

A photograph of a person wearing an Oculus Rift VR headset, looking upwards with a surprised or engaged expression. They are wearing a white t-shirt with a graphic of two hands. Their hands are resting on a black keyboard. The background is dark, suggesting an indoor setting like a studio or lab.

IMAGINATION
SEMINAR

VR WORLDMAKING with OCULUS RIFT

일시 | 2016년 7월 15일 금요일 오전 10시

강사 | Prof. Graham Wakefield

장소 | 신영균 스튜디오 (X432)

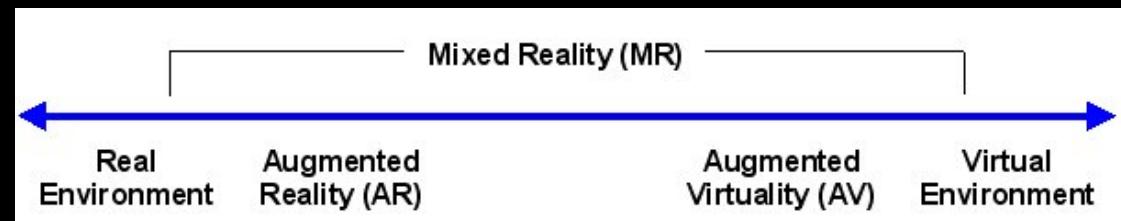
주관 | 교육부 아트&테크놀로지 특성화 사업단

ART&TECHNOLOGY
SOGANG UNIVERSITY

Graham Wakefield

York University:

- Assistant Professor, Computational Arts, Visual Art & Art History
- Canada Research Chair (II) Interactive Information Visualization
- Alice lab for Computational Worldmaking
- Sensorium, Centre for Vision Research ORUs
- Artificial Nature (w/ Prof. Ji)
- Cycling '74



The virtuality continuum ranges between the completely virtual and the completely real. The concept was first introduced by Paul Milgram and Fumio Kishino in 1994.

It places both Augmented Reality (including lens, screen, and projected variants) and Virtual Reality (including HMD and CAVE variants) within a broader set of Mixed Reality.

The VR illusion of non-mediation

- **Persistence of vision.** Plausibly similar images at 12-15 fps fuse into movement.
Plausibility in this case is a function of neurophysiology and cognition.
- **Stereoscopic parallax effect.** Emulating the depth cue due to lateral displacement of eyes, as in 3D cinema. However since there is no screen frame, objects can be right in front of your nose.
- **Head tracking** to register the images seen with the head orientation. The illusion breaks down if the **motion-to-photon latency** is greater than around 10ms. 90 fps is recommended to avoid "judder". If head position is not tracked you cannot look around, over and under things, and there is increased nausea.

Instead of an image moving in front of your eyes, the world appears as a fixed space in which you are moving your own head. Together with the qualities of content, this leads to the evocation of **presence**, the sense of actually being-there in the world, sometimes referred to as the *continuous illusion of non-mediation*.

VR isn't new

1838: Sir Charles Wheatstone invents [stereoscopic photography](#).

1965: Ivan Sutherland pens [The Ultimate Display](#). [Ivan E Sutherland, 1965](#), inspiring everything from the Holodeck to the Matrix.

1968: Ivan Sutherland's Sword of Damocles, widely considered to be the first virtual reality (VR) and augmented reality (AR) head-mounted display (HMD) system. DARPA.



A 3-D trip inside a drawing, via computer graphics

Slip this display device on your head and you see a computer-generated 3-D image of a room before your eyes. Move your head and your perspective changes, just as though you were actually inside the room. Architects could use it to draw buildings in three dimensions; realtors could use it to show buyers the interiors of homes without even leaving the office. Dr. Ivan Sutherland, University of Utah, invented the device, essentially a computer-graphics version of the old stereoscope.

(See also [The Rise and Fall and Rise of Virtual Reality](#))

1985: VR at NASA:

1980's Virtual Reality - NASA Video



6 / 56

The Legible City. Shaw, Jeffrey, 1988.

Jeffrey Shaw: Legible City, Responsive Environment 1988-91



7 / 56

Massive VR hype in the 90's

1991: ABC Primetime covers the VR scene (from vrtifacts.com)

Virtual Reality in 1991



1995: Char Davies' Osmose:

- Char Davies was painter, became co-founder of SoftImage (‐> Autodesk)
- Wanted to **demonstrate medium's potential**, and "aspects related to the medium of "virtual reality" that are often overlooked"

The author calls for a subversion of conventional approaches to VR on the basis that they reinforce an outdated dualist (and masculine) worldview. She redefines immersive virtual space as a medium for de-habituating perception and re-sensitizing us to our own being in the world.

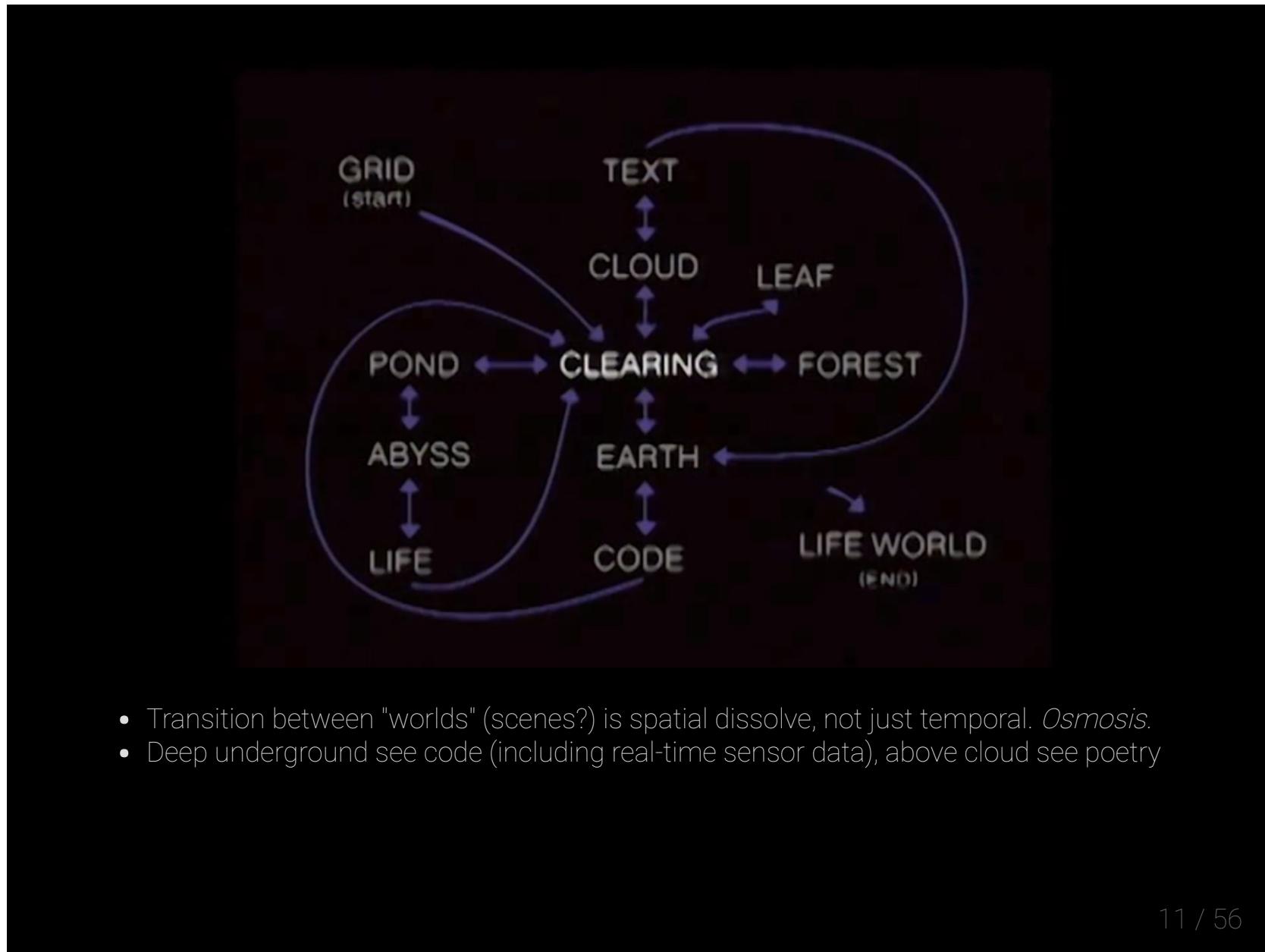
- "Evoke rather than illustrate"; metaphors, avoid solid objects, use translucencies
- Parallels with deep-sea diving (floating, breathing to rise/fall, leaning to move)
- Quote from Bachelard's Poetics of Space



Osmose (1995) - Char Davies - 16 min.



10 / 56



1995: The death of VR

Nintendo releases [VirtualBoy](#) for US\$ 180, and discontinues it just six months later. ("Nail in the coffin for 90's VR")

What went wrong?

- Inadequate Image Resolution
- "Motion to photon latency" too high
- Limited Position Tracking
- Cumbersome Equipment
- Lack of Interpretation of Body Movements
- Simulation Sickness
- Cost
- Slow computers
- Poor software design
- Lack of data/understanding the human body, lack of haptics research etc.
- Premature launches & inflated expectations
- Charlatans
- Concern about liability (user accidents)
- Single-user problem
- No consumer "killer app"

VR went to the CAVE

For the next two decades, VR develops in research labs, was steadily successful and continued to grow in big-budget industrial, science & health research, as well as military training.

"VR was used to visualize oil fields and to visualize machinery to extract oil more efficiently from old fields. Similar things happened in medicine. We understand more about large molecules, we understand more about how the body heals from surgery through VR simulations." - Whatever happened to VR -- interview with Jaron Lanier (2007)



VR went to the garage

2009: A teenage Palmer Luckey announces on a BBS post his home-made Oculus "Rift" HMD.

2011: Now 18, Palmer hacks together a rough prototype in his parents' garage in Long Beach, California.

2012: John Carmack (lead programmer of Doom, Quake, and many other pioneering 3D games) introduces a duct taped head-mounted display based on Luckey's prototype at the Electronic Entertainment Expo. Palmer's company, Oculus VR, launches a [Kickstarter campaign](#) to fund the development of the Rift. It is phenomenally successful, raising US\$2.4 million for the development of the Rift.

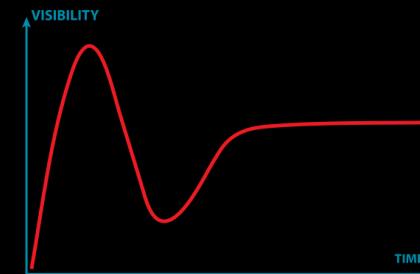
2013: First Oculus Rift developer kit (DK1) ships, for \$300. Developer kits are released to give developers a chance to develop content in time for the Rift's release; these have also been purchased by many virtual reality enthusiasts for general usage.

2014: Second Oculus Rift developer kit (DK2) ships, for \$350. More than 100,000 DK2's have shipped by 2015. Oculus VR is acquired by Facebook for \$2 billion

2016: First consumer version (CV1) shipping, \$600.

2016 "the year of VR"

- Sony, Facebook, Google, Microsoft, Samsung, Valve, nVidia, Apple and many other large corporations are now gambling on VR's success.
- Why now?
 - Technological feasibility & affordability
 - Advances in small displays (thanks to cellphone industry)
 - Advances in 3D graphics (thanks to gaming industry)
 - Gaming industry crisis? Looking for the next big thing?
- Expect a slow rise/uptake. Still not exactly cheap!
- Are we in the beginning of the plateau of productivity, or in another hype cycle?



For more on [hype cycles](#) -- Gartner in 2013 placed the plateau for VR in the 5-10 year range.

Current Hardware

- Desktop-based: Oculus Rift, HTC Vive, (OSVR, etc.)
- Console-based: Sony PlayStation VR
- Cellphone-based: Samsung Gear VR, Google Cardboard, etc.
 - no tracking, lower FPS, but \$99 or less + phone



(Future hardware likely to move toward AR -- Tango, Hololens, Magic Leap...)

16 / 56

Rift | Vive + PC specs

- **Resolution:** 2160 x 1200
 - **Refresh rate:** 90 fps
 - **Field of view:** 110 degrees
-

- **Tracking area:** 5 x 11 feet | 15 x 15 feet
 - **Video:** no input | front-facing camera
 - **Audio:** mic + headphones | mic + headphone jack
 - **Price:** \$600 (without Touch) | \$800 (with controllers)
-

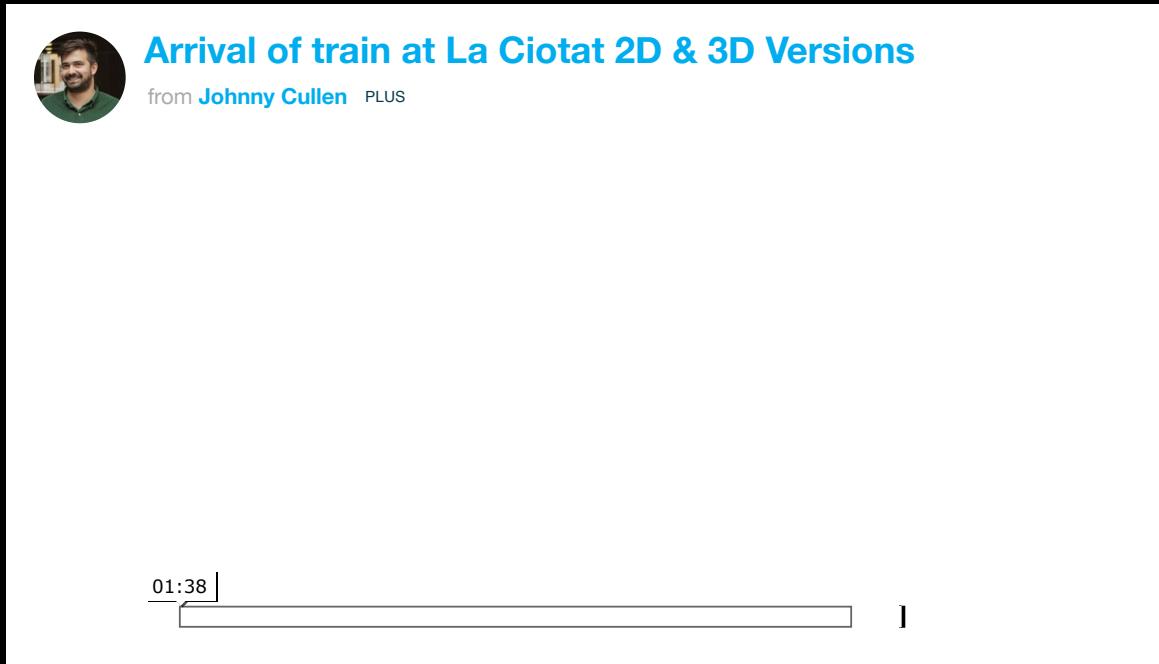
But that price doesn't include the PC... add another \$2000 or so for:

- **GPU:** NVIDIA GTX 970 / AMD R9 290 equivalent or greater
- **CPU:** Intel i5-4590 / AMD FX 8350 equivalent or greater
- **Memory:** 8GB+ RAM
- **Video Output:** HDMI 1.4 or DisplayPort 1.2 or newer
- **USB:** 3x USB 3.0 ports plus 1x USB 2.0 port
- **OS:** Windows 7 SP1 64 bit or newer

Palmer Luckey, Oculus CEO: "I think it will be VR content and software that will drive the industry long term".

Richard Marks, Sony Magic Lab: "Wild West... there are no established genres. You don't get that opportunity very often."

Michael Abrash, Chief Scientist, Oculus: "The future of VR lies in the unique experiences that get created in software, and if I knew what those would be, even in broad outline, I would be very happy."



The train moving directly towards the camera, shot in 1895, was said to have terrified spectators at the first screening, a claim that has been called an urban legend. What most film histories leave out is that the Lumière Brothers were trying to achieve a 3D image even prior to this first-ever public exhibition of motion pictures, and later re-shot the film in stereoscopic 3D, first screened in 1935. Given the contradictory accounts that plague early cinema and pre-cinema accounts, it's plausible that early cinema historians conflated the audience reactions of the 2D and 3D screenings of *L'Arrivée d'un Train*.

360 Video (not VR? not cinema?)

- Forget what you knew about cinema
 - frame, focus, attention
 - cuts & editing in general
- "inside-out" 360
 - Google Jump, JauntVR, VRSE, **many many** others -- a huge boom in 360 cameras right now
 - [Various contributors \(open source\)](#). Making 360. Github, ongoing.
 - where does the crew go?
 - actors are unaware of viewer
 - stitching & stereo artifacts
 - doesn't allow head movement (but light-field cameras like [Lytro Immerge](#))?
 - till, massive interest & investment!

"Outside-in" filming, point-clouds

- markerless mocap / RGB-D cameras
- embed in CG world



21 / 56

RealityCapture LIVE



22 / 56

Think beyond cinema/game...

Birdly

Flying the Birdly Virtual Reality Simulator



24 / 56

Tiltbrush

Tilt Brush: Painting from a new perspective



25 / 56

The Machine to be Another

Be Another Lab



Gender Swap - Experiment with The Machine to Be Another

from [BeAnotherLab](#)

02:35

26 / 56

In the eyes of the animal

In the Eyes of the Animal



IN THE EYES OF THE ANIMALS TEASER

from **Marshmallow Laser Feast** PLUS

01:38

27 / 56

Social

- Is this why Facebook bought Oculus?
- Several VR SecondLifes (e.g. AltSpace)
- VR bangs, VR arcades

Zero Latency VR - Survival Trailer



- Ethics

VR Worldmaking

29 / 56

VR worldmaking software

- **Sandbox platforms** with existing VR support
 - such as Minecraft, SecondLife (see [this collection of Rift-oriented examples](#))
 - limited
- **Browser-based**: MozVR for Firefox or WebVR for Firefox & Chrome
 - combine with browser-based WebGL, e.g. using Three.js
 - performance limitations
- **Game engines**: Unity, Unreal, etc.
 - Large VR community in games, gentle learning curve, lots built-in.
- **Visual programming**: Max/MSP/Jitter, Touch Designer, VVVV, etc.
 - Also gentle learning curve, less built-in (that's a feature!)
- **C++ frameworks**: Cinder, OpenFrameworks, etc.
 - Building upon Oculus / OpenVR etc. C/C++ SDKs
 - See also scientific/engineering frameworks, e.g. VRUI

Unreal

Unreal has long been used in many "AAA" (large-scale/high-production value/high-budget) games, but was open-sourced with an amenable license in early 2015; and now has built-in support for VR and the Oculus Rift.

Creating a quick Unreal Engine 4 Cave Entrance Scene



Note: A lot of visual effects need to be turned off / turned down for VR.

31 / 56

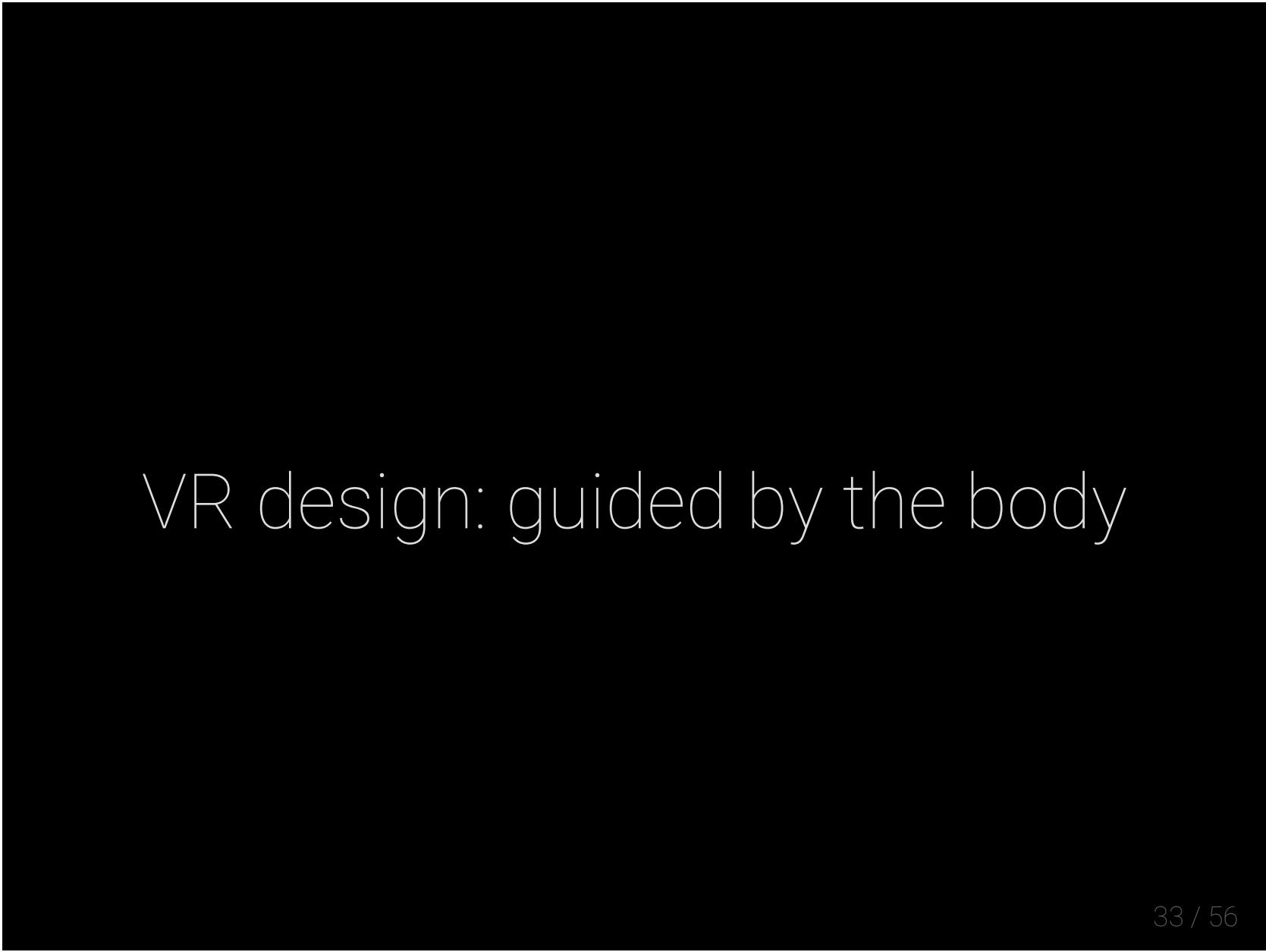
Max/MSP/Jitter

A full kit of creative tools for sound, graphics, music and interactivity in a visual environment. Max is one of the most widely-used platforms for computer music and interactive/digital media art. It originated in work at IRCAM, a computer music laboratory in Paris, over 20 years ago.

In general, what Unreal gives you automatically, in Max you often have to build yourself. But Max will let you do things experimentally, particularly mathematically and generatively, that are much more difficult in Unreal.

https://github.com/worldmaking/Max_Worldmaking_Package - a package for Max/MSP/Jitter to support computational worldmaking.

Supports Oculus Rift and HTC Vive. Just drop it into Documents/Max 7/Packages & restart Max :-)



VR design: guided by the body

33 / 56

Simulator sickness

- Known since the earliest flight simulators of the 1950's, but is still not fully understood.
 - Oculomotor: Headaches, fatigue, eye strain, can't focus
 - Nausea: Sweating, salivation, can't concentrate, burping/stomach awareness
 - Disorientation: Blurry vision, dizziness (with eyes open or closed), vertigo (24%)
- **Cue Conflict Theory** -- what some parts of the visual system are reporting does not match what other sensory components. Probably not the only cause.
- Affects different people in different ways.
 - Younger less susceptible
 - Decreases with exposure
 - Around 5% will never overcome it

Avoiding sim sickness

Maintain low latency, high frame-rate, and tracking

- 90 fps, < 20ms motion-to-photon latency, high accuracy tracking
- Reliably: no dropped frames, no tracking dropouts, etc.
- Demanding on hardware -> simplified content
- (Also low persistence display helps)

Rendering gotchas

- No deferred shading (latency)
- No motion blur, DOF (takes away viewer control)
- No image-based FX (breaks S3D)
- Beware of particle-based effects (look flat)

Avoid overstimulation

- Bright lights/heavy contrast
- Flickering & flashing (esp. in peripheral)
- Avoid large untextured spaces (no depth cues)
- Also avoid high-frequency tiling textures, overly repetitive shapes

Avoiding sim sickness

Never take away head tracking

- No 'cutscenes' / 'cinematics'
- HUDs and overlays need to be in-world
- Don't ever take away user's control of the camera
- (ideally, don't move it)
- Fade out instead of stopping camera to avoid sticking head through walls

Avoiding sim sickness

Especially avoid accelerations (and decelerations, and curves...)

- Vestibular conflict. Rollercoasters!
- Start & stop suddenly is better, no smoothing!
- No head-bob. Avoid stairs. Avoid strafe.
- Better still, don't move
- For seated-VR, even looking behind you is problematic: simple yaw rotation is "VR poison" - John Carmack

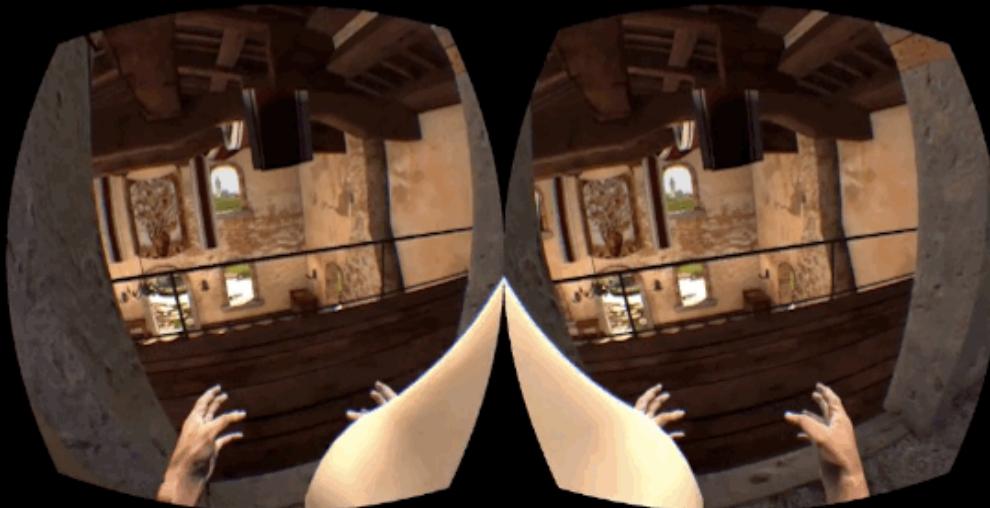
Hence, the locomotion problem

- Some say locomotion is the biggest problem for VR.
- Most of us don't have treadmills (or spherical equivalents)
- Any movements should be much slower than we're used to in games (~1.4 meters per second)
- Even room-scale VR is a fairly small space
- Zoom scopes don't work in first-person
- i.e. **VR is not suited to first-person gaming tropes**

Some "solutions", mostly immersion-breaking

Anchoring: a perceptual frame of reference

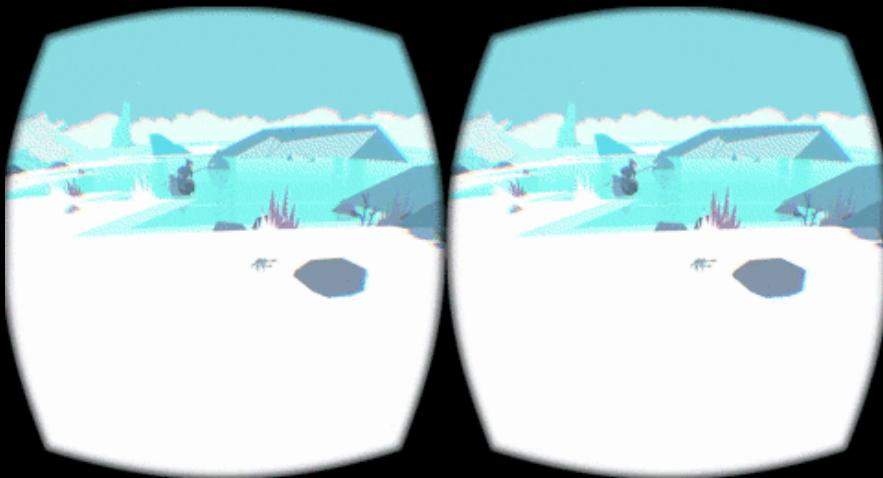
- cockpit-based simulations can handle much greater accelerations
- semi-transparent mesh, only while moving
- a body, even a nose (but issues of mismatch...)



Research at Purdue suggests that overlaying the peripheral image of a nose helps reduce simulator sickness by 13.5%

38 / 56

'Limbo' effect: abstract away world content when moving camera



Jumping between angles

VR Comfort Mode Explained



40 / 56

Point to a place on the floor then teleport

How to explore Vive games using strategic teleportation



41 / 56

Reduce FOV while moving (works by reducing *vection*)



42 / 56

Portal variant

Budget Cuts - Vision Summit 2016 Awards (pre-alpha trailer)

43 / 56

More

Locomotion in VR: Overview of different locomotion methods on H...



44 / 56

Uncanny valleys

- Scale should be accurate, or wildly different
- NPR etc. can have stronger presence
- Characters not looking at you / not responding to you properly
- Sticking your head through walls etc.
- Avatar mismatch. Abstract trumps real - [Valve advice for VR](#)

Use near-space

- 3D depth perception is extremely powerful < 3m.
- With hand-tracking, the 1m radius becomes even more important
- Beyond 10m, stereopsis ceases to be the most important depth cue.
- Beyond 60m there is no difference at all
- Fade out < 10cm, hard to focus, psychological effects

Use spatial audio!

- Headphone audio should use head orientation, ideally HRTF
- Located sounds should get significantly louder when you lean toward them closely, etc.

UI should be located in-world

- on walls
- on objects, on screens in world
- or cockpit,
- or floating over its subject



47 / 56

Touch

Even with tracked hand-held devices, like those provided with VIVE, or the Oculus Touch, or tracking via Leap Motion or the Kinect, there is still no haptic feedback -- no sense of touch.

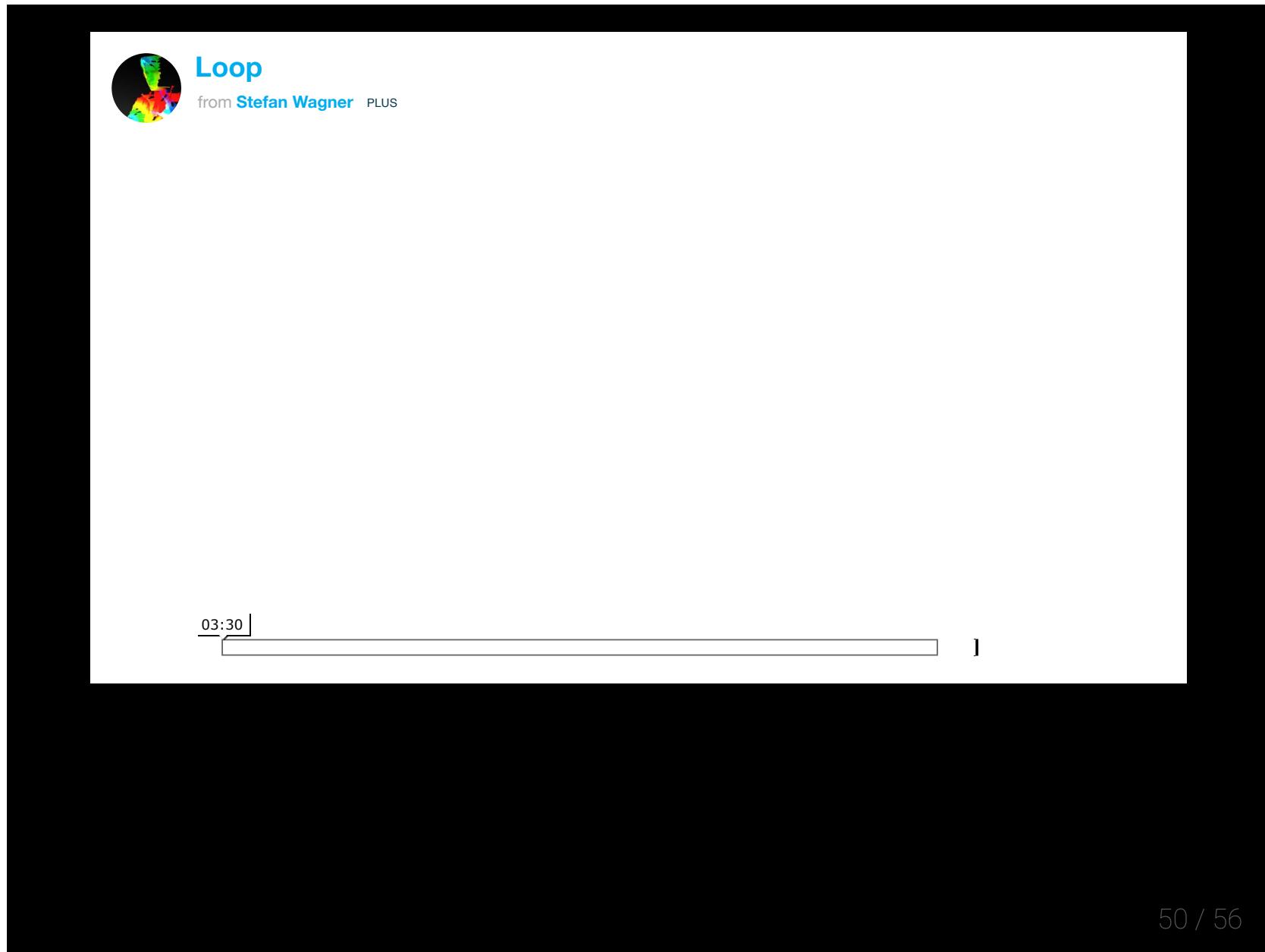
- Gloves?
- Acoustic (ultrasonic) haptics?

THE VOID - Still the most realistic VR experience



Authoring within VR?

- Impact of switching contexts between HMD and coding-at-the-desk
- Can't find the keyboard... time to go beyond text?



Rumpus



51 / 56

Building VR in VR with Unreal Engine 4 - Early Preview



52 / 56

The message of the medium?

"A new medium can suggest a multitude of approaches. In 1929, Dziga Vertov's *The Man with the Movie Camera* catalogued possibilities for the evolution of film. From narrative structures to special effects, it shows *what cinema could have become*. Virtual reality occupies a similar historical moment--it is unformed and hence its possibilities seem unconstrained."

"Although the artistic community has often been excluded from the development of new technologies, this situation is changing. Artists no longer sit on the sidelines eventually to become grateful users of borrowed tools but have become active in development, creating a disturbance in the field with new contingencies... A new medium like Virtual Reality challenges traditional conventions not because the participant wears a helmet or glove but because it suggests new relationships between the viewer and the viewed... Unfortunately, as the medium of virtual environments becomes more and more defined, different approaches will be ignored, abandoned, or forgotten as the medium coalesces into a mature form."

Douglas MacLeod, Director of the Banff Art and Virtual Environments Project, in the preface of Moser, Mary Anne, and Douglas MacLeod. Immersed in technology: art and virtual environments. MIT Press, 1996., emphasis added.

Zimmerman, Eric, and Heather Chaplin. "Manifesto for a Ludic Century" (2013)

The last century's media was based on information communication: linear, often unidirectional; creating bureaucratic systems. This century's media is non-linear, systemic, modular, participatory, customizable, playful. Environmental: immersive, inhabitable, explorable. Complex systems thinking.

It is not enough to merely be a systems-literate person; to understand systems in an analytic sense. We also must learn to be playful in them. A playful system is a human system, a social system rife with contradictions and with possibility.

Artificial Nature / Endless Current

55 / 56

