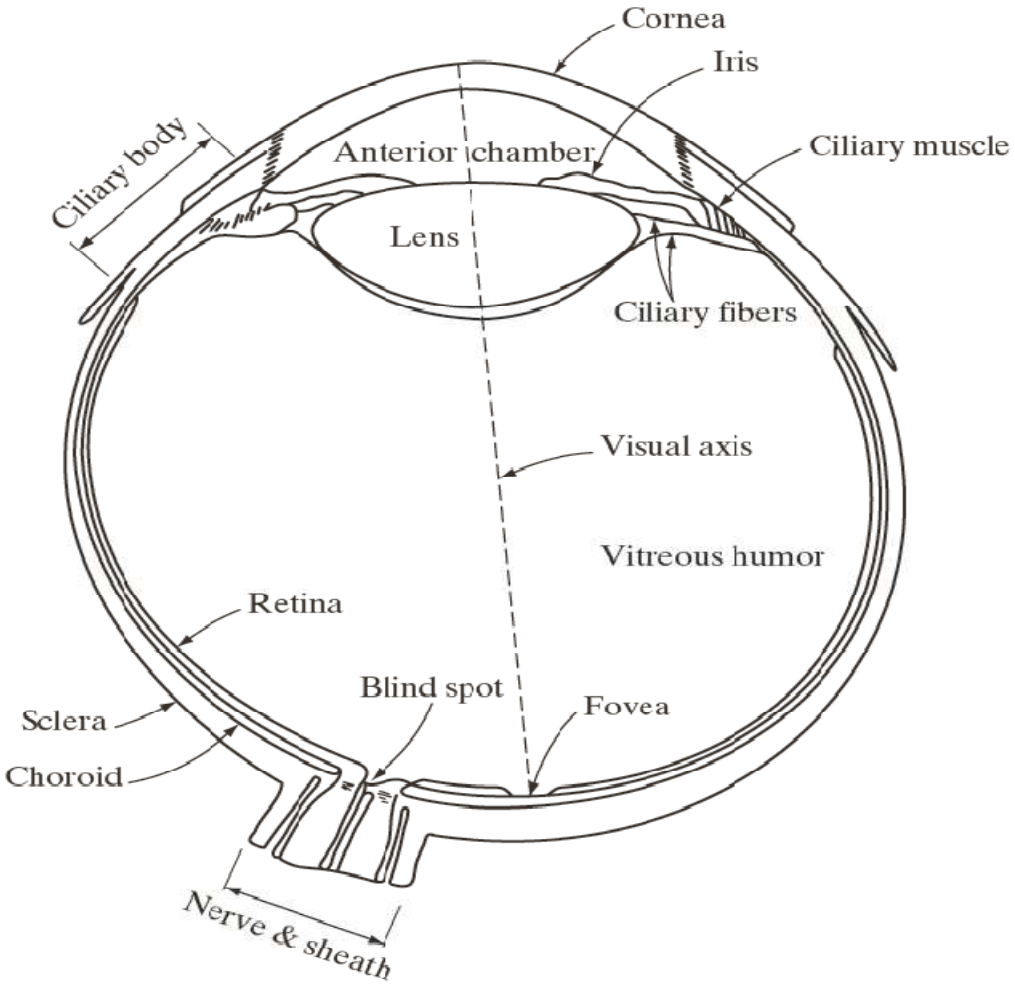
ELEMENTS OF VISUAL PERCEPTION

OVERVIEW

- **Structure of the human eye**
- **Image formation in the eye**
- **Brightness adaptation and discrimination**
- **Mach band effect and Simultaneous contrast**
- **Optical illusion**

STRUCTURE OF THE HUMAN EYE



STRUCTURE OF THE HUMAN EYE

Digital images are processed for enhanced visual perception by humans. It is important to understand how humans perceive images.

- The eye nearly sphere in shape
  - Measures diameter of 20 mm
  - Three membranes enclose the eye
    - Cornea and sclera (outer cover)
    - Choroid
    - Retina

STRUCTURE OF THE HUMAN EYE

- **Cornea**:
  - The anterior of the eye has the outer coating called cornea
  - The cornea is a transparent, curved, refractive window through which the light enters the eye.
  - It connects to larger portion, sclera which covers the posterior portion of the optic globe
  - Cornea and Sclera are connected by a ring called the limbus.

STRUCTURE OF THE HUMAN EYE

Choroid :

- Beneath the sclera is a membrane called choroid.
- Contains blood vessels to nourish the cells in the eye.
- Heavly pigmented and helps reducing the amount of light entering the eye from any other direction other than the pupil.
- Anterior exterme of the chorid divides into ciliary body and Iris diaphragm.

Iris:

- Contracts and expands to control the amount of light that enters the eye.
- Front of the iris contains the visible pigment whereas back contains a black pigment.

STRUCTURE OF THE HUMAN EYE

Pupil:

- It is the opening at the center of the iris.
- Its diameter varies from 1 to 8 mm in response to illumination changes.
- In low light conditions it dilates to increase the amount of light reaching the retina.
- Behind the pupil is the lens of the eye.

Lens:

- Made of concentric layers of fibrous cells, suspended by fibers attaching the ciliary body
- Contains 60 – 70% water, 6% fat and more protein
- Colored by yellow pigmentation and increases with age
- Lens absorbs 8% of visible light spectrum

STRUCTURE OF THE HUMAN EYE

- Retina:
  - The innermost membrane of the eye where the light entering the eye is sensed by the receptor cells.
  - The retina has 2 types of photoreceptor cells- rods and cones.
  - Retina helps in formation of image
- Cones:
  - There are about 6 million cones in the eye.
  - The cones help in the bright-light (photopic) vision, highly sensitive to color.
  - Located primarily in the fovea (center portion of retina) where the image is focused by the lens.
  - Each cone cell is connected to its separate nerve ending and have the the ability to resolve fine details.

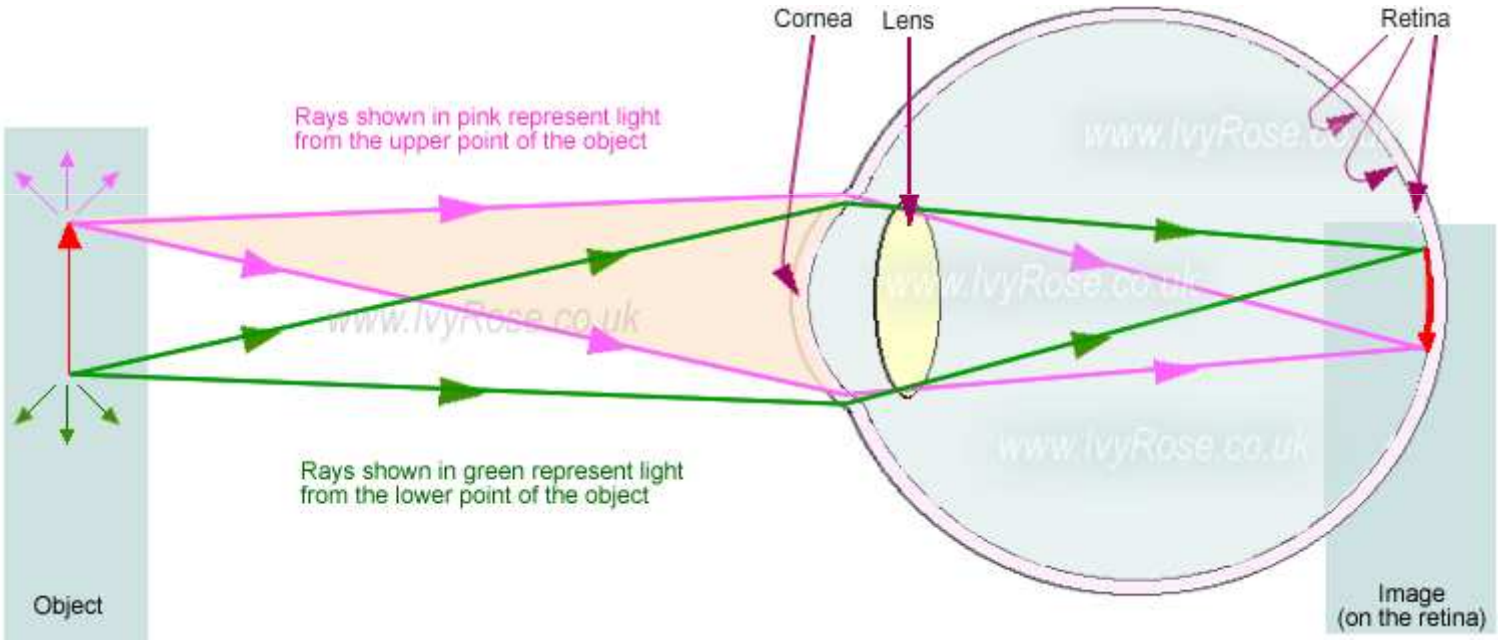
STRUCTURE OF THE HUMAN EYE

- **Rods:**
  - 100 million rods in the eye.
  - Helps in the dim-light (scotopic) vision.
  - They are distributed over a larger area in the retina.
  - Not involved in color vision.
  - Cannot resolve fine spatial detail because many rods are connected to a single nerve.
- **Blind spot:**
  - Though the photo-receptors are distributed in radially symmetric manner about the fovea,
  - Region near the fovea where there are no receptors. This region is called as the blind spot.
  - This is the region where the optic nerve emerges from the eye.
  - Light falling on this region cannot be sensed.

STRUCTURE OF THE HUMAN EYE

- Eye lens is flexible
- Radius of curvature at the anterior surface is greater than the posterior
- The shape is controlled by the tension in the fibers of the ciliary body
- Lens become thicker to view objects near the eye and flattened to view the farthest.
- Focal length varies from 17mm to 14mm
- Farthest – less refractive
- Closest – strongly refractive

IMAGE FORMATION



BRIGHTNESS ADAPTATION AND DISCRIMINATION

- Digital images are displayed as a discrete set of intensities, the eye's ability to discriminate these variations matters .
- The range of light intensity levels for which the human eye can adapt is around 10^{10} from scotopic to glare limit.
- The total range of distinct intensity levels it can discriminate simultaneously is small when compared to total adaption range.
- The sensitivity level for a given lighting condition is called as the **brightness adaption level.**
- The response of the visual system can be characterized with respect to a particular brightness adaption level.

BRIGHTNESS ADAPTATION AND DISCRIMINATION

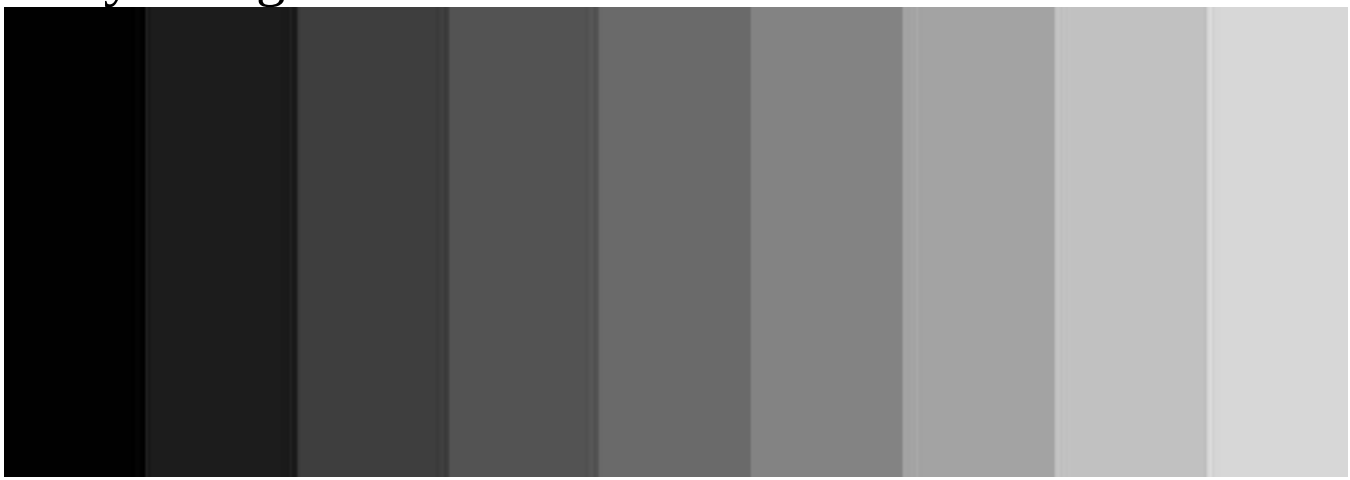
- The ability of eye to discriminate between changes in light intensity at any specific adaptation level is brightness discrimination
- The discriminability of the eye also changes with the brightness adaption level.
- If the background illumination I is less, the ability of the eye to discriminate a small change in intensity is less.
- Larger increment in intensity ΔI is required for the eyes to be able to discern it if the ambiance illumination I is low.
- However if the background illumination is at a higher level, the eye has a better discrimination, i.e. a smaller ΔI is required for the eyes to discern it.

BRIGHTNESS ADAPTATION AND DISCRIMINATION

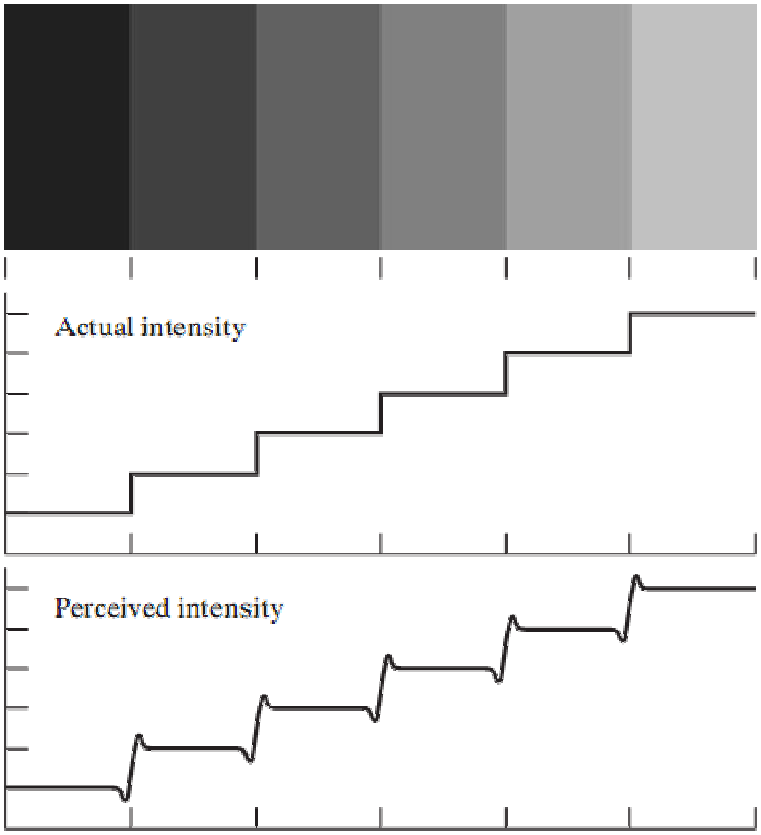
- The ratio $\triangle I/I$ is called as the Weber ratio.
- Smaller value of the Weber ratio has better discrimination at that brightness adaptation level
- Larger value of the Weber ratio –> poor discrimination
- This leads to interesting phenomena like Mach band effect and Simultaneous contrast.
- This two phenomenon demonstrates the preceived brightness is not a simple function of intensity

Mach Band Effect

- Mach bands is an optical illusion named after the physicist Ernst Mach.
- It exaggerates the contrast between edges of the slightly differing shades of gray, as soon as they contact one another, by triggering edge-detection in the human visual system.
- Although the intensity of the stripes is constant, we actually perceive a brightness pattern that is strongly near the boundaries.
- The visual system tends to undershoot or overshoot around the boundary of regions of different intensities.



Mach Band Effect

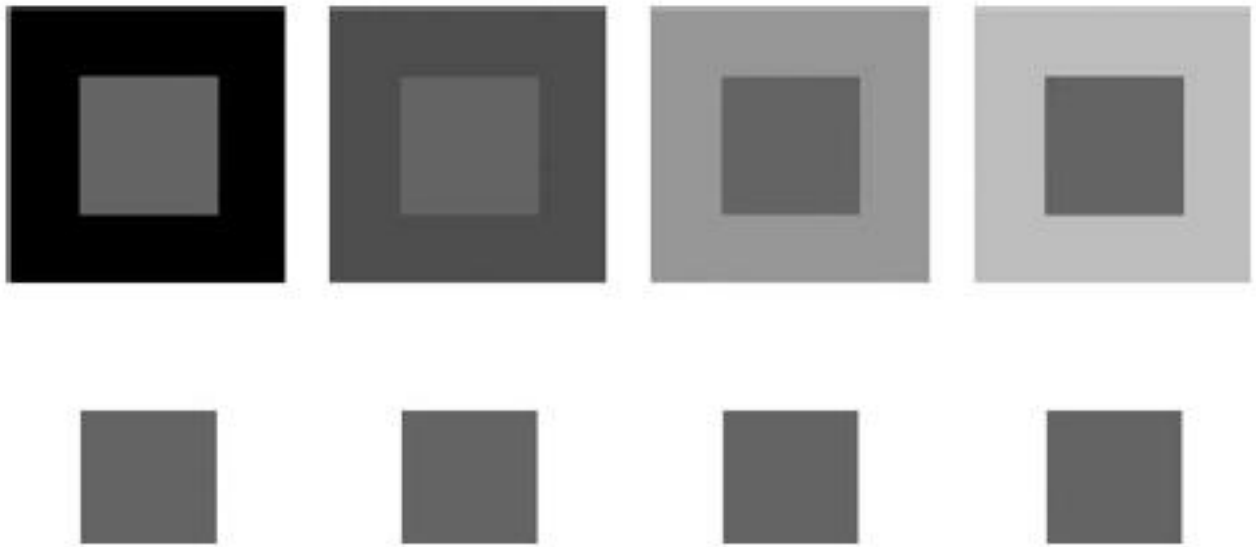


perceived Intensity is not a simple function of actual intensity.

Simultaneous contrast

A region's perceived brightness does not depend simply on its intensity.

They appear to the eye to become darker as the background gets lighter.



Optical Illusions