

Modern Trends in IT

Stereo Vision, Stereoscopy & Virtual Reality

Concepts and Terminology Overview



Intended Learning Outcomes

Following this lecture, you will be able to:

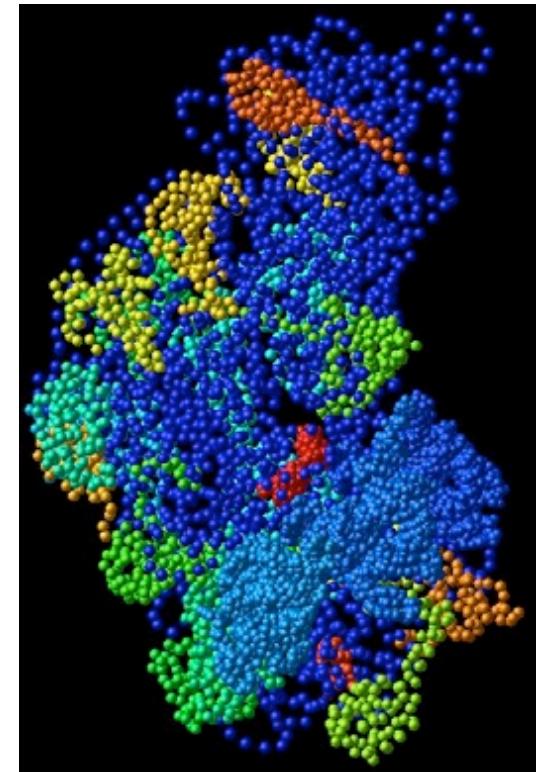
- ▶ Explain how the **Human Visual System** works.
- ▶ Explain the fundamental concepts of **Stereo Vision and Stereoscopy**.
- ▶ Experiment on the fundamental concepts of **Stereo Vision and Stereoscopy**.
- ▶ Explain foundation concepts in **Virtual Reality Technologies** and Experiment on them.

Lesson Overview

- ▶ How the **Human Visual System** works.
- ▶ fundamental concepts of **Stereo Vision** and **Stereoscopy**.
- ▶ foundation concepts in **Virtual Reality Technologies**.

Stereo Vision

- A large part of our brain is devoted to understanding visual cues.
- Depth information can help us to understand spatial relationships in a complex data set

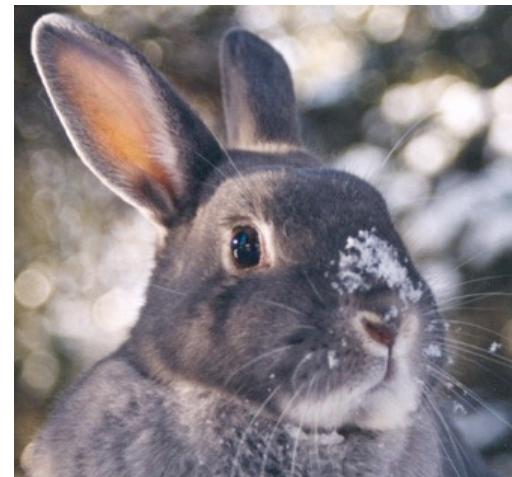


Binocular Vision

- Our two eyes produce a single image in the brain:
a “Cyclopean image”
- Creatures with binocular vision generally have
forward-facing eyes that move together

Binocular Vision

- Animals that tend to get chased find it useful to have a **panoramic** view of the world.
 - A rabbits have almost 360 field of vision
- Animals that do the chasing need to be able to judge distance to their prey accurately.
 - Predators tend to move fast, if they are inaccurate in distance estimates they will starve or injure themselves
- Tree apes need to be able to judge the distance to the next branch accurately.



IPD: (*Human*) Inter-Pupillary Distance

- Need separation between our eyes to see in stereo.
- Different sources provide different values for this number.
- **Mean adult IPD** is around **63 mm**.
- The **vast majority** of adults have IPDs in the range **50-75 mm**.
- The wider range of **45-80 mm** is likely to include (almost) all adults
- Minimum IPD for children (down to five years old) is around **40 mm**

Binocular Vision

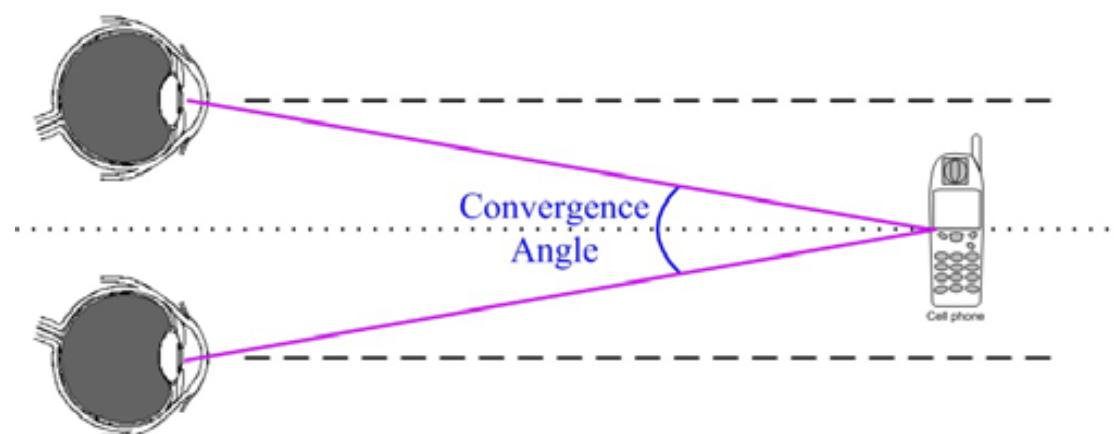
- Our eyes are separated by about 6.5 cm so our retinas each get a slightly different view of the world.
- The right actually sees more distance between the objects.
(as well as slightly different parts of the surfaces)



Binocular Vision

Components of Stereo Vision:

- **CONVERGENCE** of the eyes (achieved by the eye muscles)
- **ACCOMODATION** (focus) of the lens to provide sharp images on the retinas



Binocular Vision

The following table shows convergence angles for different distances given for 6.3 cm IPD.

Convergence Angle is Inversely Proportional to Stereo Effect.

Distance	Convergence Angle (deg)
10 cm	35.0
30 cm	12.0
60 cm	6.0
100 cm	3.6
200 cm	1.8
500 cm	0.72
1000 cm	0.36



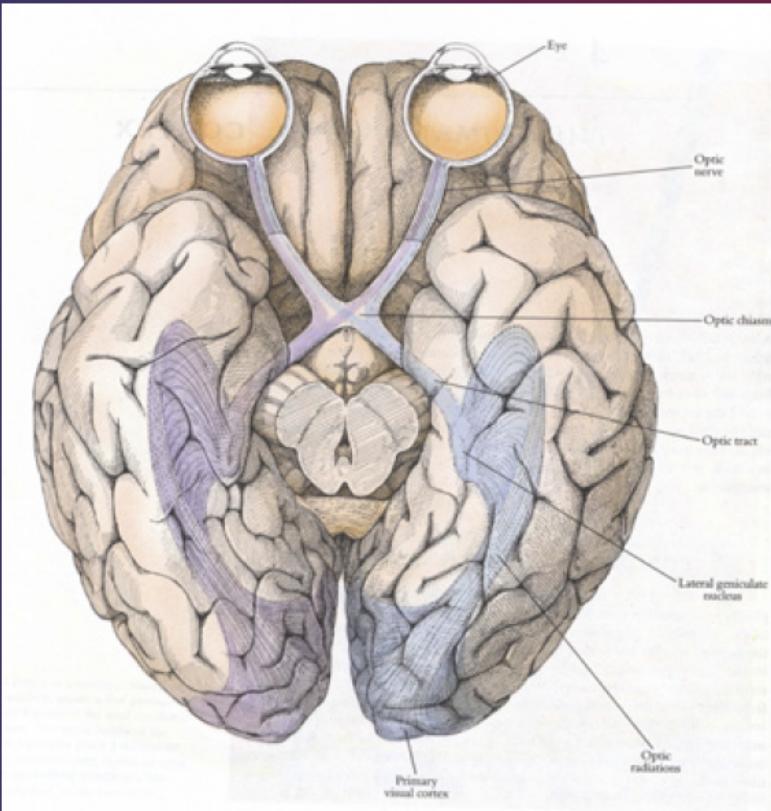
Seeing in 3D

- If retinal images are very different the eyes try to adjust to make them more similar.
- Once the brain has fused the images into one object, the small differences on the retina are interpreted as the **3rd Dimension**.
- Our brain interprets the two views as a scene with depth and does a great job of judging distances from us, up to about 20 feet. (diminishes but works up to ~200 m)

Seeing in 3D

Binocular Vision

- image from left eye is sent to the right half of the brain
- the brain deciphers retinal differences and interprets them as 3D information
- the interpretation can take time
- with practice the computations can go faster (they get “hardwired”)
- image from “Eye Brain and Vision” by David H. Hubel



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Non-Stereo Depth Cues

Monocular cues

Occlusion - near objects block the view of distant objects.

Apparent size - if two objects are actually the same size, but one appears smaller, then the small one is farther away than the larger.

Motion parallax - near objects appear move faster than distant objects.

Perspective - parallel lines converge in the distance.

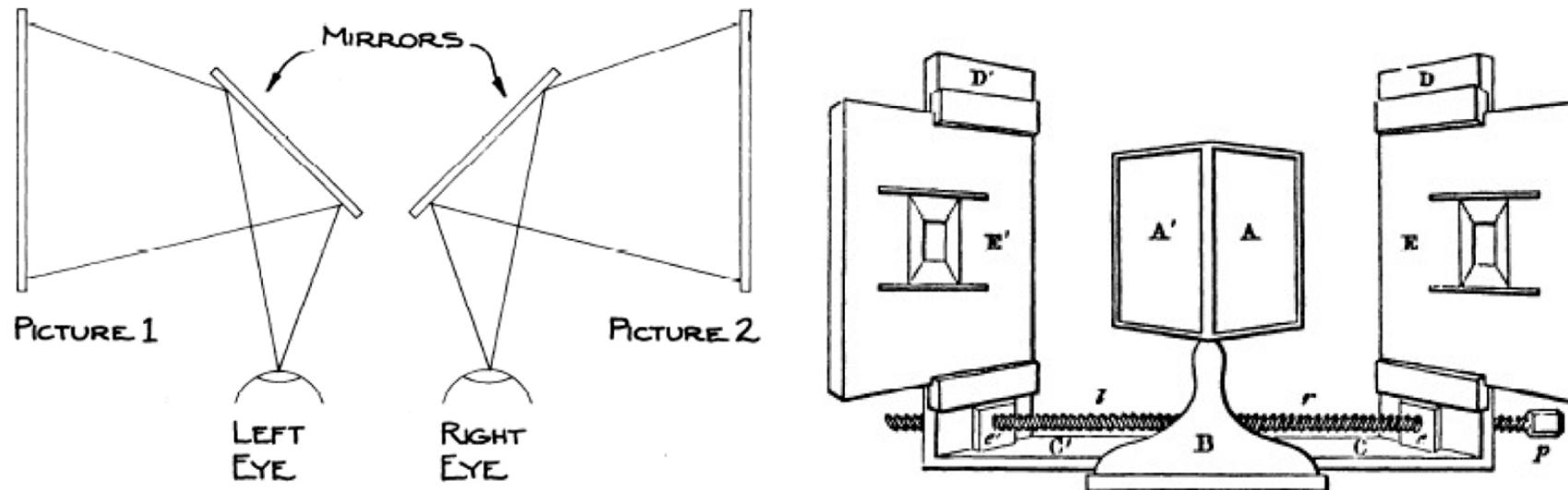
Stereoscopy

- A technique to create the illusion of depth in a photograph, movie, or other two dimensional image.
- Need to present a slightly different image to each eye.
- Our brain interprets the two views as a scene with depth and does a great job of judging distances from us, up to about 20 feet. (diminishes but works up to ~200 m).
- **Stereoscopic Viewer invented by Sir Charles Wheatstone in 1838.**

Stereoscopy

Stereoscopic Viewer by Sir Charles Wheatstone (1838)

- Note: No PHOTOGRAPHY yet!



Stereoscopy

Stereoscopic Viewer - Upgraded (1905 ~ 2000's)



Non-Stereo Depth Cues

Monocular cues

Texture - becomes finer with the distance.

Colour change - colours become more blue with the distance.

Haze - objects become fuzzy with the distance.

Accommodation - our brain knows how hard our eyes are working to provide continues focus.

Stereoscopy

- To create depth perception in the brain provide to the eyes of the viewer with two different images.
- Two perspectives of the same object.
- Minor deviation similar to the perspectives that both eyes naturally receive in binocular vision.

Stereoscopy: a simple test?

- Hold a pencil in front of your nose and look into the distance.
- Do you see 2 pencils?
- Some people don't see 2 pencils because their brains suppress information from one eye.
- The suppressed eye can shift from left to right.
- There might be permanent suppression of one eye.
- people with one eye suppressed won't be able to see in 3D.



Cross-eyed Stereo

- Look at the following stereo image pair by slightly crossing your eyes.
- Left eye sees the right image and right eye sees the left image

3D Movies: Feeling of Realism

Feeling of realism is generated by:

- Creating a **visual illusion of depth** by cheating our brain.
- Calibrated **surround sound effects** representing the visual environment.

Making us believe that we are one with what we see... or... what we see actually exist in front of us!

*Which is something that
really isn't there!*

Stereoscopic 3D Video Content



- A common term: 3D movies!
- Need special eye ware (3D glasses)
 - Active Stereo
 - (battery Powered) Chemical Shutter Glasses
 - Passive Stereo
 - Anaglyph 3D
 - Polarized 3D
 - Linear Polarized
 - Circular Polarized
- Need special projection systems.
 - Need to be able to project frames alternatively, representing Left-eye and Right-eye image components.



VR Headsets

Cost Effective (Budget) Solutions

- Google Cardboard
- VR-Box

High End Solutions

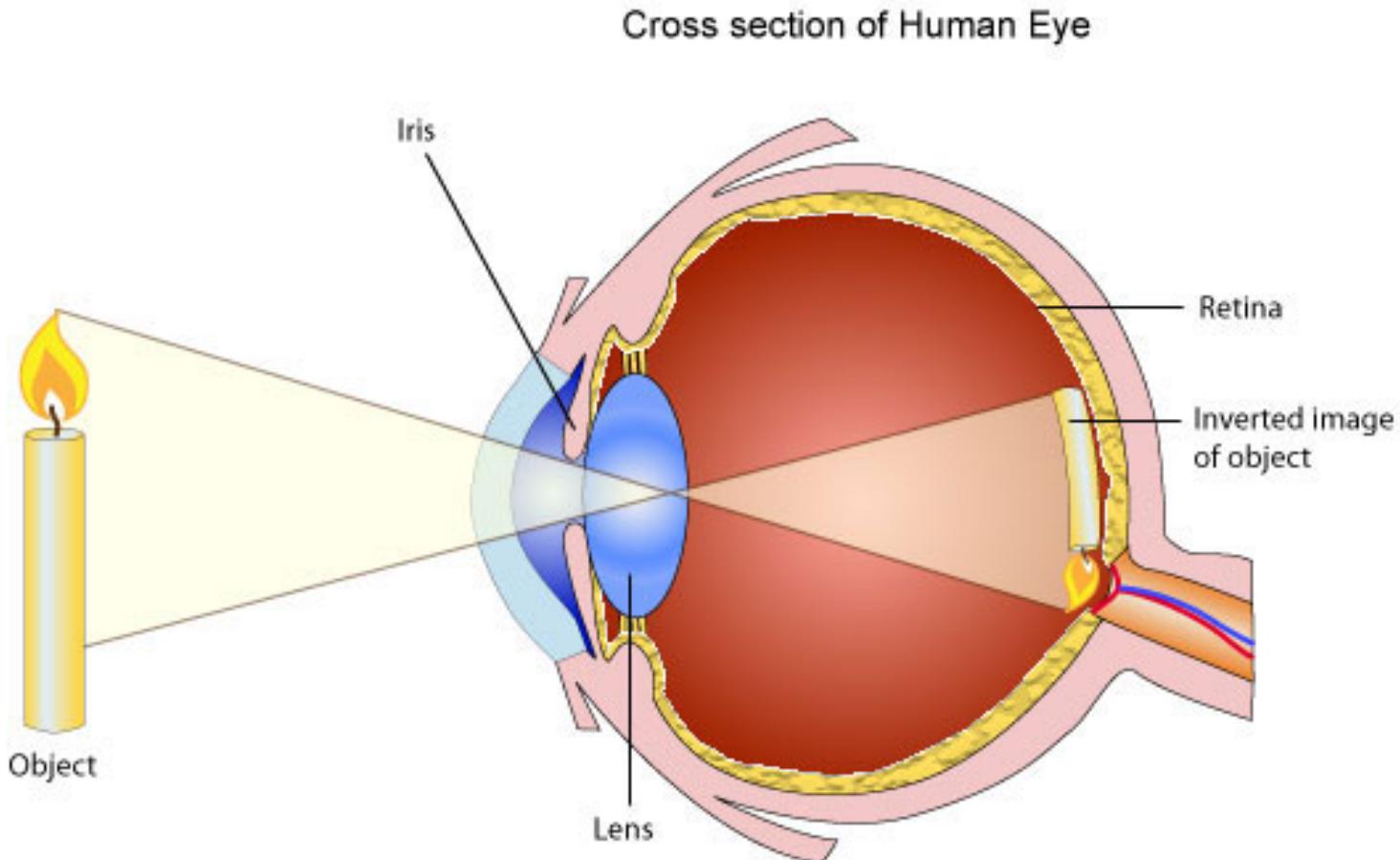
- Samsung Gear VR
- Oculus Rift
- HTC Vive



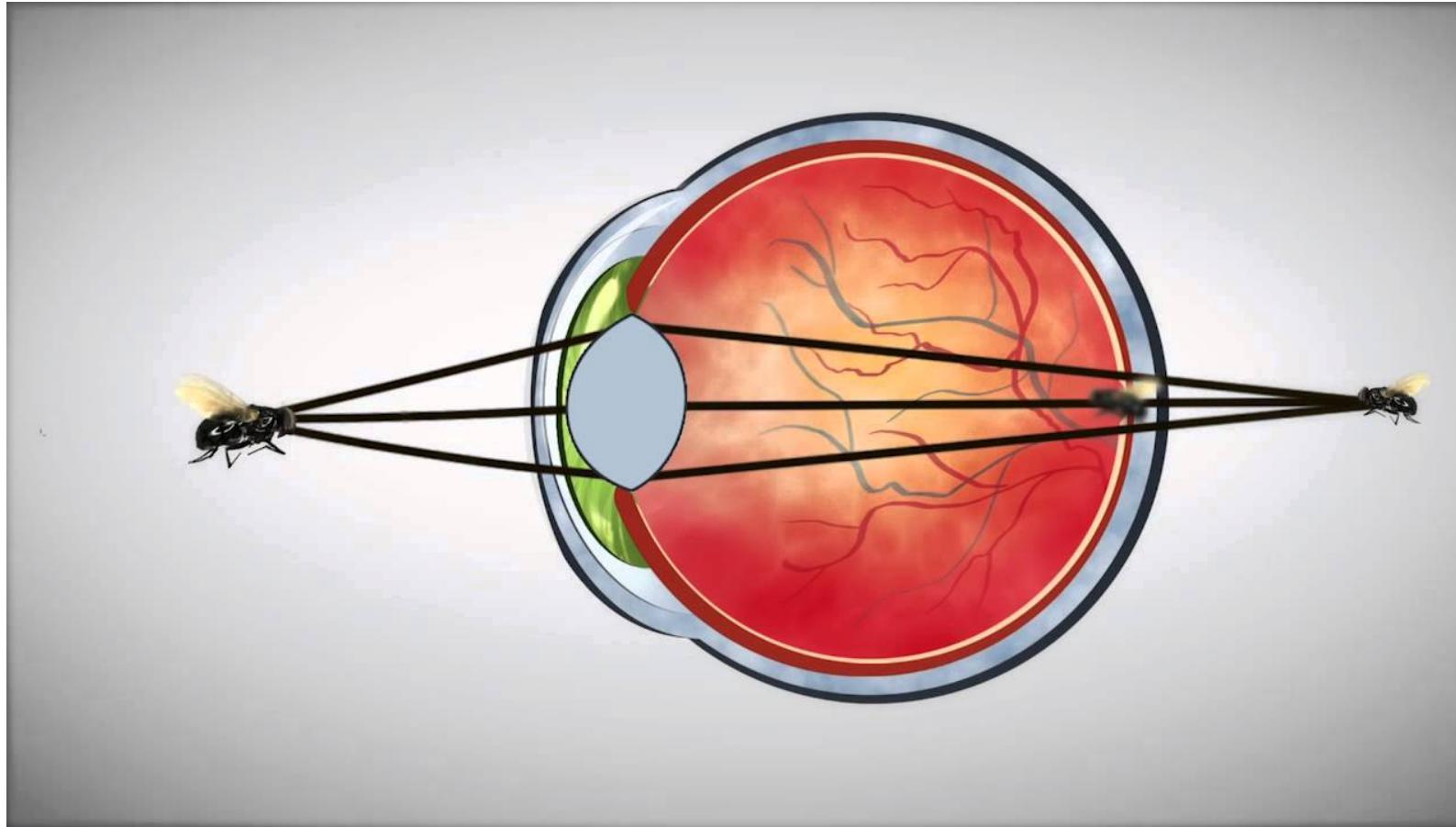
Remember, all products use the same basic, simple elements to bring in the Virtual Reality. Only the technological ways of presenting the Visual content is different.



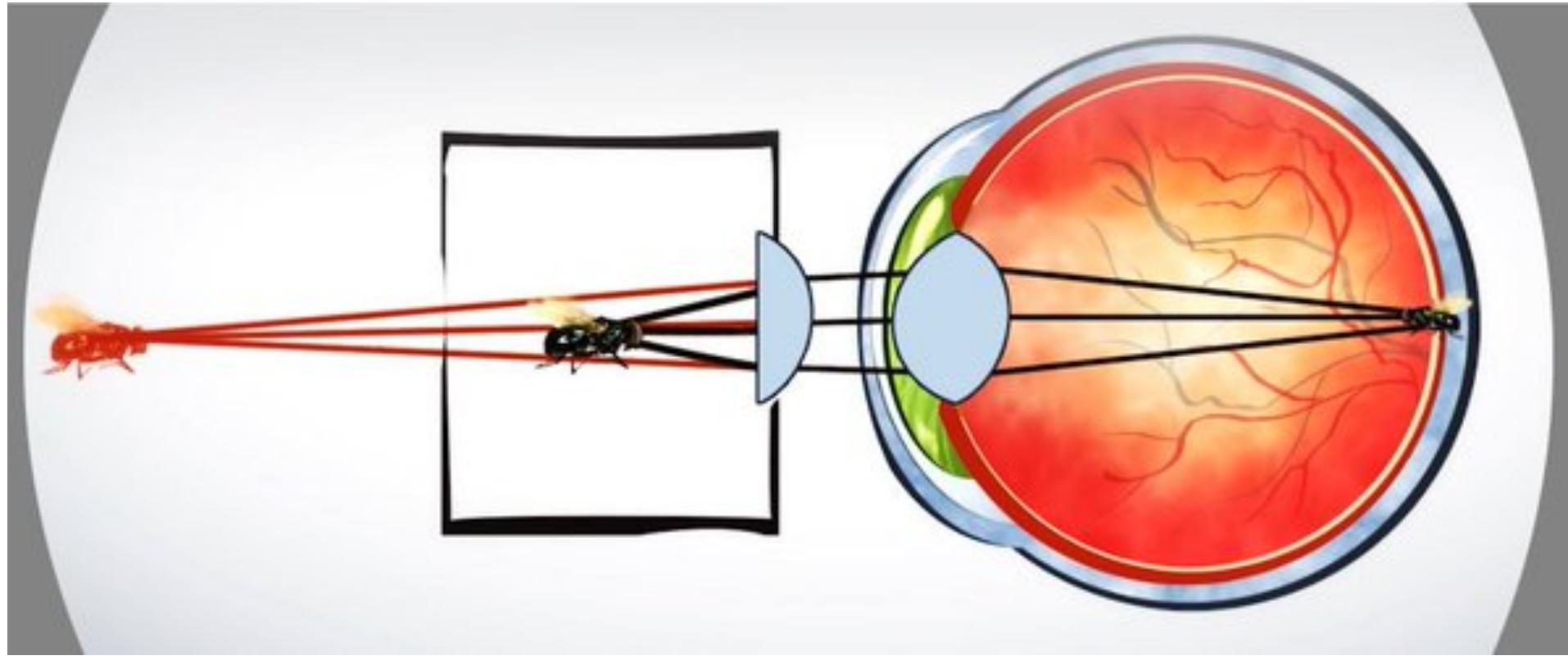
VR Headsets: How they work?



VR Headsets: How they work?



VR Headsets: How they work?



Virtual Reality

Virtual Reality (VR) is the **illusion** of a

- Three-Dimensional
- Interactive,

Computer-Generated Reality where

- Sight
- Sound, and sometimes even
- Touch

are **simulated** to create

- Pictures
- Sounds,

and objects that actually seen and **feel real**.

VR Headsets: How they work?

Functionality of the VR Special lenses

Correct the angle of light that is coming into eye and make a forced perspective of the object being farther away than it really is.

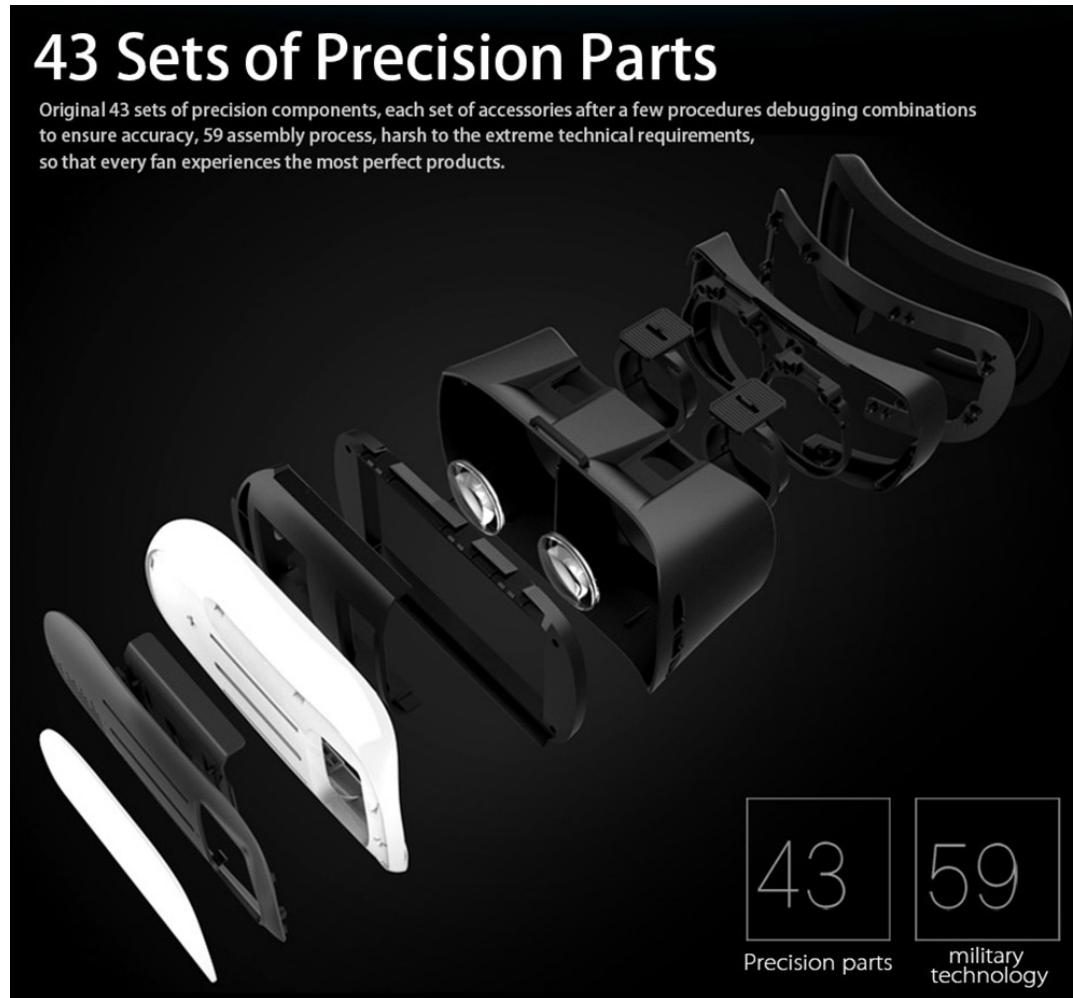
Virtual Reality: Major Concepts

- VR must allow the user to **view the environment** from any point and at **any angle**. (*360 degree view*)
- VR must allow the user to **interact with objects** in the environment.

VR Box - Component Breakdown

43 Sets of Precision Parts

Original 43 sets of precision components, each set of accessories after a few procedures debugging combinations to ensure accuracy, 59 assembly process, harsh to the extreme technical requirements, so that every fan experiences the most perfect products.



Virtual Reality

What makes the sense of realism?

“Feeling of the existence of a non-existing object or environment”

Again - Virtual Reality - Concept Baseline

What makes the sense of realism?

**“Feeling of the existence of a
non-existing object or environment”**

Any Questions?



Thank You!



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