

# 3D Interaction in Mixed Reality

## Class 02 – 3D interaction

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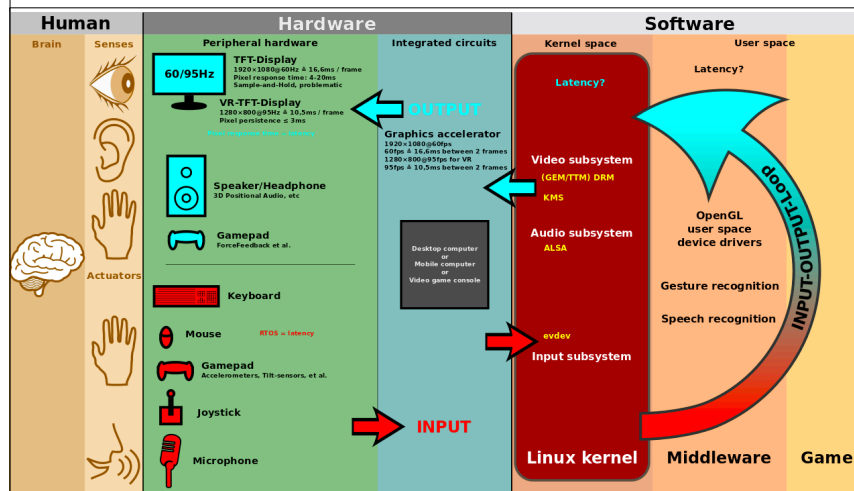
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# Topics

- Interface x User Experience x Usability
- User Experience x Design
- 2D x 3D interface
- 2D x 3D interaction
- Brief history of computer interfaces
- Examples of 3D interfaces

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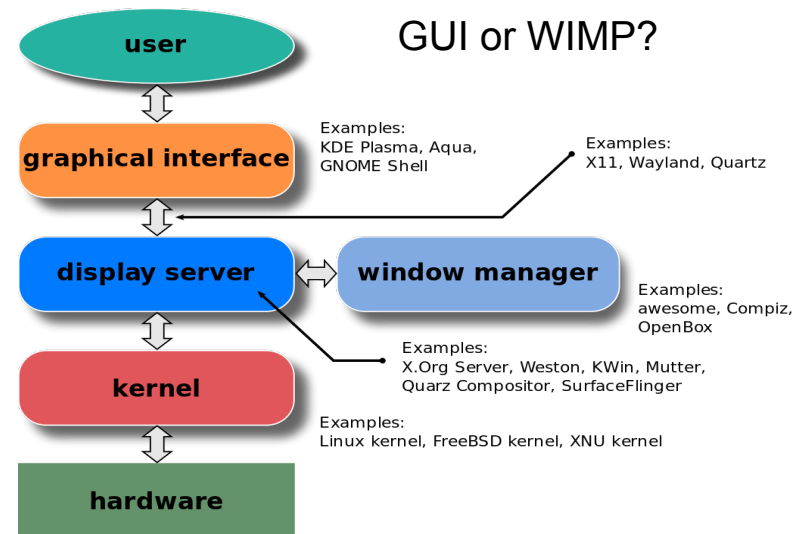
# Computer Interface



[https://en.wikipedia.org/wiki/User\\_interface#/media/File:Linux\\_kernel\\_INPUT\\_OUTPUT\\_evdev\\_gem\\_USB\\_framebuffer.svg](https://en.wikipedia.org/wiki/User_interface#/media/File:Linux_kernel_INPUT_OUTPUT_evdev_gem_USB_framebuffer.svg)

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# GUI or WIMP?



[https://en.wikipedia.org/wiki/Graphical\\_user\\_interface#/media/File:Schema\\_of\\_the\\_layers\\_of\\_the\\_graphical\\_user\\_interface.svg](https://en.wikipedia.org/wiki/Graphical_user_interface#/media/File:Schema_of_the_layers_of_the_graphical_user_interface.svg)

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## Usability



### Carelman pot

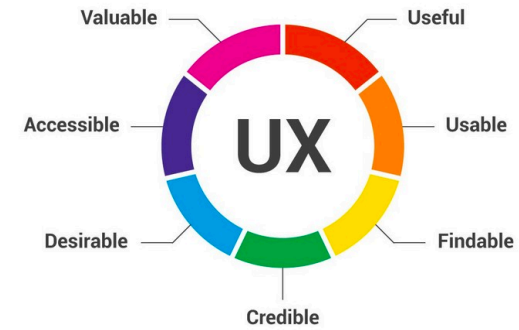
The impossible teapot. (Author's collection, after Carelman's "Coffeepot for Masochists.")

<https://www.interaction-design.org/literature/topics/usability>



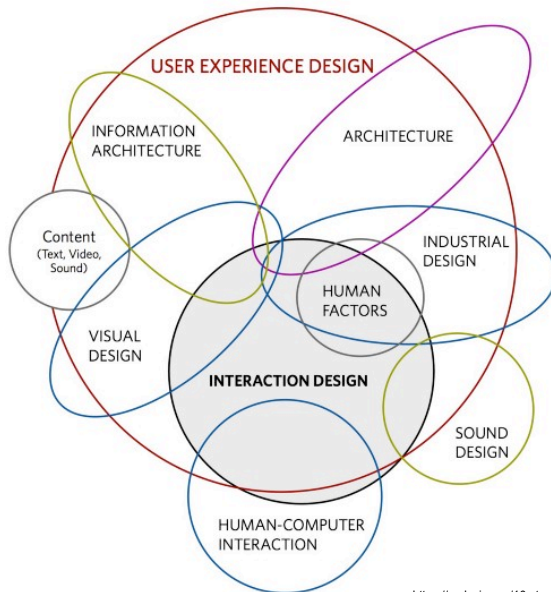
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## User Experience



<https://www.interaction-design.org/literature/article/the-7-factors-that-influence-user-experience>

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<https://uxdesign.cc/10-steps-to-interaction-design-ixd-6abe778cb8b8>

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A bit of history about  
Graphical User Interfaces

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## 1963 - Ivan Sutherland Sketchpad

1963 - Ivan Sutherland thesis

“Sketchpad, A Man-Machine Graphical Communication System”

Run on a TX-2 Computer (1958)

discrete transistors

64K of 36 bit words (~272 KBytes)

Interface

oscilloscope

light pen

push buttons



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## 1968 - Douglas Engelbart

The mother of all demos

complete computer hw and sw called oN-Line System (NLS)

windows

hypertext

graphics

video conferencing

computer mouse

word processing

dynamic file linking

revision control

collaborative work



[https://en.wikipedia.org/wiki/The\\_Mother\\_of\\_All\\_Demos](https://en.wikipedia.org/wiki/The_Mother_of_All_Demos)

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## 1973 - Xerox Alto

1<sup>st</sup> computer designed to support an OS with GUI, later using the desktop metaphor.

total production: about 2000

1979: Steve Jobs licenses the concepts.

Apple Lisa (1983)

Macintosh (1984)



[https://en.wikipedia.org/wiki/Xerox\\_Alto](https://en.wikipedia.org/wiki/Xerox_Alto)

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## 1981 - Xerox Star

Star Workstation - Xerox 8010 Information System

1<sup>st</sup> commercial system to incorporate

bitmapped display

window based GUI - WIMP

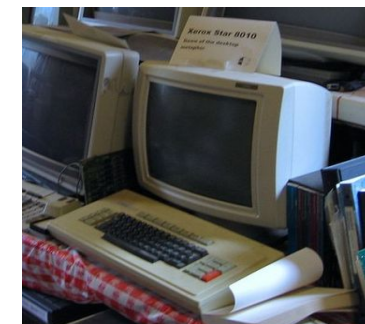
mouse

ethernet networking

file servers

print servers

e-mail



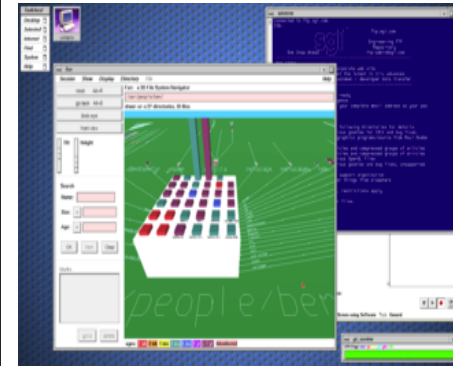
[https://en.wikipedia.org/wiki/Xerox\\_Star](https://en.wikipedia.org/wiki/Xerox_Star)

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## 3D Interfaces

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## 1993 FSN (File System Navigator)



an experimental application to view a file system in 3D, made by SGI for IRIX systems.

Even though it was never developed to a fully functional file manager, it gained some fame after appearing in the movie Jurassic Park in 1993.

[https://en.wikipedia.org/wiki/Fsn\\_\(file\\_manager\)](https://en.wikipedia.org/wiki/Fsn_(file_manager))

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## 1996 - Web Forager



<https://open-video.org/details.php?videoid=4572>

Thomas Malone, How do people organize their desks? Implications for the design of office information systems, ACM TOIS, 1(1), 1983.

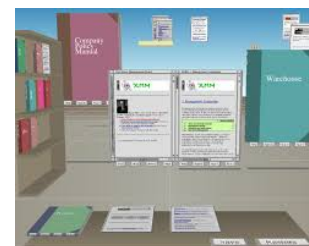
- what to do
- cognitive difficulty

Card, Robertson, and York The WebBook and the Web Forager: an information workspace for the WWW. CHI'96.

Hierarchical workspace  
- Focus: page/book/pile  
- immediate memory: air and desk for objects in use but not in focus  
- tertiary: bookcase for storing objects not in use

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## Web Forager



Objects in the air can be moved forward and backward or moved to focus



Touch bookcase



touch an object

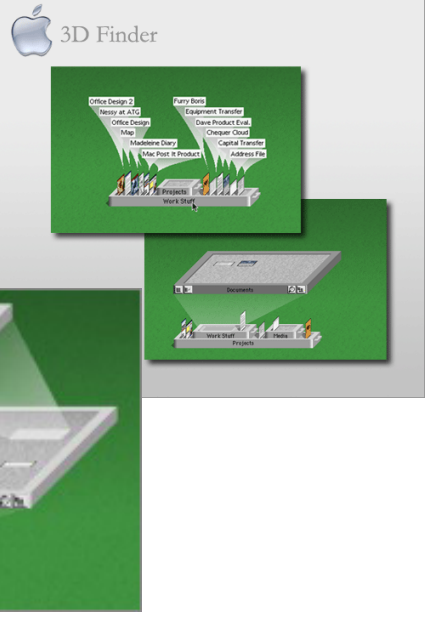


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# 1999 - 3Desque

Miller, Grisedale, and Anderson  
 Visualization and Computer Animation,  
 10(2), 1999, 109-119.

3D Finder prototype  
 Trays contain subtrays  
 Automated layout  
 Popup names for browsing



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# 2000 - The Task Gallery



Robertson et al.  
 The Taks Gallery:  
 a 3D window manager,  
 CHI 2000.

Task become artwork  
 hung at the  
 walls of a gallery

Selected task shows  
 on stage

<http://research.microsoft.com/pubs/64327/taskgallery-submitted.pdf>

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# The Task Gallery



Tasks contain  
 windows

Room contains  
 tasks

Task Gallery  
 contains rooms  
 arranged as a  
 long hall.

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# Task gallery palette



Palette: opens when the user  
 looks to the left

Contains apps and docs

Adds to current task

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## The Task Gallery



Task windows:  
Selected set  
Loose stack  
Ordered Stack

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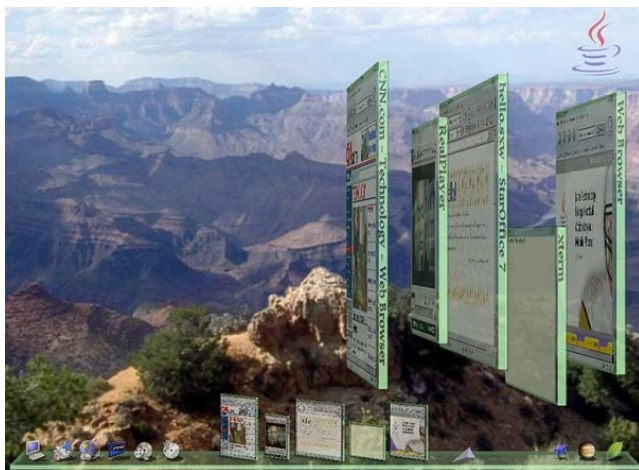
## 2003 - Project Looking Glass



Reversible windows

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## Looking glass



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## Bump Top

bumptop.com



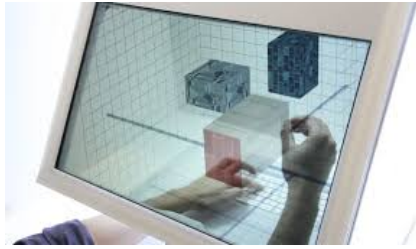
Agarawala and Balakrishnan

Initial project circa 2006  
Acquired by google on 2010  
Piles  
Selective use of physics  
pen-based interaction

<http://www.youtube.com/watch?v=M00DskdEPnQ>

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## 2013 - Space Top



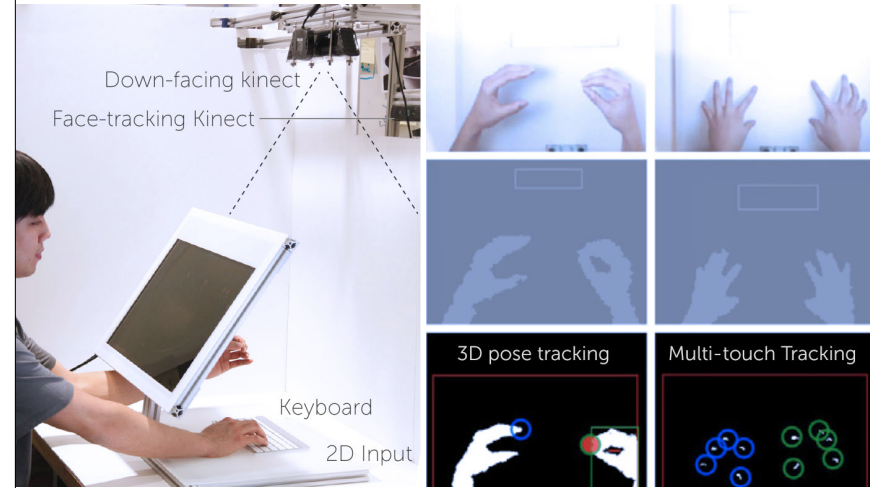
Lee, Olwal, Ishi, and Boulanger  
CHI 2013i

Transparent LCD  
Depth camera track head and hands  
Main window in front



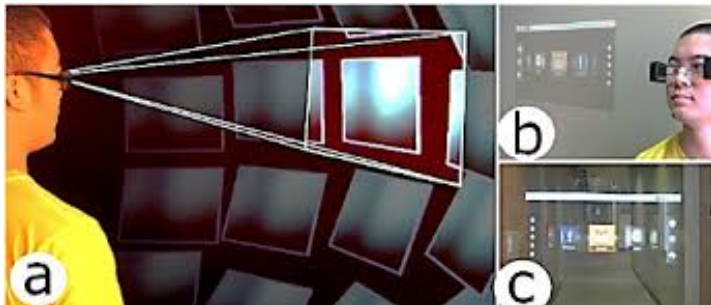
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## Space Top



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## Personal Cockpit. Ens, Finnegan, and Irangi, CHI 2014



Exploration of layout and interaction with arrays of window in AR  
Accounting for  
asymmetric interaction around the body  
Limited FOV (2:08–2:50)

<http://hci.cs.umanitoba.ca/projects-and-research/details/personal-cockpit-spatial-user-interface>  
<https://www.youtube.com/watch?v=L0ZjmEP-c1E>

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Is 3D better than 2D?

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How to evaluate?

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## 2D is better than 3D

Jakob Nielsen, 1998 <https://www.nngroup.com/articles/2d-is-better-than-3d/>

The screen and the mouse are both 2D devices, so we don't get true 3D unless we strap on weird head-gear and buy expensive bats (flying mice)

It is difficult to control a 3D space with the interaction techniques that are currently in common use since they were designed for 2D manipulation (e.g. dragging, scrolling)

Users need to pay attention to the navigation of the 3D view in addition to the navigation of the underlying model: the extra controls for flying, zooming, etc get in the way of the user's primary task

Poor screen resolution makes it impossible to render remote objects in sufficient detail to be recognizable; any text that is in the background is unreadable

The software needed for 3D is usually non-standard, crash-prone, and requires an extra download (which users don't want to wait for)

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## Bad uses of 3D?

Most **abstract information spaces** work poorly in 3D because they are non-physical...

...**navigation through a hyperspace** (such as a website) is often very confusing in 3D, and users frequently get lost. 3D navigation looks very cool in a demo, but that's because you are not flying through the hyperspace yourself ...

Avoid **virtual reality gimmicks** (say, a virtual shopping mall) that emulate the physical world...

Jakob Nielsen, 1998 <https://www.nngroup.com/articles/2d-is-better-than-3d/>

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## Good uses of 3D?

When you **visualize physical objects** that need to be understood in their solid form. Examples include:

surgeons planning where to cut a patient: the body is 3D and the location of the tumor has a 3D location that is easier to understand from a 3D model than from a 2D X-ray

mechanical engineers designing a widget that needs to fit into a gadget

chemistry researchers trying to understand the shape of a molecule

planning the layout of a trade-show booth...

...**entertainment applications** and some educational interfaces can benefit from the fun and engaging nature of 3D,... Note that 3D works for games because the user does not want to accomplish any goals beyond being entertained....

Jakob Nielsen, 1998 <https://www.nngroup.com/articles/2d-is-better-than-3d/>

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3D interaction

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## RR-VR Continuum

Milgram, Paul; H. Takemura; A. Utsumi; F. Kishino (1994)

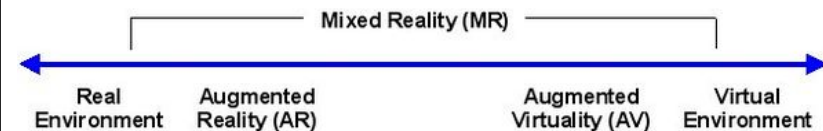
Real environment -> completely real world

Virtual environment -> completely synthetic

Mixed reality -> mix of real and synthetic

Augmented reality (AR) -> more real

Augmented virtuality (AV) -> more synthetic



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## RR-VR Continuum Properties

Milgram, Paul; H. Takemura; A. Utsumi; F. Kishino (1994)

Reality

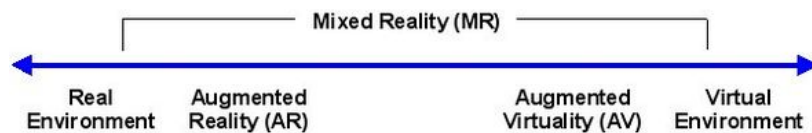
varies from R to V

Immersion

egocentric x exocentric

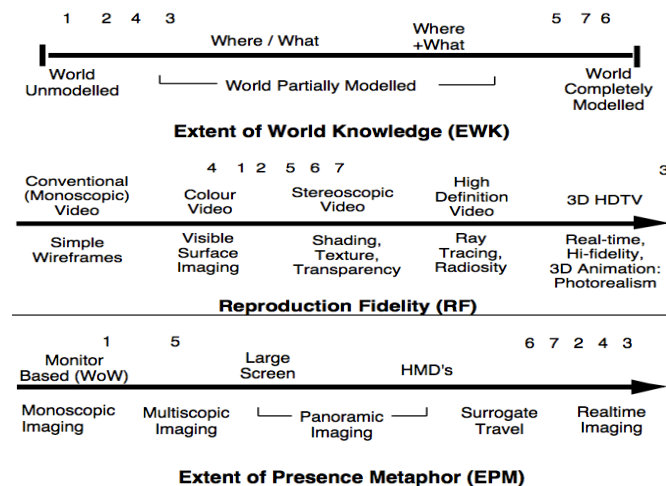
Directness

Objects are experienced: Directly (e.g., optical see-through)  
x  
Synthesized (e.g., video see-through)



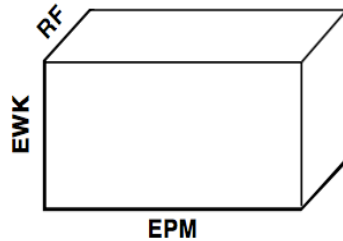
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## Taxonomy for Mixing Real and Virtual



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## 3D taxonomy



EWK = Extent of World Knowledge  
RF = Reproduction Fidelity  
EPM = Extent of Presence Metaphor

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## Interactive graphics history

- 1967 SIGGRAPH is founded
- 1969 SIGGRAPH becomes SIGGRAPH
- 1972 Atari introduces Pong
- 1974 1st SIGGRAPH conference with 600 participants
- 1977 SIGGRAPH in San Jose - commercial exhibits
- 1994 PlayStation
- 1996 Nintendo 64
- 2001 Xbox
- 2005 Xbox 360
- 2006 Wii
- 2010 Kinect
- 2013 PlayStation 4 + Xbox One
- 2013 Oculus Rift
- 2016 HoloLens, HTC Vive, PlayStation VR



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## 3D Interaction - why it took so long?

Technology issues

- Interactive 3D rendering
  - affordable since the late 90s
- 3D interaction devices
  - useless without affordable 3D graphics
- 3D interaction techniques
  - tradeoff between complex and familiar
- Head tracking / stereo display
  - required for true 3D, hard to do well
- Wide field of view
  - size/weight/quality/cost tradeoffs
- Interaction
  - high latency
  - displays that can combine real and virtual



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## Other issues

- Applicability to task
- Knowledgeable developers
- Resistance to change

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