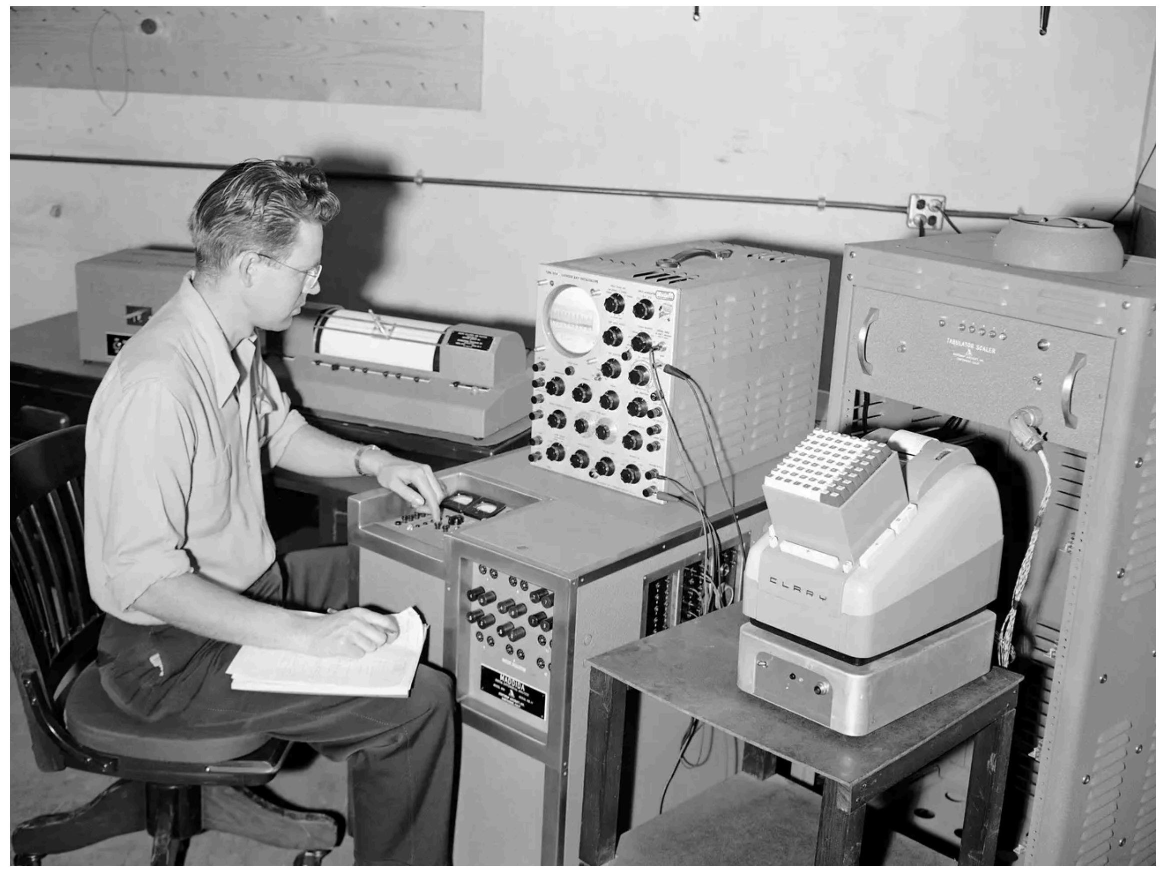
Great Ideas in Computing
(Human-Computer Interaction)

Virtual Reality

Fanny Chevalier
University of Toronto

When do you believe that *Virtual Reality* was invented?

1930's

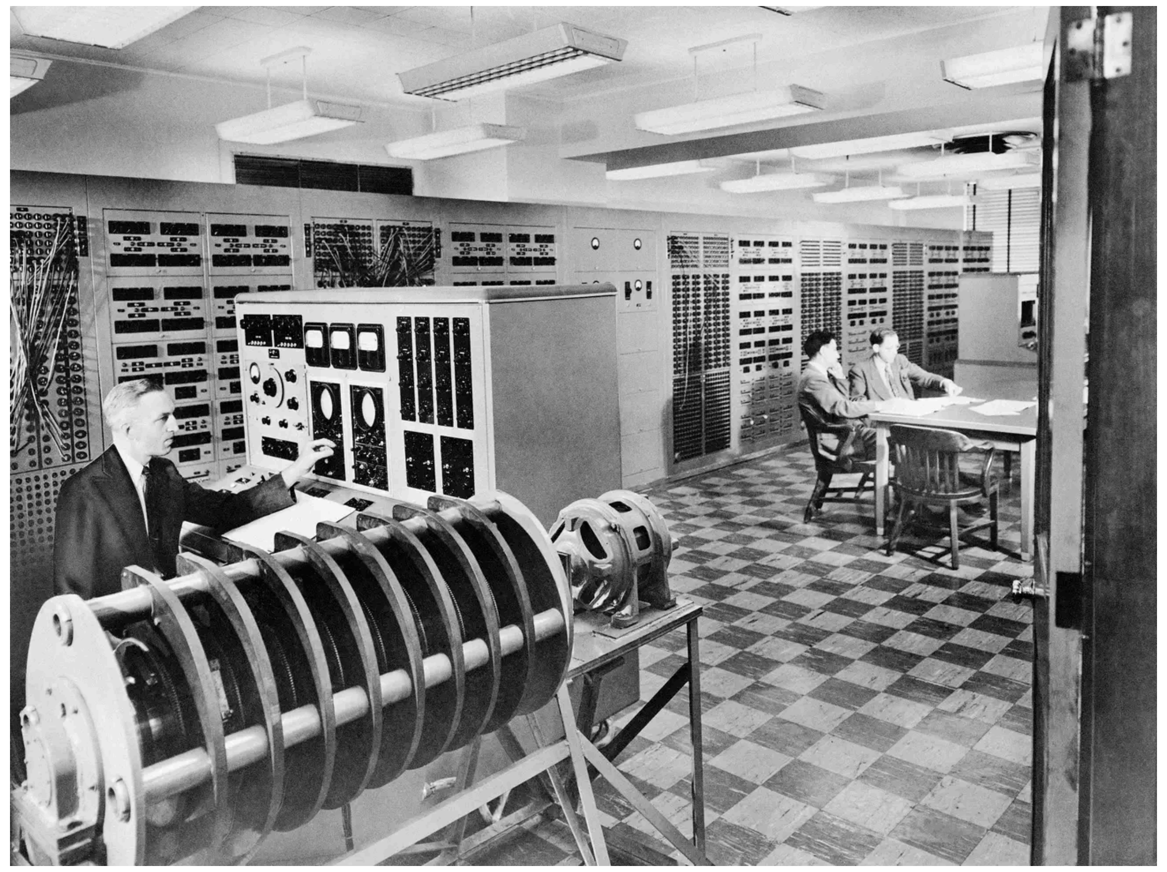


1950's

1970's

1990's

1940's



1960's

1980's

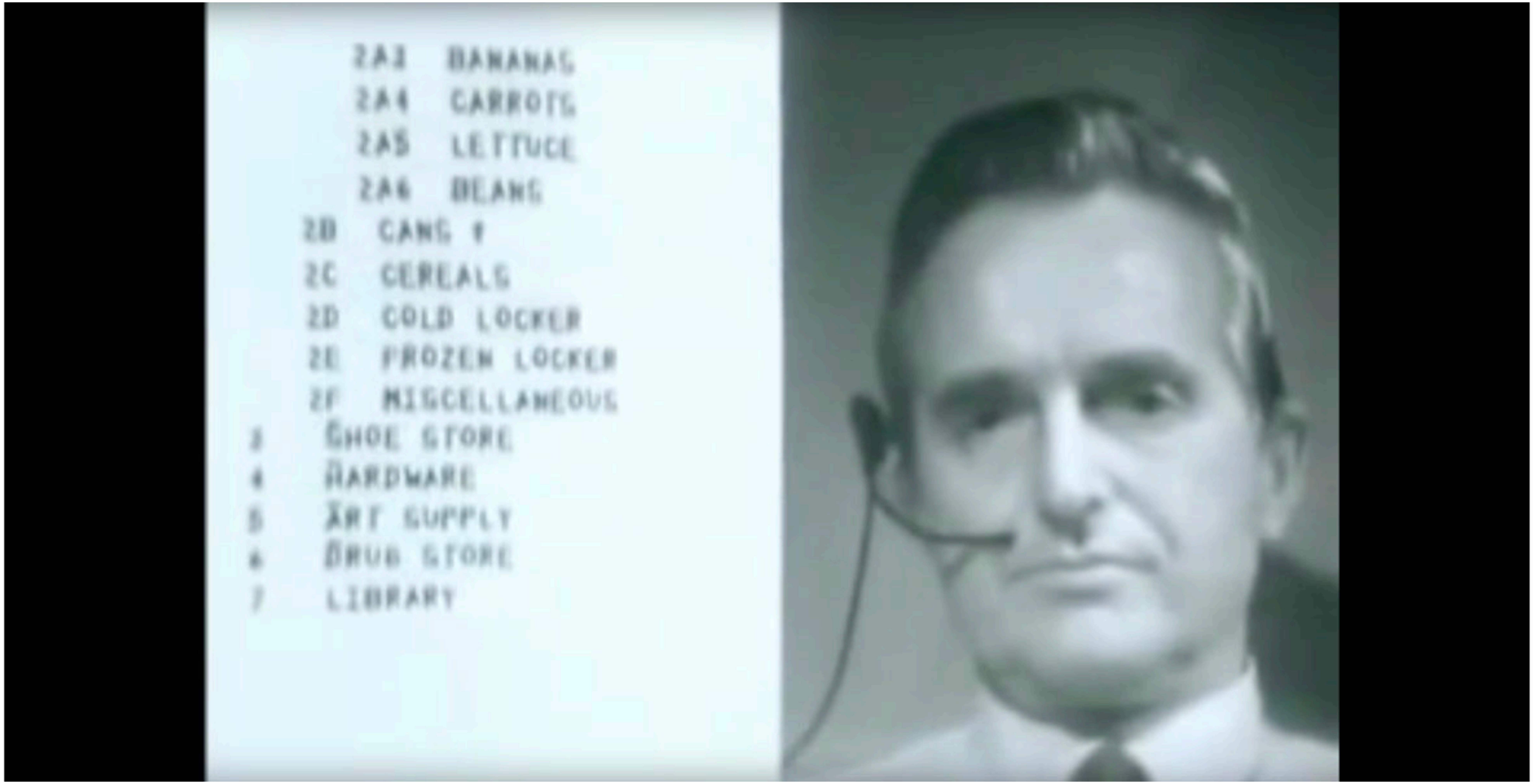
Sketchpad (1963)

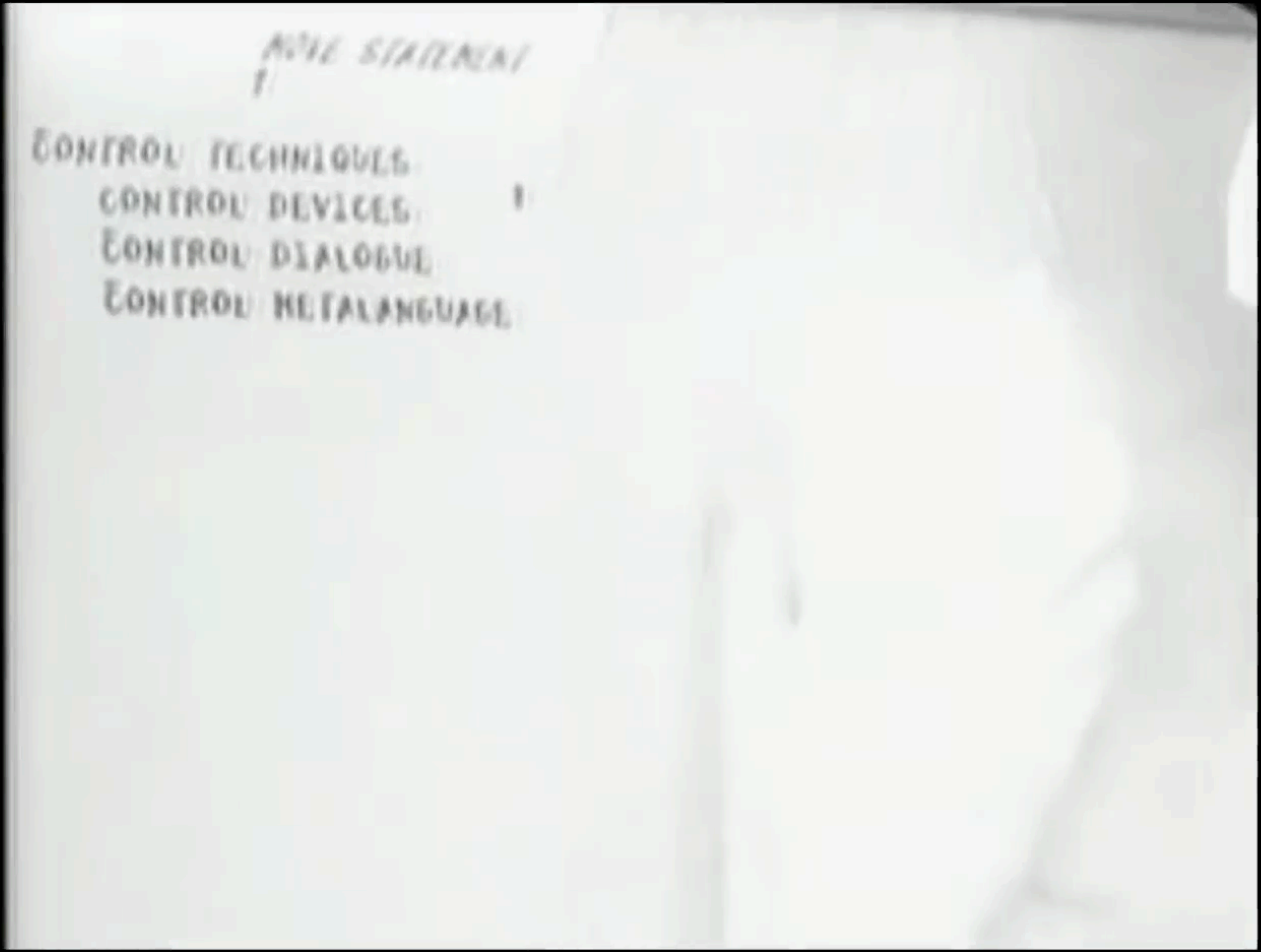
Ivan Sutherland

https://www.youtube.com/watch?v=6orsmFndx_o

Mother of All Demos (1968)

Douglas Engelbart





https://www.youtube.com/watch?v=yJDv-zdhzMY

SPECIAL 11

USAGE

APPLICATION EXAMPLES

USER DOCUMENTATION:

PAPER STUDYING OR MODIFYING

PRINTOUT-DIRECTIVE GUIDE,

JOINT-FILE USAGE, MESSAGES

OPEN-HOUSE DUTY ROSTER

HARDWARE-DESIGN DOCUMENTATION,

SYSTEM-ANALYSIS RECORDS

TWO-PERSON COLLABORATION

INFORMATION RETRIEVAL (BILL)

https://www.youtube.com/watch?v=yJDv-zdhzMY

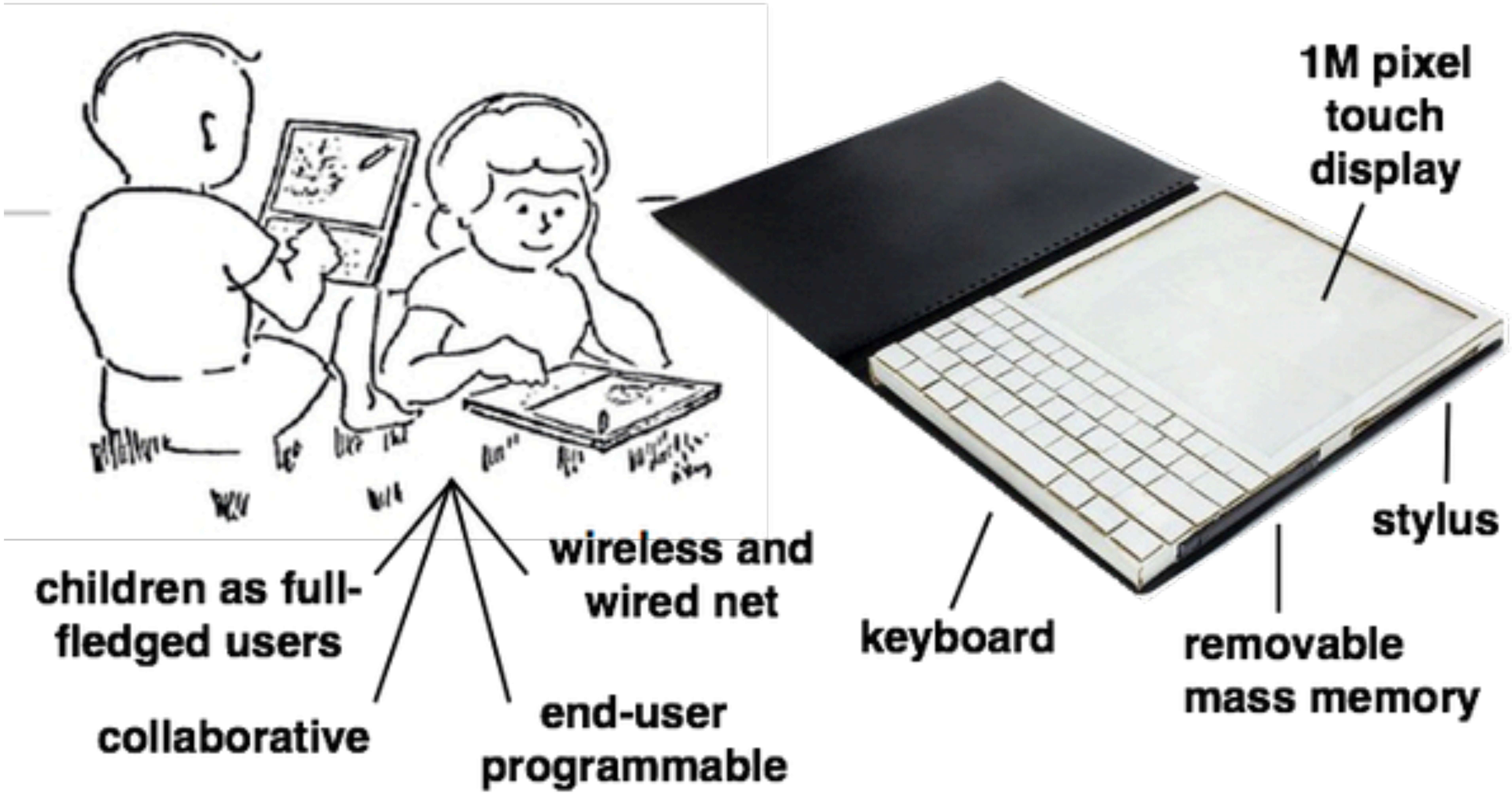
When do you believe that *Virtual Reality* was invented?

iPad (2010)

THE VERGE
TWEET
SHARE
theverge.com
Purple Rain
Prince & The Revolution — The Very
Shuffle
Lyrics

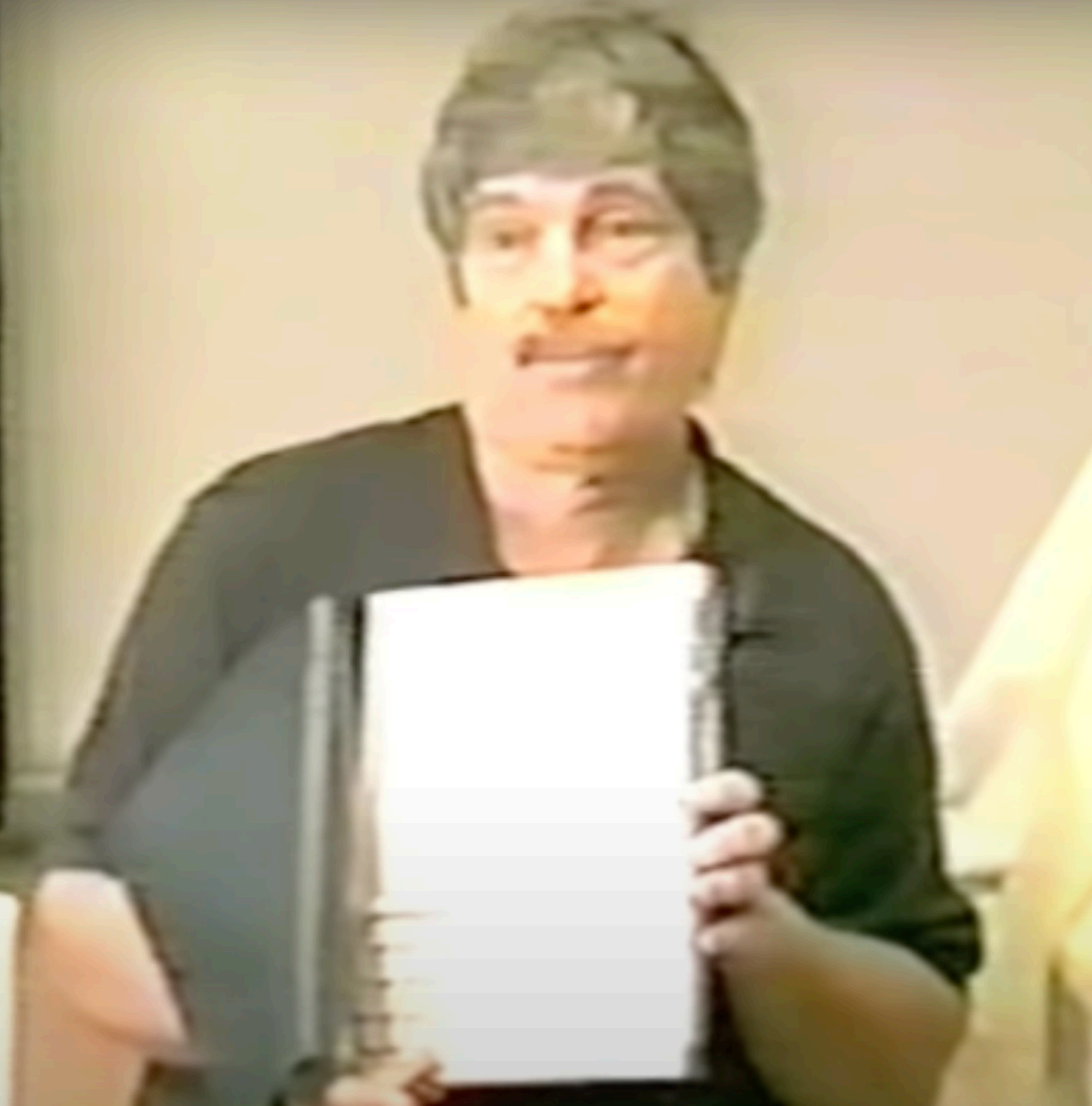
Dynabook (1968)

Alan Kay



https://www.youtube.com/watch?v=r36NNGzNvjo

“The best way to predict the future is to invent it.”



The Long Nose of Innovation

Bill Buxton

Buxton, B. (2008). The long nose of innovation. Business Week, 2.
https://www.billbuxton.com/01%20The%20Long%20Nose%20of%20Innovation%20Revised.pdf

The Long Nose of Innovation

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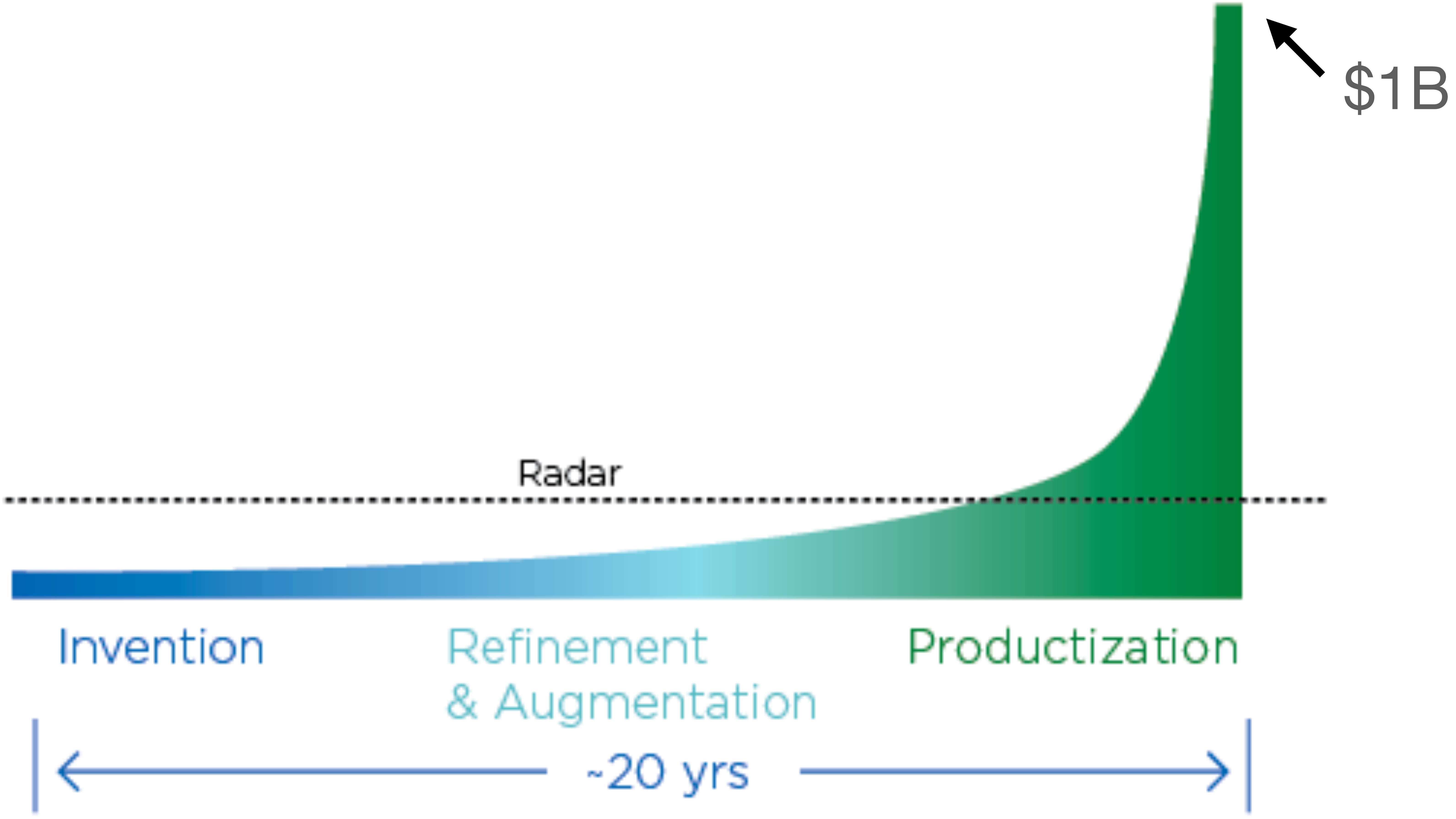

Buxton, B. (2008). The long nose of innovation. Business Week, 2.
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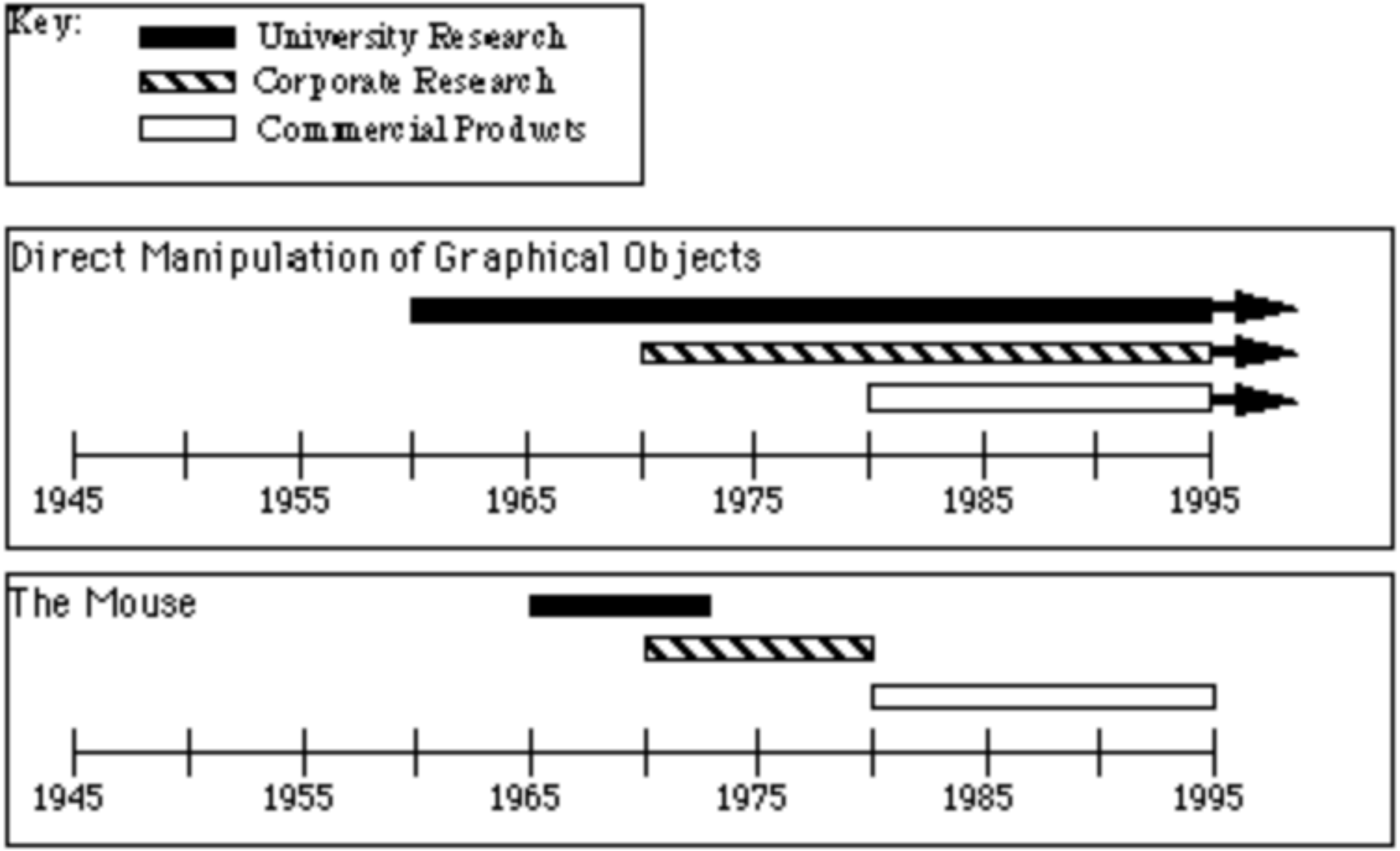

Myers, B. A. (1998). A brief history of human-computer interaction technology. *interactions*, *5*(2), 44-54.


PORTLAND
State University

The Ultimate Display

Ivan E. Sutherland

Information Processing Techniques
Office, ARPA, OSD

We live in a physical world whose properties we have come to know well through long familiarity. We sense an involvement with this physical world which gives us the ability to predict its properties well. For example, we can predict where objects will fall, how well-known shapes look from other angles, and how much force is required to push objects against friction. We lack corresponding familiarity with the forces on charged particles, forces in non-uniform fields, the effects of nonprojective geometric transformations, and high-inertia, low friction motion. 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.

Computer displays today cover a variety of capabilities. Some have only the fundamental ability to plot dots. Displays being sold now generally have built in line-drawing capability. An ability to draw simple curves would be useful. Some available displays are able to plot very short line segments in arbitrary directions, to form characters or more complex curves. Each of these abilities has a history and a known utility.

It is equally possible for a computer to construct a picture made up of colored areas. Knowlton's movie language, BEFLIX [1], is an excellent example of how computers can produce area-filling pictures. No display available commercially today has the ability to present such area-filling pictures for direct human use. It is likely that new display equipment will have area-filling capability. We have much to learn about how to make good use of this new ability.

The most common direct computer input today is the typewriter keyboard. Typewriters are inexpensive, reliable, and produce easily transmitted signals. As more and more on-line systems are used, it is likely that many more typewriter consoles will come into use. Tomorrow's computer user will interact with a computer through a typewriter. He ought to know how to touch type.

A variety of other manual-input devices are possible. The light pen or RAND Tablet stylus serve a very useful function in pointing to displayed items and in drawing or printing For input to the computer. The possibilities for very smooth interaction with the computer through these devices is only just beginning to be exploited. RAND Corporation has in operation today a debugging tool which recognizes printed changes of register contents, and simple pointing and moving motions for format relocation. Using RAND's techniques you can change a digit printed on the screen by merely writing what you want on top of it. If you want to move the contents of one displayed register into another, merely point to the first and "drag" it over to the second. The facility with which such an interaction system lets its user interact with the computer is remarkable.

Knobs and joysticks of various kinds serve a useful function in adjusting parameters of some computation going on. For example, adjustment of the viewing angle of a perspective view is conveniently handled through a three-rotation joystick. Push buttons with lights are often useful. Syllable voice input should not be ignored.

In many cases the computer program needs to know which part of a picture the man is pointing at. The two-dimensional nature of pictures makes it impossible to order the parts of a picture by neighborhood. Converting from display coordinates to find the object pointed at is, therefore, a time-consuming process. A light pen can interrupt at the time that the display circuits transfer the item being pointed at, thus automatically indicating its address and coordinates. Special circuits on the RAND Tablet or other position input device can make it serve the same function.

What the program actually needs to know is where in memory is the structure which the man is pointing to. In a display with its own memory, a light pen return tells where in the display file the thing pointed to is, but not necessarily where in main memory. Worse yet, the program really needs to know which sub part of which part the man is pointing to. No existing display equipment computes the depths of recursions that are needed. New displays with analog memories may well lose the pointing ability altogether.

Other Types of Display

If the task of the display is to serve as a looking-glass into the mathematical wonderland constructed in computer memory, it should serve as many senses as possible. So far as I know, no one seriously proposes computer displays of smell, or taste. Excellent audio displays exist, but unfortunately we have little ability to have the computer produce meaningful sounds. I want to describe for you a kinesthetic display.

The force required to move a joystick could be computer controlled, just as the actuation force on the controls of a Link Trainer are changed to give the feel of a real airplane. With such a display, a computer model of particles in an electric field could combine manual control of the position, of a moving charge, replete with the sensation of forces on the charge, with visual presentation of the charge's position. Quite complicated "joysticks" with force feedback capability exist. For example, the controls on the General Electric "handyman" are nothing but joysticks with nearly as many degrees of freedom as the human arm. By use of such an input/output device, we can add a force display to our sight and sound capability.

The Ultimate Display (1965)

Ivan Sutherland

*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.

The Ultimate Display

Ivan E. Sutherland

Information Processing Techniques
Office, ARPA, OSD

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"With appropriate
programming, such a
display could literally be
the **wonderland into which
Alice walked.**"

Ivan Sutherland’ VR Challenge (1965)

- Complete visual ***immersion*** in virtual world
- Viewpoint and other ***tracking***; the world stays ***stationary*** as viewpoint moves
- Improve image generation until world looks ***real***
- User ***directly manipulates*** virtual objects
- Manipulated objects ***move realistically***
- Computer maintains world model in ***real time***
- Virtual world also ***sounds real***, and ***feels real***

What did the vision require? (1/2)

Display

- Visual: Resolution, color, stereo, field-of-view
- Sound: binaural, 3D?
- Haptics: touch, pressure, heat-flow

Modelling the Virtual World

- Geometry, texture, color
- Illumination, optics, mechanics

What did the vision require? (2/2)

Rendering

- 10^4 polygons to pixels

Tracking

- Position, and pose of eyes, etc…

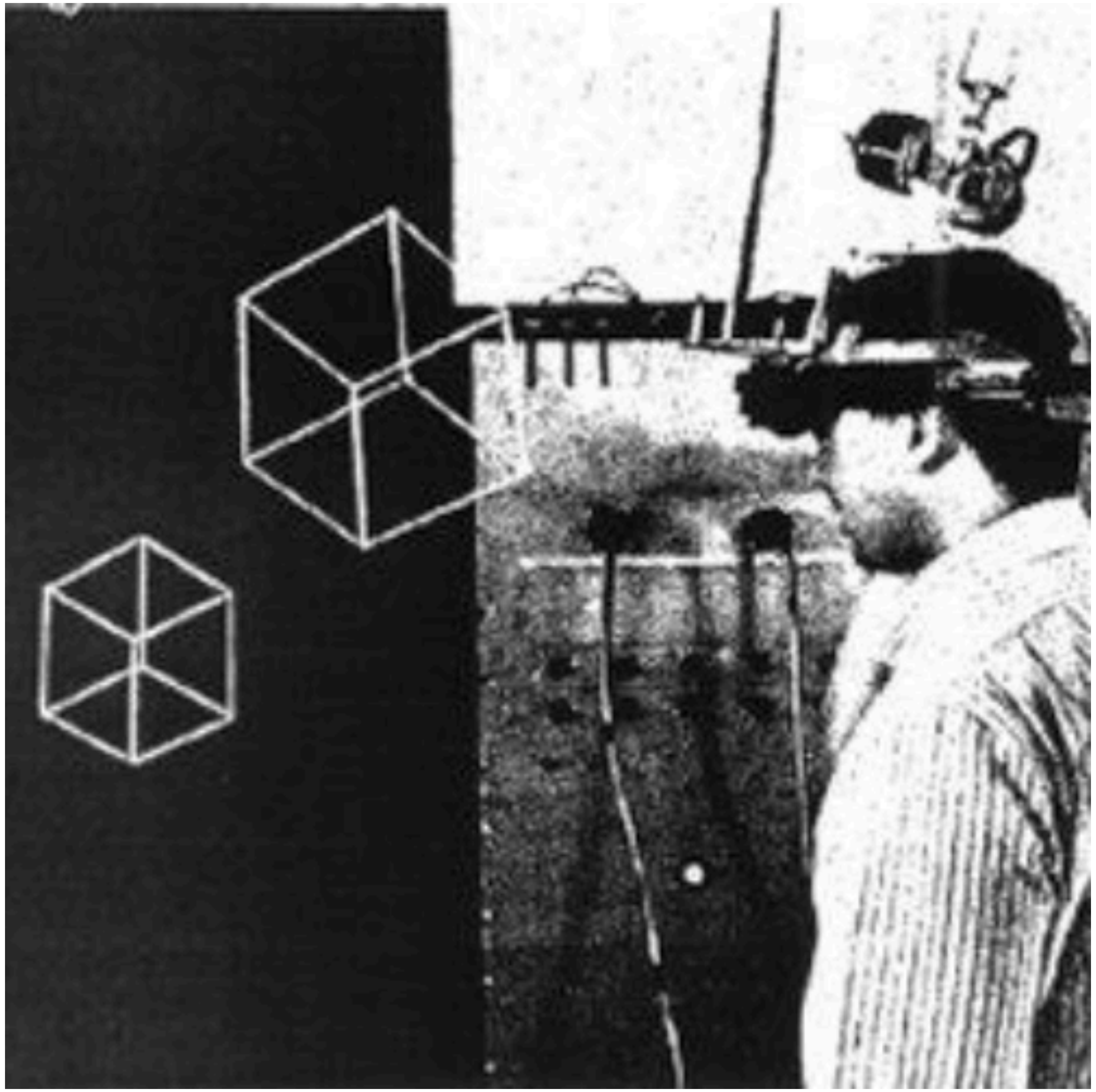
System

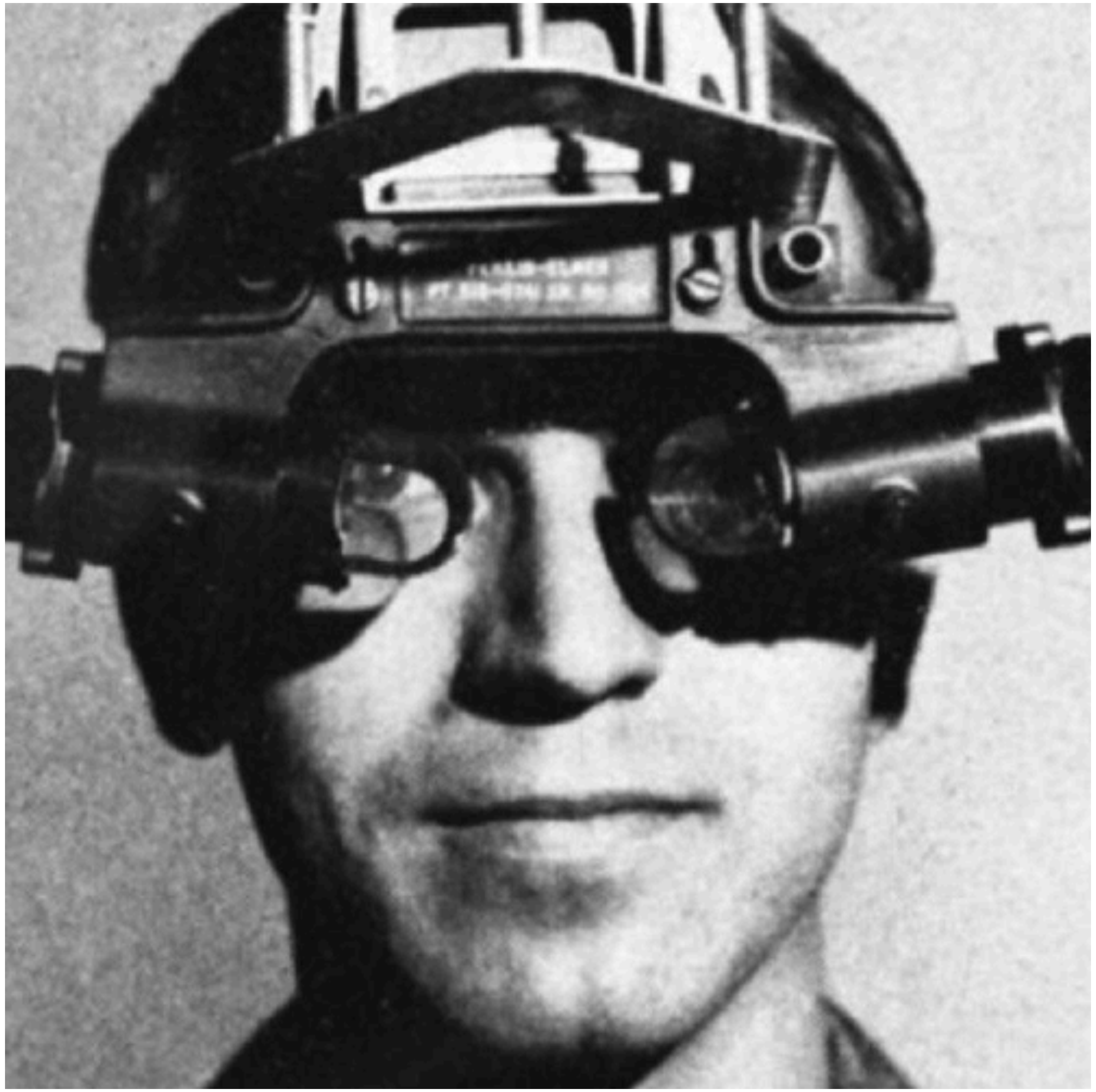
- Update rate, no latency
- Cost

https://www.youtube.com/watch?v=eVUgfUvP4uk

The Sword of Damocles (1968)

Ivan Sutherland





Pygmalion’s Spectacles (1935)

Stanley Weinbaum

“a movie that gives one sight and sound [...] taste, smell, and touch. [...] You are in the story, you speak to the shadows (characters) and they reply [...] the story is all about you, and you are in it.”

PYGMALION’S SPECTACLES

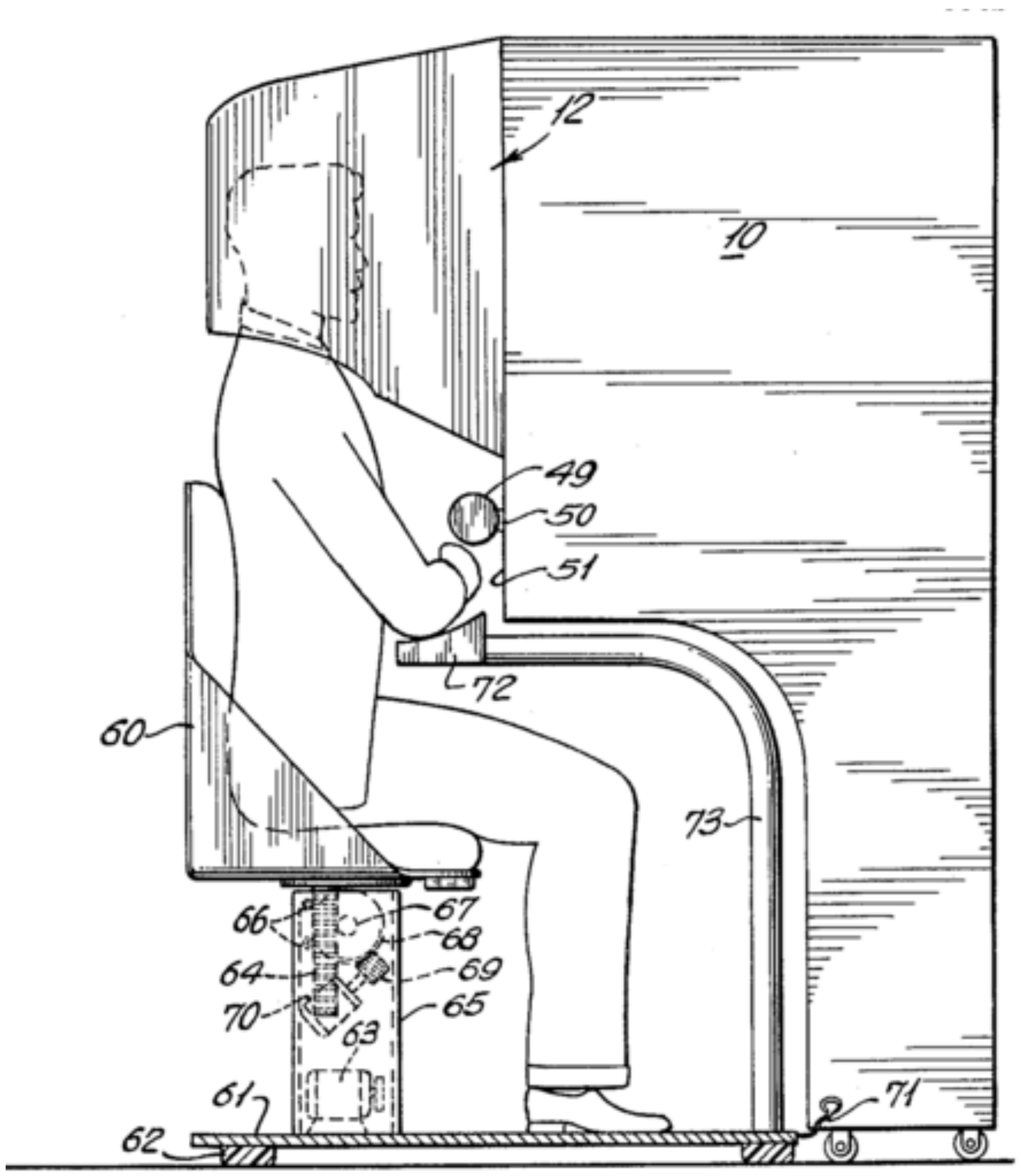
By STANLEY G. WEINBAUM

Author of “The Black Flame,” “A Martian Odyssey,” etc.

Unbelieving, still gripping the arms of that unseen chair, Dan was staring at a forest

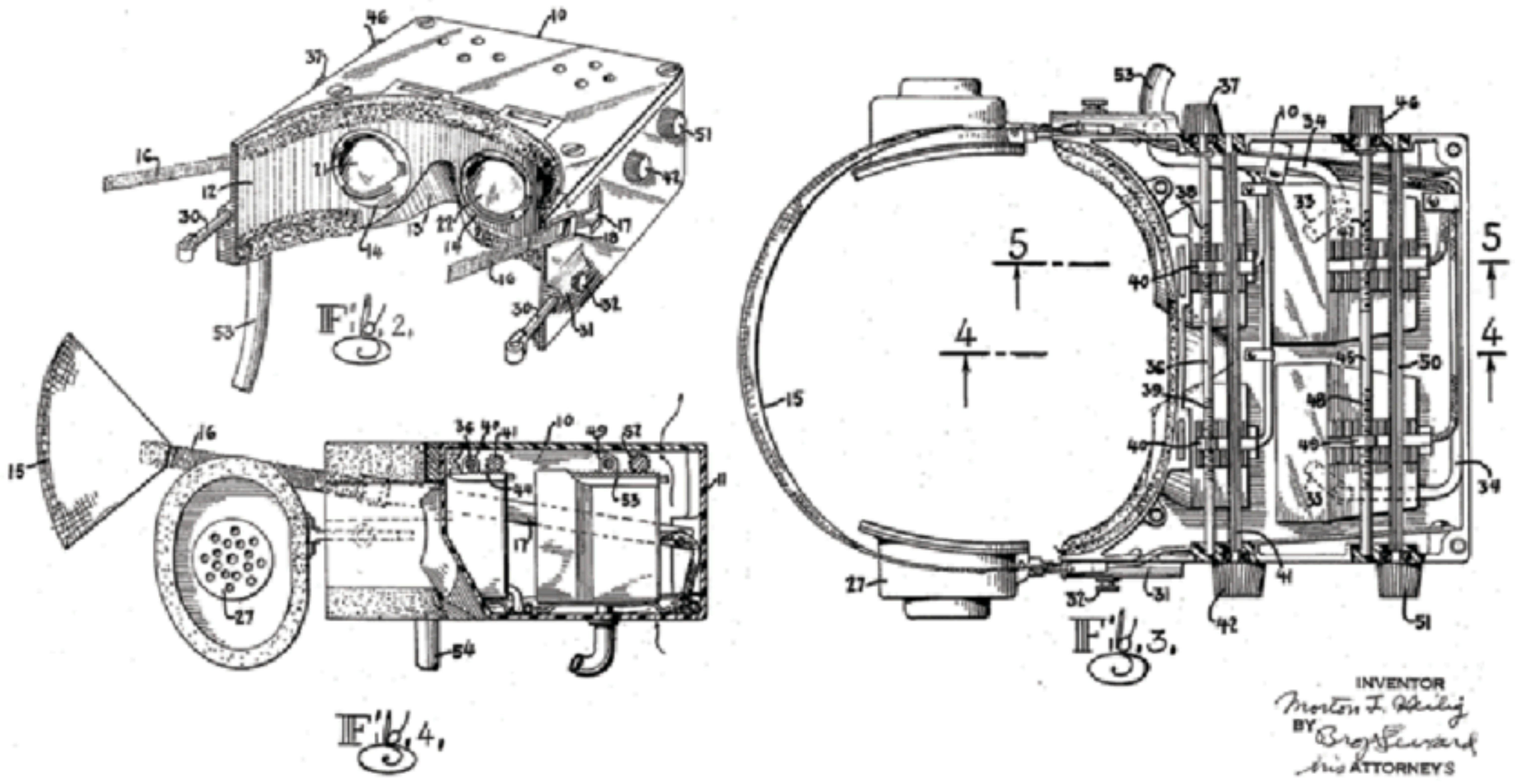
Sensorama (1956)

Morton Heilig



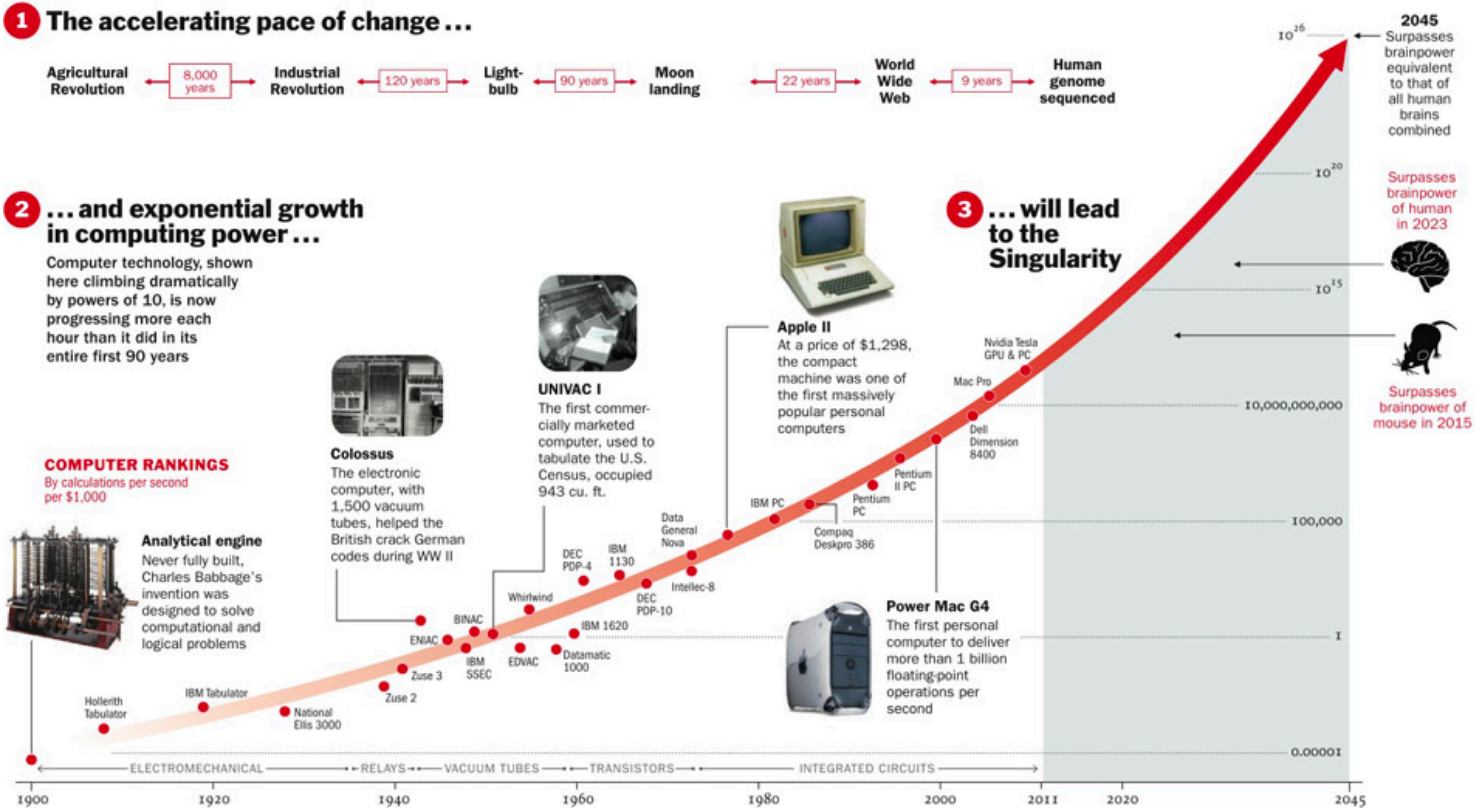
Telesphere Mask (1960)

Morton Heilig

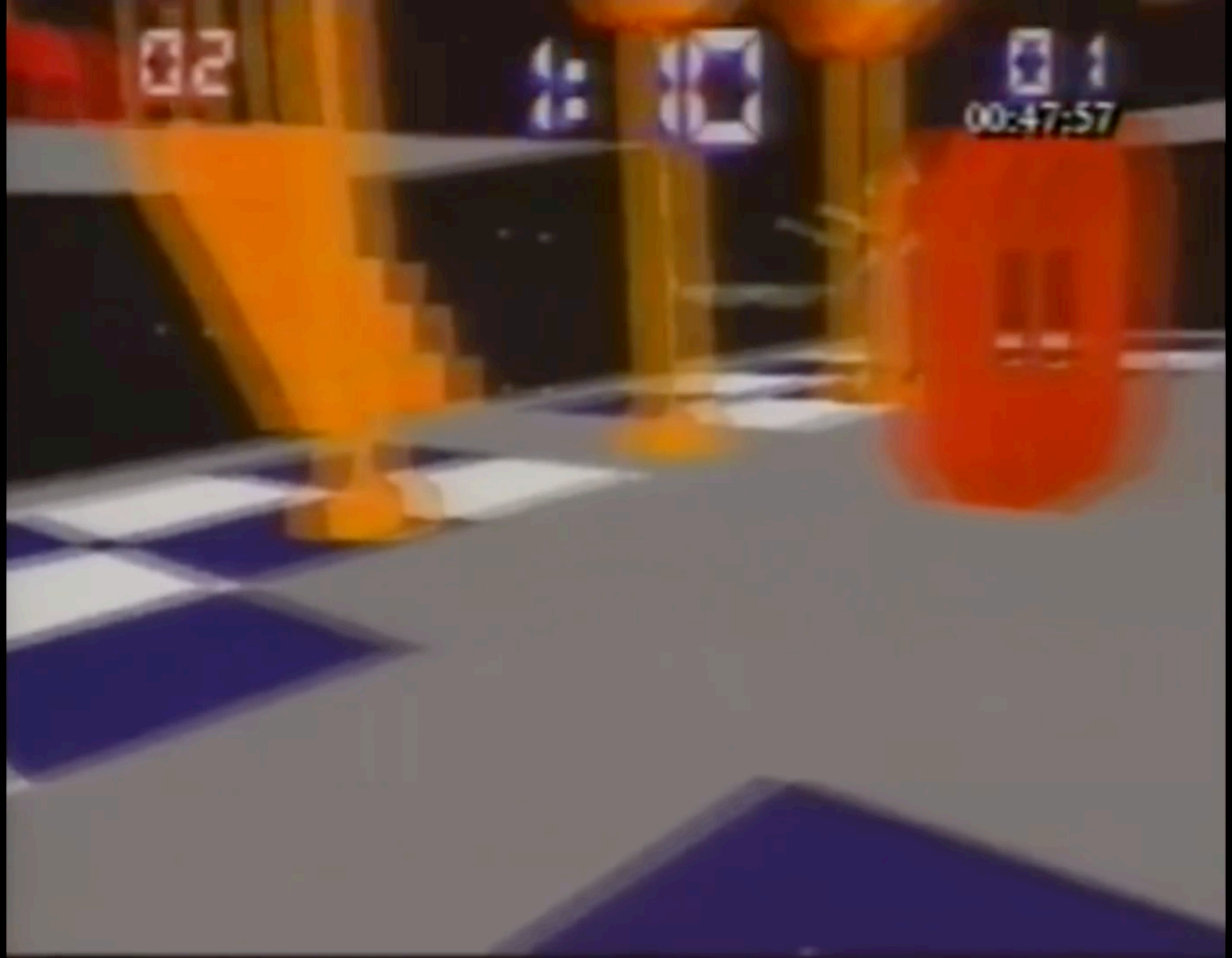


HeadSight (1961)

Comeau and Bryan


1 The accelerating pace of change . . .
Agricultural Revolution
8,000 years
Industrial Revolution
120 years
Light-bulb
90 years
Moon landing
22 years
World Wide Web
9 years
Human genome sequenced
2 . . . and exponential growth in computing power . . .
Computer technology, shown here climbing dramatically by powers of 10, is now progressing more each hour than it did in its entire first 90 years
3 . . . will lead to the Singularity
2045
Surpasses brainpower equivalent to that of all human brains combined
Surpasses brainpower of human in 2023
Surpasses brainpower of mouse in 2015
COMPUTER RANKINGS
By calculations per second per $1,000
Analytical engine
Never fully built, Charles Babbage's invention was designed to solve computational and logical problems
Colossus
The electronic computer, with 1,500 vacuum tubes, helped the British crack German codes during WW II
UNIVAC I
The first commercially marketed computer, used to tabulate the U.S. Census, occupied 943 cu. ft.
Apple II
At a price of $1,298, the compact machine was one of the first massively popular personal computers
Power Mac G4
The first personal computer to deliver more than 1 billion floating-point operations per second
Hollerith Tabulator
IBM Tabulator
National Ellis 3000
Zuse 2
Zuse 3
ENIAC
IBM SSEC
BINAC
EDVAC
Whirlwind
Datamatic 1000
IBM 1620
DEC PDP-4
IBM 1130
DEC PDP-10
Data General Nova
Intellec-8
IBM PC
Compaq Deskpro 386
Pentium PC
Pentium II PC
Dell Dimension 8400
Mac Pro
Nvidia Tesla GPU & PC
10^{26}
10^{20}
10^{15}
10,000,000,000
100,000
1
0.00001
ELECTROMECHANICAL
RELAYS
VACUUM TUBES
TRANSISTORS
INTEGRATED CIRCUITS
1900
1920
1940
1960
1980
2000
2011
2020
2045


VIRTUAL BOY
Nintendo
VUE-S-RA(JPN)
ML
3D DISPLAY GAME SYSTEM
VIRTUAL BOY
バーチャルボーイ
JAGUAR
VFX1
H·E·A·D·G·E·A·R



https://www.youtube.com/watch?v=dji9YiPZ4AM

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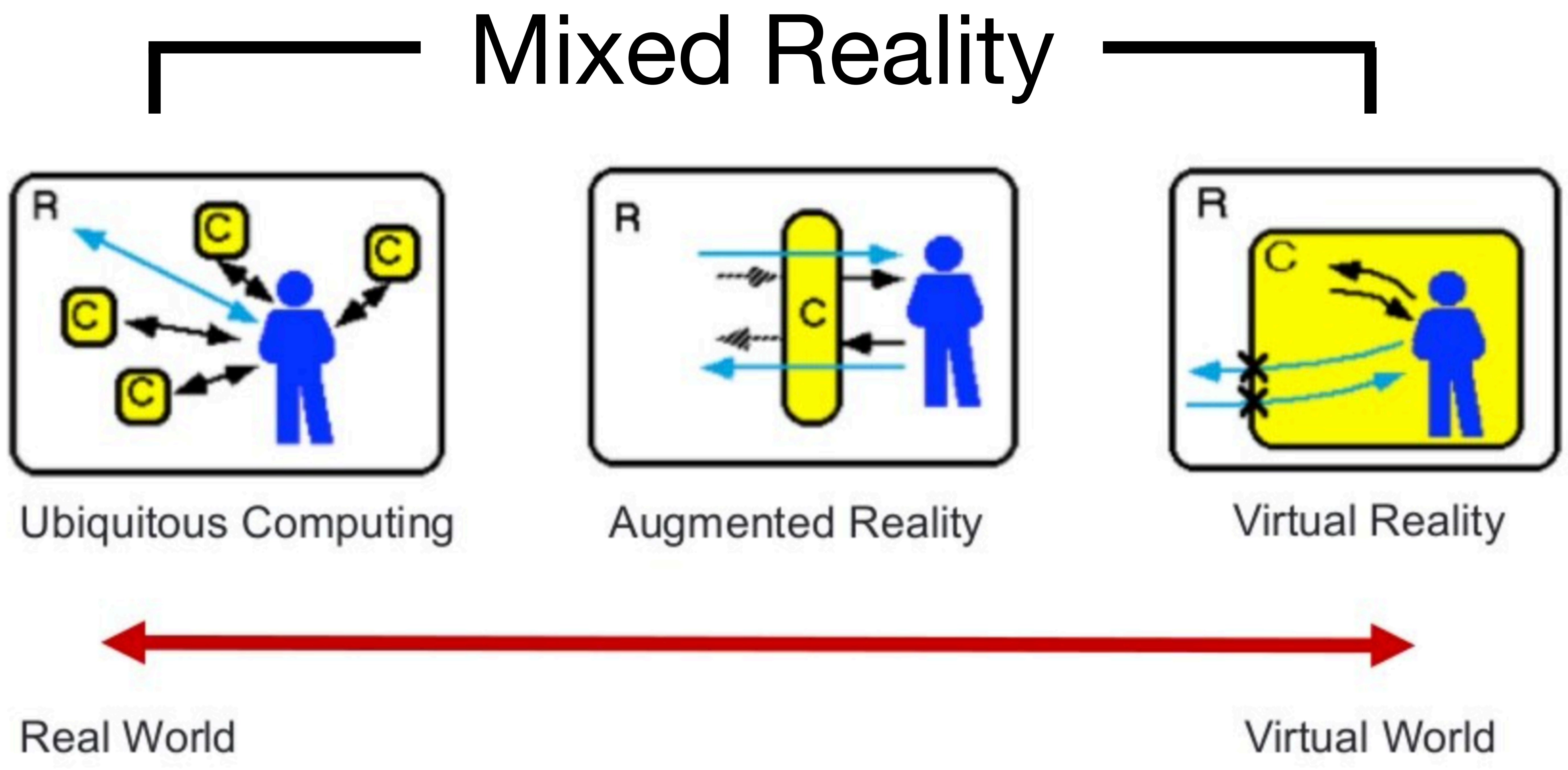
“VR is Dead…”


93% 17:51
m.facebook.com
MAIS
Voltar
Avançar
Início
Favoritos
Abas
Senado Federal

Milgram's Mixed Reality (MR) Continuum

"… anywhere between the extrema of the ***virtuality continuum****"*



Milgram, P., & Kishino, F. (1994). A taxonomy of mixed reality visual displays.
IEICE TRANSACTIONS on Information and Systems, *77*(12), 1321-1329.

Mixed-Reality (MR) Technology


SAMSUNG
Gear VR
Powered by
oculus

	Oculus Quest 2	Pico Neo 2	HP Reverb G2	Valve Index	HTC Vive Pro
					
Support in The Wild	☑	☑	☑	☐	☑
Resolution / Eye	1832 x 1920	1920×2160	2160x2160	1440x1600	1440x1600
Refresh Rate (HZ)	90	75	90	144	90
Field of View	100°	101°	114°	130°	110°
Weight	503g	670g	544g	570g	563g
Tracking	Inside-out	Inside-out	Inside-out	Base Stations (more equipment = more precise hand tracking)	Base Stations (more equipment = more precise hand tracking)
Type	**Standalone** (no wires, less powerful processor) + **option to tether** to a PC with a cable	**Standalone** (no wires, less powerful processor)	**Tethered** (wired to your PC, more powerful, can run larger models)	**Tethered** (wired to your PC, more powerful, can run larger models)	**Tethered** (wired to your PC, more powerful, can run larger models)
Price	**$299 / 💼 $799**	**💼 $699**	**$599**	**$999**	**$1,199**
Summary	A best-in-class standalone headset for personal or business use. What you lose in processing power you gain in easy setup and freedom of movement. AirLink and the Oculus Link cable makes this a great option for running larger models as well.	A great, newer to the market standalone headset that presents an alternative to the Oculus Quest. Designed for enterprise customers.	An affordable, high-res, tethered headset for running large models from your PC.	A top-of-the-line gaming headset. Base stations and wires require more setup and configuration, but create a smooth and powerful experience in-headset.	A top-of-the-line gaming headset. Base stations and wires require more setup and configuration, but create a smooth and powerful experience in-headset.

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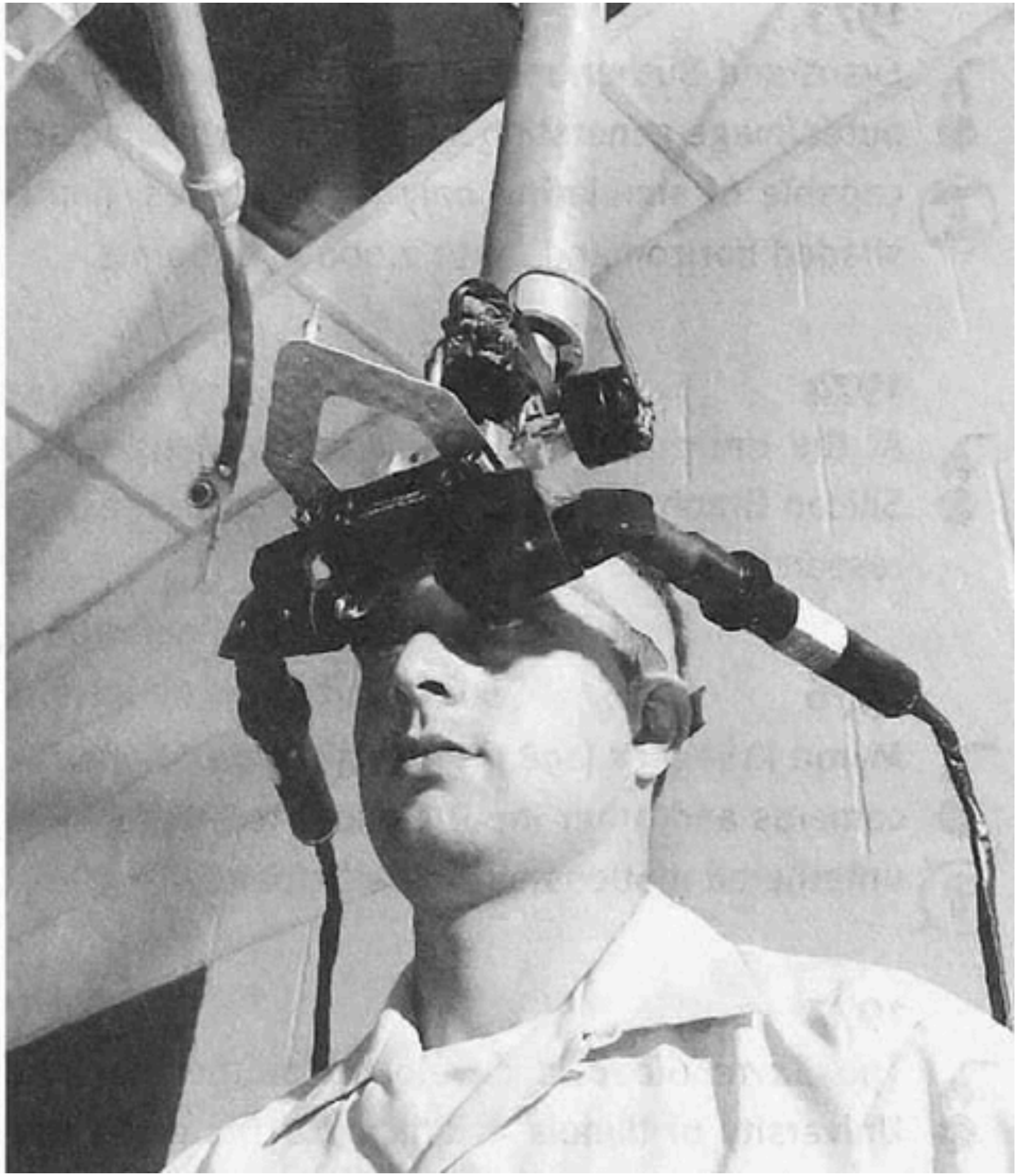
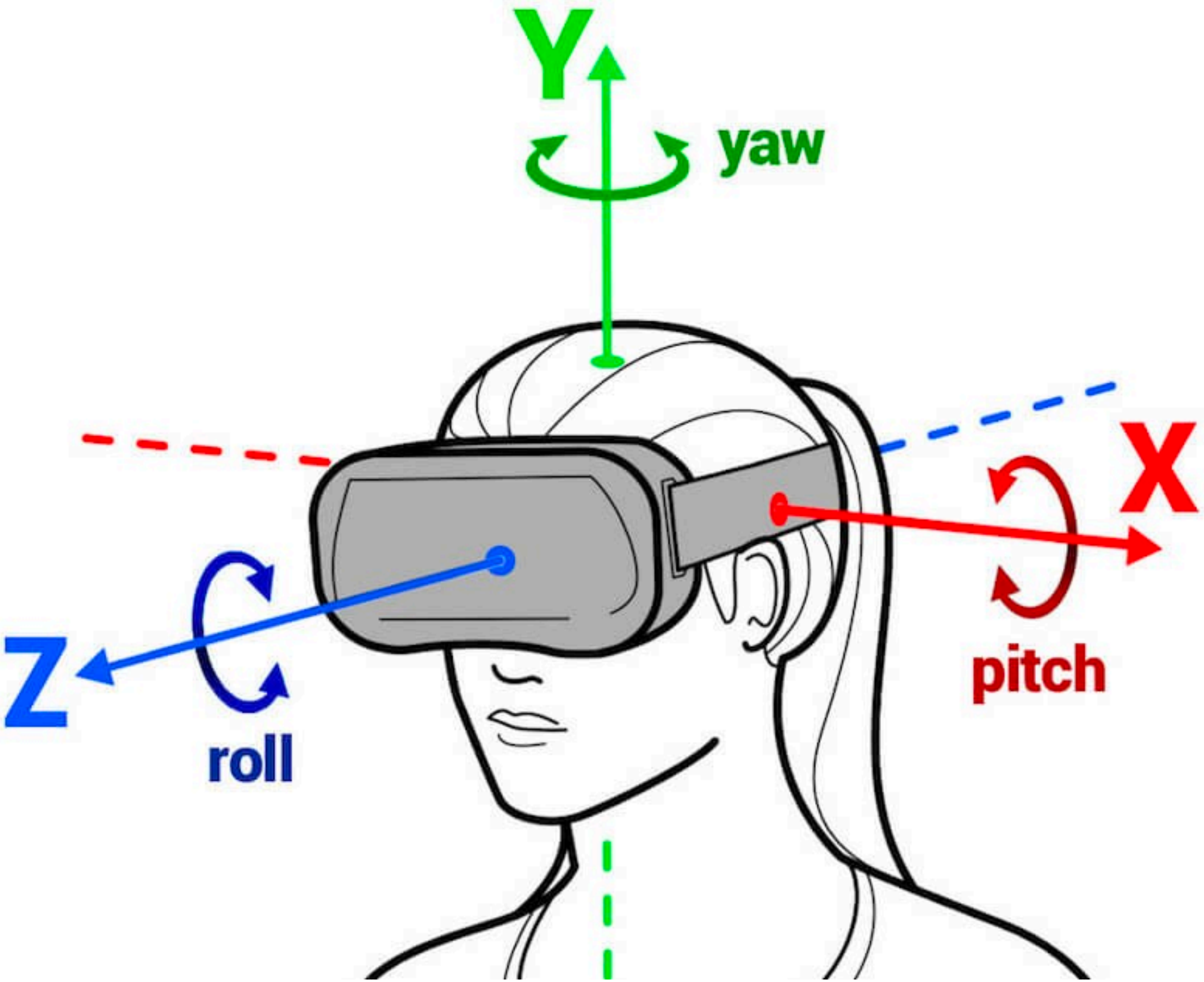
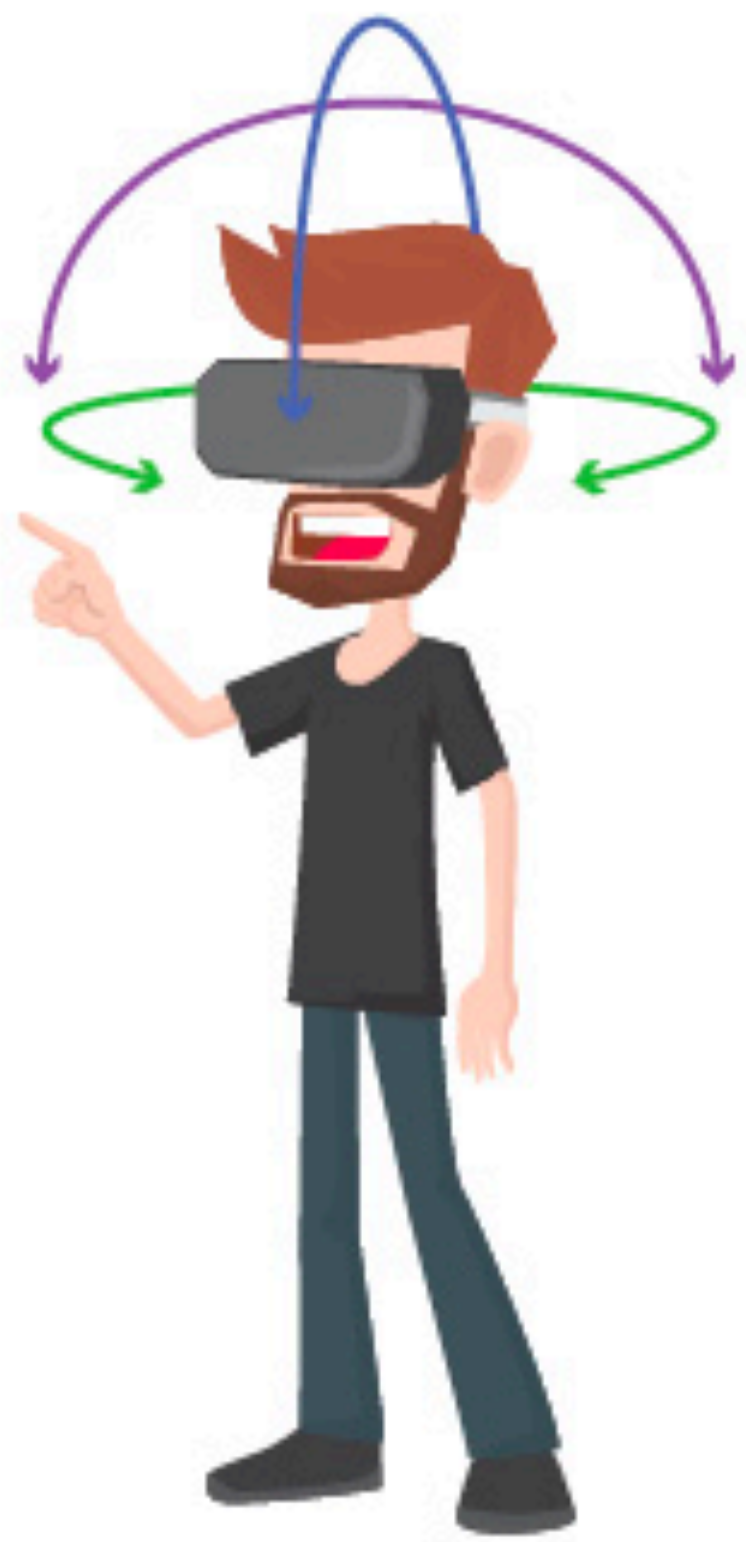
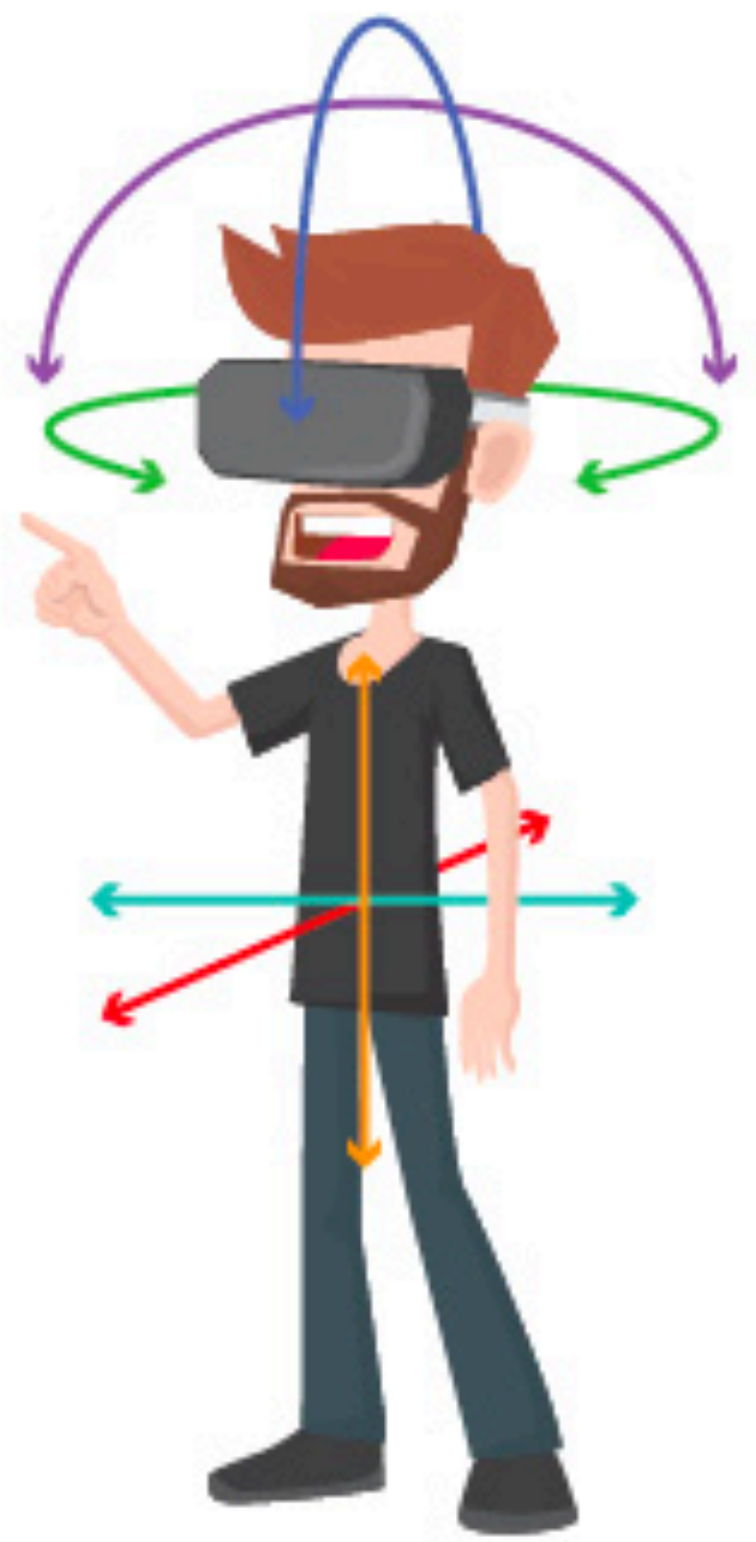
Tracking


Y
yaw
X
pitch
Z
roll

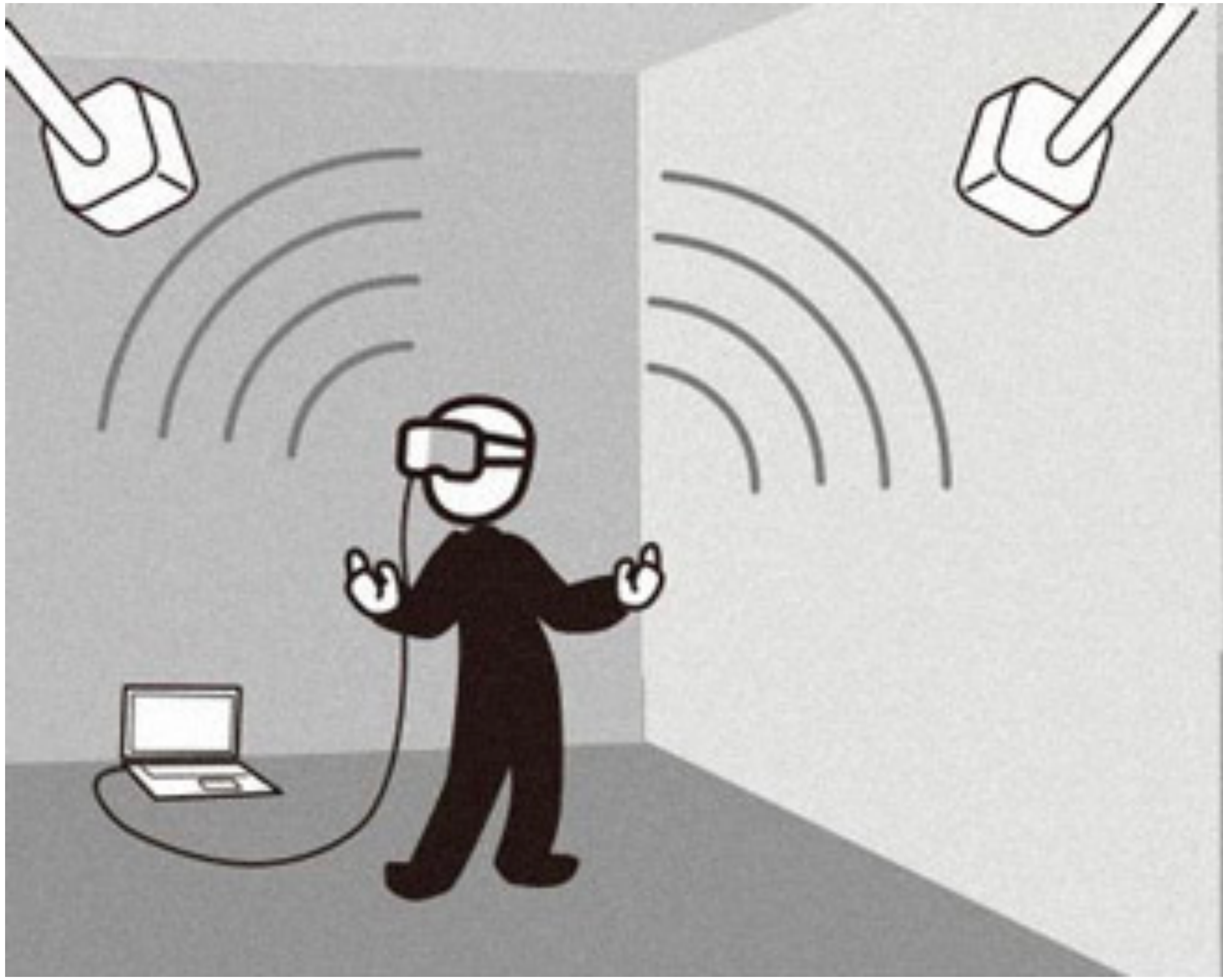


3DoF

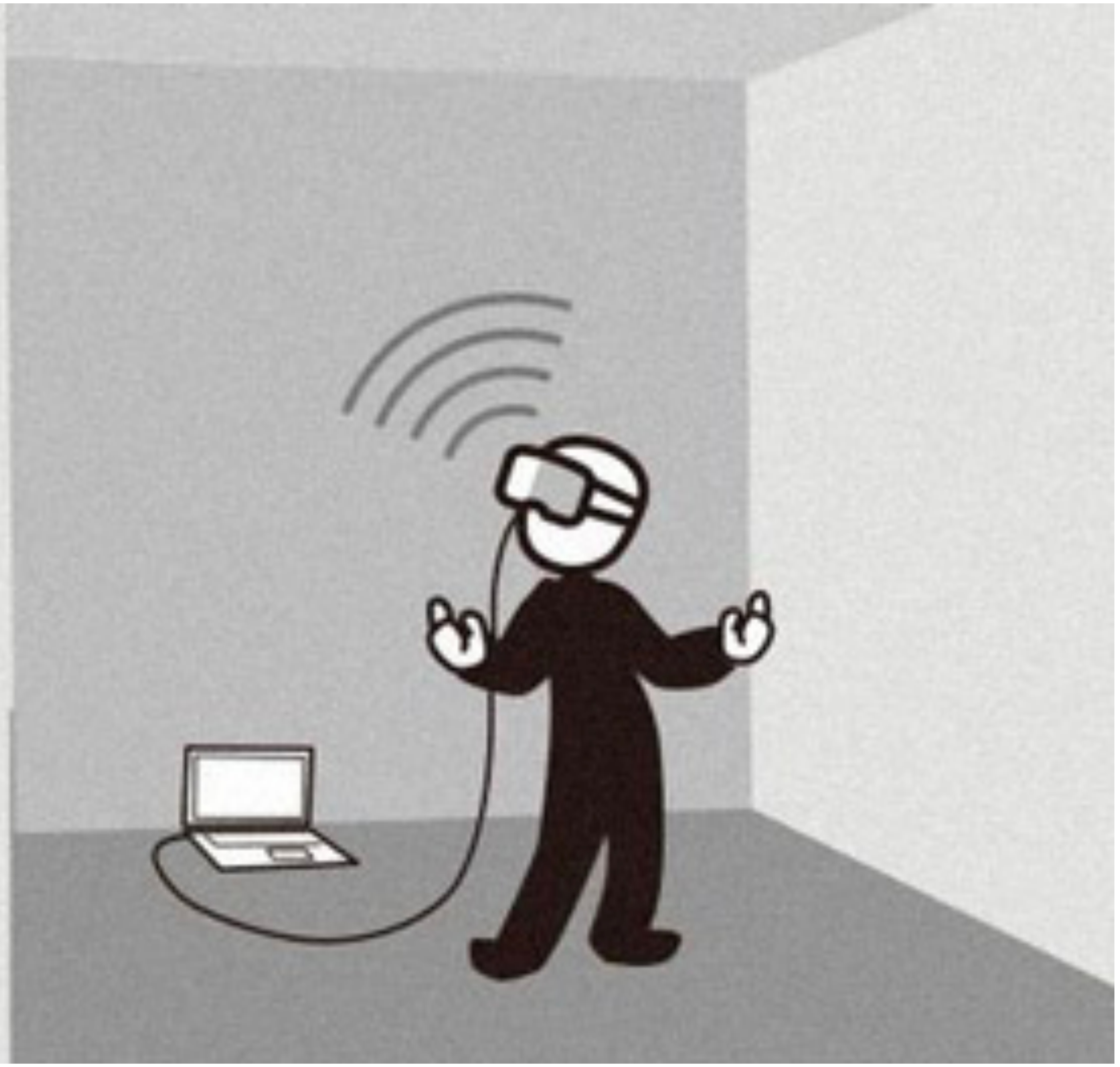


6DoF

Outside-In Tracking



Inside-Out Tracking



Steinicke, F., Bruder, G., Jerald, J., Frenz, H., & Lappe, M. (2009). Estimation of detection thresholds for redirected walking techniques. IEEE transactions on visualization and computer graphics, 16(1), 17-27.

K. Bretschneider: Infinite Dimensions in the VOID, 2015

Han, S., Liu, B., Cabezas, R., Twigg, C. D., Zhang, P., Petkau, J., ... & Wang, R. (2020). MEgATrack: monochrome egocentric articulated hand-tracking for virtual reality. ACM Transactions on Graphics (TOG), 39(4), 87-1.


CTRL Labs

Haptics

Araujo, B., Jota, R., Perumal, V., Yao, J. X., Singh, K., & Wigdor, D. (2016, February). Snake charmer: Physically enabling virtual objects. In *Proceedings of the TEI'16: Tenth International Conference on Tangible, Embedded, and Embodied Interaction* (pp. 218-226).

Benko, H., Holz, C., Sinclair, M., & Ofek, E. (2016, October). Normaltouch and texturetouch: High-fidelity 3d haptic shape rendering on handheld virtual reality controllers. In *Proceedings of the 29th Annual Symposium on User Interface Software and Technology* (pp. 717-728).

Meta Reality Labs (Nov. 2021)

Azmandian, M., Hancock, M., Benko, H., Ofek, E., & Wilson, A. D. (2016, May). Haptic retargeting: Dynamic repurposing of passive haptics for enhanced virtual reality experiences. In Proceedings of the 2016 chi conference on human factors in computing systems (pp. 1968-1979).

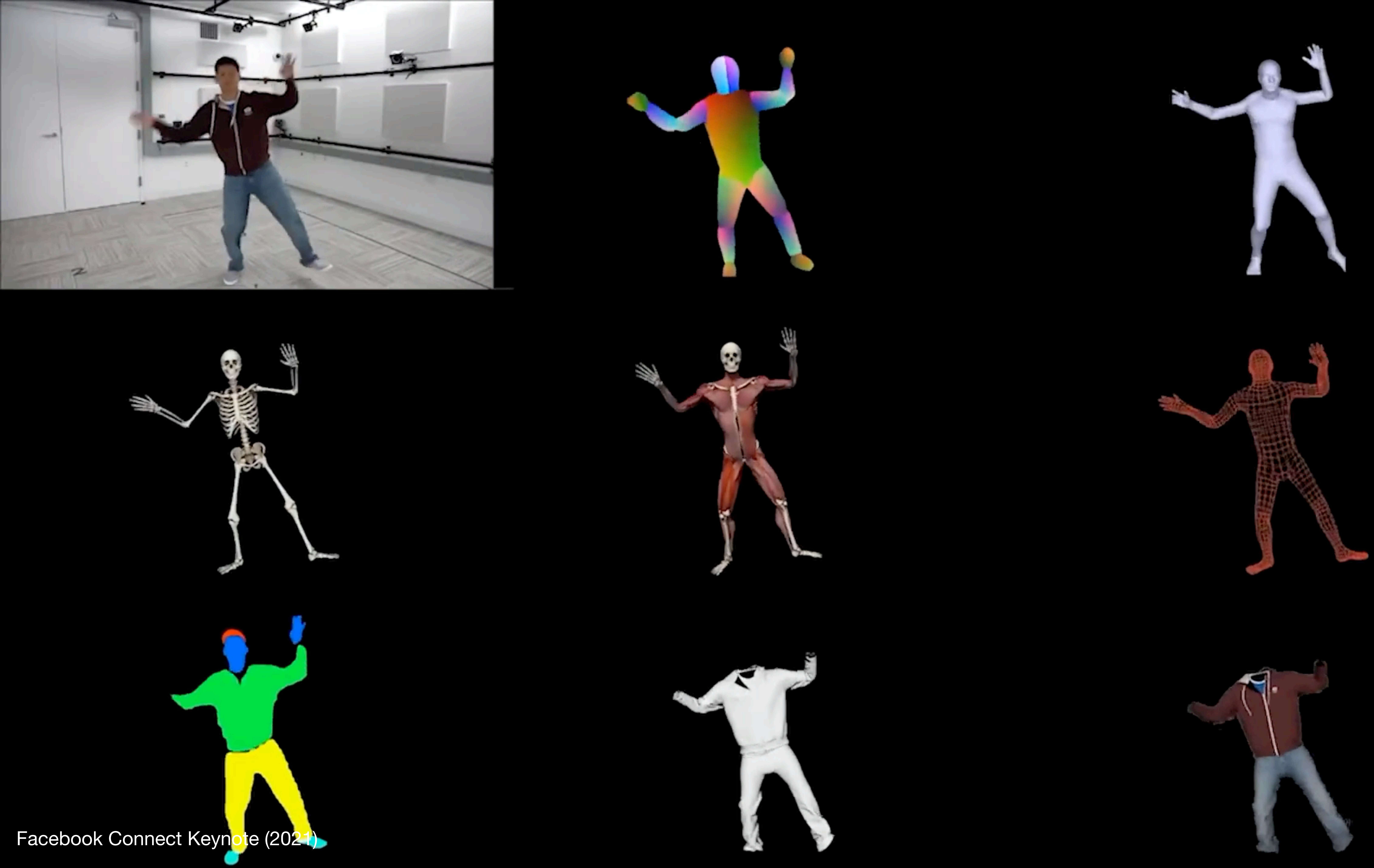
Graphics Turing Test

http://imgur.com/gallery/354XL

1996 → 2013 … → 2030

http://imgur.com/gallery/354XL

Wei, S. E., Saragih, J., Simon, T., Harley, A. W., Lombardi, S., Perdoch, M., ... & Sheikh, Y. (2019). Vr facial animation via multiview image translation. *ACM Transactions on Graphics (TOG)*, *38*(4), 1-16.



Facebook Connect Keynote (2021)

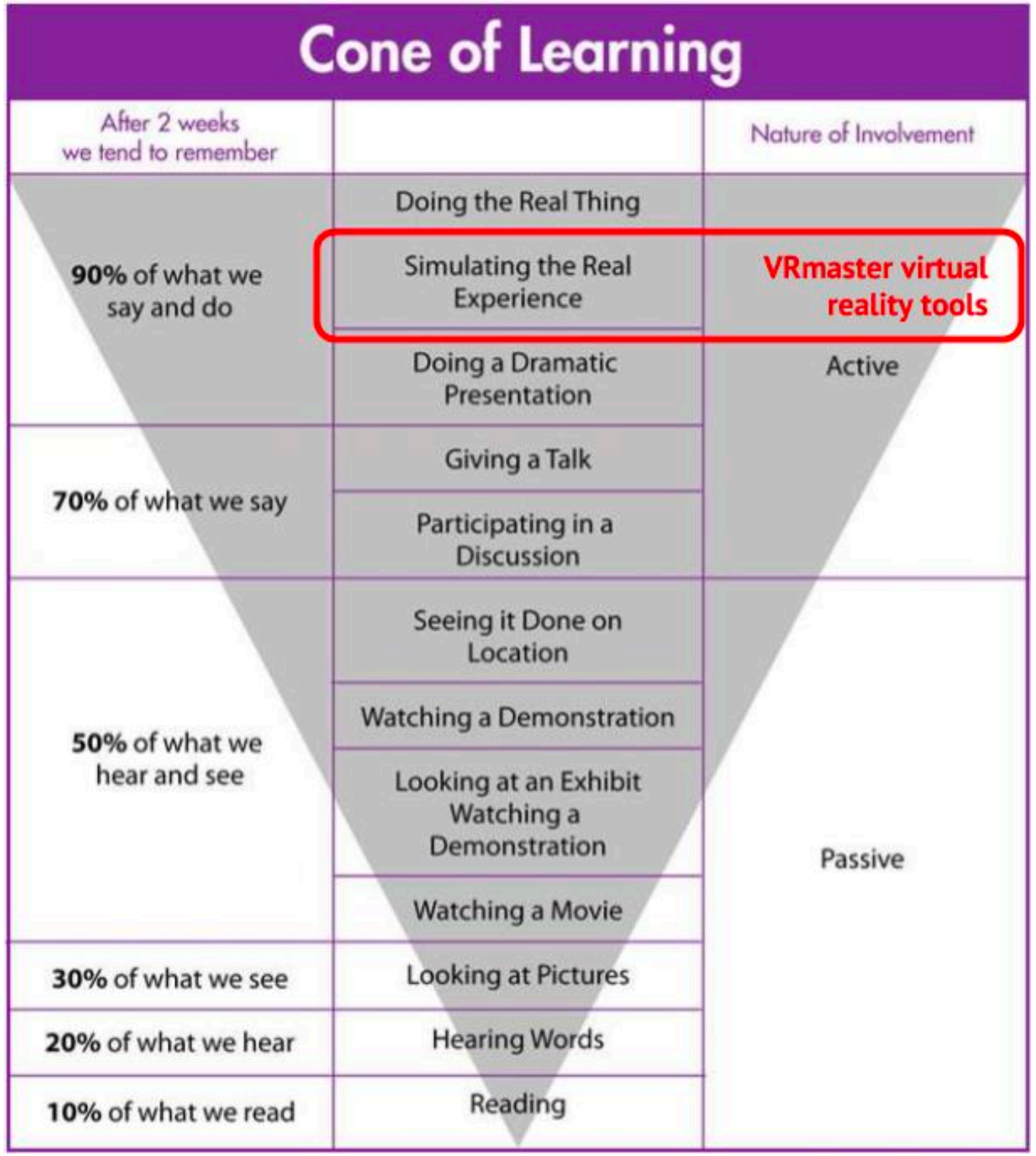
Applications


THE
REC
ROOM
EATS & ENTERTAINMENT
VOID


ANSWER
THE CALL

Learning

MOVE DOWN
MOVE LEFT
MOVE RIGHT



Cone of Learning
After 2 weeks we tend to remember
Nature of Involvement
Doing the Real Thing
90% of what we say and do
Simulating the Real Experience
VRmaster virtual reality tools
Doing a Dramatic Presentation
Active
Giving a Talk
70% of what we say
Participating in a Discussion
Seeing it Done on Location
Watching a Demonstration
50% of what we hear and see
Looking at an Exhibit Watching a Demonstration
Passive
Watching a Movie
30% of what we see
Looking at Pictures
20% of what we hear
Hearing Words
10% of what we read
Reading

Therapy

Arachnophobia

https://www.youtube.com/watch?v=I8_XTD_F0Cw

Acrophobia

https://ovrhealth.com/

Social Phobia

https://www.youtube.com/watch?v=ZpC3f0G0RX0

Bouchard, S., Côté, S., St-Jacques, J., Robillard, G., & Renaud, P. (2006). Effectiveness of virtual reality exposure in the treatment of arachnophobia using 3D games. *Technology and health care*, *14*(1), 19-27.

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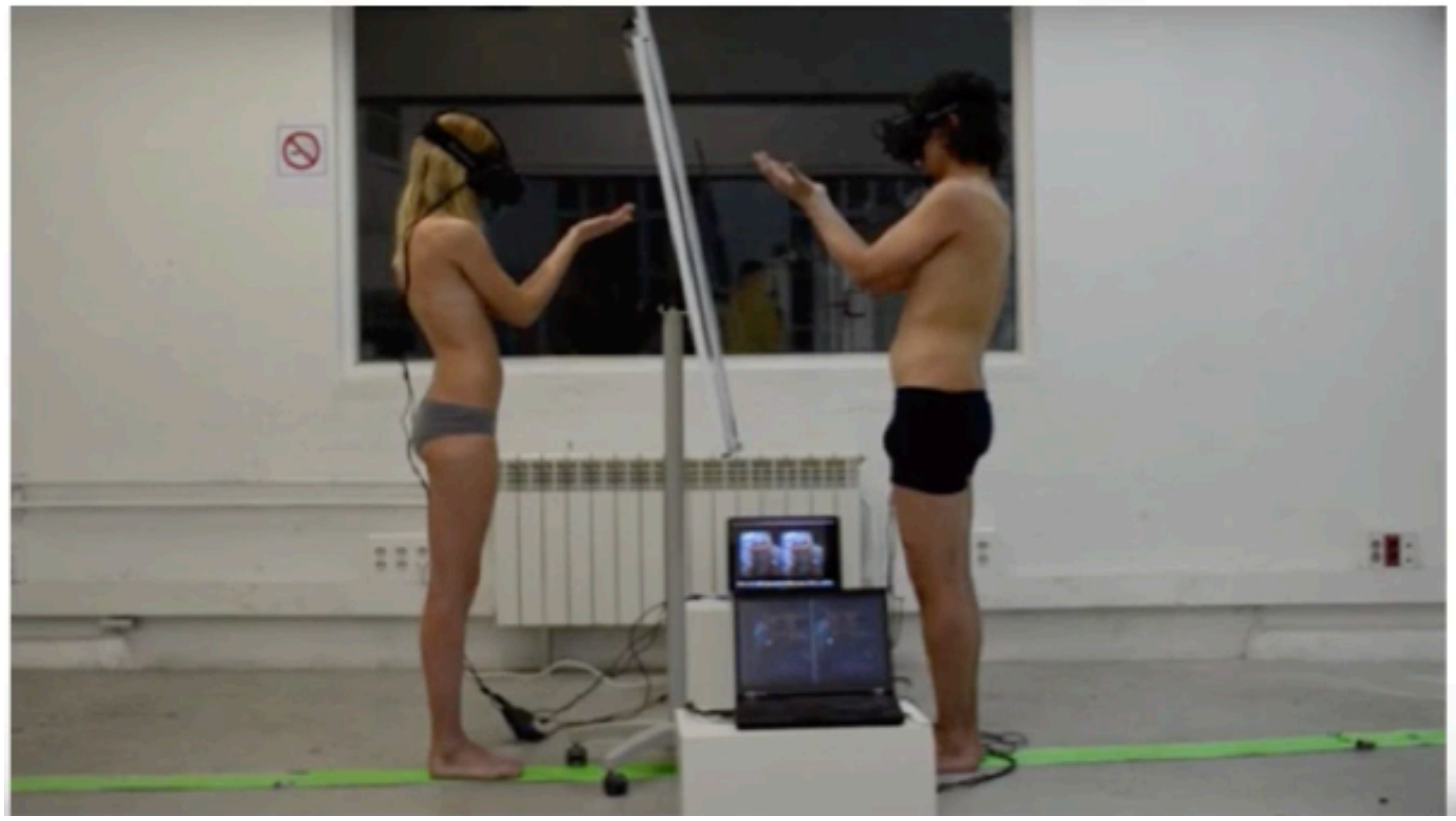
Ultimate Empathy Machine



The Machine to Be Another

https://www.youtube.com/watch?v=_Wk489deqAQ

Event Lab

https://ovrhealth.com/

Clouds over Sidra

https://www.youtube.com/watch?v=mUosdCQsMkM

Muller, D. A., Van Kessel, C. R., & Janssen, S. (2017, October). Through Pink and Blue glasses: Designing a dispositional empathy game using gender stereotypes and Virtual Reality. In *Extended Abstracts Publication of the Annual Symposium on Computer-Human Interaction in Play* (pp. 599-605).

Bertrand, P., Guegan, J., Robieux, L., McCall, C. A., & Zenasni, F. (2018). Learning empathy through virtual reality: multiple strategies for training empathy-related abilities using body ownership illusions in embodied virtual reality. *Frontiers in Robotics and AI*, *5*, 26.

Alberghini, D. (2020). Improving empathy: is virtual reality an effective approach to educating about refugees?.

The future?

Smart Glasses