The Eye

Eyes are the organs of vision and people obtain about 80% of their information from vision. Eyes react to light and convert it into electrochemical impulses. Rod and cone cells in the retina allow conscious light perception and vision along with color differentiation.

The eye is a fused two piece unit. The small frontal unit is known as the cornea which is attached to the larger white unit sclera. The iris is the colored circular structure concentrically surrounding the center of the eye, the pupil, which appears to be black. The size of the pupil, which controls the amount of light entering the eye, is adjusted by the iris. Light falling on the light-sensitive cells of the retina is converted into electrical signals that are carried to the brain by the optic nerves.

Fovea Centralis

The fovea is composed of closely packed cones in the eye. The fovea is responsible for sharp central vision also known as foveal vision. It comprises less than 1% retinal size but takes up over 50% of the visual cortex in the brain.

The fovea sees only central two degrees of the visual field. Approximately half of the nerve fibers in the optic nerve carry information from the fovea, while the remaining half carry information from the rest of the retina.

Figure 1: Labelled diagram of the human eye

Figure 2: The figure depicts the foveal vision field with an angle of 2 degrees
Visual Stimulus

Frequency and intensity are the physical properties of light. Frequency helps in the perception of color of light. The visible spectrum is the portion of electromagnetic spectrum that is visible to the human eye. A typical human eye will respond to wavelengths from about 390 to 700 nm.

![Visible Spectrum Diagram](image)

*Figure 3: The figure depicts the visible spectrum which is a part of the electromagnetic spectrum.*

Eye Movements

Eye movements are voluntary and involuntary movements that help the eye in acquiring and fixating on visual stimuli. Fixations and saccades are two kinds of eye movements.

- **Fixations**
  Fixation is maintaining visual gaze on a single location. They may be long or short but typically last for least 200 nanoseconds.

- **Saccades**
  A saccade is a quick simultaneous movement of both eyes. It involves rapid repositioning of the eye to fixate on a new location. These are relatively quick and last for about 120 nanoseconds.
Yarbus Eye Tracking Research

Alfred L. Yarbus was a Russian psychologist who studied eye movements. He recorded eye movements performed by people while looking at normal objects and scenes. Yarbus showed that the trajectories followed by the gaze depend on the task that the observer has to perform.

Scan Paths

Scan paths are visual depictions of saccades and fixations. Saccades are depicted as straight lines which show movement from one stimulus to another. Whereas fixations are depicted by circles where the diameter of the circle is directly proportional to the duration of fixation.

![Scan Path Image](image.png)

Figure 4. The image depicts scan path of a viewer viewing a webpage.

Eye Tracking Data

\[
(x_1,y_1,t_1) \rightarrow (x_2,y_2,t_2) \rightarrow (x_3,y_3,t_3)
\]

Figure 5. The figure shows a scan path to be analyzed

Eye tracking data analysis is divided into spatial and spatio–temporal analysis.

Spatial Analysis

In spatial analysis we are interested in the spatial spread of the image. The order is less important as compared to the spatial clustering.

Spatial analysis is further divided into Saliency maps and Grid based analysis.

Saliency Maps are like likelihood maps. These maps are evaluated in a bottom up manner from a region of low value to high value.
**Grid based analysis** involves analysis using a grid and looking for the area of interest inside the grid.

![Grid Based Analysis](image)

**Figure 6. The image shows a grid matrix to be analyzed**

**Spatio Temporal Analysis**

In spatio temporal analysis we arrange our scan paths in form of vectors and then analyze our scan paths. Input is taken in form of ordered vectors.