Digital image processing (EEC 022)

Digital image processing:

Digital image processing means there are three terms first one is processing then image then Digital. So a Digital image processing means the processing of images which are digital in nature by a digital computer.

Interest in Digital image processing methods stems from two principle application area:
it is motivated by two major applications ; Improvement of Pictorial information for human perception means whatever image you get wants to enhanced the quality of image. so that the image will have a better look and it will much better when you look at the image.(Need of Process of Image)

What is Digital Image Processing?

- An image may be defined as a two dimensional function f(x, y), where x and y are spatial (Plane) coordinates.
- Amplitude of at any pair of Coordinates(x, y) is called the intensity or grey level of image at that point.
- When x, y and Intensity values of f are all finite, discrete quantity .We called the image is digital image.
- The field of Digital Image Processing refers to processing digital images by means of a digital computer.
- A digital image is composed of a finite number of elements ,each of which has a particular location and value stop these elements are called picture elements, image elements , pels and pixels.
- Pixel is the term used most widely to denote the elements of a digital images .
- Images play the single most important role in human perception.
- Perception as a process of recognizing (being aware of) , Organizing (gathering and storing) and interpreting (binding to knowledge) sensory information.
- Perception deals with the human senses that generate signals from the environment through sight, hearing, touch, smell and taste.
- Humans, who are limited to the visible band of electromagnetic (EM) spectrum . (A typical human eye will respond to wavelengths from about 380 to 740 nanometeres.

- In frequency this corresponds to a band in the vicinity of 405 to 7 90 THz.

[The visible spectrum is the portion of the electromagnetic spectrum that is visible to the human eye . Electromagnetic radiation in this range of wavelengths is called visible light or simple light .] Vicinity means the area near or surrounding a particular place.

- Imaging mechanic cover the entire EM spectrum , ranging from Gamma to radio waves .

- spectrums operate on image generated by source that humans are not text two associated with image these include ultrasound electron microscopy and computer generated image. Thus digital image processing have a wide and varied field of application (accustomed-usual, normally)

- The area of Image analysis is in between image processing and computer vision.

- Digital image processing have process whose inputs and outputs are images and includes process that extract attributes from images up to and includes process that extract attributes from image up to and including the reorganization of individual objects.

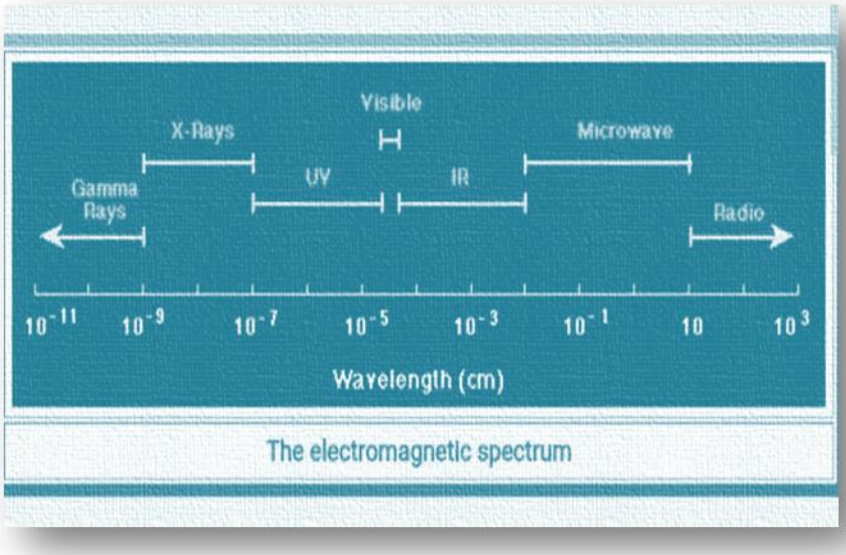
- The process of acquiring an image of the area containing the text, pre-processing that images, extracting (segmenting) the individual character describing the characters are call digital image processing.

- In Digital Image Processing there are three type of computerized process. Low, Mid and High level process.

- Low level process involves primitive operations such as image preprocessing to reduce noise, Contrast enhancement and image sharpening. in this process both inputs and outputs are images.

- Mid-level process involved task such as segmentation (Partitioning an image into regions or objects . Mid-level process is characterized by the fact that its input generally are images but its output are attributes extracted from those images (e.g. Edges, Contours and the identity of individual objects)

- Higher level Processing involves “making sense” of an ensemble of recognized objects as in image analysis and performing the cognitive functions normally associated with the human vision (Cognitions concerned with the act or process of knowing.)



The electromagnetic spectrum

Spectrum of Electromagnetic Radiation				
Region	**Wavelength (Angstroms)**	**Wavelength (centimeters)**	**Frequency (Hz)**	**Energy (eV)**
Radio	$> 10^{9}$	> 10	$< 3 \times 10^{9}$	$< 10^{-5}$
Microwave	$10^{9} - 10^{6}$	10 - 0.01	$3 \times 10^{9} - 3 \times 10^{12}$	$10^{-5} - 0.01$
Infrared	10^{6} - 7000	$0.01 - 7 \times 10^{-5}$	$3 \times 10^{12} - 4.3 \times 10^{14}$	0.01 - 2
Visible	7000 - 4000	$7 \times 10^{-5} - 4 \times 10^{-5}$	$4.3 \times 10^{14} - 7.5 \times 10^{14}$	2 - 3
Ultraviolet	4000 - 10	$4 \times 10^{-5} - 10^{-7}$	$7.5 \times 10^{14} - 3 \times 10^{17}$	$3 - 10^{3}$
X-Rays	10 - 0.1	$10^{-7} - 10^{-9}$	$3 \times 10^{17} - 3 \times 10^{19}$	$10^{3} - 10^{5}$
Gamma Rays	< 0.1	$< 10^{-9}$	$> 3 \times 10^{19}$	$> 10^{5}$

Typical Applications:

Some of major fields in which digital image processing is widely used are :

Noise filtering:
In some cases, the images that you get may be very noisy. So, we have to filter the images so that the noise present in that image can be removed and the image appears much better.

Contrast enhancement:
Sometimes the image may be very poor contrast and we have to enhance the contrast of that image so that it is better visually.

Deblurring:

In some cases, the image may be blurred. This blurring may occur because of various reasons. Sometime the camera setting is not proper or the lens is not focused properly, if we take a picture from a moving platform.In that case you might have absorbed that the image is not a clear image. it is a blurred image.

Medical applications:

In area of medicine. Image processing techniques are very important in medical applications . it helps the doctor to plan the operation process . By this process doctors can find out the exact location of the tumor, the size of the tumor and many other things.
CT scan images where the images of the human brain are formed by using the CT scan machines. CT scan image is used to determine the location of a tumor.

Autonomous machine application:

Image processing for autonomous machine application various application in industrial particular for quality control assembly automation and many such application.

Efficient storage and transmission:

Example: if we want to store image to a computer then this image needs to certain amount of disk space. Whether it is possible to process the image using certain image properties so that the disk space required for storing the image will be will be less.

example : Application if transmit the image or video signal over the transmission medium in that case if the bandwidth of transmission medium is very low we will see that how to process the image over video so that image or video can be transmitted over the low bandwidth communication channel.

Gamma Ray Imaging -Nuclear medicines and astronomical observations.

X-ray imaging -X rays of body

Ultraviolet Band – Lithography, industrial inspection, microscopy , laser

Visual and infrared band -Remote sensing

Microwave Band -Radar Imaging.

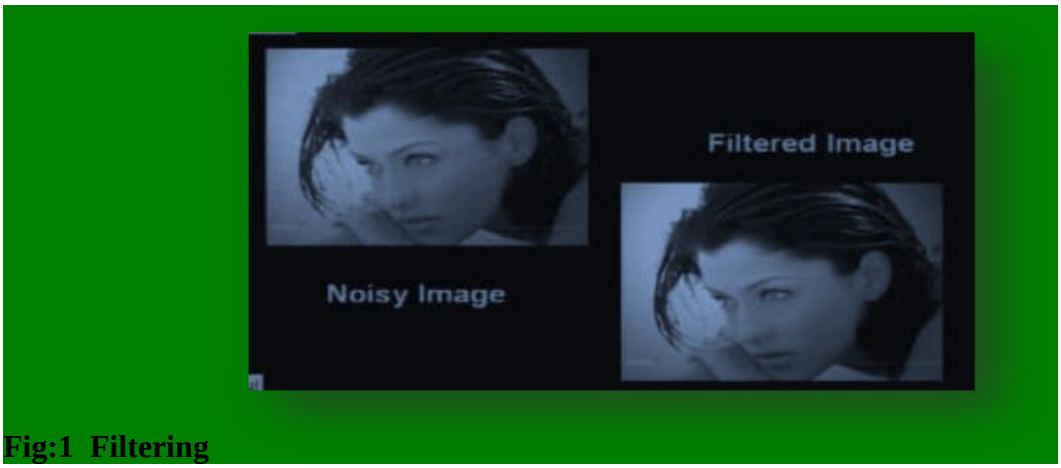


Fig:1 Filtering

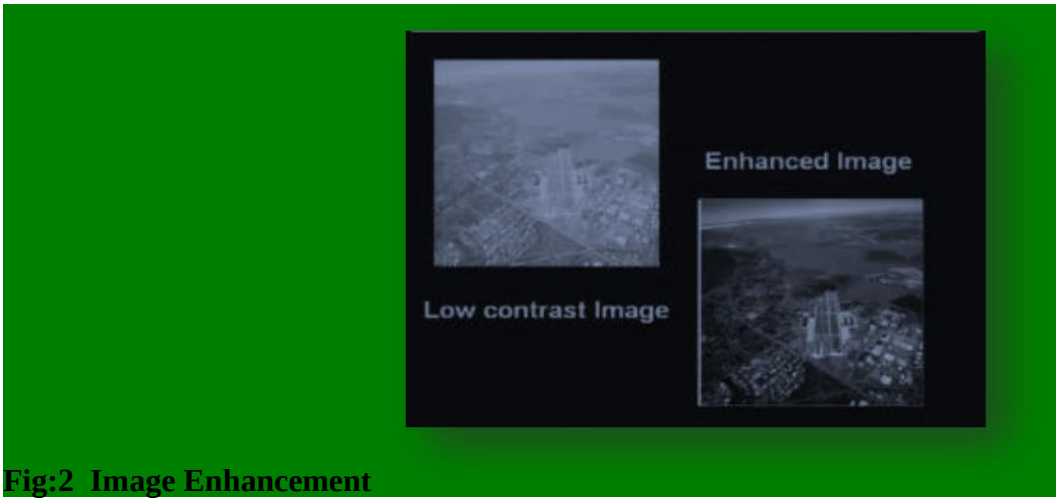
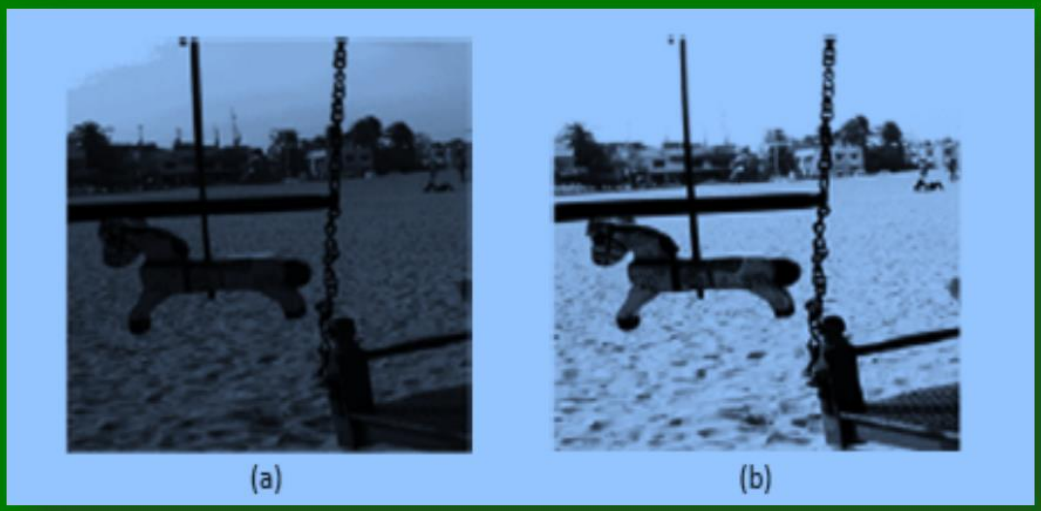


Fig:2 Image Enhancement

Fig:3 Image Deblurring

Fig:3 Medical Imaging

Fig: Image Enhancement(a) Dark Image(b)EnhancedImage



Components of an image processing system:

Figure shows the basic components comprising a typical general-purpose system used For digital image processing. The function of each component will be discussed below, Starting with image sensing.

Two subsystems are required to acquire digital images.

1. **Physical sensor**- physical sensor that respond to the energy radiated by the object we Wish to image.
2. **Digitizer**- Digitizer is a device for converting the output of physical sensing devices into digital form. In a digital video camera the sensor (CCD chips) produces an electrical output proportional to light intensity. The digitizer converts these outputs to digital data.

- Specialised image processing hardware usually consists of digitizer plus hardware that performs other primitive operations such as an arithmetical logic unit (ALU) , that performs arithmetic and logical operations in parallel on entire images. ALU is used in averaging images as quickly as they are digitized for the purpose of noise reduction. This type of hardware sometimes is called a front end subsystem and its most distinguishing characteristic is speed this unit performs functions that require fast data through put (e.g., digitizing and averaging video images at 30 frames per second) that the typical main computer cannot handle. One or more GPS also are common in image processing systems that perform intensive Matrix operations.
- The computer in an image processing system is general purpose computer and can range from a PC to a supercomputer. Almost any well equipped PC type machine is suitable for offline image processing tasks.
- **Software for image processing** consists of specialized models that perform specific task. Image processing software, such is the well-known MATLAB image processing toolbox, is also common in a well-equipped image processing system.
- **Mass storage** is a must in image processing applications. An image of size 1024 X 1024 pixels in which the intensity of each pixel is and 8 bit quantity, requires one megabyte of storage space if the image is not compressed. Digital storage for image processing applications falls into three principal categories :

short term storage for use during processing; short term storage is computer memory that is called frame buffers ,that is store one or more images and can be accessed rapidly usually at video rates.

Online storage for relatively fast recall; online storage generally takes the form of Magnetic disc are optical media storage. the key factor characterizing online storage is frequent access to the stored data.

Archival storage**,** characterized by infrequent access. Magnetic tapes and optical disk housed in juckboxes are usual media for archival applications.

Storage is measured in bytes, Kilobytes, Megabytes, GBytes 10 and Terabytes.

- **Image displays** in use today are mainly color, flat screen monitors. Monitors are driven by the outputs of image and graphics display cards that are an integral part of the computer system.

  In some cases it is necessary to have stereo displays, and these are implemented in the form of headgear containing two small displays embedded in googles won by the user.

- **Hard copy devices** for recording image include laser printers, film cameras, heat sensitive devices, ink-jet units and digital units such as optical and CD ROM disks. Film provides the highest possible resolution but paper is the obvious medium of choice for written material.

- For presentations, images are displayed on film transparencies or in a digital medium if image projection equipment is used.

- **Networking and cloud communication** are almost default functions in any computer system in use today. Because of the large amount of data inherent in image processing applications ,the key consideration in image transmission is bandwidth .Transmission bandwidth is improving quickly as a result of optical fiber and other broadband Technologies.

- **Image data compression** continues to play a major role in the transmission of large amounts of image data.

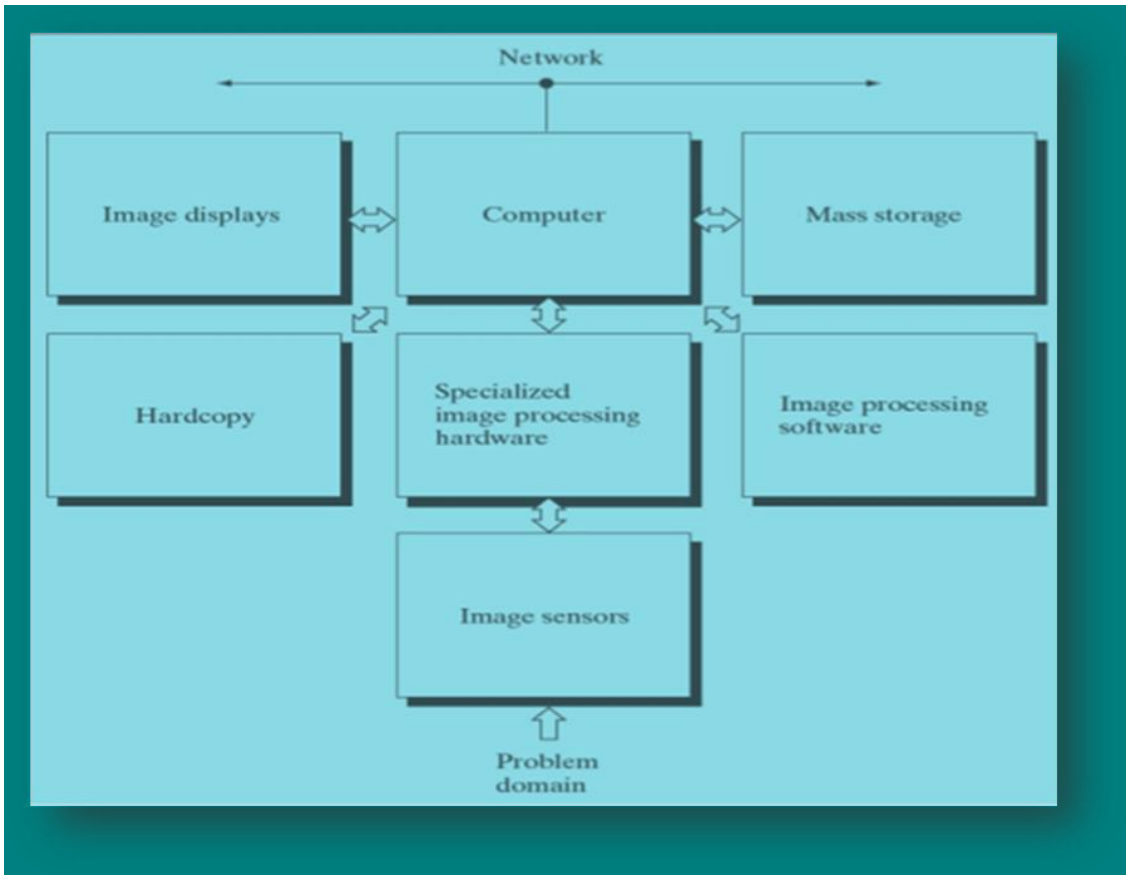


Figure: Components of an image processing system

Elements of visual Perception:

There are three elements in our interest.

A basic understanding of human visual perception as a first step in understanding digital image processing is must.

This topic covers

- The mechanics of the human visual system (Structure of the human eye)
- Image formation in the eye
- Its capability for brightness and adaptations and discrimination

The mechanics and parameters related to how images are formed and perceived by human is the key interest here.

The physical limitations of human vision in terms of factors like resolution and ability to adapt to changes in illumination are important from a particular point of view.

Human visual system:

The human visual system consists of two primary components the eye and brain which are connected by the optic nerve.

Eye: Receiving sensor (Camera, Scanner)

Brain: Information processing unit (Computer system)

Optical nerve: Connection Cable (Physical wire), Connection between eye and brain

The function of a visual system is to detect electromagnetic radiation (EMR) are emitted by the objects.

Humans can detect light wavelength between 400 to 700 nm. Hear the perceived color (hue) is related to the wavelength of light . Brightness is related to the intensity of the radiation.

Function of vision:

- Discriminate figure from background (food or rock)
- Detect movement (predator /pray)
- Detect color (Adaptive value of color vision)

The visible spectrum can be divided into three bands :

Blue (400 to 500 nm)

Green (500 to 600 nm)

Red (600 to 700 nm)

The sensors sense the color and are distributed across retina of our eye

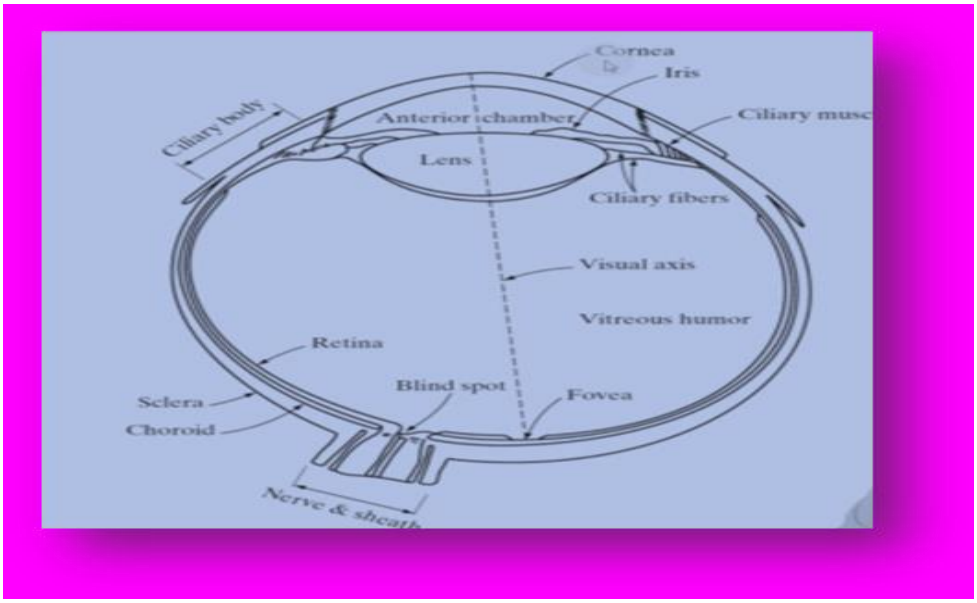
Structure of the human eye:

The eye is nearly a Sphere with an average diameter of approximately 20mm.

Three membranes enclose the eye:

- The cornea and sclera outer cover the choroid and retina(combined of outer cover)
- Choroid
- Retina

These are the structure of anatomy of human eye.



Figure(a): Simplified diagram of a cross section of human eye

In this diagram[(fig(a)] we can see the cornea is a tough , transparent tissue that covers the anterior surface of the eye. Continuous with the cornea , the sclera is an opaque membrance that enclosed the remainder of the optic globe.

The choroid lies directly below the sclera. This membrane contains a network of blood vessels that serve as the major source of nutrition to the eye.

The choroid coat is heavily pigmented (Substance used as a coating to protect a surface) and hence helps to reduce the amount of extraneous light entering the eye and the back scatter with in the optic globe .(if the high amount of light is incident or illuminated to our eyes .So the effect be most of the time experience. So the somewhat minimize by this particular membrane)

The choroid, at its anterior extreme is divided into the ciliary body and the iris .

The iris contracts or expands to control the amount of light that enters the eye. The central opening of iris (the pupil) varies in diameter from approximately 2 to 8 mm.

The lens is made up of concentric layers of fibrous cells and is suspended by fibers that attach to the ciliary body. lens is composed of 60% to 70% water , about 6% fat and more protein than any other tissues in the eye. The lens absorbs approximately 8% of the visible light spectrum, with relatively higher absorption at shorter wavelengths.

The innermost membrane of the eye is the retina which lines the inside of the walls entire posterior portion.

The lens is colored by a slightly yellow pigmentation that increases with age. In extreme cases excessive clouding of the lens, referred to as cataracts ,can lead to poor color discrimination and loss of clear vision.

Both infrared and ultraviolet light are absorbed by proteins within the lens and excessive amounts can damage the eye.

Retina: when the eye is focused, light from an object is imaged on the retina.

There are two classes of receptors: cones and rods(figb)

Cones: The cones in each eye number between 6 and 7 million. They are located primarily in the central portion of the retina called the fovea and are highly sensitive to color. cone vision is called photopic or bright light vision.

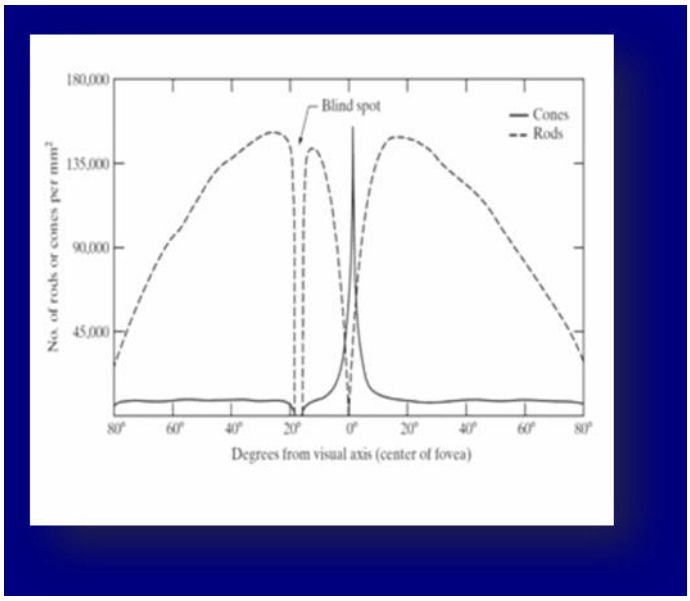
Cones have higher resolution than rods because they have individual nerves tied to each sensor.

Cons for daylight vision , sensitive to color, concentrated in the central region of eye, high resolution capability (differentiate small changes)

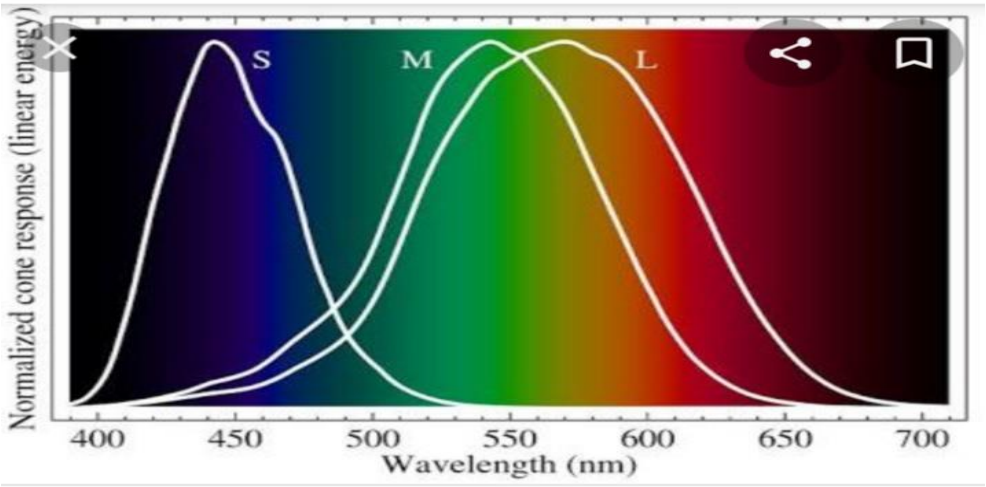
Rods: The number of rods is much larger; some 75 to 150 million are distributed over the retinal surface. Rods serve to give a general overall picture of the field of view . They are not involved in color vision and are sensitive to low levels of illumination. The related phenomenon is known as scotopic or dim light vision.

Rods have multiple sensors tied to each nerve. rods react even in low light but see only a single spectral band. They cannot distinguish color.

Rods for night vision , see only brightness gray level and not color, distributed across retina. medium and low level resolution, serve to give a general overall picture of the field of view.



Figure(b) Distribution of rods and conesintheretina



Blind spot: No Sensors

Place for optic nerve

we do not perceive it as a blind spot because the brain feels into missing visual information

In figure(b) ; cones are most dense in the center of the retina (in the center area of the fovea)

rods increase in density from the center of out to approximately 20 degree off Axis and then decrease in density out to the extreme periphery of the retina .we can imagine the fovea as a square sensor array of size 1.5 mm * 1.5 mm.

Image formation in the Eye:

In structure of human eye the formation of image, these constitude human visual system where we actually have the learn the mechanism how the image sensed by the human eye and the image generated onto the retina and see all these things know a days digital image processing system ,the image generated to the image processing system.

Image formation into the eye: In an ordinary photography camera the lens has a fixed focal length and focusing at various distance is achieved by varying the distance between the lens and the imaging plane, where the film (or imaging chip in the case of a digital camera) is located.

In the human eye the Converse is true; the distance between the lens and the imaging region(the retina) is fixed and the focal length needs to achieve proper focus is obtained by varying the shape of the lens.

How image visual system work as below; here light energy is focused by the lens of the eye into sensors and retina. The sensors respond to the light by an electrochemical reaction that sends an electrical signal to the brain (through the optic nerve). The brain uses the signals to create neurological pattern that we perceives as image.

The retina image is focused primary on the region of the fovea. Perception then takes place by the relative excitation of light receptors , which transform radiate energy into electrical impulses that ultimately are decoded by the brain.

Image formation in the eye; the distance between the centre of lens and the retina along the visual axis is approximately 17 mm. The range of focal length is approximately 14mm to 17mm. the latter taking place when the eye is relaxed and focused at distance greater than about3m. The geometry in the next figure illustrates how to obtain the dimension of an image formed on the retina.

For (fig c)example suppose that a person is looking at a tree 1.5 m high at a distance of 100m. letti ng h denote the height of that object in the retinal image, the geometry yields

15 /100 = h/17 or h=2.55mm

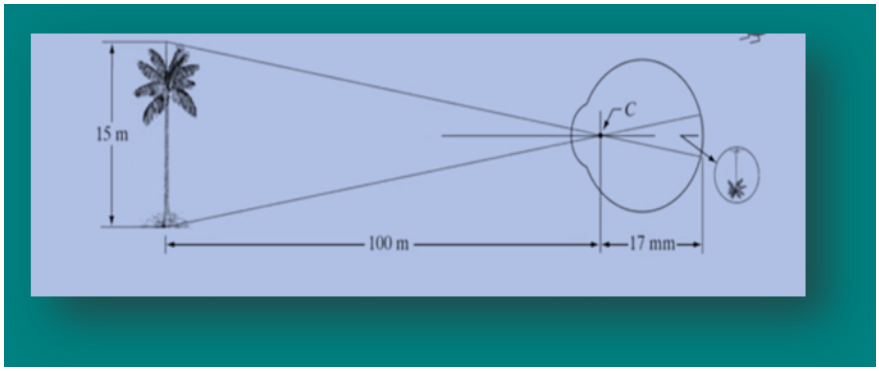


Figure:(c) Graphical representation of the eye looking at a palm tree. Point C is the focalcenterof the lens.

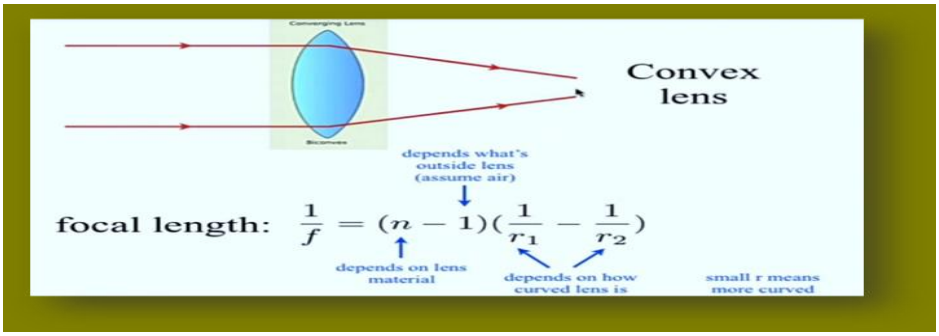


Figure:(d)

QUESTION BANK (1)

DIGITAL IMAGE PROCESSING

1. Define Image?

2. What is Dynamic Range?

3. Define Brightness.?

4. Describe in detail the elements of digital image processing system .

5. Describe sampling and Quantization.

6. Explain the properties of images which can be described by histogram also explain normalised histogram

7. Explain the 4, 8 and m connectivity of pixels.

8. Explain region is in context with connectivity of pixel.

9. Explain the need of histogram matching (specification). Deduce the formula for histogram Matching

10. Discuss image smoothing with the following :(1) lopa special filter (2) median filtering.

11. Distinguish spatial domain techniques and frequency domain techniques of image enhancement.

12. Define Resolutions?

13. What is meant by pixel?

14. Explain Wiener filter with SNR, MSE ratio for spatial and frequency domain .

15. Explain local noise reduction adaptive filter.

16. Explain morphological image processing in context with set theory

17. Explain erosion , delation , opening and closing with proper example.

18. Explain band reject filte.

19. Why band reject filter suitable for reducing periodic noise.

20. Explain all band reject filter in detail.

21. what is digital image processing?

22. discuss some of digital image processing major application.

23. Explain the process of image segmentation using region growing

24. Define Quantization?

25. What do you meant by Gray level?

QUESTION BANK (2)

DIGITAL IMAGE PROCESSING

26. Define Digital image?

27. Describe the technique of three shoulding for image segmentation.

28. Prove that rotation and translation are not communicating operations.

29. Prove the opening and closing are dual transformation.

30. Name the different types of derivative filters?

31. Explain the procedure of region filtering with an example.

32. How cones and rods are distributed in retina?

33. .Define subjective brightness and brightness adaptation?

34. What is maximum filter and minimum filter?

35. Write the application of sharpening filters?

36. What is contrast stretching?

37. Write a note on noise model in image restoration.

38. Describe winner filter.

39. Describe inverse filters.

40. What do you understand by Weber ratio?

41. What does alone value for Weber ratio indicate?

42. What are the different approaches for segmentation question mark?

43. Explain the properties of 2D Fourier Transform.

44. Explain convolution property in 2D Fourier transform.

45. In which situation we use region margin and region splitting?

46. Draw the graph for Power law (Gamma) transformation (for Gamma >1).

47. Explain spatial filtering?

48. What is a Median filter?

49. Explain the components of an image processing system.

50. Explain various approaches used for edge detection.

Reference: • ● Rafael C. Gonzalez Richard E woods , “Digital image processing” , Pearson, 4th Ed. 2009.