Introduction to Image Processing

Lecture 1
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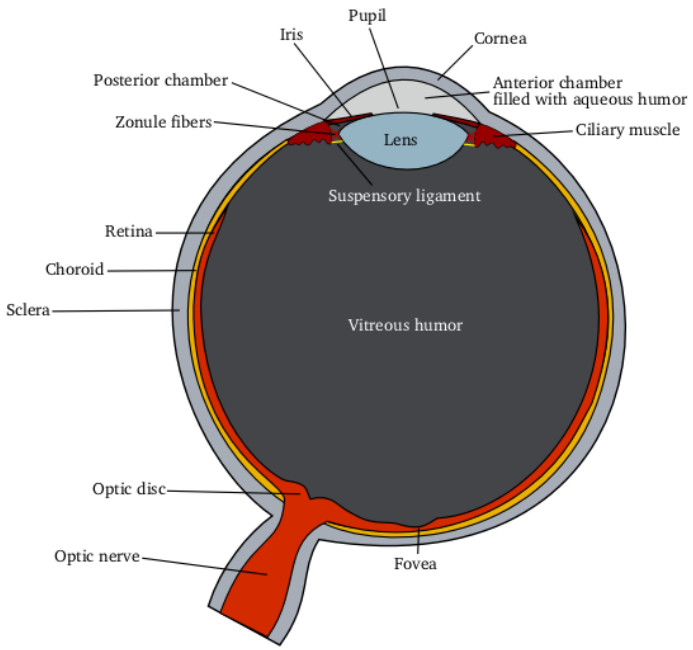
1. Human Vision
    - Human eye
    - Image formation in the eye
    - Brightness adaptation & discrimination

Human Vision
Human eye

From the eye to a camera

Choroid

- Composed of blood vessels serving as source of nutrition
- Avoid the entrance of external light or backscatter
- See relation with physics experiments

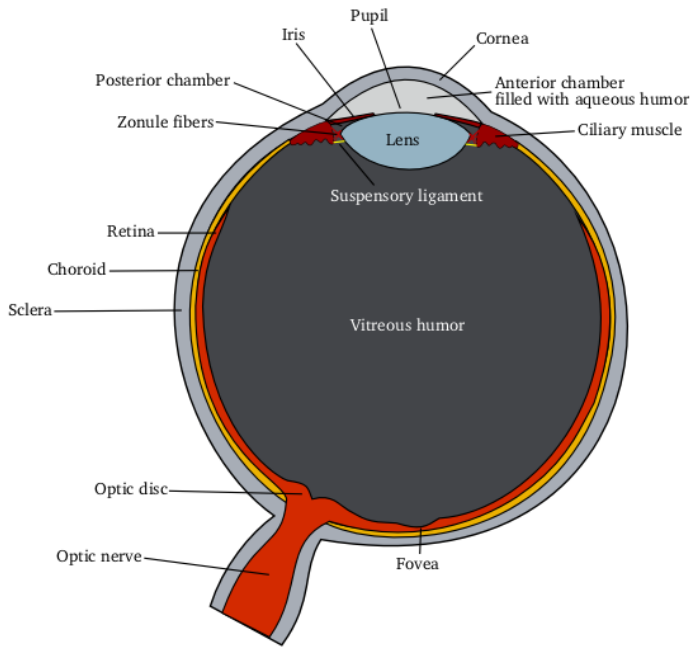


Human Vision
Human eye

From the eye to a camera

Ciliary body & iris

- Control the amount of light (2 mm to 8 mm)
- Relation with the camera aperture

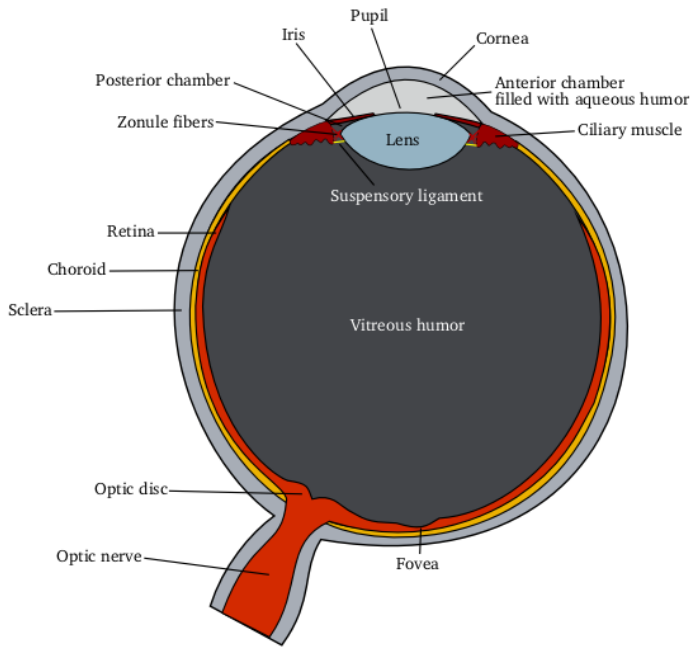


Human Vision
Human eye

From the eye to a camera

Lens

- Made of fibrous cells and attached to ciliary body
- Absorb 8 % of visible light and all the IR and UV
- Cataract diseases
- Idem to an optical lens

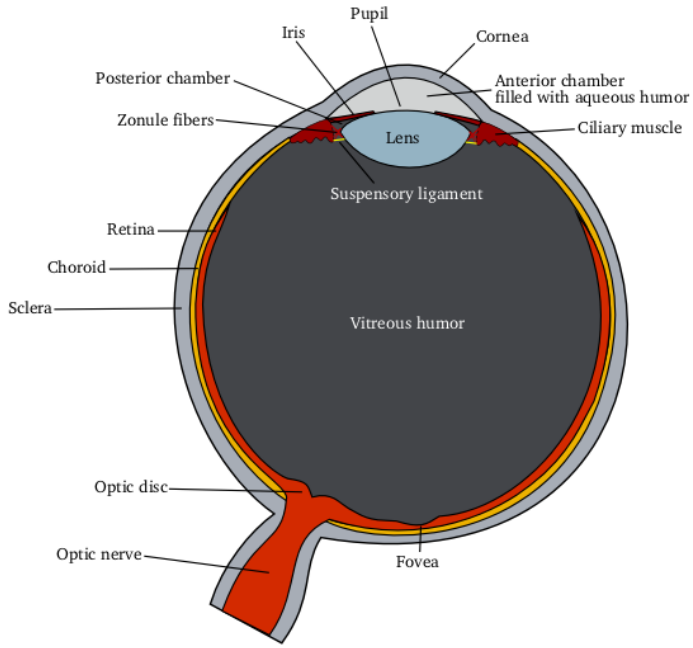


Human Vision
Human eye

From the eye to a camera

Retina

- Contains 2 types of discrete light receptors: the cones and the rods
- Myopia & hyperopia

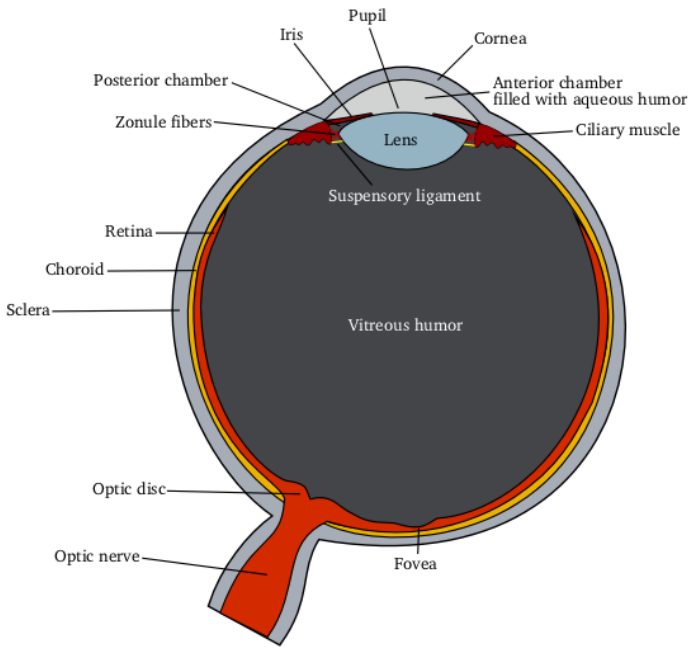


Human Vision
Human eye

From the eye to a camera

Cones

- Account for about 6 to 7 million per eye
- Are sensitive to color and details
- Each one connected to a single nerve end
- Cone vision is called *photopic* and is sensitive to high levels of illumination
- Similar to a high frequency receptor

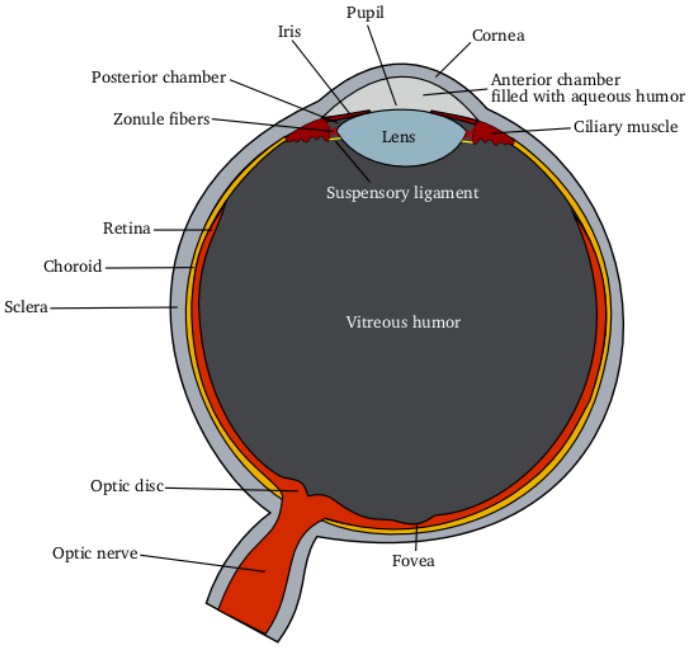


Human Vision
Human eye

From the eye to a camera

Rods

- Account for 75 to 150 millions per eye
- Not involved in color
- Give a general and overall picture of the FOV
- Several rods connected to a single nerve end
- Sensitive to low levels of illuminations: *scotopic*
- Similar to a low frequency receptor

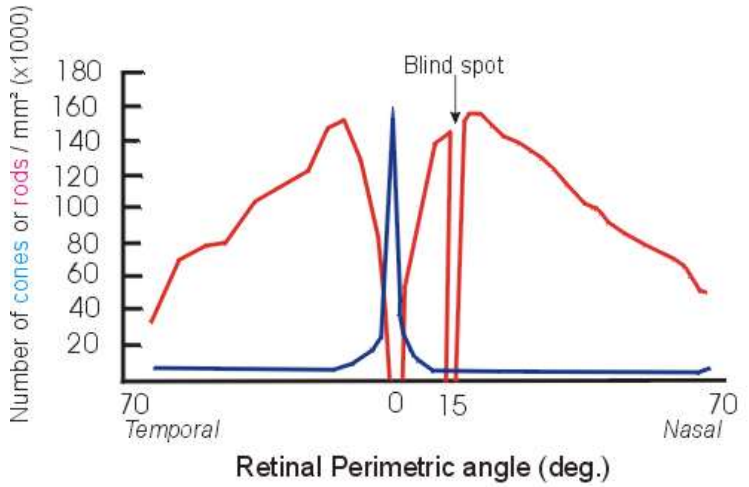


Human Vision
Human eye

From the eye to a camera

Cones & Rods

- Symmetrically distributed
- Note the presence of the blind spot



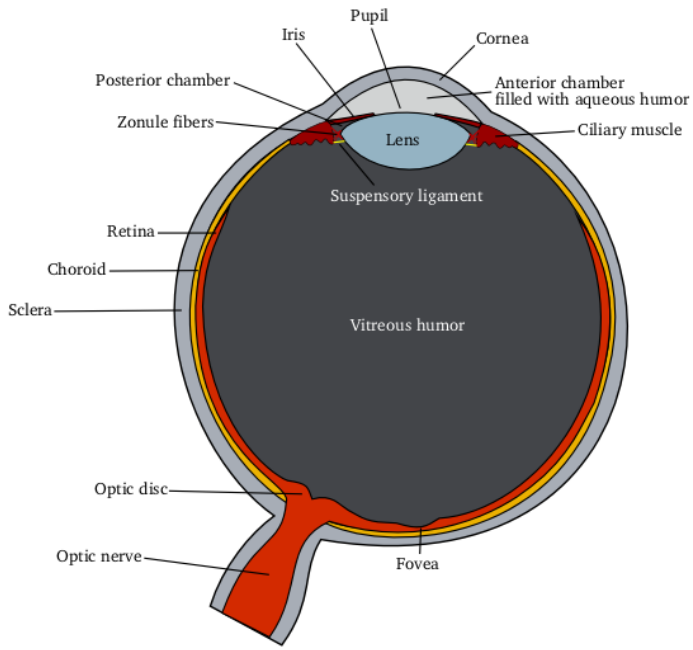
Adapted after Østerberg, 1935

Human Vision
Human eye

From the eye to a camera

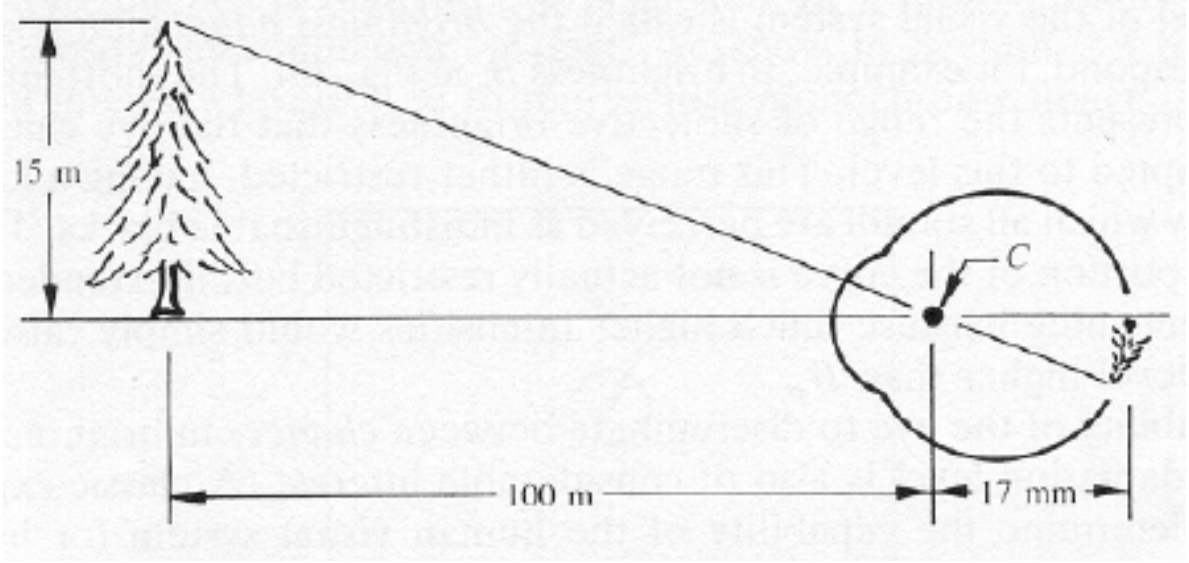
Fovea

- Localisation of the cones in this area
- 1.5 mm $\times$ 1.5 mm
- 150,000 elts/mm^2 to 337,000 elts/mm^2
- CCD imaging ship would need a 5 mm $\times$ 5 mm to achieve similar density



Human Vision
Image formation in the eye

Example

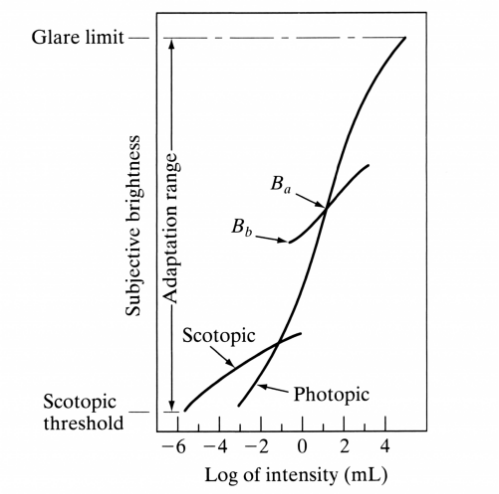


- Focal length varies from 17 mm to 14 mm
- Perception takes place by the relative excitation of light receptors.
- The receptors transform this energy to electrical impulses

Human Vision
Brightness adaptation & discrimination

Human visual system

- The human vision system (HVS) can adapt to 10^{10} light intensity levels
- Subjective brightness is a logarithmic function of the light intensity incident on the eye



- The HVS cannot operate over such a range simultaneously
- For a given set of conditions, the current sensitivity level is called *brightness adaptation level*

Human Vision
Brightness adaptation & discrimination

Human visual system

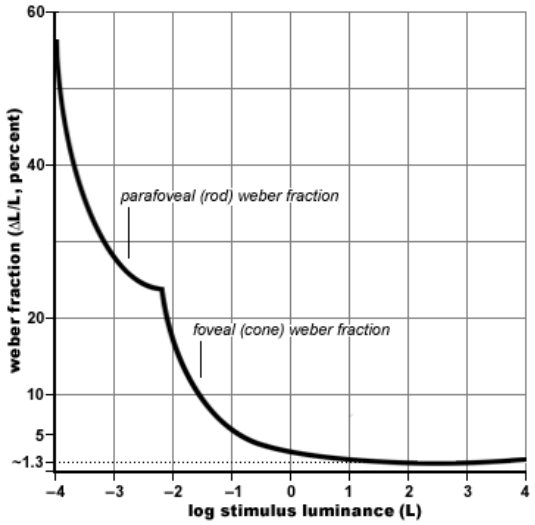
- The eye also discriminates between changes in brightness at any specific adaption level
- This is characterised by the Weber ratio

$$\frac{\Delta I_c}{I}, \tag{1}$$

where ΔI_c is the increment of illumination discriminable 50 % of the time and I is the background illumination

Human Vision
Brightness adaptation & discrimination

Human visual system



- Small values of Weber ration mean good brightness discrimination and vice versa
- At low levels of illumination brightness discrimination is poor (rods)
- It improves significantly as background illumination increases (cones)
- The typical observer can discern one to two dozen different intensity changes

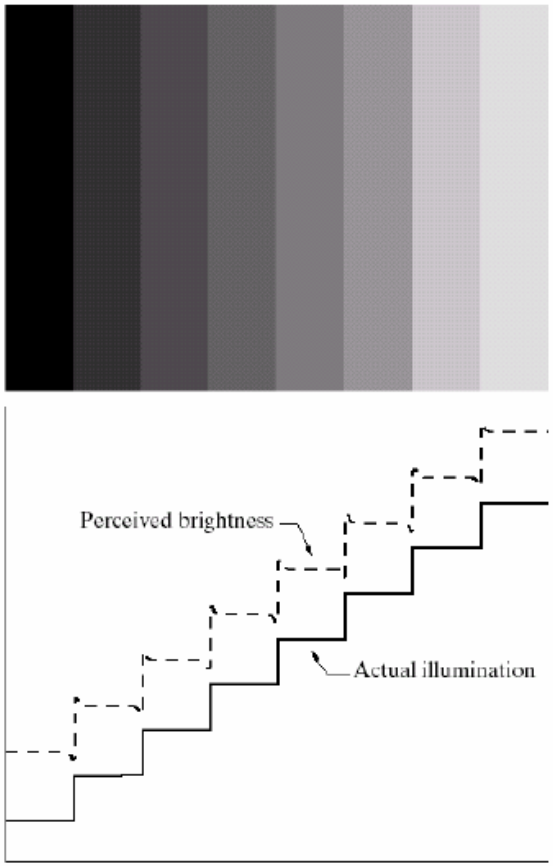
Human Vision
Brightness adaptation & discrimination

Human visual system

- Overall intensity discrimination is broad due to different set of incremental changes to be detected at each new adaptation level
- Perceived brightness is not a simple function of intensity: Mach band effect, simultaneously contrast, and optical effect

Human Vision
Brightness adaptation & discrimination

Mach band effect



Human Vision
Brightness adaptation & discrimination

Simultaneously contrast

Human Vision
Brightness adaptation & discrimination

Optical effect