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# **Introduction to Virtual Reality**

**(based on a talk by Bill Mark)**

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## **I will talk about...**

**Why do we want Virtual Reality?**

**What is needed for a VR system?**

**Examples of VR systems**

**Research problems in VR**

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## Most Computers Today:



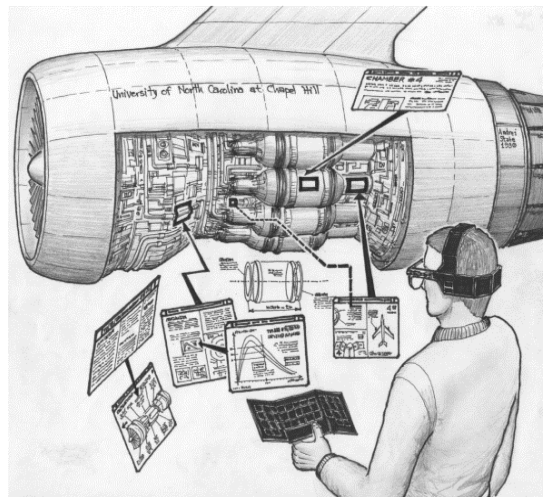
### 2D “Desktop”

- Good for word processing
- Not so good for thinking in 3D
- No interaction with real world

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## What we'd like:



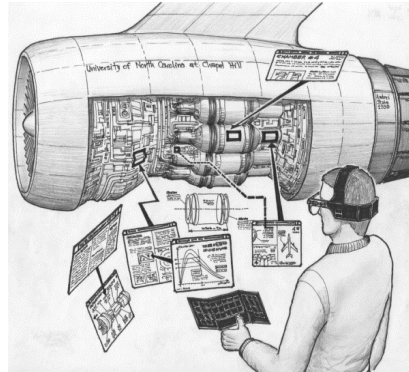
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**Images look 3D**

**Real + Computer  
objects.**

- **Jet engine is real**
- **Documents are  
computer-generated**



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## **Goal for VR: Efficient tool**

**Good tools help people work more efficiently**

**VR can be a good tool.**

**Of course, it's good for games too.**

- **But I won't talk much about that.**

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## **VR gives tighter Human-Computer Interface**

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### **3D images communicate more efficiently**

- **Humans think in 3D**
- **World is 3D**

### **3D interface is more natural**

- **Less learning time**

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## **Next...**

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## What is VR? (Part 1)

### Immersive

- **Computer-generated images surround user**
- **Head-Mounted Display, or 360 degree display**



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## What is VR? (Part 2)

### Interactive

- **Move through world**
- **Change the world**
- **Fast update of display; typically > 12 frames/sec**



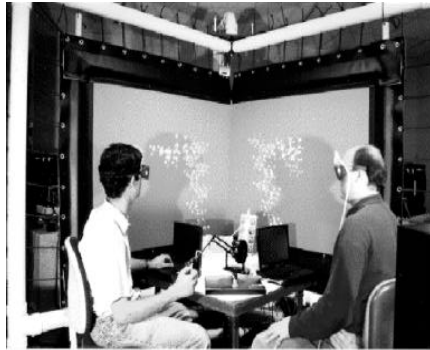
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## “VR” sometimes used for

### Non-immersive systems

- “Through-the-window”
- Large display, but doesn’t surround the user.



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## 3D Graphics $\neq$ VR

3D graphics is not necessarily immersive or interactive.

So, VR  $\implies$  3D Graphics

But, 3D Graphics  $\not\Rightarrow$  VR

- VRML is not usually used for VR, despite the name!

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## “VR” vs. “AR”

### Virtual reality

- virtual world imagery totally replaces real world

### Augmented reality

- virtual world imagery merged into real world (as in the jet engine repair picture)

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## VR system has:

Head-motion tracker

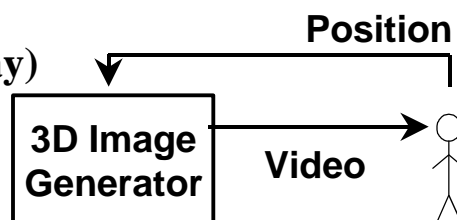
Video Display (often head-mounted display)

3D image generator

Something to display

Other input/output devices

Lots of Software



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## Tracking

### Where are your head/eyes?

- $(x,y,z)$
- And, in which direction are you looking?

### Technologies

- Magnetic
- Optical
- Mechanical
- Accoustic

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## Optical Tracker

### “Navigation by the Stars”

- L.E.D.’s on ceiling

Photodiodes on user’s head  
determine relative location  
of L.E.D.’s



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## Display Devices – Stereo Glasses

**LCD shutter  
for each eye**

**Synchronized  
with display  
device**



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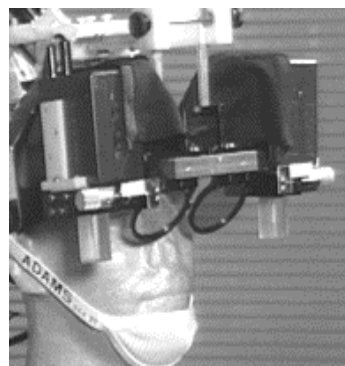


## Display Devices – Head Mounted

**Fully Immersive**



**See-Through**



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## Two types of see-through HMD's

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### Optical see-through

- See real world directly
- See 3D graphics using half-silvered mirror
- Disadvantages: No occlusion, hard to register

### Video see-through

- Camera captures real-world
- Computer combines video with 3D graphics
- Disadvantages: Resolution, delay

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## 3D Image Generators

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### Silicon Graphics

- Best commercially available machines for 3D graphics
- Expensive: ~\$500,000 for best SGI machine.

### PC's

- 3D Graphics for PC's is rapidly getting better.

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## Something to display

It's difficult and expensive to build 3D models



**Model of an actual house**

**18 rooms**

**3 man-years**

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## Other Devices – Feeling Forces

User can feel objects in virtual environment



**PHANToM  
(SenseAble Devices)**



**PHANToM in use**

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## Software

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### **VR systems software is hard to build**

- **Complex**
- **Real-time**
  - **Lots of optimizations used to speed up system.**
  - **These optimizations add to complexity.**
- **Many different I/O devices**

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## Next...

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## Architectural Walkthrough



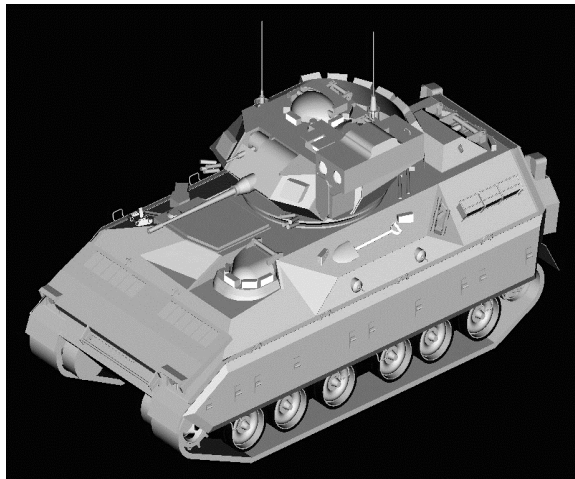
Brooks kitchen model

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## Mechanical Design



Bradley fighting vehicle

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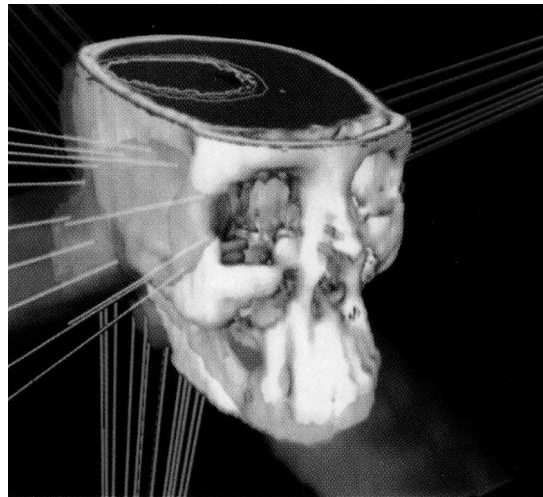
## Nano-manipulator



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## Radiation Treatment Planning



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## Exposure Therapy for Acrophobia



Virtual Elevator

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## AR: 3D Ultrasound

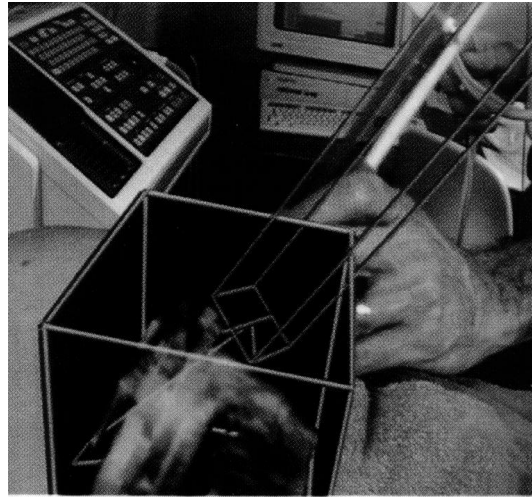


see-through HMD (HMD + camera),  
head/hand tracking, (ultrasound probe)

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## Real 3D Ultrasound Experiment



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## Games

**VR for games is easier than VR for real work.**

- **Design the game to avoid shortcomings of VR**
- **Can't do this for real applications.**

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## In the future -- Tele-presence



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## **Trackers**

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**More accurate**

**Greater range**

**Easily portable**

- **No fixed sensors or fiducials in the world.**

**Cheaper!**

**Lower latency**

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## Image Generation

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**More realistic**

**UNC is working on this problem**

- **“PixelFlow” is fastest graphics machine in the world (But you can’t buy it).**

**Much cheaper!**

- **Better hardware**
  - **Better software to simplify models**
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## More Realistic – Image Based

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**Acquire models directly from real world**

- **Avoid constructing 3D model**



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## Real-time acquisition of depth

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**It's difficult to determine depth of pixels**

**Very primitive systems now:**



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## Better Displays

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**Higher resolution**

- **You are legally blind in most head-mounted displays!**

**Smaller, lighter-weight**

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## Interaction

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**2D paradigms do not translate directly to 3D**

**Accurate control with many degrees of freedom is difficult in a non-solid environment**

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## In summary

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**VR is still a primitive technology**

- **But, some people are using it for real work today.**
- **It will be much better in the future.**

**It's not like you see it in the movies.**

**Need research in every area of VR systems.**

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## Some suggested VR reading

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### Special Issues

- *Computer Graphics*, November 1996
- *Computer Graphics & Applications*, Nov. 1996
- *Computer Graphics & Applications*, Sept. 1995
- *Computer*, July 1995

### SIGGRAPH *Proceedings*

### *Presence*

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