

VR First Introduced in a Concept Paper

• Ivan Sutherland 1965: "The Ultimate Display"

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

- Ivan Sutherland 1968: "A head-mounted three dimensional display"
- Even in this old system, Sutherland says the 3D effect felt "real."
- Evoking "presence"



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 physically in



Place & Plausibility Illusions

- Mel Slater 2009: "Place illusion and plausibility can lead to realistic behaviour 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 than watching a movie on a screen



Immersion & Presence

Sanchez-Vives '05: "From presence to consciousness through virtual reality" and Meehan 2002: "Physiological Measures of Presence in Stressful Virtual Environments"

Argue that presence has strong connection to neuroscience and is measurable

- Sanchez-Vives: Psychological measurement
- Meehan: Physiological measurements





Physiological responses

- They had a user drop some items into 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 indicat of presence (esp. Heart rate), but not skin temperature
 Some people get cold when stressed, some 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* 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 2018 (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 gesture HOWEVER, gestures are not the only important factor as this paper suggests



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 (Review)

- 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 & parameters of the environment)



Movement/Motion Accuracy Reconstruction of limbs • Hands/head in right place Resolution (or frame rates) reasonable Later in lectures, we'll 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 E.g. Change blindness Phantom limbs & extra appendages are possible if we convince the user they are controlling them The term "ownership" often used

• 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

"Multimodal"



Avatars and "Ownership"

From Waltemate 2018: "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 correlated



Distinguished Lecture on XR

Measuring What Matters: Lessons Learned From Taking Virtual Human Patients from Ideation to Realization

> Prof. Ben Lok University of Florida & Shadow Health

> > 3:30pm @ IRB 4105 Thursday, March 3rd

Smoke & 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







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



"Smoke"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 15.65 m × 15.85 m v/riad mazes used in this study. Left: the maze used during the naive search will serve targets. Figs: the maze used during the primed search with the targets. Artificiants stander each

Telepresence

- Related to VR & presence....more on it when we talk about AR
- Idea that multiple people can be in different physical places but feel like they're sharing the same place
- E.g. Raskar 1999: "The Office of the Future"
- E.g. Holoportation by Microsoft .





Measuring Presence: Slater-Usoh-Steed (Usoh 2000)

Standard presence questionnaire

- Please rate your errors of leving in the office space, on the following scale from 1 to 7, where 7 represents your around experiment of leving in a place.
 I. Net at all ... You presch.
 To what extent were there times during the experience when the office space was the reality for you?

 - To show return twee them times during the experience when the effice space was the reality for you? *Nars wave inten during the experience when the effice space was the reality for me.*. 1. At an inter. J. Advanial the times due do you think of the office space more as integrate *the efficiency of the efficienc*



Count Highs/Binary

- Count highs & convert to binary
 - 6-7 is the "high" response, the one I'm trying to prove. So 6-7 maps to 1 and others map to 0 We bias the questionnaire in favor of null hypothesis that this condition does NOT matter. 4-5 are iffy/uncertain so they are NOT high responses.
 - · Like in court (unless you're rich), burden of proof lies on us so biased against the accuser

í	A	B	С	D	E	F	G	H	1.1	1	K	L	M	N
	User ID	FOV	Q1	Q2	Q3	Q4	Q5	Q6	Q1Binary	Q2Binary	Q3Binary	Q4Binary	Q5Binary	Q6Binary
	1	45	1	2	2	3	3	4	0	0	0	0	0	
	2	45	4	4	2	1	1	2	0	0	0	0	0	
	3	45	3	2	1	1	2	6	0	0	0	0	0	
	4	90	7	7	6	6	7	7	1	1	1	1	1	
	5	90	7	6	5	5	6	7	1	1	0	0	1	
	6	90	6	5	7	7	7	5	1	0	1	1	1	

Measuring Sickness: Simulator Sickness Questionnaire (Kennedy 1993)									
Ask these questions before an	nd after	study							
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: Simulator Sickness Quest	ionnaire (Kenn	edy	199	93)		
		Weight				
 Calculate categories (nausea, oculomotor, 	SSQ Symptom	N	0	D		
disorientation total sicknoss)	General discomfort	1	1			
uisonemation, total sickness)	Fatigue		1			
 ([weights]*[user's responses from 0-3])*value 	Headache		1			
	Eyestrain		1			
provided below (9.54, 7.58, 13.92, 3.74)	Difficulty focusing		1	1		
	Increased salivation					
 Run analysis on resulting categories 	Sweating	1				
	Nausea			1		
	Difficulty concentrating	1	1			
	Fullness of head			1		
	Blurred vision		1	1		
	Dizzy (eyes open)			1		
	Dizzy (eyes closed)			1		
	Stomash sworanass			1		
	Burning	1.				
	Total		[2]	[3]		
	Total	1.00	[4]	120		
	N = [1	[1] × 9.54 [2] × 7.58				
	O = [2					
	D = [3	× 13.9	2			
	TS = ([1] + [1])	$[1] + [2] + [3]) \times 3.74$				

Short Demo

Using JASP