



TECH 1711 - Mixed Reality Studio



New Class (Be Ready for Changes)

1st Year of this class

“Future of Digital Media” and “AR/VR in Architectural Environments”

Most Up-to-date Syllabus:



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

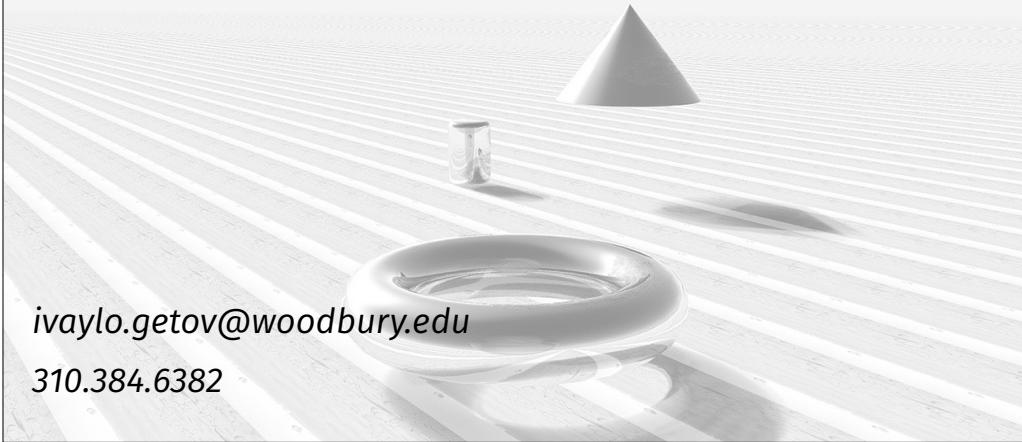
I will do my best to keep the Moodle page updated, but I can promise that most up-to-date class materials will be here:

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

Contact Me

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About me





I am cofounder of creative-tech/experience-design studio Luxloop (<http://luxloop.com>)

Mediating the intersection of Virtual and Physical

Activating Spaces with Story and Technology

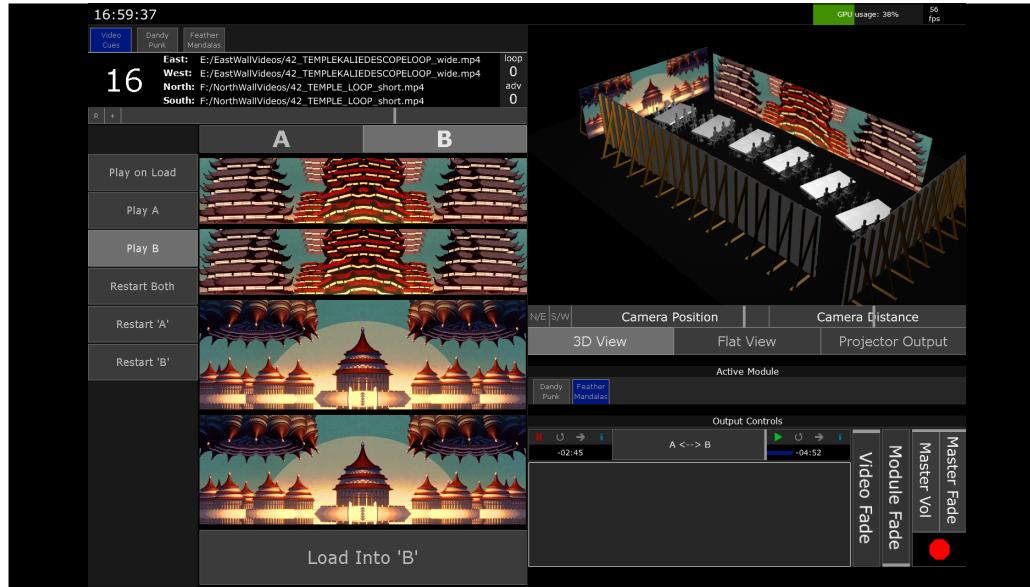


Work with artists - Most recently (current): AR project for artist Pierre Huyghe at Skulptur Projekte Munster

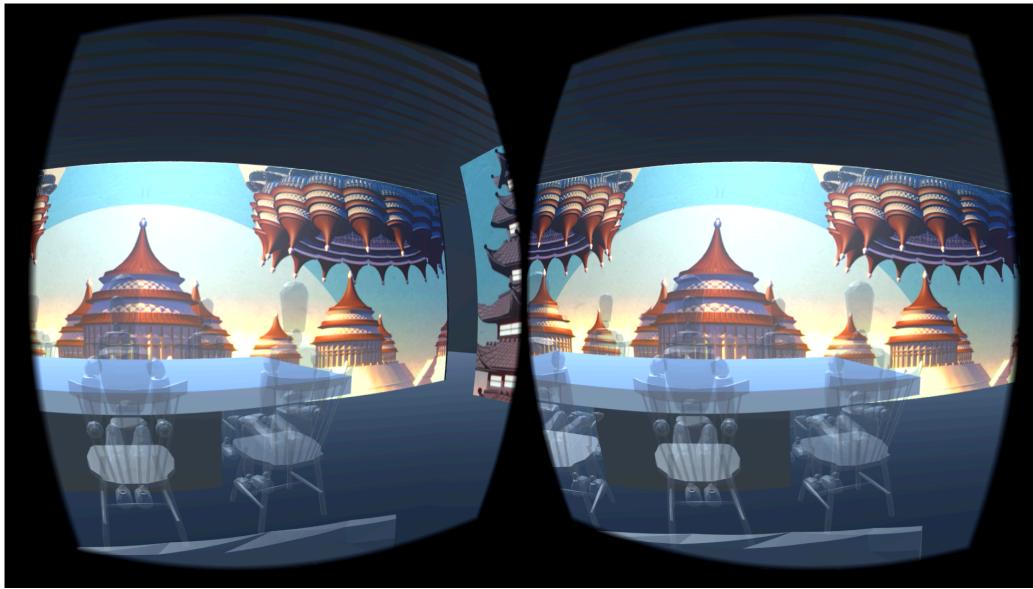




work with event companies - immersive experiences (is this AR? More on that later!)



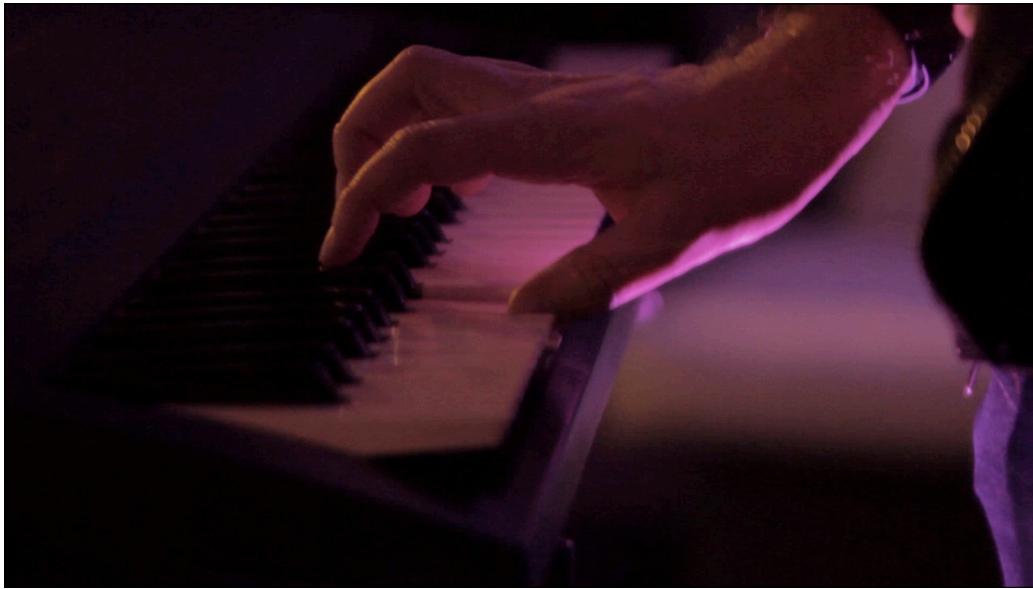
Otherwise we do stuff that ranges from large-scale projections...



(Which we use VR to pre-visualize, but more on that later)



...to installation art and other creative applications of technology





My personal background is Film/TV (Mostly Documentary) & Philosophy

Recent emphasis on creative direction and technical direction for interactive/immersive work



About YOU?



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

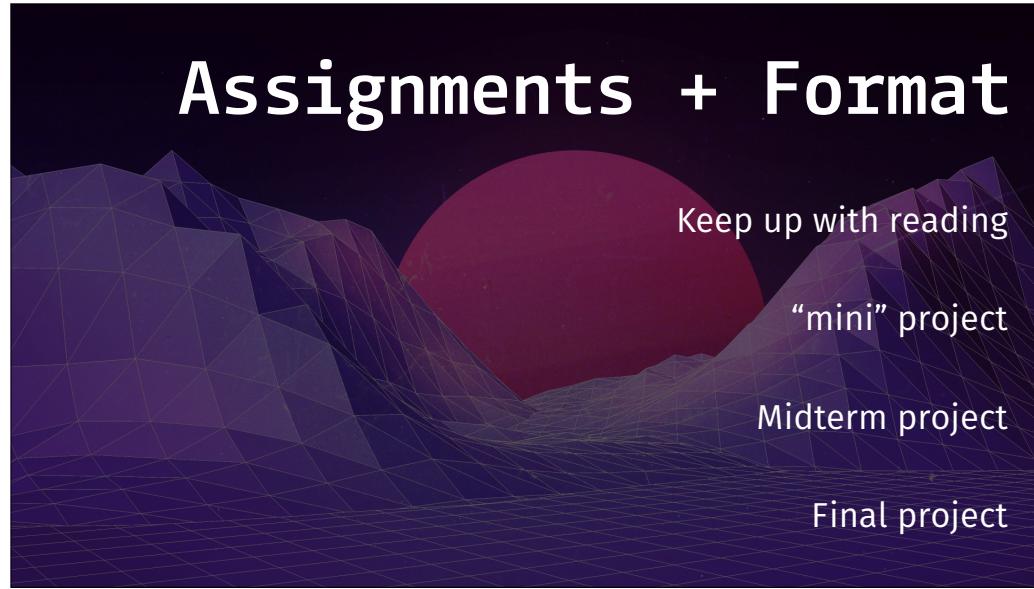
Expectations

Participation

Flexibility

I do not want to talk at you. I want to **facilitate - help you try things**. Participation is a huge part of that - the class should evolve into a *dialogue*.

Please be flexible as the class itself is an experiment and subject to change.



Discussion - readings will help get better intuition and deeper understanding.

More time explaining = less time making actual projects. I trust you to keep up with the reading, so please do or I will have to assign HW.

“Mini” project will be completed in class time over three sessions.

Midterm and Final projects will require out-of-class time

Your final grade will be made up from:

- * Participation, attendance, in-class projects/exercises: 60%
- * Midterm project: 15%
- * Final project: 25%

First session of each week will usually be talking/discussion, second sessions will be more technical.

I don't want to get too literal with lecturing on the future of media. This **is** the future of media. Thinking about design, bridging tech and creativity. We'll be **doing it**. We will have some recap at the end of the semester to put it into more bite size takeaways, but the point is I don't care if you can **talk** about the future of media - I want us to be the ones **actually making it**.

Goals

Specific Skills

- Completed multiple VR/AR Projects
- HTC Vive, Hololens
- Unity

Conceptual Proficiency

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



If you're using your own computer - Work on own **WINDOWS** if you can, bring portable drives if you don't. **You are not required to have your own computer.**

Let's Go!



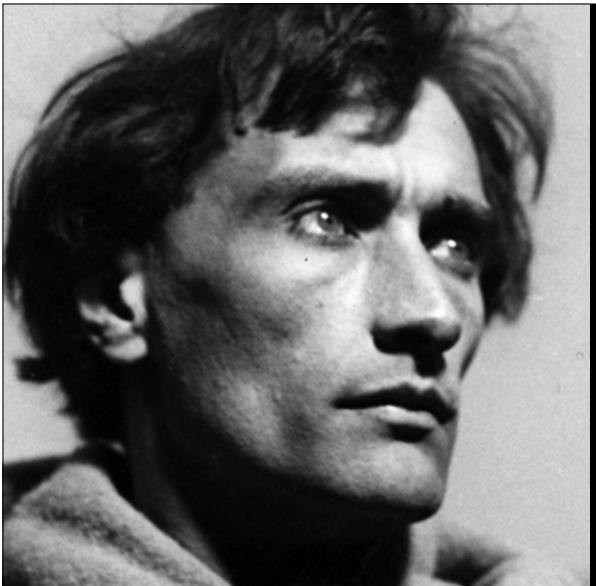


Immanuel Kant 1781 - Critique of Pure Reason - Dual Nature of Reality

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.

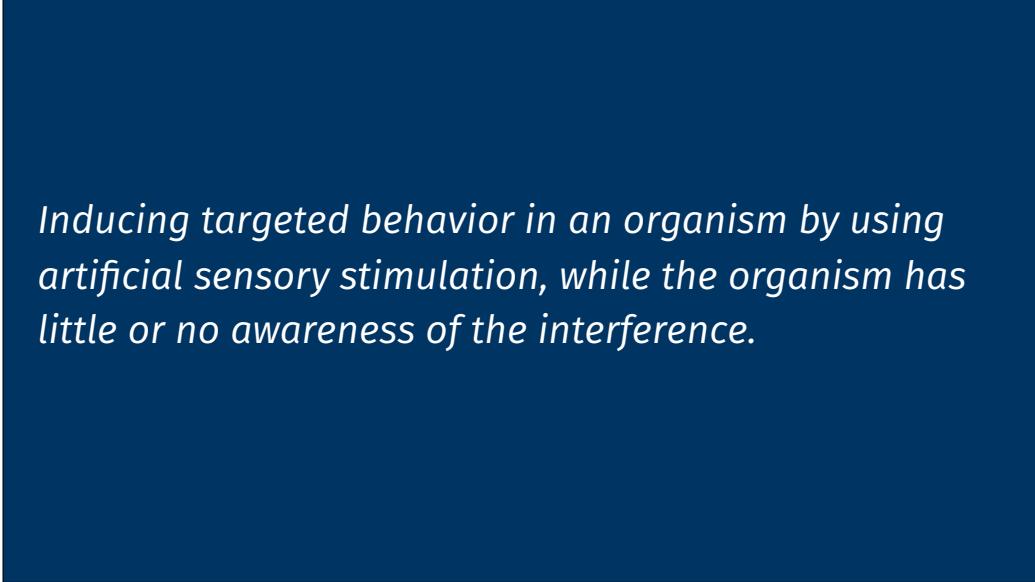
Attack on theatrical convention: opposing the **viewer's sensual experience** vs **theatre as a contrived literary form**

“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



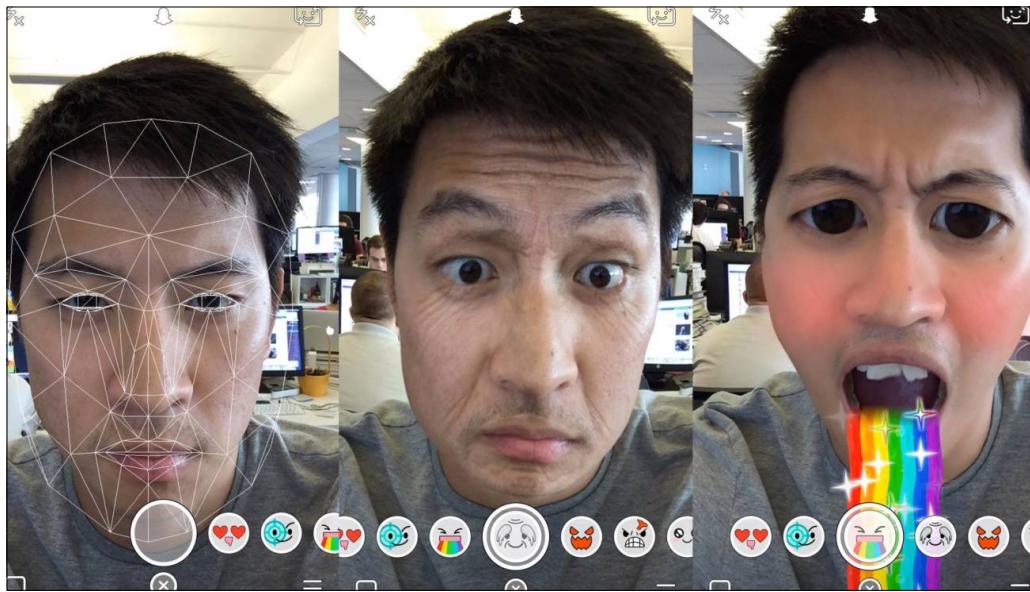
Examples:

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



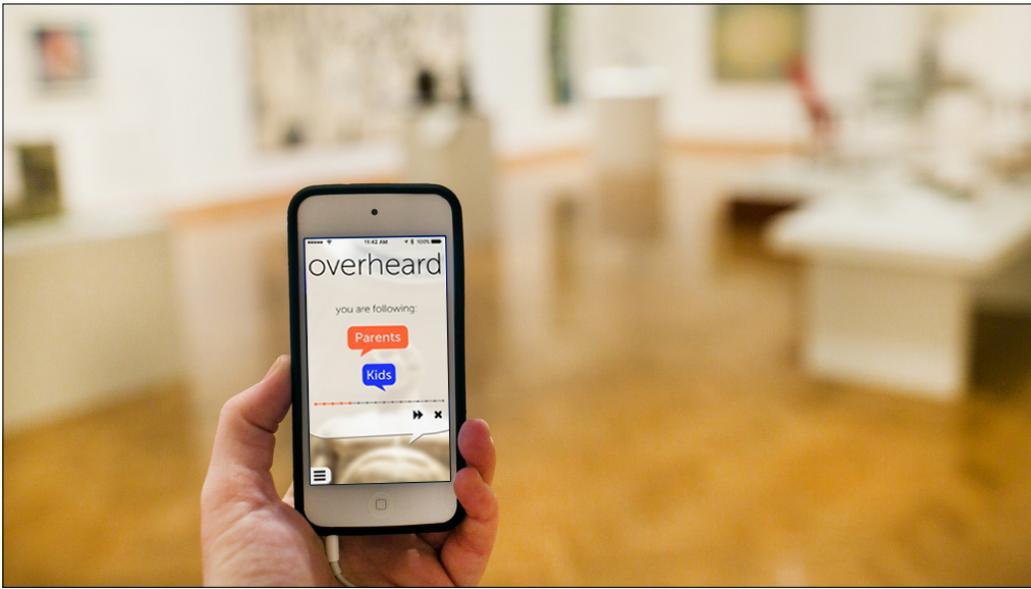
Examples:

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



Examples:

Snapchat Filters? Do they count as AR? YES!



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.



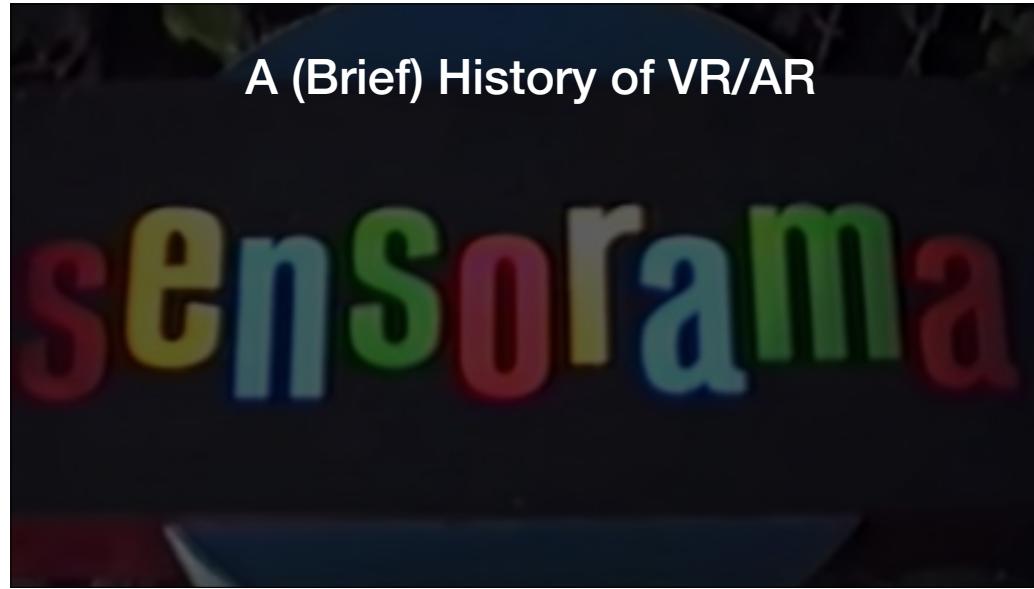
Where do we draw the line?

"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?

Look at quick history of “modern” Virtual Reality.



Stereoscope

Early 19th Century



Morton Heilig, Sensorama, 1957-1962

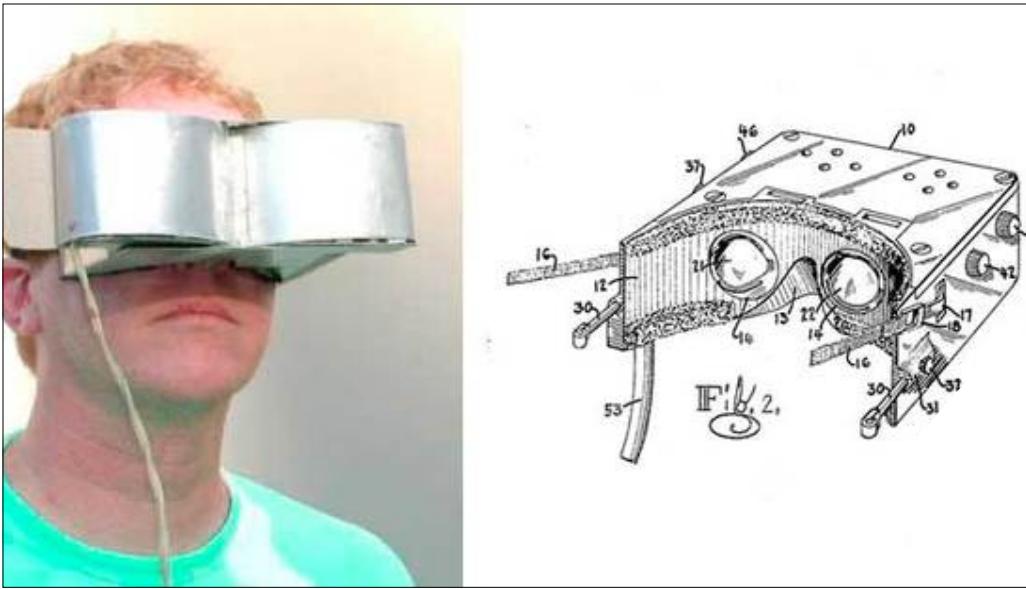
Sensorama

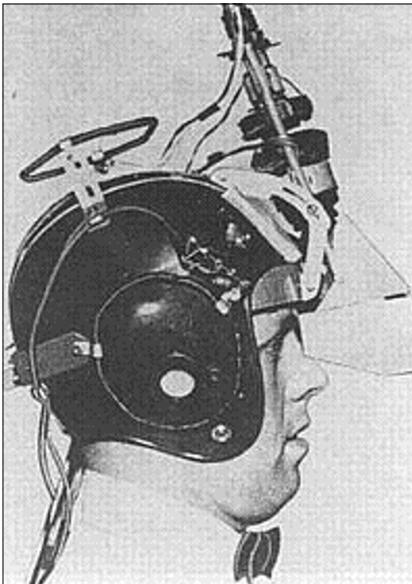
- stereoscopic 3-D images
- wide-angle view
- tilting,
- stereo sound
- also had tracks for wind and aromas to be triggered during the film.

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



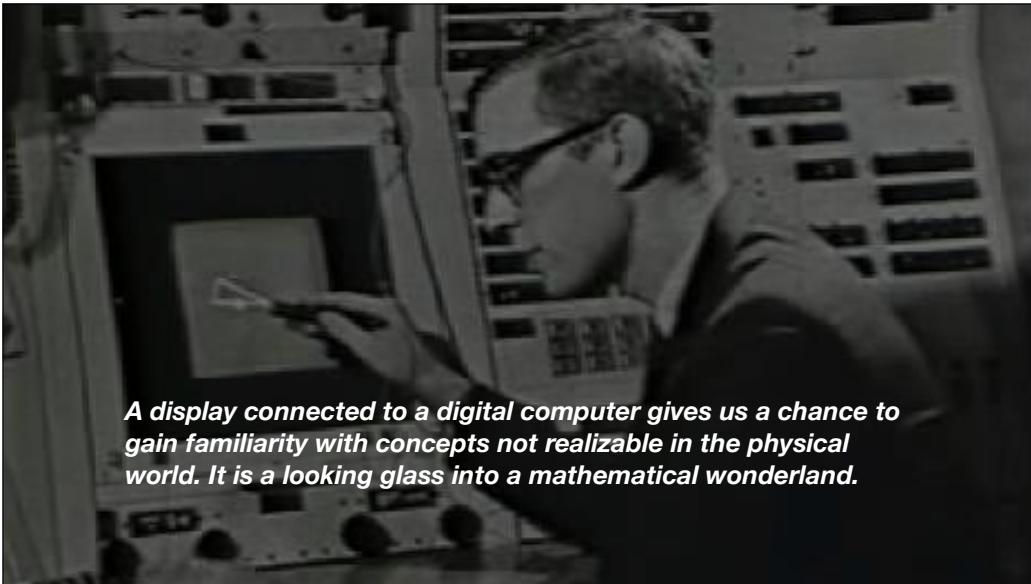


Philco HMD

Philco 1961 - "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.

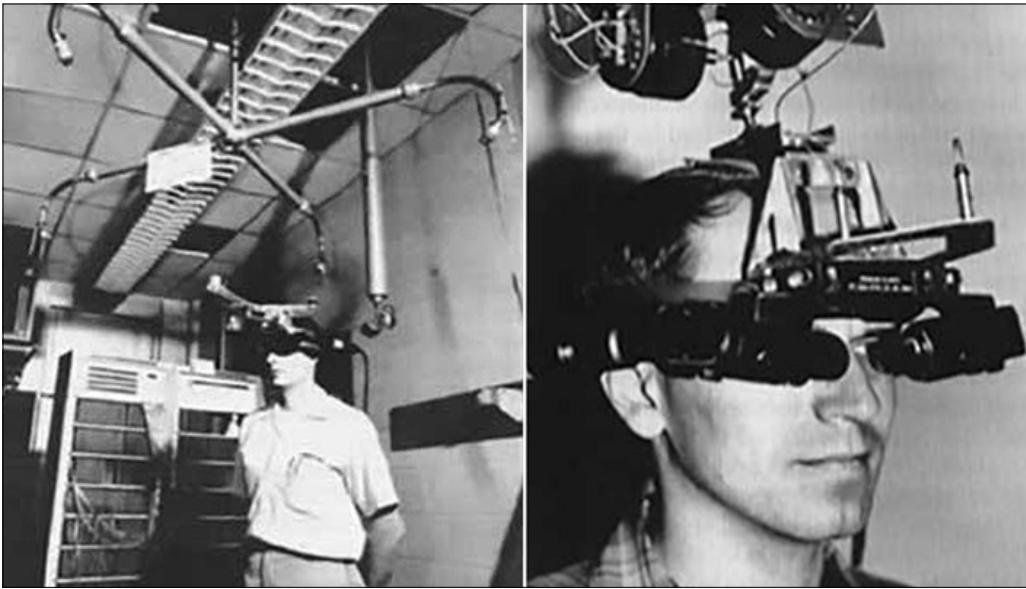


A display connected to a digital computer gives us a chance to gain familiarity with concepts not realizable in the physical world. It is a looking glass into a mathematical wonderland.

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)



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...

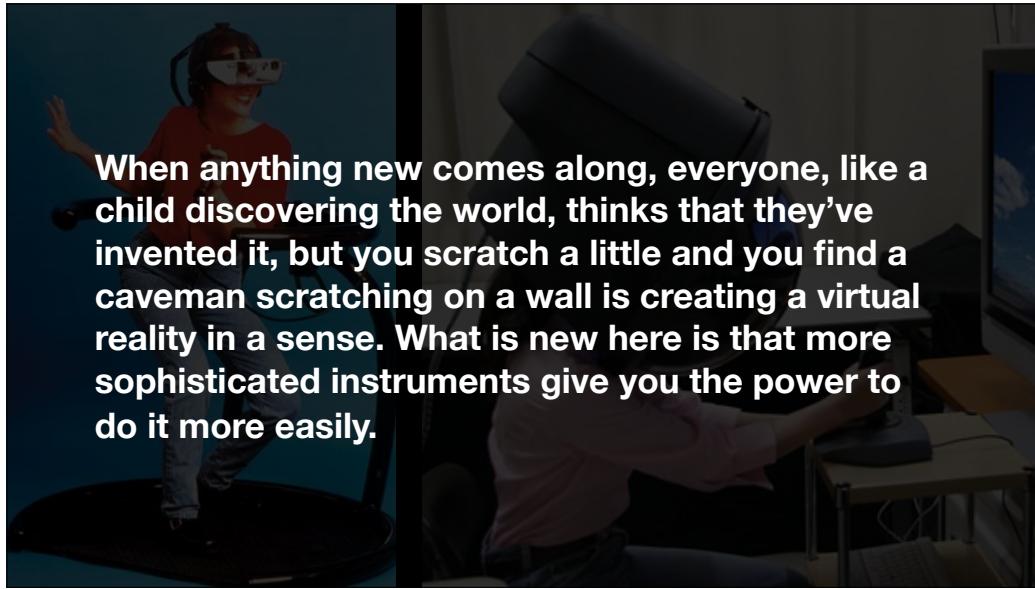


...Leading to the MIT Wearable Computing Project

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.

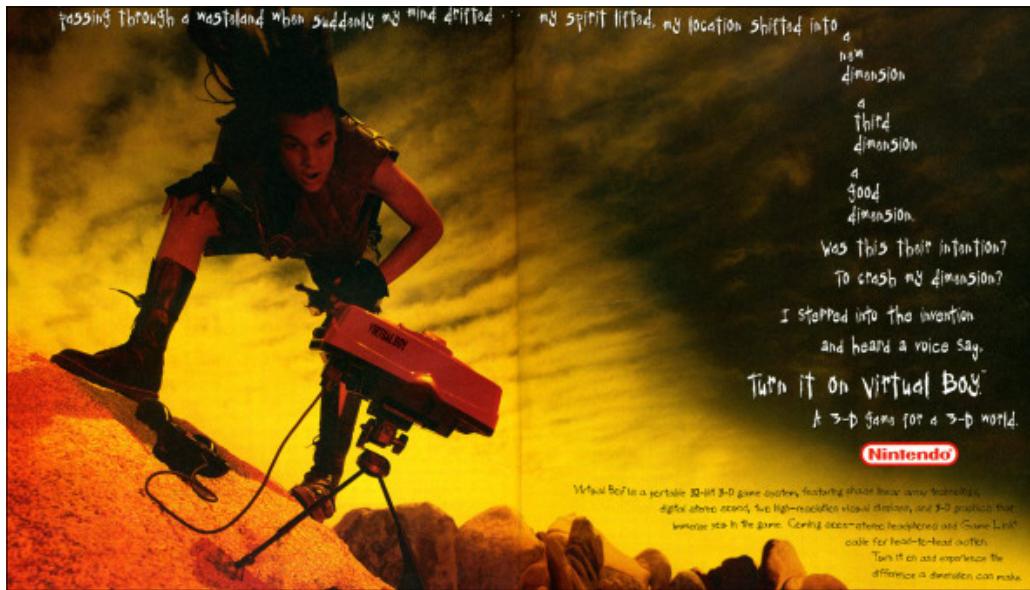


When anything new comes along, everyone, like a child discovering the world, thinks that they've invented it, but you scratch a little and you find a caveman scratching on a wall is creating a virtual reality in a sense. What is new here is that more sophisticated instruments give you the power to do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

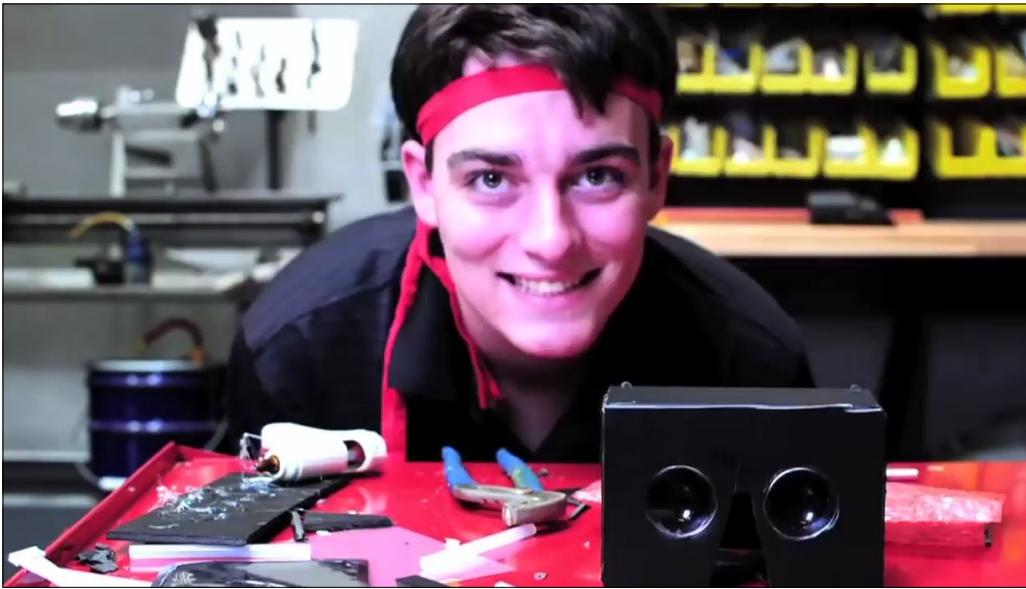
Lastly (probably most importantly) the time AOL and the first dot-com bubble came and captured the public imagination with a much more viable technology to be obsessed by.



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.

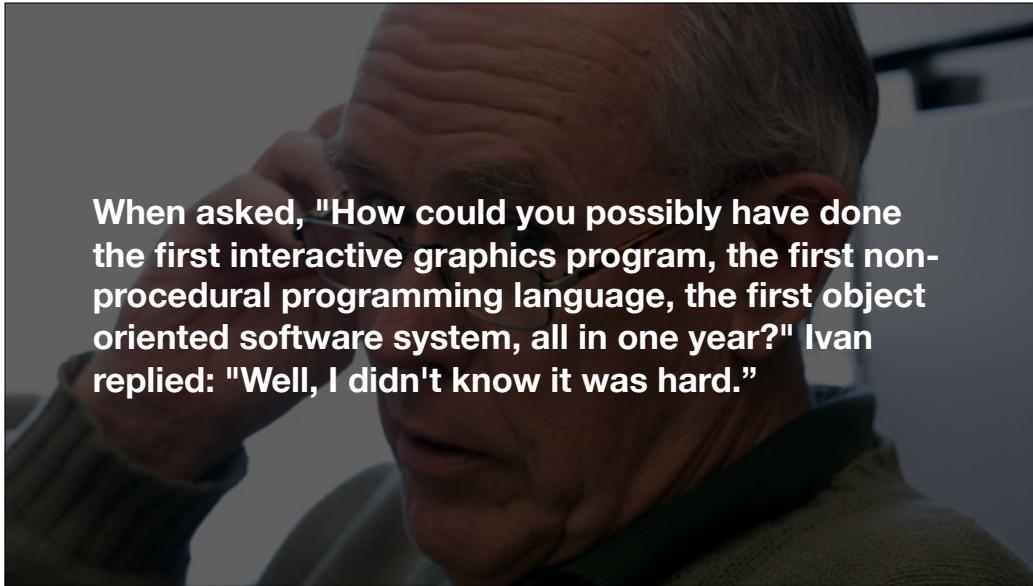


We're back in the Hype Machine, baby!



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.

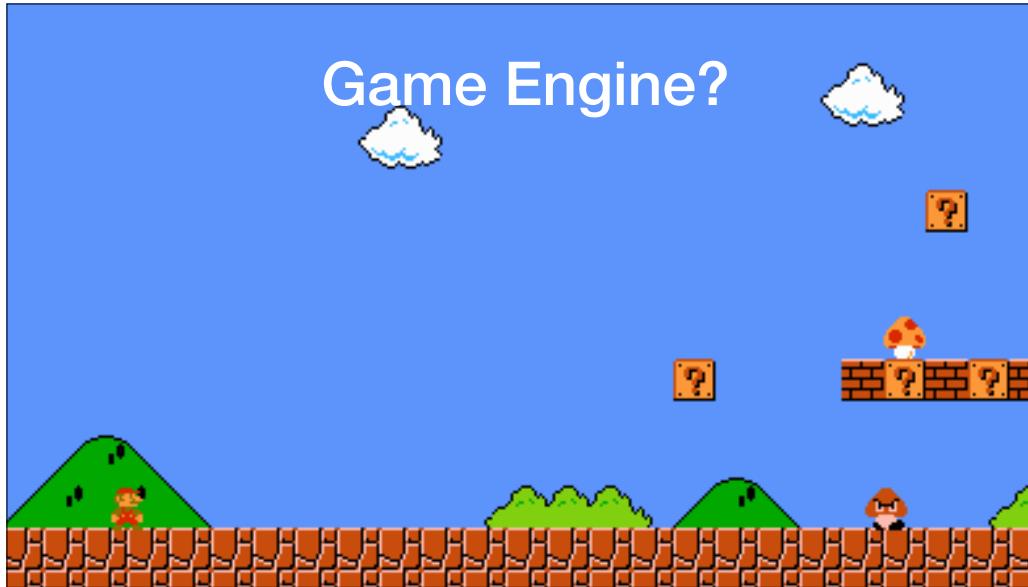
[https://en.wikipedia.org/wiki/Abstraction_\(software_engineering\)](https://en.wikipedia.org/wiki/Abstraction_(software_engineering))



Lets talk sandwiches

<https://www.youtube.com/watch?v=DvIHYdI0MWc>

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

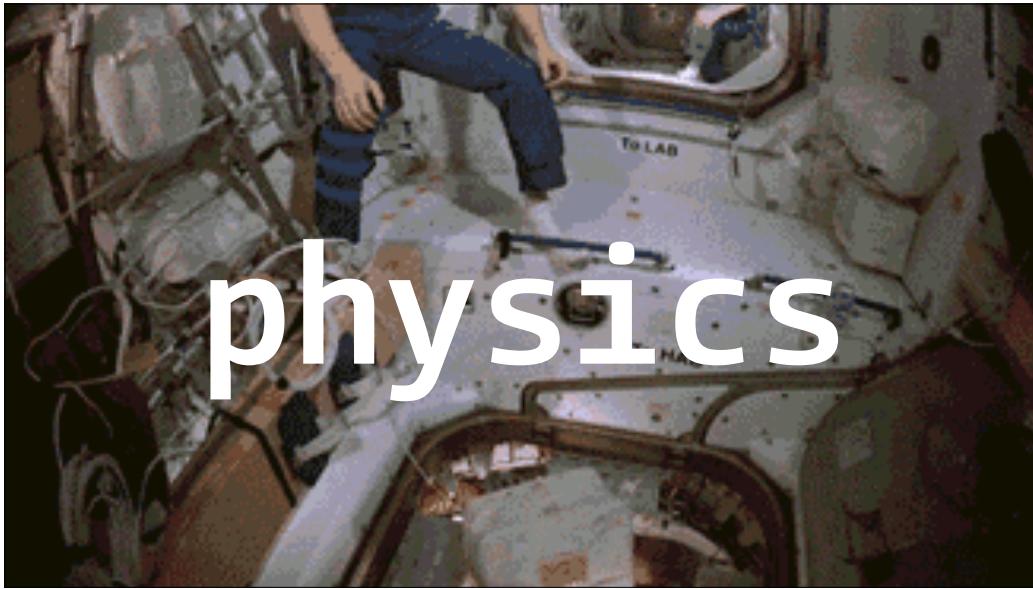


Why Unity?

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.



physics

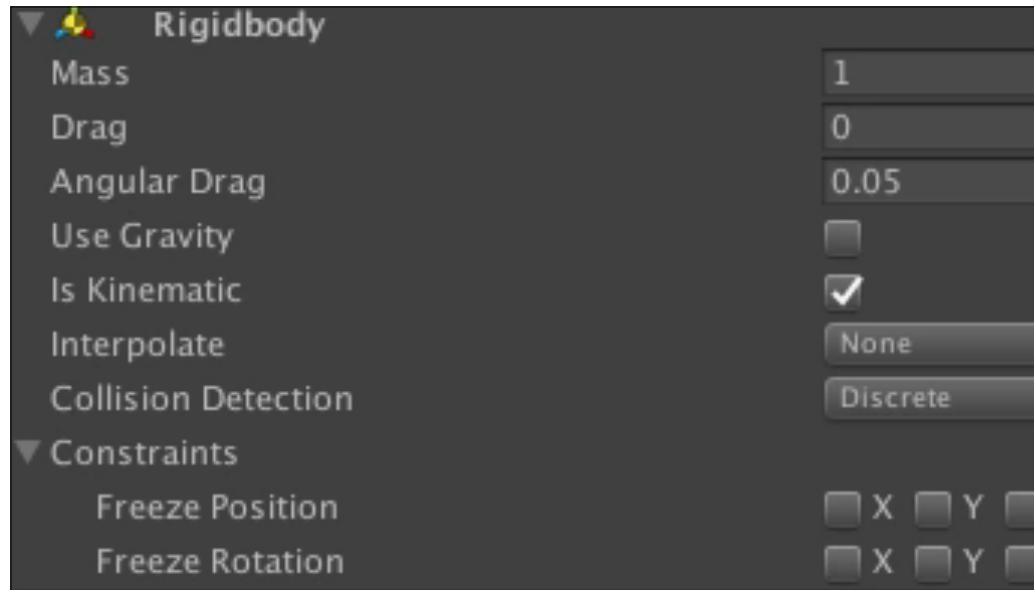
Abstracts the math/physics/graphics away for us and we get to work on a higher level.

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

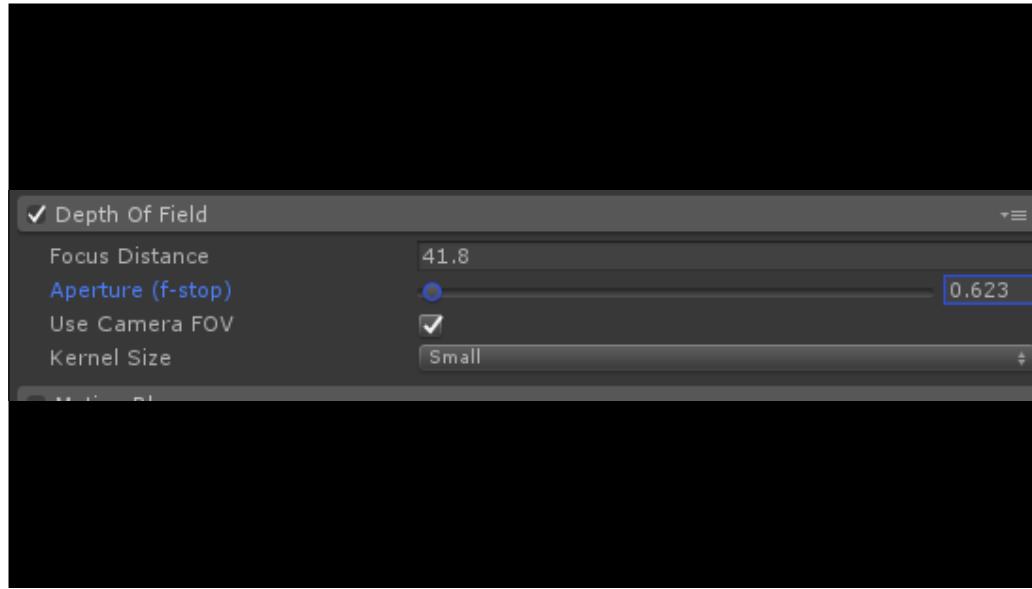
```
int n = 10;
float aperture = 0.05;
glm::mat4 projection = glm::perspective(...);

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, its 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



Let's jump into Unity.



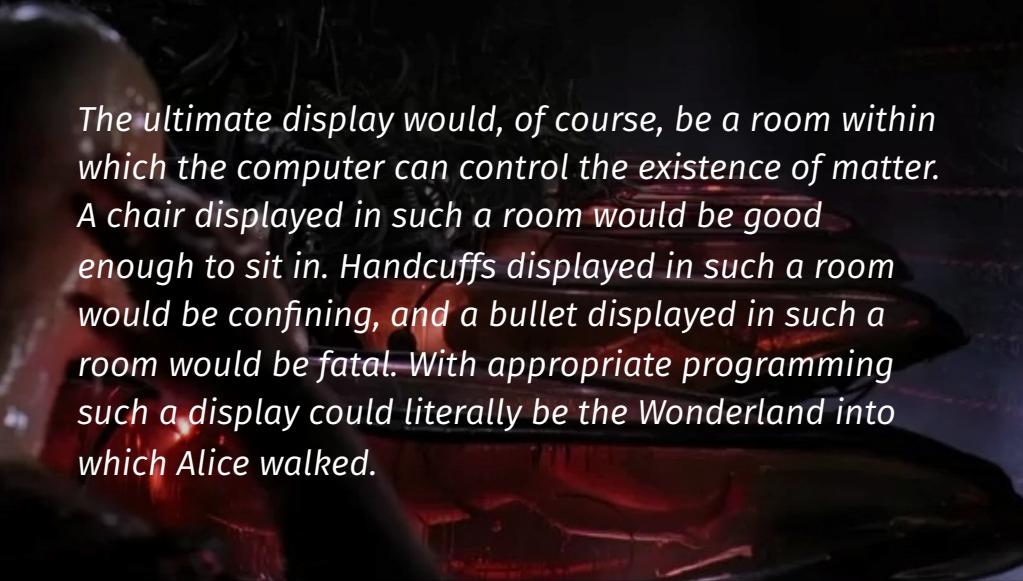
Virtual Reality (LaValle) - Chapter 1

<http://vr.cs.uiuc.edu/>

Set up Unity!

Reading for next time:

<http://vr.cs.uiuc.edu/>



The ultimate display would, of course, be a room within which the computer can control the existence of matter. A chair displayed in such a room would be good enough to sit in. Handcuffs displayed in such a room would be confining, and a bullet displayed in such a room would be fatal. With appropriate programming such a display could literally be the Wonderland into which Alice walked.

Important to keep in mind that we are in the middle of a step forward. This technology will get better, be replaced, disappear - become indistinguishable from reality. We are thinking of the how and why.

- * CS people - put on designer hats
- * Designers - think algorithmically

Quote by Sutherland, naturally.



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