UNIT-1
IMAGE FUNDAMENTALS AND TRANSFORMS

1.1 Introduction

The digital image processing deals with developing a digital system that performs operations on a digital image. An image is nothing more than a two dimensional signal. It is defined by the mathematical function f(x,y) where x and y are the two co-ordinates horizontally and vertically and the amplitude of f at any pair of coordinate (x, y) is called the intensity or gray level of the 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 image digital image processing refers to the processing of digital image 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 values of these elements are referred to as picture elements, image elements and pixels.

Digital image processing focuses on two major tasks

- Improvement of pictorial information for human interpretation
- Processing of image data for storage, transmission and representation for autonomous machine perception.

Digital image processing deals with manipulation of digital images through a digital computer. It is a subfield of signals and systems but focus particularly on images. DIP focuses on developing a computer system that is able to perform processing on an image. The input of that system is a digital image and the system process that image using efficient algorithms, and gives an image as an output. The most common example is Adobe Photoshop. It is one of the widely used applications for processing digital images.

1.2 Structure of Human Eye:

The eye is nearly a sphere with average approximately 20 mm diameter. The eye is enclosed with three membranes

a) The cornea and sclera - it is a tough, transparent tissue that covers the anterior surface of the eye. Rest of the optic globe is covered by the sclera

b) The choroid –It contains a network of blood vessels that serve as the major source of nutrition to the eyes. It helps to reduce extraneous light entering in the eye.

It has two parts

Iris Diaphragms- it contracts or expands to control the amount of light that enters the eyes

Ciliary body

c) Retina – it is innermost membrane of the eye. When the eye is properly focused, light from an object outside the eye is imaged on the retina. There are various light receptors over the surface of the retina. The two major classes of the receptors are-

1) Cones - it is in the number about 6 to 7 million. These are located in the central portion of the

retina called the fovea. These are highly sensitive connected to its own nerve end. Cone vision is called photopic or bright light vision

2) Rods – these are very much in number from 75 to 150 million and are distributed over the entire retinal surface. The large area of distribution and the fact that several roads are connected

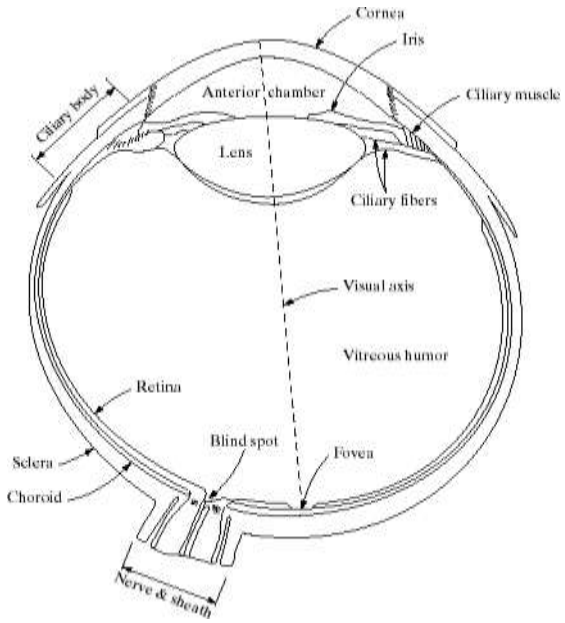


Fig 1.1 Structure of Eye

to a single nerve give a general overall picture of the field of view. They are not involved in the color vision and are sensitive to low level of illumination. Rod vision is called is scotopic or dim light vision. The absent of reciprocators is called blind spot.

1.3 Image Formation in the Eye:

- The major difference between the lens of the eye and an ordinary optical lens in that the former is flexible.
- The shape of the lens of the eye is controlled by tension in the fiber of the ciliary body. To focus on the distant object the controlling muscles allow the lens to become thicker in order to focus on object near the eye it becomes relatively flattened.
- The distance between the center of the lens and the retina is called the focal length and it varies from 17mm to 14mm as the refractive power of the lens increases from its minimum to its maximum**.**
- When the eye focuses on an object farther away than about 3m.the lens exhibits its lowest refractive power. When the eye focuses on a nearly object. The lens is most strongly refractive.
- The retinal image is reflected primarily in the area of the fovea. Perception then takes

place by the relative excitation of light receptors, which transform radiant energy into electrical impulses that are ultimately decoded by the brain.

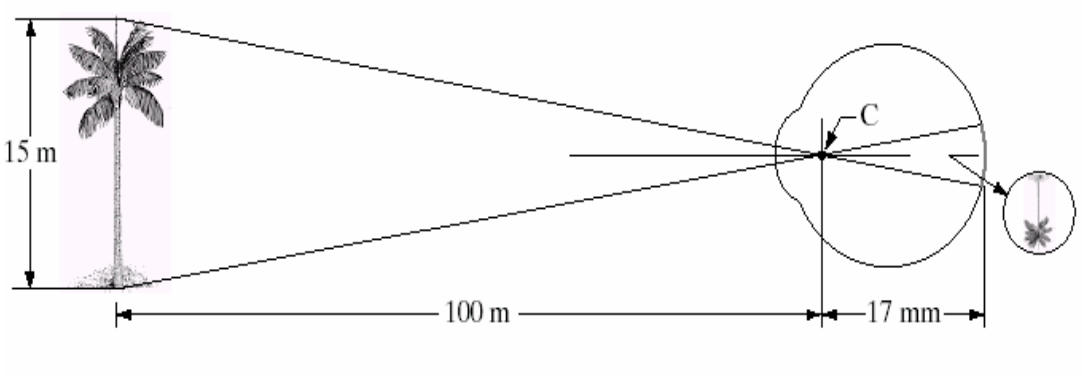
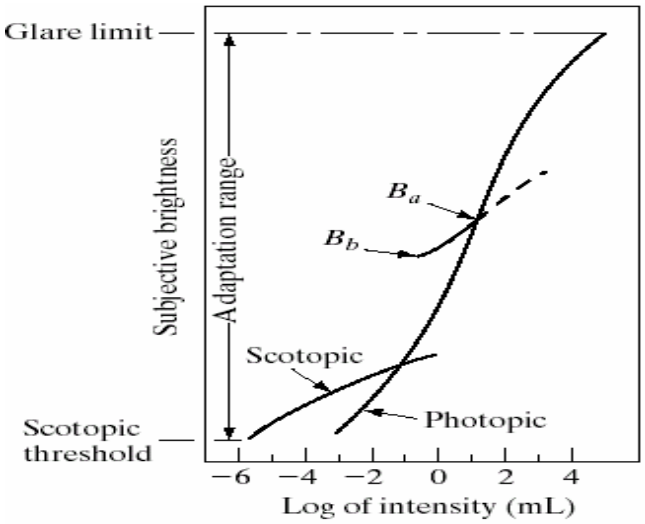


Fig 1.2 Image Formation in eye

- Focal length of the eye: 17 to 14 mm
- Let *h* be the height in mm of that object in the retinal image, then 15/100 = *h* / 17 , *h* = 2.55mm
- The retinal image is reflected primarily in the area of the fovea.

1.4 Brightness Adaption and Discrimination:

Digital image are displayed as a discrete set of intensities. The range of light intensity levels to which the human visual system can adopt is enormous- on the order of 10^{10}-from scotopic threshold to the glare limit. Experimental evidences indicate that subjective brightness is a logarithmic function of the light intensity incident on the eye.



- The curve represents the range of intensities to which the visual system can adopt. But the visual system cannot operate over such a dynamic range simultaneously. Rather, it is accomplished by change in its overcall sensitivity called B**rightness adaptation.**
- For any given set of conditions, the current sensitivity level to which of the visual system is called brightness adoption level , B_a in the curve. The small intersecting curve represents the range of subjective brightness that the eye can perceive when adapted to this level. It is restricted at level B_b, at and below which all stimuli are perceived as indistinguishable blacks. The upper portion of the curve is not actually restricted. Whole simply raise the adaptation level higher than B_a.
- The ability of the eye to discriminate between changes in light intensity at any specific adaptation level is also of considerable interest. This is called as **Brightness Discrimination.**
- The fact brightness discrimination in known by Weber's law. Take a flat, uniformly illuminated area large enough to occupy the entire field of view of the subject. It may be a diffuser such as an opaque glass, that is illuminated from behind by a light source whose intensity, I can be varied. To this field is added an increment of illumination ΔI in the form of a short duration flash that appears as circle in the center of the uniformly illuminated field.
- If ΔI is not bright enough, the subject cannot see any perceivable changes.

Weber's Law states that the ratio of the increment threshold to the background intensity is a constant.

$$\frac{\Delta I}{I} = K$$

Weber Ratio: ΔIc / I where I is the light source intensity and ΔIc is increment in illumination. A small value of Weber ratio means Good brightness discrimination. A large value of Weber ratio means Poor brightness discrimination.

An image is a two-dimensional function f(x,y), where x and y are the spatial (plane) coordinates, and the amplitude of f at any pair of coordinates (x,y) is called the intensity of the image at that level.

(b)Photopic vision is the vision of the eye under well-lit conditions (luminance level 10 to 108 cd/m²). In humans and many other animals, photopic vision allows color perception, mediated by cone cells, and a significantly higher visual acuity and temporal resolution than available with scotopic vision.

(c)Weber Ratio: ΔIc / I where I is the light source intensity and ΔIc is increment in illumination.

A small value of Weber ratio means Good brightness discrimination.

A large value of Weber ratio means Poor brightness discrimination.

(d)The principle objectives of image enhancement techniques is to process an image so that

the result is more suitable image than the original image for a specific application.

(e)Log transformation technique is applied to compress the dynamic range of gray levels in an

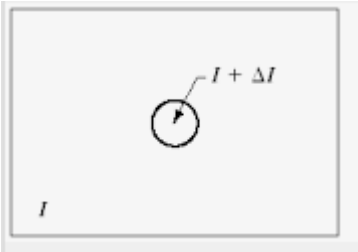
image.

s=c log (1+r) where c is constant and it is assumed that r≥0 .

(f)The enhancement techniques that are using arithmetic operators are

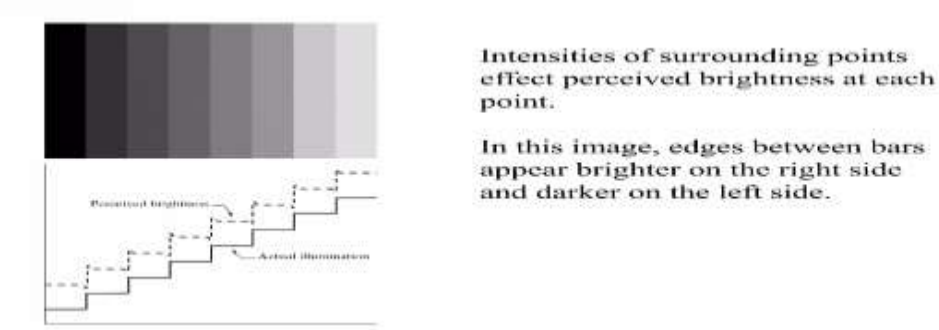
(i)Image subtraction

(ii)Image Averaging



Match band Effect

Mach bands or the Mach effect refers to an optical phenomenon from edge enhancement due to lateral inhibition of the retina 2. This is an inbuilt edge enhancement mechanism of the retina, where the edges of darker objects next to lighter objects will appear darker and vice versa, creating a false shadow



1.5 Fundamental Steps in Digital Image Processing:

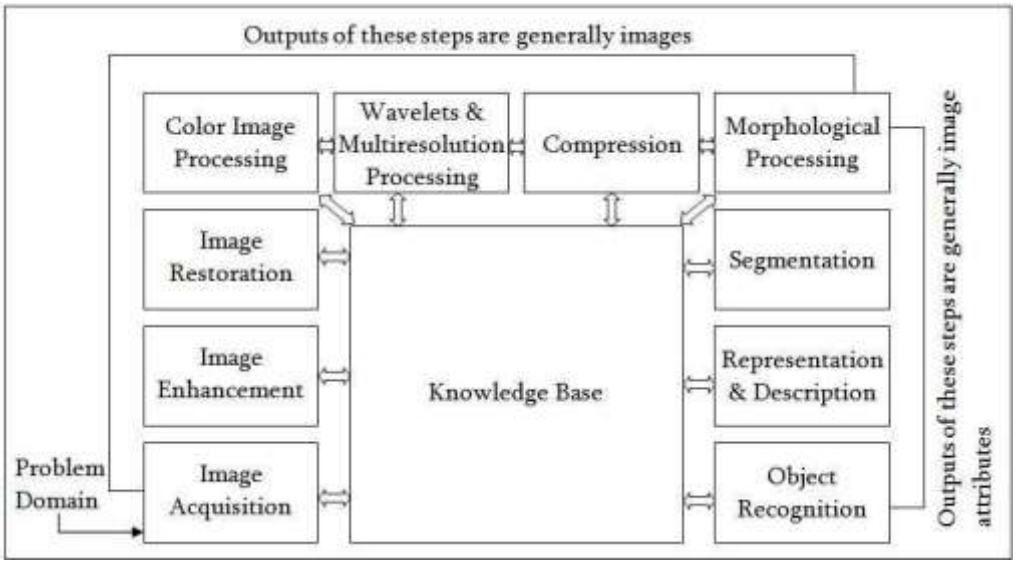


Fig 1.3 Fundamental Steps of Digital Image Processing