

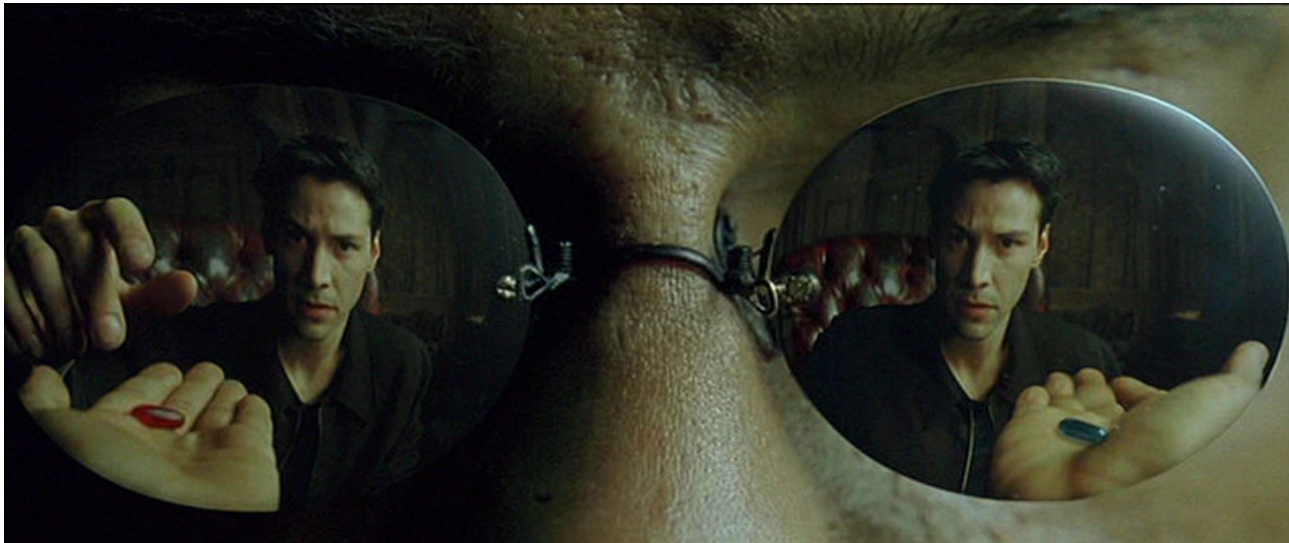
Virtual Reality and Presence

Michael Wang

What you should get out of this session

- What is the fundamental principle behind the design of a truly immersive virtual reality?

What is reality?



What constitutes reality?

- What would Gibson say?
- Look around you.
 - Remember **ambient light**?

Sensorimotor Contingency

- Sensorimotor contingency refers to the actions that we know to carry out in order to perceive (O'Regan & Noë)
- What we perceive changes as we move in a lawful manner.
 - Predictable sensory consequences as a result of motor behaviors, such as eye, head, and bodily movement.
 - E.g., motion parallax - we “know” what would happen if we move our head to the side.

Sensorimotor Contingency

This theory postulates that, for a given subjective experience, the perceiver must have certain bodily engagement with the environment, which subsequently gives rise to a particular set of sensorimotor dependencies that are characterized by modality-specific invariants as a result of such an engagement.

What senses do we have?

- Perceptual (see)
- Auditory (hear)
- Olfactory (smell)
- Gustatory (taste)
- Tactile (touch)
- Vestibular (balance and spatial orientation, from your inner ear)
- Proprioceptive (body position, from your muscles and joints)

What about a truly immersive virtual environment?

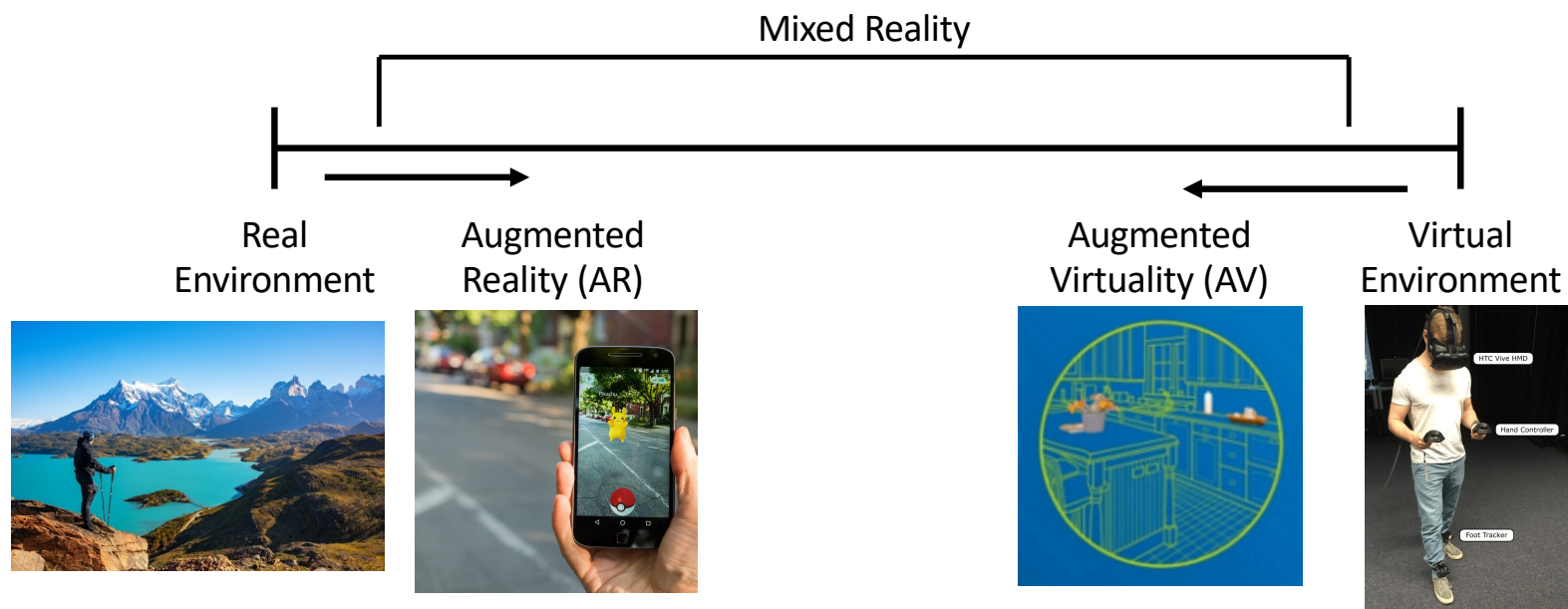
- Inside a truly immersive virtual environment, every piece of sensory information that was mentioned previously should all converge to the same environment.
- Think about the most immersive virtual environment that you have ever experienced, what is still lacking?
 - Almost everything?

The Sense of Presence/Telepresence

- “The sense of being there”
 - Originated from the German term *Dasein*, coined by German philosopher Martin Heidegger.
- Originated from teleoperator systems (telepresence; Minsky, 1980)
 - The feeling of being at the place of a remote physical robot that the user is operating.
- Transplanted to virtual reality
 - The feeling of being at the place depicted by the virtual displays (Held & Durlach, 1992; Sheridan, 1992).
- Place Illusion (Slater, 2009)
 - The strong illusion of being in a place *in spite of the sure knowledge that you are not there*.

The Reality-Virtuality Continuum

- A continuous scale between the completely virtual (virtuality) and the completely real (reality).



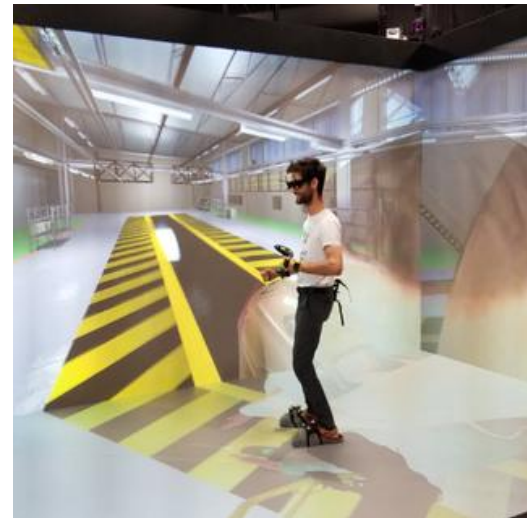
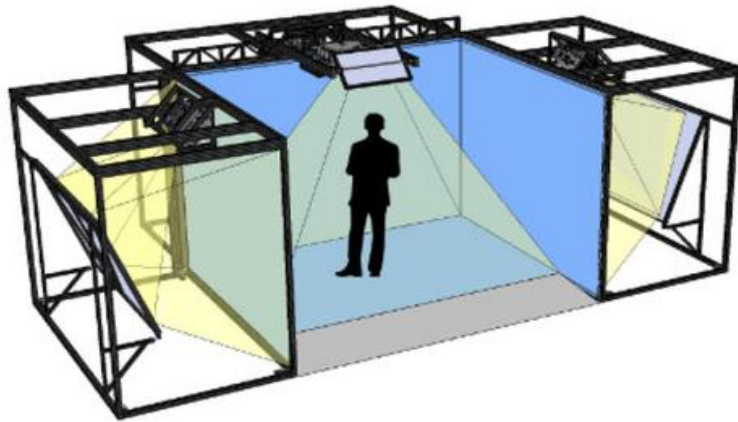
Milgram et al, 1994

Key Aspects of Immersive Virtual Reality

- Vision
 - Stereopsis
 - Two screens display images with a slight offset
 - 3D movie
 - Position tracking
 - Sensorimotor contingency
 - Avatar (body) rendering
 - Field of View (FOV)
 - A wider FOV can improve the sense of presence
 - (Think about optic flow)
 - Latency
 - Whether there is a lag in the display
 - Sensorimotor contingency
 - Resolution
 - Frame rate
- Remember that we have not even start to talk about other senses yet!

CAVE (Cave Automatic Virtual Environment)

- An alternative form of immersive virtual reality



<https://www.wavin.ca/vr-cave.html>

Head-Mounted Display (HMD)

- Dual displays
 - Provides stereopsis (more on this later)
 - High resolution (for HTC Vive, 1440×1600 per eye, or 2880×1600 combined)
 - Ensures relatively large FOV (for HTC Vive, 110°)
 - Relatively high refresh rate (normally at 90 Hz)
 - Interpupillary distance (IPD)

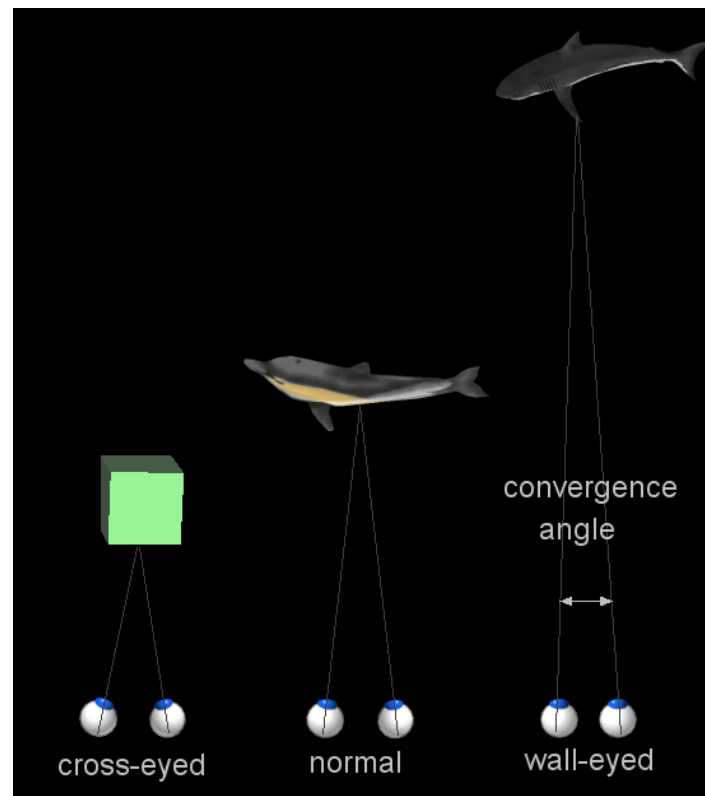
Head-Mounted Display (HMD)

- Position tracking
 - Optical tracking
 - IR-based
 - Lighthouse (SteamVR and HTC Vive)
 - Constellation (Oculus)
 - Machine vision based
 - Google's WorldSense (uses front-facing cameras to detect edges in the environment and use them as reference points).
 - Markerless.
 - Inertial tracking
 - Inertial measurement units (IMU) systems
 - Accelerometers
 - Gyroscope
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Vergence-Accommodation Conflict

- One of the persisting challenges for VR.
- Vergence
 - Simultaneous movement of both eyes in opposite directions to obtain or maintain single binocular vision.

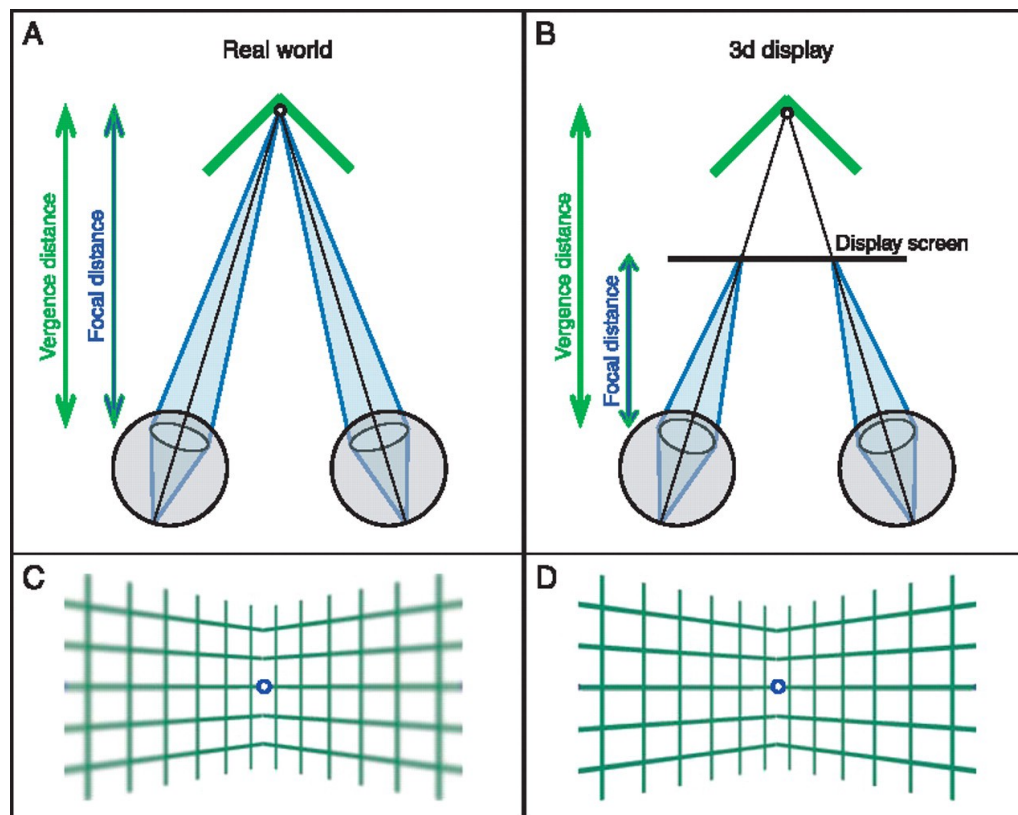
Vergence



Vergence-Accommodation Conflict

- One of the persisting challenges for VR.
- Vergence
 - Simultaneous movement of both eyes in opposite directions to obtain or maintain single binocular vision
- Accommodation
 - Where you eyes are focusing on.

Vergence-Accommodation Conflict



<https://medium.com/vrinflux-dot-com/vergence-accommodation-conflict-is-a-bitch-here-s-how-to-design-around-it-87dab1a7d9ba>

Vergence-Accommodation Conflict

- One of the persisting challenges for VR.
- Vergence
 - Simultaneous movement of both eyes in opposite directions to obtain or maintain single binocular vision
- Accommodation
 - Where you eyes are focusing on.
- This can cause discomfort, fatigue, headaches, and even nausea.

Cybersickness

- Motion sickness
 - Types
 - Motion that is felt but not seen.
 - Seasickness, carsickness, etc.
 - Motion that is seen but not felt.
 - Space motion sickness (when you are in space, zero gravity).
 - Screen images.
 - Both systems detect motion, but they do not correspond.
 - Simulated gravity.
 - Requires real self-motion.
 - Causes
 - Sensory conflict theory (Reason & Brand, 1975)
 - Vection vs. kinesthesia.
 - Postural instability theory (Riccio & Stoffregen, 1991)
 - Novel motion cues lead to prolonged instability in postural control, which causes motion sickness until the observer adapts.

Cybersickness

- Simulator sickness
 - Occurs in simulated environments **without** actual motion.
 - Simulator Sickness Questionnaire (SSQ)
 - Kennedy et al. (1993)
 - Three subscales
 - Nausea: salivation, sweating, nausea, stomach awareness, burping
 - Oculomotor: fatigue, headache, eyestrain, difficulty focusing
 - Disorientation: vertigo, dizziness (eyes open/eyes closed), blurred vision

Cybersickness

- Cybersickness
 - Occurs when one is inside a virtual environment
 - Symptoms
 - Nausea
 - Disorientation
 - Headaches
 - Sweating
 - Eye strain
- Difference between cybersickness and simulator sickness in terms of SSQ.
 - Disorientation symptoms predominate cybersickness.
 - Oculomotor symptoms predominate simulator sickness.



<https://www.techspot.com/news/52800-omnidirectional-treadmill-lets-you-run-through-your-favorite-games.html>

Other senses



<https://teslasuit.io/the-suit/>



<https://feelreal.com/>

The importance of consistency

- The challenges and issues that we have seen thus far are all results of perturbation to our perceptual systems (not only visual, but also other senses).
- Implementing a system that implements every aspect of reality is one solution.
- But what can you do to mitigate the effects of a lack of sensorimotor contingency without having a completely immersive system?

What you should get out of this session

- What is the fundamental principle behind the design of a truly immersive virtual reality?
 - Sensorimotor contingency – every piece of sensory information should converge to the same environment, virtual or not.

See you next time!