CS-525H: Immersive HCI

Introduction

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Course Goals

- Learn about designing, building, and evaluating immersive interfaces
- Look at how humans function
- Look at application areas
- Look at usage environments
- Understand the main problems/sub-fields
- Build something cool!
Assignments

- Three Programming Assignments
  - Each uses different technologies

- Paper summaries
  - You will write short summaries for several papers

- Final Project
  - Done in groups of two
  - Go deeper into one application/technology
  - Evaluate your system with a user study
Final project

- Choose
  - User population
  - Application
  - Usage environment (e.g., mobile)

- Choose I/O devices/techniques

- Design the application

- Design the interface & interaction

- Build the system

- Assess the result
Programming Assignment (cont.)

- Can be done in teams
  - Clearly define what each member will be responsible for

- Can use any software/language you like
  - You must program the experience though, so don't use tools that are too high-level

- Samples
  - OpenGL, DirectX, Java3D, OpenSceneGraph, OpenSG, FreeVR, Android, iphone
  - Game engine code

- HIVE resources
  - We have many devices for you to use.
  - Field trip later in the semester
What is Virtual Reality?

☐ You tell me!
## Virtual Reality Systems

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1929</td>
<td>Link Flight Simulator</td>
</tr>
<tr>
<td>1946</td>
<td>First computer (ENIAC)</td>
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<tr>
<td>1956</td>
<td>Sensorama</td>
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<tr>
<td>1960</td>
<td>Heileg’s HMD</td>
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<tr>
<td>1965-68</td>
<td>The Ultimate Display</td>
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<tr>
<td>1972</td>
<td>Pong</td>
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<td>1973</td>
<td>Evans &amp; Sutherland Computer Corp.</td>
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<tr>
<td>1976</td>
<td>Videoplace</td>
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<td>1977</td>
<td>Apple, Commodore, and Radio Shack PCs</td>
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<tr>
<td>1979</td>
<td>First Data Glove [Sayre] (powerglove -89)</td>
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<td>1981</td>
<td>SGI founded</td>
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<td>1985</td>
<td>NASA AMES</td>
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<td>1986-89</td>
<td>Super Cockpit Program</td>
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<tr>
<td>1990s</td>
<td>Boom Displays</td>
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<tr>
<td>1992</td>
<td>CAVE (at SIGGRAPH)</td>
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<tr>
<td>1995</td>
<td>Workbench</td>
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<td>1998</td>
<td>Walking Experiment</td>
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Link Flight Simulator

- 1929 - Edward Link develops a *mechanical flight simulator*
- Train in a synthetic environment
- Used mechanical linkages
- Instrument (blind) flying

http://www.wpafb.af.mil/museum/early_years/ey19a.htm
Sensorama

Morton Heilig, 1956

Motorcycle simulator - all senses
• visual (city scenes)
• sound (engine, city sounds)
• vibration (engine)
• smell (exhaust, food)

Extend the notion of a ‘movie’
Heilig's HMD (1960)

Simulation Mask from Heilig’s 1960 patent

- 3D photographic slides
- WFOV optics with focus control
- Stereo sound
- Smell
Ivan Sutherland

- The Ultimate Display (FIPS 1965)
  - Data Visualization: “A display connected to a digital computer...is a looking glass into a mathematical wonderland.”
  - Body Tracking: “The computer can easily sense the positions of almost any of our body muscles.”
Virtual Environments that mimic real environments: “A chair display in such a room would be good enough to sit in. Handcuffs displayed in such a room would be confining, and a bullet displayed in such a room would be fatal.”

VEs that go beyond reality: “There is no reason why the objects displayed by a computer have to follow ordinary rules of physical reality with which we are familiar.”
First HMD-Based VR

1965 - The Ultimate Display paper by Sutherland
1968 - Ian Sutherland’s HMD
Molecular Docking Simulator

- Incorporated force feedback
- Visualize an abstract simulation
Data Gloves

- Light, electrical or metal detectors compute “bend”
- Electrical sensors detect pinches
- Force feedback mechanical linkages
1985 - NASA Ames HMD

- McGreevy and Humphries
  - Wearable immersive HMDs
  - LCD “Watchman” displays
  - LEEP Optics

- Led to VIVID, led by Scott Fisher
FakeSpace Boom Display:
Early 1990s
CAVE - 1992
Virtual Workbench-1995
(Responsive Workbench, Immersidesk, etc.)
Current Best VE

- UNC Pit Experiment
- Fear of Heights a Strong Response
- Thousands of visitors
- Compelling Experience
  - Haptics
  - Low Latency
  - High Visual Quality
VPL Founded - 1985

- First VR Company
- VPL Research by Jaron Lanier and Thomas Zimmerman
  - Data Glove
  - Term: Virtual Reality
1995 - Effectiveness of computer-generated (VR) graded exposure in the treatment of acrophobia in *American Journal of Psychiatry*
Major Reinvigoration: Hardware Evolution

- High expense
- PC performance surpasses Graphics supercomputers
  - SGI RealityEngine (300k tris – 1993)
  - XBOX (150 mil tri/sec - 2001)
  - XBOX360 (500 mil tri/sec - 2005)
  - WiiMote/MotionPlus
  - Sony MOVE (SHOW MOVIE!)
  - MS Kinect (SHOW MOVIE!)
- Large LCDs are “cheap”
- 3D displays are here
  - Useful?
Why Study Immersive HCI?

- Relevant to real-world tasks
  - Can use familiarity to ease adaptation
  - Can increase realism of experience

- Mature technology
  - Cheap, robust solutions
  - Need to create interface mappings

- 3D interaction is difficult
  - Many VR/gaming systems lack necessary cues
  - Adapting WIMP techniques is not adequate
Why Study Immersive HCI? (cont.)

- Current approaches are either too simple or unusable
  - Since users have problems, dumb it down!
  - Need to be able to perform all actions though!

- Ripe area for study
  - Very hot area of HCI
  - We know a lot about doing things in 2D
  - And also about doing things in the real world
A Brief History (cont.)

- HCI draws on
  - Perception
  - Cognition
  - Linguistics
  - Human factors
  - Ethnography
  - Graphics design
  - Computer science
  - ...

A Brief History (cont.)

- Technology developments also drove growth
  - Flight simulators
  - 3D Graphics
  - Augmented Reality (AR)
  - Virtual Reality (VR)
  - Flight
Basic Interaction Tasks in VR

(Bowman et al.)

- Object Selection
  - What do I want to manipulate?

- Object Manipulation
  - How can I manipulate it?

- Navigation
  - Wayfinding: How do I know where I am, and how to get where I am going?
  - Travel: How do I get there? (locomotion)

- System Control
  - How do I change system parameters?

- Symbolic Input
  - Inputting text and numbers
Dealing with Objects

- Problems
  - Ambiguity
  - Distance

- Selection Approaches
  - Direct / enhanced grabbing
  - Ray-casting techniques
  - Image-plane techniques

- Manipulation Approaches
  - Direct position / orientation control
  - Worlds in miniature
  - Skewers
  - Surrogates

Courtesy: D. Bowman
Navigation: Wayfinding

- People get lost/disoriented easily
- Traditional tools
  - Maps (North-up vs. Forward-up)
  - Landmarks
  - Spoken directions
- Non-traditional
  - Callouts
  - Zooming

Images: http://vehand.engr.ucf.edu/handbook/Chapters/Chapter28/Chapter28.html
Navigation: Travel

- Problems
  - Limited physical space, unlimited virtual space
  - Cables

- Approaches
  - Fly where you point/look
  - Treadmills
  - Walking in place
  - Big track ball

Image: www.virtusphere.com
System Control

- Need to manipulate widgets
  - Lighting effects
  - Object representation
  - Data filtering

- Approaches
  - Floating windows
  - Hand-held windows
  - Gestures
  - Menus on fingers
System Control Examples

Courtesy: R. Lindeman

Courtesy: D. Bowman
User, Task & Environment

- The "optimal" interface will depend on the capabilities of the user, the nature of the task being performed, and the constraints of the environment.

- User
  - Dexterity, level of expertise

- Task
  - Granularity and complexity of task

- Environment
  - Stationary, moving, noisy, etc.
Direct Manipulation
Can We Do WIMP in VR?
Desktop Interaction: SensAble PHANToM
Wearable Interaction with Haptics: Immersion *CyberGrasp*
Wearable Interaction: Rob's *Hand-Held Windows*
How Do We Do Menus?
Interface Devices
Augmented Reality (AR)