





Mixed Reality Studio

Most Up-to-date Syllabus:

<https://github.com/ivaylopg/MixedRealityStudio>

I will do my best to keep the Moodle page updated, but I can promise that most up-to-date class materials will be here:
<https://github.com/ivaylopg/MixedRealityStudio>



Experiential Experimental Test Lab

The focus of this class:

- Things that are “*Experienced*” rather than “*Used*”
- Trying and failing is OK!
- We will test ideas and develop tools that you can use

Goals

Specific Skills

- Completed multiple VR/AR Projects
- HTC Vive, Magic Leap, Hololens, ARKit/ARCore
- Unity

Conceptual Proficiency

- New paradigms of design
- A new set of tools available to you



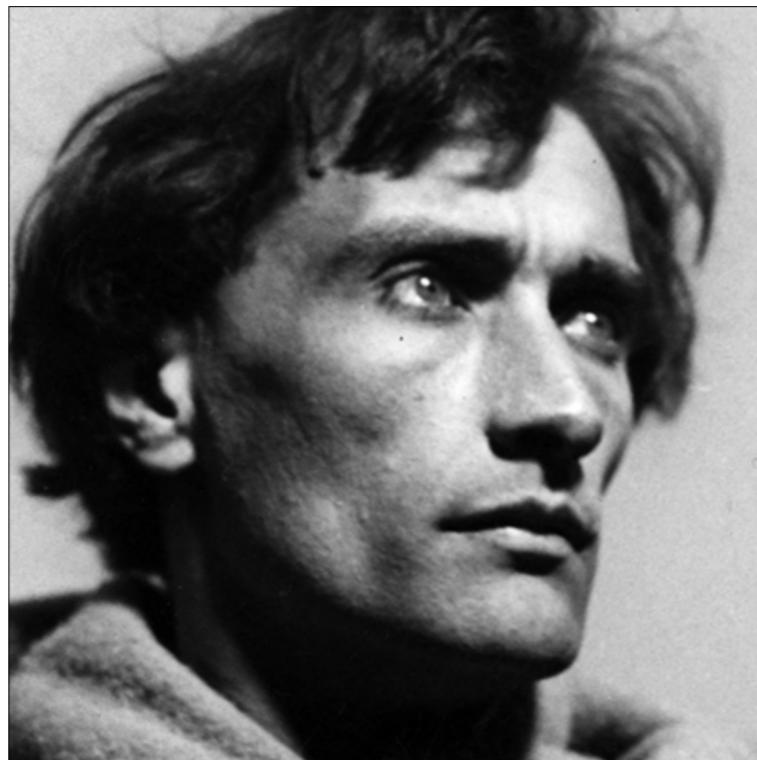
Lots of info coming your way today - don't worry about *memorizing* it so much as *absorbing* it - this is all context, foundation.



Immanuel Kant 1781 - Critique of Pure Reason - Dual Nature of Reality

Metaphysics is a branch of philosophy exploring the **fundamental nature of reality**.

Stated that there are two parallel worlds: the **nouminal** and the **phenomenal**. The nouminal world is the objective external world, which is the source of the light that stimulates the retina. This is the world studied by science, and is populated by invisible entities such as atoms, electrons, and invisible forms of radiation. The phenomenal world is the internal perceptual world of conscious experience, which is a copy of the external world of objective reality constructed in our brain on the basis of the image received from the retina. The only way we can perceive the nouminal world is by its effects on the phenomenal world. Therefore the world we experience as external to our bodies is not actually the world itself, but only an internal virtual reality replica of that world generated by perceptual processes within our head.



*[T]he theater is a mirage....
And the principle of theater...
should be understood as the
expression of an identity...in
which the characters,
objects, images, and all that
constitutes the **virtual reality**
of the theater develops, and
the purely fictitious and
illusory world [is] evolved.*

Jumping ahead a few hundred years, first use of “Virtual Reality”

Antonin Artaud - The Theatre and Its Double Part III: The Alchemical Theater - 1938.

Attack on theatrical convention: opposing the **viewer's sensual experience vs theatre as a contrived literary form**

All true alchemists know that the alchemical symbol is a mirage as the theater is a mirage. And this perpetual allusion to the materials. and the principle of the theater found in almost all alchemical books should be understood as the expression of an identity (of which alchemists are extremely aware) existing between the world in which the characters, objects, images, and in a general way all that constitutes the virtual reality of the theater develops, and the purely fictitious and illusory world in which the symbols of alchemy are evolved.

These symbols, which indicate what might be called philosophical states of matter, already start the mind on its way toward that fiery purification, that unification and that emaciation (in a horribly simplified and pure sense) of the natural molecules; on its way toward that operation which permits, by sheer force of destructive analysis, the re-conception and re-constitution of solids according that equilibrium of spiritual descent by which they ultimately become gold again. It is not sufficiently understood how much the material symbolism used to designate this mysterious operation corresponds to a parallel symbolism in the mind, a deployment of ideas and appearances by which all that is theatrical in the theater is designated and can be distinguished philosophically.”

What is AR/VR/MR?

OK....so that's some philosophical foundation, but let's find up with a more modern/practical definition to work with...



Inducing targeted behavior in an organism by using artificial sensory stimulation, while the organism has little or no awareness of the interference.

Definition by Steven M. LaValle, Professor, University of Illinois, Chief Scientist of VR/AR/MR at Huawei Technologies Co. Ltd.

Intentionally Broad

This, plus Kant's dual realities, will be our working definition of what we're doing here.

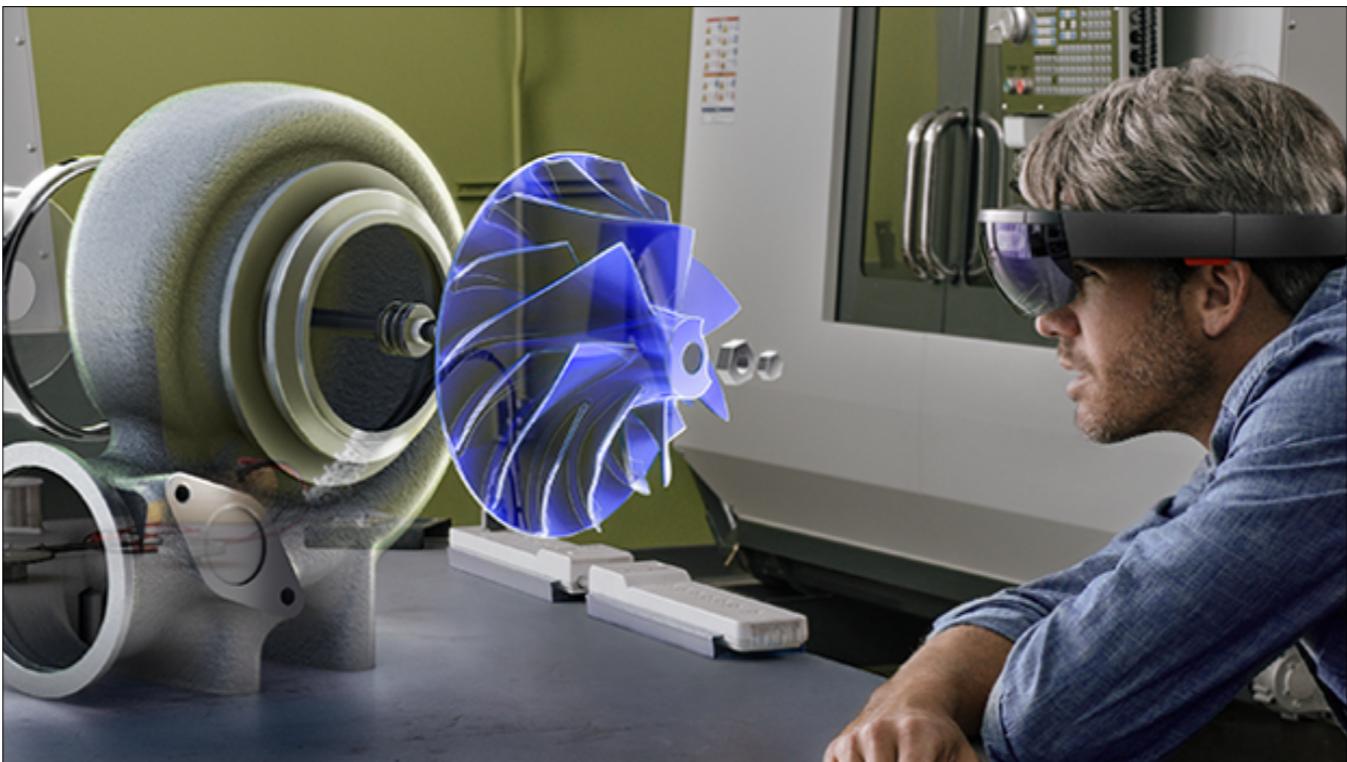


Examples:
HMD, head tracking



Examples:

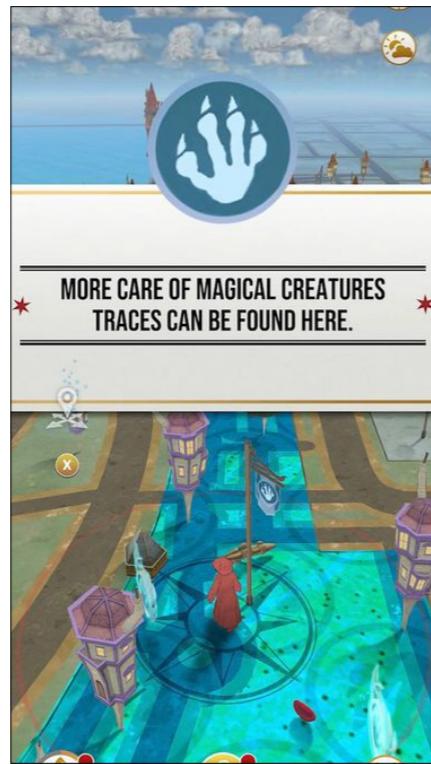
Augmented Reality (HoloLens) - Transforms experience by **adding** to world instead of creating one from scratch.

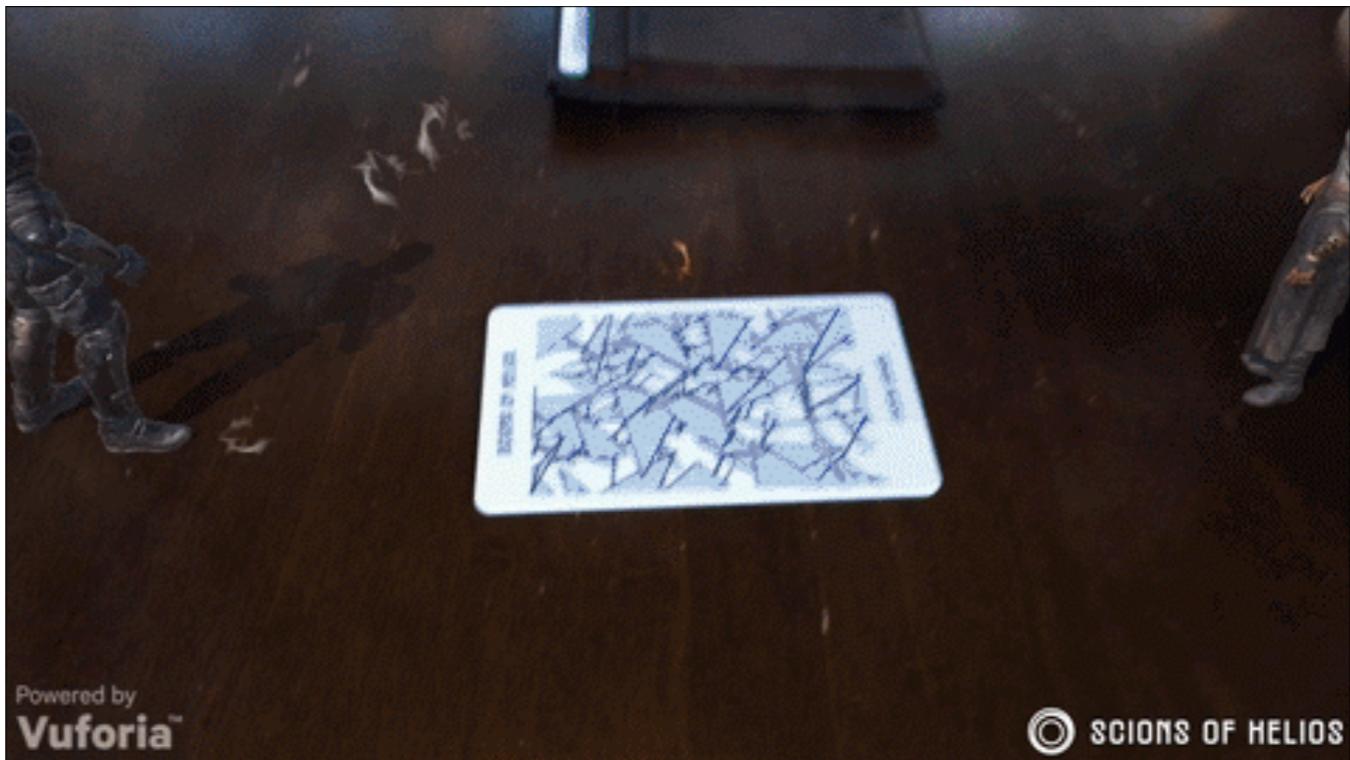




Examples:

Pokemon GO - AR does not need to be a headset. Pokemon GO is a like a “Lens” into another world.





Then: adding networking.

This could be inter-device communication...



Smarter Objects by Valentin Heun, Shunichi Kasahara, Pattie Maes · MIT Media Lab

... or interfacing with IoT



Examples:

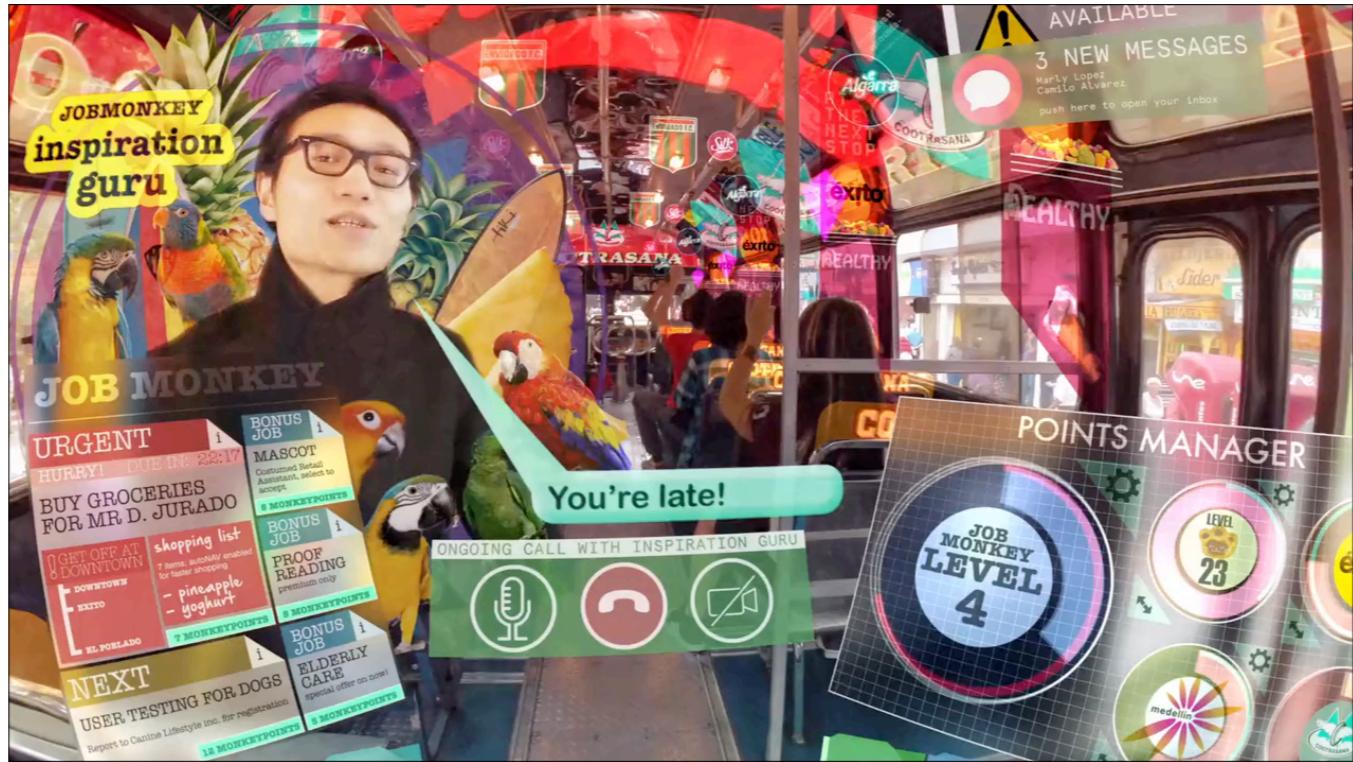
Snapchat Filters? Do they count as AR? YES!



You can use Google's Translate app to translate this sign in realtime!



Looking at a slightly darker application. What happens when we go from this...

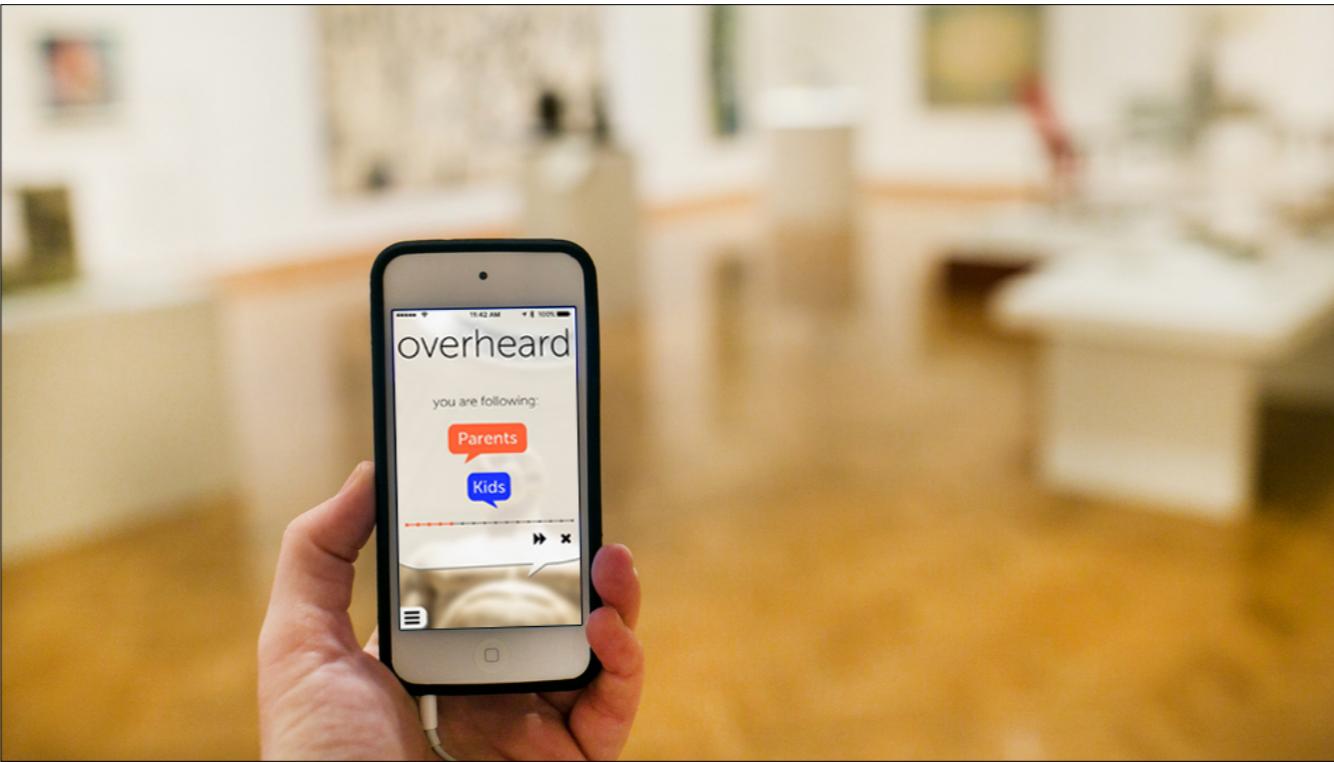


... to this? (i.e. when Times Square follows a user everywhere they go)

Keiichi Matsuda

<http://km.cx/projects/hyper-reality>

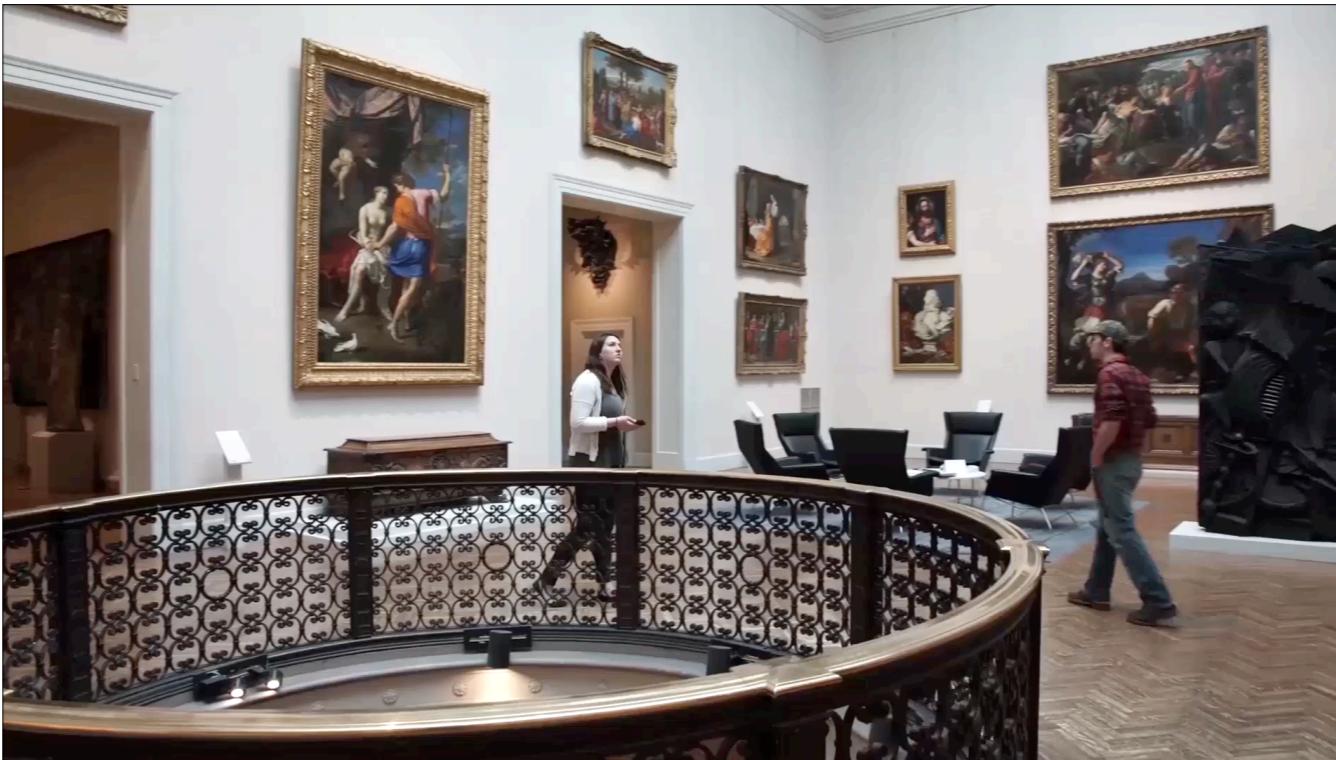
<https://twitter.com/keiichiban>



Expanding the definition of AR is something I'm very interested in exploring with personal/studio work

"Overheard" - Luxloop, 2016

Overheard is a site-specific audio narrative woven into the Minneapolis Institute of Art. Similar to immersive theatre, it allows you to explore stories in your own way, at your own pace as you journey through the museum.

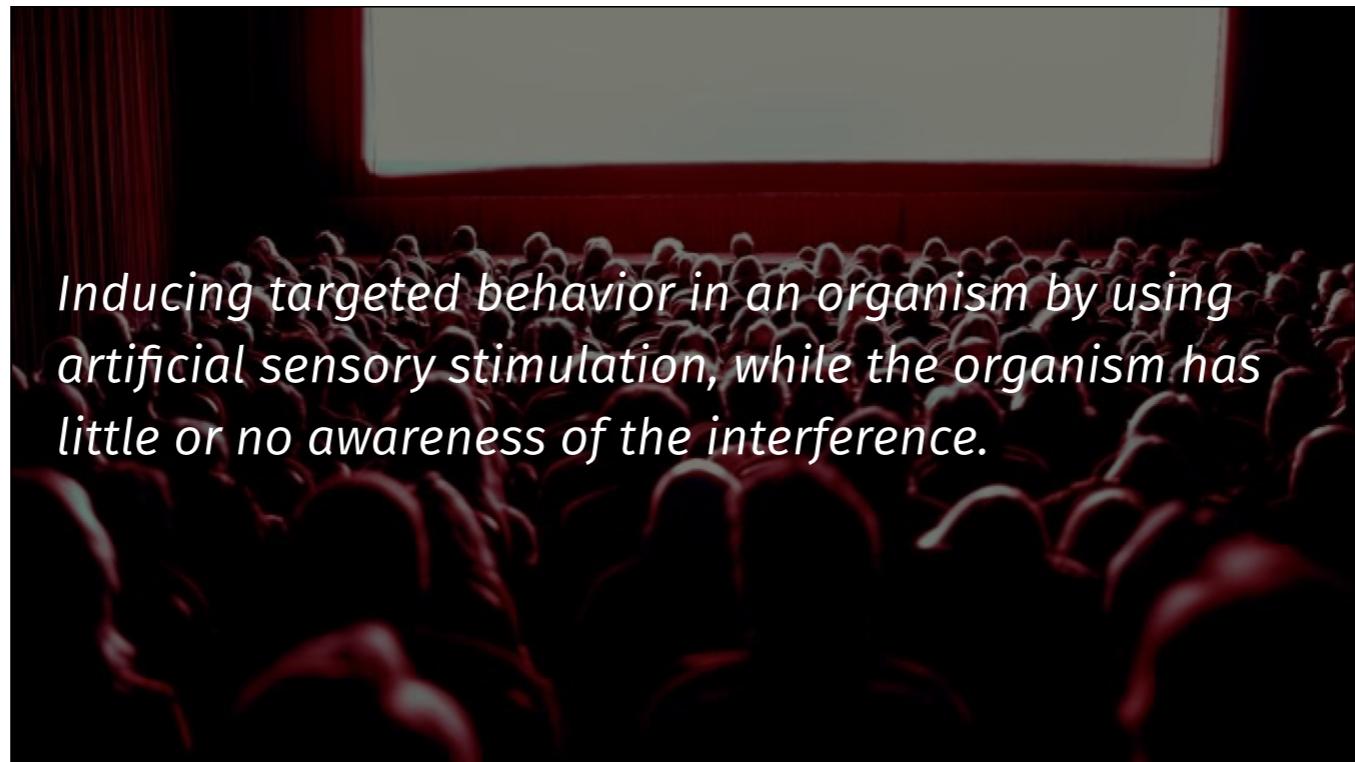


As visitors explore the galleries, the custom app recognizes their location, allowing them to "overhear" characters through their headphones as if they are eavesdropping on their conversations. Visitors can listen in on a first date, go on a ghost hunt with children, or catch up with a couple of old friends. It is a new way to move through the museum, experience the incredible works on view through different people's perspectives, and explore the fascinating ways that people can connect with art.



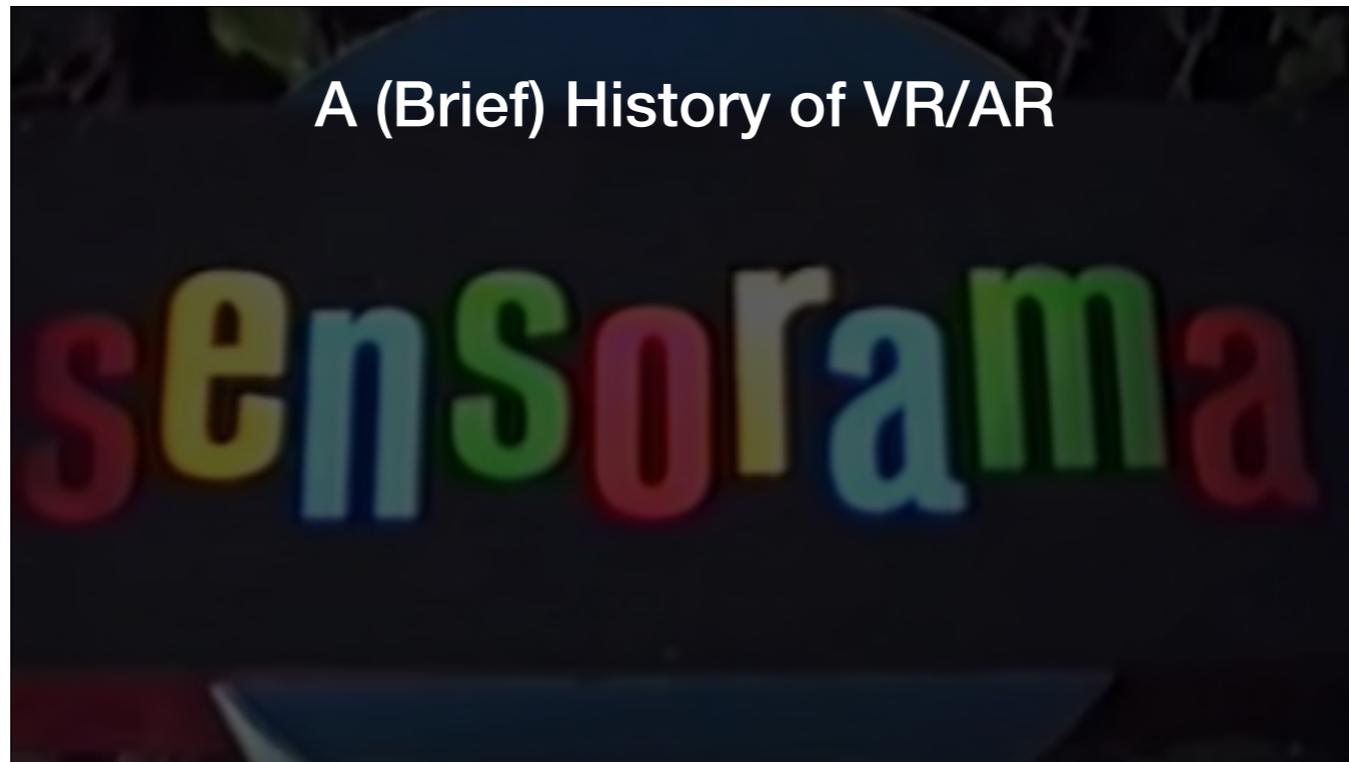
Where do we draw the line?

"Perhaps **listening to music through headphones** should be included. What about **watching a movie at a theater**? Clearly, technology has been used in the form of movie projectors and audio systems to provide artificial sensory stimulation. Continuing further, **what about a portrait or painting** on the wall? The technology in this case involves paints and a canvass. Finally, we might even want **reading a novel** to be considered as VR. The technologies are writing and printing. The stimulation is visual, but does not seem as direct as a movie screen and audio system. **We will not worry too much about the precise boundary of our VR definition.** Good arguments could be made either way about some of these border cases. They nevertheless serve as a good point of reference for historical perspective." - LaValle



Inducing targeted behavior in an organism by using artificial sensory stimulation, while the organism has little or no awareness of the interference.

I want you to separate the concept of AR/VR from any specific technology or kind of interaction.



So why are we so excited *now*? Why does it seem like AR/VR is a new thing?

I think it's important to look at the philosophy and intent of VR/AR/MR separately from the TECHNOLOGY

Look at quick history of "modern" Virtual Reality.



Stereoscope

Early 19th Century





Morton Heilig, Sensorama, 1957-1962

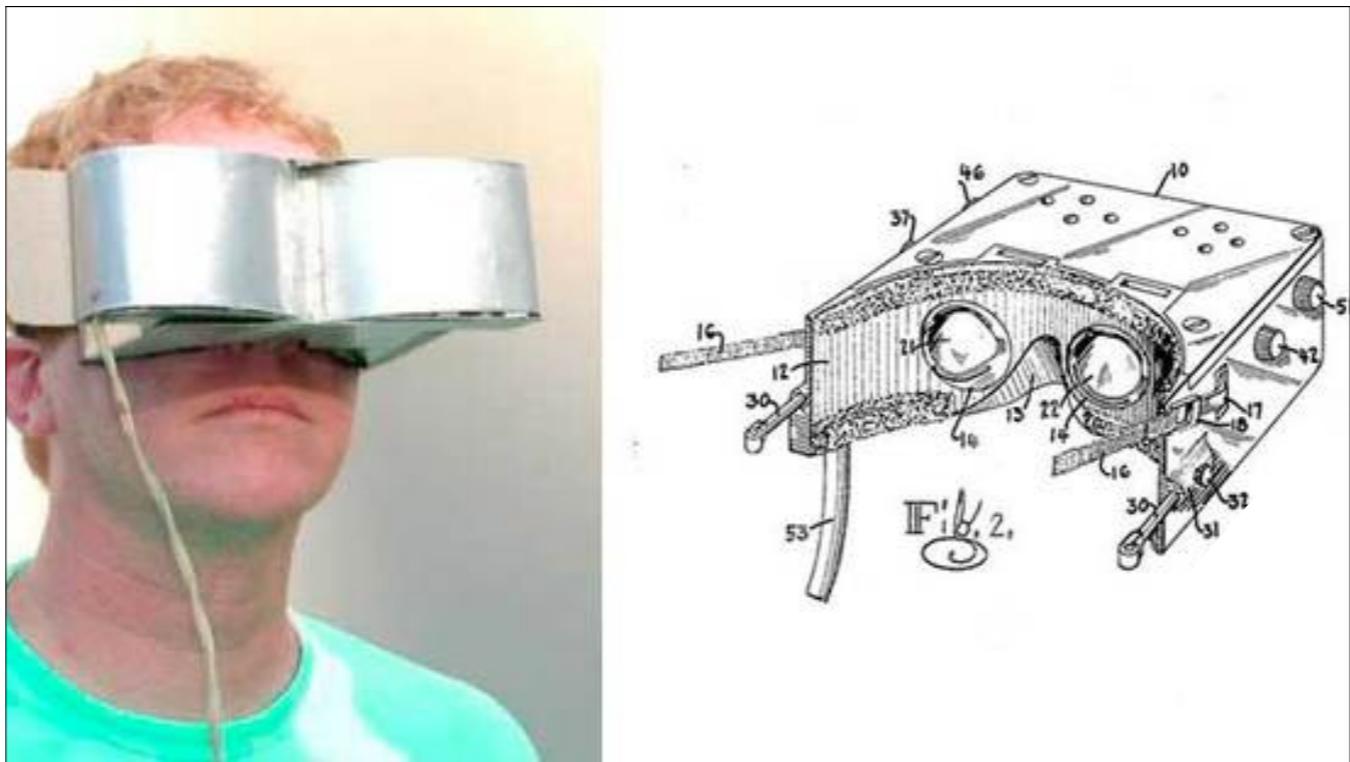
Sensorama

- stereoscopic 3-D images
- wide-angle view
- tilting,
- stereo sound
- also had tracks for wind and aromas to be triggered during the film.

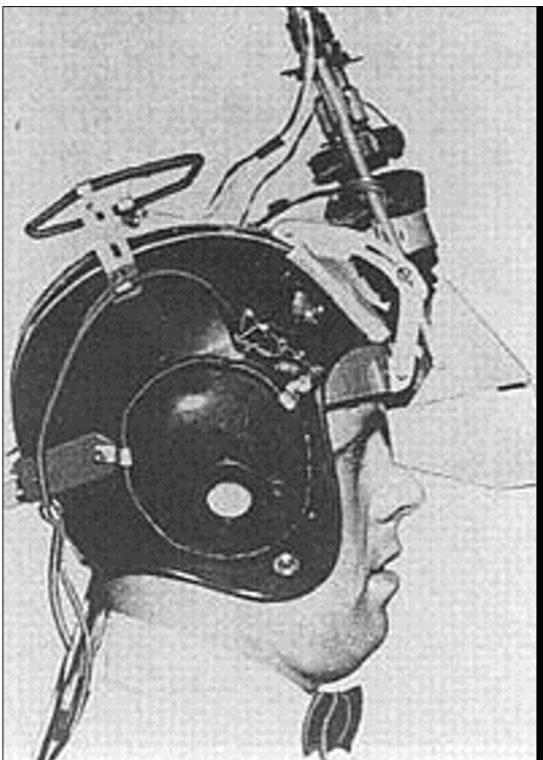
Heilig was **unable to obtain financial backing** for his visions and patents, and so the Sensorama work was halted.

He was not able to find the amount of funds necessary to create new 3-D films "obtained with three 35 mm cameras mounted on the cameraman."

Before it's time

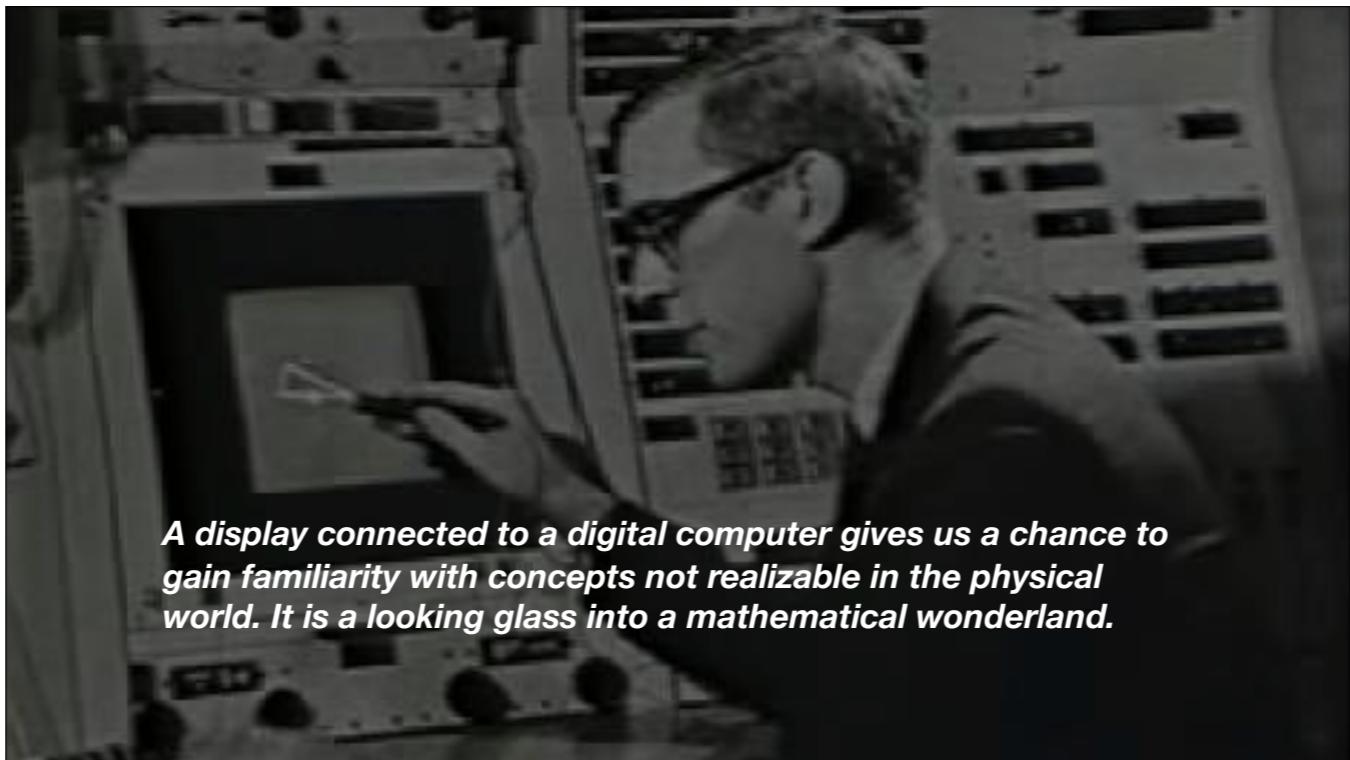


Morton Heilig, Telesphere Mask, 1960



Philco HMD

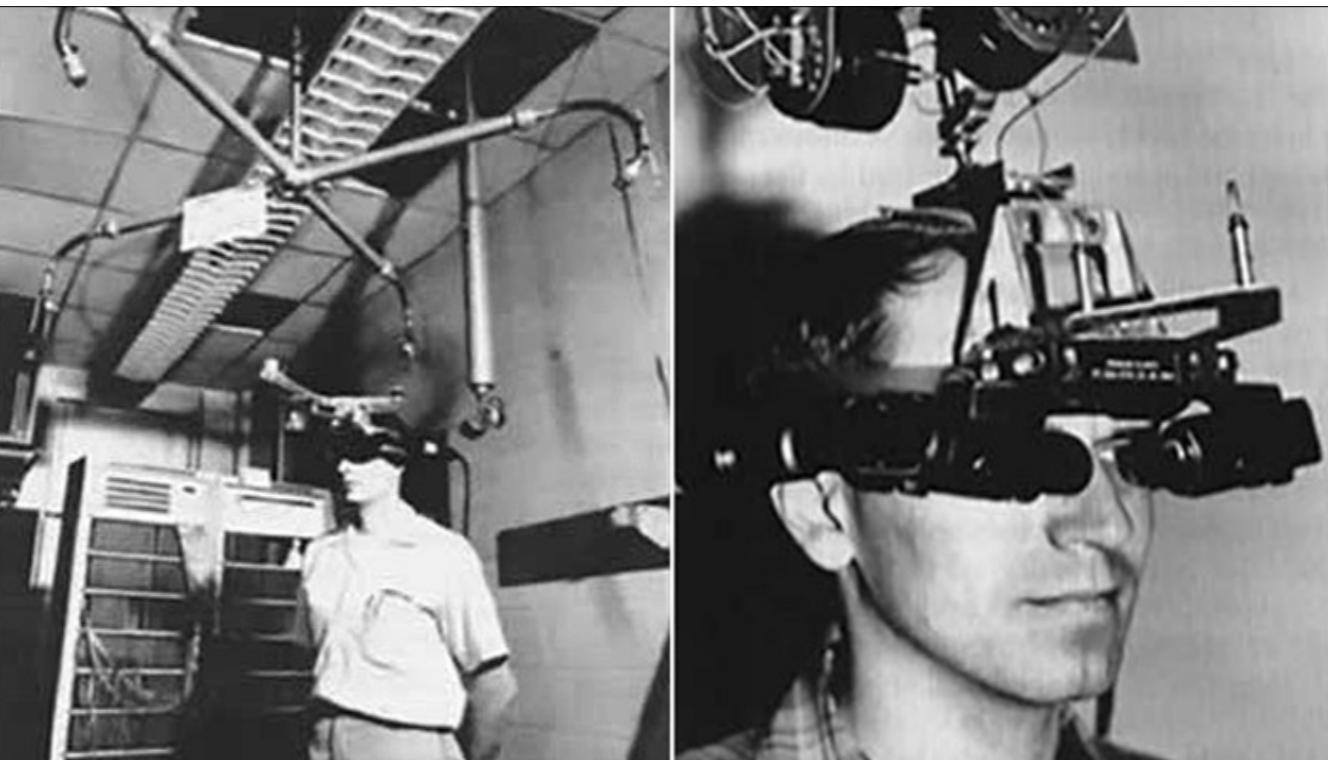
Philco1961 - "Headsight"
First Head Mounted Display (HMD)
Controls Remote Camera - user's head movements would pan/tilt a camera placed somewhere where they could not go themselves.



A display connected to a digital computer gives us a chance to gain familiarity with concepts not realizable in the physical world. It is a looking glass into a mathematical wonderland.

Ivan Sutherland 1963

Invents the concept of an interactive Graphical User Interface, interacting with computers visually instead of with text.
(He does this as his PhD. No big deal)



Insight: use a computer to make images - not a camera feed.

In 1968, he invents the *Sword of Damocles*. A tracked headset that superimposed a 3D cube over the wearer's field of view.

[https://en.wikipedia.org/wiki/The_Sword_of_Damocles_\(virtual_reality\)](https://en.wikipedia.org/wiki/The_Sword_of_Damocles_(virtual_reality))



For most of the 70s and 80s, AR and VR research is done for the military with few notable viable inventions moving substantially beyond Sutherland's tech.

Over the course of the 80s and 90s, **Steve Mann** becomes obsessed with wearable computing, tinkering with several prototypes...

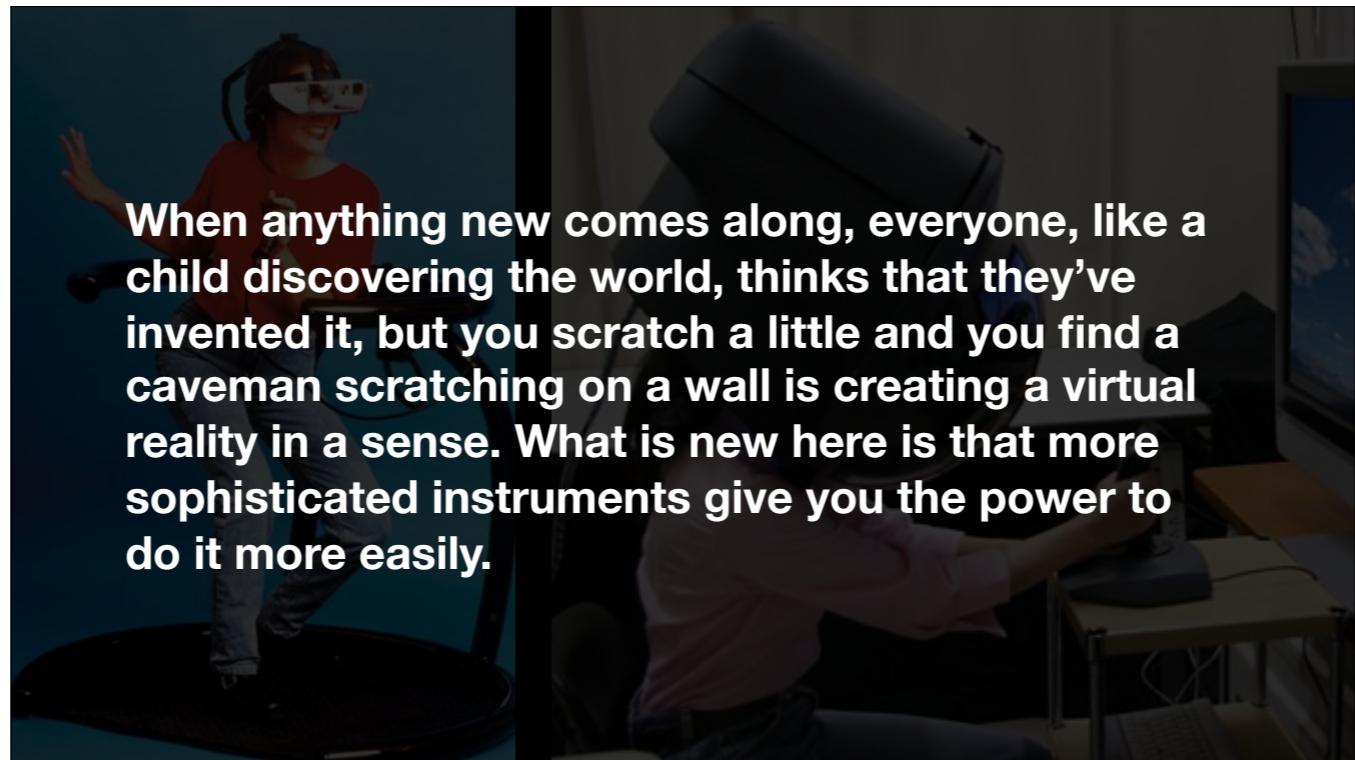


...Leading to the MIT Wearable Computing Project

The 90s saw a curious intersection of academic interest in VR, “CyberPunk” fashion, and the mainstreaming of computers into popular culture, which led to...



The first VR hype wave in the 1990s.

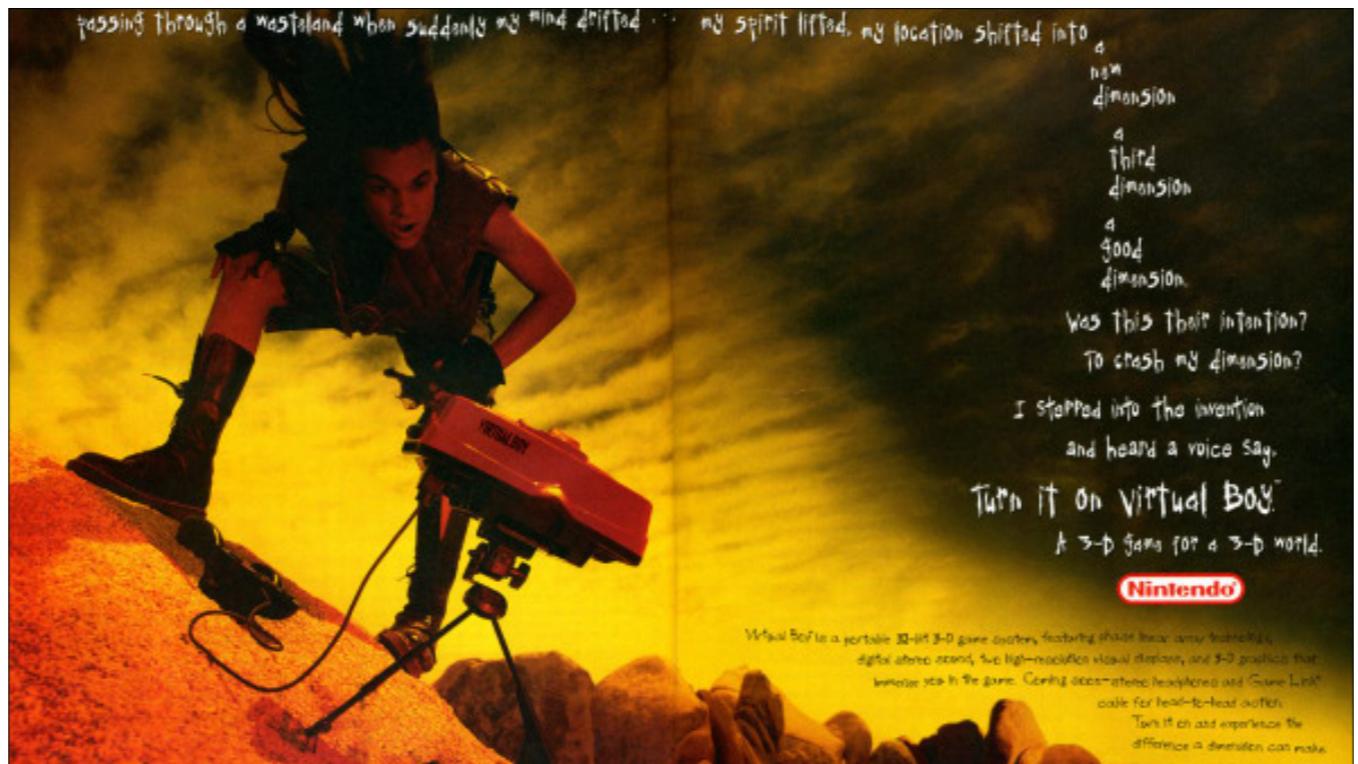


When anything new comes along, everyone, like a child discovering the world, thinks that they've invented it, but you scratch a little and you find a caveman scratching on a wall is creating a virtual reality in a sense. What is new here is that more sophisticated instruments give you the power to do it more easily.

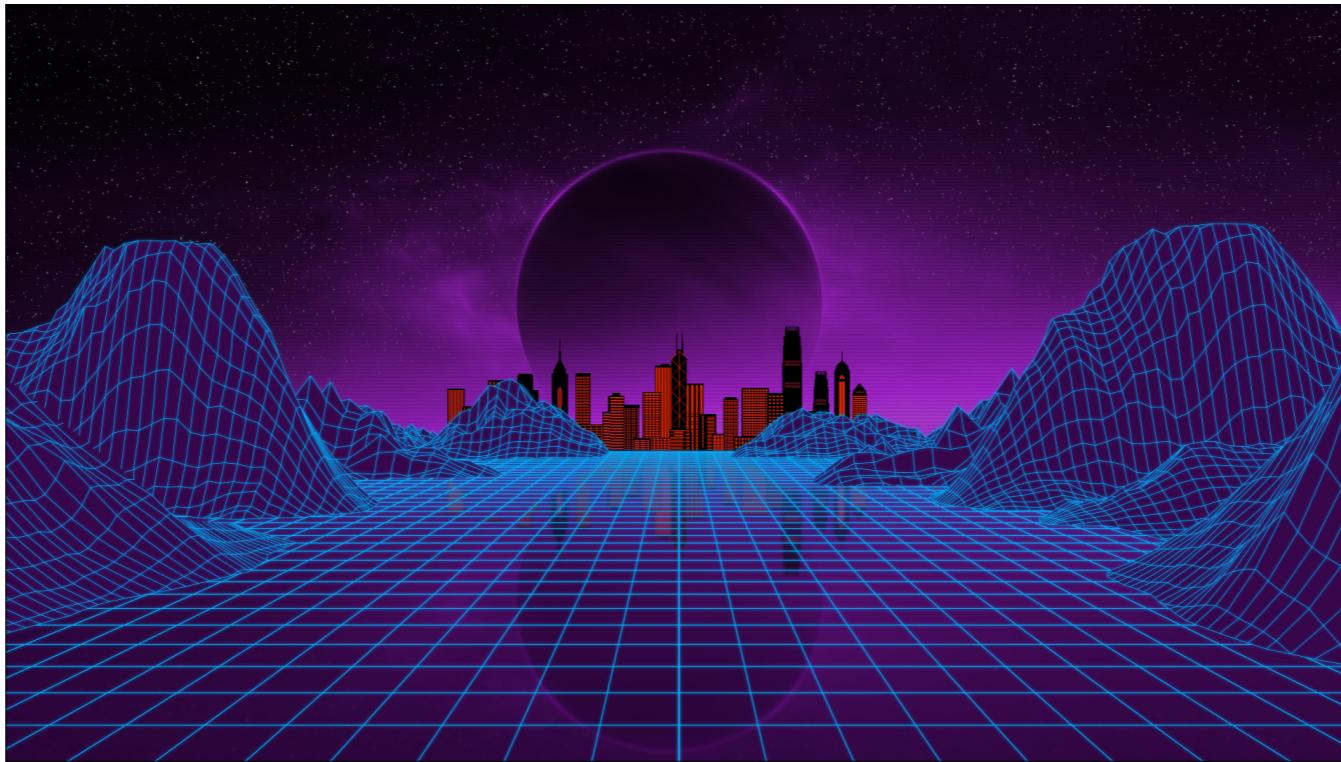
Morton Heilig (Sensorama and Telesphere inventor)



Vertek AR - I waited in line for this at an arcade. It was terrible, and it was the coolest thing ever.



Even Nintendo made a commercial 3D headset: the Virtual Boy. As close as mainstream as VR got in the 90s, but still a commercial flop.



So, It's nothing new. It's been around for 50 years. So why don't we all live in the Metaverse already? Why did that first wave fizzle-out?

Because the tech was **very expensive**. It was hard to *make* content for it, so few people actually did, which means that the content that did exist wasn't enough to satisfy consumers.

Lastly (probably most importantly) the time AOL and the first dot-com bubble came and captured the public imagination with a much more viable technology to be obsessed by.



2004

Nonny De La Pena collaborated with digital media artist Peggy Weil to adapt a portion of her 2004 documentary *Unconstitutional: The War on Our Civil Liberties* into 2nd Life.



Immersive environment called 'Gone Gitmo.'

With a grant from the Bay Area Video Coalition and the MacArthur Foundation, they ported the Guantanamo Bay sequence to simulation video game Second Life to construct a virtual prison, allowing users to be incarcerated and subjected to torture techniques.



As a senior research fellow at USC in 2009, de la Peña began experimenting with virtual reality headsets.

By 2010, she started work on 'Hunger in Los Angeles,' an offshoot of the USC and Center for Investigative Journalism project 'Hunger in the Golden State.' With USC's Mixed Reality Lab, de la Peña built the VR piece.

'Hunger in Los Angeles' became the first-ever VR documentary to be showcased at the Sundance Film Festival in January 2012.

To ensure a headset for the event, Palmer Luckey, then a part-time employee of the MxR lab, was commissioned to create goggles for the Sundance premiere. Nine months later, Luckey started Oculus Rift.



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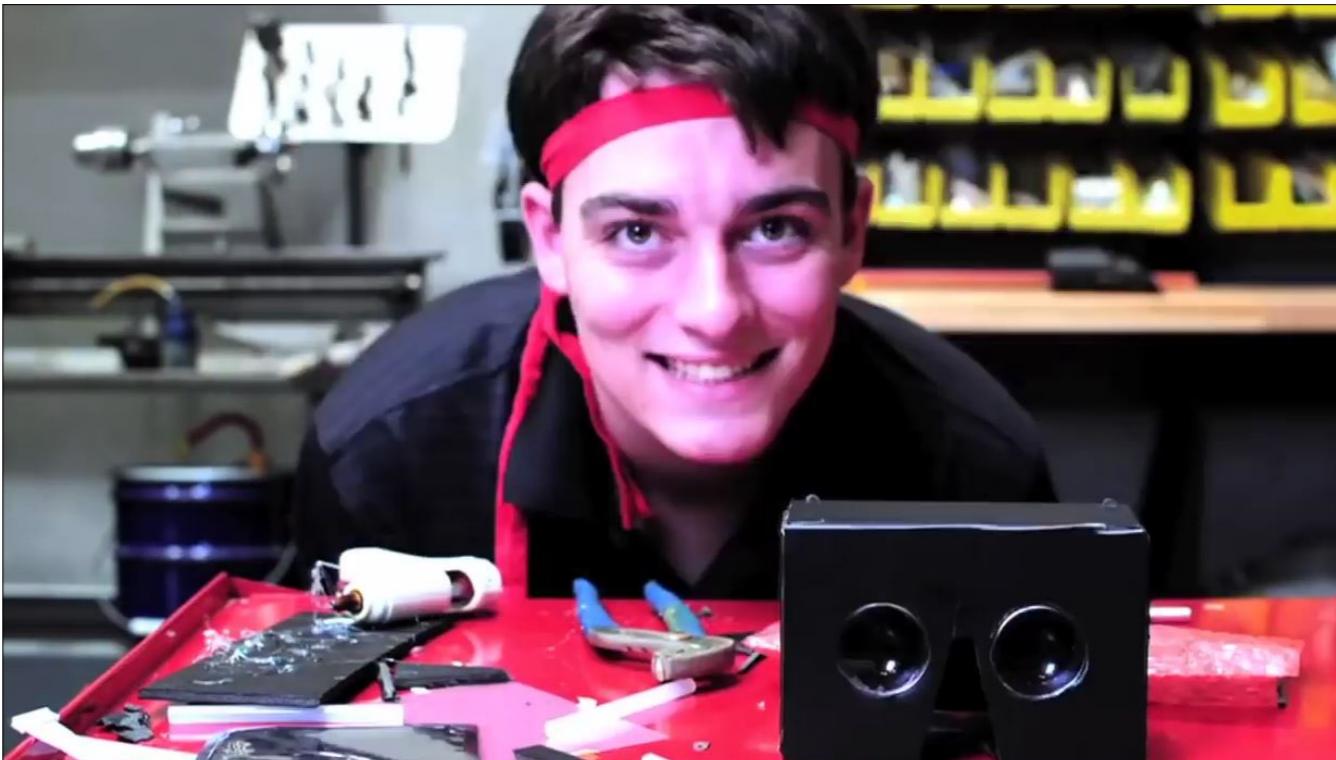
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What Happened?

June 29, 2007 - Apple released the first iPhone. This phone had **nothing to do with VR**, but it contained some very important technology: small, high-res screens and IMUs (Inertial Measurement Units) aka Gyroscopes and Accelerometers.

The phone's popularity, and the subsequent wave of similar phones, drove the cost of these components waayyy down (supply & demand)



Palmer Luckey - 2012.

Luckey is an intern at the USC lab where filmmaker Nonny De La Pena develops her VR project "Hunger in LA" using a \$35,000 VR headset called the Wide5. The project is the first VR film to get into Sundance, but they realize that they can't afford to bring the headset to the festival.

Using these now low-cost electronic components , Luckey is able to hack together two headsets that are good enough to replaces the \$35k headset for audiences to experience the project.

6 months later, launches the Oculus Rift kickstarter.

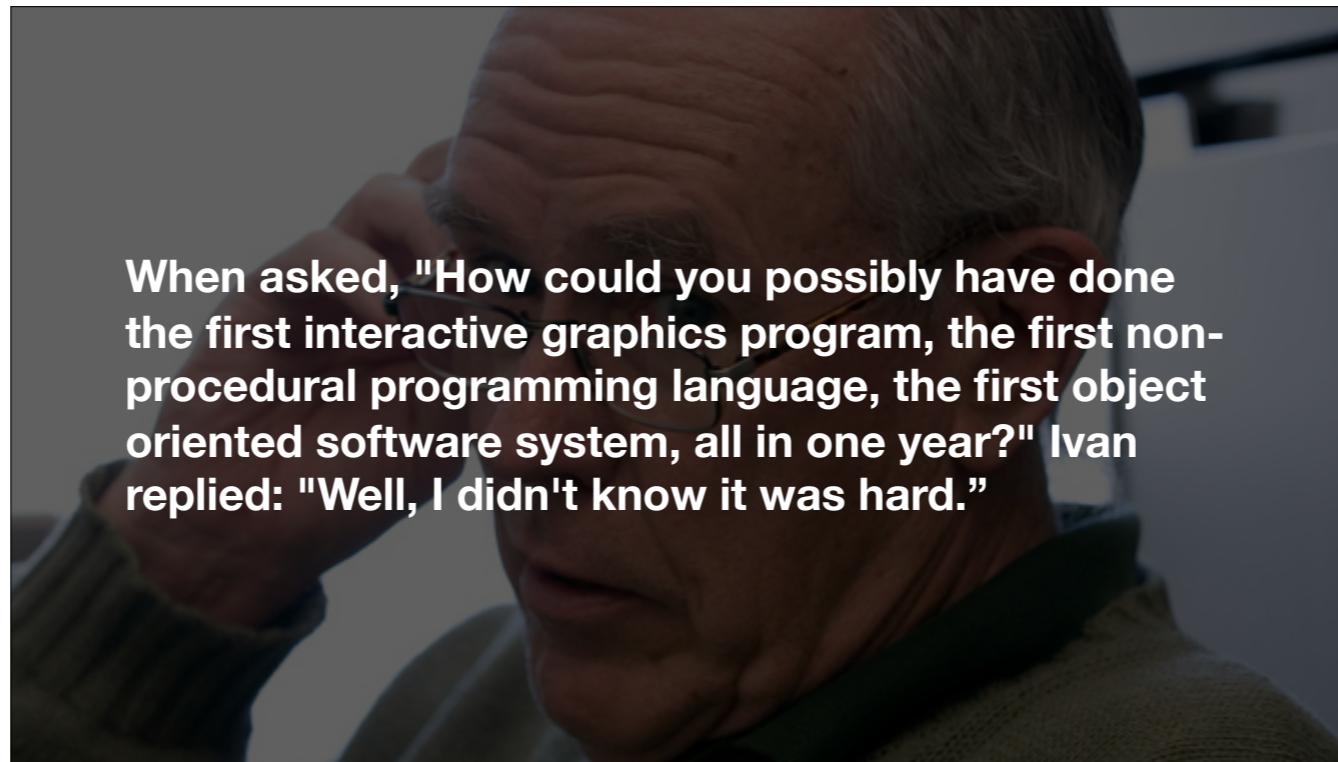


We're back in the Hype Machine, baby!



It's likely that the VR/AR tech of today looks just as silly in 20 years as this stuff looks to us now.

The important thing is that now the tools for making *content* are much more democratized, and content is poised to drive adoption.



When asked, "How could you possibly have done the first interactive graphics program, the first non-procedural programming language, the first object oriented software system, all in one year?" Ivan replied: "Well, I didn't know it was hard."

We'll cut it off there, for now.

Haven't even touched on google glass, snapchat spectacles.
Will talk more when we go over AR as social interaction.

Ivan Sutherland (Again)



Ok...let's talk about the Unity game engine.

abstraction

First, let's talk about **Abstraction**:

In software engineering and computer science, **abstraction** is a technique for arranging complexity of computer systems. It works by establishing a level of complexity on which a person interacts with the system, **suppressing the more complex details below the current level**. The programmer works with an idealized interface (usually well defined) and can add additional levels of functionality that would otherwise be too complex to handle. For an example, **a programmer writing code that involves numerical operations may not be interested in the way numbers are represented in the underlying hardware** (e.g. whether they're 16 bit or 32 bit integers), and where those details have been suppressed it can be said that they were abstracted away, leaving simply numbers with which the programmer can work. In addition, a task of **sending an email message across continents would be extremely complex if the programmer had to start with a piece of fiber optic cable and basic hardware components**. By using layers of complexity that have been created to abstract away the physical cables and network layout, and presenting the programmer with a virtual data channel, this task is manageable.

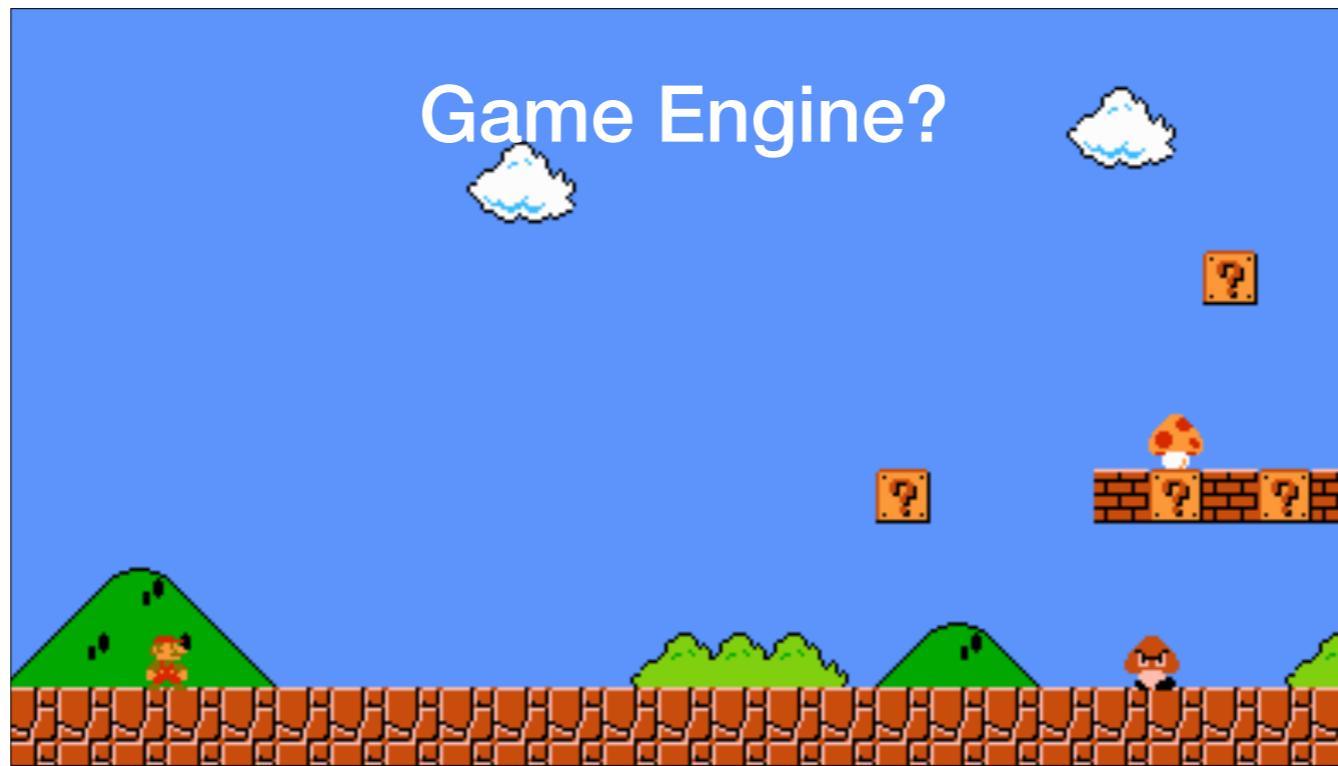
[https://en.wikipedia.org/wiki/Abstraction_\(software_engineering\)](https://en.wikipedia.org/wiki/Abstraction_(software_engineering))



Lets talk sandwiches

<https://www.youtube.com/watch?v=DvIHYdl0MWc>

How specific do you have to be with what you tell the computer?

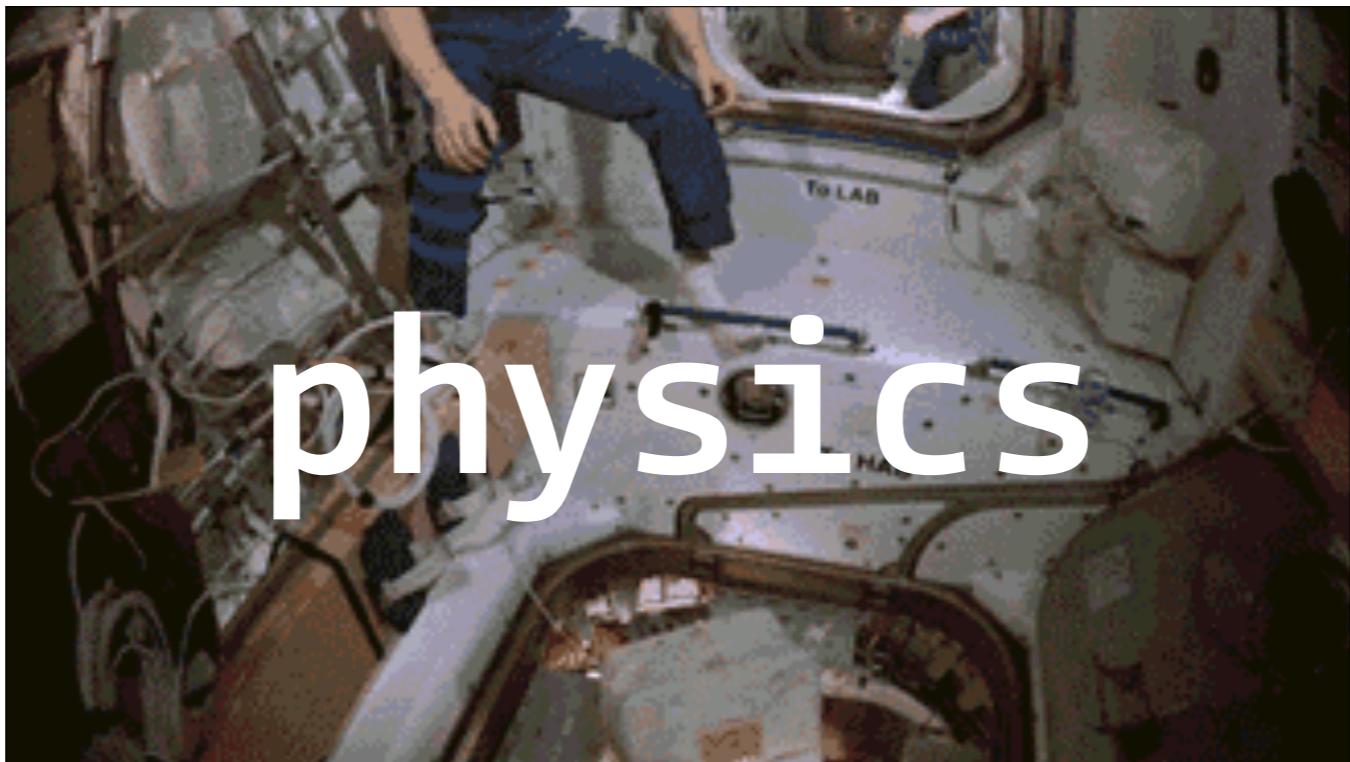


Why Unity?

Why use a *Game Engine*? (Are we making games?)

Unity Has some knowledge about the world. It knows some rules.

Specifically, games assume that you're working with physical forces and bodies in some kind of space.

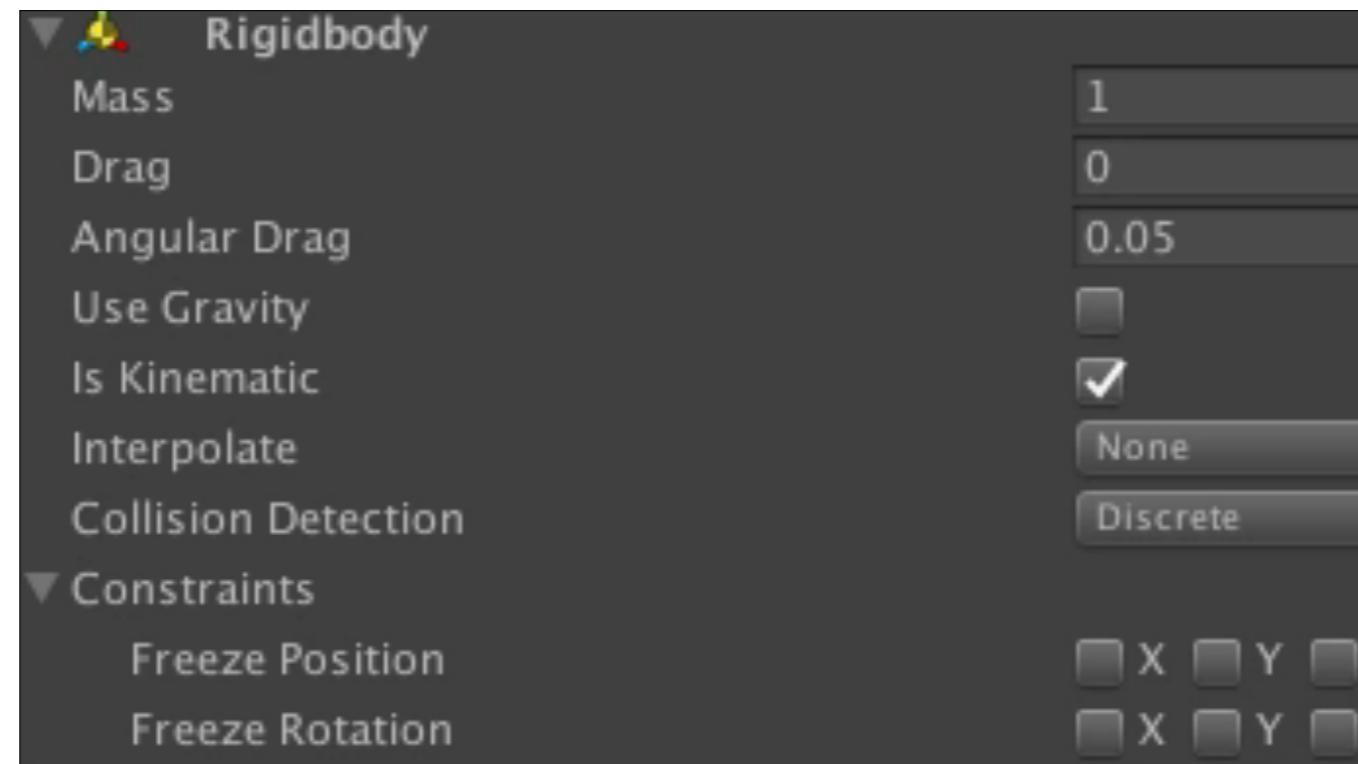


Abstracts the math/physics/graphics away for us and we get to work on a higher level.
Knows about: Mass, gravity, inertia, acceleration...

```
PVector position = new PVector(0,0);
PVector velocity = new PVector(0,0);
PVector gravity  = new PVector(0, 9.8);

void draw() {
    velocity.add(gravity);
    position.add(velocity);
    drawObject(position.x,position.y);
}
```

This is a very rudimentary implementation of **gravity** in the programming language Processing



This is **gravity** in Unity

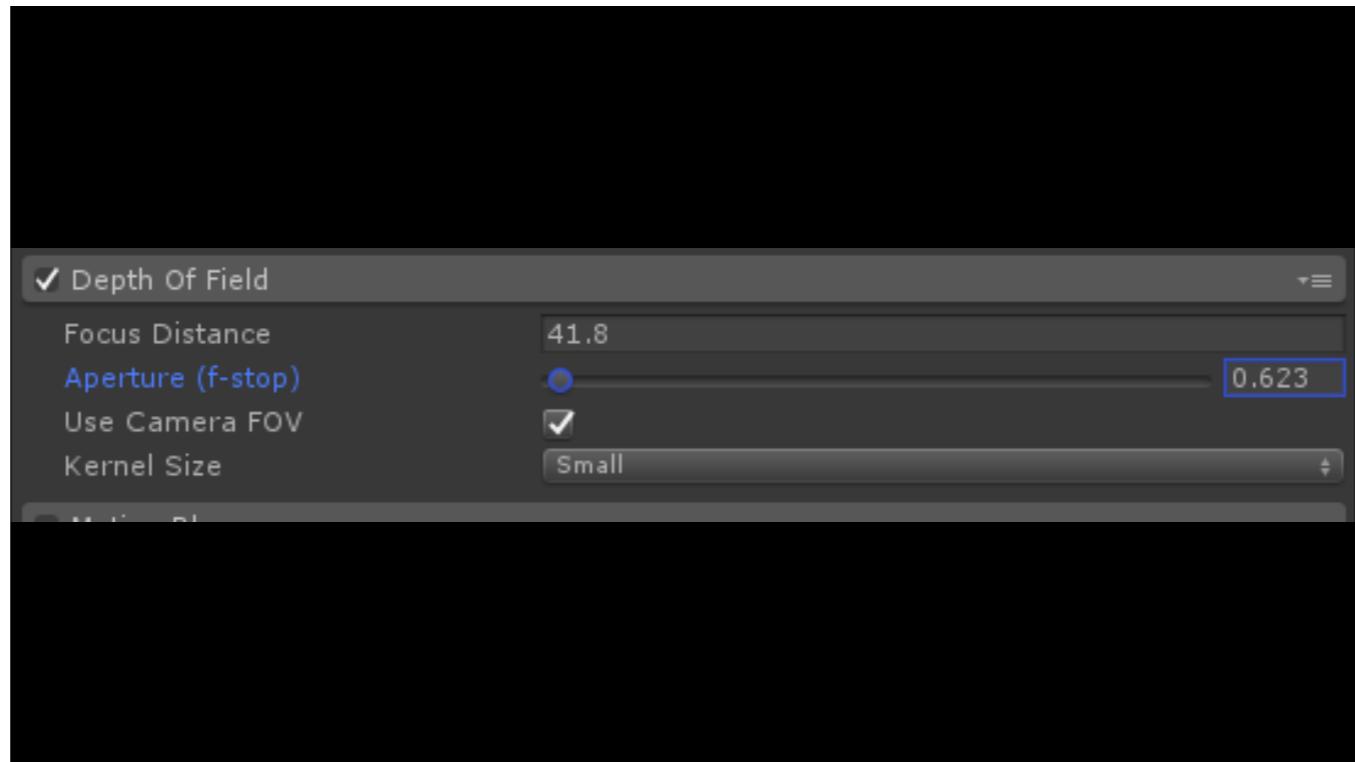
```
int n = 10;
float aperture = 0.05;
glm::mat4 projection = glm::perspective(...);

glm::vec3 right = glm::normalize(glm::cross(object - eye, up));
glm::vec3 p_up = glm::normalize(glm::cross(object - eye, right));

for(int i = 0; i < n; i++) {
    glm::vec3 bokeh = right * cosf(i * 2 * M_PI / n) + p_up * sinf(i * 2 * M_PI / n);
    glm::mat4 modelview = glm::lookAt(eye + aperture * bokeh, object, p_up);
    glm::mat4 mvp = projection * modelview;
    glUniformMatrix4fv(uniform_mvp, 1, GL_FALSE, glm::value_ptr(mvp));
    draw_scene();
    glAccum(i ? GL_ACCUM : GL_LOAD, 1.0 / n);
}

glAccum(GL_RETURN, 1);
glSwapBuffers();
```

This is how to implement depth-of-field (i.e. focus blur) in GLSL, a language used for graphics programming



This is the same concept in Unity

designing for the real world

It's not that we're making games, it's that we're designing for the **real world** so it would be helpful not to have to reinvent the wheel every time.

Pros/cons of abstraction

- Find a balance between power and ease
- We'll talk a LOT about this over the next few weeks



Yay! Exciting!



What do we mean by *interaction*?

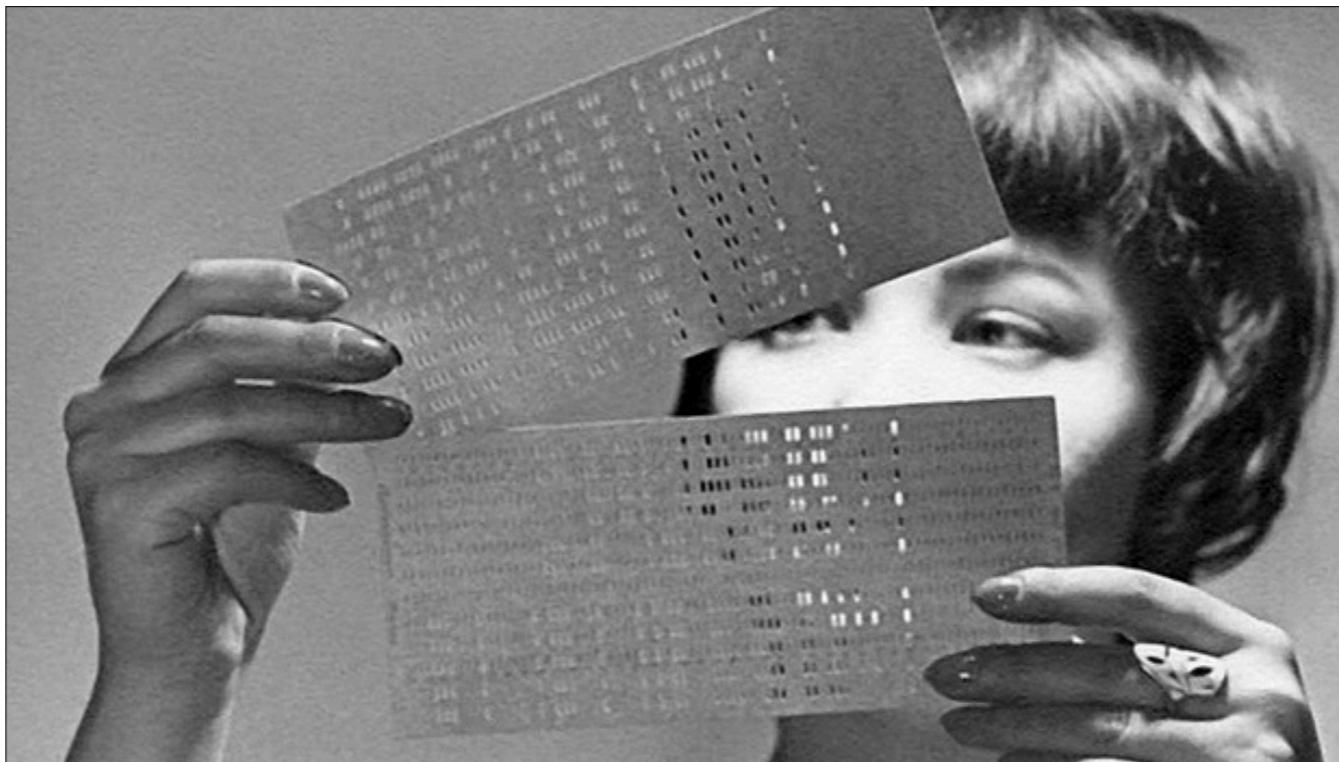
- How do you act **upon** the HARDWARE of the computer/device?
- What does that **action** DO?



VR/AR can be seen as an evolution of **content** (what are we looking at) and an evolution of **platform** (how are we looking at it)

Progression from “usable by a small few” to “usable by everyone”

Computers started as **Single Purpose** - performing math calculations



Computer used to be a person that would compute - that would do the calculations. Eventually replaced by computers that would be programmed using punched cards



Even the idea of a keyboard as input had to be invented - that you could interact with computers using an alpha-numeric alphabet

This is a layer of *abstraction*

```
C:>>chkdsk
Volume Serial Number is 3E76-4B58

2,146,467,840 bytes total disk space
    131,072 bytes in 2 hidden files
        32,768 bytes in 1 directories
    7,405,568 bytes in 124 user files
2,138,898,432 bytes available on disk

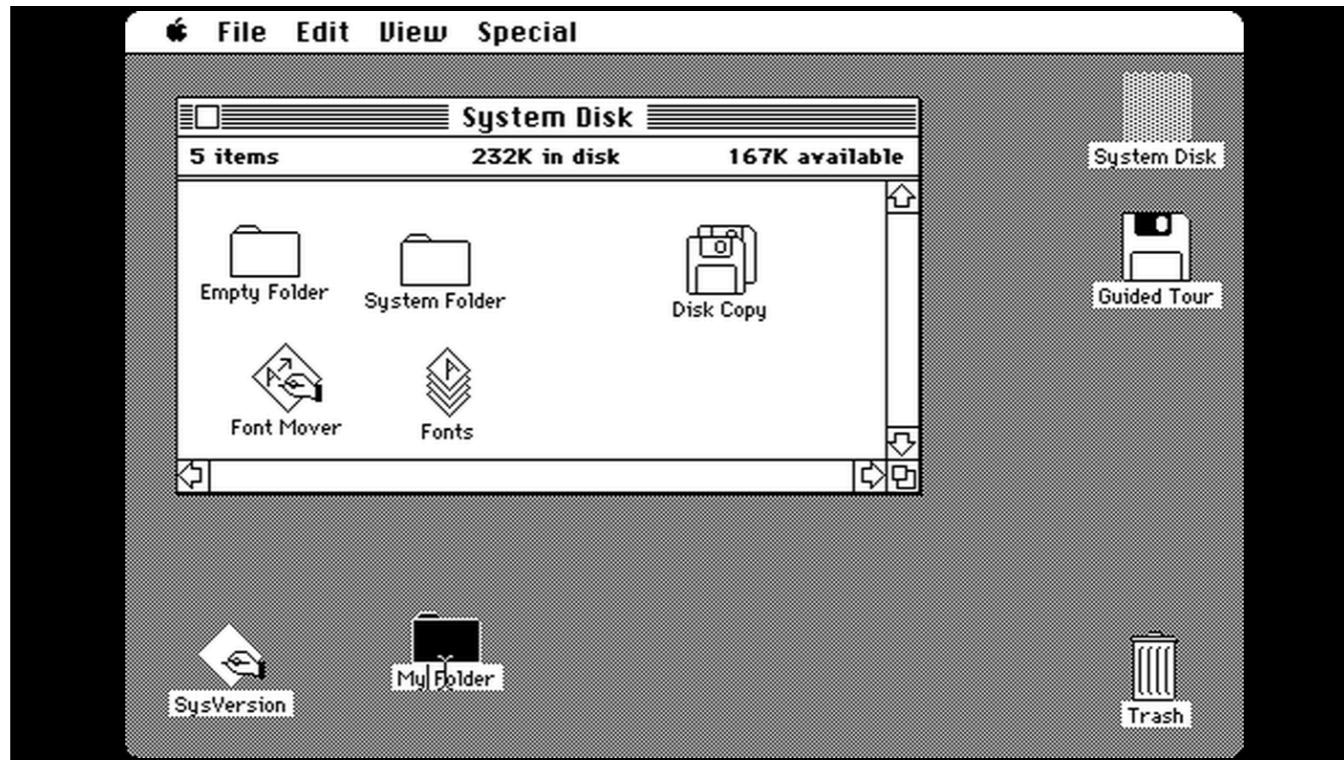
        32,768 bytes in each allocation unit
    65,505 total allocation units on disk
    65,274 available allocation units on disk

    655,360 total bytes memory
    602,704 bytes free

Instead of using CHKDSK, try using SCANDISK. SCANDISK can reliably detect
and fix a much wider range of disk problems. For more information,
type HELP SCANDISK from the command prompt.
```

```
C:>>_
```

Computers were for long time (and many still) used with a text-based interface.

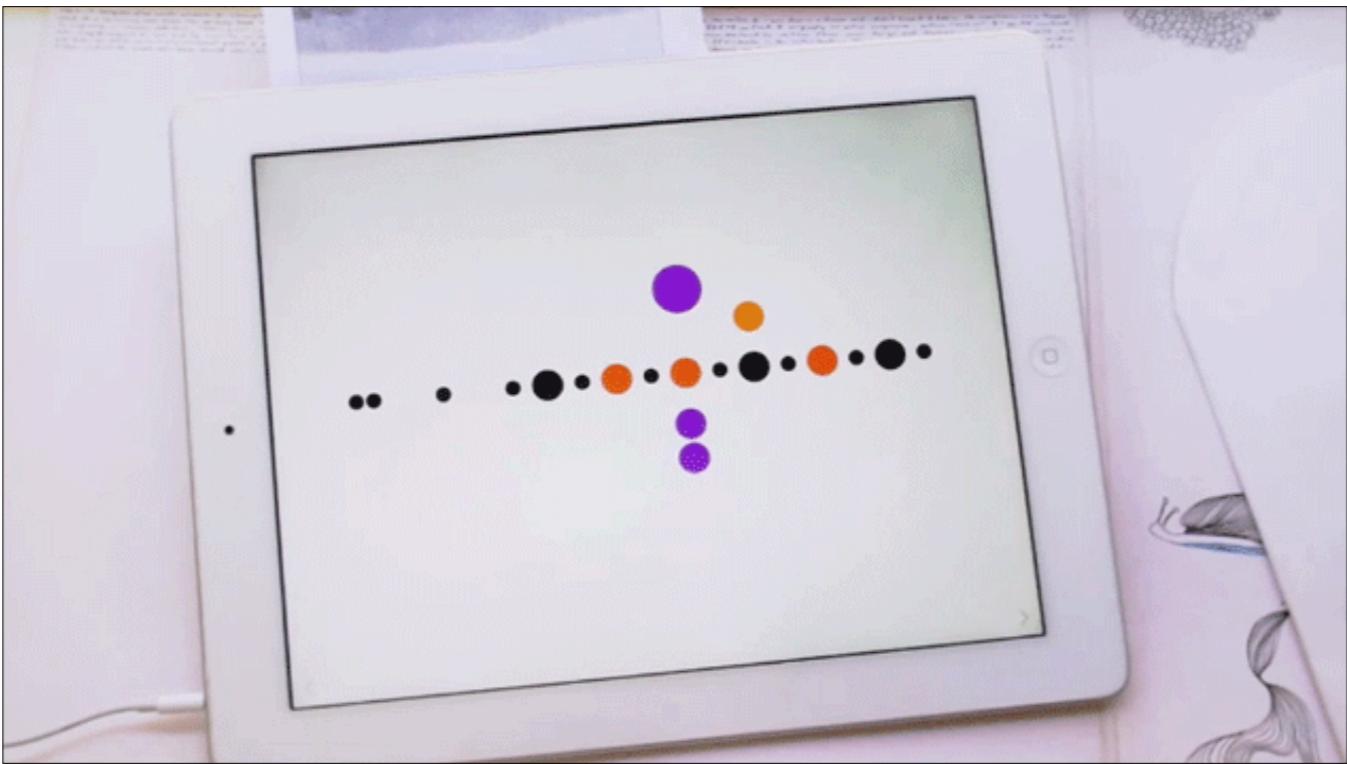


GUI (Graphical User Interface)

Invented by Douglas Engelbart and implemented by researchers at the Augmentation Research Center(ARC) at the Stanford Research Institute (SRI)

Later developed at Xerox

Popularized by Apple



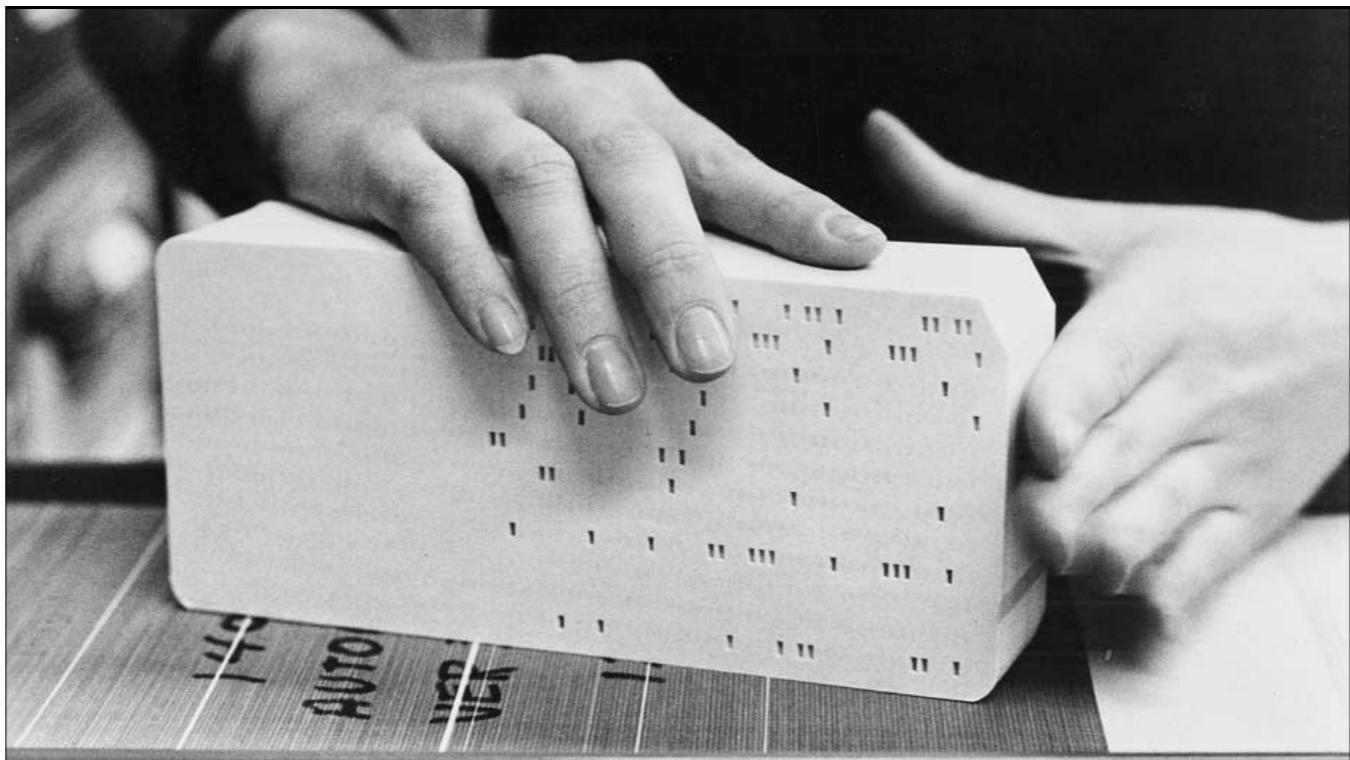
And finally (currently) touch-based interfaces.



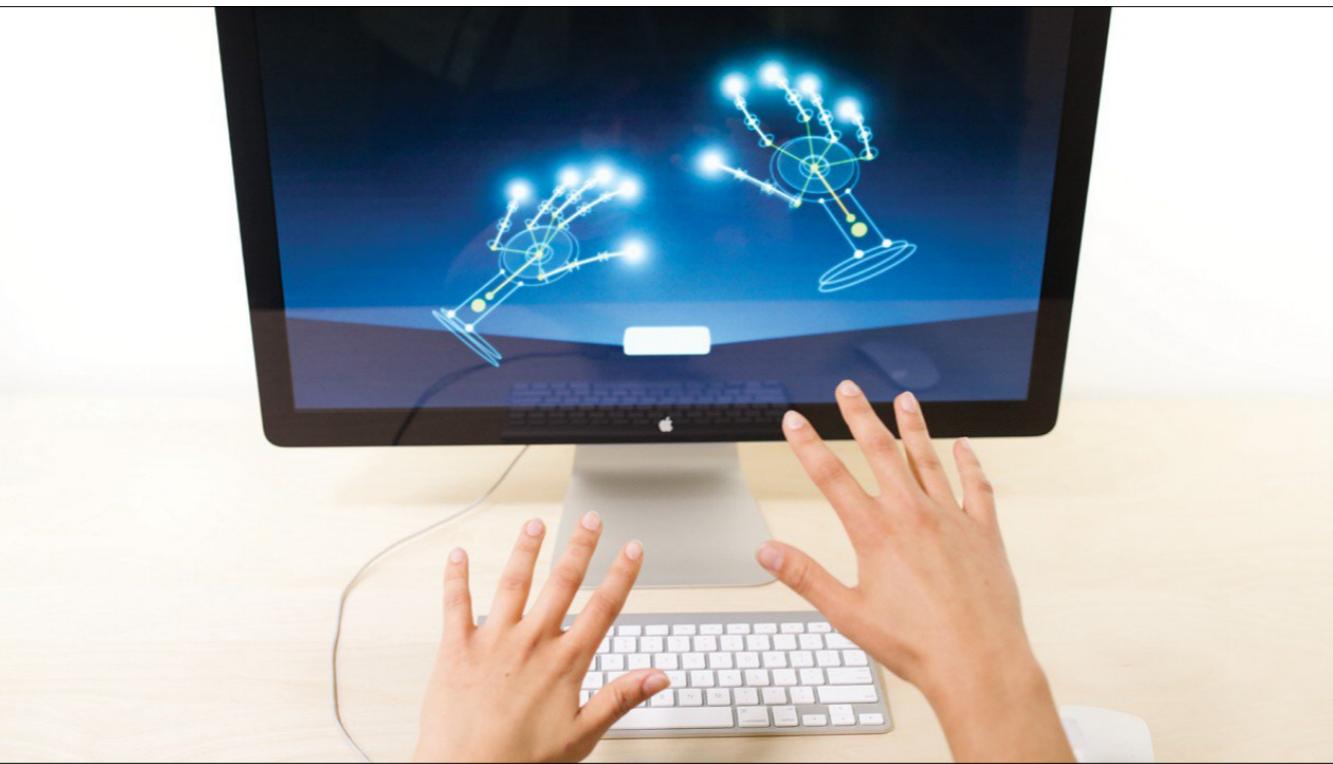
What's next?

Current state-of-the art is all based on 2D interfaces.

How do we break into 3D?



We are back in the *punch card* era of a new type of computer interface.



Sci-fi thinking often is the driver of what later becomes possible.

Gestural interfaces like LEAP motion.



VR systems use handheld remotes tracked in space.

Expectations

With new types of interface, we must teach users *how* to perform new kinds of interactions.

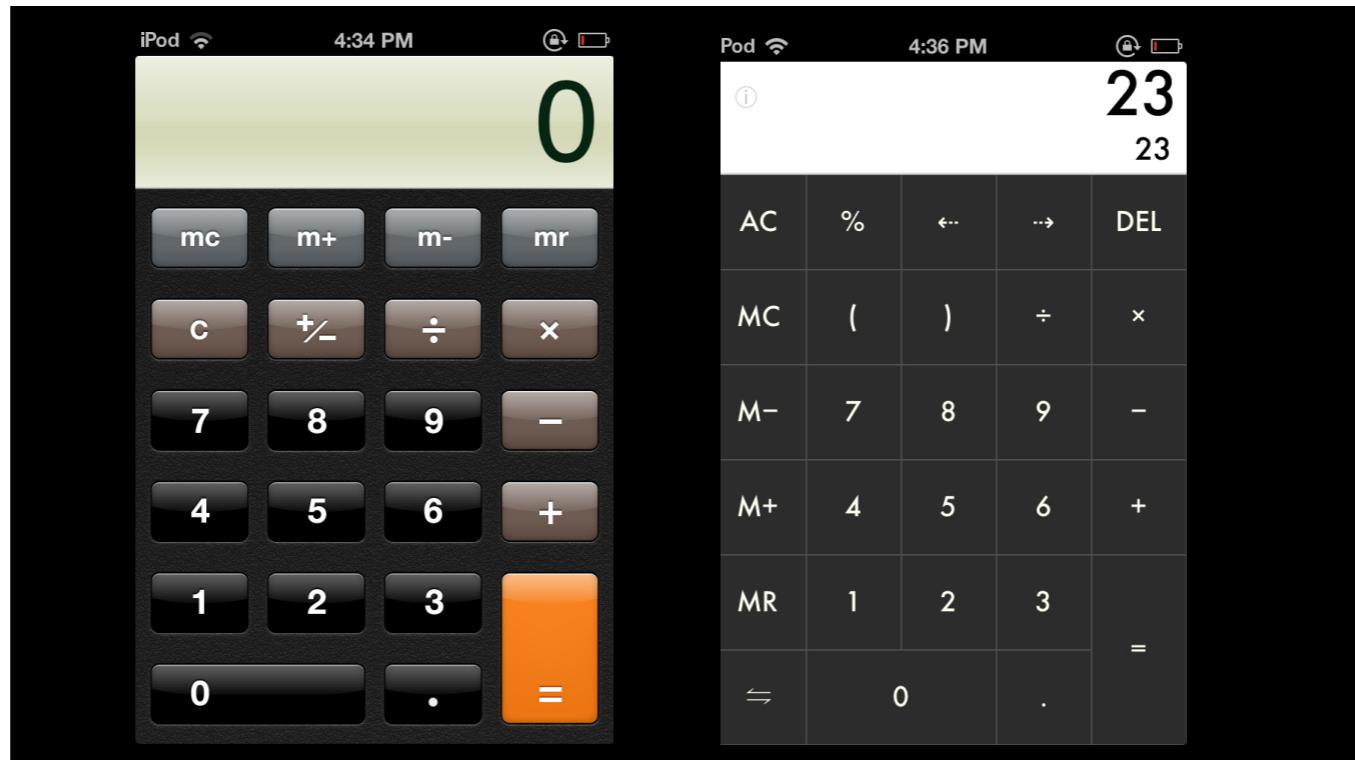


Baby trying to pinch/zoom on magazine after using iPad - 2011

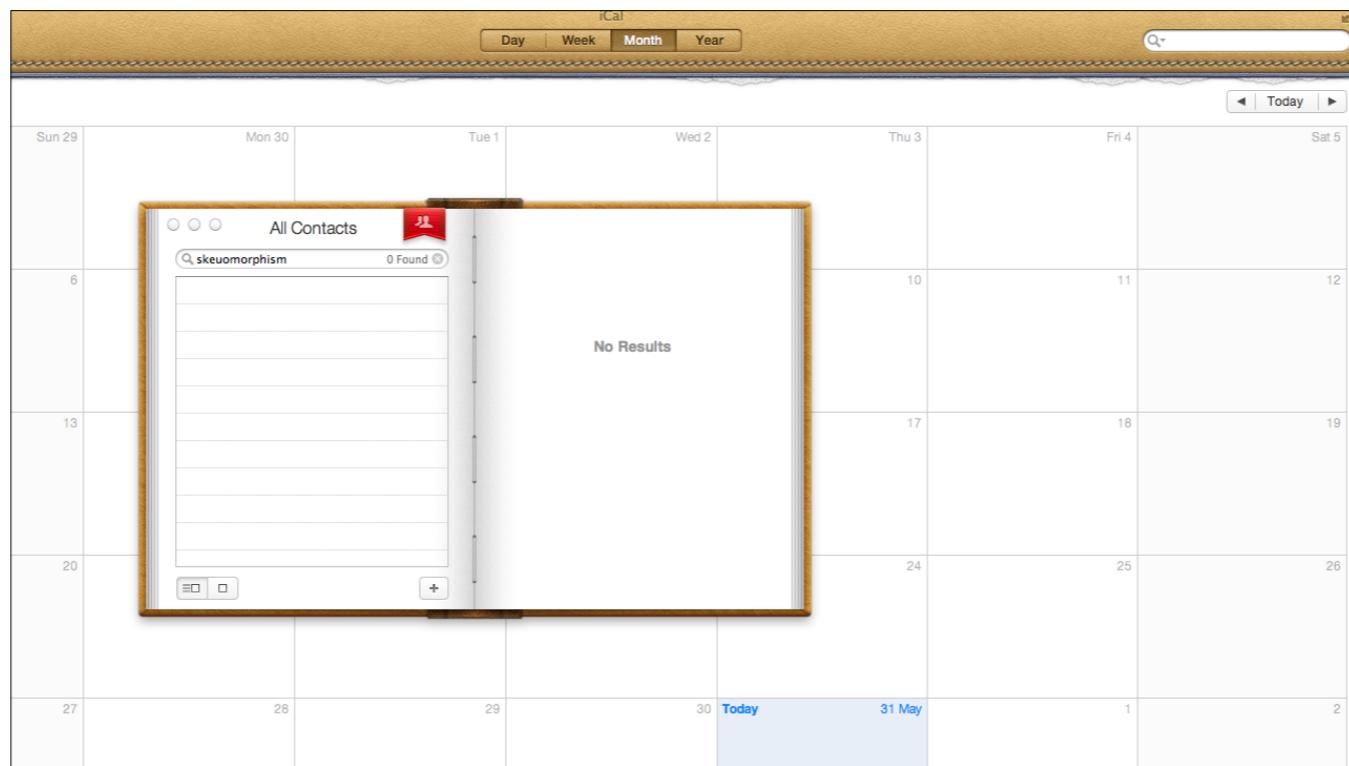
We have to be *taught* the possibilities and limitations



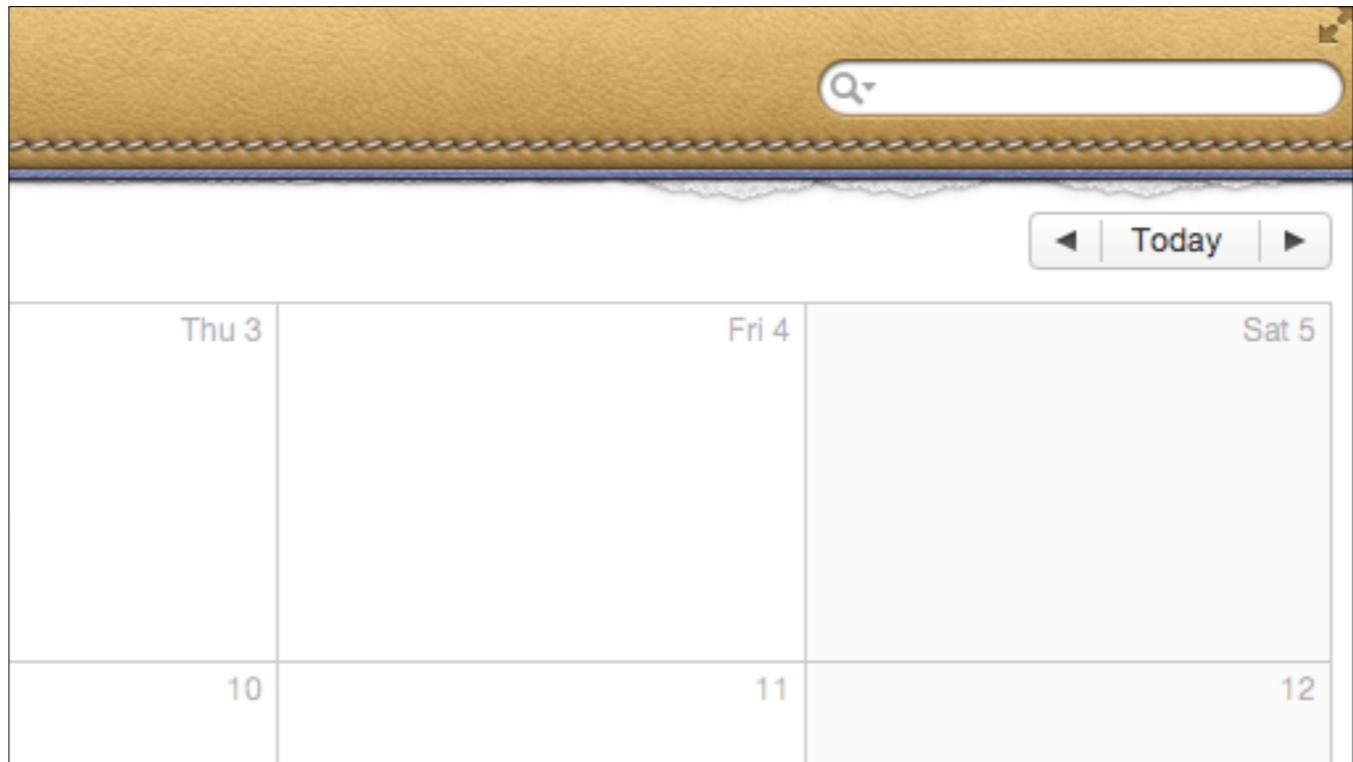
One approach is Skeuomorphism - creating interfaces that resemble their physical counterparts.



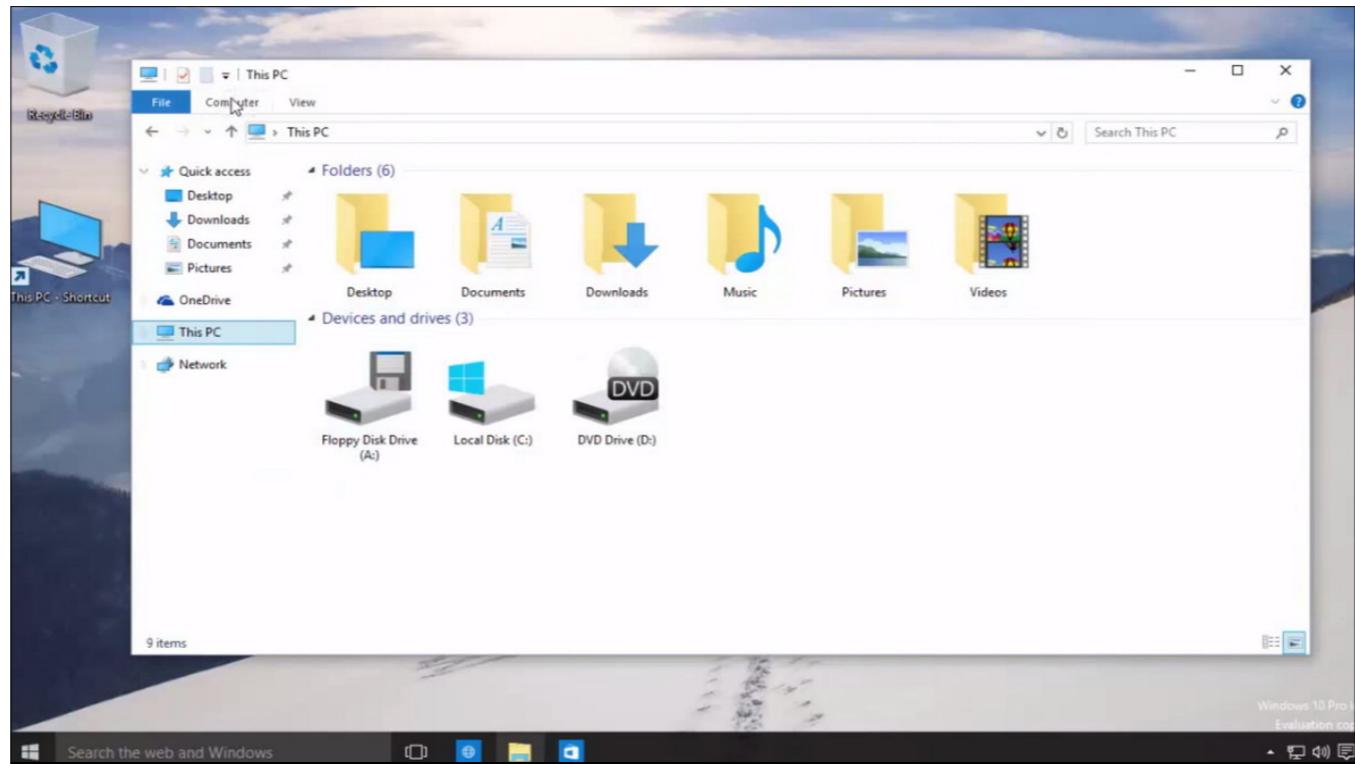
Textured leather calculator with bulgy/reflective buttons to cue people that they can be pressed.



Can easily be taken too far. Why is this calendar leather-bound?



Why does it have a ripped page?!



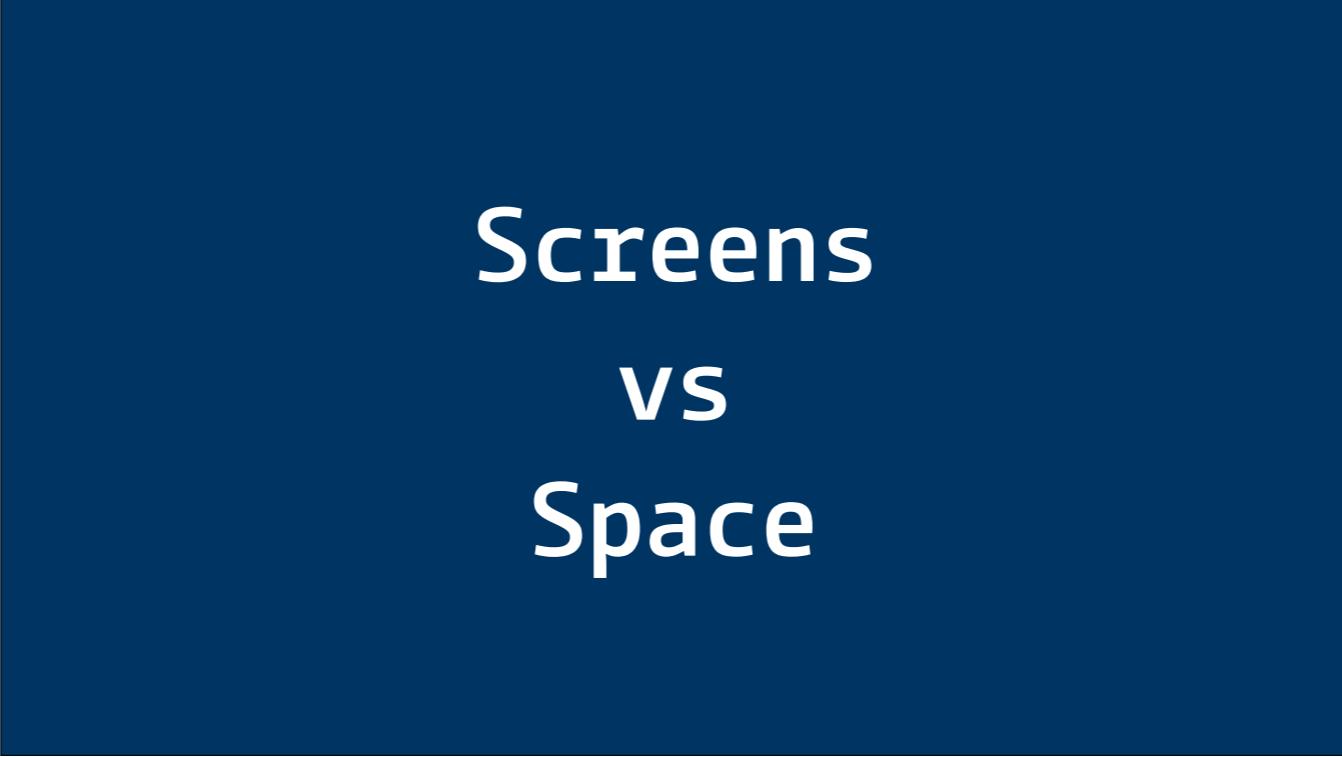
The computer desktop itself is a skeuomorphic design: file-folders full of documents on a desktop, with an adjacent trash-bin for waste.



Designing for Interaction

Design to the available tools or invent new tools

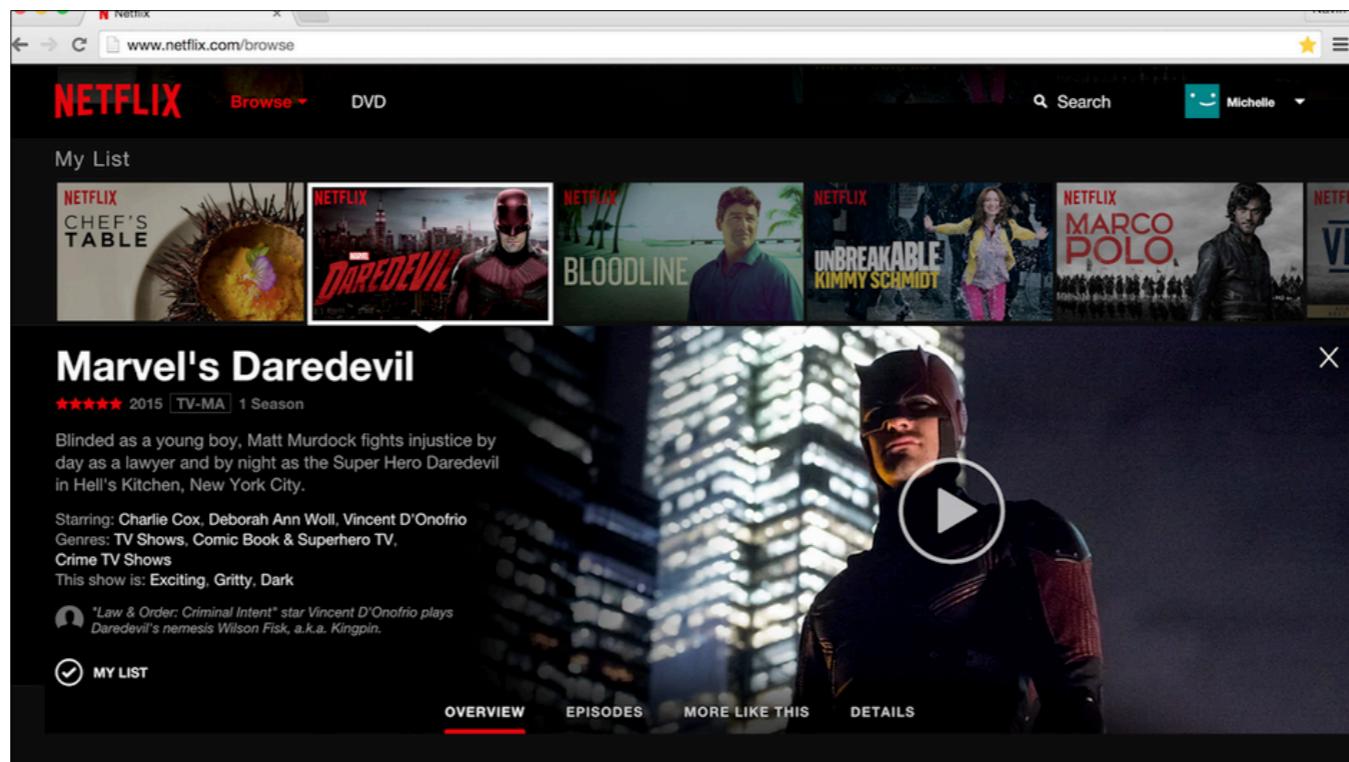
Don't try to find a new interface for email, REPLACE EMAIL



Screens vs Space

All of a sudden we have to think about a spatial context for what we make

We are not limited by pixels or the dimensions of a rectangle, but by the available space.



VR - deals with it by creating new environments

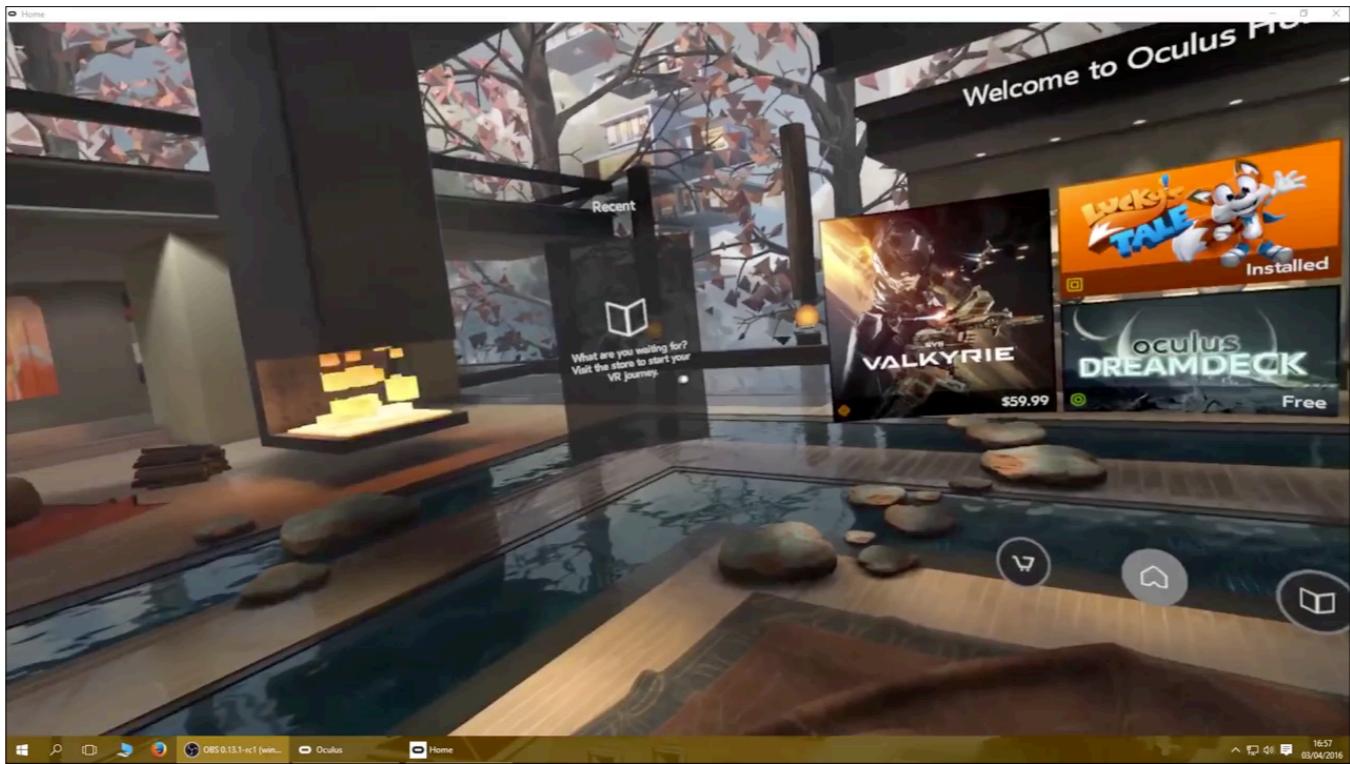
Netflix web interface...



..vs Netflix VR interface

Anticipating a future where we can comfortably sit in VR for a long time, Netflix creates the ideal context in which to watch movies (All of it's existing content is 2D)





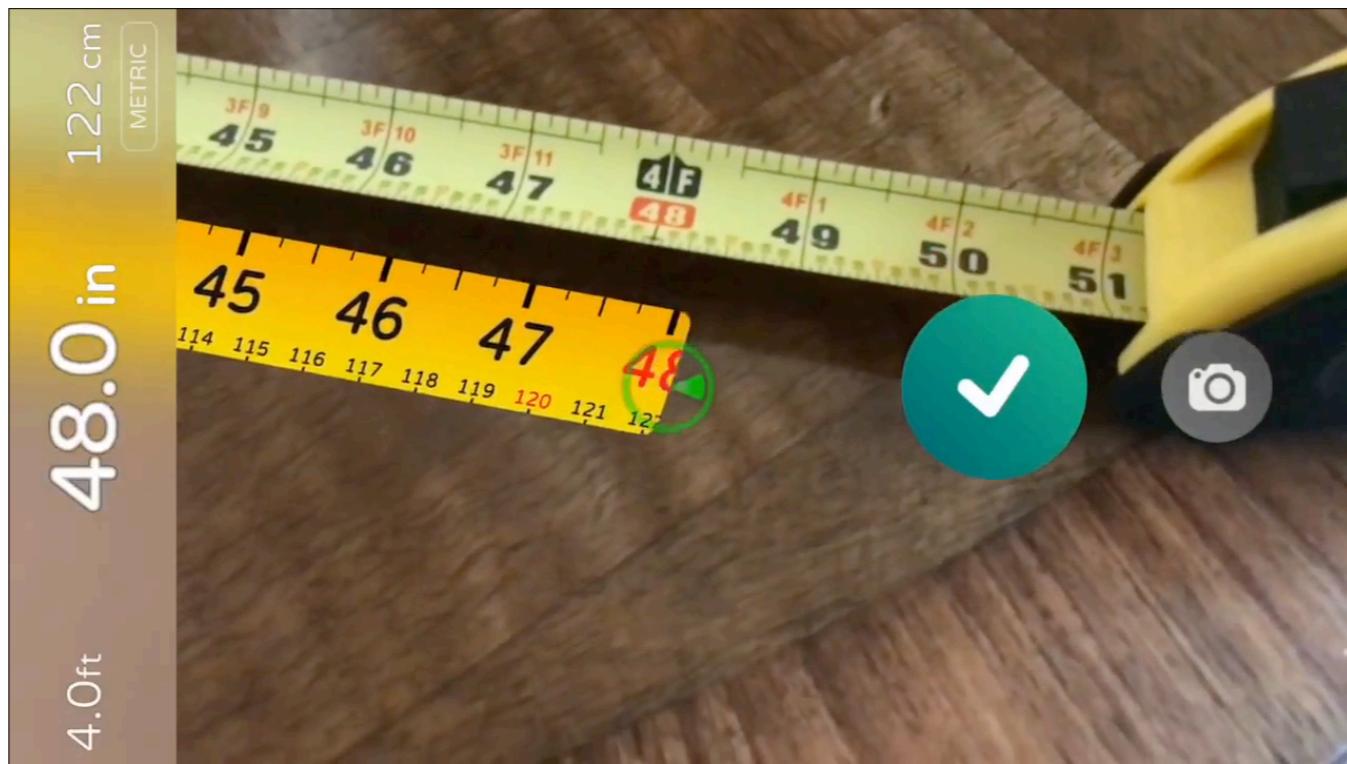
Oculus VR “Home” for your apps instead of a desktop/list.

Biggest criticism was that people couldn't change this home environment to suit their personality. Oculus changed this at last year's announcements.



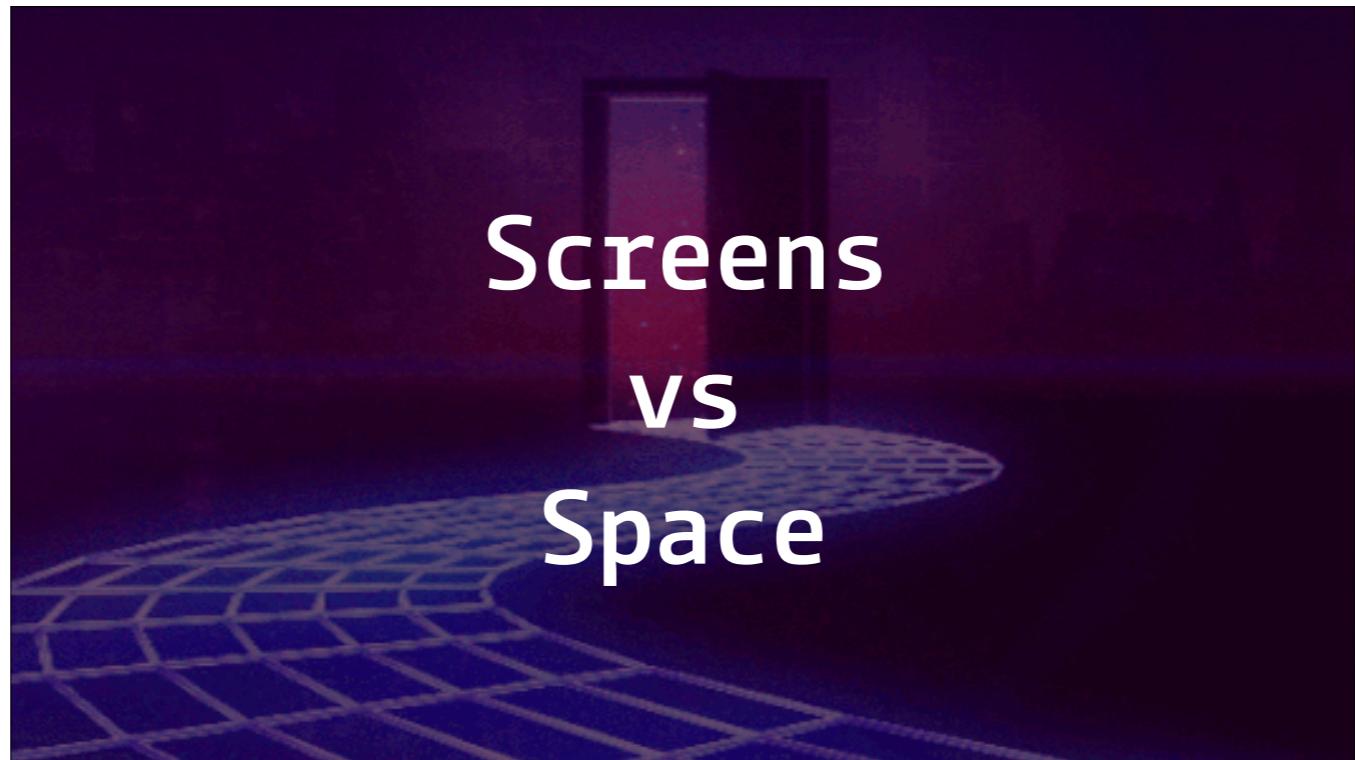
Screens vs Space

Scale is very important
Real world units

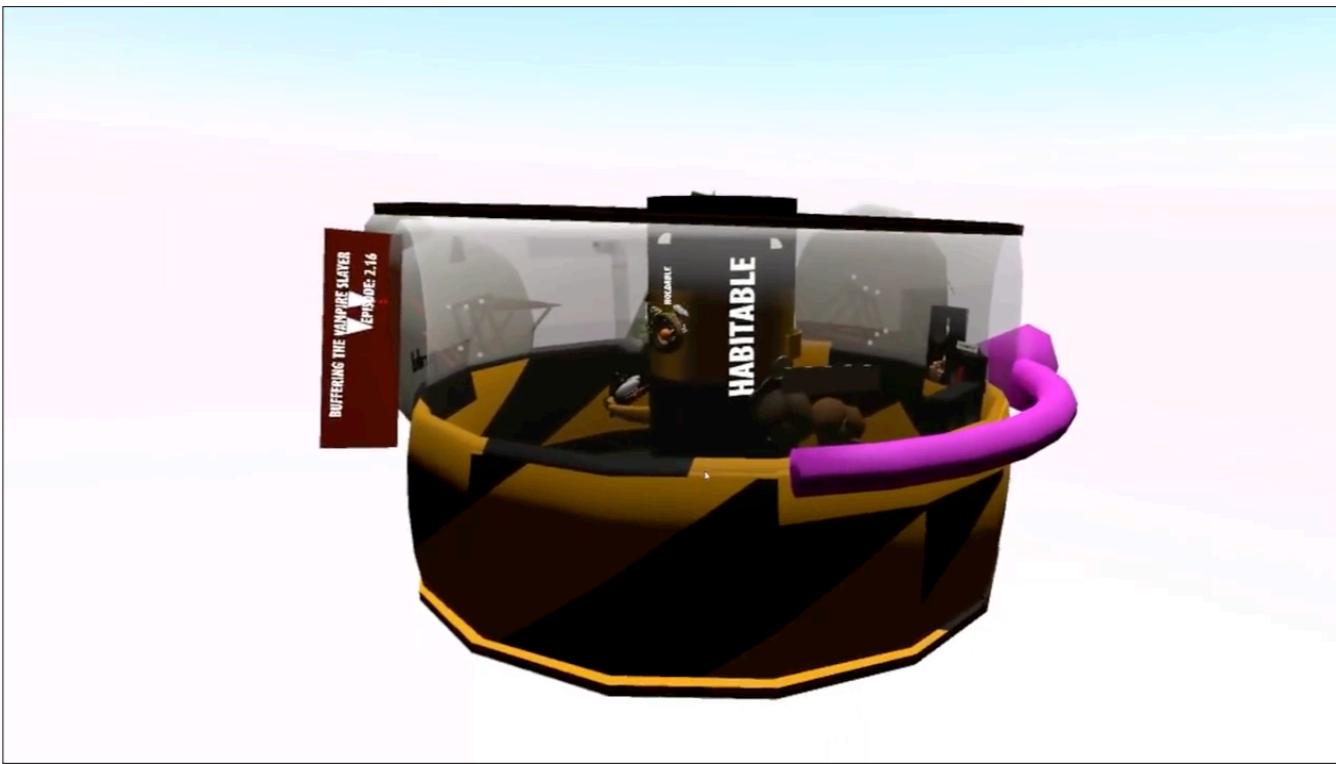


1:1 relationship with real-world scale

AR apps that can measure the environment



Screens
vs
Space



M EIFLER, AKA BLINKPOPSHIFT.

<http://elevr.com/studio-metaphor-an-embodied-software-paradigm/>

Different scales allow different interactions. Podcast app as a space you can go inside

This relates to something called **Modality** - we will explore this in a later session

Modality - A particular mode in which something exists or is experienced or expressed.

(Basically, the way that you do something.)



Two main concepts to look at today: **Manipulation** and **Exploration**



Manipulation

What is the interface?

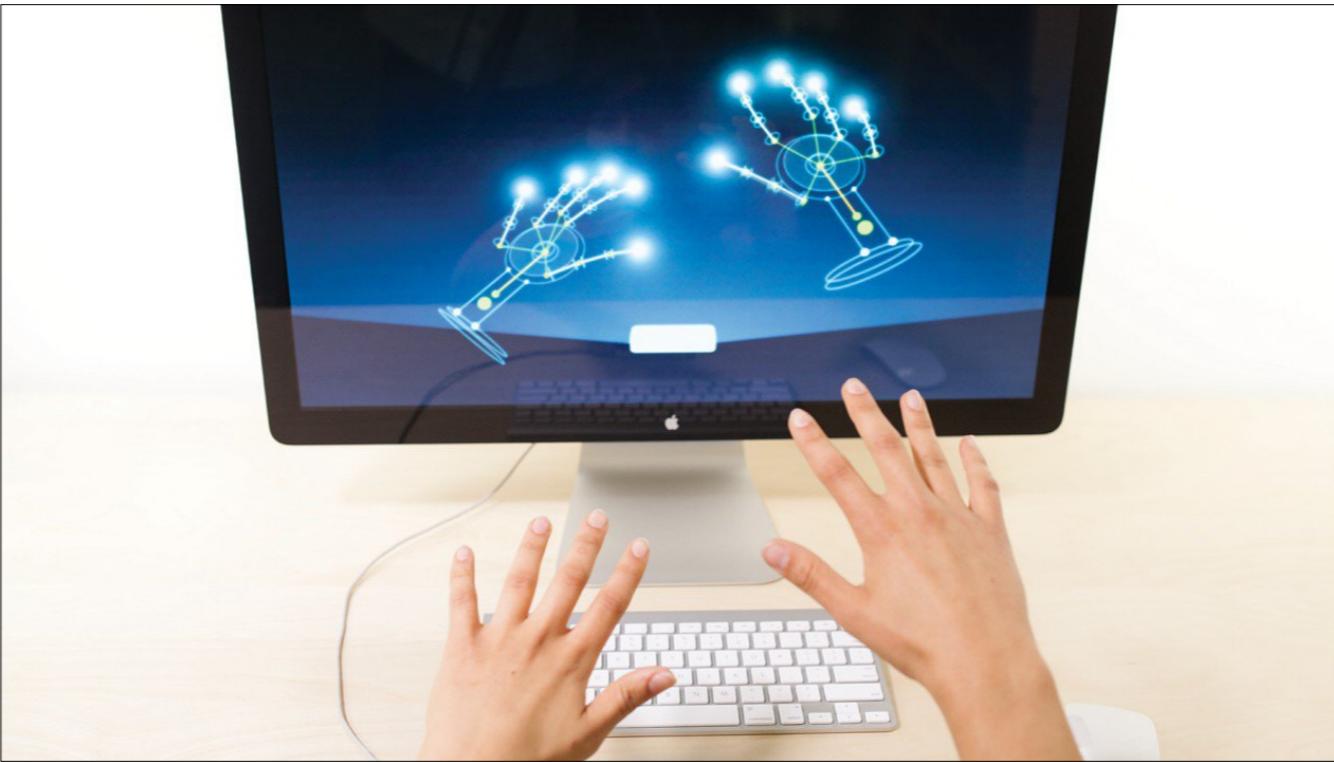


Physical interface/action and it's relationship to the effect it has

two-dimensional



Attempts at 3D interfaces go way back.



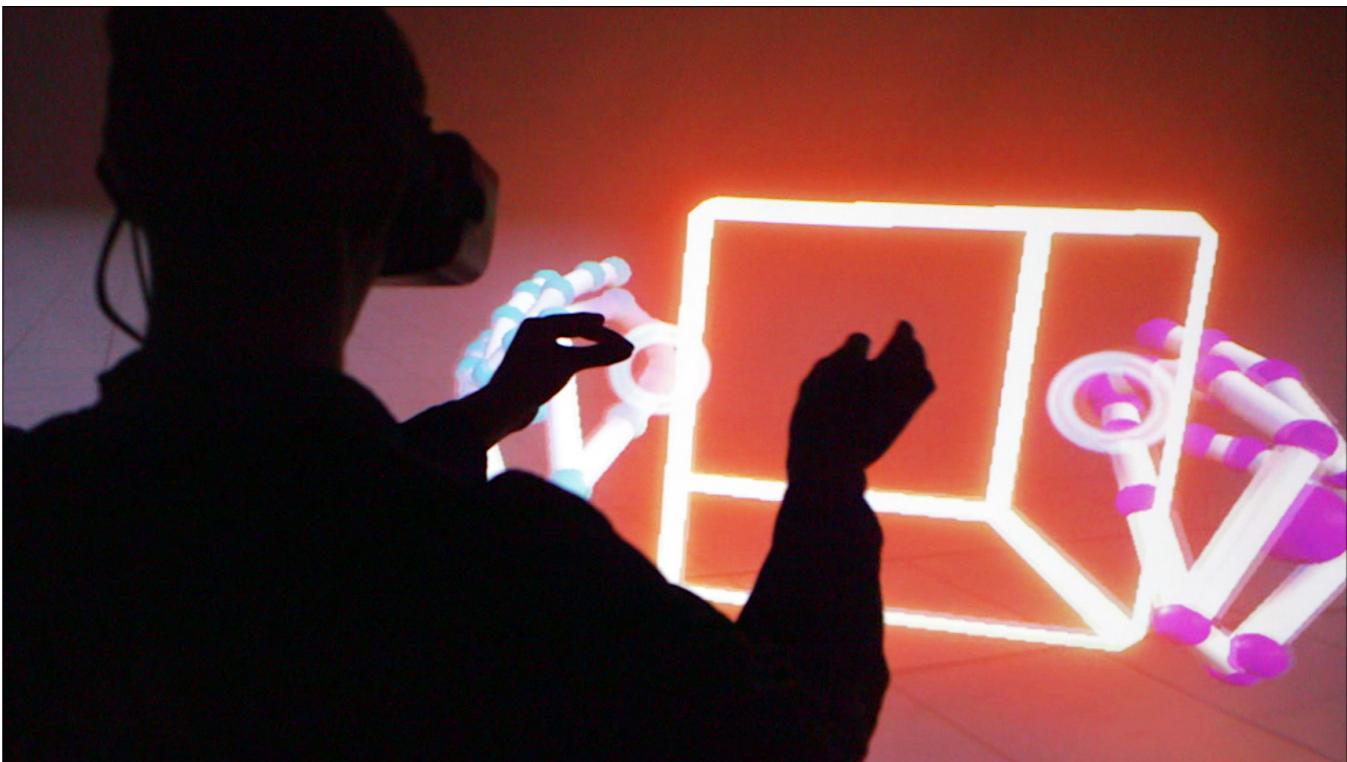
Technology is finally catching up.

LEAP almost failed because nobody wanted to interact with their email by waving their arms around: too much cardio!

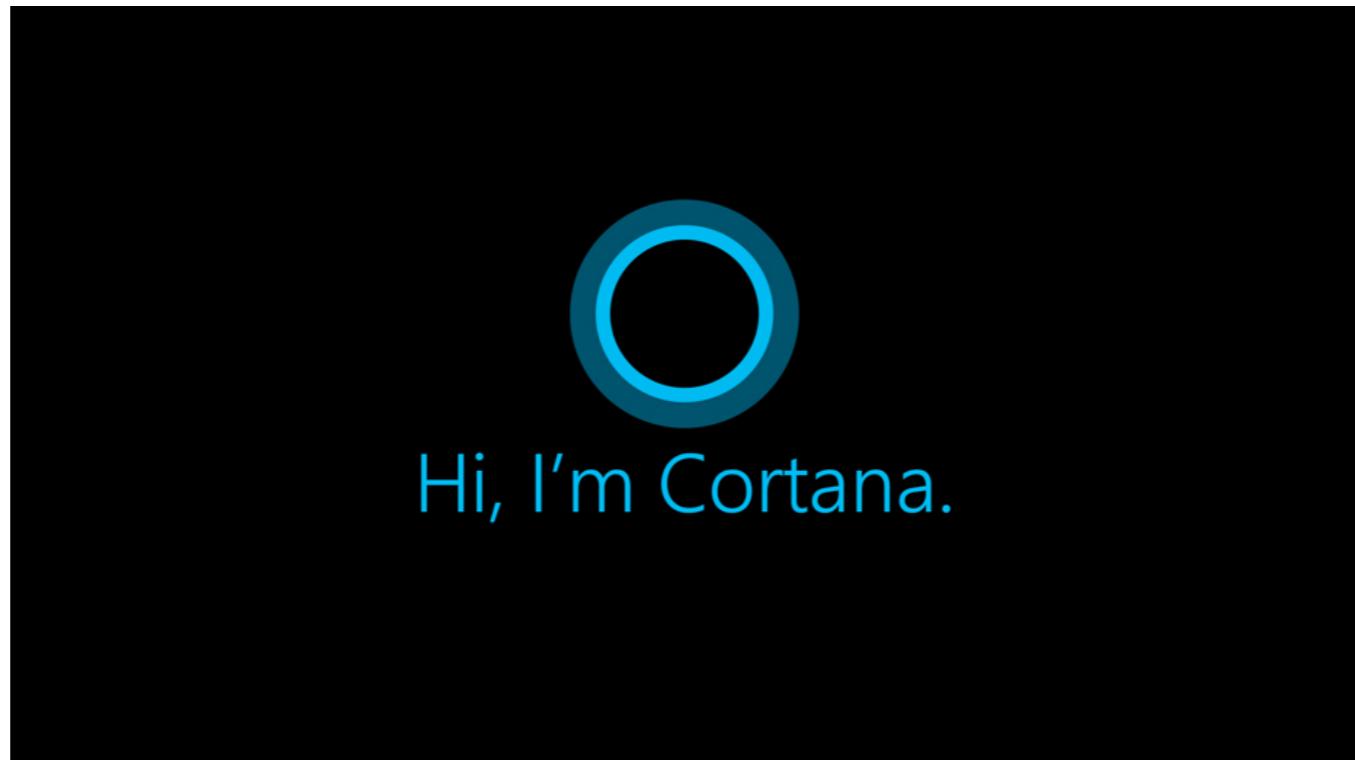
Needed new kinds of interaction.



Flip the sensor, put it on a headset, and now it is used to bring hands into VR experiences without remotes



Gestures can be used to manipulate

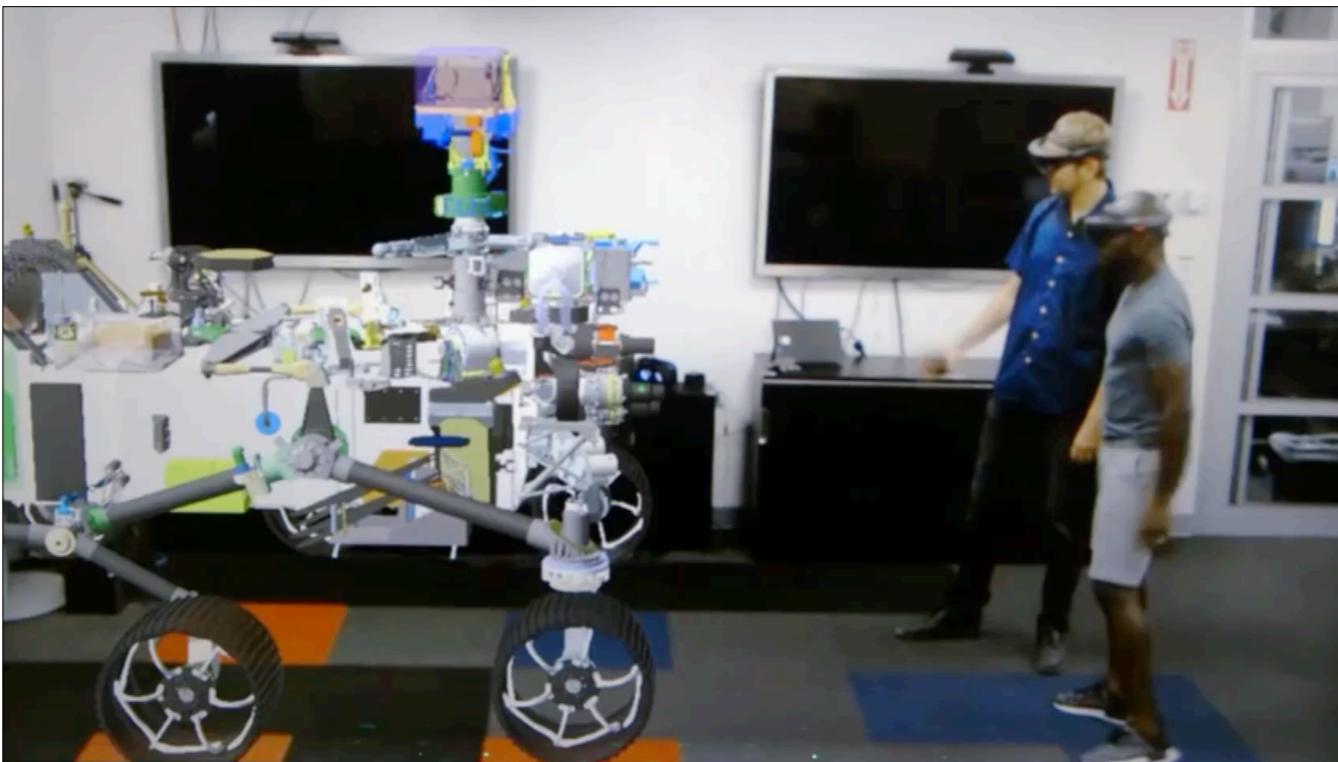


Voice recognition is a very powerful (if socially awkward) way to interact with interface-less experiences.





Moving through an environment to discover content - no direct manipulation.



JPL uses Hololens to visualize 1:1 models of rovers, allowing designers to discover relationships and problems before anything is actually built.

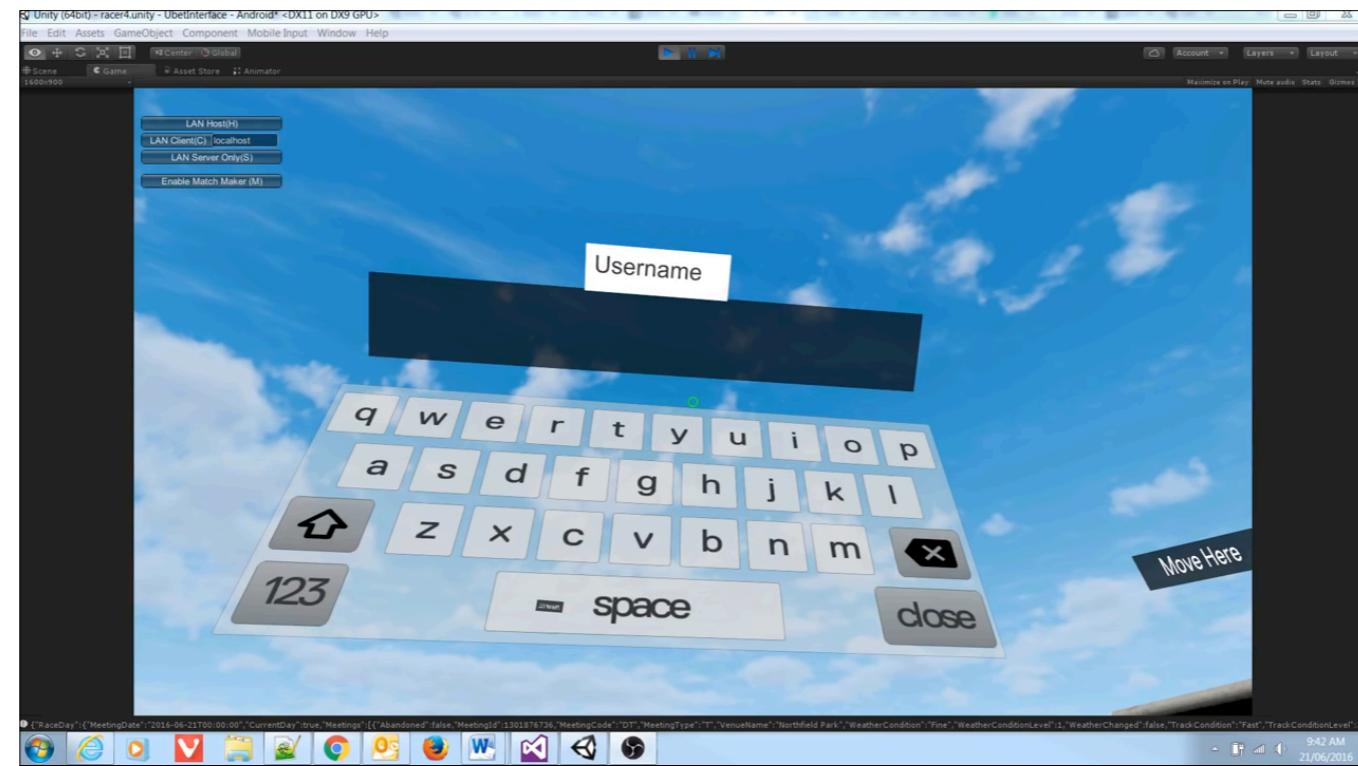


Exploration can still be a manipulation - content can react to viewers position

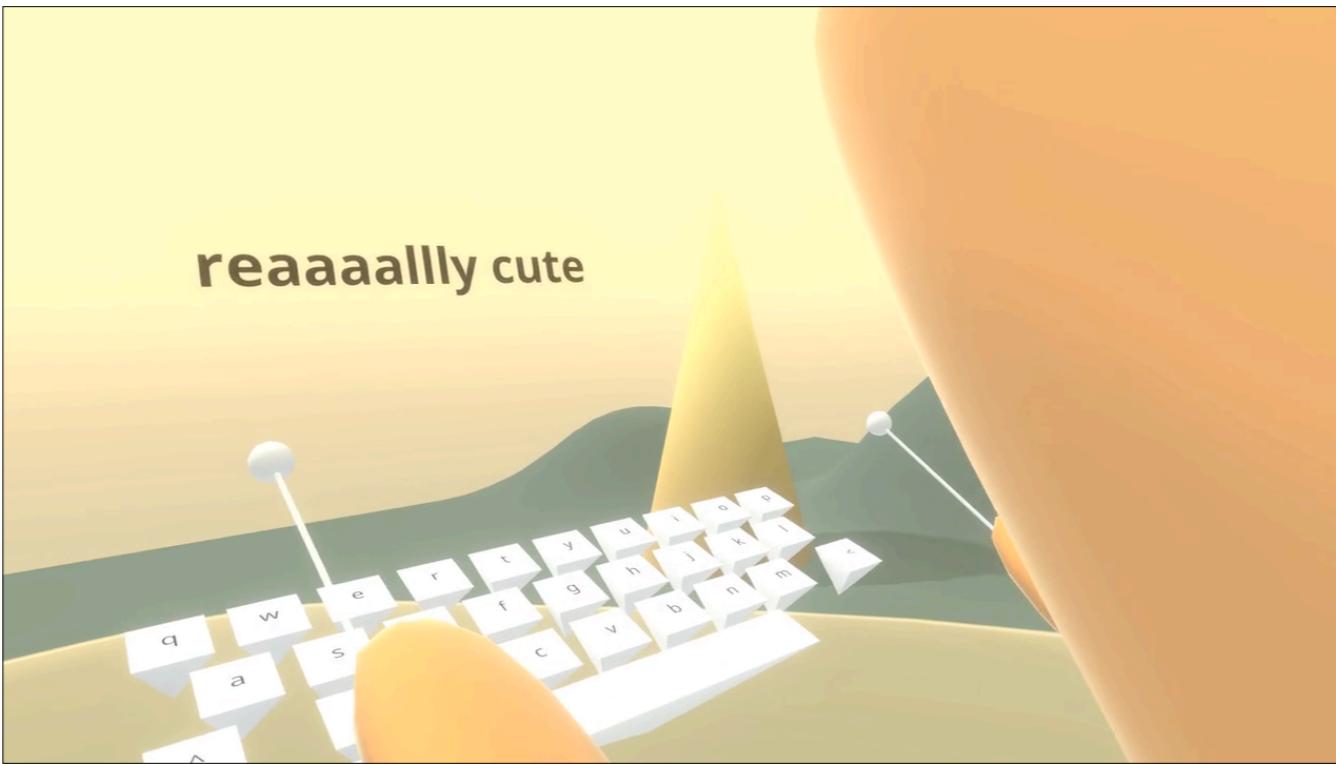
Designing for Interaction

Why

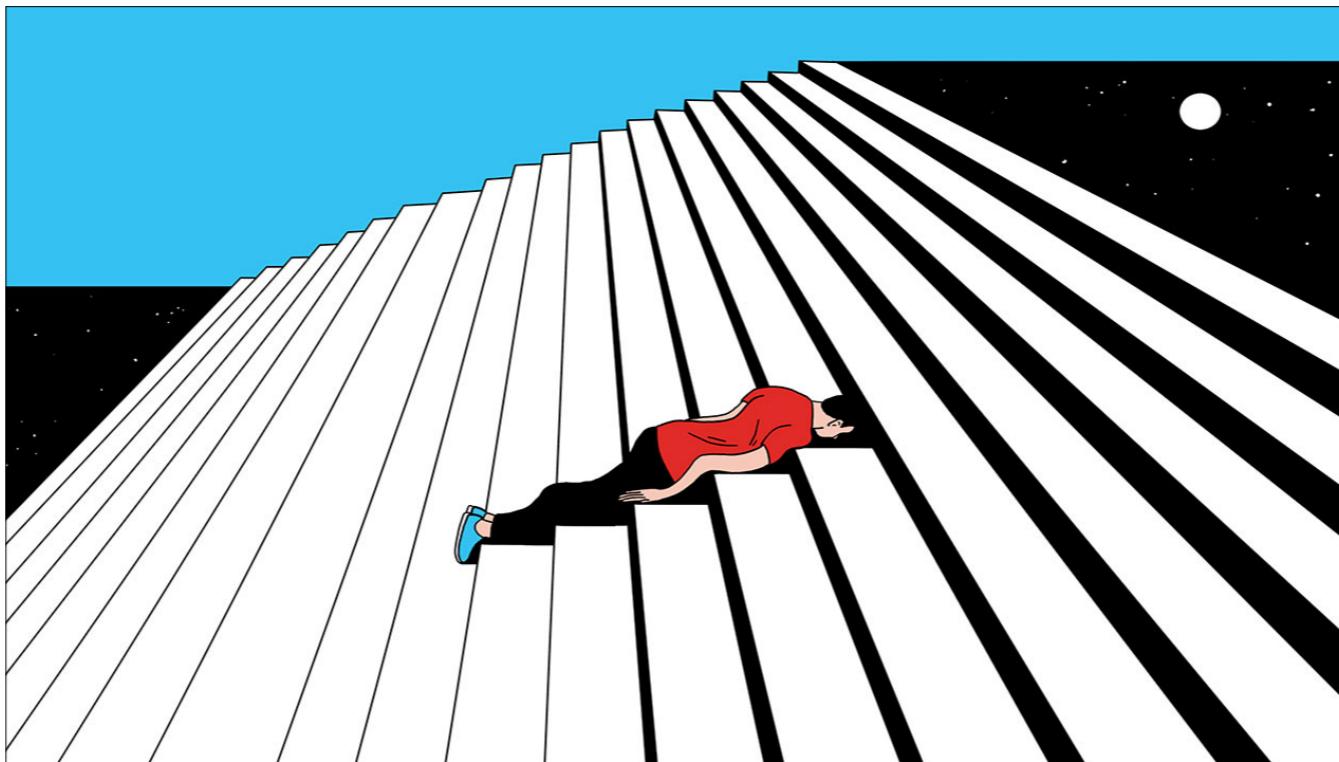
To Reveal
To Change
To Visualize



Bad/frustrating example of bringing keyboard into space: using gaze direction + time.



Good example: uses space and natural interaction for the tools you have available (handheld remotes)



Ok ok...break time so we can switch gears.

