Bremen

CG VR

Virtual Reality & Physically-Based Simulation
Introduction, Immersion, Presence

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Brainstorming – What Do You Associate with VR?

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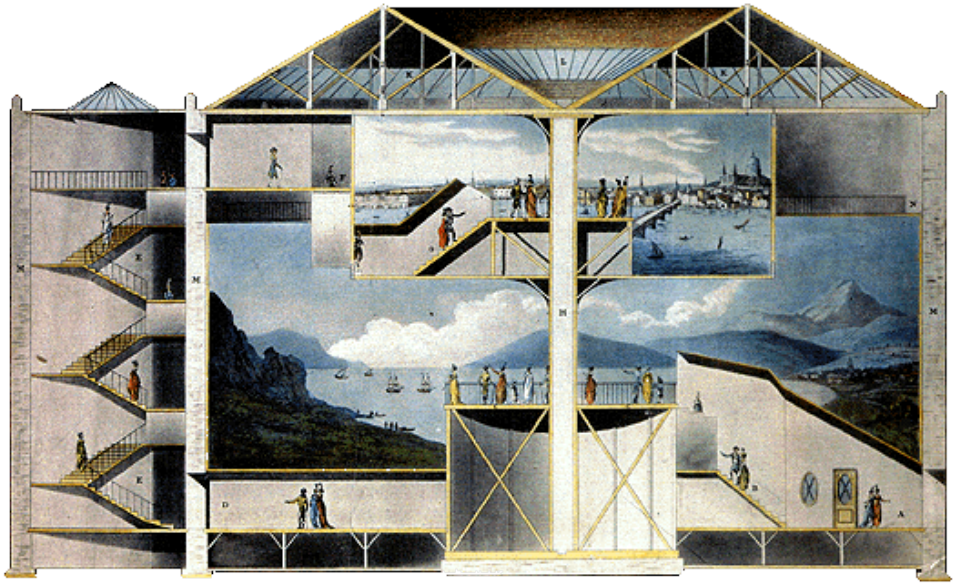
- "[Diese] *sind überhaupt eine der glücklichsten Erfindungen unserer Zeit.* [...] *Was vor Jahren Hunderte von Pfund gekostet hätte, ist jetzt für ein paar Schilling zu haben* [...]. *Ein vollkommener Eindruck und das ohne endlose Formalitäten, Ungeziefer, schlechtes Wetter und eine 1200-Meilen-Reise.* [An diesen läßt sich ohnehin] *gründlicher Lernen als im Original* ..."

- Worum handelt es sich hier? ...

- Um das *Panorama* ! ...
  [1824, Blackwood's Edinburgh Magazine]

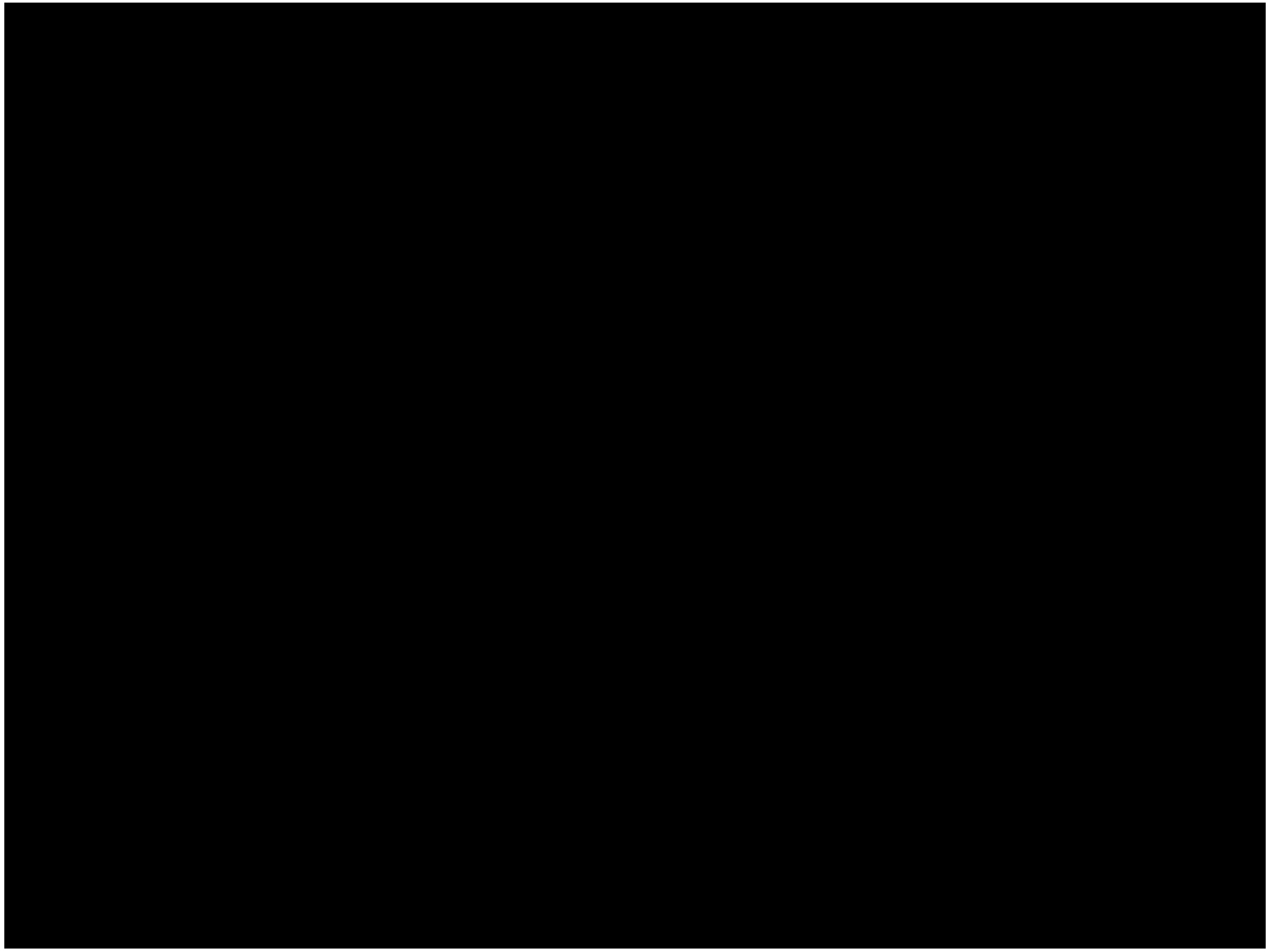
Encyclopædia Britannica



Cross section of
Robert Barker's Panorama,
Leicester Square, London, 1789

Bourbaki Panorama
in Luzern

The 2-Minute Introduction to VR



(Ursprünglich eine "60 second introcution to VR" ☺
Quelle: www.not-for-wimps.org; Fhg-IGD)

The Goal of Virtual Reality

- More efficient Human-Computer-Interaction (HCI)
  - "Post WIMP interfaces"
- Better user performance

Real Value of VR for Customers

- Intuitive & pleasurable user experience (consumers)
- Shorter time-to-market (manufacturing)
- Helps non-experts with spatial understanding of designs at early stage (visualization, car design, architecture, etc.)
- Platform for communication among teams

What Is VR?

Steve Bryson:

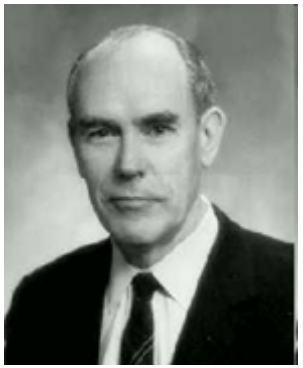
Virtual Reality (VR) refers to the use of three-dimensional displays and interaction devices to explore real-time computer-generated environments.

Carolina Cruz-Neira:

Immersive, interactive, multi-sensory computer-generated experiences.

Ivan Sutherland, 1966:

Indeed, in the ultimate display one will not look at that world through a window, but will be immersed in it.



Myron Krueger:

The promise of artificial realities is not to reproduce conventional reality, or to act in the real world. It is precisely the opportunity to create synthetic realities, for which there are no real antecedents, that is exciting conceptually, and ultimately important economically.

Lynne Dittmar:

VR emulates the information presented to the human visual (aural, tactile) system by the "real world".

Kommunikationstheoretisch:

Ein Medium für Kommunikation, bestehend aus synthetischen Räumen und den Menschen als gleichberechtigten, integralem Bestandteil eines digitalen Systems.

What is VR *NOT*!

David Mizell:

Jedes Computergraphik-System nach 1990. ☺

Fertigungsindustrie (insbesondere Manager dort):

Visualisierung von Simulationen, bzw.
interaktive 3D-Computergraphik.

Multimedia:

QuicktimeVR
VRML

David Blatner:

Virtual Reality is a way for humans to visualize, manipulate and interact with computers and extremely complex data.

Business Week:

Virtual Reality is a new tool to amplify *the mind.*

William Gibson (Neuromancer):

Cyberspace.

Marketing:

Ist der Kunde gegenüber neuer Technologie aufgeschlossen?

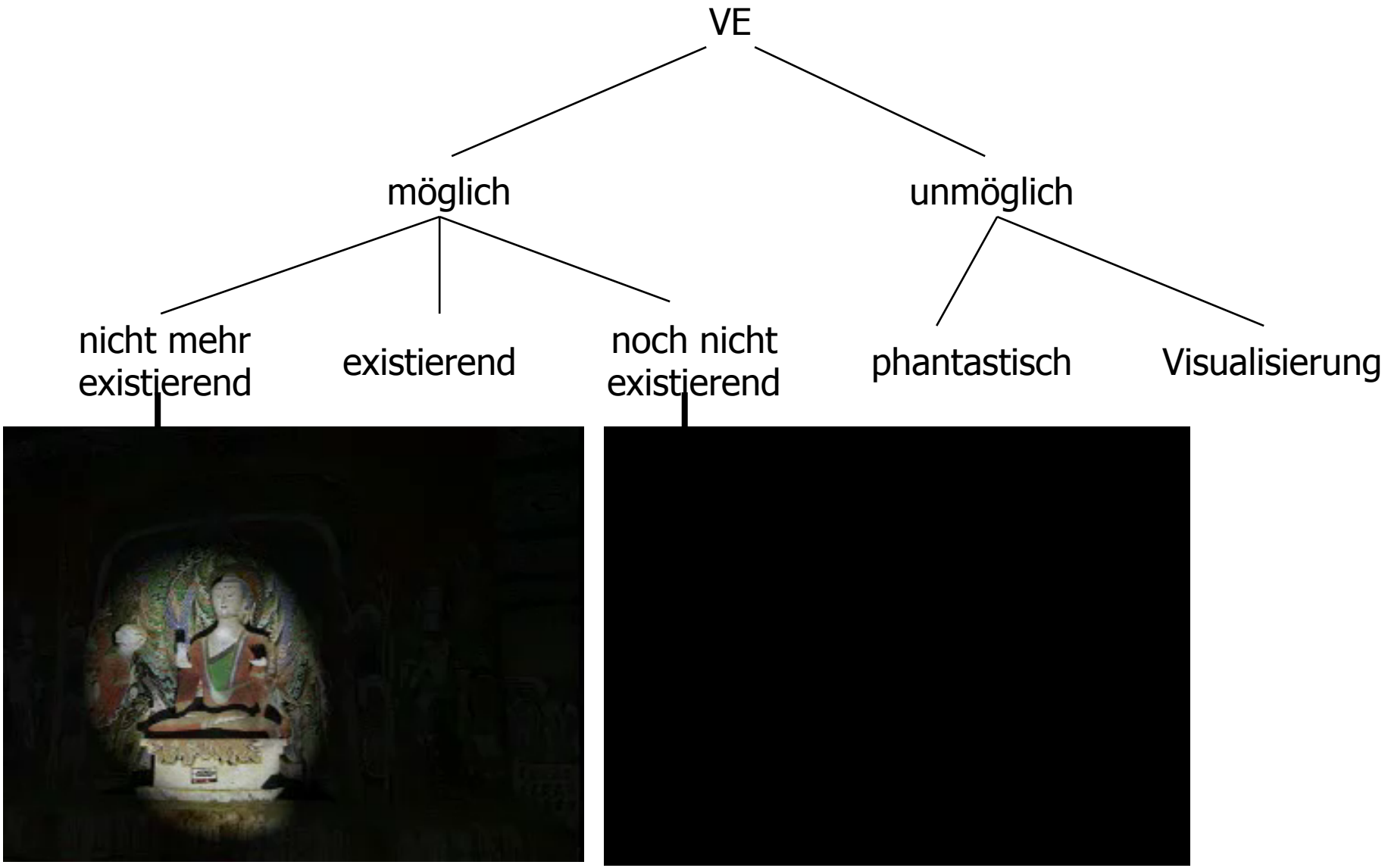
Ja → es ist VR;

Nein → es ist *nicht* VR;

A 5-Points Definition [GZ]

- It is virtual reality, if the following criteria are met:
  1. Rendering in real-time,
  2. Simulation in real-time,
  3. Interaction in real-time,
  4. Intuitive interaction (usually involves input devices with 3+ DOFs),
  5. Immersion: stimulation of as many senses as possible by the computer,
  6. Presence, possibly.
- In order to achieve that, you take …
  - Novel, multi-dimensional input devices
  - Visuelle displays that can present an image with depth
  - Haptic devices
  - Graphics hardware (is a commodity today)
  - Speech input & sound output
  - Algorithms!

Klassifikation verschiedener VEs



How do You Fool the Mind?

The mind has a strong desire to believe that the world it perceives is real. [Jaron Lanier]

- By depth cues:
  - Occlusion (Verdeckung),
  - Perspective
  - Stereo parallax (convergence of eyes),
  - Head motion parallax (Kopfbewegungsparallaxe),
  - Accomodation (Fokussierung),
  - Color/contrast change with increasing distance.
- By interaction:
  - Grasping and moving virtual objects,
  - Walking in a virtual environment.
- Proprioceptive queues (Selbstwahrnehmung): Gesehenes stimmt mit Körperhaltung überein.

Immersion

- *Immersion* = "Eintauchen"
- Definitions of immersion:
  1. Complete immersion ⇔ all senses are stimulated consistently.
  2. Complete immersion ⇔ user doesn't perceive real world any more.
- Can be determined relatively easily:
  - Count number of senses that are stimulated by the computer
  - Count number of senses that are shielded from reality
- Immersion ≠ Plausibility! (Bsp. SciFi-VE)

Fidelity

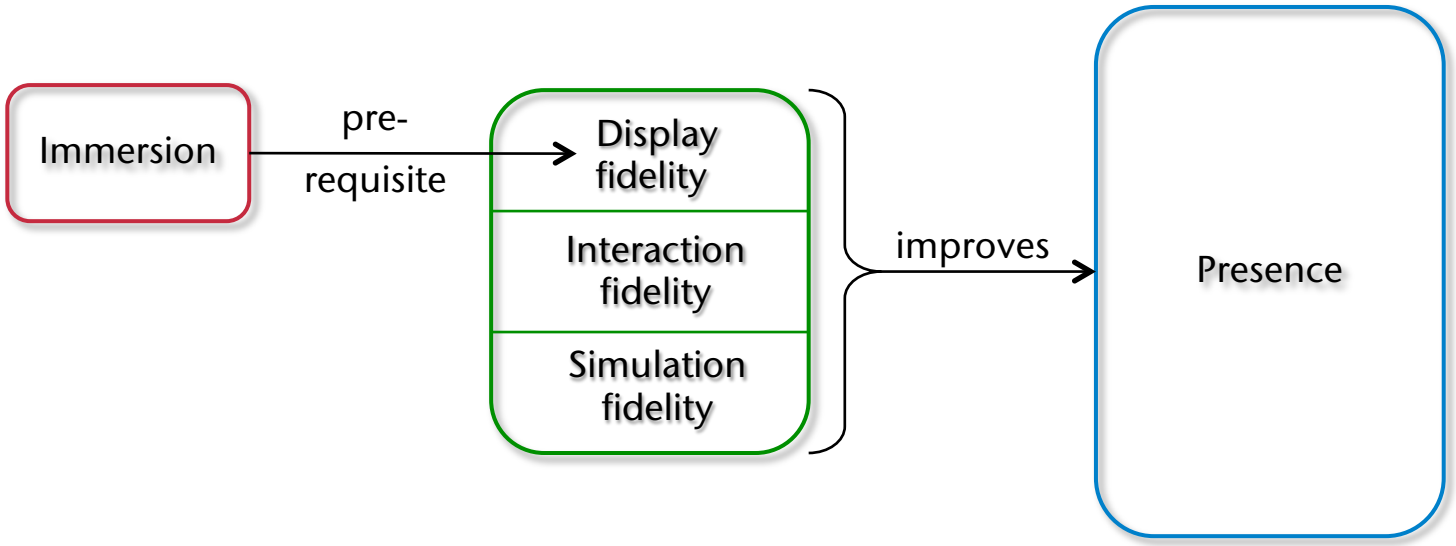
- *Fidelity* := objective level of realism of a technological system
  - Ground truth, i.e., 100% fidelity = real world
- The three important components of the fidelity of a VR system:
  1. Rendering fidelity := level of realism of rendering
     - Visual rendering : image resolution, detailed textures, correct lighting, etc.
     - Haptic rendering : do rigid objects feel stiff? Forces on all fingers, or one handle only?
     - Auditory rendering : does the virtual room sound like real rooms?
  2. Interaction fidelity := level of realism of interaction with virtual objects
  3. Simulation fidelity := level of realism of behavior of virtual objects
     - E.g., does the cloak of a virtual character behave like real cloth?
- Note: higher fidelity does not necessarily imply higher user performance!

Presence (Präsenz)

1. *You* are there (*you* are part of the virtual environment)
   - VR without presence creates a *"suspension of disbelief that they are in a world other than where their real bodies are located"* (Slater & Usoh).
2. You are *there* (you are *part of the remote environment*)
   - Tele-presence
   - Tele-operation
3. It is *here*
   - Bsp.: Karosserie-Styling-Review im virtuellen Showroom.
4. *We* are *there* (distributed users are in *one common* virtual environment)
   - E.g., Second Life

- Presence is subjective = user's psychological response to the system

Relationship Between Immersion, Fidelity, and Presence



- Many other factors can influence the presence of a VR user:
  e.g., the cognitive load;
  Cognitive load is high ⟶ presence is high (example: Doom)
- A simple test for presence: does the user show reflexes?

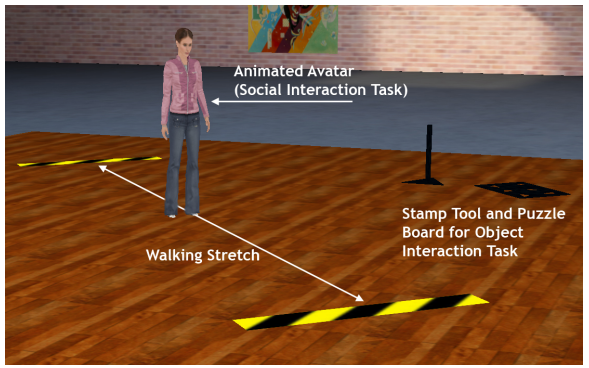
The "Pit Experiment"

- The experiment:
  - Subjects start in a real room, then put on an HMD, see the real room in the virtual environment, walk through the real=virtual door, and are then in the virtual "pit room"
  - Conditions:
    - Flying by joystick
    - Virtual walking (virtual camera moves up & down)
    - Real walking

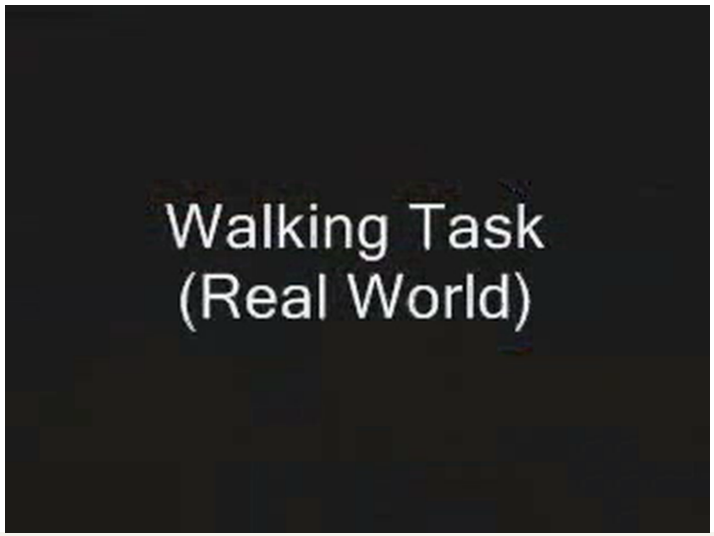
- Results: high sense of presence when really walking
- Reason (probably): high fidelity
  - Low latency
  - Real walking (proprioception)
  - Visual fidelity of the detailed, textured, radiosity-lit scene
  - Stereopsis, spatial audio, passive haptics

What Else Can Increase Presence?

- One hypothesis: a self-avatar
- Experiment:
  - Self-avatar in virtual environment with full-body tracking
  - Tasks:
    - Walk a specific distance;
    - Put stamps into templates; ...



- Conclusions are not clear
- Possible reasons:
  - Head-mounted display, field-of-view was too small
    → self-avatar rarely seen by subject!

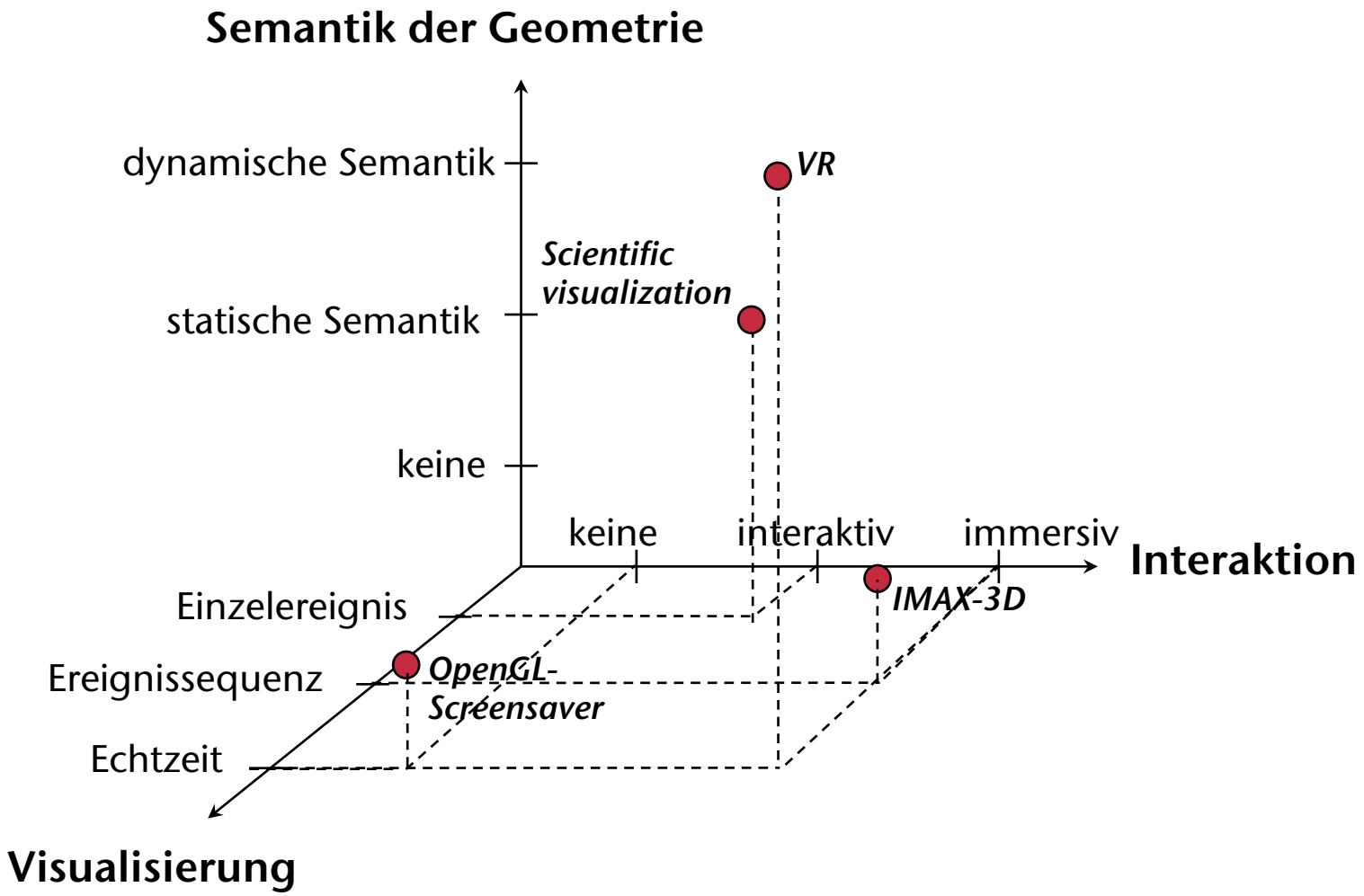


Virtual Reality and Games Have a Lot in Common

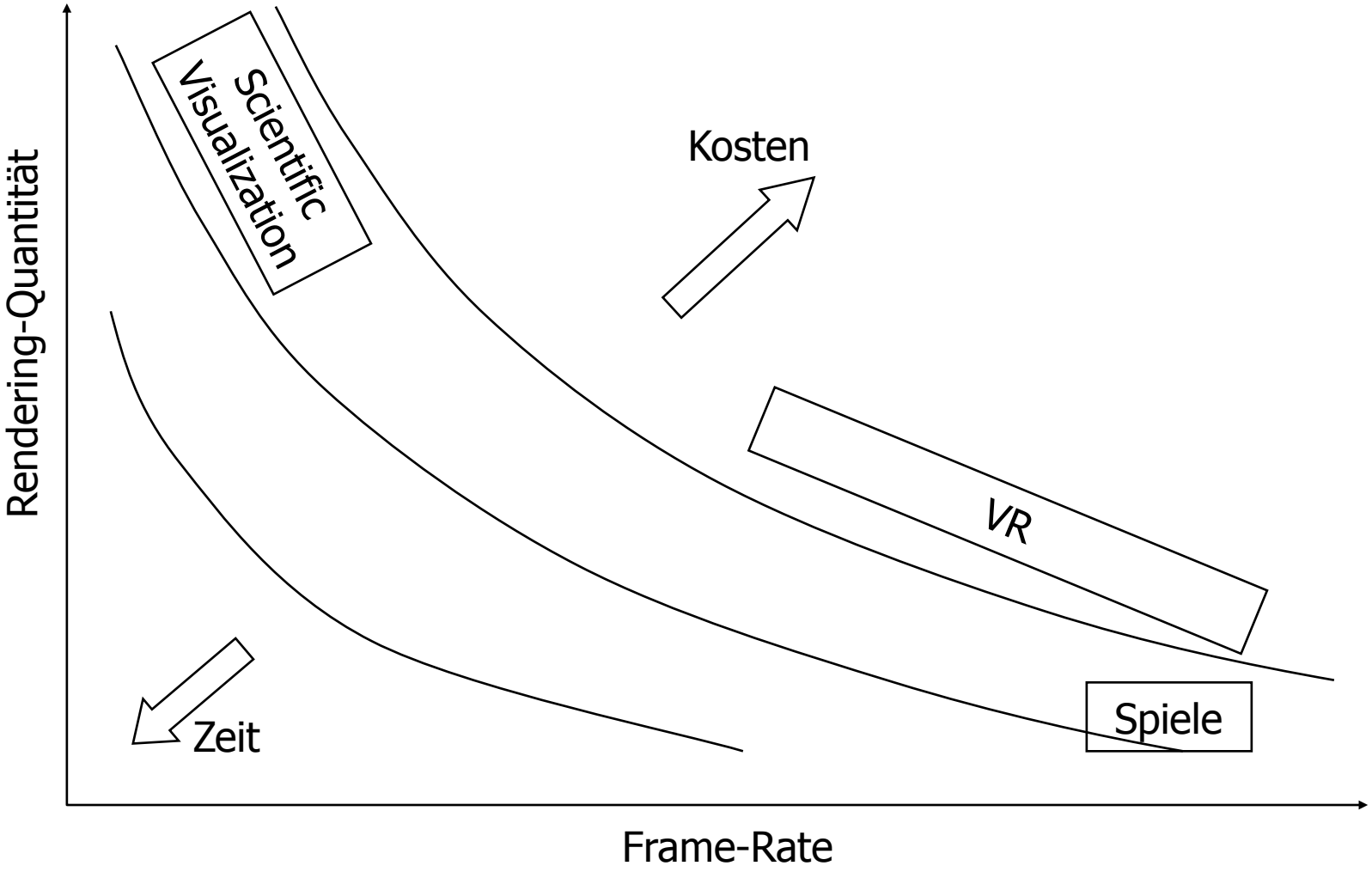
- Very high demands on rendering:
  - VR: 1. high polygon count, 2. high frame-rate, sometimes quality
  - Games: 1. high frame-rate, 2. special effects
- Interaction: efficient, "non-intrusive", natural,
- Object behavior:
  - Physcally-based
  - Autonomous (aka. AI in games)

- Differences:
  - Size of market
  - Costs
  - Respective market segment targeted by each technology/industry

Einordnung


Semantik der Geometrie
dynamische Semantik
statische Semantik
keine
VR
Scientific visualization
keine
interaktiv
immersiv
Interaktion
IMAX-3D
Einzelereignis
Ereignissequenz
OpenGL-Screensaver
Echtzeit
Visualisierung

Kosten vs. Zeit



What is a Virtual Environment (VE)

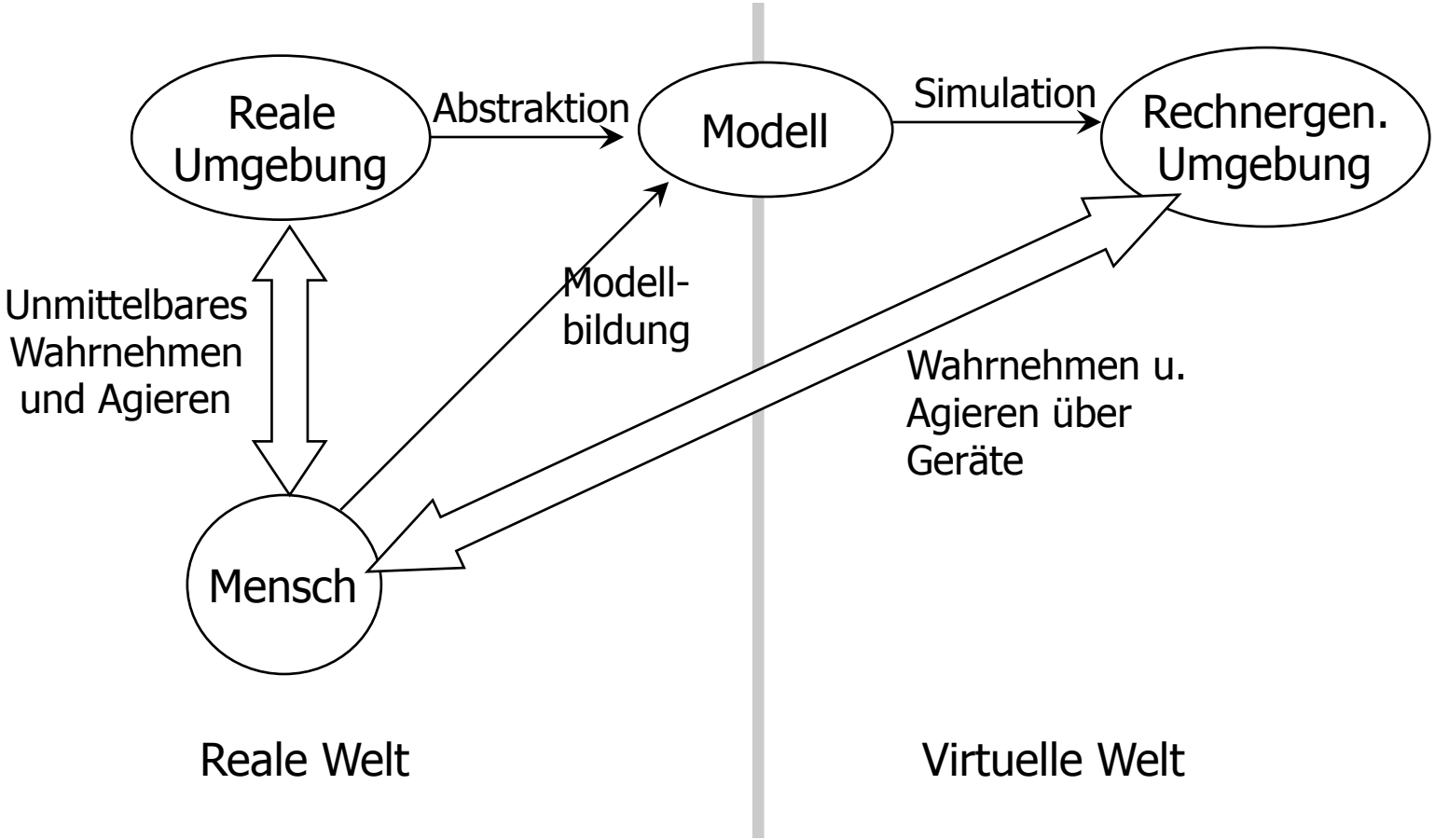
Laufen,
Greifen,
...

Sehen,
Hören,
Riechen,
Fühlen, ..

Interaktions-
metaphern

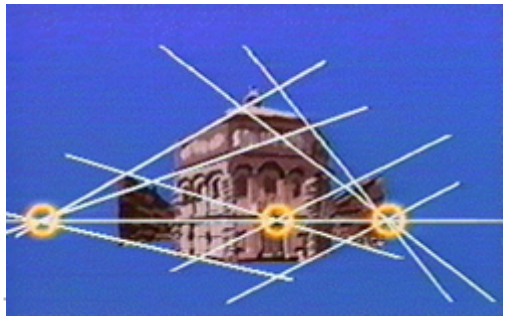
Sehen,
Hören,
(Riechen?)
(Fühlen?)

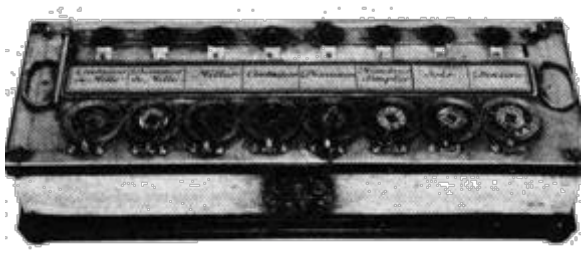
Virtualisierung (Modellbildung)



The Growing Virtualization of Our World ...

2 strands: first it happened in the arts, then technology took over





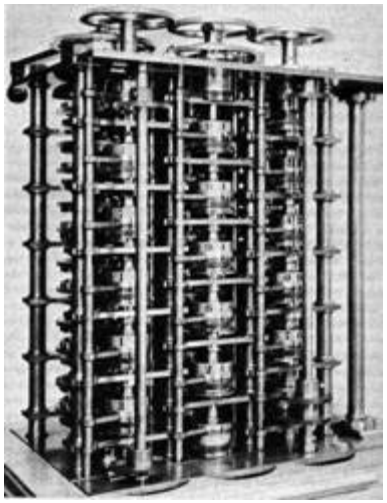
30,000 v. — Höhlen von Lascaux

400 v. — Abakus

15. Jh. — Zentralperspektive (Brunelleschi)

1642 — Rechenmaschinen von Schickard u. Pascal

1801 — Lochbrettchen für Webstühle (Jacquard)



1834 – Difference / Analytical machine (Babbage)

1854 – Boole "erfindet" binäres System

1890 – Volkszählung in USA mit Holleriths Lochkartenmaschine

1924 – Gründung IBM

1929 – 1.Flugsimulator (Link-Trainer)

1936 – Turing-Maschine

1938 – Z1

1958 – Z60: Vorläufer der CAD-Systeme

1963 – Sutherland's "Sketchpad"

1962 – Sensorama (Morton Heilig)

1981 – Datenhandschuh (Zimmermann)

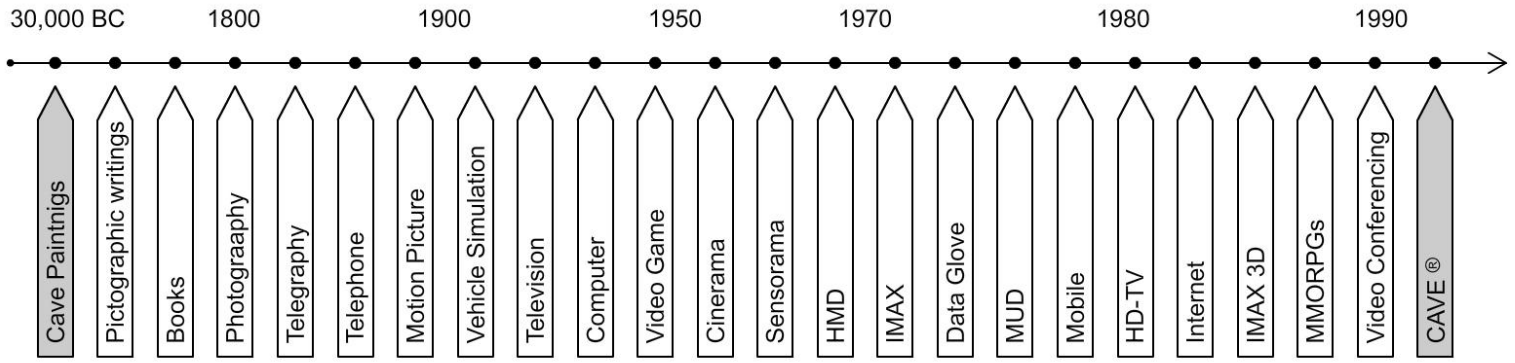
1983 – Erstes kommerzielles HMD

1985 – "Virtual Environment Display System" Programm der NASA

More Example for Virtualization

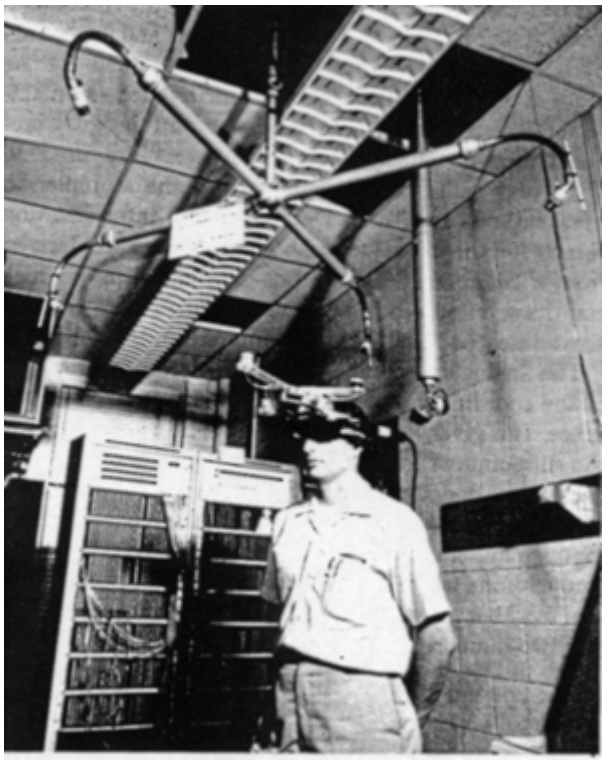
- Ca. 1900: Telephone
- C.a 1950: TV
- Ca. 1980: MUDs (text-based multi-user adventures)
- Ca. 2000: Shopping via internet
- Ca. 2005: "Social" platforms (Facebook, et al.)
- Ca. 2008: Second Life
- ...

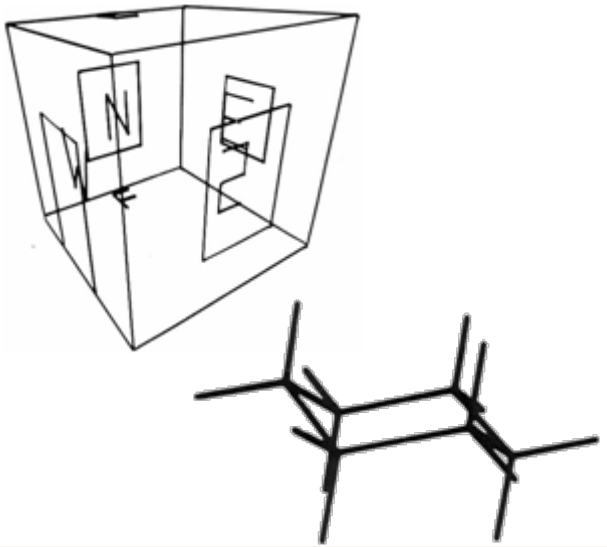
from caves to CAVEs



"The ultimate display .."

- Sutherland 1965
- Quotes from the paper:
  - "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."
  - "I want to describe for you a kinesthetic [= force-feedback] display."
  - "Machines to sense and interpret eye motion can and will be built."
  - ".. We have little ability to have the computer produce meaningful sounds."
  - "The ultimate display would, of course, be a room within which the computer can control the existence of matter."





Hip, hype, hop

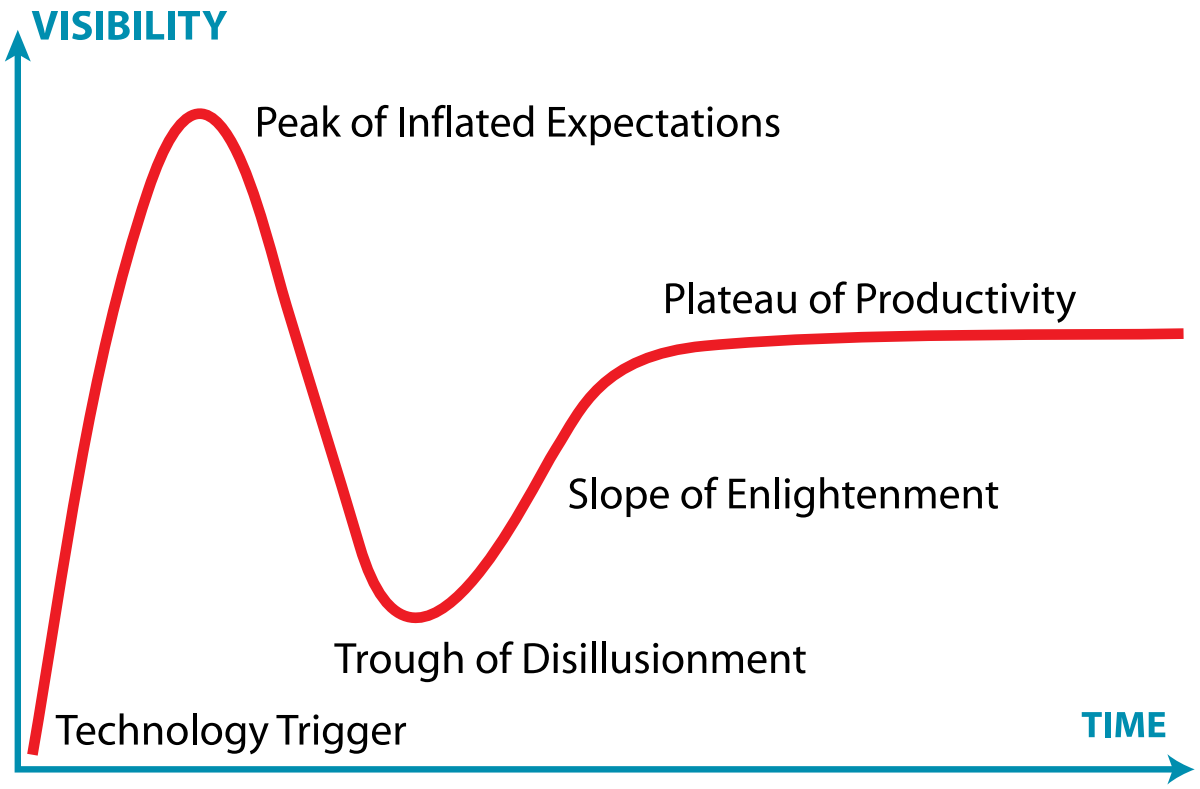
- Siggraph 95
- Caveat the fate of AI
- Beware of the press (TV, popular-scientific journals)
- Science fiction: *Brave New World*, *Fahrenheit 451*, *Neuromancer*, *Snowcrash*, *Idoru*, *The Hacker and the Ants*, *Otherland*, Star Trek [Holodeck], ...
- Hollywood: Lawnmower Man, Total Recall, ...
- Currently, VR is not jeopardized by these perils

Johnny Mnemonic

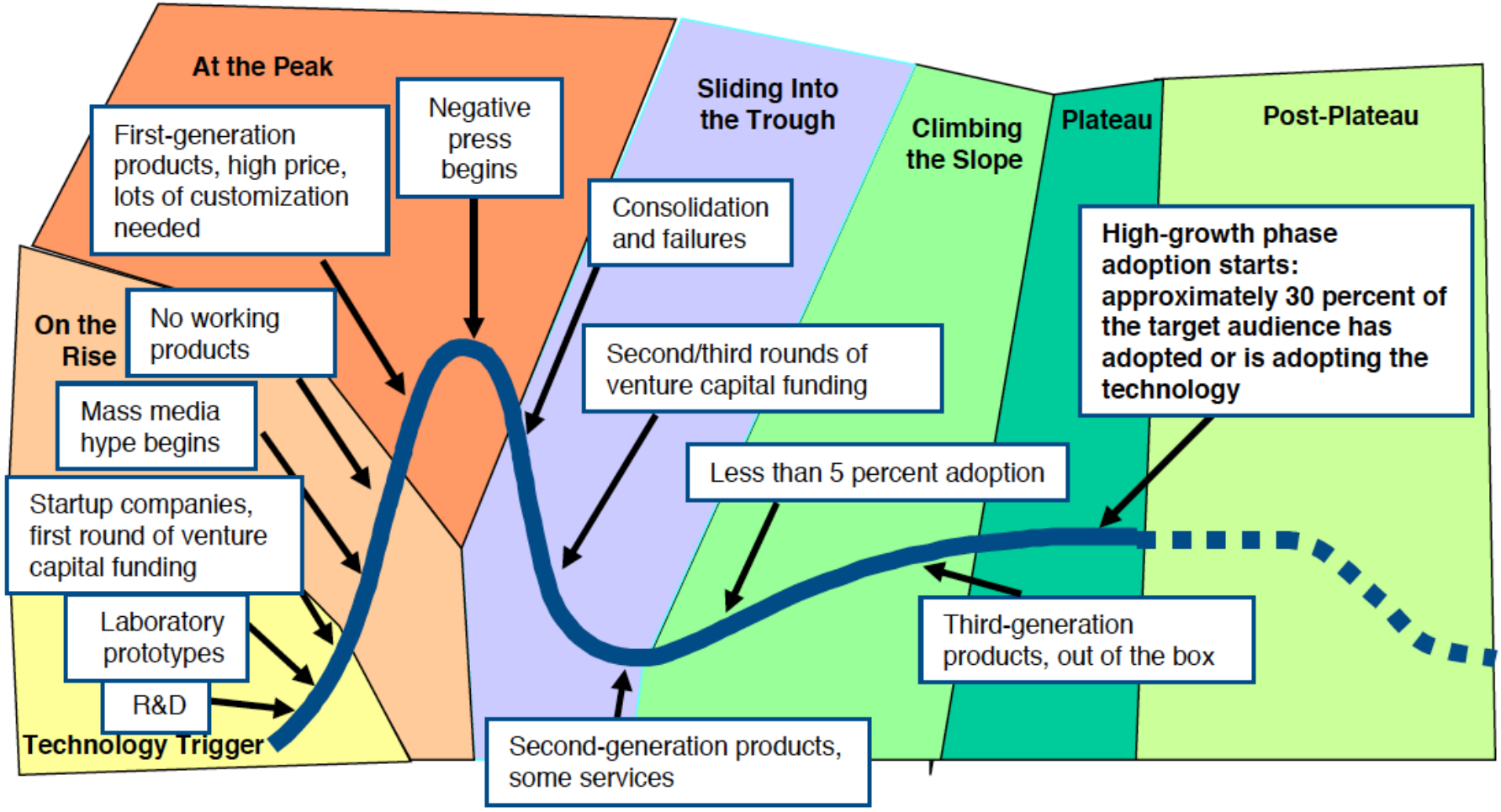
Lwanmower Man

Gartner's Hype Cycle for Emerging Technologies

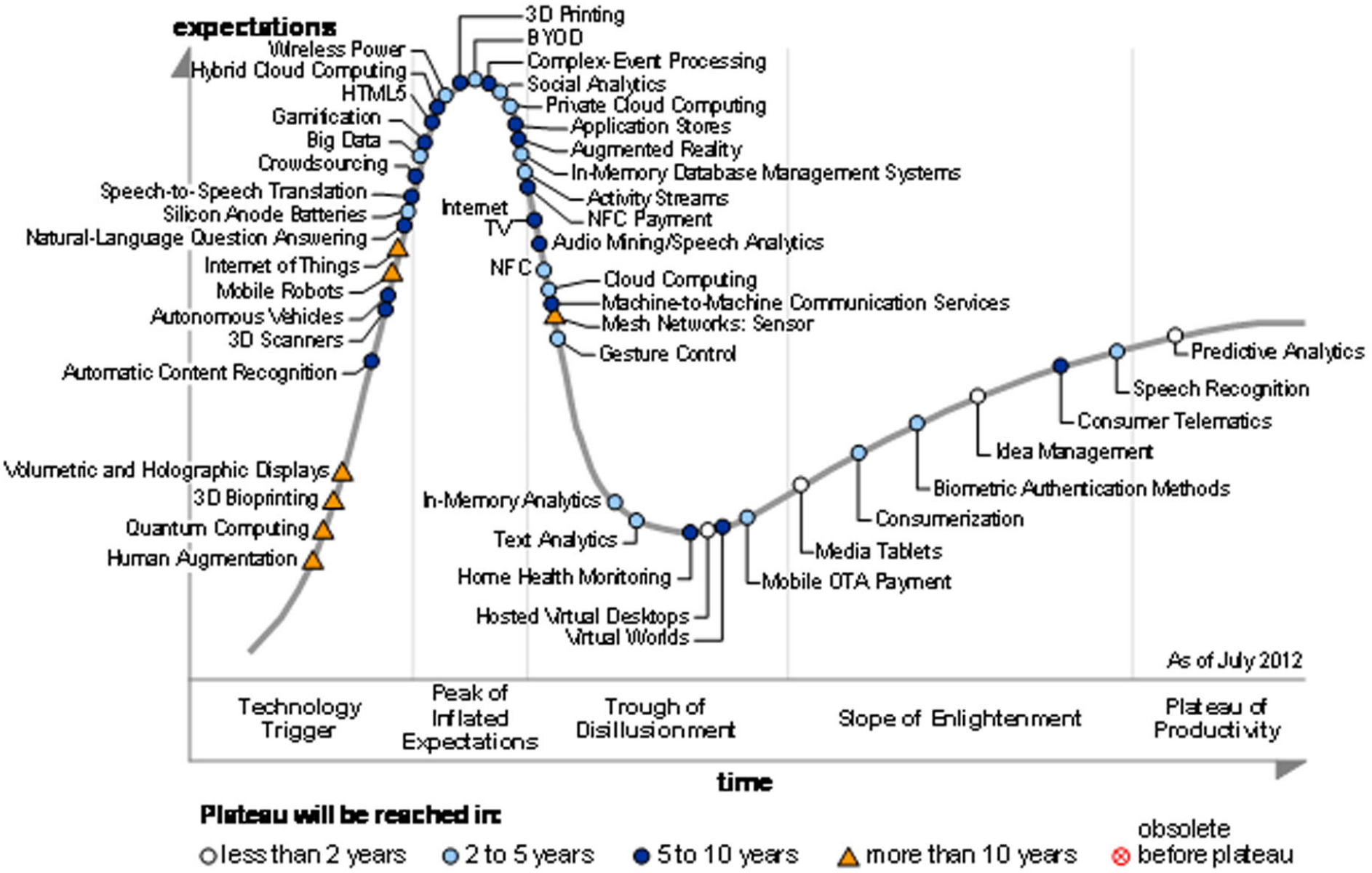
- Hype cycle = graphic representation of over-enthusiasm, disillusionment, and eventual realism that accompanies each new technology



In more detail

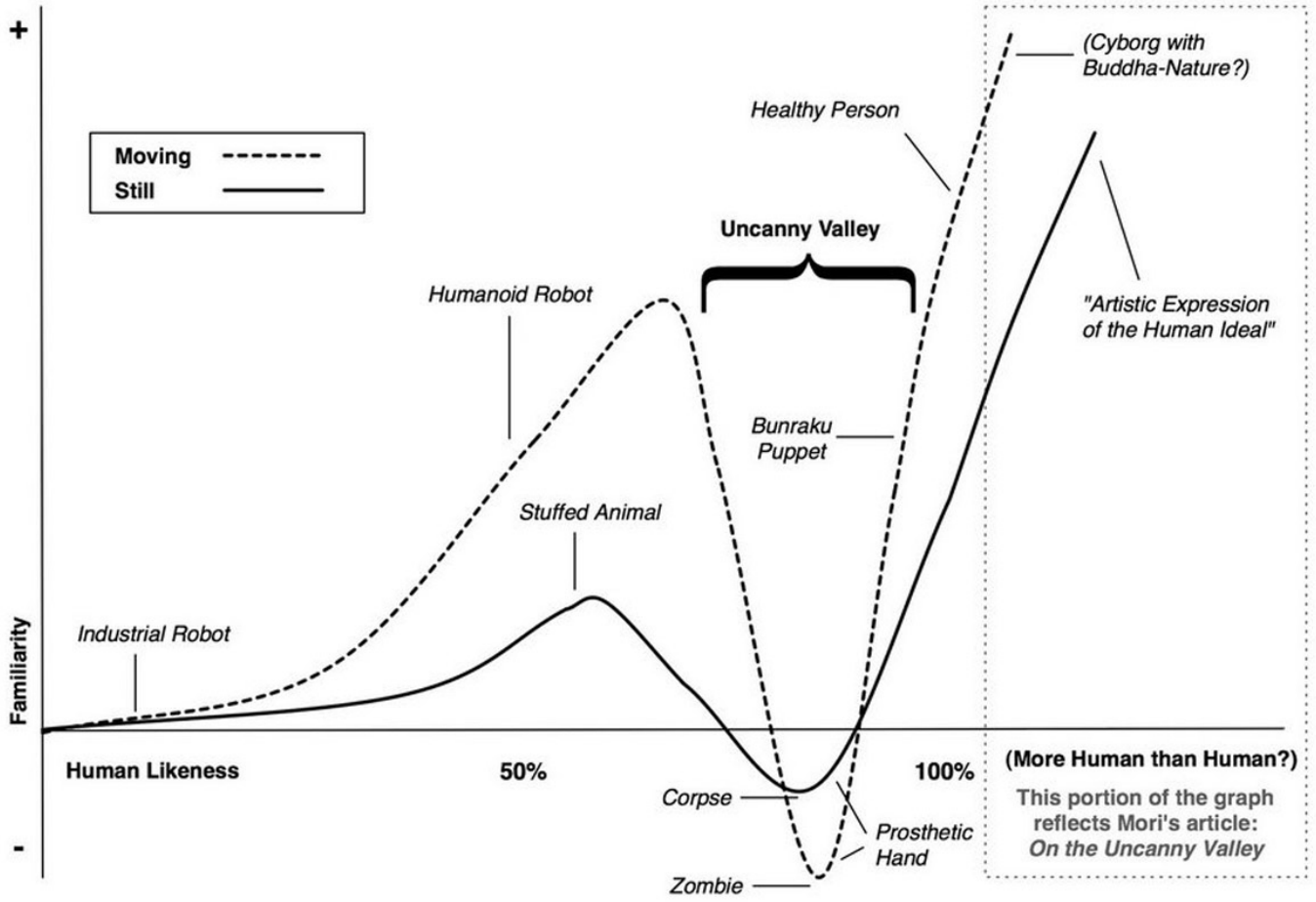


A Few Examples

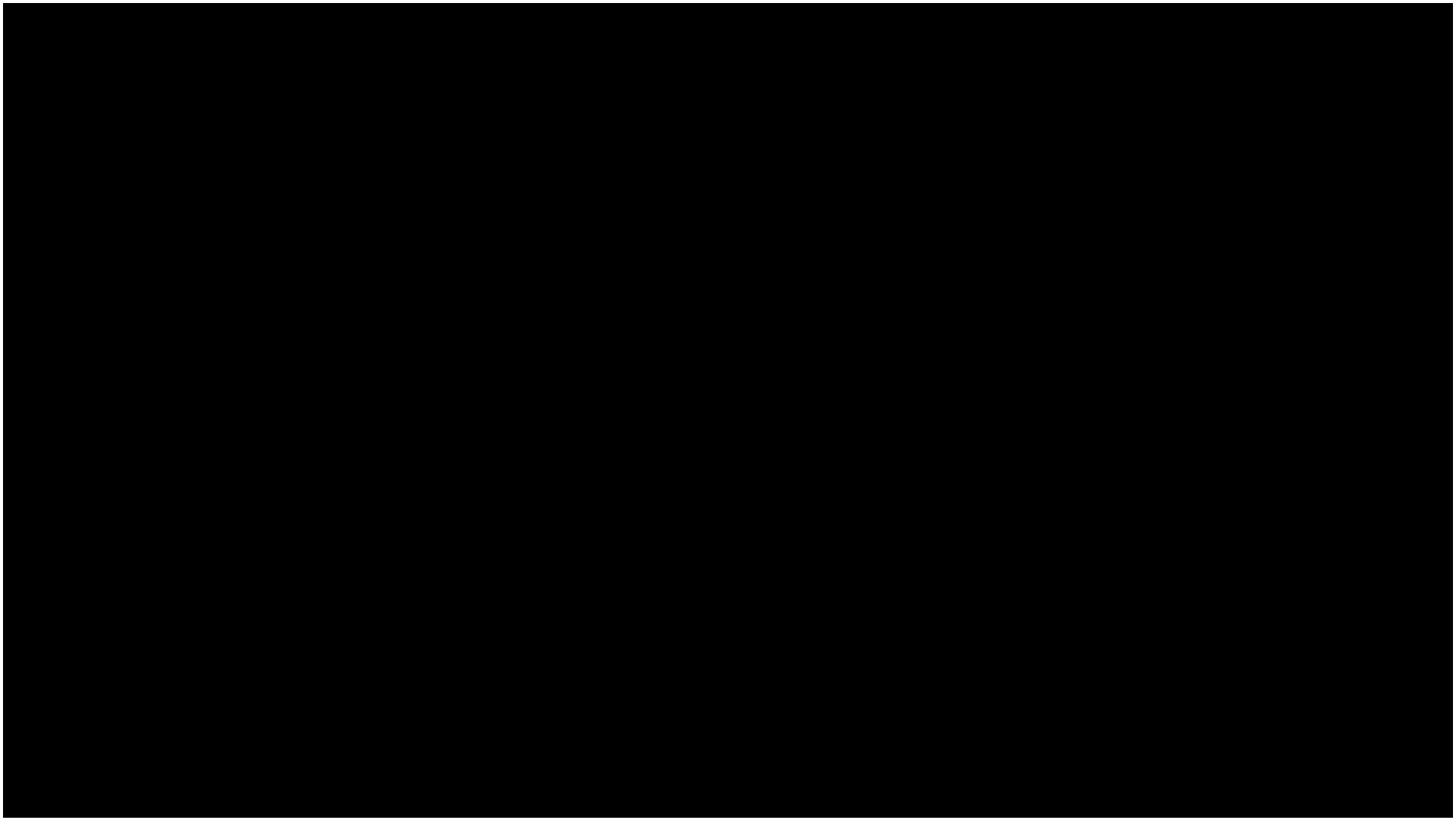


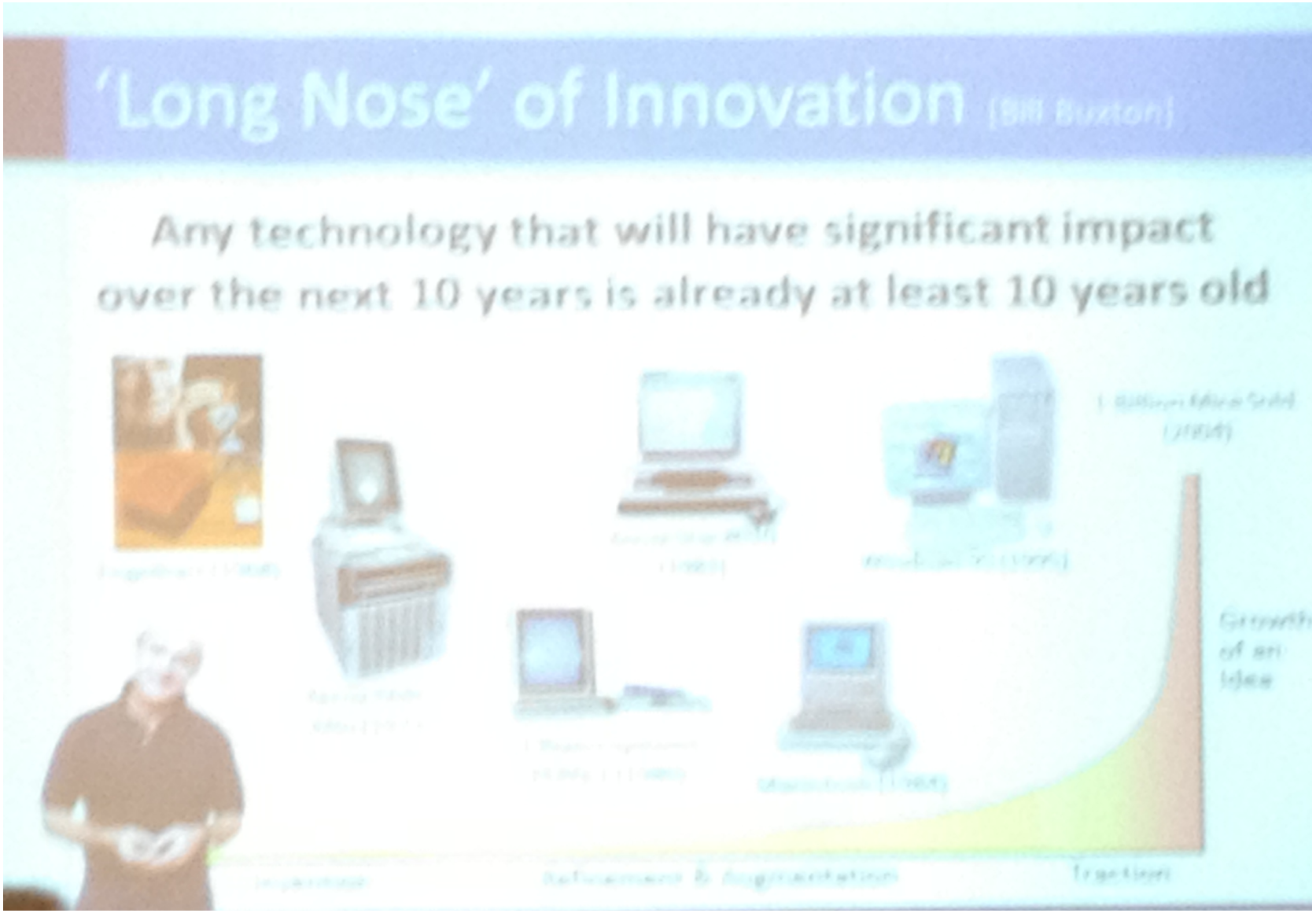
The Uncanny Valley

- "When human replicas look and act almost, but not perfectly, like actual human beings, it causes a response of revulsion among human observers."



Example




'Long Nose' of Innovation (Bill Buxton)
Any technology that will have significant impact over the next 10 years is already at least 10 years old