sensors are quite different, but common in many aspects. The similarities are as follows.

These sensors first convert the incoming light into the charge. So the photosites or the pixels are exposed to the light for certain amount of time. During this time, the charge will get collected in these pixels. Then, the charge is collected by the pixels and transferred for further processing. Finally, the charge is converted into voltage and amplified using an amplifier.

DO YOU KNOW?

CCDs were invented by Willard Boyle and George E. Smith from AT &T Bell Labs, in the year 1969. The first self-contained digital camera (1975) was built by engineer Steven Sasson of Kodak, which gave a black–and–white image of 0.01 megapixels.

6.5.1 Working of CCD Sensors

The CCD sensor consists of millions of pixels. When these pixels are exposed to the incoming light, they convert the light into the charge. Then, the charge gets accumulated in these pixels. The accumulated charge is then transferred to the horizontal shift registers. Figure 6.12 shows the mechanism of flow of charge carrier in CCD sensor.

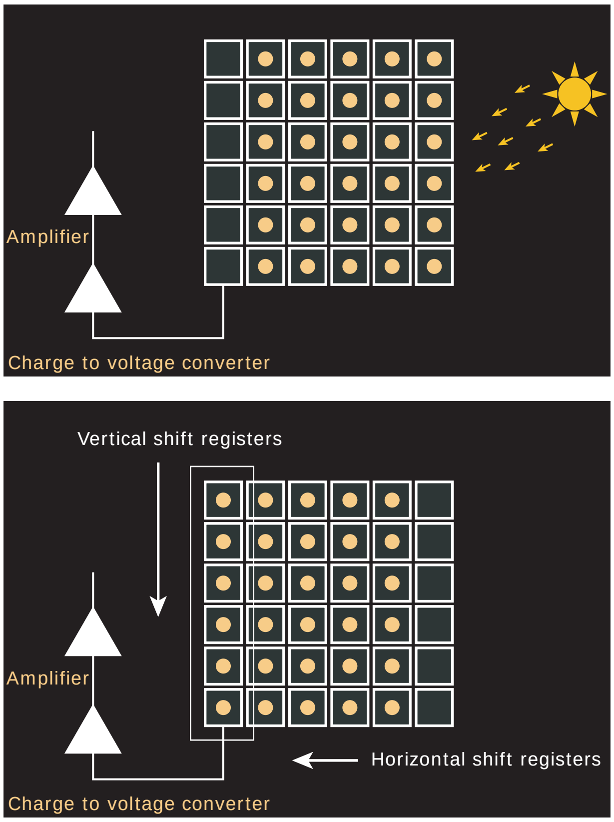

FIGURE 6.12 Mechanism of charge production in CCD sensors

Further, the charge has been transferred into the vertical shift register. In the shift registers, the charge is converted into voltage, sequentially. After voltage conversion, voltage corresponding to each pixel is amplified by an amplifier. Then, the output voltage is converted into the digital data by an analog to digital convertor. In this way, the charge of each pixel is converted into corresponding voltage level. This procedure is repeated for all the frames.

Applications

CCD sensors widely used in many scientific, engineering and technological applications. It is mainly used in many instruments such as,

1. Photocopiers
2. Security Surveillance Camera
3. Fax machine
4. Dentistry X-rays
5. Camcorder

6.5.2 CMOS Sensor

DO YOU KNOW? Eric R. Fossum is one of the inventors of CMOS image sensors in the year 1995, which is used in nearly all smart phones and digital cameras.

The fabrication technology of CMOS sensor is similar to that of the integrated circuit. In this sensor, many peripherals circuits are integrated inside the single chip. In the CMOS sensor, charge-voltage conversion as well as voltage amplification is carried out in the pixel itself. By using this technique, the processing speed of the CMOS sensor is much higher than the CCD sensor. In CMOS sensor, the voltage which is entering into each pixel is read in a line by line fashion. Figure 6.13 shows the working principle of CMOS sensor. Initially, the first row pixel is activated using the pixel select switch. Then, this switch connects the output voltage of the pixel to the column line. By activating the column select switch, one-by-one, the data of each pixel of the specific row are read. The same procedure is repeated for the remaining lines.

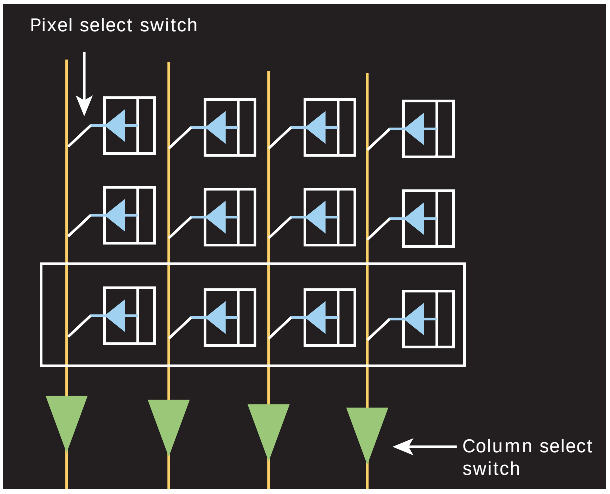

FIGURE 6.13 Working Principle of CMOS sensor

Applications

CMOS sensors can be used for various industrial and medical applications. Some of imported applications are given here:

1. Machine vision
2. Coin detection
3. Finger print pattern imaging

Comparison of CCD and CMOS sensors

The comparison between CCD and CMOS sensors are summarized in Table 6.1.

6.6 Digital Cameras

A camera is an imaging device which uses the spectrum of light to capture still images on a light sensitive medium (a photographic film or an electronic sensor). The functioning of a camera is not very different from the functioning of human eye, however the latter is more advanced and its precision is unmatched.

Basically, camera can be classified into two types. They are

1. Analog camera
2. Digital camera

In analog camera, the light from the scene travels through the lens and strikes some sort of light sensitive surface inside the camera, called photographic

TABLE 6.2 **Comparison of CCD and CMOS sensors**

S. No.	Specification	CCD	CMOS
1	System Integration	Being old technology, it is not possible to integrate the timers and ADC to the main sensors.	It is like IC fabrication technology, quite possible to integrate with peripheral devices.
2	Power Consumption	Requires different power supplies for different timing clocks. Typically, 7 V to 10 V (Requires more power).	Requires single power supply. Typical voltage rating is from 3.3 V to 5 V (Requires Less power)
3	Processing Speed	Speed is comparatively less. It is further increased by using multiple shift registers.	The speed is high, because the charge conversion is made by the same pixel. It can be further increased by using multiple column select lines.
4	Noise and Sensitivity	It has more sensitivity, because the dynamic range is quite high. Less noise.	It has less sensitivity because the charge to voltage convertor circuit and amplification circuit integrated in the same pixel. It has low fill factor causes more noise level.
5	Image Distortion	If the sensor is exposed for a longer time, then it will be affected by Blooming effect. This distortion can be reduced by using anti-blooming technique.	This sensor is affected by the distortion called Rolling shutter. This is due to capturing the fast moving object by the sensor. This distortion can be reduced by exposing all the pixels at the same time.

TABLE: 6.3 Comparison of analog and digital camera features

Analog camera (photo film)	Digital camera
Light from the subject of the photograph enters the camera and falls on a film.	Light from the subject of the photograph enters the camera and falls on a digital sensor.
Images are captured on photographic film, which cannot be reused again.	Images are captured as digital files and stored on removable media cards, which are reusable.
Needs few days to processing the photography.	Provides real instant photography within a second or two of the exposure. Real-time visualization of the captured image while taking pictures using built-in LCD screen.
The film negative requires post processing using chemicals such as developing tank, dark room for printing negatives, etc.	The digital image file requires only a photo shop with a computer screen in light room.
No power or batteries needed.	It needs DC power.

film. The light falls on the photographic film produces the image on the film, which is chemically processed to visualize the image. Thus, analog camera mostly depends on mechanical and chemical processes for producing a picture.

Digital camera is the alteration of the conventional analog camera. This camera depends on digital processes, i. e., the light falls on the object is converted into image using a CCD or CMOS sensor, which converts the image into digital data format (0 and 1). Therefore the images are easily processed and recognized by a computer using mathematical algorithms. The 0's and 1's in a digital camera are kept as strings of tiny dots called pixels. Table 6.2 summarizes the features of analog and digital camera technologies.

6.6.1 Components of Digital Camera

All types of camera comprises of some basic components such as a lens/lenses, view finder, aperture, shutter and data memory. When the shutter is closed, no light travels through the lens. When the shutter is pressed the shutter opens and light travels through the lens, which in turn strikes the light sensitive material inside the camera. Figure 6.14 shows the components of a digital camera. In this section, we discuss about the function of the various components that are unique to digital photography.

1. Image sensor

   The image sensor is basically a micro-chip having a width of 10 mm. It contains millions of light sensitive pixels, also called arrays, which individually measures the light striking on each pixel. A color filter sits atop the image sensor, which only allows certain pixels to measure certain colors of light waves. There are two types of image sensors. They are CCD sensor and CMOS sensor.

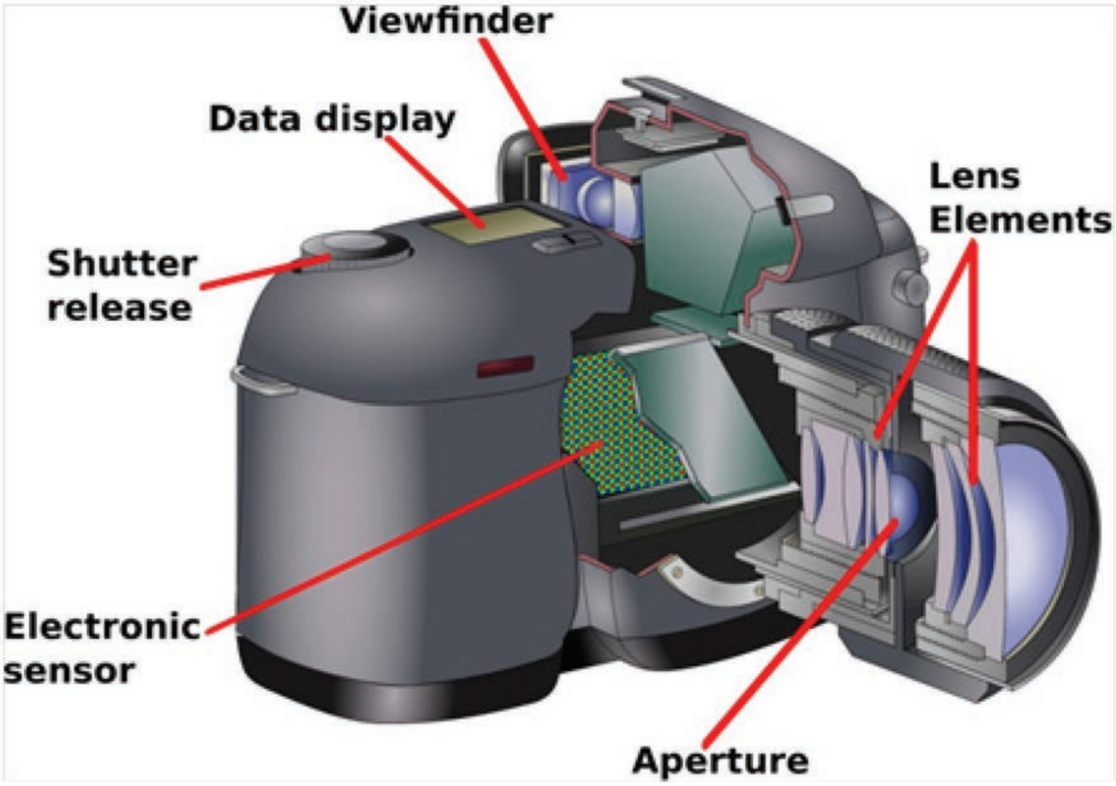

FIGURE 6.14 Basic components of a digital camera

2. Digital convertor

The data collected in each pixel is converted into a digital signal (0 and 1). This process is manipulated by the convertor.

3. Circuit Board

The digital camera carries a circuit board that holds all of the computer chips (IC), which is used to record the data. The circuitry on the board carries the data from the image sensor and other chips to the storage medium, i. e. memory card.

4. Display Screen/View Finder

The digital camera's display screen is used to make changes to the camera settings as well as to compose and to review the photos, after they are shot. Some digital cameras still use a view finder for composing the scene, offering the display screen as a second composition option. Nowadays LCD screen is used as a view finder.

5. Lens

The lens is one of the most vital parts of a camera. The light enters through the lens starts the photo process. Lenses can be either fixed permanently to the body or interchangeable. They can also vary in focal length, aperture and other details. There are four types of digital camera. They are

i. Fixed-focus lens
ii. Fixed-zoom lens
iii. Optical-zoom lens
iv. Digital-zoom lens

6. Aperture

An aperture is a hole through which light passes to the camera sensor. The size of the hole can be varied using an iris-like diaphragm.

7. Shutter Release

The shutter-release button is the mechanism that releases the shutter and enables the ability to capture the image. The time duration of the shutter is left open or exposed is determined by the shutter speed.

6.7 CCTV System

Closed Circuit Television (CCTV) is a system in which the circuit is closed and all the elements are directly connected. This system is quite different from the commercial TV broadcast, where any TV can be tuned to receive the transmitted signal. In this system, the video pictures produced from the camera can be viewed in real-time or recorded. A CCTV system comprises a video camera, camera lens, a monitor and video recorder.

6.7.1 Applications

CCTV systems have many useful security applications. It is used in retail shops, banks, hospitals, schools, government establishments, etc. The true scope for applications is almost unlimited. Some examples are listed below.

- Traffic monitoring
- Industrial process monitoring
- Survey work
- Indoor and outdoor stadium surveillance
- Zoo security
- Hidden in buses to control vandalism
- Parking lot surveillance
- Public safety

6.7.2 The camera

The starting point for any CCTV system must be the camera. The camera creates the video pictures that will be transmitted to the monitoring position. Except few specialist systems, CCTV cameras are not fitted with a lens. The lens is provided separately and is connected to the camera. The correct selection of camera and lens is important to achieving the desired results across all lighting and environment conditions. Figure 6.15 shows the parts of a CCTV camera.

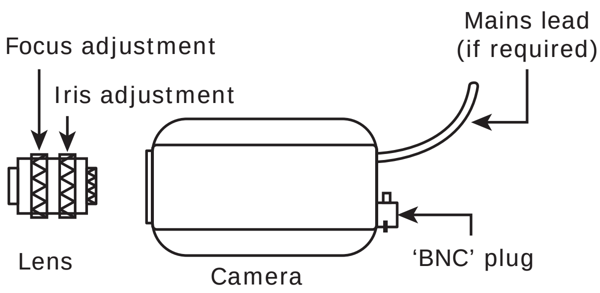

FIGURE 6.15 Parts of CCTV Camera

6.7.3 The Monitor

The picture created by the camera needs to be reproduced at the control position. A CCTV monitor is almost like a television receiver except that it does not have any tuning circuits. Previously, CRT monitors are used for all security applications including video surveillance and fire monitoring. Presently, LCD and LED displays are used in video security applications. Figure 6.16 shows the parts of CCTV Monitor.

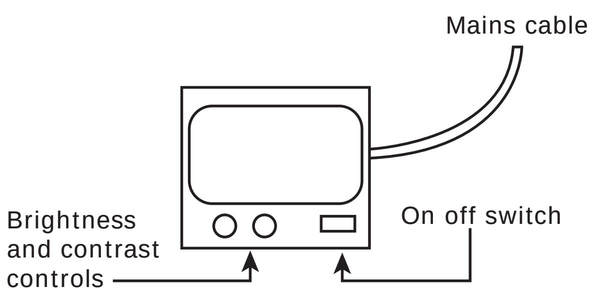

FIGURE 6.16 Parts of CCTV Monitor

6.7.4 Simple CCTV Systems

Figure 6.17 shows a simple CCTV system. In this system, a camera is directly connected to a monitor by a coaxial cable with the power to the camera being provided by the monitor. This arrangement is known as a line driven system. Multiple cameras can be connected to a single monitor, if it has sufficient powered co axial connectors. However, only one source can be observed at a time.

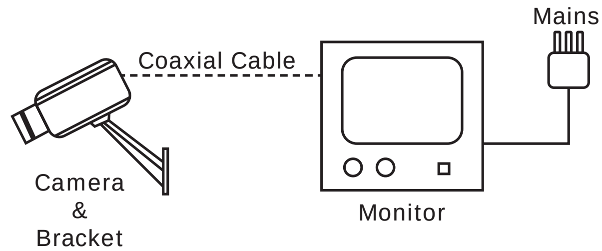

FIGURE 6.17 Simple CCTV system

6.7.5 Mains Powered Systems

Camera systems can be AC powered from a main electrical supply and a separate coaxial cable carries the video information from the camera to the monitor. This method allows cameras to be further remote from the monitor position. In case of line driven camera, the video passes along the coaxial cable to a distance of upto three hundred meters only. Figure 6.18 shows the mains powered CCTV system.

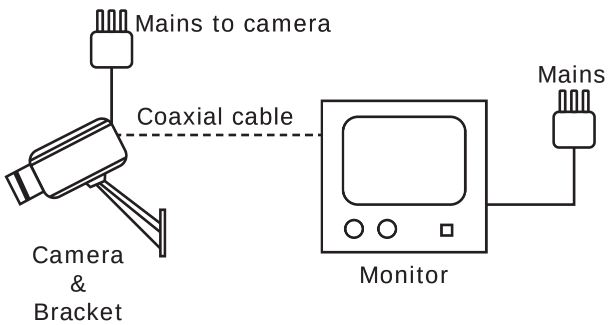

FIGURE 6.18 Mains Powered CCTV system

The arrangement allows for greater system flexibility. When more than one camera is required, a video switcher can be provided. Using video switcher, any camera can be selected by the operator for viewing or a sequence can be set to rotate the camera through the screen most suitable to the application.

6.7.6 Multiple Camera Displays

Figure 6.19 shows the multiple camera display system. In this, all the cameras are required to be viewed by each individual monitor or a Quad screen splitter. As the name implies, this allows the presentation of four cameras on a single screen. Many quads now incorporate digital image processing. This means that image is compressed to a quarter of its size. However, each picture is only 23% of the screen resolution.

6.7.7 Video Motion Detection (VMD)

A single operator watching multiple displays gets tired and not able to see all activity at all the time. The primary function of a VMD is to relieve CCTV operators from the difficulty of monitoring many screens, which may not change for extended periods. A VMD can be set to react to different types of activity observed by the camera and alert the operator and even activate recording.

6.7.8 Video Recording

Analog CCTV systems are moving to digital technology and video recording is leading this transition. The previous methods of recording video are by video cassette recorders (VCR), which were replaced by digital video recorder (DVR).

DVRs now offer so many advantages over analog VCRs in security applications. Video footage can digitally recorded, processed and streamed over digital networks at virtually any level of image quality, including high definition (HD).

Users now make use of digital-only technologies such as relative analytics, scene search, motion-and-activity-detection alarms and remote access over IP networks. The cost of storage capacity

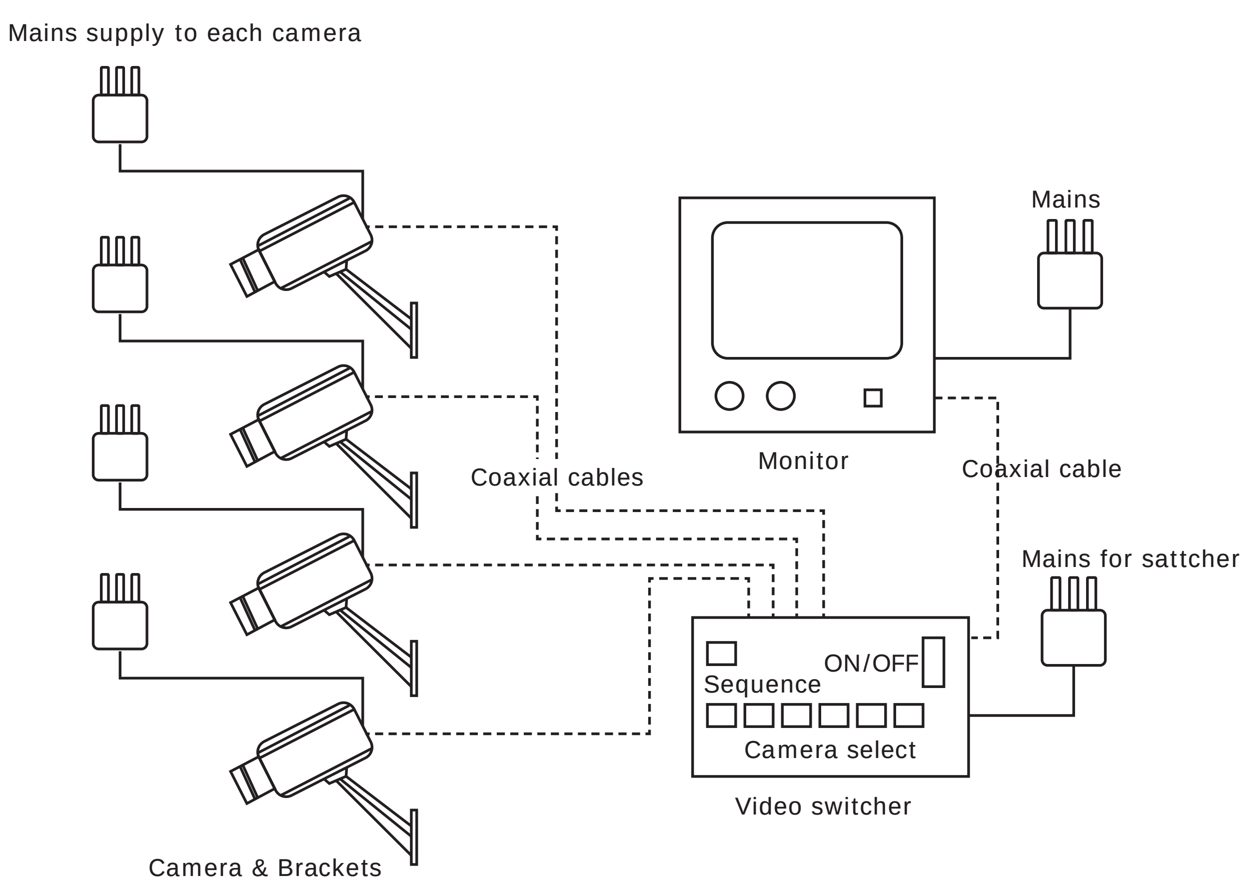

FIGURE 6.19 Multiple Camera Display System

on physical media such as hard disc drives (HDDs), digital versatile discs (DVDs), or network attached storage (NAS) is a small fraction of analog tape-based recording cost.

The use of DVR also offers permanent storage of video footage with no loss of image quality over time. All of these factors have driven the security industry toward adopting DVR as the standard for video recording.

There are three types of DVRs. They are

1. Embedded DVRs
2. Hybrid DVRs
3. PC based DVRs.

LEARNING OUTCOME

At the end of this chapter, the student could understand

- Fundamental steps of Digital image processing
- Various application of Digital image processing
- Working principles of image sensors (CCD, CMOS)
- Basic functions of Digital camera
- Fundamental elements of CCTV System

GLOSSARY

Electromagnetic spectrum	The complete range of electromagnetic radiation from short wavelength (gamma radiation) to long wavelength (radio waves).
Image	An image records visual snapshots of the world around us.
Imaging Device	A piece of equipment that captures an image. Example includes digital camera, side-scan sonar system and scanning electron microscope.
Sharpening	An area process that emphasizes the details in an image.
Pixel	A square unit of visual information that represents a tiny part of a digital image.
Dynamic range	The ratio between the brightest and dimmest gray level acceptable to an imaging system.
Mapping	The mathematical conversion of one set of numbers into a different set based upon some transformation.
Focal length	The distance between the center of a lens, or its secondary principal point and the imaging sensor. It determines the size of the image.
Infrared (IR)	Low frequency light below the visible spectrum. Infrared is used in surveillance cameras to provide a light source to record images in dark and zero light conditions.

Mega pixel	A mega pixel contains 1,000,000 pixels and is the unit of measure used to describe the size used to describe the size of the sensors in a digital camera.
Memory card	In digital photography, a memory card is a removable device used in digital cameras to store the image data captured by the camera. Example compact flash, smart media, SD/SDHS/SDXC/XD and others.
Shutter	A mechanism in the camera that controls the duration of light transmitted to the film or sensor.

QUESTIONS

Part – A (1 Mark)

I Choose the best answer

1. 1024 x 1024 image has resolution of
   a) 1048576
   b) 1148576
   c) 1248576
   d) 1348576

2. In M x N, M is number of
   a) Intensity levels
   b) Colors
   c) Rows
   d) Columns

3. Each element of matrix is called
   a) Dots
   b) coordinate
   c) pixels
   d) value

4. Imaging system produces
   a) High resolution image
   b) voltage signal
   c) Digital image
   d) Analog signal

5. Smallest elements of an image is called
   a) Pixel b) Dot
   c) Coordinate d) Digits

6. DPI stands for
   a) dots per image
   b) dots per inches
   c) dots per intensity
   d) diameter per inches

7. MRI in imaging stands for
   a) Magnetic resonance imaging
   b) Magnetic resistance imaging
   c) Magnetic resonance intensity
   d) Major resonance imaging

8. Digitizing amplitude values is called
   a) Radiance
   b) Illuminance
   c) Sampling
   d) Quantization

9. Black and white images have only
   a) 2 levels
   b) 3 levels
   c) 4 levels
   d) 5 levels

10. Gamma rays have largest
a) Wave length
b) Frequency
c) Energy
d) Power

11. In M x N, N is number of
a) Intensity levels
b) Colors
c) Rows
d) Columns

12. Luminance is measured in
a) chromens
b) Lumens
c) Degree
d) steradian

13. Image sensors produce
a) voltage waveform
b) Current
c) Audio
d) Discrete signals

14. Intensity levels in 8-bit images are
a) 255
b) 256
c) 244
d)245

15. Digitizing image requires
a) Reflection
b) Sampling
c) Quantization
d) Sampling and Quantization

16. Lens has a fixed
a) Focal length
b) Width
c) Length
d) Focal width

17. What does CCTV stands for?
a) Closed Circuit Technology
b) Closed Circuit Technology and Video
c) Closed Communication Television
d) Closed Circuit Television

18. This means that your subject is sharp and not blurry
a) Framing
b) Exposure
c) Focus
d) Image noise

19. A camera lens that magnifies the image
a) 200m lens
b) LCD Display
c) Exposure
d) Autofocus

20. Electronic flash memory data Storage device used for storing digital information
a) Flash drive
b) Tripod
c) Flash card
d) Memory card

Part – B (3 Marks)

II Answer the following

1. Define image.
2. Define sampling.
3. Define Quantization.
4. What is meant by pixel?
5. Write any four application of Digital image processing
6. What is image enhancement?
7. Which sensor is mostly used in smart phones? Why?

8. Write the applications of CCD sensor.
9. What is meant by viewfinder?
10. What are the uses of CCTV System?

Part – C (5 Marks)

III Explain the following questions

1. Explain the different types of image processing.
2. Compare CCD and CMOS sensors.
3. Explain simple CCTV system.
4. Write short notes on 'PIXEL'.

Part – D (10 Marks)

IV Answer the following questions in detail

1. With block diagram, explain the fundamental steps in Digital image processing.
2. Explain any five applications of Digital image processing.
3. Describe CMOS sensors with neat diagram.
4. Explain main powered CCTV system with neat diagram.

ANSWERS

1 (a)	2 (c)	3 (c)	4 (c)	5 (a)
6 (b)	7 (a)	8 (d)	9 (a)	10 (b)
11 (d)	12 (b)	13 (a)	14 (b)	15 (d)
16 (a)	17 (d)	18 (b)	19 (c)	20 (d)