Virtual Reality Systems

Presented by:
R. Rajkumar
rajkumar.ra@ktr.srmuniv.ac.in
Introduction to Graphics and Virtual Environments
Virtual Reality (VR) is the illusion of a three-dimensional, interactive, computer-generated reality where sight, sound, and sometimes even touch are simulated to create pictures, sounds, and objects that actually seem real.
Introduction

Major Concepts

• VR must allow the user to *view* the environment from any point and at any angle

• VR must allow the user to *interact* with objects in the environment.
History

• Ivan Sutherland (1960)
  – First head mounted display and head tracking system

• MIT (1983)
  – “Put That There”
  – “The Aspen Movie Map”

• UNC (1986)
  – Using “virtual world” term
  – Walkthrough, Pixel Flow & Nanomanipulator systems
History (cont’d)

• NASA Ames Research Center
  – HMD, VPL Datagloves and BOOM
  – Spatial (3D) Sound
  – Super Cockpit

• VPL
  – First Commercial VR Hardware & systems
  – “Reality Build for Two” (RB2)
  – “Body Electric”
History (cont’d)

- **Myron Krueger**
  - *GlowFlow, Meta play, Psychic space & Videoplace*

- **Naval Postgraduate School**
  - *SIMNET*
  - *NPSNET*
Types of VR

- Use of Special Purpose Equipment
- Feel of Presence
Types of VR

Window on the World (WoW)

- Also known as Desktop VR
- Use of a monitor to display the visual world
- Does not require special hardware
- Low Cost
- Low Performance
- Less Immersion
Types of VR

Telepresence

• Real-time telepresence
  Interactions are reflected to some real world objects.

• Delayed telepresence
  Interactions are recorded, and after satisfaction is applied to the real-world object.
Types of VR

Augmented VR

• Computer generated inputs merged with the user’s view of the real world
Components of VR

- VR Hardware
- VR Software
VR Hardware

Classification

• Primary user input interfaces
• Tracking interfaces
• Visual interfaces
• Auditory interfaces
• Haptic interfaces
• Olfactory interfaces
Primary Interfaces

• Keyboard, Mouse, Joystick
• 3D Pointing Devices
  – Spaceball
  – CyberWand
  – Ring Mouse
  – EGG
Primary Interfaces (cont’d)

• Whole-hand and body input
  – 5th Glove
  – Handmaster
  – ArmMaster
  – TCAS Dataware
Tracking Interfaces

• Measure head, body, hand or eye motion

• Major Characteristics
  – Resolution
  – Accuracy
  – System Responsiveness
    • Sample rate, data rate, update rate and latency

• Major Technologies
  – Magnetic
  – Acoustics
  – Optical
Tracking Interfaces (cont’d)

• Head & Body Tracking
  – Polhemous IsoTrak II & FastTrak
  – Flock of Bird
  – VideoDesk

• Eye Tracking
  – BioMuse
  – DPI Eyetrackey
Visual Interfaces

Important Factors

- Field of View (FOV)
- Resolution
- Refresh rate
- Brightness
- Color
Visual Interfaces (cont’d)

• Head Mounted Display (HMD)
  – Datavisor 10x HMD
  – VR4000
  – I-glasses!
  – VFX1

• BOOM
Visual Interfaces (cont’d)

• Stereoscopic Glasses
  – Shutter glasses
  – Passive glasses
• Autostereoscopic
  – HDVD
Auditory Interfaces

• Auralization
  – 3D simulation of a complex acoustic field
• Sonification
  – Audible display of data
• Speech Recognition
• Some products
  – Acoustetron II
  – RSS-10 Sound Space Processor
  – Q products
Haptic Interfaces

• Tactile (touch)
  – CyberTouch
  – Univ. of Salford

• Kinesthetic (force)
  – HapticMaster
  – PHANToM
Olfactory Interfaces

• Electronic Nose
• Storage Technologies
  – Liquid
  – Gel
  – Microencapsulation
• Some Products
  – BOC Group Olfactory Delivery System
  – Univ. of Wollongong eNose
Software Components

- Input Process
- Simulation Process
- Rendering Process
- World Database
Input Process

• Control devices that send data to the computer
• Devices should be checked regularly (eg. per frame)
Simulation Process

• The core of a VR program
• handles interactions, object behaviors, simulations of physical laws and determines the world status
• A discrete process that is iterated once for each frame
Rendering Process

- Creation of the sensations that are output to the user
- Visual Rendering
  - Using polygons to represent objects
  - Ray tracing & lights
  - Flat vs. smooth shading
  - Z buffering
- Auditory, haptic and olfactory rendering
World Database

- Stores data on objects and the world
- ASCII vs. binary
- Single file vs. Database
- Centralized vs. distributed
- Standard vs. proprietary formats
- Virtual Reality Modeling Language (VRML)
Important Issues

• Interaction Techniques
• Navigation Techniques
• Collision Detection
• Level of Detail (LOD)
Interaction Techniques

“Simple” Virtual Hand

Ray-casting
Interaction Techniques (cont’d)

Spotlight

Aperture circle

from/eye point

conic volume

Aperture
Interaction Techniques (cont’d)

Sticky Finger

Fishing reel

Scaled-world grab

1) Select
2) Grab
3) Manipulate
4) Release
Navigation Techniques

• Steering: direction and velocity
  – hand-directed
  – gaze-directed
  – physical devices (steering wheel, flight sticks)

• Target-based
  – point at object, list of coordinates

• Route planning
  – place markers in world

Mine, 1995
Collision Detection

• Very computationally intensive, but very important for presence and realism
• Bounding Volume (Sphere, Box, Convex Hull)
• Voronoi Region / Convex Decomposition
• Separating Planes
Level of Detail (LOD)

- When looking objects from a far, details not important
- Do not show details if they can’t be seen
- Reduces number of polygons significantly
- LOD management
  - Automatic
  - Pre-defined
Distributed VR

- The Multi-user environment
- A simulated world runs on several computers connected over a network.
- People can interact in real time, sharing the same virtual world
DVR Connectivity Approaches

- Send updates to every computer in the LAN
- Does not scale well
- Consumes a lot of bandwidth, so needs a dedicated LAN
- Has been used in SIMNET & DIS
DVR Connectivity Approaches

- Send updates only to those that are interested.
- Uses the concept of Area Of Interest (AOI) to limit network traffic.
- Each AOI is assigned to a multicast address.
- Has been used in NPSNET.
DVR Connectivity Approaches

- Point-to-point network connection
- Mesh model
  - All users are connected to each other
  - Has Been used in MASSIVE
- Client-server (start) model
  - All users are connected to a central location
  - Has been used in NVR, WNMS
DVR Issues

• Object Behaviour
  – Static - level 0
  – Deterministic - level 1
  – Newtonian deterministic - level 2
  – Random - level 3

• Dead Reckoning
  – Sending current location and the velocity
  – Repeat it when difference crosses threshold
VR on the Web

• Virtual Reality Modeling Standard (VRML)
• Java 3D API
VRML

Started in 1994
VRML V1.0 came out in May 95
ASCII-based, object-based modeling language
VRML v1.0 is static, objects do not have behaviors
VRML 2.0 (known as VRML97) is dynamic
VRML97 is now ISO standard
The binary version has also been developed
VRML Viewers

• Usually act as a plugin for browsers
• Some standalone versions are also available
• Files have .wrl or .wrz extensions
• MIME Type
  – V1.0   x-world/x-vrml
  – V2.0   model/vrml
• Important plugins
  – CosmoPlayer, WorldView, Cartona
#VRML V2.0 utf8
Shape {
  appearance Appearance {
    material Material {}
  }
  geometry Cylinder {}
}
Transform {
  translation 2 1 1.5
  children [
    Shape {
      appearance Appearance {
        material Material {}
      }
      geometry Box {}
    }
  ]
}
}
VRML Concept

- Right-handed Coordinate
- File Header
  
  ```
  #VRML V2.0 <encoding type> [comment] <line terminator>
  ```
- Statement syntax
  
  ```
  [DEF <name>] <nodeType> { <body> }
  ```
- Reusing nodes
  - USE statement
  - PROTO and EXTERNPROTO
- ROUTE statement
- Declaration types
  - Field, exposedField, eventIn, eventOut
VRML Concept (cont’d)

• Field types
  – SF vs. MF field
    • SFBool
    • SFCOLOR and MFColor
    • SFFloat and MFFloat
    • SFI mage
    • SFInt32 and MFInt32
    • SFNode and MFNode
    • SFRotation and MFRotation
    • SFString and MFString
    • SFT ime
    • SFVec2f and MFVec2f
    • SFVec3f and MFVec3f
VRML Concept (cont’d)

• Scripting
  – Java
  – JavaScript
  – VRMLScript
VRML Nodes

- Grouping nodes
- Geometry nodes
- Geometry related nodes
- Lighting nodes
- Sensory nodes
- Interpolator nodes
- Other nodes
Grouping Nodes

- Anchor
- Billboard
- Collision
- Group
- Inline
- LOD
- Switch
- Transform
Geometry Nodes

- Box
- Cone
- Cylinder
- ElevationGrid
- Extrusion
- IndexedFaceSet
- IndexedLineSet
- PointSet
- Sphere
- Text
Geometry Related Nodes

- Coordinate
- Color
- Normal
- TextureCoordinate
- Appearance
- Material
- ImageTexture
- PixelTexture
- MovieTexture
- TextureTransform
Lighting Nodes

- DirectionalLight
- PointLight
- SpotLight
Sensor Nodes

- Anchor
- Collision
- CylinderSensor
- PlaneSensor
- ProximitySensor
- SphereSensor
- TimeSensor
- TouchSensor
- VisibilitySensor
Interpolator Nodes

- ColorInterpolator
- CoordinateInterpolator
- NormalInterpolator
- OrientationInterpolator
- PositionInterpolator
- ScalarInterpolator

Shared Fields

- eventIn: SFFloat
  - set_fraction
- exposedField: MFFloat
  - key: [
  - keyValue: []
- eventOut: [S|M]F<type>
  - value_changed
Other Nodes

- Script node
- Background
- Fog
- Sound
- AudioClip
- ViewPoint
- WorldIndo
- NavigationInfo
JAVA 3D

• Java 3D is a network-centric, scene graph-based API, that revolutionizes 3D graphics application development

• Benefits to end-users
  – Application portability
  – Hardware independence
  – Performance scalability

• Rich set of 3D features
• High-level, Object-oriented paradigm
• Wide variety of file formats
Java 3D Architecture

• Independent asynchronous components
  – Automatic rendering
  – Behavior and sound scheduling
  – Event generation (collision detection)
  – Input device management

• Java 3D renderer chooses traversal order
  – Neither left-to-right nor top-to-bottom
  – Except spatially bounded attributes
Java 3D Scene Graph Hierarchy
VR Applications

Education

Crossing street

Construct3D
VR Application

Treatment of Acrophobia
VR Applications

Recreation
VR Application

Design
VR Application

Simulation

Being 747 Flight Simulation
VR Application

User Interface

WNMS
VR Application

Telepresence

Telesurgery
Augmented surgery

TeleRobotics
VR Application

Information Visualization

Acetic Acid

Quick Sort
VR Application

Entertainment

Virtual racing
VR Application

Military
Conclusion

• VR introduces a new way of interacting with computers
• The best of VR is yet to come
• Web is very suitable for VR applications, but the proper technology is not yet there
3D Graphics and Virtual Environments

1) Model a 3D object: polygons, curves, colors, textures, transformations
3D Graphics and Virtual Environments

2) Render the 3D objects: visibility, lights, camera, general illumination (shading, reflections, shininess, etc.)

3) Display the objects on a 2D screen: color, perspective, hardware (additional lights, shininess, camera position in 2nd picture)
3D Graphics and Virtual Environments

How do we move to a virtual environment? What else is needed?

Actions and animations, behaviors, interaction, immersion, audio, touch, gestures, smell, speech, stereo viewing, maybe more realism, physics

Some basic movement in Virtools: intro.cmo
Outline of Course

• Two themes in the course: studying 2D and 3D computer graphics; and studying virtual environments and their applications. We will be implementing many of the ideas on a computer.

• Hands-on; project-based

• Practical information: web site is at cs.conncoll.edu/com209

• Syllabus info on line; be sure to come to class prepared: readings are found on Moodle.

• Coordination and collaboration with other classes: Art 222: Techne/Technology: Investigations in 3D ART301: Sketchbooks and Artist Books BOT225: Systematic Botany and the Local Flora
Assignment for Wednesday

Syllabus info on line; be sure to come to class prepared: reading in the McConnell book; Processing1 sheet

We’ll start this in class

See how far you can get in this assignment; let me know if you have problems.
Definition of Virtual Reality

• Long history of using media to communicate, inform, express; VR is one in a long line of technologies or media

• What is VR? My working definition:
  – Interactive, multisensory, 3D computer-generated; involves some degree of immersion
Definition (from Sherman & Craig: Understanding Virtual Reality)

- Virtual world: not necessarily computer or 3D, imaginary
- Immersion: sense of experiencing the alternate environment – physical and mental- the term “presence” is also used: sense of being there (mental immersion)
- Sensory (multimodal) feedback: sound, sight, touch
- Interactivity: affect the world, navigate, physics, collision, speech, behaviors
Additional Terms

• Augmented reality: combination of virtual reality and reality
• Telepresence: interaction with a remote environment
• Cyberspace: virtual location for communication
Some possible elements of a VE

- Database of 3D objects
- Textures, images, video, sounds
- Position trackers, gesture recognition (Kinect), haptics (touch), stereo viewing, joysticks, treadmills, gloves, eye tracking, other hardware
- Interaction with objects, avatars; navigation; animation; speech
- Can be one person or many
- Computer monitor or large room
Important ideas

• Realism vs real-time
• “Reality is virtual” (Mel Slater)
• VR is a prototypical liberal art: CS, AI, physiology and anatomy, physics, psychology and cognitive science, perception, music, art, mathematics
• Applications are far-ranging: medicine, science, education, architecture, entertainment, anthropology, arts, psychology, museums, flight simulators