Chapter 11:

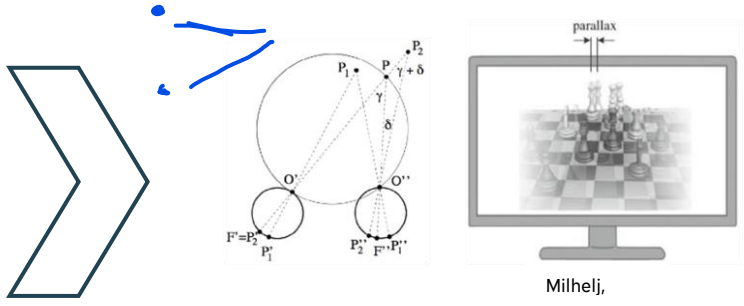
VR: Stereoscopy and Output Devices

Overview

Stereoscopy

Stereoscopy describes the human depth perception. It is based on the view difference between the left and the right eye. Classic visual displays cannot give the user the impression of depth. Stereoscopic displays on the other hand show different images to each eye to create the illusion of depth.

The illusion of depth is created by binocular parallax. Parallax is the resulting distance between the object's location viewed along 2 different lines of sight. To determine parallax, aerial photos (stereo-pairs) need to be overlapped. The effect is contingent on the viewer's position and on the distance between the viewer's eyes.

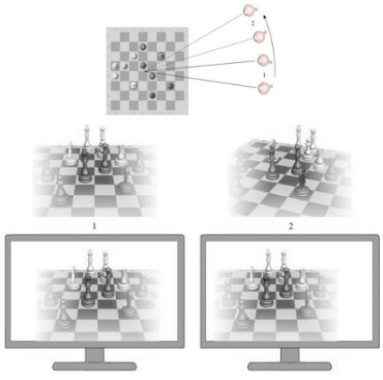


Milhelj,

If we focus on an object in the room with both eyes (e.g Point "P"), then all the objects that are in front or behind that Point P in your field of view are blurry and you get the effect of double vision.

In the binocular vision of the human eye, only horizontal parallax is created, as the eyes are aligned horizontally. This creates a depth impression in the vicinity of the fixation point. Vertical parallaxes would indicate an error in programming the virtual environment. Here, the points on the display screen seen by the left and the right eye do not lie on an epipolar plane.

Changing the viewpoint is only possible if the head movements are tracked. The view is then updated accordingly to the head movement. The effect on the viewpoint changes the view of the real and the virtual object. For spatial representation, each eye needs an individual image. The virtual camera has to be split into two cameras. Then a separate image for the left and the right eye can be rendered.

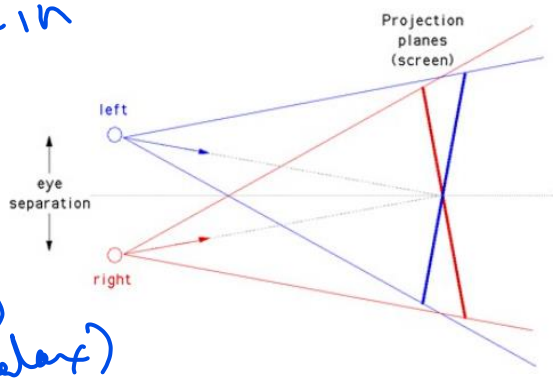


Milhelj,

If you have 2 cameras, there are 2 different methods to create the illusion of depth:

Toe-in method:

Both cameras focus on the same point in space. The computed depth is only correct in the center of the image. The further the object is away from the center of the image, the higher the error in depth representation (vertical parallax).



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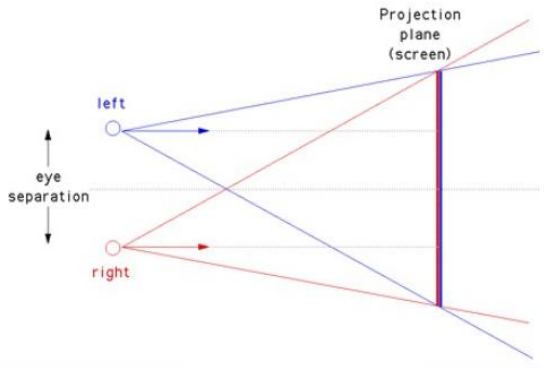
Off-Axis-Method:

This method has the correct stereo display setting. Here, you have a parallel viewing direction of both eyes. The eyes share the same projection plane.



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Output devices

The output devices simulate the senses of the user according to the feedback from the VR engine. This is based on senses like graphics (visual), haptic (contact/force), audio (aural), taste and smell.

Types of different output devices are visual display (head-mounted, projection and autostereoscopic displays), haptic display and audio display.

Head-Mounted Display (HMD): A head-mounted display is a display inside a 'helmet'. There are many different display technologies, like Cathode ray tube (CRT) displays, Liquid crystal diode (LCD) displays or Organic light emitting diode (OLED). It is very important to track the head position, which is done with sensors inside the display. Quality factors for the HMD are resolution (Screen Door Effect), framerate, field-of-view (FOV), weight and computer requirements.

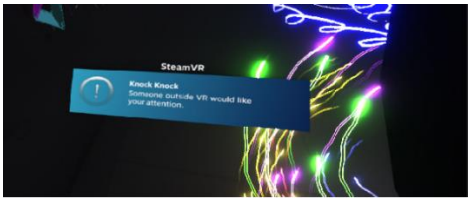
Advantages:

- Large FOV
- Good immersion
- No ambiance requirements for smartphone-compatible HMD

Disadvantages:

- Uncomfortable after a long time of use
- Distortion
- User totally immersed, no information about the real environment

Because of the problem that the user is totally immersed and doesn't have information about the real environment, HTC Vice created the "Knock Knock" feature. The people in the real world have the opportunity to become noticeable. You can get someone's attention in VR by pressing a button. Then a message appears on the screen of the player.

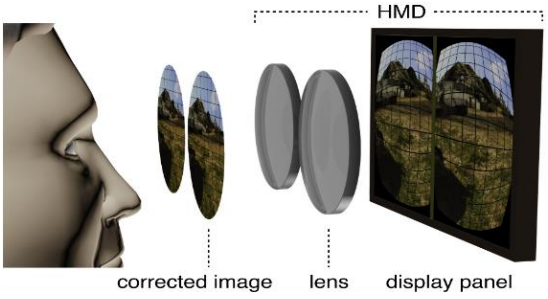


Tomshardware.com

The Technology behind HMD is that the lenses of the glasses are replaced with two screens that show the virtual environment. Each display shows the virtual environment from a slightly different viewpoint, which gives you the illusion of depth. Changing the view of the virtual environment is based on head movement. If the latency (delay between head-movement and viewpoint change) is too high, it can lead to cybersickness.

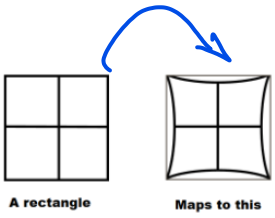
There are different types of HMD. **See-through HMD** is used in augmented reality and shows computer-generated images on real objects. You have additional virtual information to the real world. In **Opaque HMD**, the user cannot see the real world anymore. The view is totally replaced with the image of the virtual environment.

The display panel is placed at a short distance from the eye to fill the viewer's FOV. The wild-angle lens brings the image to focus.



Blog.qwrt.d

The image on the display is slightly distorted because of the large expanse of extra perspective (LEEP). We have a wide FOV for the stereoscopic images. But in the middle of the FOV we get a higher resolution and on the periphery a lower resolution. This leads to the Pincushion distortion.



Sherman&Craig,

A fresnel lens is a compact lens with a short focal length and a large aperture. It provides the possibility to make the lens very thin and capture more oblique light from the light source. It also allows the light to be visible over greater distances and has less distortion.

Haptic display

For the haptic display, we need some force on the body. This could be a tactile perception (surfaces), kinesthetic perception (movement force) or proprioception (force on muscle). The types of haptic output devices can be data gloves that are extended with devices that are simulating tactile sensations, joysticks with kinesthetic feedback or vibration under the surface of a glove.

Neurovr.org

Audio display

Audio displays are often done with headphones (head-mounted). Headphones have good portability, give you a private space and are easy to implement for spatialized sound fields.

Speakers (stationary) are suitable for stationary visual displays. They give the user great mobility and allow multi-user access.

Technobob.com

An example is using galvanic vestibular stimulation. It uses electrical impulses to stimulate the vestibular system and controls the sense of balance and inertia. It gives you the sensation of moving while standing still.

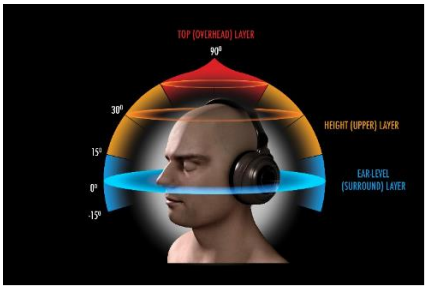
Roadtovr.com

The galvanic vestibular stimulation is for example used in Entrim 4D. Entrim 4D works by sending motion signals to the vestibular system in the ear. The users can feel motions that mimic those on the on-screen VR content.

Youtube.com

Personalized 3D audio is very important to make VR truly immersive. The convincing sound needs to match. Without the right audio cues to match visuals, the brain doesn't fully buy the illusion. You need immersive 3D audio to replicate the natural listening experience. With a rendering engine, you are capable of attaching sound to objects as they move through the setting.

Auro-3D Headphones enable listeners to experience the 3D-Sound effect using advanced binaural technology.



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