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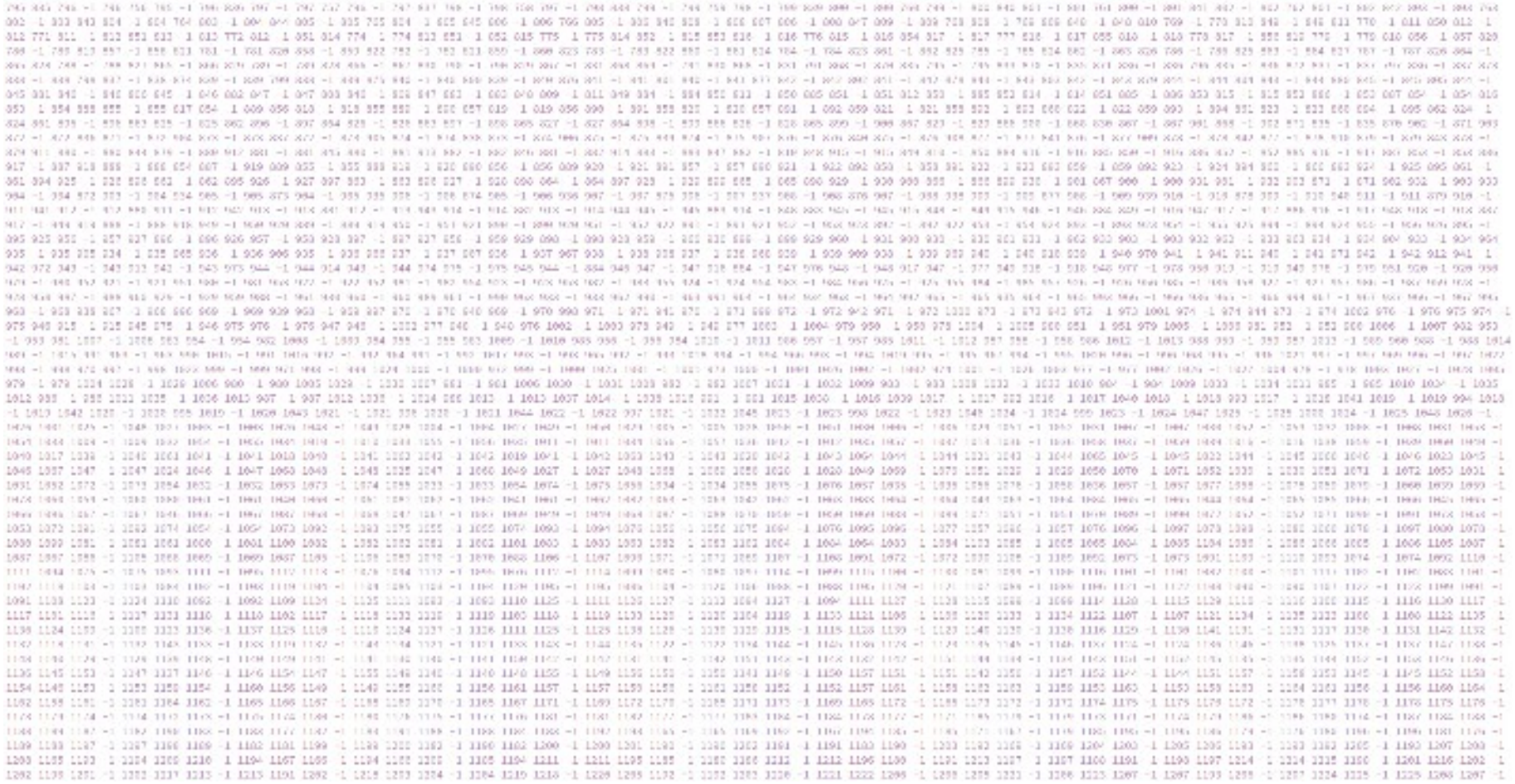
An Introduction to Virtual Reality

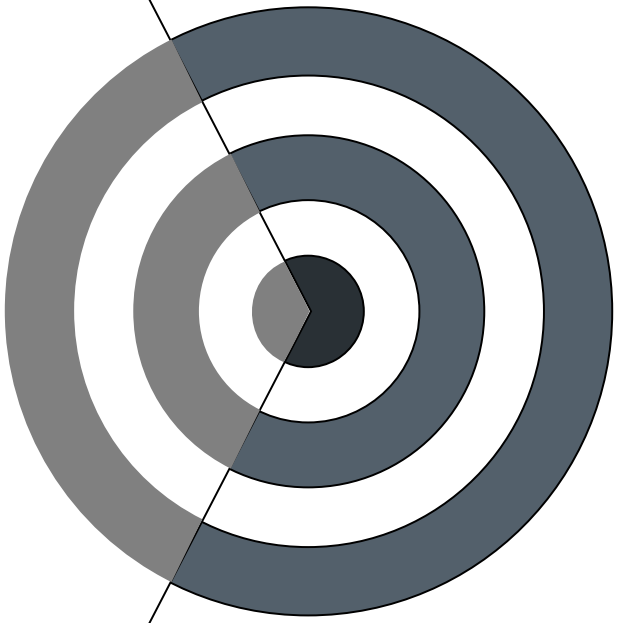
Image: DALL-E

Question: What is this?



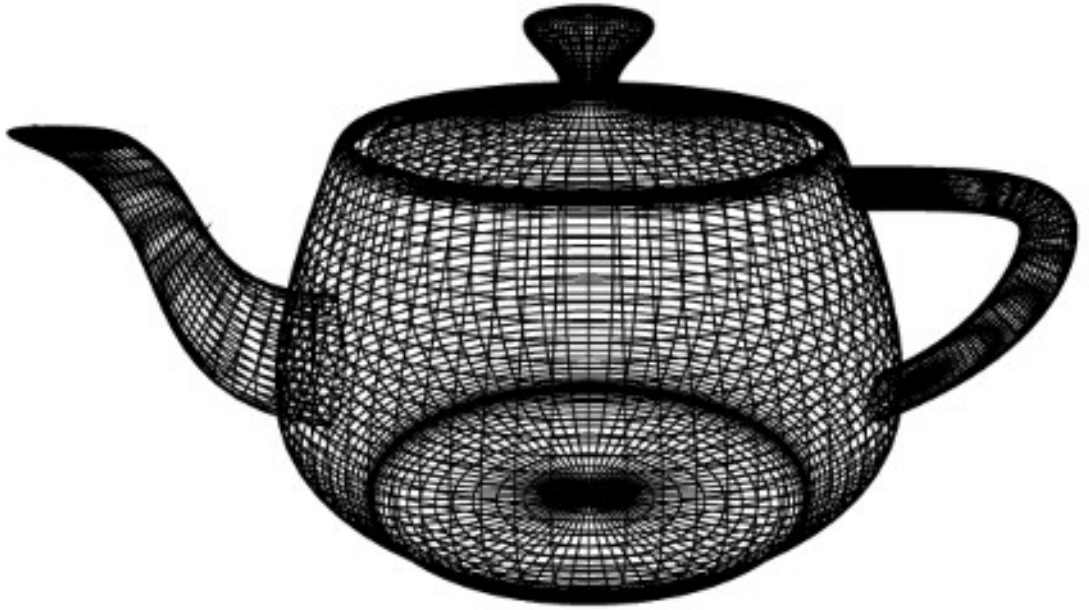
Learning Objectives

- Glimpse into computer graphics
- Challenges posed by human vision
- Some historic aspects
- Different devices
- Motion tracking concepts
- What are Immersion and Telepresence



Utah Teapot

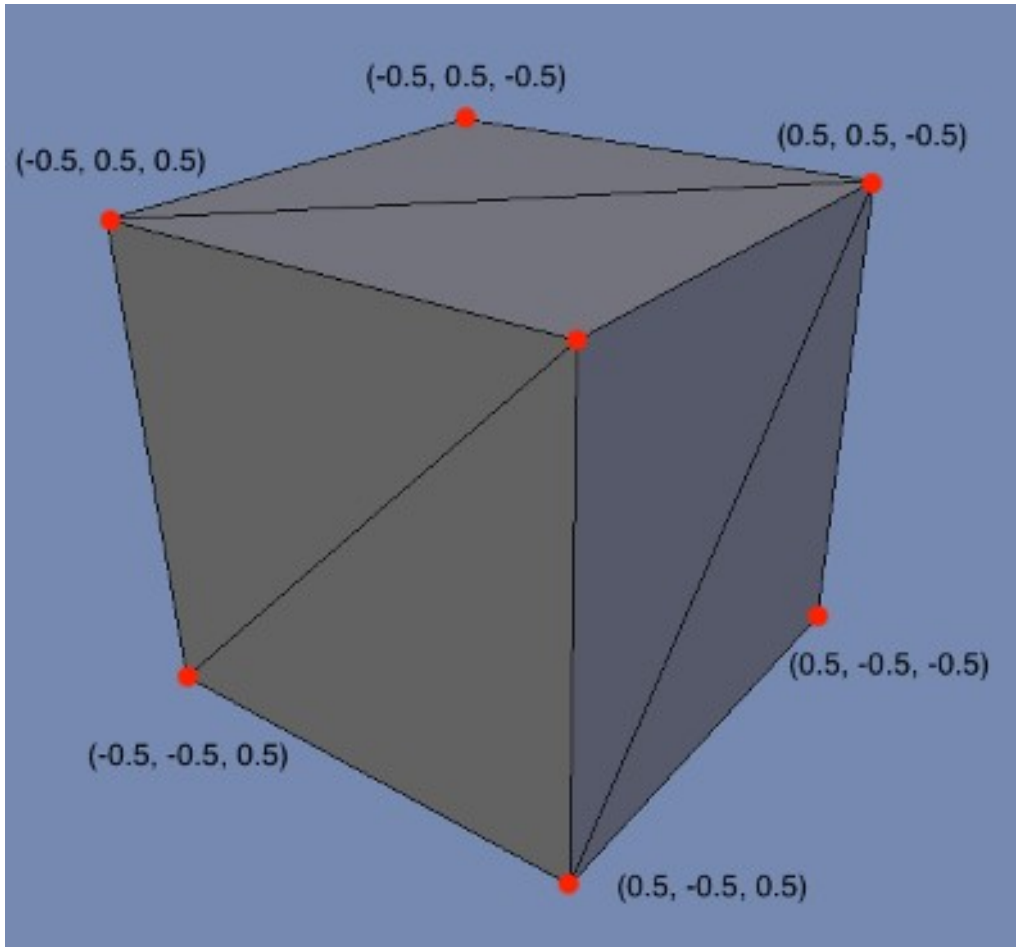
- Standard reference model in computer graphics
- 3D analogon for “Hello World” program
- Constructed from triangles



3D Objects

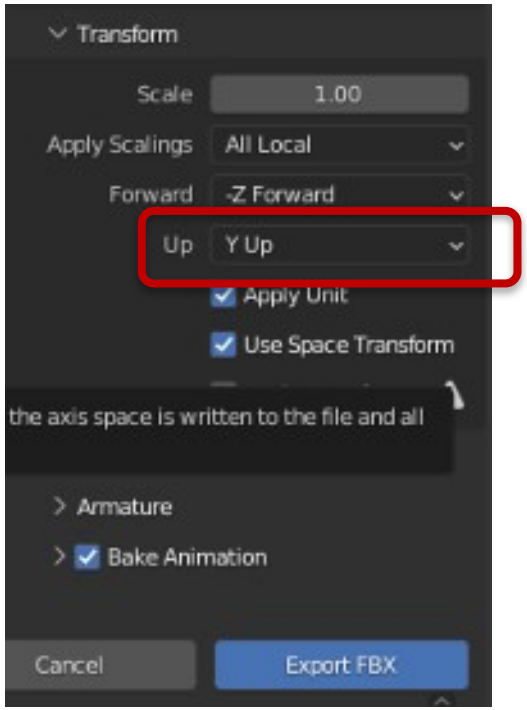
- Vertices
- Edges
- Faces

- Another “famous” object Blender’s Suzanne



Coordinate system

- Different standards
- Conversion possible:



Human visual perception

- Human eye has a temporal resolution of ~60Hz
- The field of view is 170° horizontally and 110° vertically
- Simulator sickness can occur when the experience is suboptimal
- “Cyber Sickness” Symptoms:
  Nausea, Headache, Dizziness, Blurred vision, Fatigue, General discomfort
  → Mitigated by **high fidelity**, **stereoscopic view**,
  and a **dynamic field of view**

SSQ Questionnaire Kennedy et al. (1993)

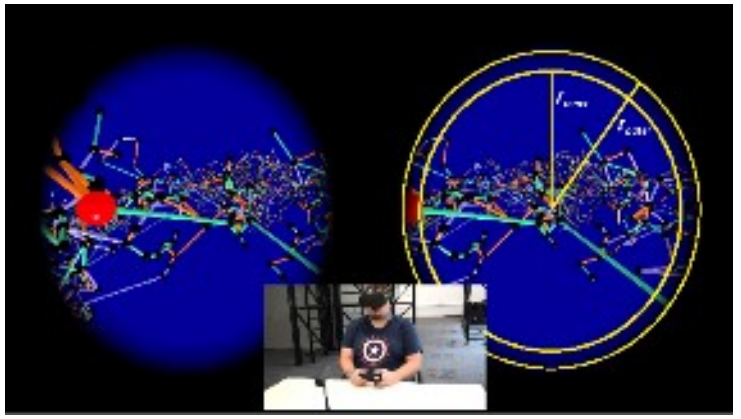
Stereoscopic images

- Monocular information is not complete
- Second projection point enables **depth** perception

https://bit.ly/3kBzXlR

https://vanderbei.princeton.edu/WebGallery/Orchid/orchid.html

Dynamic Field of View



Corpus ID: 149680434

Dynamic Field of View Reduction Related to Subjective Sickness Measures in an HMD-based Data Analysis Task

Daniel Zielasko, Alexander Meissner, +2 authors B. Weyers • Published 2018 • Computer Science

Various factors influence the degree of cybersickness a user can suffer in an immersive virtual environment, some of which can be controlled without adapting the virtual environment itself. When using HMDs, one example is the size of the field of view. However, the degree to which factors like this can be manipulated without affecting the user negatively in other ways is limited. Another prominent characteristic of cybersickness is that it affects individuals very differently. Therefore, to... Expand

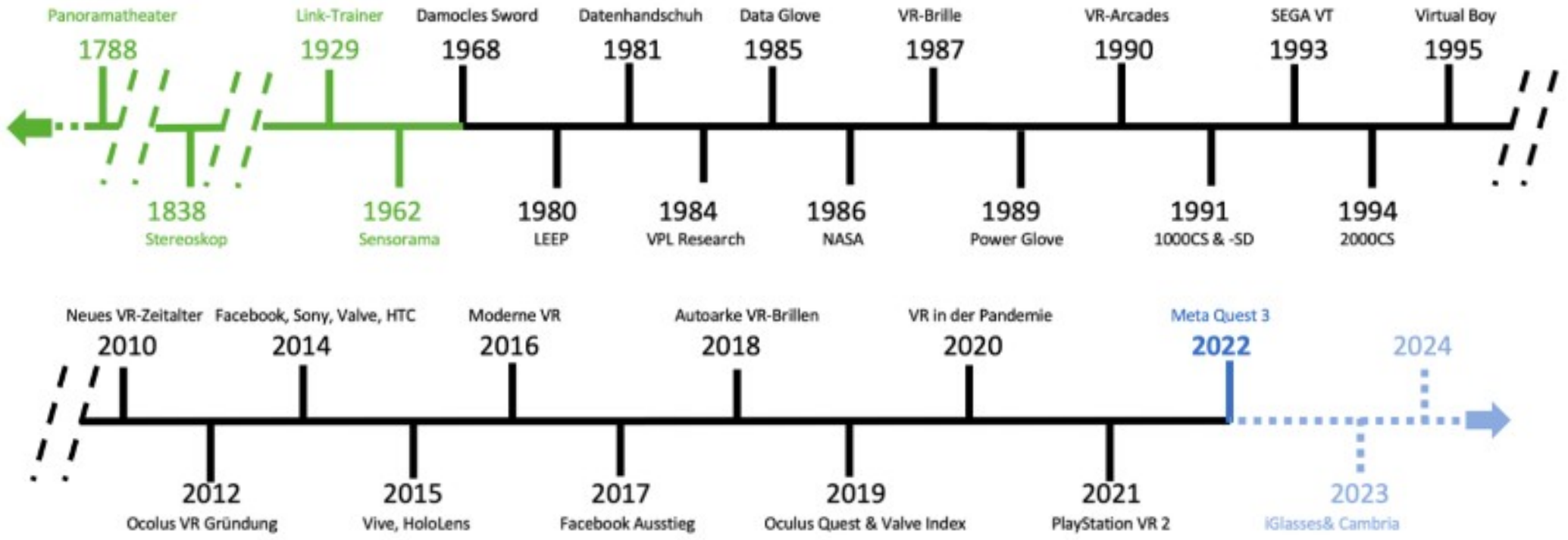
The “Father” of Virtual Reality

- Jaron Lanier is considered the founder of the scientific VR field
- Before that, for example, the term artificial reality (Myron Krueger) has been used
- However, Lanier did not provide a clear-cut definition of virtual reality

https://hds.hebis.de/ubgi/Record/HEB436656043

Von vanz - https://www.flickr.com/photos/vanz/144476323/in/set-72057594131744996/, CC BY 2.0, https://commons.wikimedia.org/w/index.php?curid=1707896

VR History

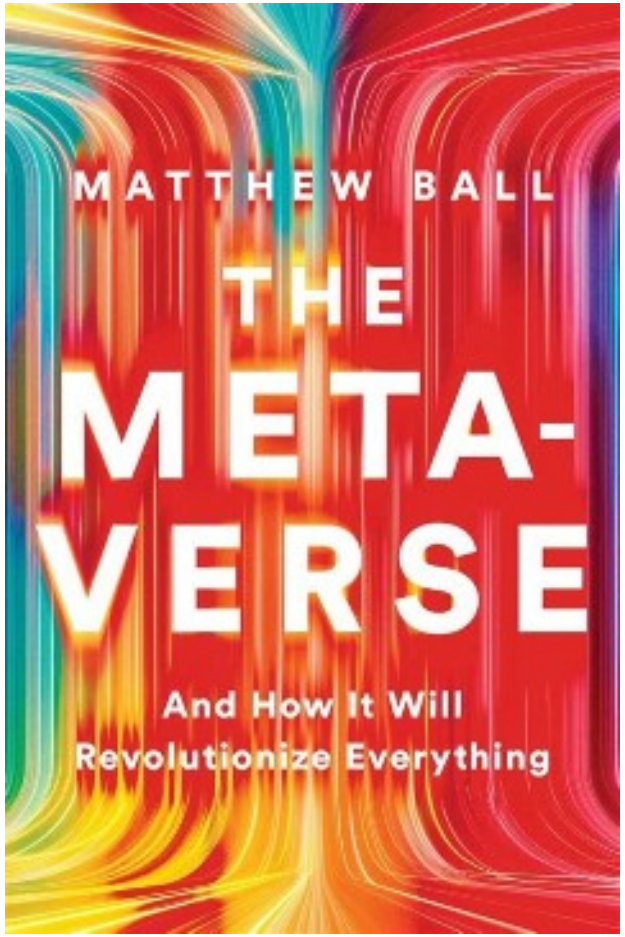


https://mixed.de/virtual-reality-geschichte/

The Metaverse

- Technical aspects
- Corporate players (Gaming industry!)
- Blockchain and NFT insights

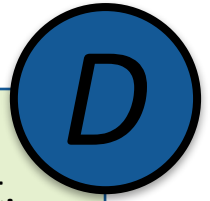
matthewball.vc



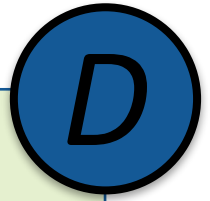
https://www.business2community.com/crypto-news/the-metaverse-and-how-it-will-revolutionise-everything-by-matthew-ball-book-review-02523970

VR Definitios

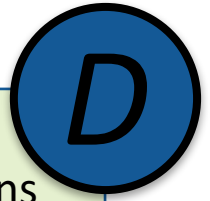
By Ivan Sutherland
Indeed, in the ultimate display one will not look at that world through a window, but will be immersed in it.



By Steve Bryson
Virtual Reality refers to the use of three-dimensional displays and interaction devices to explore real-time computer-generated environments.



By Thies Pfeiffer
Interactively generated 2nd order multimodal sensory perceptions, which are taken as 1st order perceptions by humans.

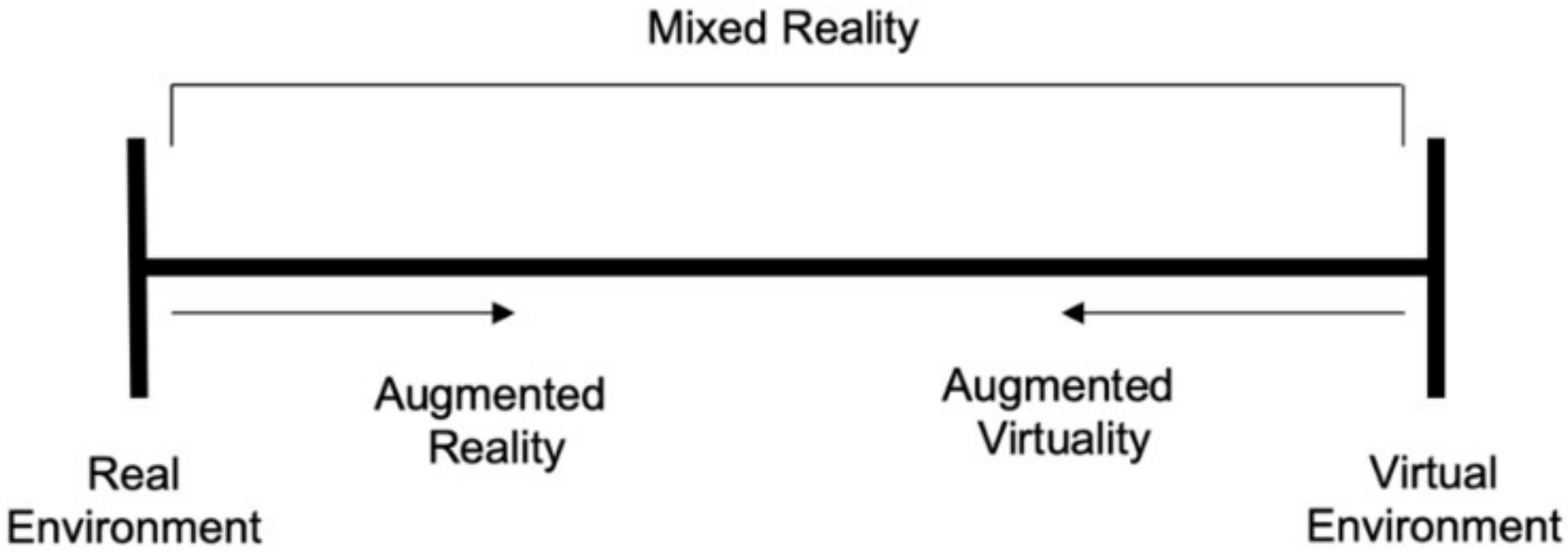


VR Definitions (cont.)

- Three common features of VR systems:
  - Immersion
  - Perception to be present in an environment
  - Interaction with that environment

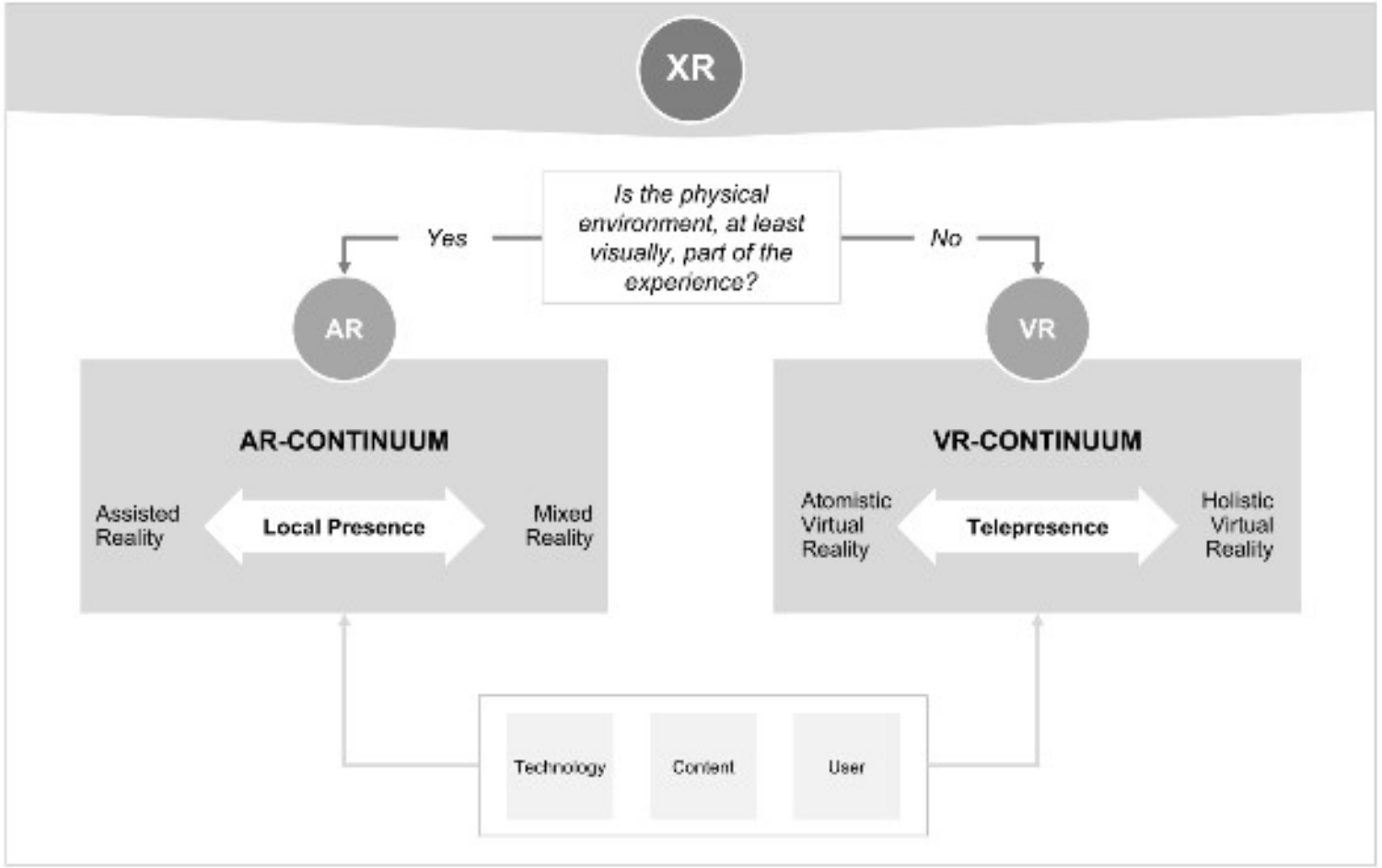
  Later, we talk about **immersion** and **telepresence** in more detail.

Reality Virtuality Continuum



Milgram and Kishino. (1994)

xR Overview - Rauschnabel



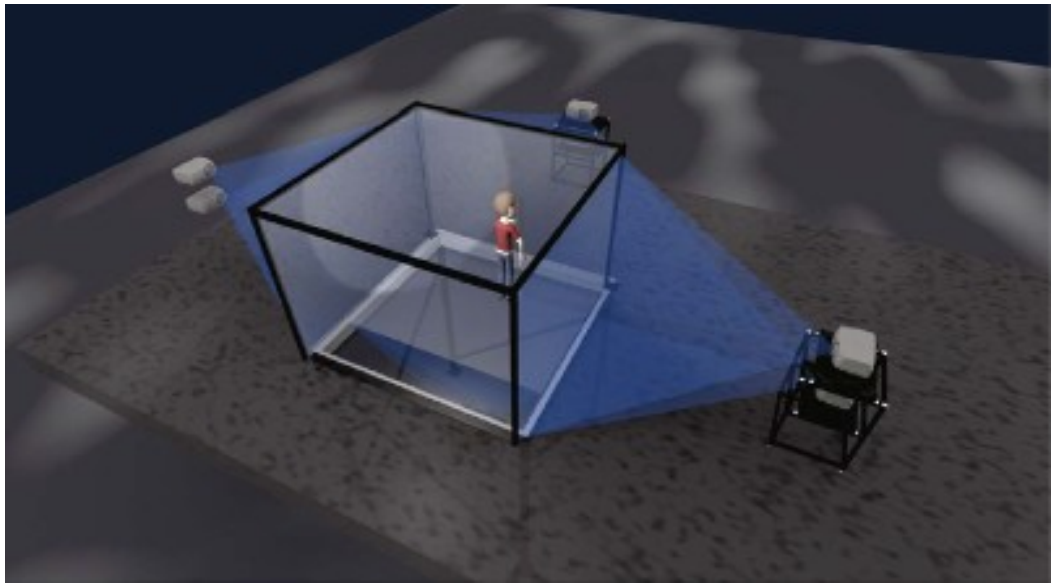
Rauschnabel et al. (2022)

VR Hardware

- Update the presented computer graphical renderings to match the current perspective of the user
- Latency ideally below 5ms
- If latency is too high, Simulator Sickness can occur

CAVE: Cave Automatic Virtual Environments

* Collaborative Environment for scientific/engineering industries
* Update of the graphical rendering with 30 Hz or faster
* Typical latency 30ms to 50ms



Meißner et al. (2017)

Head-Mounted Displays

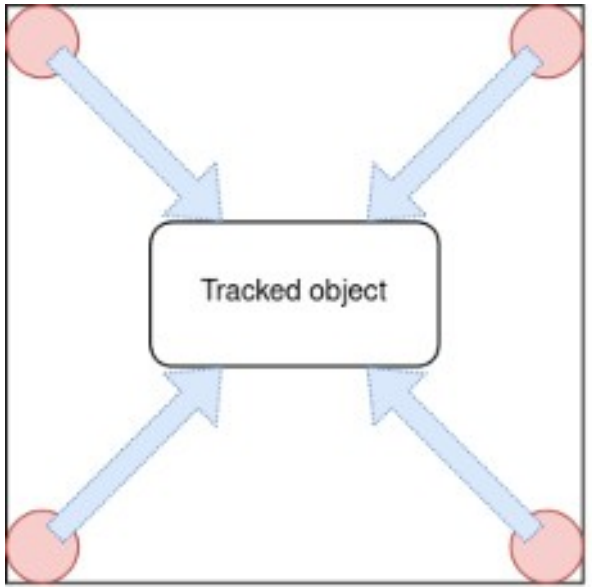
- Update of the graphical rendering with 50 Hz faster with a latency around 15 ms
- Modern HMDs have a stereo display
- Stand-Alone or PC-bound

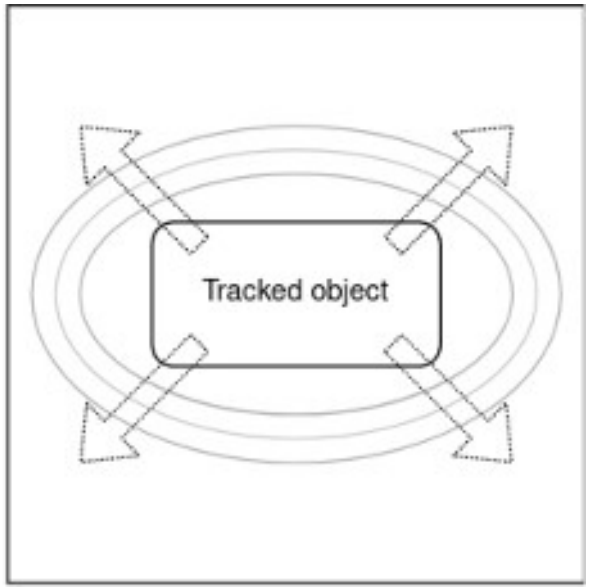
Source: Varjo

* Covers entire field of view
* Susceptible to latency, as no reference points exist

Motion tracking concepts

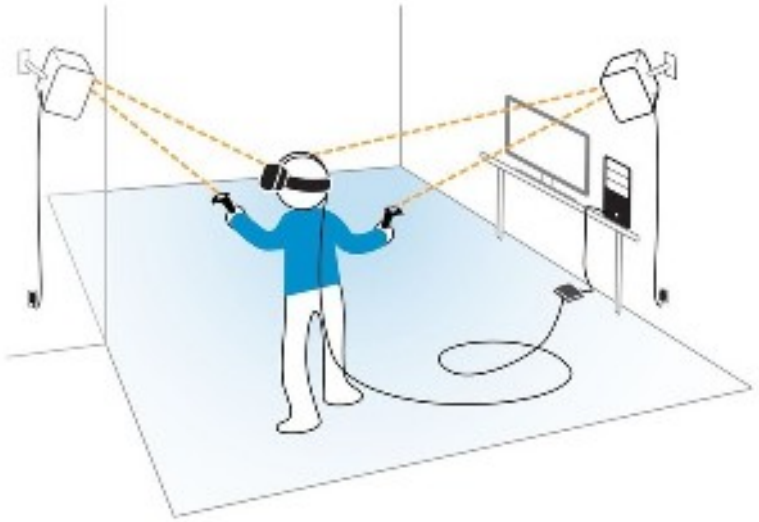
- Outside In
- Inside Out
- Who is source of truth?





Tracking: Outside in

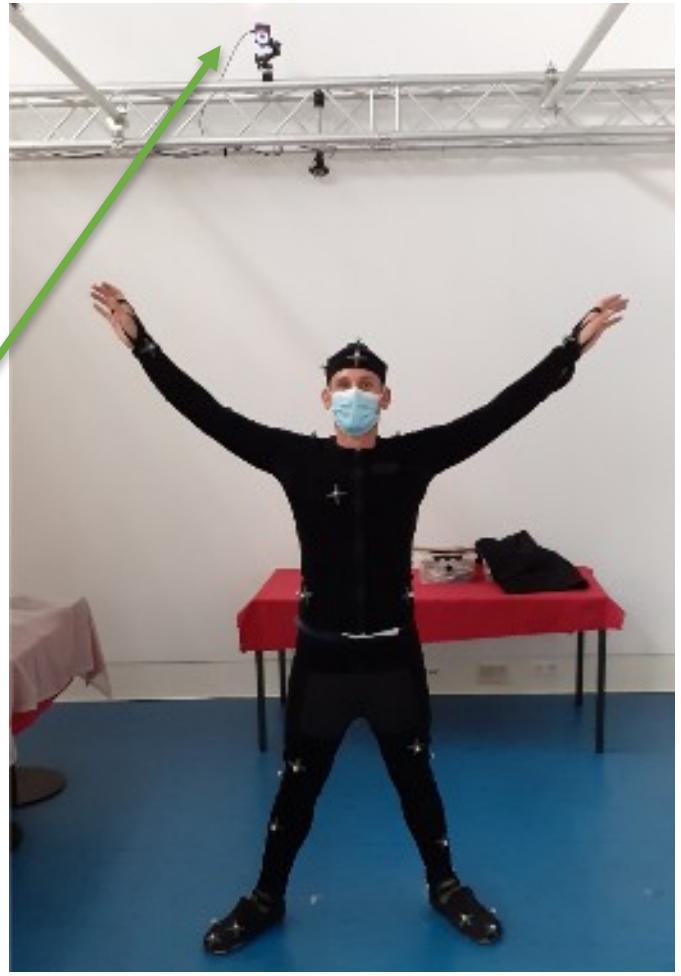
- Lighthouses for room scale tracking of the head position
- External sensor measures positions
- Typically optical detection (e.g. IR)
- Fast
- Accurate
- Requires setup



https://www.vrheads.com/least-painful-way-set-htc-vive-lighthouses

Tracking: Outside in

- Advanced Motion Tracking
  - Skeletons
  - Objects



Tracking: Inside out

- Internal sensors measure position
- Less accurate
- Faster to set up
- Marker & Markerless
- Various versions

Source: HP

HMD (R)evolution

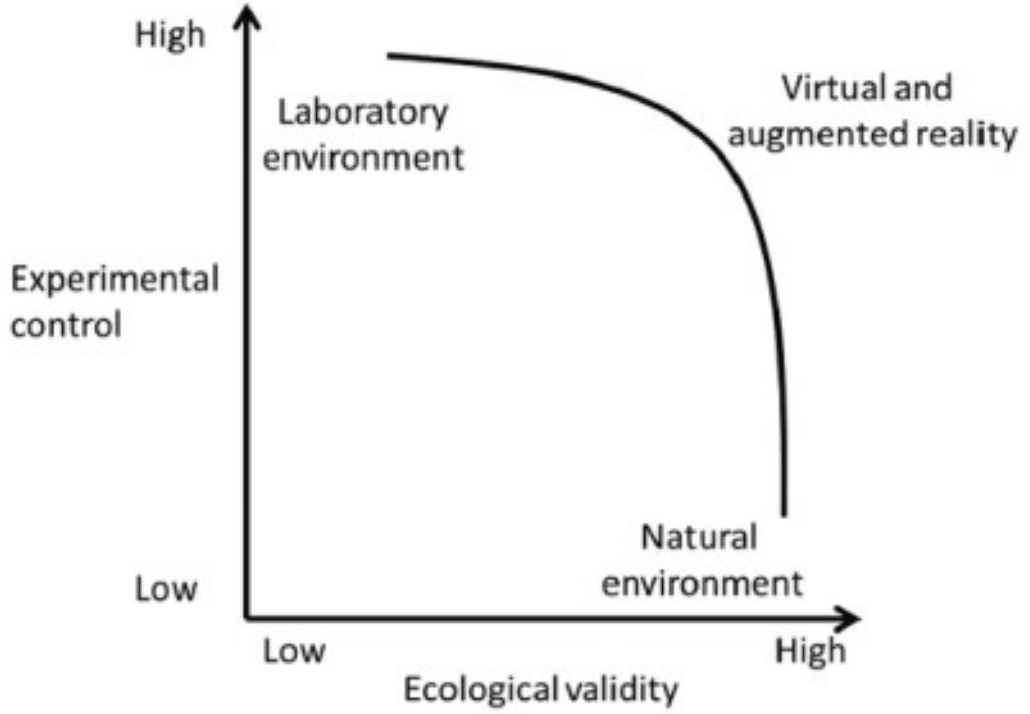
Source: Sony

Source: Meta

Source: Pico

→ Upcoming VR headsets tend to have eye tracking capability

VR as Experimental Environment

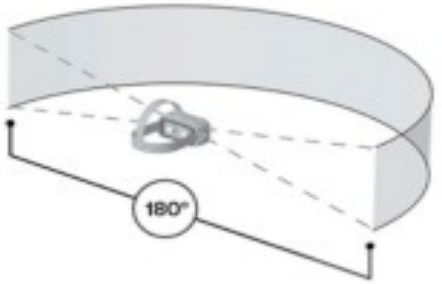


Loomis et al. 2019 and Meißner et al. 2017

Immersion – Main characteristics

Inclusive: degree of **isolation** from reality

Extensive: the number and particularly the magnitude of different **sensory channels** that are stimulated



Surrounding: the presentation format in terms of the **field-of-view** delivered by the medium

Vivid: the extent to which a system is capable of creating **naturalistic** environments from a representational point of view

http://gfxspeak.com/2016/05/16/putting-attached-virtual/
https://blog.meddigital.com/wp-content/uploads/2016/08/Field-of-view.jpg

Immersion - Definition

D

Immersion

Immersion describes to what extent technological features of the VR environment “are capable of delivering an inclusive, extensive, surrounding and vivid illusion of reality to the senses of a human participant”

Slater & Wilbur (1997)

In addition to these concepts, Steuer (1992) outlines the concept of interactivity: the degree “to which users of a medium can influence the form or content of the mediated environment”

Immersion – Wrap up and Scale

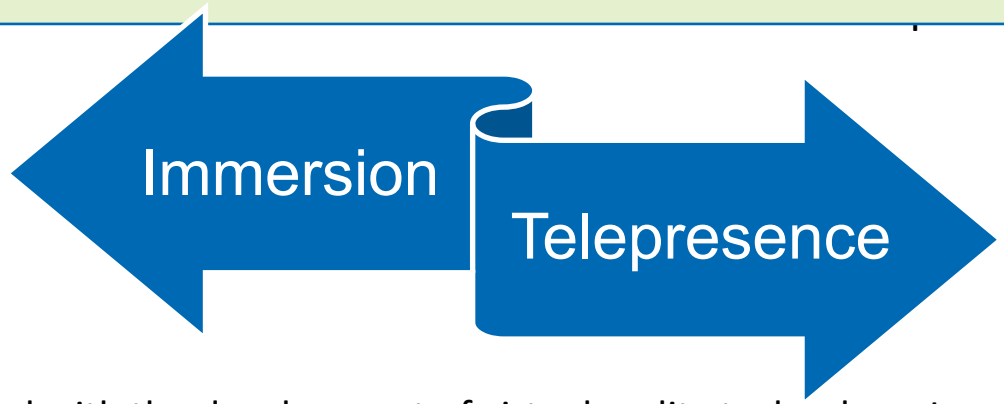
- Inclusiveness: Extent to which the physical reality is shut out
- Extensiveness: Number and magnitude of sensory channel stimulation
- Surrounding: panoramic (surrounding) versus limited (not)
- Vividness: Richness, information content, resolution, quality, naturalistic environment
- Interactivity: Influencing form or content of the environment
- Scale for measuring immersion
  - Shopping in Virtual Reality Stores: The Influence of Immersion on System Adoption (Peukert et al., 2022) https://www.tandfonline.com/doi/full/10.1080/07421222.2019.1628889
  - 7 Point Likert Scale
  - [Not at all] to [fully]

Definition Telepresense

D

Telepresence

Telepresence, often shortened to presence, is commonly referred to as a sense of 'being there' in a virtual environment and more broadly defined as an illusion of non-mediation in which users of any technology overlook or misconstrue the technology's role in their experience.



- The term immersion has been coined with the development of virtual reality technology. Immersion is tightly coupled with presence, but takes a more technical perspective and focuses more on the process of getting into the virtual world. Presence, on the other hand, describes a state.
- In virtual reality, presence can be taken as the **result of immersion** (Schubert, Friedmann & Regenbrecht 2001). Immersion can be quantified objectively, **presence is subjective**.

Presence Questionnaire

- Specifically addresses presence
- Designed together with the ITQ - Immersive Tendency Questionnaire, to assess general differences regarding the felt/permitted presence
- 32 questions on a 7-point Likert scale
- Witmer, B. G. & Singer, M. J. (1998). Measuring presence in virtual environments: A presence questionnaire, Presence, MIT Press, 7, 225-240

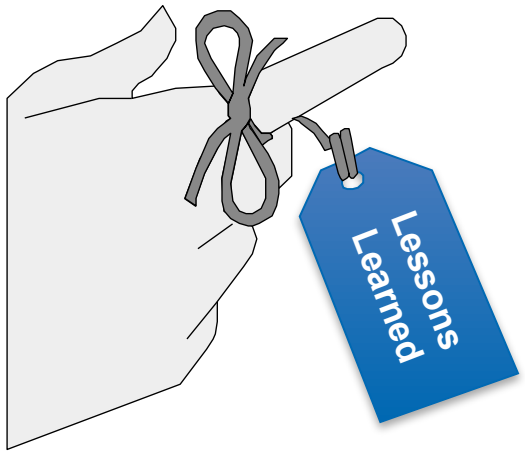
Items from the presence questionnaire

- 1. How much were you able to control events?
- 2. How responsive was the environment to actions that you initiated (or performed)?
- 3. How natural did your interactions with the environment seem?
- 4. How completely were all of your senses engaged?
- 5. How much did the visual aspects of the environment involve you?
- 6. How much did the auditory aspects of the environment involve you?
- 7. How natural was the mechanism which controlled movement through the environment?
- 8. How aware were you of events occurring in the real world around you?
- 9. How aware were you of your display and control devices?
- 10. How compelling was your sense of objects moving through space?

Outlook / Discussion

- Is VR the end?
- Are AR and VR completely different?
- What about the metaverse?
- Has all of this practical use?

Summary



- Some insight into computer graphics
- Overview over Virtual Reality as a technology
- Available VR solutions
- Immersion & Telepresence

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Questions?

Hands On: Mozilla Hubs via Oculus Quest