In This Lecture

- Elements of visual perception
- Mechanics of the human visual system
- Structure of the eye
- Image formation in the eye
- Brightness adaptation and discrimination

Elements of Visual Perception

Structure of the Human Eye

- Lens focuses light on to photoreceptive area (retina)
- Photoreceptors convert light into electrical impulses that are decoded by brain

Photoreceptors

- Rods & Cones
  - Convert light into nerve signal that is transmitted to the brain via the optic nerve.
  - Rods – Dim light vision – SCOTOPIC vision
  - Cones – Bright light vision – PHOTOPIC vision

- Distribution of receptors across retina
- 200,000 cones mm$^2$ at fovea
- Size?
**Photoreceptors**

- **Rods**
  - One type

- **Cones**
  - Three types
    - Red (R)
    - Green (G)
    - Blue (B)

**Image Formation in the Eye**

- Lens in the eye is flexible
- Shape controlled by muscles
- To focus on distance objects
  - Muscles flatten lens
- To focus on close objects
  - Muscles allow lens to thicken

**Image Formation in the Eye**

- Centre of lens to retina is called *focal length*
- Varies from 17mm to 14mm
- Refractive power min to max
- Lowest refractive power when focusing on objects further than 3m
- Highest refractive power when focusing on near objects

- Calculate the height of the image on the retina
- Calculate the image size of the Eiffel Tower on the retina
- Calculate smallest resolvable separation at 100m

**Range of Human Vision**

- Visual system can adapt to an enormous range
- Can’t operate over range simultaneously
- Accomplished by changing sensitivity
- Brightness adaptation

**Subjective Brightness**

- Perceived Intensity
- Logarithmic function of light received by eye

**Light Intensity vs Subjective brightness**

- Glass limit
- Scotopic
- Photopic
- Scotopic threshold
- Log of intensity (mcd)
Brightness Adaptation

- Range of brightnesses that can be discriminated simultaneously is small in comparison to total adaptation range.
- For a given set of conditions the current sensitivity level of the visual system is called the brightness adaptation level.

Bright Discrimination

- Digital Images are displayed as a discrete set of intensities.
- Eyes ability to discriminate intensities at a given adaptation level is an important consideration when displaying images.

Bright Discrimination

**Classic Experiment**
- **Weber Ratio:** $\Delta I/I$
- $\Delta I$ is the incremental illumination discriminable 50% of the time.
- Small Weber Ratio represents “good” brightness discrimination.

Bright Discrimination

**Plot**
- Log of $\Delta I/I$ as a function of log($I$)
- Constant $\Delta I$, Vary $I$
- Discrimination is “poor” at low light levels
- Discrimination is “good” at high light levels

Bright Discrimination

- If background is held constant & brightness of flashing spot is varied
- $\Delta I$ varied incrementally from never perceived to always perceived
- Typical observer can distinguish 12 – 24 intensity changes
- Related to number of intensities a person can see a point in monochrome image
- Does not mean that an image can be represented with such as small number of intensities...

Bright Discrimination

- Two phenomena clearly demonstrate that perceived brightness is NOT a simple function of intensity...
First Phenomenon

- Visual system tends to under or over shoot around the boundary of two regions of different intensity
- Mach Bands

Second Phenomenon

- Simultaneous Contrast

Summary

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- Mechanics of the human visual system
- Structure of the eye
- Image formation in the eye
- Brightness adaptation and discrimination