Introduction to Virtual Reality

(based on a talk by Bill Mark)
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
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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 ≠ 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

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Tracking

Where are your head/eyes?

- \((x,y,z)\)
- And, in which \textit{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.
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

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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

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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
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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
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*, July 1995

SIGGRAPH *Proceedings*

*Presence*