CS/Psych/EdPsych 770 Human-Computer Interaction

# Augmented & Virtual Reality

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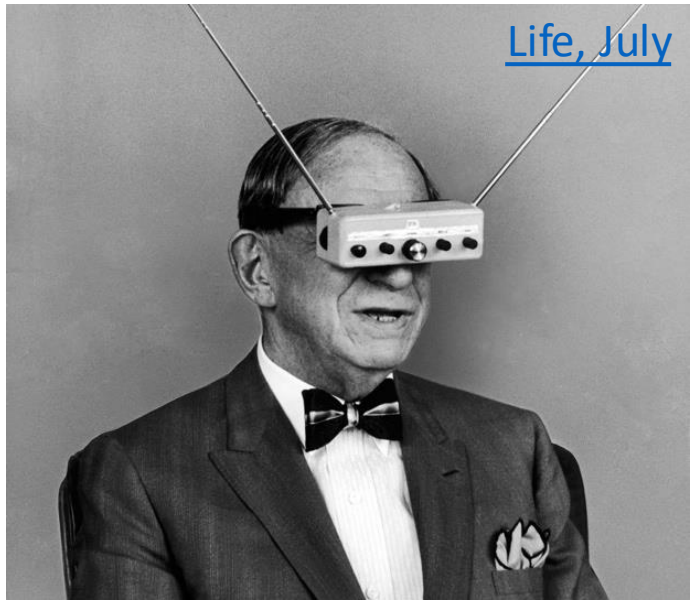
# Today's Agenda

- Topic overview: Augmented & Virtual Reality
- Discussion

# Topic: Augmented and Virtual Reality

# History of AR/VR

- Hugo Gernsback, “Teleyeglasses” concept, 1936
  - A stereo head-worn video display, but without interactive graphics or head tracking
- Ivan Sutherland, Head-tracked AR/VR, 1968
  - Stereo, see-through head-worn display
  - Synthesized imagery combined with view of real world




# What is Virtual Reality (VR)?

- Computer-generated world of virtual media
  - Embodied in 3D space
  - Interactive
  - Tracked relative to user

Image Source: OculusRift VR

# What is Augmented Reality (AR)?

- **Definition**: AR is a technology which (1) combines real and virtual imagery, (2) is interactive in real time, and (3) registers the virtual imagery with the real world.

Unlike VR, AR ***supplement*** rather than ***replace*** the real world

Image source: Epson Moverio BT-300

R.T. Azuma. A survey of augmented reality. Presence: Teleoperators and Virtual Environments 6:4, 355-385, 1997

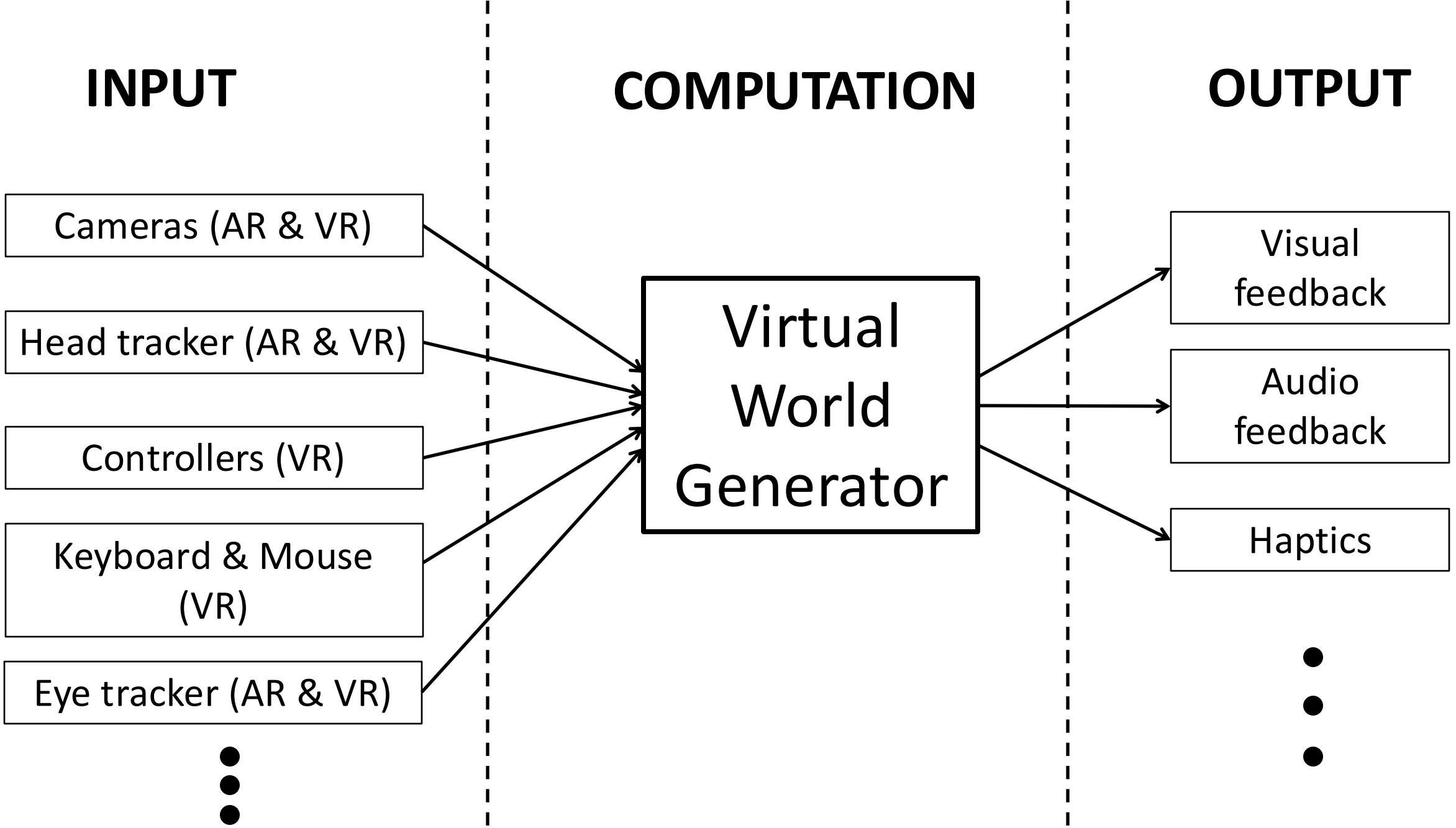

https://www.youtube.com/watch?v=E6eYQH3PtDk

# Different types of AR

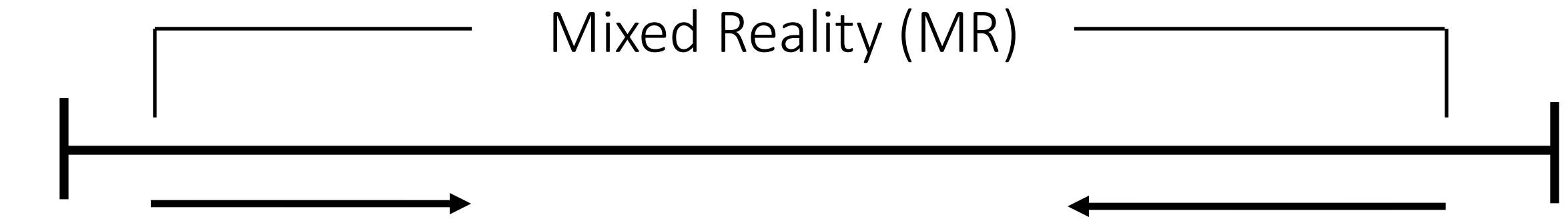
- Mobile AR
- See-through head-mounted displays (HMDs)
  - Video see-through AR (e.g., Apple Vision Pro)
    - Wider field of view; more flexibility in manipulation
  - Optical see-through AR (e.g., Microsoft HoloLens)
    - Narrower field of view; reduced motion sickness
- Projection-based AR
  - Stationary
  - Handheld/wearable

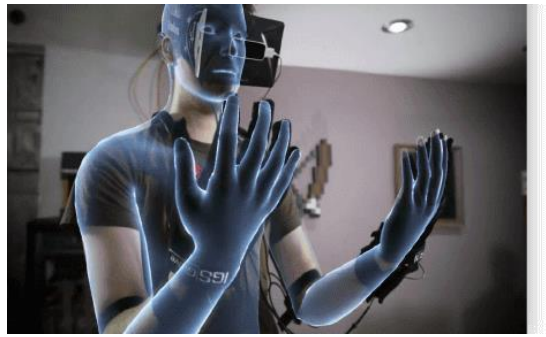
Image source: 1, 2

Harrison, Chris, Hrvoje Benko, and Andrew D. Wilson. "OmniTouch: wearable multitouch interaction everywhere." *Proceedings of the 24th annual ACM symposium on User interface software and technology*. 2011.


INPUT
COMPUTATION
OUTPUT
Cameras (AR & VR)
Head tracker (AR & VR)
Controllers (VR)
Keyboard & Mouse (VR)
Eye tracker (AR & VR)
Virtual World Generator
Visual feedback
Audio feedback
Haptics

# Reality-virtuality continuum

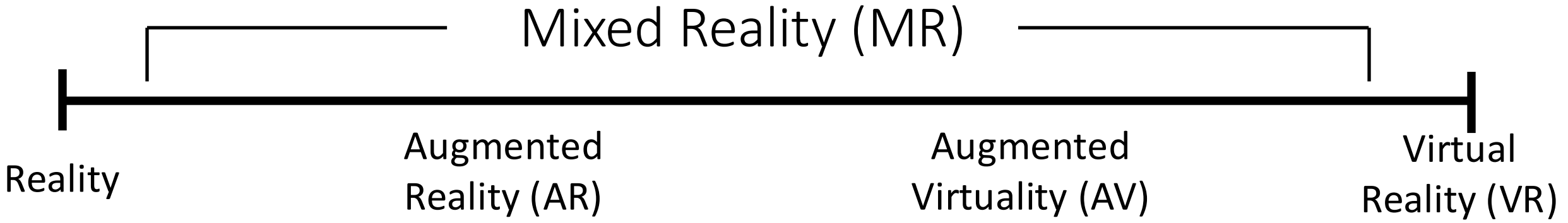


Milgram, Paul, et al. "Augmented reality: A class of displays on the reality-virtuality continuum." *Telemanipulator and telepresence technologies*. Vol. 2351. International Society for Optics and Photonics, 1995.

# Reality-virtuality continuum

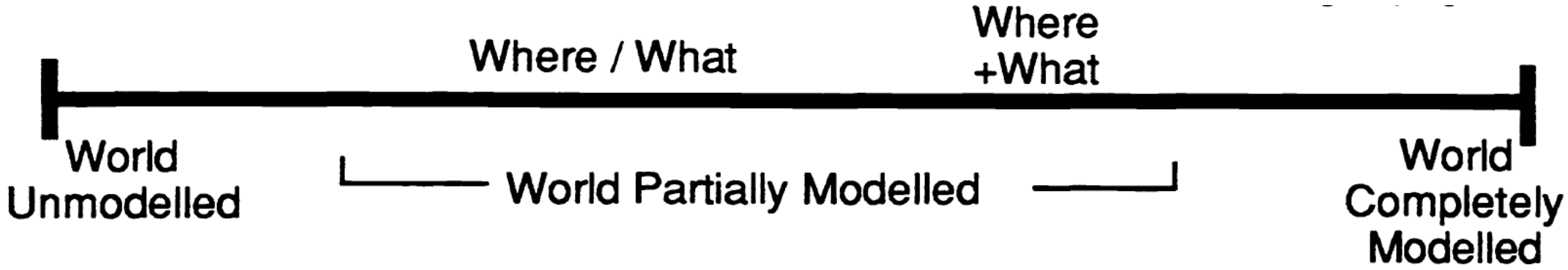
- VR: completely synthetic world
- MR: real world and virtual world presented (and experienced) together
- AR: principally real environment with added computer-generated content
- AV: principally virtual environment with added real content



# Three properties to consider

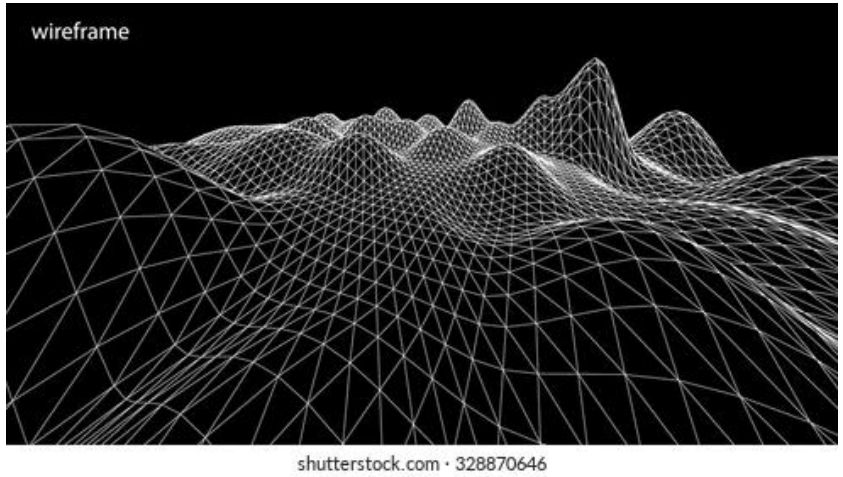
- **Reality**: whether the environment is primarily virtual or primarily real; e.g., AR ↔ AV
- **Immersion**: the extent to which the observer (or user) is immersed within the environment; e.g., Egocentric ↔ Exocentric
- **Directness**: whether primary world objects are viewed directly or by means of some electronic synthesis process; Directly (e.g., optical see-through) ↔ Synthesized (e.g., video see-through)

# Taxonomy: Extend of World Knowledge

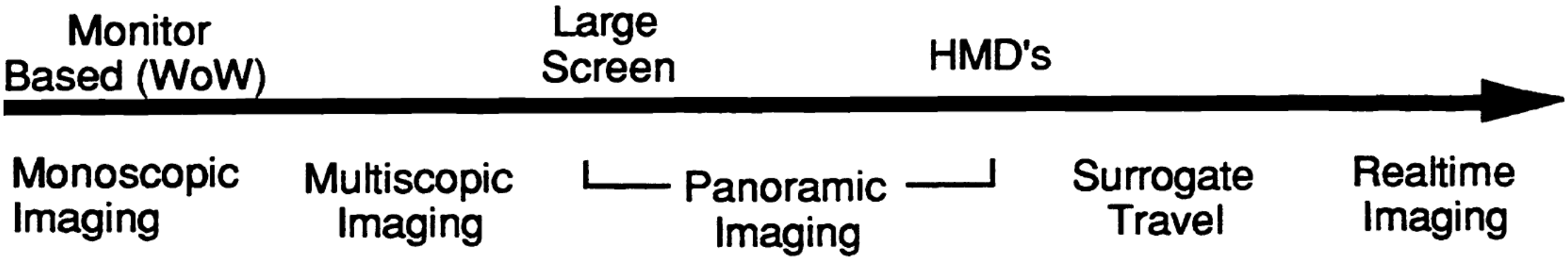


# Taxonomy: Reproduction Fidelity (RF)

| Conventional (Monoscopic) Video | Colour Video | Stereoscopic Video | High Definition Video | 3D HDTV |
|---|---|---|---|---|
| Simple Wireframes | Visible Surface Imaging | Shading, Texture, Transparency | Ray Tracing, Radiosity | Real-time, Hi-fidelity, 3D Animation: Photorealism |




# Taxonomy: Extent of Presence Metaphor



# 3D UI Design Space

- Objects
- Space
- Actions
- Users
- Tasks: locomotion; target acquisition, etc.
- Collaboration: collocated/remote

# Barriers to 3D UI

- 3D rendering (interactive, shaded graphics)
- 3D interaction techniques: tradeoff between complexity and familiarity
- Tracking & sensing: real-time, accuracy
- Hardware
  - Limited field of view; size/weight; appearance, cost
- VR sickness

# What is the state-of-the-art in research and industry?

# Sensing & tracking techniques

- Vision-based tracking
- Controllers
- Hand-worn devices

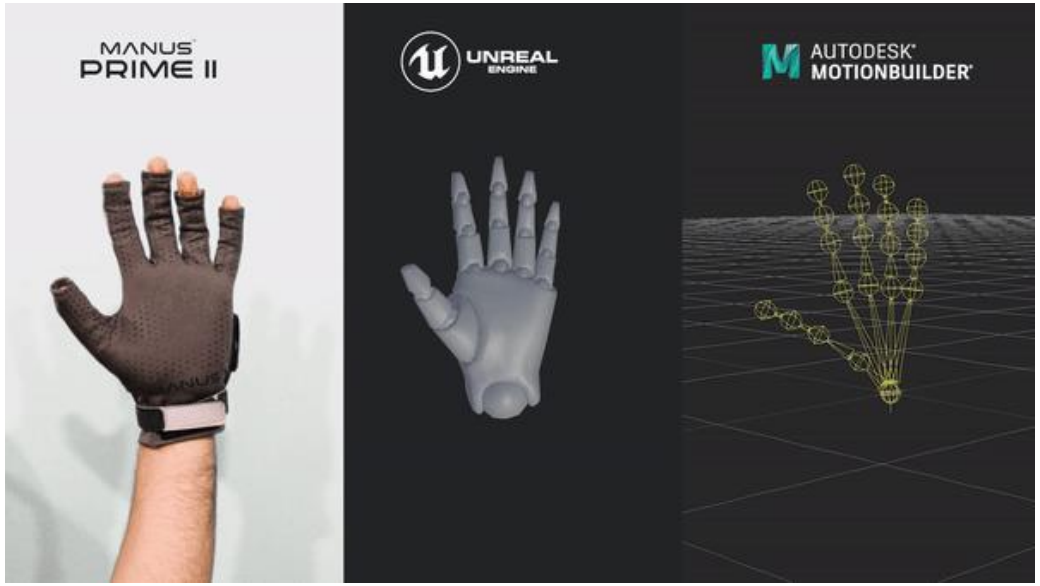




Image sources: MANUS, Oculus, Vive, Sony PlayStation VR controller

Sra et al. "Breathvr: Leveraging breathing as a directly controlled interface for virtual reality games." *CHI* 2018.

# Enhanced feedback

- Visual
- Audio
- Haptics
- Thermal
- …


Xiao, Robert, and Hrvoje Benko. "Augmenting the field-of-view of head-mounted displays with sparse peripheral displays." *CHI 2016.*.


Fang, Cathy, et al. "Wireality: Enabling complex tangible geometries in virtual reality with worn multi-string haptics." *CHI 2020*

# 3D interaction techniques

- Object manipulation
- Text entry
- Navigation/locomotion: teleporting, redirected walking, avatar scaling, etc.
- …


Fashimpaur, Jacqui, Kenrick Kin, and Matt Longest. "PinchType: Text Entry for Virtual and Augmented Reality Using Comfortable Thumb to Fingertip Pinches." *CHI EA'20*.


Zhao, et al. "Enabling people with visual impairments to navigate virtual reality with a haptic and auditory cane simulation." *CHI 2018*.

# Integrating AI into XR


Dogan, Mustafa Doga, Eric J. Gonzalez, Karan Ahuja, Ruofei Du, Andrea Colaço, Johnny Lee, Mar Gonzalez-Franco, and David Kim. "Augmented object intelligence with xr-objects." In *Proceedings of the 37th Annual ACM Symposium on User Interface Software and Technology*, pp. 1-15. 2024.

# Discussion

- What AR/VR/MR devices have you used? How's your experience?
- What opportunities do AR/VR present? What fields can this technology be applied to?
- What are the benefits and weaknesses of different AR/VR devices? Mobile vs. optical see-through vs. video see-through vs. projection-based? How do you select devices in your research?
- What challenges do AR/VR pose? How should we overcome these challenges?