Kibur College

Computer Vision and Image Processing

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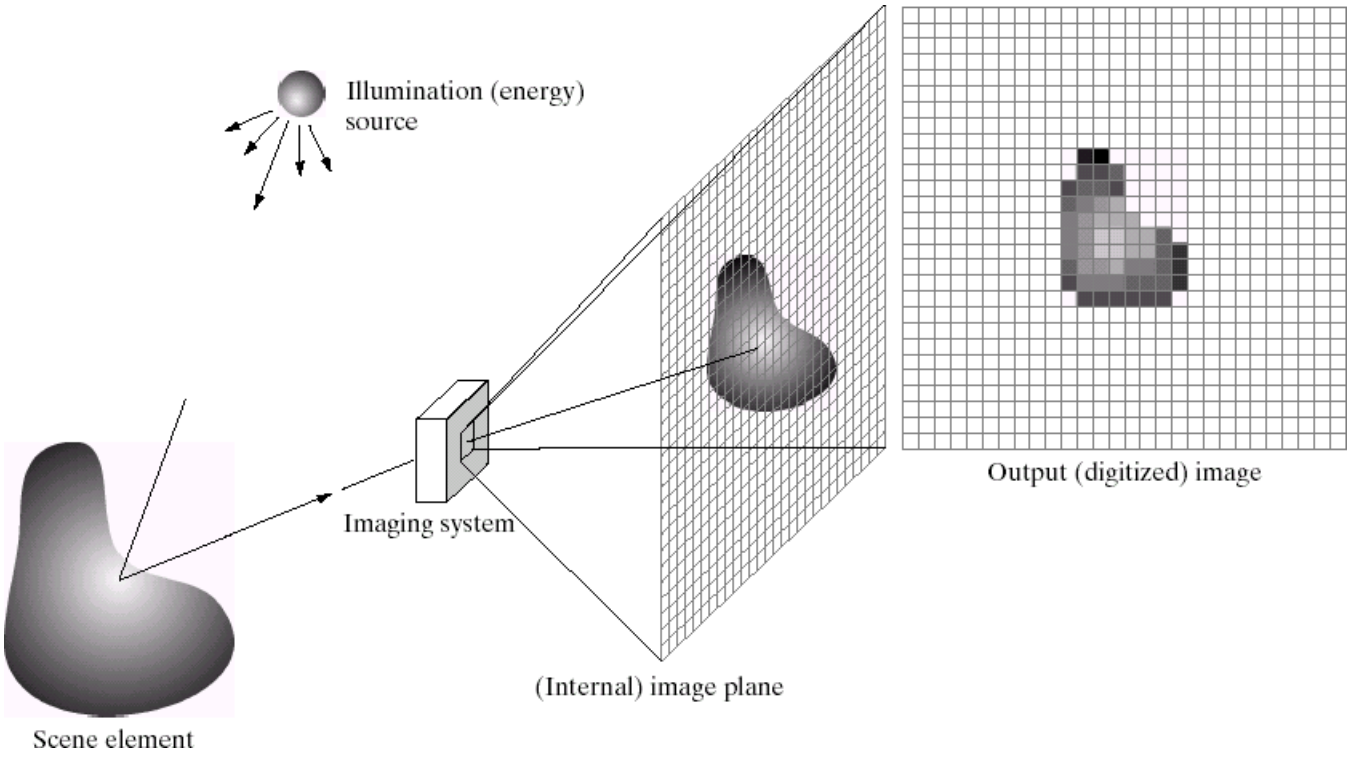
Chapter 1:
Introduction to Computer Vision and Image Processing

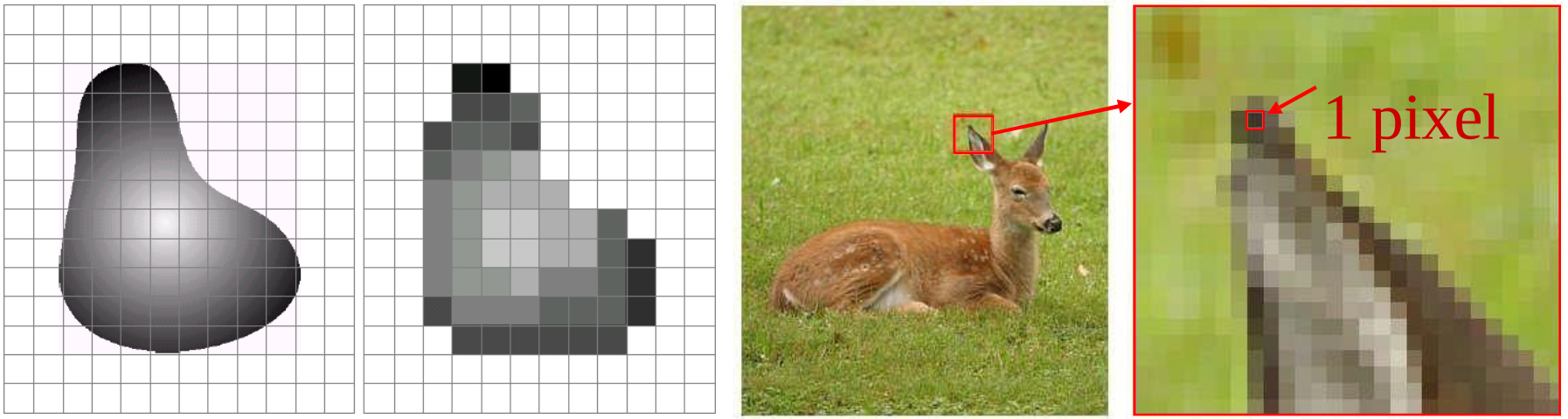
What is a Digital Image?

- A **digital image** is a representation of a two-dimensional image as a finite set of digital values, called picture elements or pixels



Cont..

- Pixel values typically represent gray levels, colours, heights, opacities etc
- **Remember** *digitization* implies that a digital image is an *approximation* of a real scene



Cont..

Common image formats include:

- 1 sample per point (B&W or Grayscale)
- 3 samples per point (Red, Green, and Blue)
- 4 samples per point (Red, Green, Blue, and "Alpha", a.k.a. Opacity)

For most of this course we will focus on grey-scale images

What is Digital Image Processing?

- 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
- Some argument about where image processing ends and fields such as image analysis and computer vision start

Overview: **Digital** Imaging

Definition of computer imaging:

—Acquisition and processing of visual information by computer.

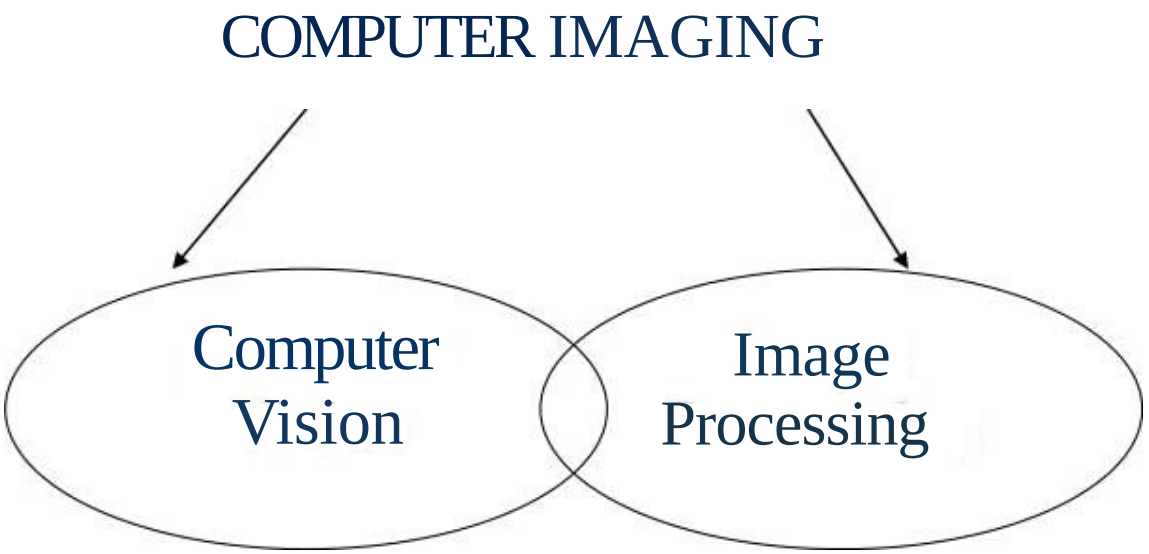
- Why is it important?
  - —Human primary sense is visual sense.
  - —Information can be conveyed well through images (one picture worth a thousand words).
  - —Computer is required because the amount of data to be processed is huge.

Overview: **Digital** Imaging

- Computer imaging can be divided into two main categories:
  - —Computer Vision: applications of the output are for use by a computer.
  - —Image Processing: applications of the output are for use by human.
- These two categories are not totally separate and distinct.

Overview: Computer Imaging

- They overlap each other in certain areas.



Computer Vision

Does not involve human in the visual loop.

- One of the major topic within this field is image analysis next Chapter.

  Image analysis involves the examination of image data to facilitate in solving a vision problem.

Computer Vision…

Image analysis process involves two other topics:

- Feature extraction: acquiring higher level image info (shape and color)
- Pattern classification: using higher level image information to identify objects within image.

Computer Vision…

Most computer vision applications involve tasks that:

—Are tedious for people to perform.

—Require work in a hostile environment.

—Require a high processing rate.

Require access and use of a large database of information.

Computer Vision…

- Examples of applications of computer vision:
  - —Quality control (inspect circuit board).
  - —Hand-written character recognition.
  - —Biometrics verification (fingerprint, retina, DNA, signature, etc).
  - —Satellite image processing.
  - —Skin tumor diagnosis.
  - —And many, many others.

Image Processing

- Processed images are to be used by human.
  —Therefore, it requires some understanding on how the human visual system operates.

Image Processing Fields

Input / Output	**Image**	**Description**
Image	Image Processing	Computer Vision
Description	Computer Graphics	AI

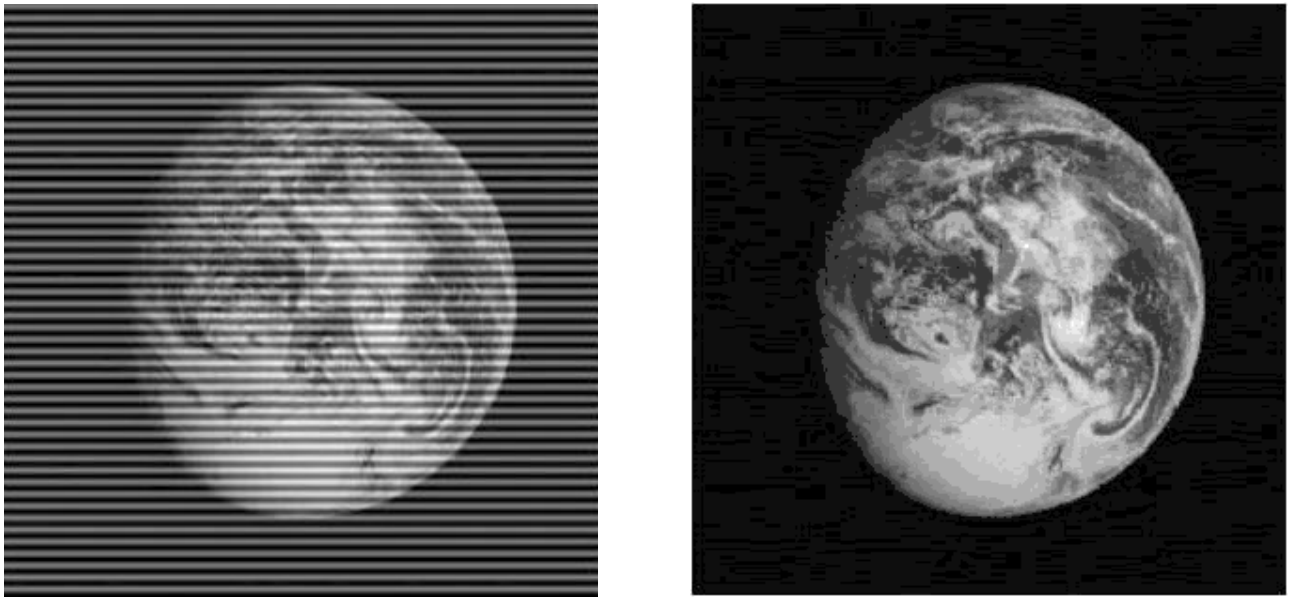
Sometimes, Image Processing is defined as “a discipline in which both the input and output of a process are images

But, according to this classification, trivial tasks of computing the average intensity of an image would not be considered an image processing operation

Image Processing…

- Image restoration:
  - —The process of taking an image with some know, or estimated degradation, and restoring it to its original appearance.
  - —Done by performing the reverse of the degradation process to the image.
  - —Examples: correcting distortion in the optical system of a telescope.

Image Processing



An Example of Image Restoration

Image Processing…

Image enhancement:

—Improve an image visually by taking an advantage of human visual system's response.

—Example: improve contrast, image sharpening, and image smoothing.

Image Processing

An Example of Image Enhancement

Image Processing

- Image compression:
  - —Remove the amount of data required to represent an image by:
    - Removing unnecessary data that are visually unnecessary.
    - Taking advantage of the redundancy that is inherent in most images.
  - —Example: JPEG, MPEG, etc.

Computer Imaging Systems

- Computer imaging systems comprises of both hardware and software.
- The hardware components can be divided into three subsystems:

  —The computer

  - Image acquisition: camera, scanner, video recorder.

    Image display: monitor, printer, film, video player.

Computer Imaging Systems

- The software is used for the following tasks:
  - —Manipulate the image and perform any desired processing on the image data.
  - — Control the image acquisition and storage process.

s The computer system may be a general-purpose computer with a frame grabber or image digitizer board in it.

Computer Imaging Systems

Frame grabber is a special purpose piece of hardware that digitizes standard analog video signal.

Digitization of analog video signal is important because computers can only process digital data.

Computer Imaging Systems

- Digitization is done by sampling the analog signal or instantaneously measuring the voltage of the signal at fixed interval in time.
- The value of the voltage at each instant is converted into a number and stored.
- The number represents the brightness of the image at that point.

Computer Imaging Systems

- The "grabbed" image is now a digital image and can be accessed as a two dimensional array of data.
  - —Each data point is called a *pixel* (picture element).
- The following notation is used to express a digital image:
  - —I(r,c) = the brightness of the image at point (r,c) where r = row and c = column.

Human Visual Perception

Human perception encompasses both the physiological and psychological aspects.

- We will focus more on physiological aspects, which are more easily quantifiable and hence, analyzed.

Human Visual Perception

- Why study visual perception?

  —Image processing algorithms are designed based
  on how our visual system works.

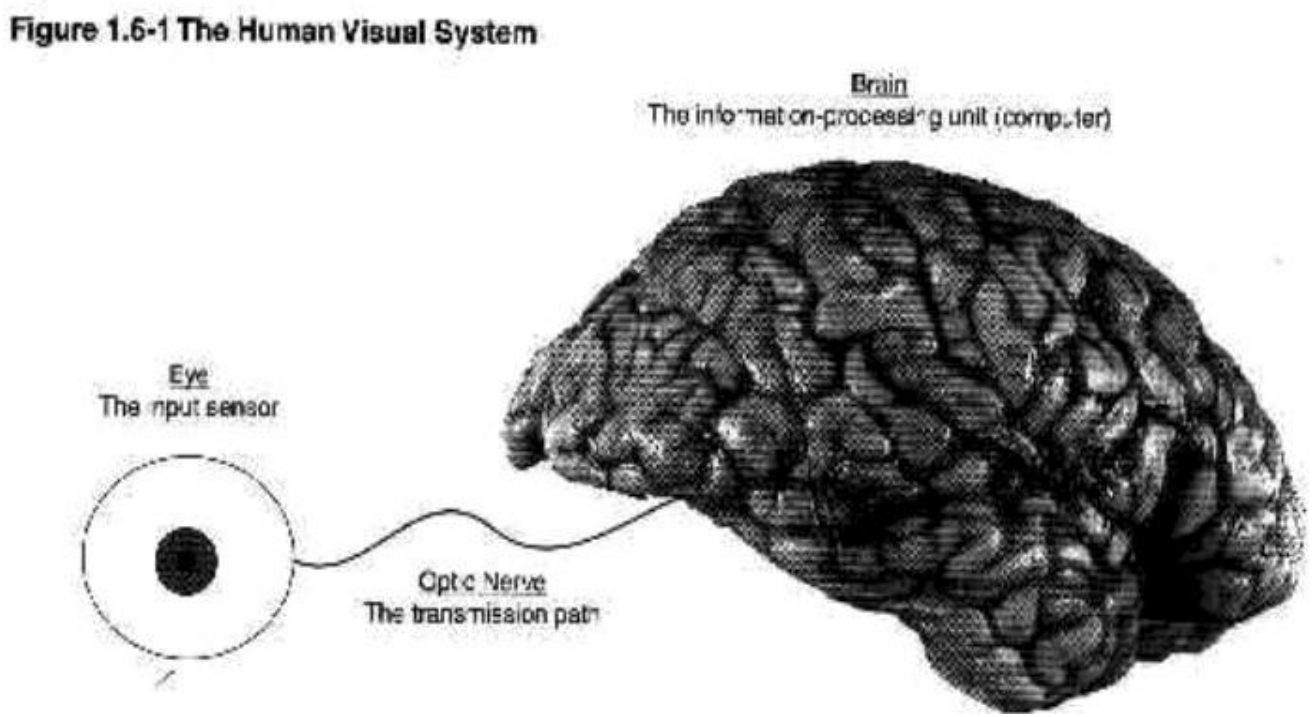
  - In image compression, we *need* to know what information is not perceptually important and can be ignored.

  —In image enhancement, we need to know what types of operations that are likely to improve an image visually.

The Human Visual System

- The human visual system consists of two primary components — the eye and the brain, which are connected by the optic nerve.
  - —Eye — receiving sensor (camera, scanner).
  - —Brain — information processing unit (computer
  - system).
  - —Optic nerve — connection cable (physical wire).

The Human Visual System



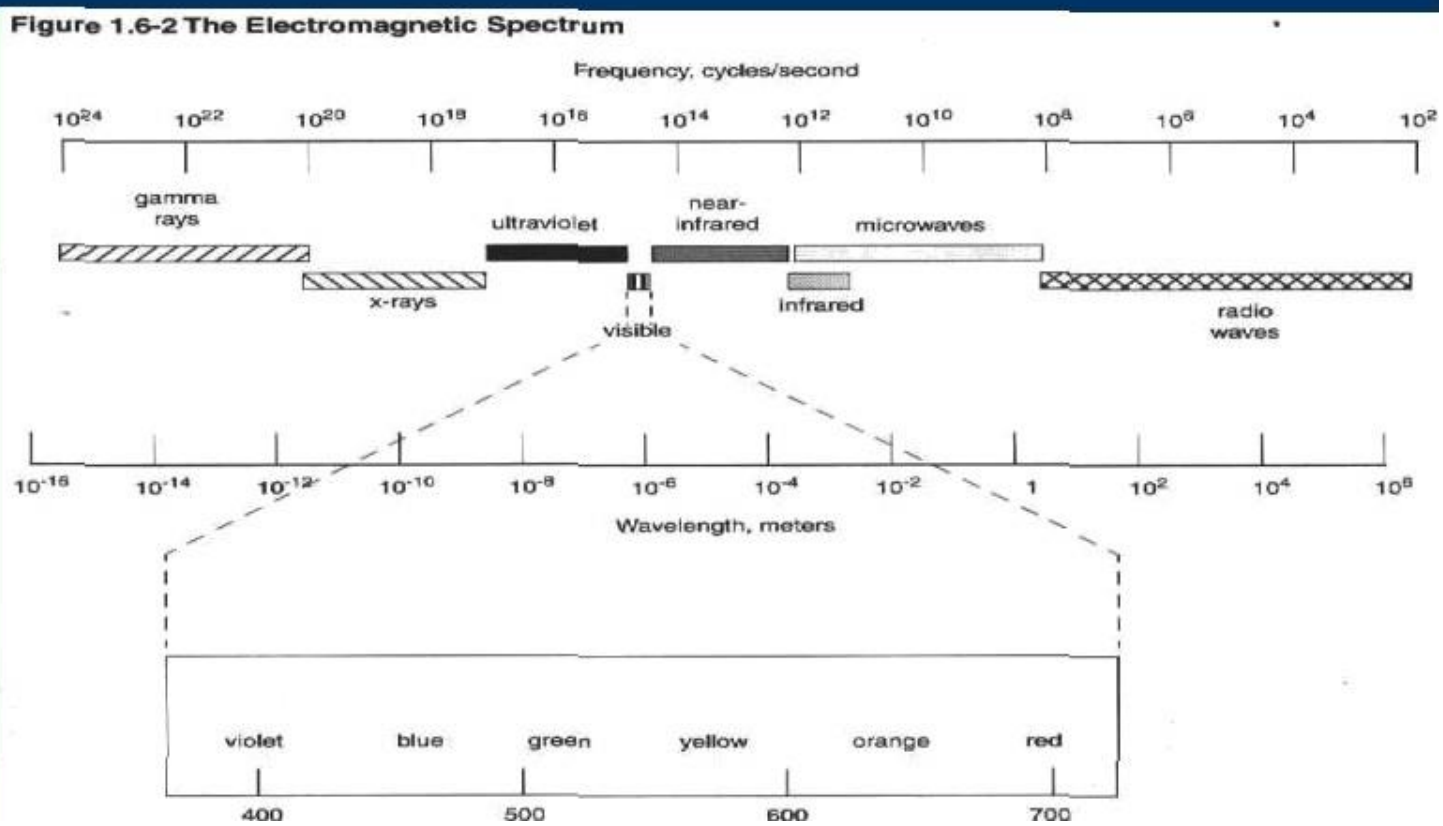
The Human Visual System

- This is how human visual system works:
  - —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 patterns that we perceive as images.

The Human Visual System

- The visible light is an electromagnetic wave with wavelength range of about 380 to 825 nanometers.
  - However, response above 700 nanometers is minimal.
- We cannot "see" many parts of the electromagnetic spectrum.

The Human Visual System



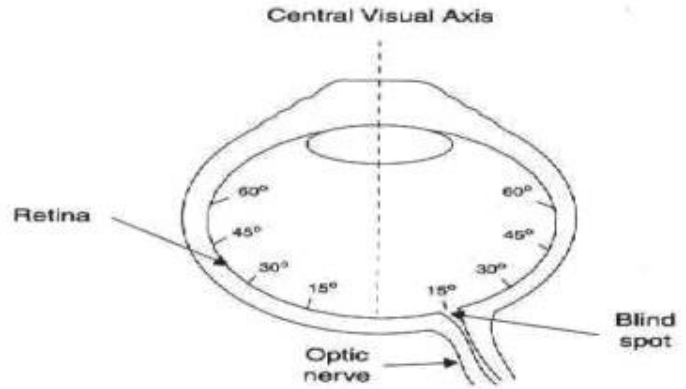
The Human Visual System

- The visible spectrum can be divided into
  three bands:
  —Blue (400 to 500 nm).
  —›?r=rn (500 to 600 nm).
  —Red (600 to 700 nm).

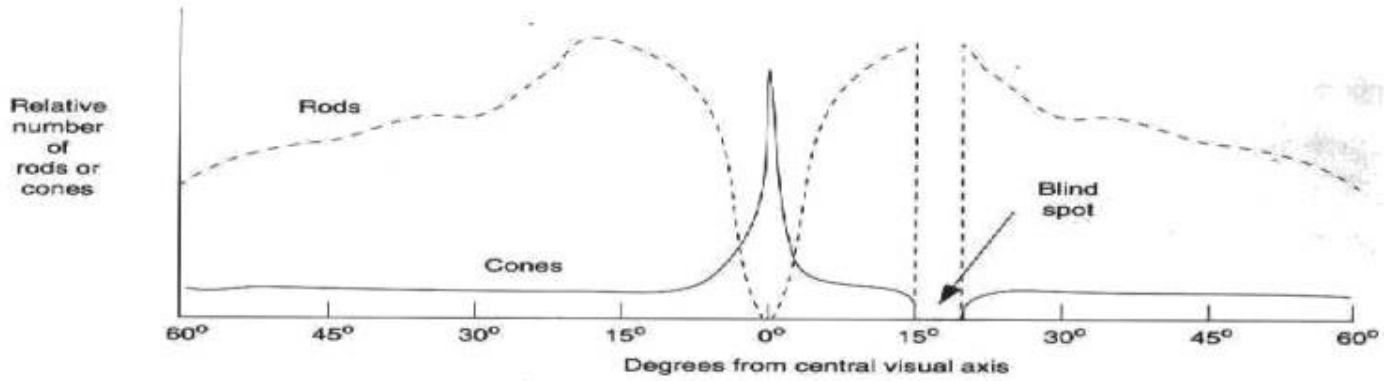
e The sensors are distributed across retina.

The Human Visual System

Figure 1.6-3 The Human Eye



a. Basic eye structure.



b. Concentration of rods and cones across retina.

The Human Visual System

- There are two types of sensors: rods and cones.
- Rods:
  - —For night vision.
  - —See only brightness (gray level) and not color.
  - —Distributed across retina.
  - —Medium and low level resolution.

The Human Visual System

- Cones:
  - —For daylight vision.
  - —Sensitive to color.
  - —Concentrated in the central region of eye.
  - —High resolution capability (diflerentiate small changes).

The Human Visual System

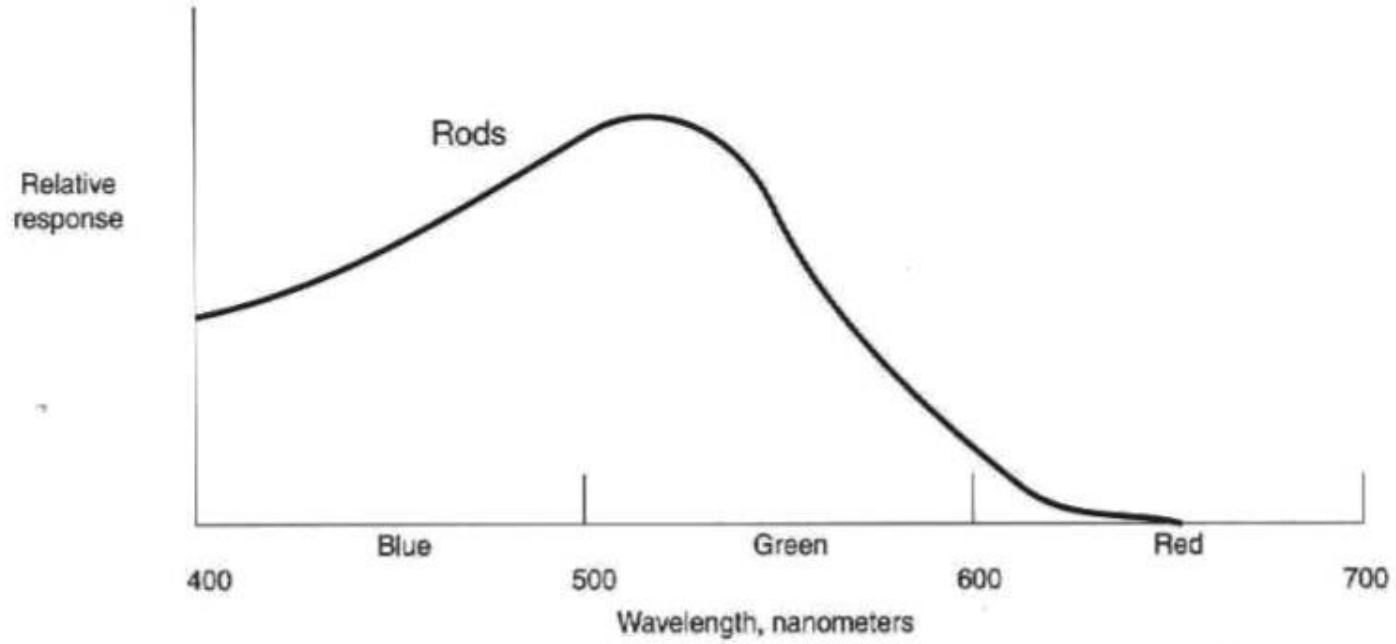
- Blind spot:
  - —No sensors.
  - —Place for optic nerve.
  - —We do not perceive it as a blind spot because the brain fills in the missing visual information.
- s Why does an object should be in center field of vision in order to perceive it in fine detail?
  - —This is where the cones are concentrated.

The Human Visual System

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

The Human Visual System

Figure 1.6-4 Relative Responses of Rods and Cones

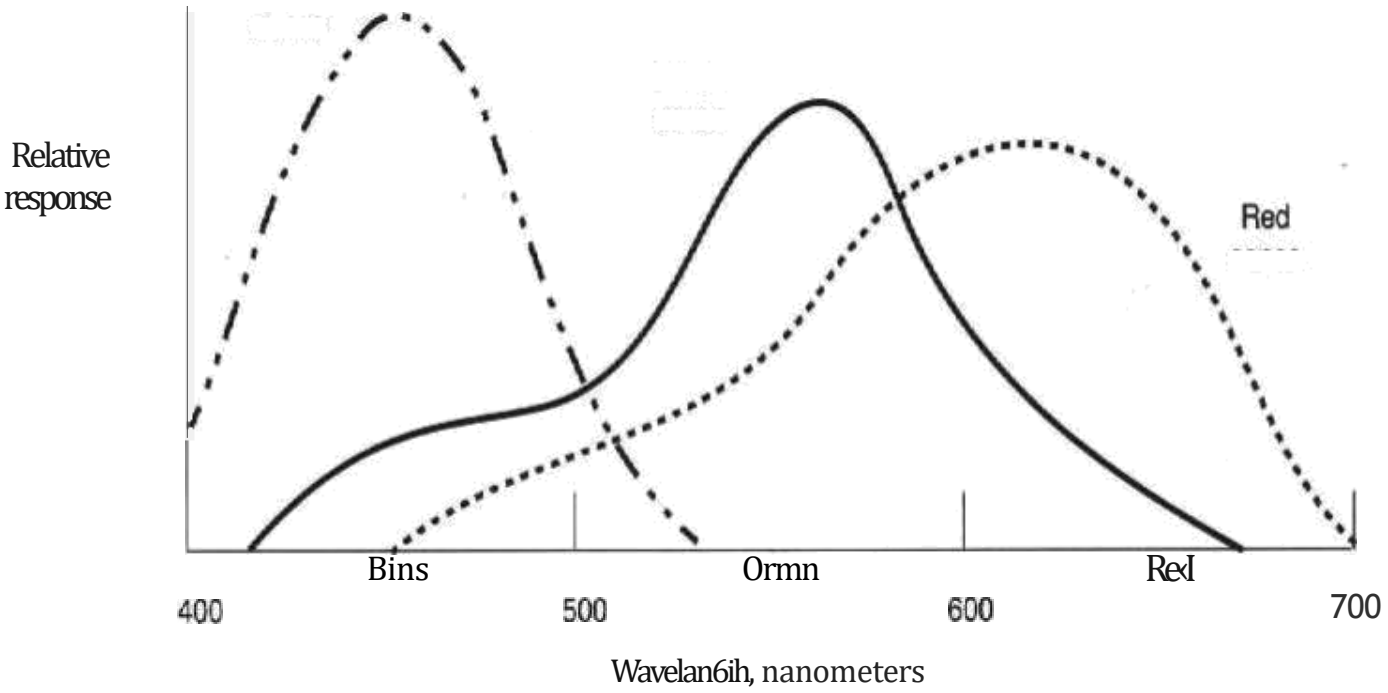


a. Rods react even in low light levels but see only a single spectral band; they cannot distinguish colors.

The Human Visual System

- There are three types of cones. Each responding to diñerent wavelengths of light energy.
- The colors that we perceive are the combined result of the response of the three cones.

The Human Visual System



b. Cones raact only to high lighl intensities; the three types enable us fa see cobrs.