Immersion, Presence, Self-Perception and Avatars

02.15.2024

The First Introduction of VR

- VR was first introduced in a concept paper
- Ivan Sutherland 1965: ”The Ultimate Display”
- Ivan Sutherland 1968: “A head-mounted three dimensional display”
- Even in this old system, Sutherland says the 3D effect felt “***real***”.
- Evoking ***presence***

https://dl.acm.org/doi/pdf/10.1145/1476589.1476686

Immersion & Presence

- Brooks ’99: “What’s Real About Virtual Reality?”
- Immersion vs Presence
  - Immersion: Sense of being engaged in VR systems/activities somewhere in a flow state
  - Presence (aka “being there”): refers to psychological feeling of being in a different place than what you’re physical in
- Brooks describes it as the ***illusion*** of presence

3 NASA-Houston’s “Charlotte” Virtual Weightless Mass lets astronauts practice handling weightless massy objects.

Courtesy of NASA

Courtesy of Georgia Institute of Technology

4 Vietnam war simulation at the Atlanta Veterans Administration Hospital (a) in use. (b) Imagery seen by the user.

https://www.cs.unc.edu/~brooks/WhatsReal.pdf

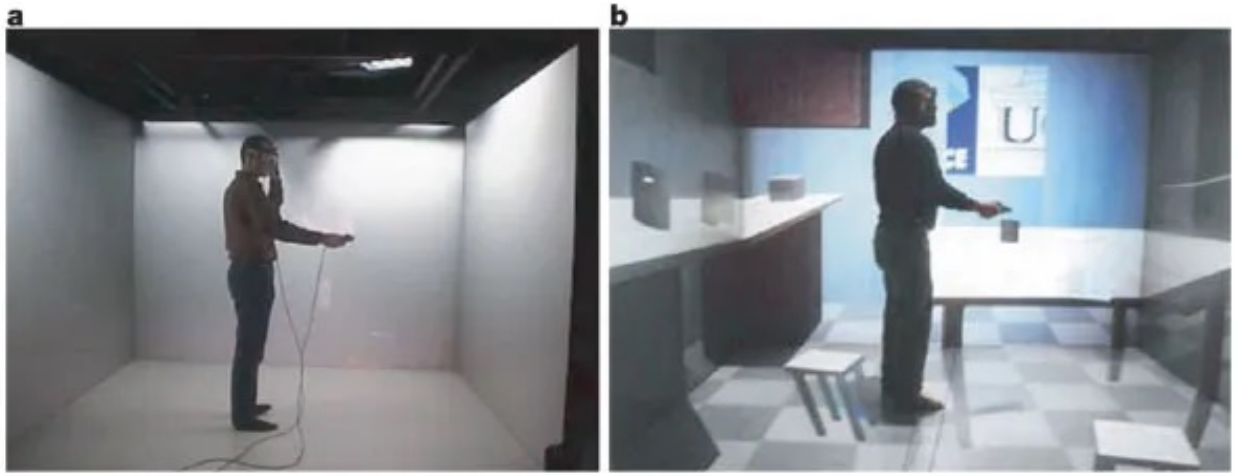
Place & Plausibility Illusions

- Mel Slater ’09: “Place illusion and plausibility can lead to realistic behavior in immersive virtual environments”
  - Great paper on formalizing VR psychological concepts
- Slater refers to presence as “***place illusion***”, the illusion that you are somewhere else instead of in some lab
- “***Plausibility illusion***”: what is happening in the VE is actually happening and you’re not just a third-party observer
  - Being in VR should feel different then watching a movie on a screen

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2781884/

Immersion & Presence

- Sanchez-Vives ’05: “From presence to consciousness through virtual reality” and Meehan ‘02: “Physiological Measures of Presence in Stressful Virtual Environments”
  - Argue that presence has strong connection to neuroscience and is measurable
  - Sanchez-Vives: Psychological measurements
  - Meehan: Physiological measurements



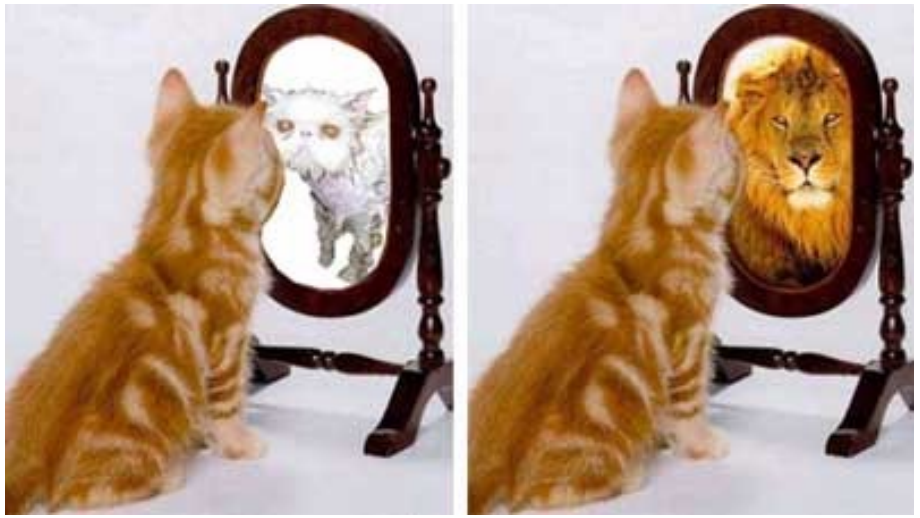
https://www.nature.com/articles/nrn1651
http://www.cs.unc.edu/~whitton/ExtendedCV/Papers/2002-SIGGRAPH-meehan.pdf

Physiological Responses

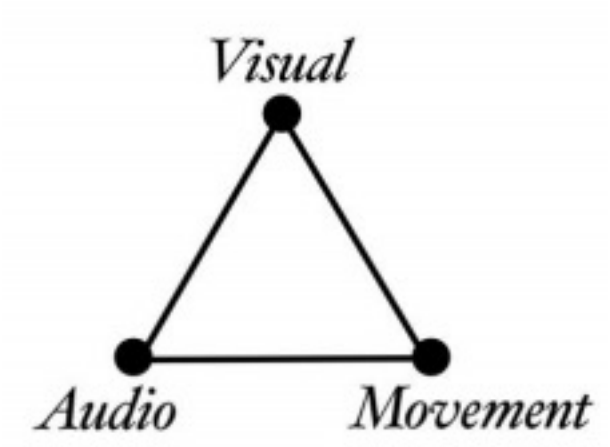
- They had a user drop some items in to a pit
- Passive haptics: exact match between virtual and physical object
  - Users standing on a ledge in real life/ physical environment (PE) and VE
- Findings:
  - Heart rate and skin conductance (e.g. sweating) good objective indicators of presence (esp. Heart rate), but not skin temperature
    - Some people get cold when stressed, others heat up

Perception of Self

- In general, the more you feel like yourself or the character you're controlling (avatar), the more immersed you are
  - E.g. You can still be immersed in a low-poly game if you can be convinced that you 'ARE' a character in that world
- Can accomplish this in many ways:
  - Accurate 1-to-1 perception (motion, vision, audio, etc.)
  - Smoke & Mirrors (trickery and manipulation)
  - Physics/impact on world (look at BoneWorks/Alyx)
  - Good avatar design
  - Etc.
- General idea:
  - 1. Trick people into thinking they're someone else (an avatar)
  - 2. Trick people into thinking they're somewhere else(an immersive VE)
  - State-of-the-art research suggests people are mentally more flexible than you would expect.



“The Immersive VR Self”
Schwartz ‘18 (Oculus)



- Elements of the accurate virtual avatar
  - Visual: perspective-correct visual representation
  - Audio: spatialized sounds
    - Generalize to accurate audio field, good HRTFs, traversal, etc.
  - Movement: physical body gestures
    - HOWEVER, gestures are not the only important factor as this paper suggests.

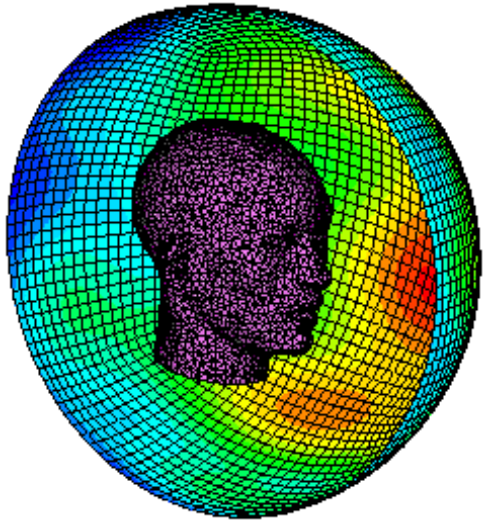
https://research.fb.com/wp-content/uploads/2018/02/the-presentation-of-self-in-immersive-virtual-environments.pdf

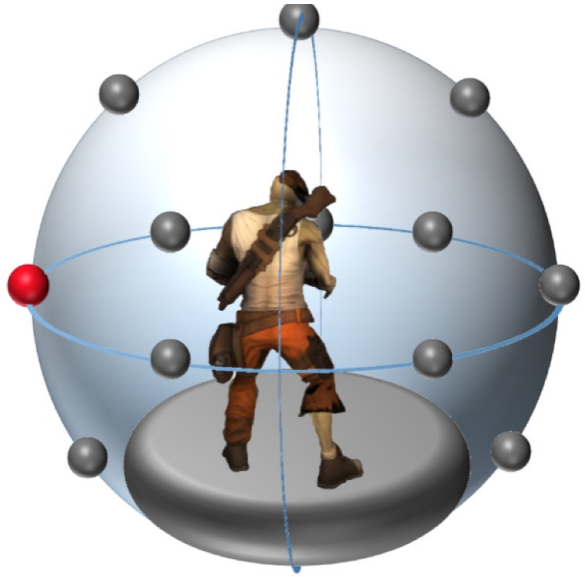
Visuals

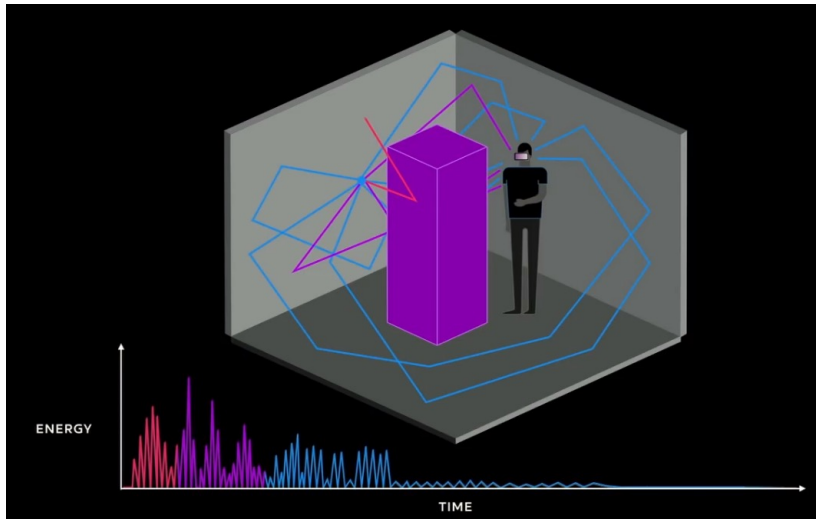
- High-resolution
  - Prevent ”screen door effect”, where resolution is so low, individual pixels are visible and make you feel like looking through a screen door
- High Frame rates
  - At least 60 fps for most cases
  - 90 fps+ even better
- In many cases, high visual fidelity/nice graphics (but not necessary)

Audio

- Accurate HRTFs that estimate ear parameters and how audio bounces
- 3D spatialized audio
  - Audio source always sounds like it’s in the right place
- Propagation/Filters
  - Audio responds accurately to dynamics and parameters of the environment





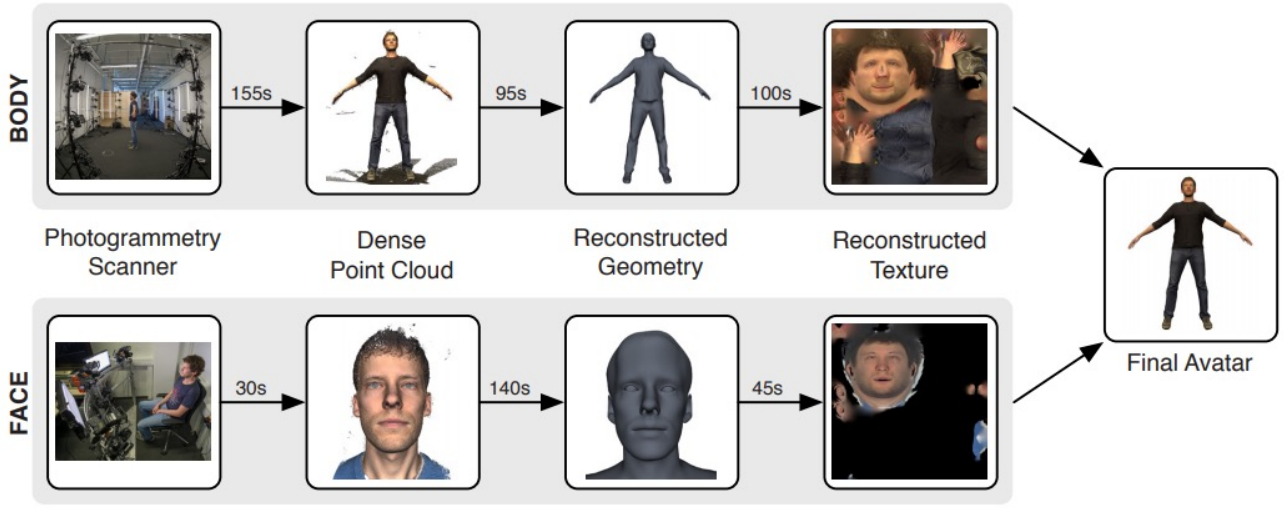


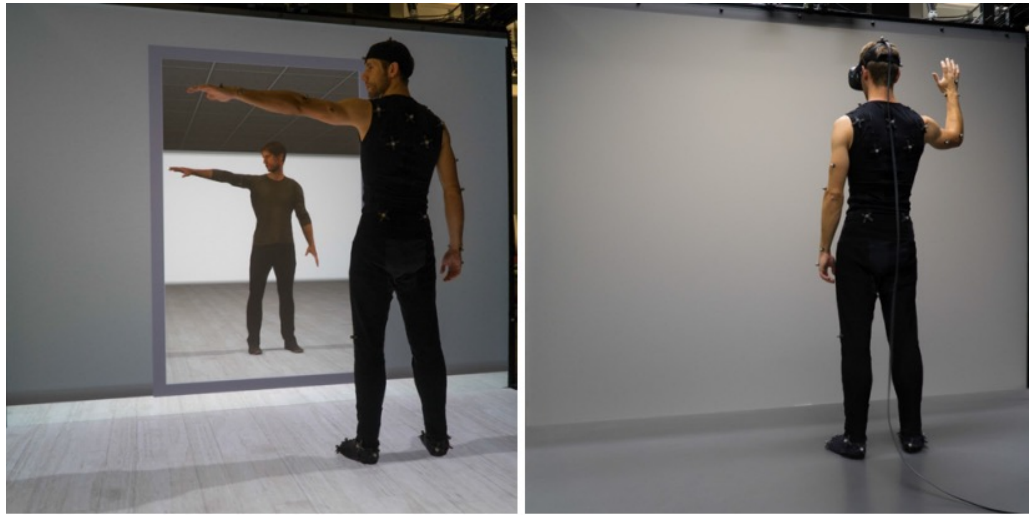
Movement/Motion Accuracy

- Reconstruction of limbs
  - Hands/head in right place
  - Resolution (or framerates) reasonable
  - Later in lectures, we will introduce inverse kinematics (IK)
  - Handling clipping
- Accurate 1-to-1 motions
  - More like 1-to-(1 minus threshold) motions… usually some leeway
  - Any kind of distortion should never be noticeable
  - Alterations of the scene should not be obvious
  - Phantom limbs & extra appendages are possible if we convince the user they are controlling them
  - The term “ownership” often used

Avatars and “Ownership”

- From Waltemate ‘18: “The impact of Avatar Personalization and Immersion on Virtual Body Ownership, Presence, and Emotional Response”
  - Personalized avatars significantly increase feeling of ownership
  - Ownership and presence are correlated





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Multi-modal

- Appealing to multiple senses.. or “Modes’ of interactions
- Multimodal applications tend to be the most immersive
    - Goal of VR is to replace sensory data with synthetic stimuli

Smokes and Mirrors

Trickery to create sense of presence,
place illusion, & plausibility illusion

Literal Mirrors

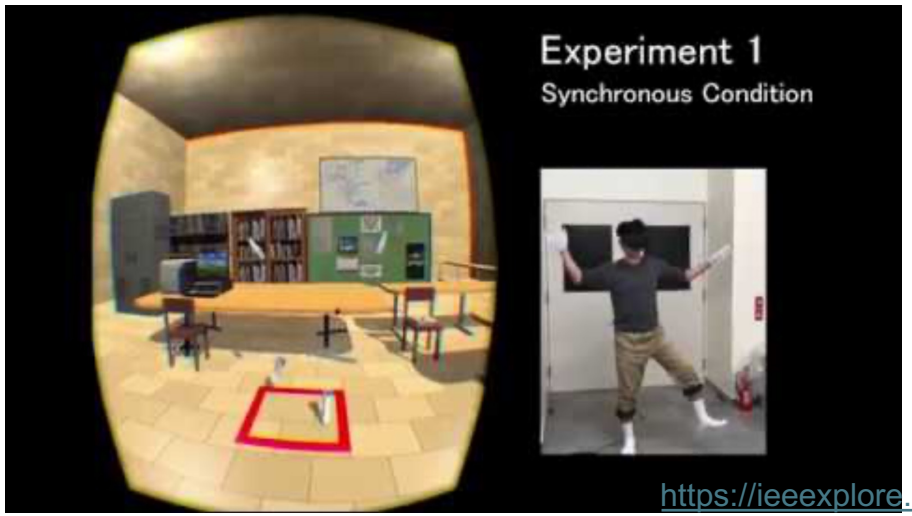
- Used for pain management
  - Transitioning from having a limb to not having one
  - Burn victims: convince them they’re somewhere cold
  - Stroke recovery (Lupu 2016): Try to replicate a target pose and provide feedback

Similar to Lupu ‘16’s idea

https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=7790681

Literal Mirrors

- Used to convince user of body ownership
  - E.g. weird paper, “Human Tails” Steptoe 2013
  - Found that the body motion itself was good enough to convince user of ownership
- Low-latency reconstruction of entire body best to get best ownership
  - (“Illusory body ownership of an invisible body interpolated between virtual hands and feet via visual-motor synchronicity” by Kondo ‘18)

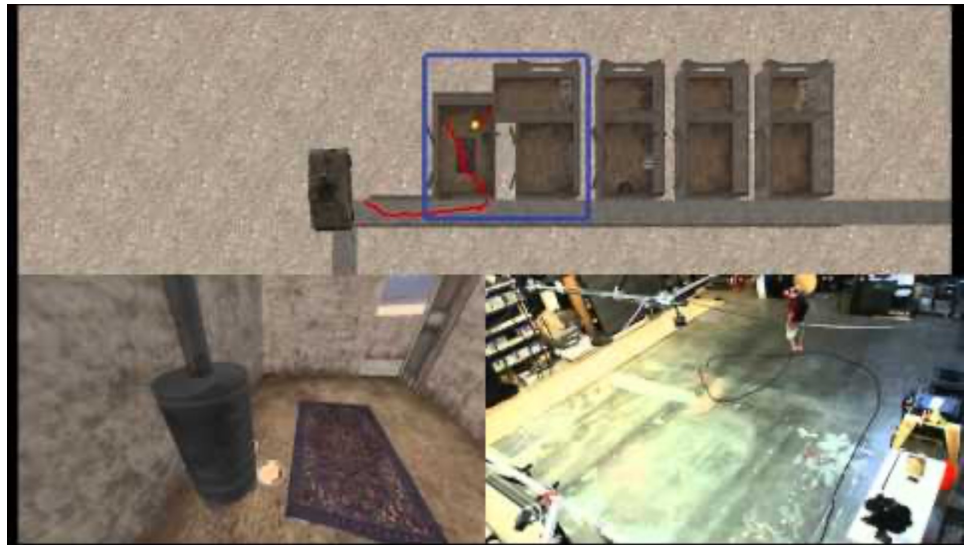


https://ieeexplore.ieee.org/document/6479185

https://www.nature.com/articles/s41598-018-25951-2

“Smokes”

- Objects of interest & distortion
- Lack of interest in parts of the scene can be used to distort it
  - E.g. Change blindness
  - Cool idea: imagine if we could use eye-tracking to figure out which areas to distort
- Can mess with mental maps
  - (e.g. Peck 2011: “The Design and Evaluation of a Large-Scale Real-Walking Locomotion Interface”)



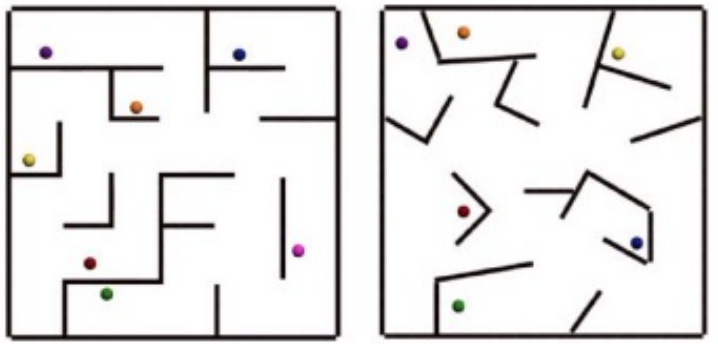
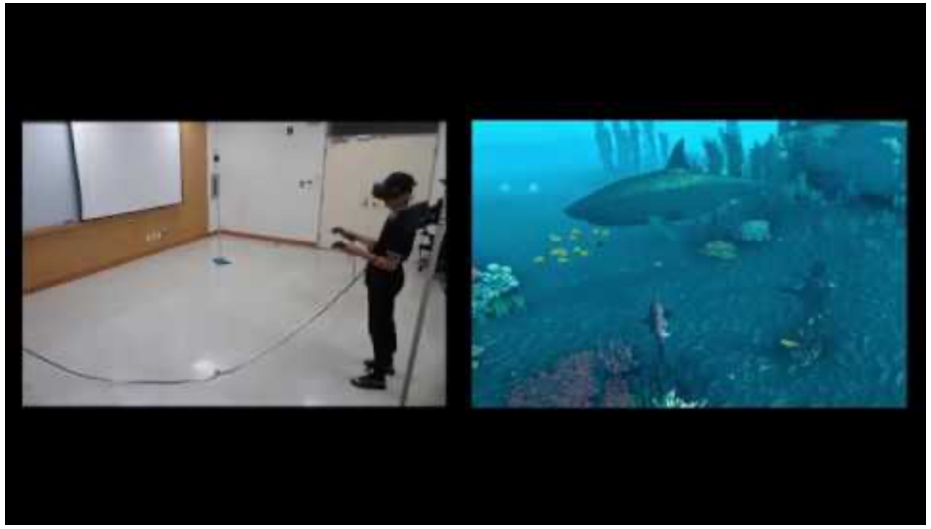


Fig. 5. The 15.85 m × 15.85 m virtual mazes used in this study. Left: the maze used during the naive search with seven targets. Right: the maze used during the primed search with six targets. Participants started each maze in the bottom left corner.

“Smokes”

- Simulating haptics
  - Leveraging the dominance of vision when our senses conflict
    - E.g. Haptic Retargeting: a single physical prop can provide passive haptics for multiple virtual objects
    - E.g. Changing the limbs velocity to simulate the sense of drag force under water

Haptic Retargeting, Azmandian et al., CHI’16



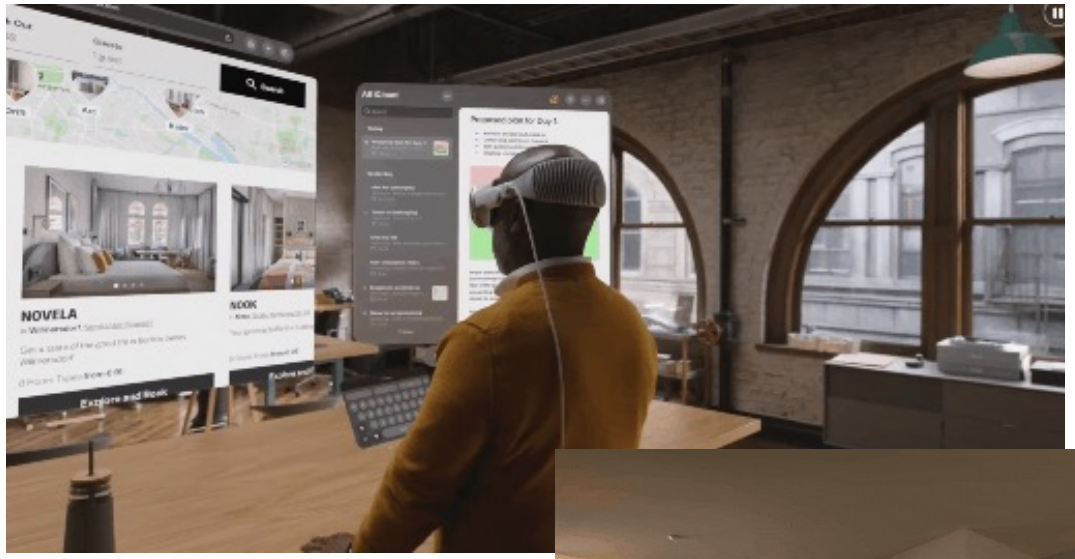
Pseudo-Haptic Drag Force, Kang et al., IEEE VR ‘19

Telepresence

- Related to VR & presence
- Idea that multiple people can be in different physical places but feel like they're sharing the same place
  - Raskar 1999: "The Office of the Future"
  - Holoportation by Microsoft

Figure 1: A conceptual sketch of the *office of the future*. By replacing the normal office lights with projectors, one could obtain precise control over all of the light in the office. With the help of synchronized cameras, the geometry and reflectance information can be captured for all of the visible surfaces in the office so that one can project images *on* the surfaces, render images *of* the surfaces, or interpret changes *in* the surfaces. The inset image is intended to help differentiate between the projected images and the real objects in the sketch.

Telepresence



Measuring Presence
Slater-Usoh-Steed (Usoh 200)

- Standard presence questionnaire

1. Please rate *your sense of being in the* office space, on the following scale from 1 to 7, where 7 represents your *normal experience of being in a place*.
   I had a sense of "being there" in the office space:
   1. Not at all ... 7. Very much.
2. To what extent were there times during the experience when the office space was the reality for you?
   There were times during the experience when the office space was the reality for me...
   1. At no time ... 7. Almost all the time.
3. When you think back about your experience, do you think of the office space more as *images that you saw*, or more as *somewhere that you visited*?
   The office space seems to me to be more like...
   1. Images that I saw ... 7. Somewhere that I visited.
4. During the time of the experience, which was strongest on the whole, your sense of being in the office space, or of being elsewhere?
   I had a stronger sense of...
   1. Being elsewhere ... 7. Being in the office space.
5. Consider your memory of being in the office space. How similar in terms of the *structure of the memory* is this to the structure of the memory of other *places* you have been today? By 'structure of the memory' consider things like the extent to which you have a visual memory of the office space, whether that memory is in colour, the extent to which the memory seems vivid or realistic, its size, location in your imagination, the extent to which it is panoramic in your imagination, and other such *structural* elements.
   I think of the office space as a place in a way similar to other places that I've been today...
   1. Not at all ... 7. Very much so.
6. During the time of the experience, did you often think to yourself that you were actually in the office space?

Measuring Presence
Data Analysis

- Independent variable:
  - Experimental variables: which group they are in, can be directly manipulated by reserachers
  - Subject variables: meta data (e.g. user ID), cannot be manipulated by researchers
- Dependent variable
  - Variable that changes as a result of the independent variable manipulation
  - The outcome you're interested in measuring

	A	B	C	D	E	F	G	H
1	User ID	FOV	Q1	Q2	Q3	Q4	Q5	Q6
2	1	45	1	2	2	3	3	4
3	2	45	4	4	2	1	1	2
4	3	45	3	2	1	1	2	6
5	4	90	7	7	6	6	7	7
6	5	90	7	6	5	5	6	7
7	6	90	6	5	7	7	7	5

Measuring Presence
Data Analysis

- Count highs & convert to binary
  - 6-7 is “high” response, the one I’m trying to prove. Hence, 6-7 maps to 1 and other values map to 0
  - We bias the questionnaire in favor of null hypothesis: hypothesis that this condition does ***NOT*** matter

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	User ID	FOV	Q1	Q2	Q3	Q4	Q5	Q6	Q1Binary	Q2Binary	Q3Binary	Q4Binary	Q5Binary	Q6Binary
2	1	45	1	2	2	3	3	4	0	0	0	0	0	0
3	2	45	4	4	2	1	1	2	0	0	0	0	0	0
4	3	45	3	2	1	1	2	6	0	0	0	0	0	1
5	4	90	7	7	6	6	7	7	1	1	1	1	1	1
6	5	90	7	6	5	5	6	7	1	1	0	0	1	1
7	6	90	6	5	7	7	7	5	1	0	1	1	1	0

Measuring Sickness
Simulator Sickness Questionnaire (Kennedy 1993)

- Standard questionnaire to ask pre- and post- experiment

General discomfort	None	Slight	Moderate	Severe
Fatigue	None	Slight	Moderate	Severe
Headache	None	Slight	Moderate	Severe
Eye strain	None	Slight	Moderate	Severe
Difficulty focusing	None	Slight	Moderate	Severe
Increased salivation	None	Slight	Moderate	Severe
Sweating	None	Slight	Moderate	Severe
Nausea	None	Slight	Moderate	Severe
Difficulty concentrating	None	Slight	Moderate	Severe
“Fullness of the head”	None	Slight	Moderate	Severe
Blurred vision	None	Slight	Moderate	Severe
Dizzy (eyes open)	None	Slight	Moderate	Severe
Dizzy (eyes closed)	None	Slight	Moderate	Severe
Vertigo (Giddiness)	None	Slight	Moderate	Severe
Stomach awareness	None	Slight	Moderate	Severe
Burping	None	Slight	Moderate	Severe

Measuring Sickness
Data Analysis

- Calculate categories
  - Nausea, oculomotor, disorientation, total sickness
- ([weights]*[user's responses from 0-3])*value provided below
- Run analysis on resulting categoreis

SSQ Symptom	Weight		
	N	O	D
General discomfort	1	1	
Fatigue		1	
Headache		1	
Eyestrain		1	
Difficulty focusing		1	1
Increased salivation	1		
Sweating	1		
Nausea	1		1
Difficulty concentrating	1	1	
Fullness of head			1
Blurred vision		1	1
Dizzy (eyes open)			1
Dizzy (eyes closed)			1
Vertigo			1
Stomach awareness	1		
Burping	1		
Total	[1]	[2]	[3]

$$N = [1] \times 9.54$$
$$O = [2] \times 7.58$$
$$D = [3] \times 13.92$$
$$TS = ([1] + [2] + [3]) \times 3.74$$