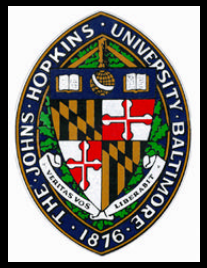
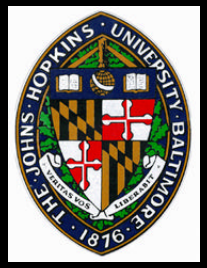


Introduction to Virtual Reality

(based on a talk by Bill Mark)

Johns Hopkins Department of Computer Science
Course 600.460: Virtual Worlds, Spring 2000, Professor: Jonathan Cohen



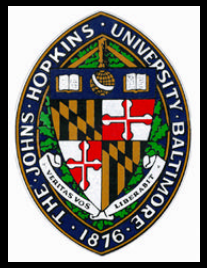
I will talk about...

Why do we want Virtual Reality?

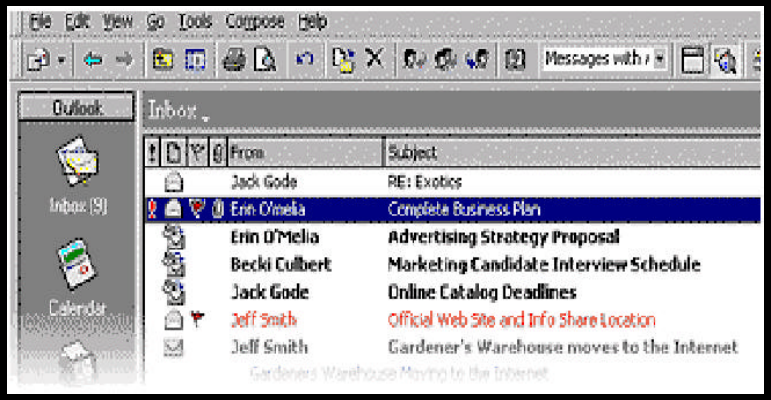
What is needed for a VR system?

Examples of VR systems

Research problems in VR

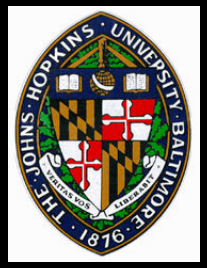


Most Computers Today:

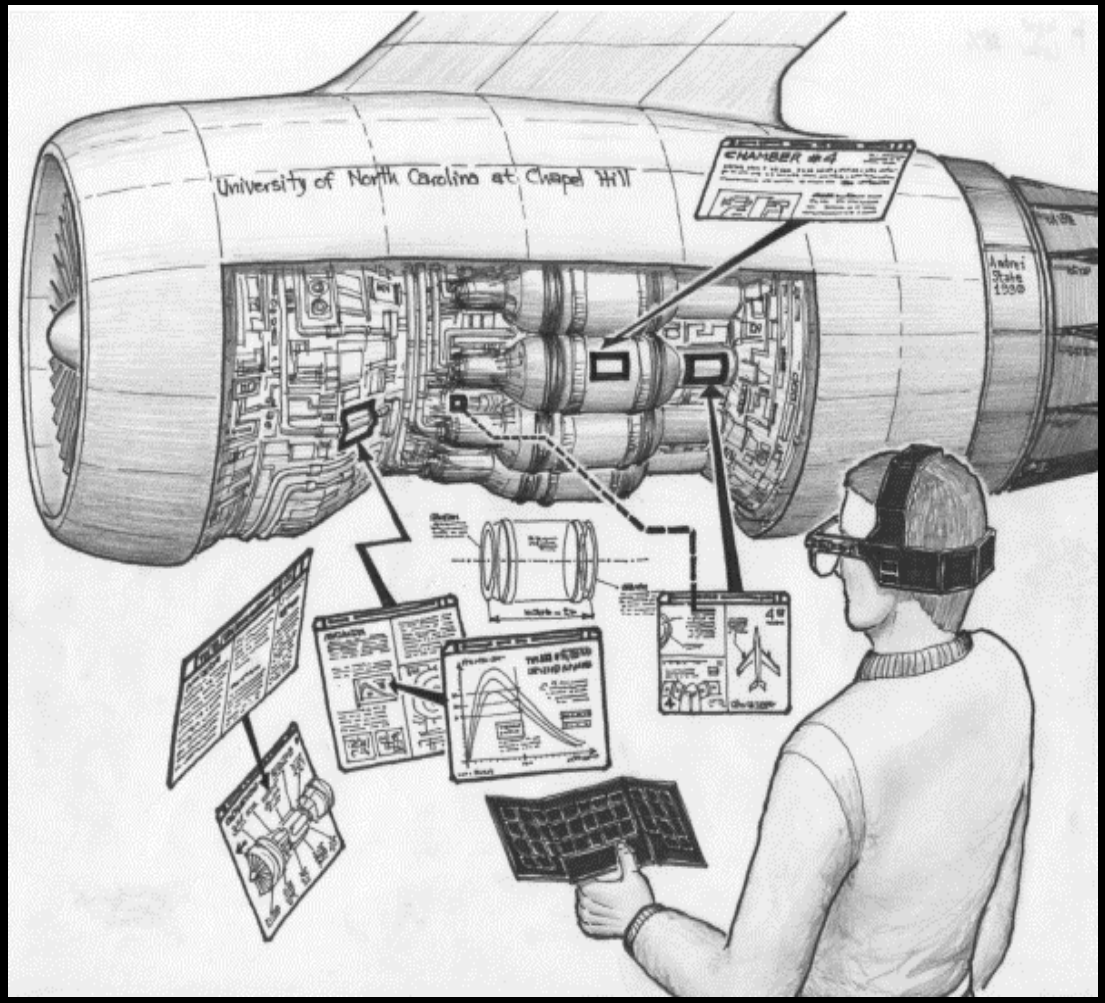


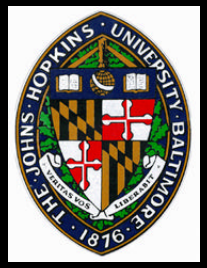
2D “Desktop”

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



What we'd like:

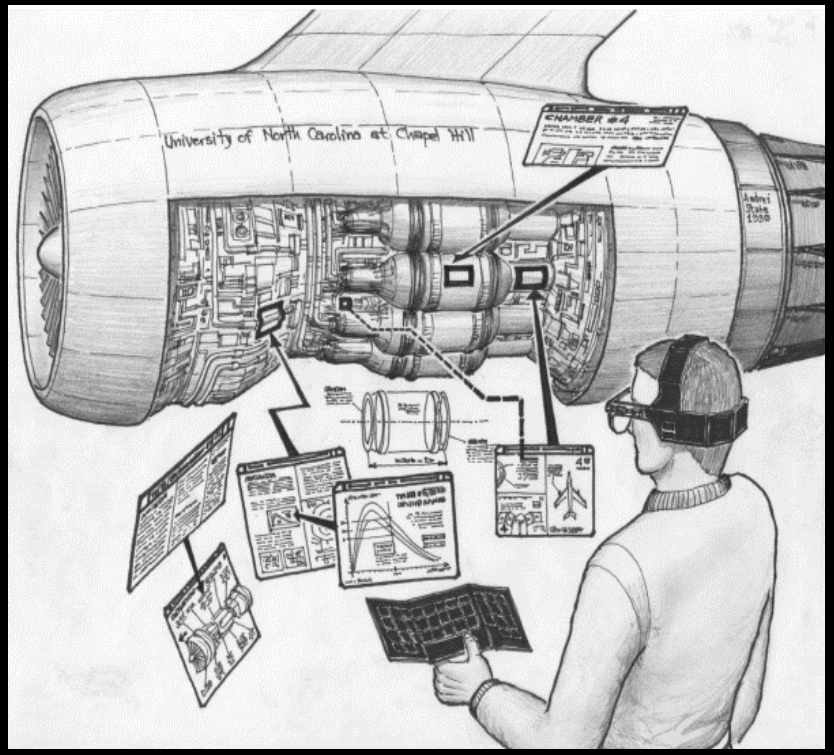


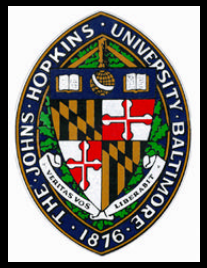


Images look 3D

Real + Computer objects.

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





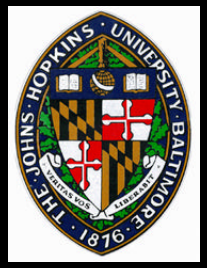
Goal for VR: Efficient tool

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.**



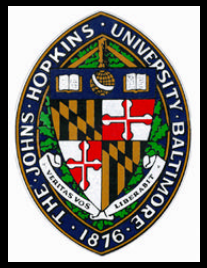
VR gives tighter Human-Computer Interface

3D images communicate more efficiently

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

3D interface is more natural

- **Less learning time**



Next...

Why do we want Virtual Reality?

What is needed for a VR system?

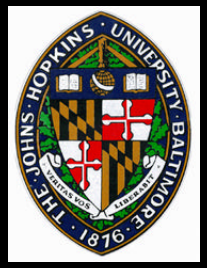
Examples of VR systems

Research problems in VR

What is VR? (Part 1)

Immersive

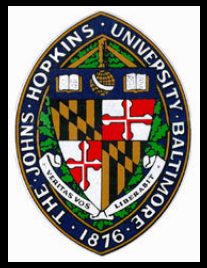
- Computer-generated images surround user
- Head-Mounted Display, or 360 degree display



What is VR? (Part 2)

Interactive

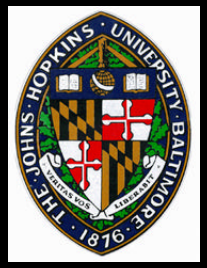
- Move through world
- Change the world
- Fast update of display; typically > 12 frames/sec



“VR” sometimes used for

Non-immersive systems

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



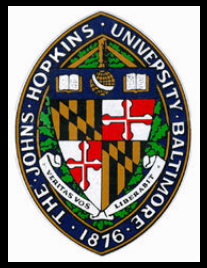
3D Graphics $\not\Rightarrow$ VR

3D graphics is not necessarily immersive or interactive.

So, VR $\Rightarrow$ 3D Graphics

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

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



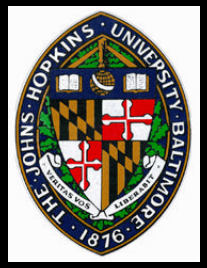
"VR" vs. "AR"

Virtual reality

- **virtual world imagery totally replaces real world**

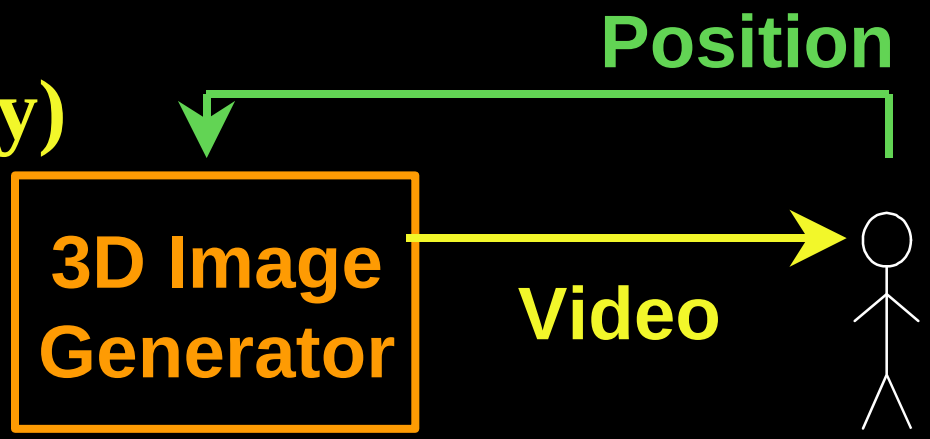
Augmented reality

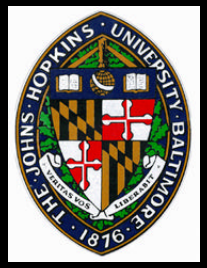
- **virtual world imagery merged into real world (as in the jet engine repair picture)**



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





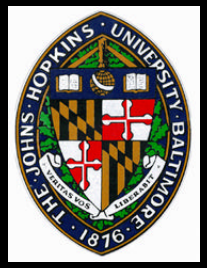
Tracking

Where are your head/eyes?

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

Technologies

- **Magnetic**
- **Optical**
- **Mechanical**
- **Accoustic**

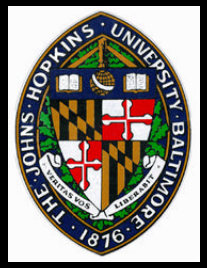


Optical Tracker

"Navigation by the Stars"

- L.E.D.'s on ceiling

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



Display Devices – Stereo Glasses

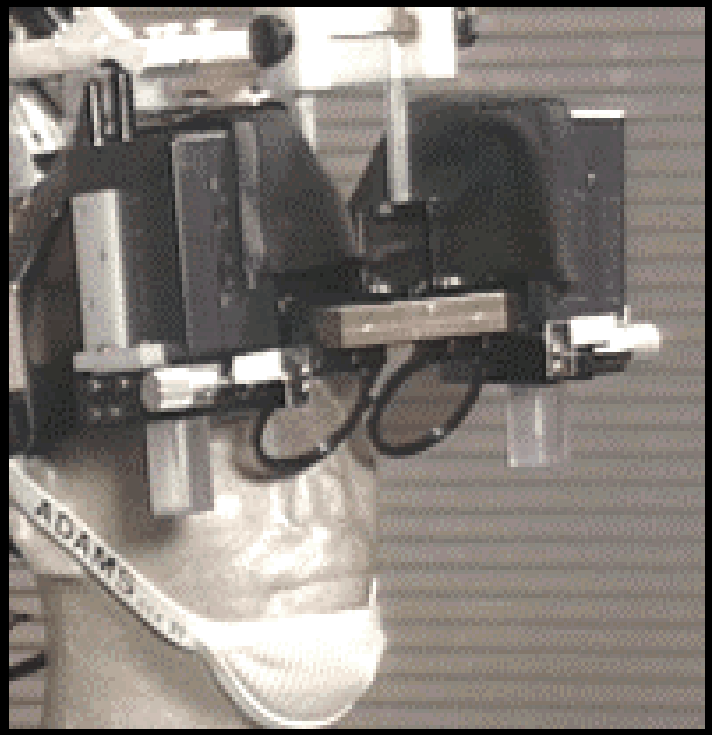
LCD shutter for each eye

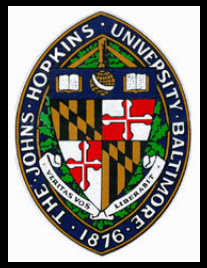
Synchronized with display device

Display Devices – Head Mounted

Fully Immersive

See-Through





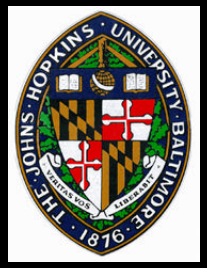
Two types of see-through HMD's

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



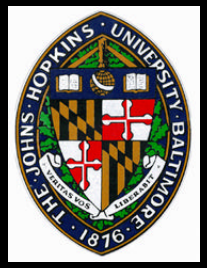
3D Image Generators

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.



Something to display

It's difficult and expensive to build 3D models

Model of an actual house

18 rooms

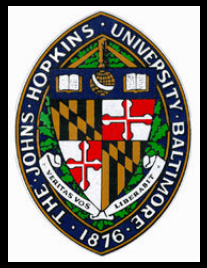
3 man-years

Other Devices – Feeling Forces

User can feel objects in virtual environment

PHANToM (SenseAble Devices)

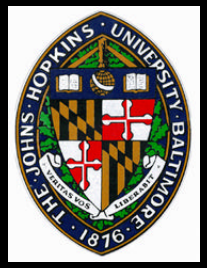
PHANToM in use



Software

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**



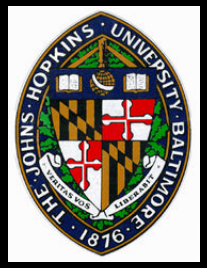
Next...

Why do we want Virtual Reality?

What is needed for a VR system?

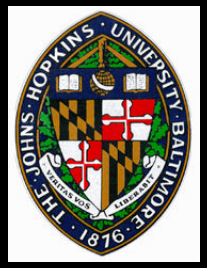
Examples of VR systems

Research problems in VR

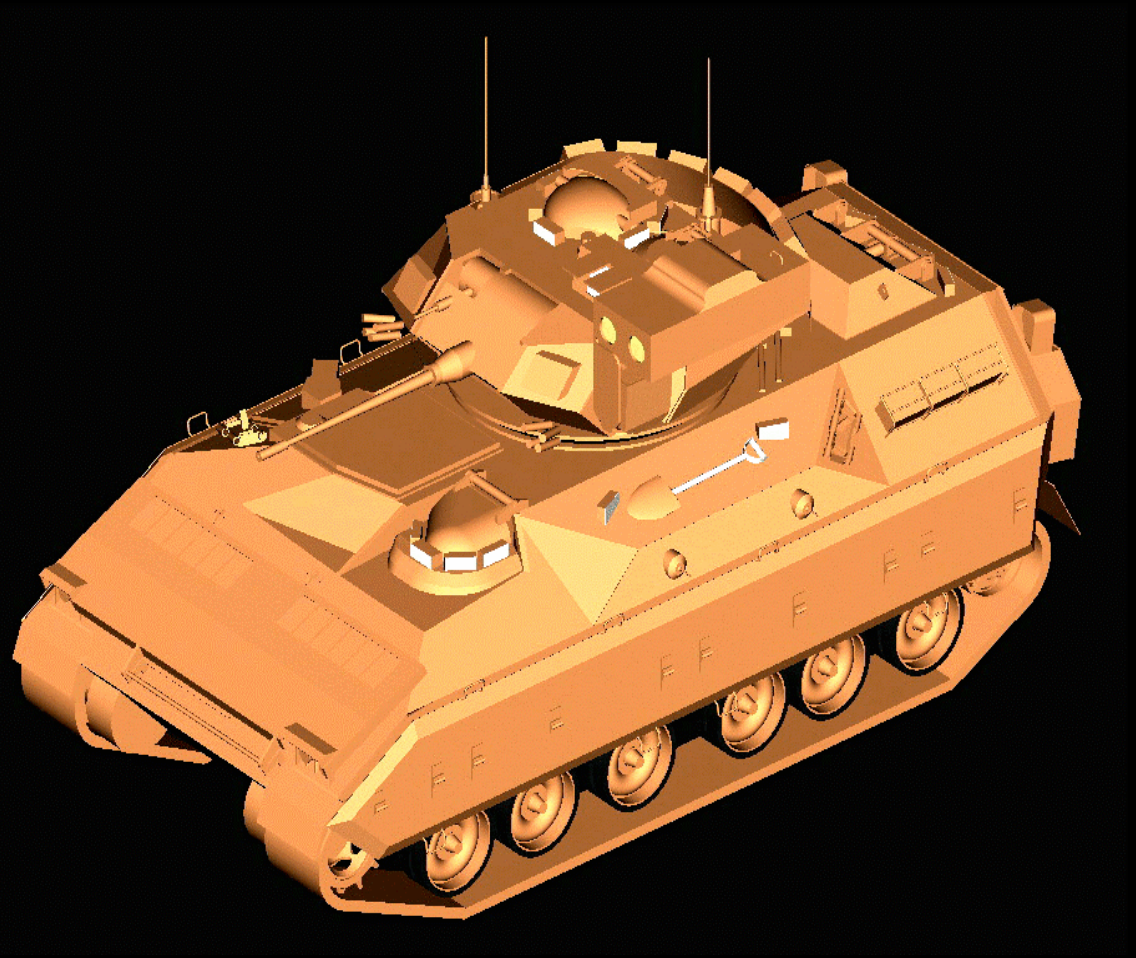


Architectural Walkthrough

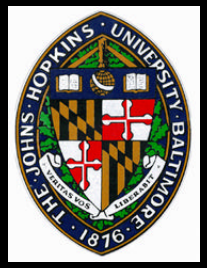
Brooks kitchen model



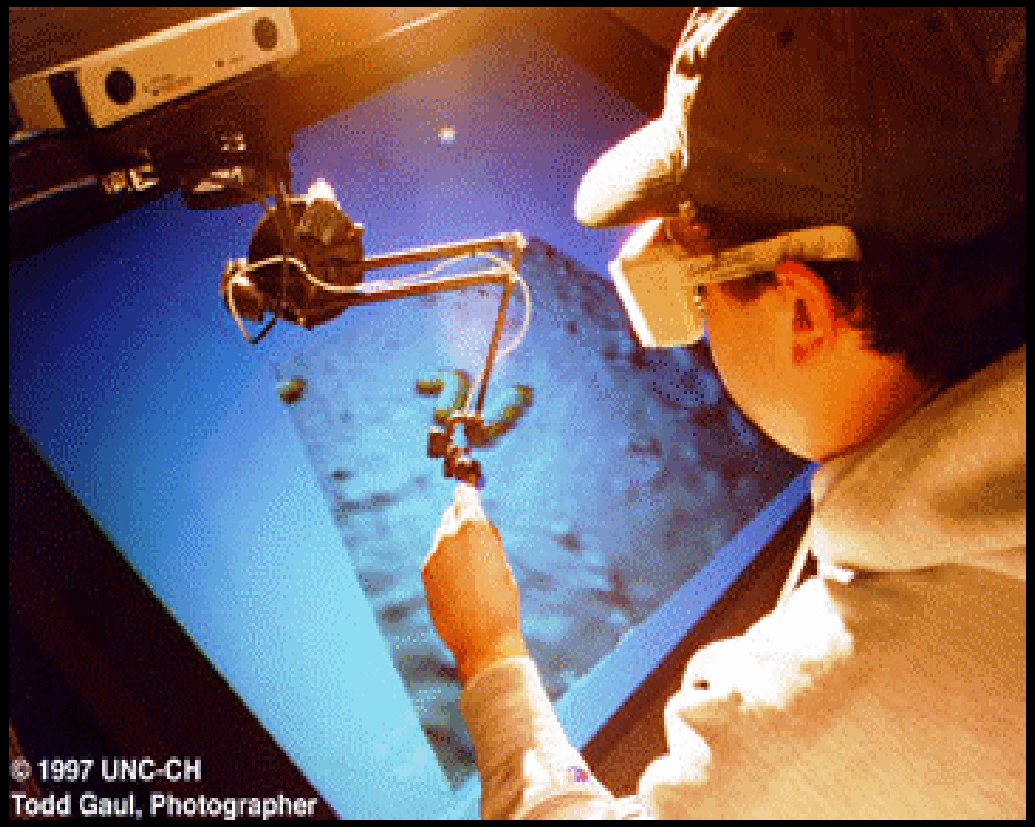
Mechanical Design

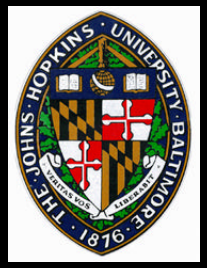


Bradley fighting vehicle

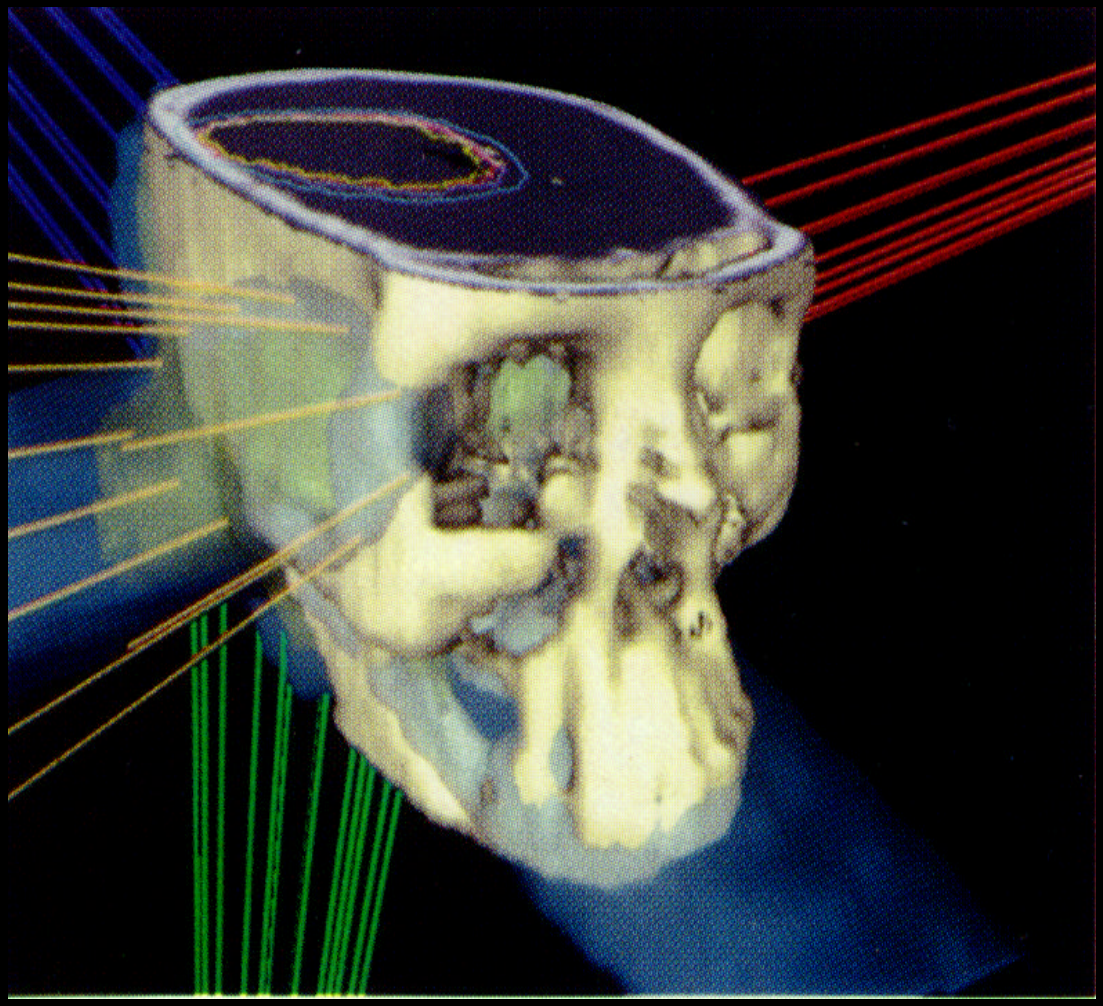


Nano-manipulator

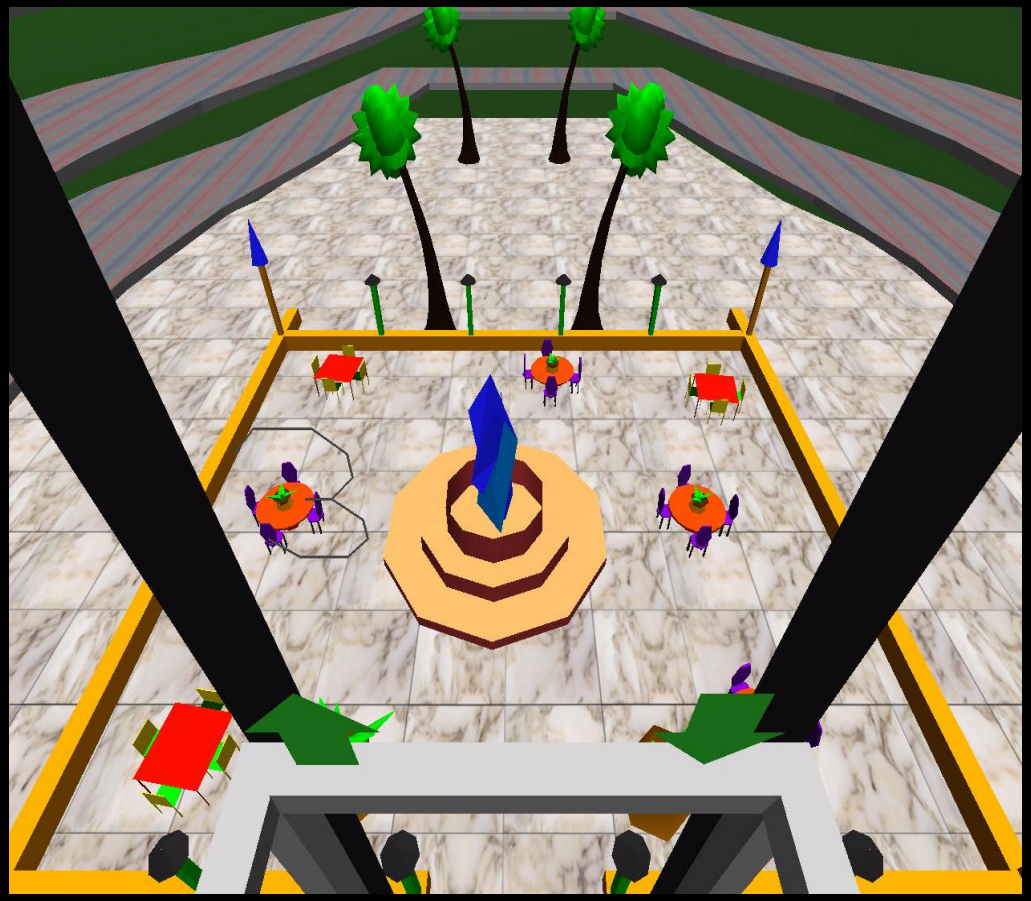




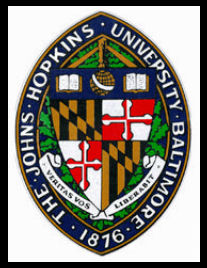
Radiation Treatment Planning



Exposure Therapy for Acrophobia



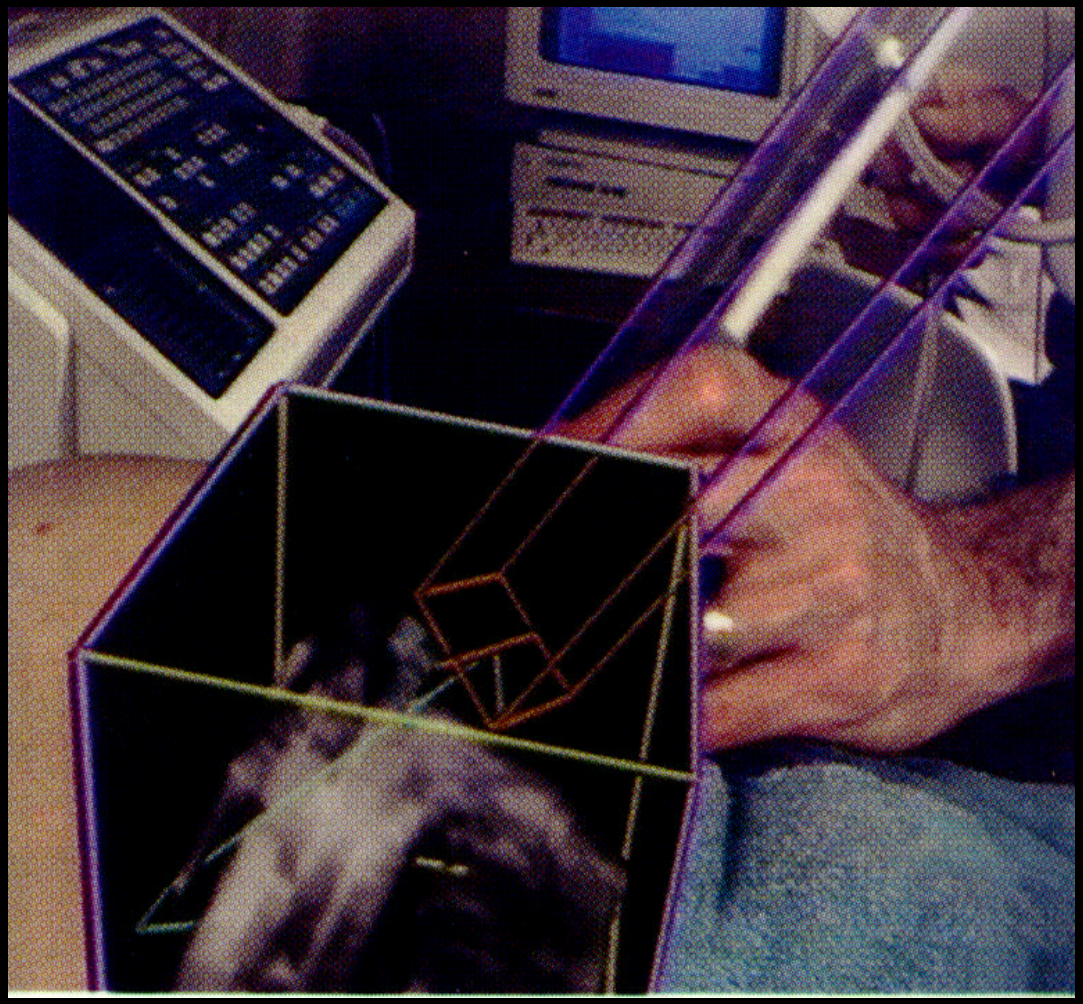
Virtual Elevator

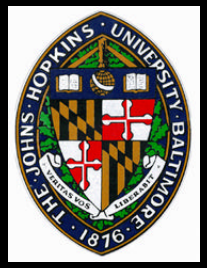


AR: 3D Ultrasound

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

Real 3D Ultrasound Experiment

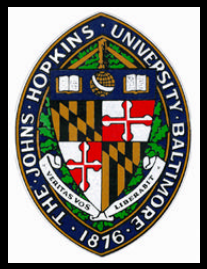




Games

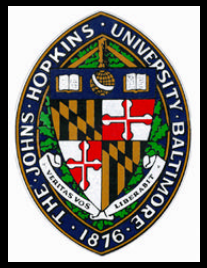
VR for games is easier than VR for real work.

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



In the future -- Tele-presence

Johns Hopkins Department of Computer Science
Course 600.460: Virtual Worlds, Spring 2000, Professor: Jonathan Cohen



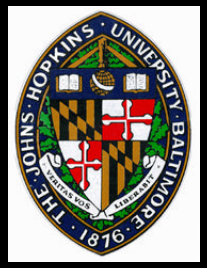
Next...

Why do we want Virtual Reality?

What is needed for a VR system?

Examples of VR systems

Research problems in VR



Trackers

More accurate

Greater range

Easily portable

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

Cheaper!

Lower latency

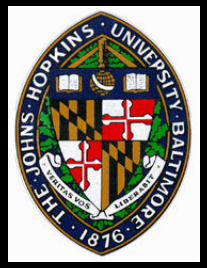


Image Generation

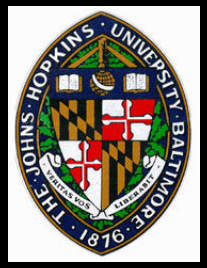
More realistic

UNC is working on this problem

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

Much cheaper!

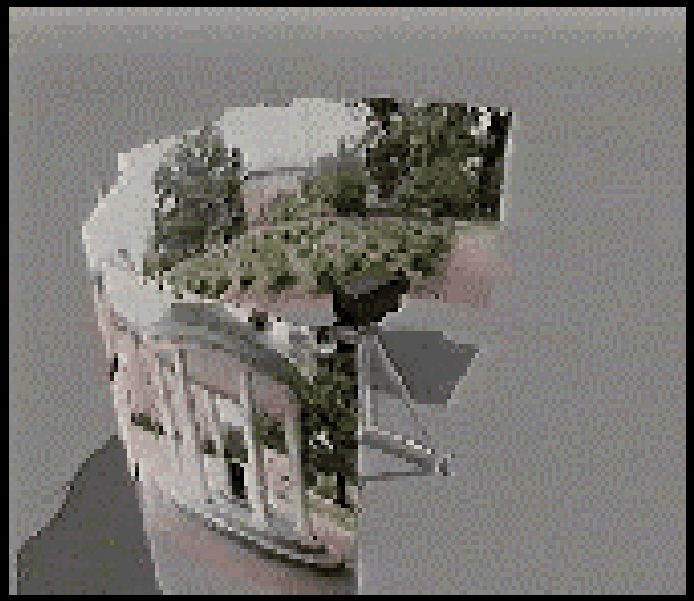
- **Better hardware**
- **Better software to simplify models**

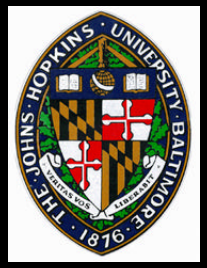


More Realistic – Image Based

Acquire models directly from real world

- Avoid constructing 3D model

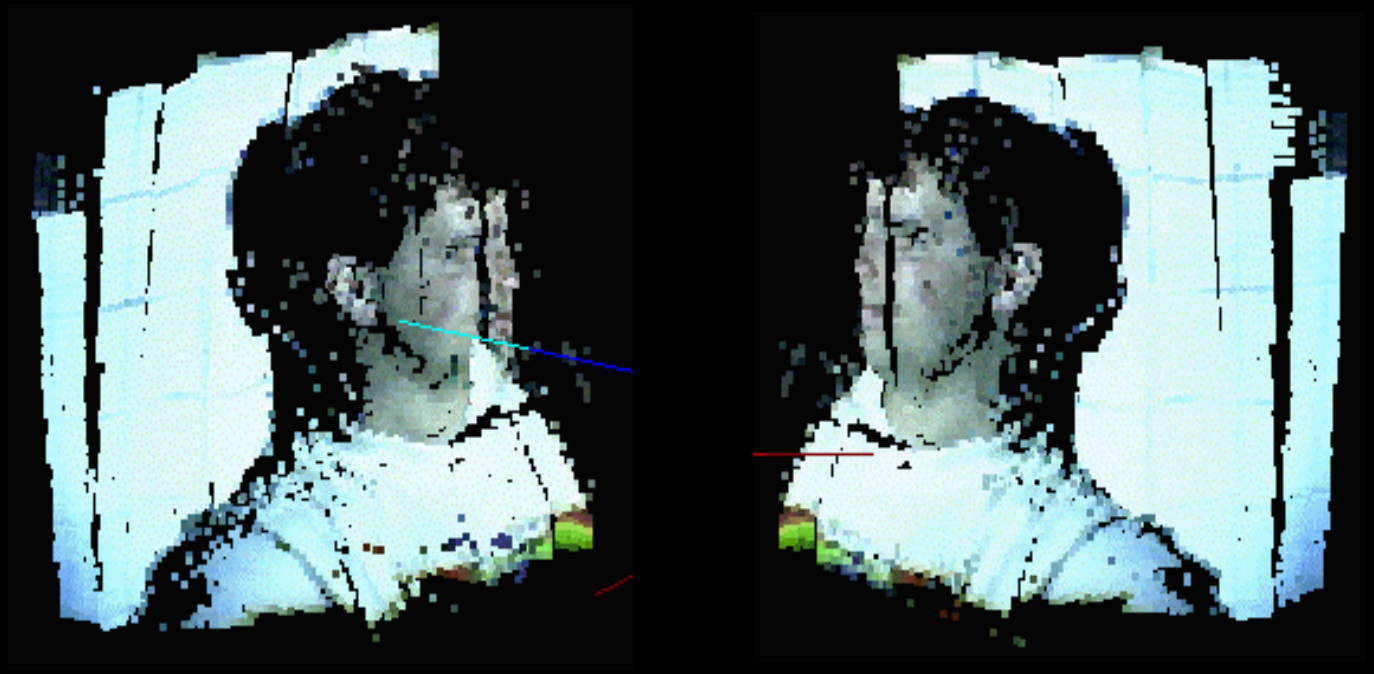


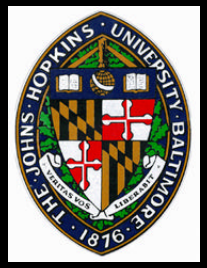


Real-time acquisition of depth

It's difficult to determine depth of pixels

Very primitive systems now:



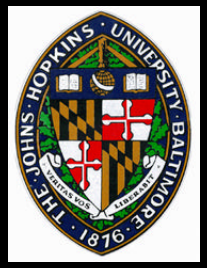


Better Displays

Higher resolution

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

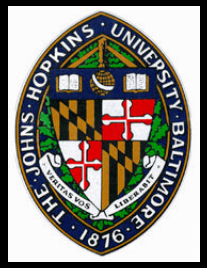
Smaller, lighter-weight



Interaction

2D paradigms do not translate directly to 3D

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



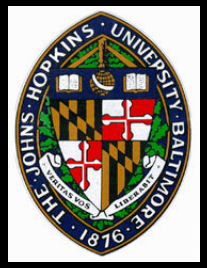
In summary

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.



Some suggested VR reading

Special Issues

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

SIGGRAPH *Proceedings*

Presence