VR based HCI
Techniques & Application

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stefan.seipel@it.uu.se

What is Virtual Reality?

Coates (1992):
*Virtual Reality is electronic simulations of environments experienced via head mounted eye goggles and wired clothing enabling the end user to interact in realistic three-dimensional situations.*

Greenbaum (1992):
*Virtual Reality is an alternate world filled with computer-generated images that respond to human movements. These simulated environments are usually visited with the aid of an expensive data suit which features stereophonic video goggles and fiber-optic gloves.*

Krueger (1991):
*....The term (virtual worlds) typically refers to three-dimensional realities implemented with stereo viewing goggles and reality gloves.*
Variables to define Virtual Reality

**Vividness**
(richness of an environment's representation)

- breadth (visibility, audibility, touch, smell)
- depth (quality, fidelity)

**Interactivity**
(extend to which a user can modify form and content of a mediated environment)

- speed (update rates, time lag)
- mapping (text, speech, gestures, gaze, complex behavior patterns)

Classification of Virtual Reality and other Media

![Diagram showing the classification of various media based on vividness and interactivity](image-url)
History of Virtual Reality
(technological milestones)

1956 Sensorama *(Morton Heilig)*
3D visuals, vibration, stereo sound, wind, smell, little interaction

1961 Headsight System *(Philco Corp.)*
HMD, head tracking, remote video camera, telepresence

1965 The Ultimate Display *(Ivan Sutherland)*
Stereoscopic HMD, computer generated images, tracking, visually coupled system

1967 Grope *(University of North Carolina)*
6 degree of freedom force feedback

1977 The Sayre Glove *(Sandin, Sayre, DeFanti Univ. Illinois)*
Gesture recognition

1987 Virtual Cockpit *(British Aerospace)*
head and hand tracking, eye tracking, 3d visuals, 3D audio, speech recognition, vibro tactile feedback

VR - (visually) coupled systems

- computer simulation
- real-time
- multimodal input
- multimedia feedback
- replication
- real world
How Do We Perceive 3D?

Visual depth cues:

a) monoscopic cues
   relative size
   interposition and occlusion
   perspective distortion
   lighting and shadows
   texture gradient
   motion parallax

b) binocular (stereoscopic) cues
   stereodisparity
   convergence
How can we recreate 3D sensation?

Providing visual cues:

a) monoscopic cues
   realistic rendering / lighting simulation

b) stereoscopic cues -> stereodisparity
   presentation of appropriate view to each eye
   - time multiplexing of images
   - multiplexing with chromatic filters (anaglyph)
   - multiplexing with polarizer filters
   - providing two views simultaneously
Realistic 3D rendering

http://www.agh.edu.pl/htdocs/gifs/computer_art/raytracing/final18.jpg

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Stereoscopic rendering

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Time Multiplexed Stereo Image Pair

Additioanl V-Sync at 120 Hz (enforced with sync. doubler)

V-Sync at 60 Hz

Active Shutter Glasses (LCD-Shutters)

Dual Channel Head Mounted Display (HMD) (© nVision)

Datavisor 80

Datavisor
What Renders VR Applications Specific?

1. Visual and Acoustic Realism of Objects
   - 3D effect
   - level of detail
   - specularity
   - color and texture

2. Real-time Response (approx. >15 Hz)

3. Natural Like Interaction Metaphors
   (many degrees of freedom input)

4. Peripheral Visual Stimuli

System Architecture in Virtual Environments

- Display Devices
- Sensor Devices
- User
- Render Engine
- Simulation Manager
- Sensor Handler
- Scene Generator Simulation Loop
- Scene DB

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Types of Virtual Reality Environments

1. Immersive Virtual Environments
   • subjects are visually isolated from the real environment
   • virtual scene is responding to the subjects actions
   • subjects are unable to perform in the real environment

2. Semi-Immersive Virtual Environments
   • subjects can perform both in the real and virtual environment
   • subjects perceive a strong involvement into the VE
   • subjects may perform less in the real environment

3. Non-Immersive Virtual Environments
   • the three-dimensional scene is considered as a part of the physical environment
   • subjects do fully respond in the real environment
   • relatively little involvement into the VE

(4. Augmented Reality Interfaces)

Display Devices

Visual Displays (3D imagery)
   • Head Mounted Displays (HMD)
   • Projection Displays (CAVE, Virtual Plane)

Acoustic Displays (spatial sound)
   • Multi-Channel Sound Systems
   • Specialized Convolution Processors (e.g. Convolvotron)

Haptic Displays (force feedback)
   • Robot Arms (e.g. Grope, Phantom)
   • Active Joysticks (e.g. Microsoft Sidewinder)
   • Vibrotactile Devices (e.g. Logitec Cyberman)
An Immersive Car Simulator Using HMD
(© British Aerospace)

A BOOM Display Application in Aerodynamics
(© NASA Ames Research Center)
CAVE - An Immersive VR Environment
(EVL, University of Illinois at Chicago)

Six-sided CAVE
(KTH, Stockholm)
The ImmersaDesk - A Semi-Immersive Device
(University of Illinois at Chicago)

Non-Immersive Desktop VR : 3D Implant Planning
(© 1995 CMD, Uppsala University)
The Haptic Display *Grope III*  
(© University of North Carolina)

Examples of Haptic Devices

**Low Cost Force Feedback Device**

**High Fidelity Force Feedback Devices**

**Low Cost Force Feedback Device**
Sensor Devices

1. Spatial Position/Orientation Sensors
   • 2DOF (Mouse)
   • 3DOF (Microscribe, FreeD Joystick)
   • 6DOF (Polhemus Fastrack)

2. Directional Force Sensors
   • 5 DOF (Spacemouse)
   • 2 DOF (Joystick)

3. Gesture Recognition
   • Data Gloves

4. Eye Tracking

5. Speech Recognition Systems
Example: Spatial Position/Orientation Sensors

- Polhemus InsideTrack (Magnetic Tracking)
- FreeD Joystick (UltraSonic Tracking)
- MicroScribe (Mechanical Tracking)

Example: Directional Force Sensors

- SpaceMaster
- SpaceBall 3003
- SpaceBall 2003
Example : Gesture Recognition

Dextrous Hand Master, Exos

SUPERGLOVE, Nissho

Cyberglove, 5th Dimension

Example : Eye Tracking Systems

http://psych.utoronto.ca/~reingold/eyelink/eyelink.htm
Application Examples from the Uppsala VR Lab

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The Virtual Plane
(© 1999 CMD, Uppsala University)

Virtual Implant Planning
Stefan Seipel, 1999

Flight Mission Rehearsal
Examensarbete Anders Seton, VT99

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The Role of Dynamic Perspective

The alternate-ego view

The primary-ego view
The Stereoscopic Powerwall
(© 1999 CMD, Uppsala University)

Automatic Dental Occlusion Analysis

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Multi-User Collaborative Shared Virtual Environments

Virtual Teaching Settings for Learning

- low-bandwidth protocols for network VR
- intelligent clients rather than full state replication
- transformation driven state propagation
- highly aggregated objects for net VR
Other Examples from the Medical Field
Planning and Rapid Prototyping
The Surgicase System

- Manual segmentation
- Surface Rendering
- Rapid prototyping


Automatic Segmentation

- Automatic segmentation of mandibular nerve
- Hybrid rendering

1999 S. Haßfeld et al.
Mund-, Kiefer- und Gesichtschirurgie,
Universität Heidelberg
Registration and Visualization of Prosthetic Design

- CT Scanning of jaws
- CT Scanning of dentures
- Correlation of datasets
- Planning with regard to prosthetic restoration

1998 K. Verstreken et al., Laboratory for Medical Imaging Research (ESAT & Radiology), K.U.Leuven/Belgium

Haptic Simulators for Training of Tooth Brushing

Quelle: http://wwwipr.ira.uka.de/~salb
Haptic Simulators for Training of Tooth Brushing

Visual Simulation

Quelle: http://www.ipr.ira.uka.de/~salb

Haptic Manipulator

Computer manufactured mechanical templates

Planning

http://www.materialise.be/surgicase/

CAM Template

• Stereo-lithography
• Machine milling

Surgery

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Augmented Vision Guidance

- Registration of view on real world
- Correlation with computer data
- Fusion of real world view with computer generated information
VoxelMan - 3D Anatomy Atlas

- Data from “The Visible Human Project”
- Segmentation of anatomic structures
- Labeling of anatomic structures
- Semantic database
A Prototype Haptic Lumbar Puncture Simulator

A Prototype Haptic Suturing Simulator
Dynamic Tissue Simulation

Quelle: http://cs.millersv.edu/haptics/suture/suture.html

3D GUI for mobile computing

Physical client area = virtual client area: 640x480 pixels
Display tilt at 15 degrees

Virtual client area: 640x526 pixels

Display tilt at 30 degrees

Virtual client area: 640x626 pixels
Display tilt at 45 degrees

Virtual client area: 640x844 pixels