# Image Processing and Computer Vision

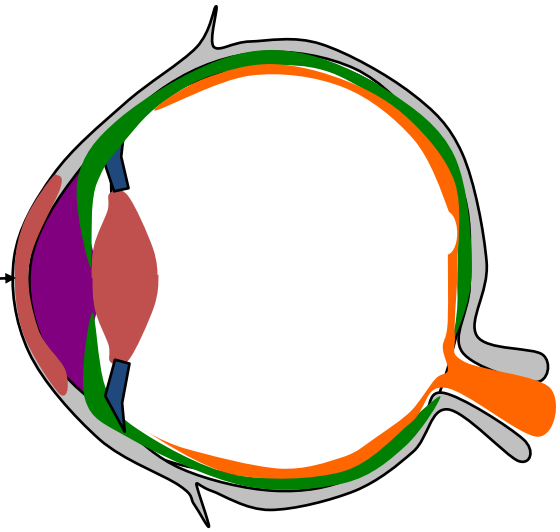
# Elements of Visual Perception

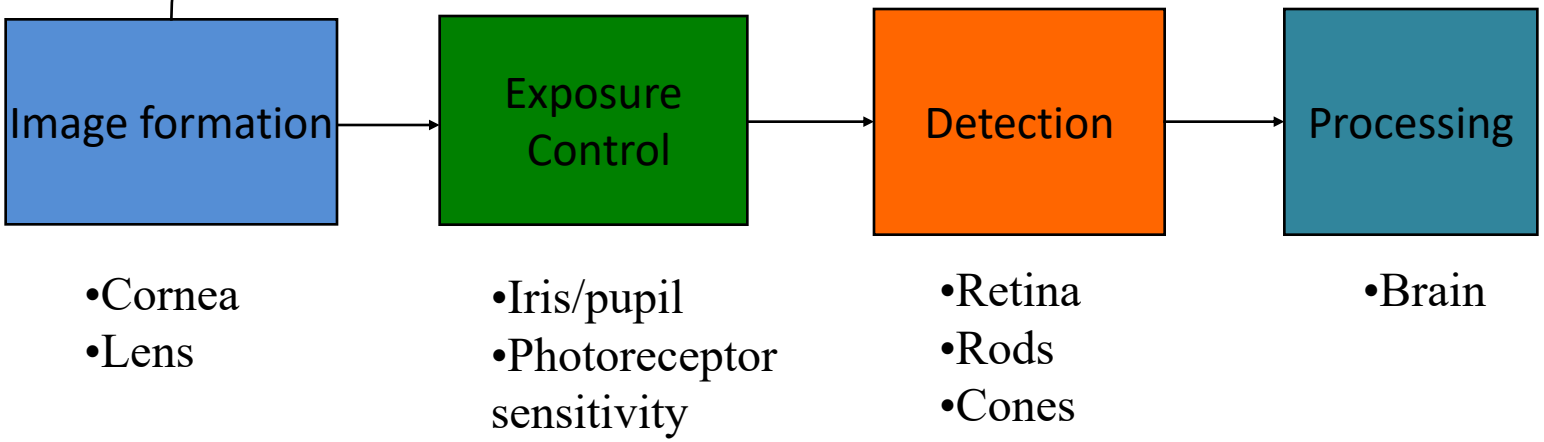
- The field of digital image processing is built on the foundation of mathematical and probabilistic formulation, but human intuition and analysis play the main role to make the selection between various techniques, and the choice or selection is basically made on subjective, visual judgments.

- In human visual perception, the eyes act as the sensor or camera, neurons act as the connecting cable and the brain acts as the processor. The basic elements of visual perceptions are:

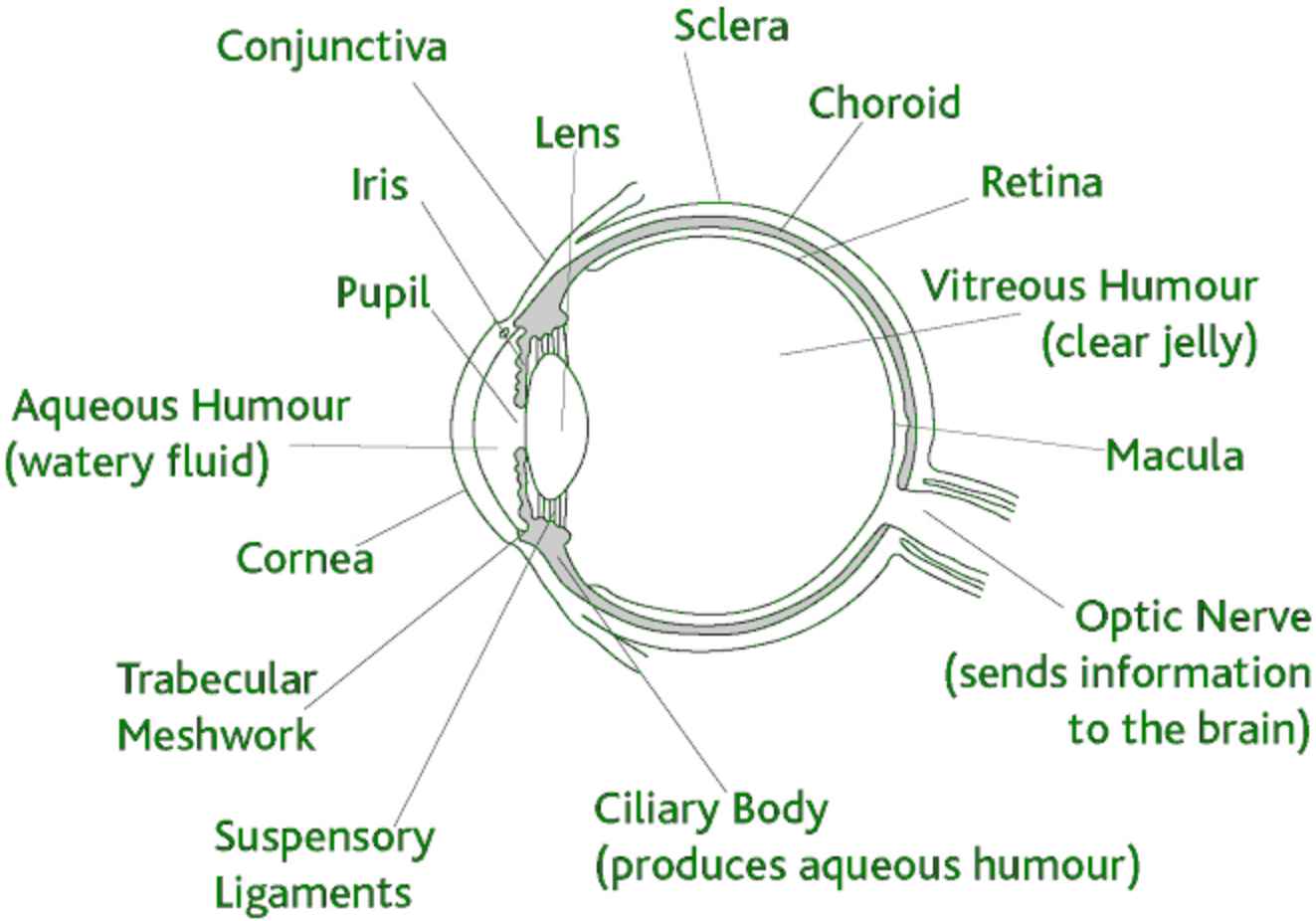
  - Structure of Eye
  - Image Formation in the Eye
  - Brightness Adaptation and Discrimination

# Human Visual System





# Structure of eye



# Structure of eye

- The human eye is a slightly asymmetrical sphere with an average diameter of the length of 20mm to 25mm.

- It has a volume of about 6.5cc. The eye is just like a camera. The external object is seen as the camera take the picture of any object.

- Light enters the eye through a small hole called the pupil, a black looking aperture having the quality of contraction of eye when exposed to bright light and is focused on the retina which is like a camera film.

- The lens, iris, and cornea are nourished by clear fluid, know as anterior chamber.
- The fluid flows from ciliary body to the pupil and is absorbed through the channels in the angle of the anterior chamber.

# Structure of eye

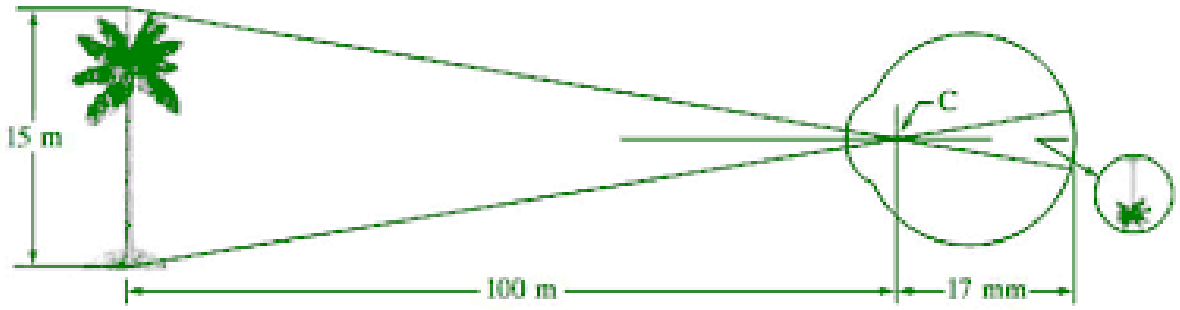
- The delicate balance of aqueous production and absorption controls pressure within the eye.

- Cones in eye number between 6 to 7 million which are highly sensitive to colors. Human visualizes the colored image in daylight due to these cones. The cone vision is also called as photopic or bright-light vision.

- Rods in the eye are much larger between 75 to 150 million and are distributed over the retinal surface.
- Rods are not involved in the color vision and are sensitive to low levels of illumination.

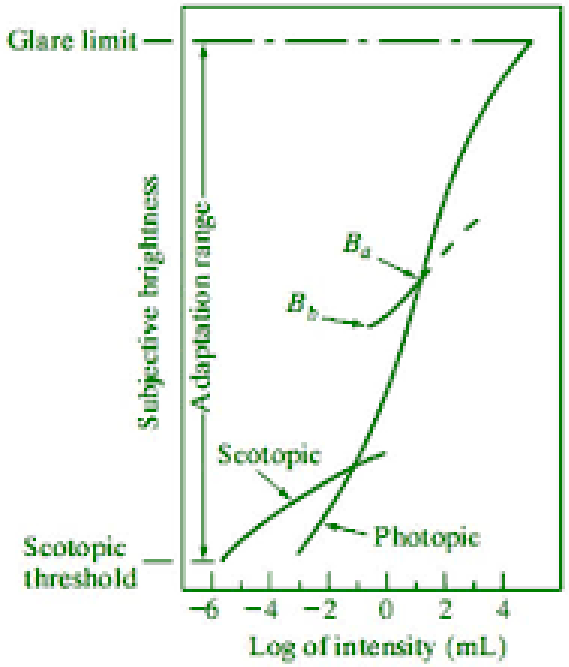
# Image Formation in the Eye

- When the lens of the eye focus an image of the outside world onto a light-sensitive membrane in the back of the eye, called retina the image is formed.
- The lens of the eye focuses light on the photoreceptive cells of the retina which detects the photons of light and responds by producing neural impulses.
- The distance between the lens and the retina is about 17mm and the focal length is approximately 14mm to 17mm.



# Brightness Adaptation and Discrimination

- Digital images are displayed as a discrete set of intensities.
- The eyes ability to discriminate black and white at different intensity levels is an important consideration in presenting image processing result.
- The range of light intensity levels to which the human visual system can adapt is of the order of $10^{10}$ from the scotopic threshold to the glare limit. In a photopic vision, the range is about $10^{6}$.



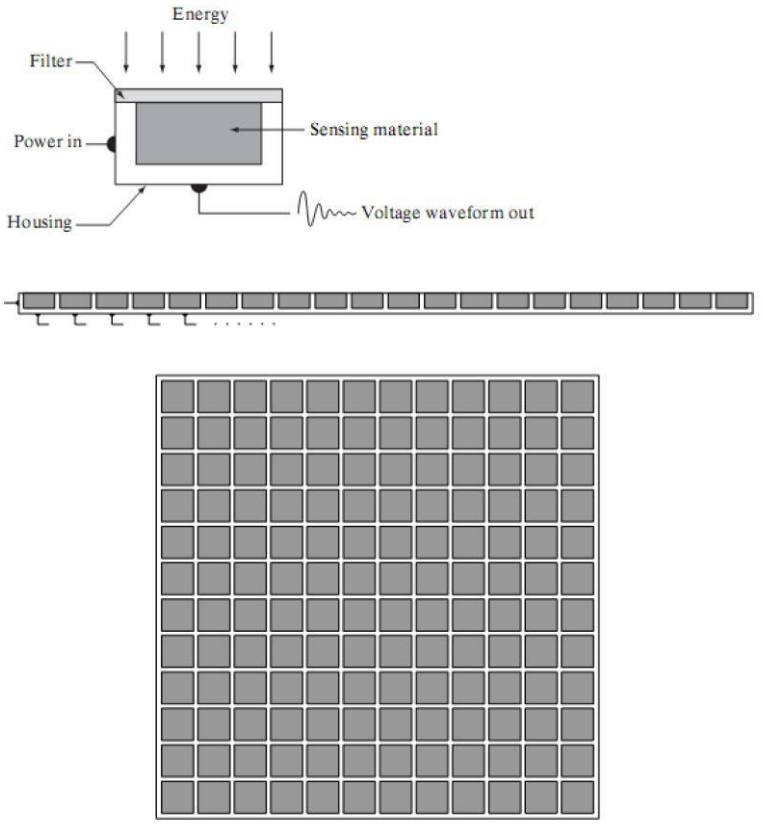
# Image Sensing and Acquisition

- There are 3 principal sensor arrangements (produce an electrical output proportional to light intensity).

(i)Single imaging Sensor

(ii)Line sensor

(iii)Array sensor



# Image Acquisition using a single sensor

- Example of a single sensor is a photodiode. Now to obtain a two-dimensional image using a single sensor, the motion should be in both x and y directions.
- Rotation provides motion in one direction.
- Linear motion provides motion in the perpendicular direction.
- This is an inexpensive method and we can obtain high-resolution images with high precision control. But the downside of this method is that it is slow.

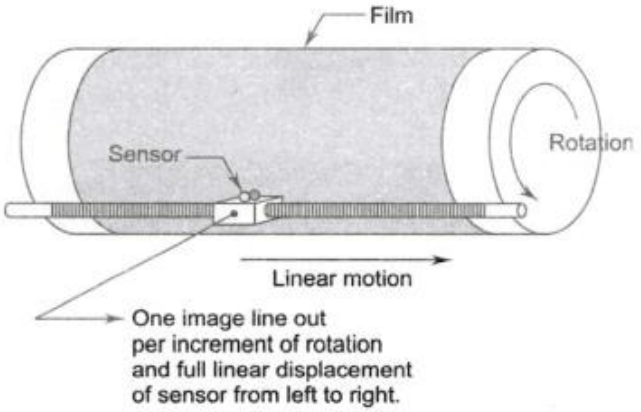



Fig: Combining a single sensor with motion to generate a 2D image

# Image Acquisition using a line sensor (sensor strips)

- The sensor strip provides imaging in one direction.
- Motion perpendicular to the strip provides imaging in other direction.

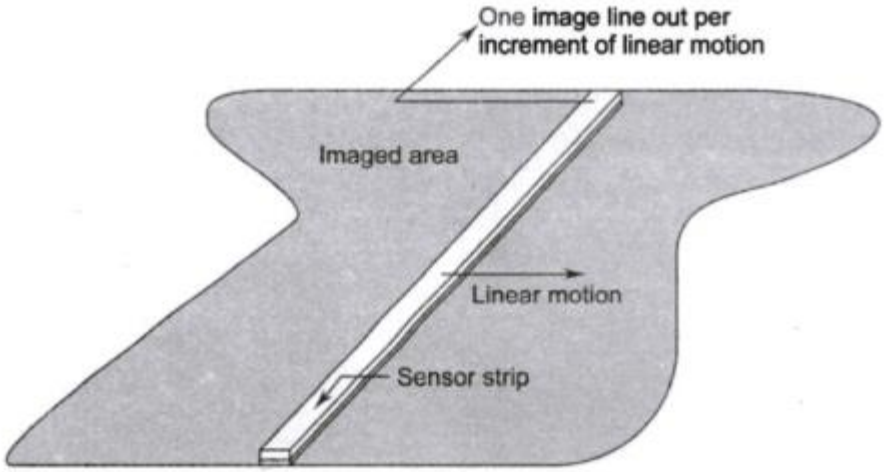



Fig: Linear sensor strip

# Image Acquisition using an array sensor

- In this, individual sensors are arranged in the form of a 2-D array. This type of arrangement is found in digital cameras. e.g. CCD array
- In this, the response of each sensor is proportional to the integral of the light energy projected onto the surface of the sensor. Noise reduction is achieved by letting the sensor integrate the input light signal over minutes or ever hours.
- Advantage: Since sensor array is 2D, a complete image can be obtained by focusing the energy pattern onto the surface of the array.
- The sensor array is coincident with the focal plane, it produces an output proportional to the integral of light received at each sensor.
- Digital and analog circuitry sweep these outputs and convert them to a video signal which is then digitized by another section of the imaging system. The output is a digital image.

# Image Acquisition using an array sensor

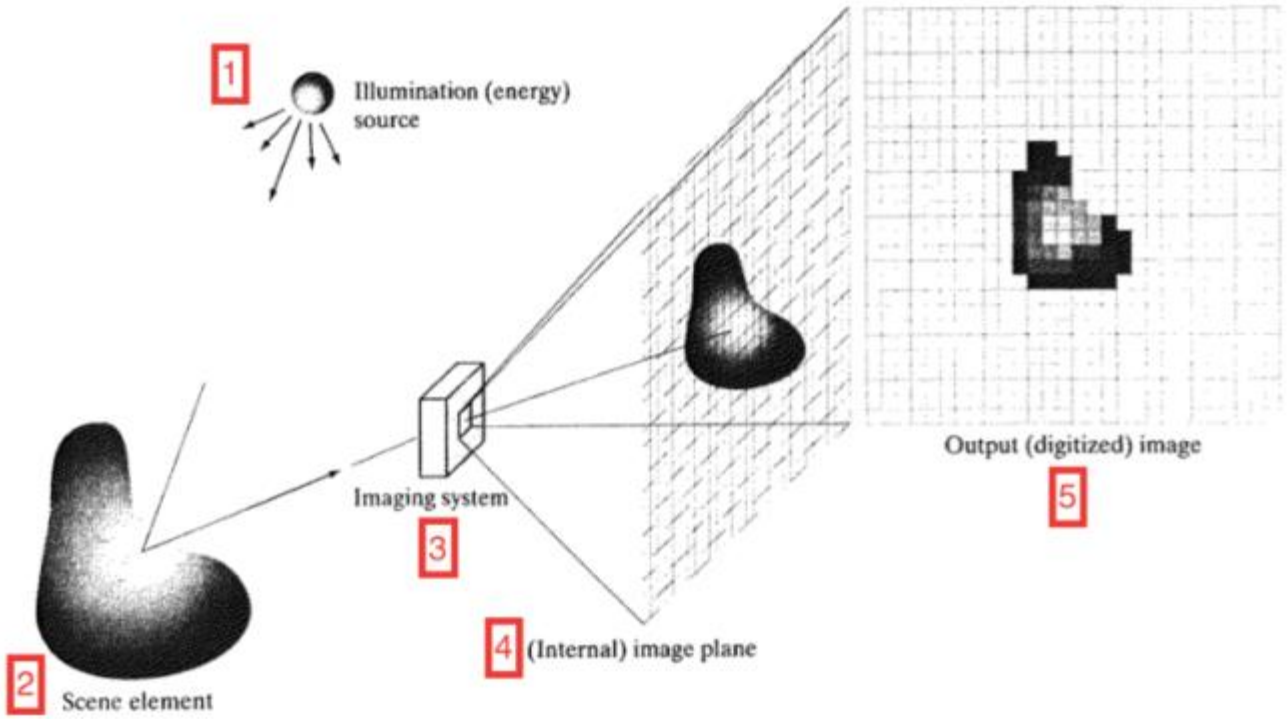



Fig: An example of digital image acquisition using array sensor