Introduction to Virtual Reality

(thanks, 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...

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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 ➔ 3D Graphics
• But, 3D Graphics ➔ 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
  – Acoustic

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 HMDs

- 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](image1)
- 18 rooms
- 3 man-years

Other Devices -- Feeling Forces

- User can feel objects in virtual environment

![PHANTom](image2)
(SenseAble Devices)

![PHANTom in use](image3)

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

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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

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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

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.

Bill Mark’s suggested VR reading

• Special Issues
  Computer Graphics, November 1996
  Computer, July 1995
• SIGGRAPH Proceedings
  Presence