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

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 ≠ 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

Johns Hopkins Department of Computer Science
Course 600.460: Virtual Worlds, Spring 2000, Professor: Jonathan Cohen
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)
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.
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*, July 1995

SIGGRAPH Proceedings

*Presence*