Theories of Perception

Dr Pradipta Biswas, PhD (Cantab)
Assistant Professor
Indian Institute of Science
https://cambum.net/
Vision
Same stimuli – Different Perception
Eye

- pupil
- cornea
- lens
- fovea
- optic nerve
- photoreceptors
- retina
- optic nerve fibers
Human Eye

- FoV, both eyes combined 200-220°
- Peak visual acuity 0.5-1°
- Fovea 1-2°
- Head movement range approximately 50°
- Ratio of maximum to minimum perceivable light intensity is $10^{10}$
Principle of Vision

◊ Top down theory: You perceive what you want to

◊ Bottom up theory: You decompose & reconstruct

◊ Visual Search
  ◊ Serial (search time \(\propto\) number of items)
  ◊ Parallel (pop out effect)
Recording from an eye tracker
Visual Cortex

- Visual Pathway
  - Where and What Pathway
  - M and P pathway
- V1 – Primary visual cortex
  - Feature extraction
  - Colour and orientation feature
  - Mapping of retina on surface of cortex
- V2 region
  - Visual orientation map
  - Colour map
  - Disparity map
- V4 region
  - Colour recognition
  - Object discrimination
- V3 and V5 regions
- Motion
- Stereoscopic vision
- Visual guidance and scanning
Modelling Vision

Spotlight metaphor of attention

1. Feature Extraction
2. Probable points of attention fixation
3. Trajectory of eye movement
Points of fixation

- Colour histogram coefficient
- Shape context coefficient

Neural Network

Points of fixation
Simulation Result

Visual Search Time

Eye Gaze Movement
Icon design

Right hand side icons are more distinctive, but not necessarily ‘better’
Types of Eye Gaze Movement

- Saccades
- Smooth Pursuits
- Vergance
Eye Movement Strategies

- Points of fixation
- Nearest
- Cluster
- Cluster Centre
Eye movement in interfaces

Eye gaze needs to move more distance on right hand side interface but again it does not mean the LHS interface is better.
Cone spectral sensitivities
Distribution of Colour Sensitive Cells

We have less Blue photoreceptors than Red or Green ones

Blue cones are organized away from the fovea
Colour in computers and printers
## Colour blindness

<table>
<thead>
<tr>
<th>Original Image</th>
<th>Protanopia</th>
<th>Deuteranopia</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ishihara test</strong></td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
</tr>
<tr>
<td><strong>Plate 16</strong></td>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
</tr>
</tbody>
</table>

| | ![Image](image5.png) | ![Image](image6.png) |
| | ![Image](image7.png) | ![Image](image8.png) |

| **Plate 17** | ![Image](image9.png) | ![Image](image10.png) |
| | ![Image](image11.png) | ![Image](image12.png) |
Main challenges in modelling vision

- Modelling for complex scenes
- Developing eye-movement strategy
- Modelling prior knowledge
## Visual Angle Calculation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Icon</th>
<th>Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimal visual angle (x)</td>
<td>1.433 degrees</td>
<td>0.333 degrees</td>
</tr>
<tr>
<td>Tan(x)</td>
<td>0.025</td>
<td>0.0058</td>
</tr>
<tr>
<td>Symbol Height (H)</td>
<td>$D \times \tan(x) = 120 \times 0.025 = 3 \text{ cm} = 1.18 \text{ in}$</td>
<td>$D \times \tan(x) = 120 \times 0.0058 = 0.7 \text{ cm} = 0.275 \text{ in}$</td>
</tr>
<tr>
<td>Symbol height (H)</td>
<td>320.4 px</td>
<td>72.09 px</td>
</tr>
</tbody>
</table>

### Definitions of Variables Used in the Equations

- $H =$ Symbol height in millimeters
- $D =$ Viewing distance in meters (0.5–1.1 m)
- $V =$ Visual angle subtended in arcminutes
Designers’ points

- Keep similar interface items together

- Use distinctive symbols but keeping in mind consistency

- Remember how a colour will be rendered, considering colour blind users

- Remember top down theory, means users’ expectation from an interface
Hearing
Hearing impaired users

- Difficult to listen soft sound
- Loud sound may seem louder (Loudness recruitment)
- Reduced response to spectral contrast (like blurring of an image)
Hearing impairment examples
Designers’ points

- Increasing volume cannot solve the problem

- Background noise and music may reduce audibility

- Certain words or syllabi have higher chances to be confused, which should be taken care of during designing audio based dialog system
Take away points

✧ Principles of vision and hearing

✧ Modelling visual perception
  ✧ Visual search → Icon design
  ✧ Eye movement strategies → Screen layout
  ✧ Colour vision → Colour contrast of interface

✧ Auditory perception
  ✧ Issues with loudness recruitment