Panel - Teaching Virtual Reality: Why and How

Drew Kessler, Lehigh University
Bill Sherman, University of Illinois
Skip Rizzo, University of Southern California
Greg Burdea, Rutgers University
Rudy Darken, Naval Postgraduate School

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IEEE Virtual Reality 2004 Conference
Teaching Virtual Reality: Why and How?

Grigore C. Burdea Ph.D.
Professor of Computer Engineering,
Rutgers University.
Why should VR be taught?

- So that more standards of quality of VR education are established;
- So that we have more instructors qualified to teach.
- So that we bring “new blood” in the research and development of VR
Worldwide survey of VR teaching

- My web survey found 148 universities teaching VR courses;
- Currently only 3% of universities have VR courses;
- Distribution is not uniform...
Worldwide survey: North America 64 universities

- 5 universities
- 57 universities
- 2 universities
Worldwide survey: Europe 52 universities

1 university
7 universities
3 universities
22 universities
5 universities
1 university
1 university
1 university
1 university
4 universities
2 universities
3 universities
1 university
Worldwide survey: Asia 20 universities

- 5 universities
- 4 universities
- 3 universities
- 4 universities
- 2 universities
- 1 university
Worldwide survey: South America 8 universities

3 universities

3 universities

2 universities
Worldwide survey: Africa – 3 universities

1 university

2 universities
Worldwide survey: Oceania – 1 university
# 2004 Worldwide Survey Summary

<table>
<thead>
<tr>
<th>Continent</th>
<th>General VR</th>
<th>Specialty VR</th>
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</thead>
<tbody>
<tr>
<td>North America (64)</td>
<td>5-Canada, 2-Mexico, 57-US</td>
<td>1-Austria, 1-Czech Republic, 1-Denmark, 3-Finland, 5-France, 7-Germany, 3-Holland, 1-Norway, 1-Spain, 4-Sweden, 1-Switzerland, 22-UK</td>
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<tr>
<td>Asia (20)</td>
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<td>1-Mauritius, 2-South Africa</td>
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<td>Europe (52)</td>
<td>1-Austria, 1-Czech Republic, 1-Denmark, 3-Finland, 5-France, 7-Germany, 3-Holland, 1-Norway, 1-Spain, 4-Sweden, 1-Switzerland, 22-UK</td>
<td>1-Australia</td>
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<td>South America (8)</td>
<td>3-Brazil, 3-Colombia, 2-Peru</td>
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<td>Oceania (1)</td>
<td>1-Australia</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>148 universities</strong></td>
<td><strong>136</strong></td>
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Worldwide survey of VR teaching

- An updated survey table is maintained at www.vrtechnology.org (click on “Instructor’s resource page”)

INSTRUCTOR'S WEB SITE FOR

Grigore Burdea and Philippe Coiffet
Virtual Reality Technology
ISBN 0471368699

Table of Contents
Browse

Go to Instructor’s Resource Page:
Lecture notes, Quizzes, Exams, Solutions, Sample Term Projects etc.

- New instructors who have adopted the textbook register here.
- To update the information in your account click here.
- For examination copies please e-mail your Wiley campus representative. Who is my rep?
- To purchase the book click here @WILEY or here @amazon.com.
- To get more information send e-mail to info@vrtechnology.org
- For book corrections send e-mail to corrections@vrtechnology.org

Last update: September 12, 2003 - 09:46 AM
To report problems with the website send e-mail to technote@vrtechnology.org

http://www.vrtechnology.org
How should we teach VR?

- We need supporting textbooks, as well as laboratory manuals
- The programming assignments need to be in a free toolkit
- We need dedicated teaching laboratories
A laboratory example (Rutgers U.)
A laboratory example (Rutgers U.)

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<td>Polhemus Fastrack</td>
<td>Com 1</td>
<td>37%</td>
</tr>
<tr>
<td>5DT glove</td>
<td>Com 2</td>
<td>10%</td>
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<tr>
<td>Stereo Glasses</td>
<td>FireGL2</td>
<td>3%</td>
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<tr>
<td>FF joystick</td>
<td>USB</td>
<td>2%</td>
</tr>
<tr>
<td>Java/Jave3D</td>
<td>NA</td>
<td>0%</td>
</tr>
<tr>
<td>VRML</td>
<td>NA</td>
<td>0%</td>
</tr>
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</table>
Java 3D is faster

WTK – Release 9
50k poly, Gouraud shaded, stereo

Java3D – Release 1.2
50k poly, Gouraud shaded, stereo

Java3d is faster on average than WTK, but has higher variability
(Boian and Burdea, 2001)
Java 3D has smaller latency

Java3d has smaller latency than WTK over all scene complexities and light sources (Boian and Burdea, 2001)
Announcement

- Presence will start a Forum on VR Education this Summer;
- Larry Hodges and Greg Burdea are the Special Section Editors
The MOVES* Program at the Naval Postgraduate School

Rudy Darken

*Modeling, Virtual Environments, and Simulation
Overview

• M.S. in 1996, PhD. in 1999
  – Developed by Mike Zyda
  – Over 100 graduates so far
• Specifically designed for military officers, but has civilians as well
• Part operations research, part computer science
• Our students know (approximately) what their job is before they get to NPS
Motivation

• Why do military officers need to know about VR?
  – Large number of simulators utilize VR technologies
  – “Modeling and simulation” fast becoming an interactive visual field
  – Need to know how to apply VR technologies to new problems
  – Need to know how to analyze systems
    • Both technical and human performance
Core Topics

- Programming
- Statistics and probability
- Networked visual simulation
- Simulations & combat modeling
- AI, agents
- Real-time computer graphics
- Training systems
- Human factors
- Physically-based modeling
- Management

see http://www.movesinstitute.org
Approach to Instruction

1. a. Programming skills
   b. VR familiarization*
   c. Human factors/training introduction*
   d. Quantitative skills

2. a. Computer graphics (OpenGL/OpenSceneGraph)
   b. AI, networks

3. a. Advanced graphics (Game engine)
   b. Networked VEs*
   c. Agents
VE Specific Courses

• Introduction to VE Technologies
  – Hardware, software, applications

• Simulation and Training
  – Theories of training, applications, measurement

• Human factors of VE
  – Human performance, cybersickness, presence, measurement

• Networked VEs
  – Implementation, scalability, interoperability, applications
New Directions

- **Program availability**
  - Technical managers (acquisition)
  - Human factors engineers
  - Human systems integration

How do we make advanced VE courses available to non-programmers?

Need less emphasis on building (architecture) and greater emphasis on using, specifying
New Directions

• Distance Learning
  – Very early in this process
  – Need to be able to share courses with ODU due to Navy concentration in Norfolk, VA area, UCF may be next ...
  – Unresolved questions about course quality and best practices in DL mode
New Directions

• Content
  – Why the interest in game engines and gaming technologies?
    • Cost, availability, applicability ...
  – Advanced graphics course will be taught in an open source game engine
  – Students graduate with all source code and sample programs
What can students do?

Deployable Training
Rudy Darken
Discussion Topics
Why?

• Why do so few colleges and universities teach VR today?
  – Is there a need?
  – Barriers
    • Cost, instructors, market for graduates?
Program Content

• What should be the content of a VR educational program?
  – Baccalaureate? Graduate?
  – Technical
    • Architectures, hardware, system engineering, programming
  – Design
    • Visual design for VR, designing interaction
  – Science
    • VR as a psychological tool, sociological studies
Program Delivery

• What learning modes tend to work best?
  – Traditional classroom,
  – Laboratory hands-on,
  – Distance learning,
  – a mix?

• How do we ensure quality regardless of learning mode?
Educational Markets

• What professions and career paths should VR be marketed to?
  – Technical, artists, medical, military, etc.
• Would there be a market for short courses or certificates?
• Since there are so few schools teaching VR, should they pool resources and offer joint programs?
Teaching Virtual Reality: When and How?

"Human Factors and Integrated Media Systems"

Skip Rizzo, Ph.D.
Integrated Media Systems Center and School of Gerontology
University of Southern California
213-740-9819
arizzo@usc.edu
Purpose of the course:

Provide an introduction to the design, development and evaluation of Virtual Reality and Integrated Media Systems from a HUMAN user perspective.

Targeting EE and CS Graduate Students
But first...what do these questions have in common?

- What is the difference between Sensation and Perception?
- What are three processes or cues that govern human depth perception?
- Name or describe two different types of Attention Processes?
- What is Fitt’s Law?
- What is an emotion and how would you measure one to determine its influence on human performance in a VE?
But first... what do these questions have in common?

- What is an Institutional Review Board?
- What is the difference between a within and between groups design?
- What is a control group?
- What are independent and dependent variables?
- Name a test of statistical significance.
- Name one method used in Usability Engineering?
- What is a requirements analysis?
But first... what do these questions have in common?

- What are the 4 Universal 3D User Interface Tasks?
- What is the difference between Travel and Wayfinding?
- What is the difference between Immersion and Presence?
- Name 3 methods used to infer Presence?
- What is the difference between Simulator Sickness and Aftereffects?
The course is broken down into 3 Main Components:

- The Human User (Classes 1-5)
- The Technology (Classes 6-10)
- Hands-on Weekly Projects (Classes 11-15)
The course is broken down into 3 Main Components

- The Human User (Classes 1-5)
The course is broken down into 3 Main Components

- The Human User (Classes 1-5)
  - History of Human Factors, HCI & VR/Info Tech
  - Technology Lifecycles, Universal Access, Information Society for All, Digital Divide, etc.
  - Sensation and Perception
  - Cognitive Processes
  - Emotional & Social Factors
  - Basic Human Research Methodology
  - More Specific Research Methodologies (HF, HCI, User-Centered Design, Usability Engineering, etc.)
The course is broken down into 3 Main Components

- The Technology (Classes 6-10)
The course is broken down into 3 Main Components

• The Technology (Classes 6-10)
  – Display Technology (Visual, Auditory, Haptics, Olfaction)
  – Software
  – Tracking
  – The User Interface and Interaction Methods
  – Virtual Humans and Autonomous Agents
  – SWOT Analysis of Virtual Reality
  – Overview and Analysis of Application Areas
  – Strategic VR Research Areas (Presence, Side Effects, Transfer of Training, etc.)
  – The Future: Technology, Applications & Impact on Society
The course is broken down into 3 Main Components:

- Hands-on Weekly Projects (Classes 11-15)
The course is broken down into 3 Main Components (Classes 11-15).

- Hands-on Weekly Projects

"Unless individuals take a very active role in what it is that they are studying, unless they learn to ask questions, to do things hands on, the ideas just disappear."

Harvard psychologist, Howard Gardner on the basic premise behind "project-based" learning.
The course is broken down into 3 Main Components

- Hands-on Weekly Projects (Classes 11-15)

*In the final third of the course, students see two research presentations/demos from IMSC labs during each class session.*

*For Example:*
- Graphics Lab
- Immersive Audio Lab
- Haptics Lab
- Vision-Based Tracking Lab
- Panoramic Video Lab
- Data Mining Lab
The course is broken down into 3 Main Components
– Hands-on Weekly Projects (Classes 11-15)

In the final hour of the class, the students are broken into groups and each group will be responsible for the production of a 3-page technology and human factors review paper. In addition to the actual content challenge for this, the "process" is hoped to be an exercise in the type of "cooperative" effort that is required in a multidisciplinary work or academic environment (as well as in the regular old "real-world").
Students have electronic access to all course notes, powerpoints and a library of required and optional readings.
What do Engineers and Computer Scientists Think about “Psychology, etc.” trying to sneak into the “Hard” Sciences?
IEEE VR1999 ‘Best Paper’ Award

"User-Centered Design and Evaluation of a Real-Time Battlefield Visualization Virtual Environment"

Dorothy Hix, et al.
“Using the Virtual World to Improve Quality of Life in the Real World”

Larry Hodges
IEEE VR2002 Keynote Address

“Do Avatars Dream of Digital Sheep? Virtual People and the Sense of Presence”

Mel Slater
IEEE VR2003 “Best Paper” Award

“Human Movement Performance in Relation to Path Constraint—The Law of Steering and Locomotion”

Shumin Zhai & Rogier Woltjer
IBM Almaden Research Center
Designing for Society', Bath University, UK, 8-12 September 2003 -

HCI 2003, the 17th annual Human-Computer Interaction Conference organised by the British Computer Society HCI Group, will take place in Bath, England, 8-12 September 2003. The conference will bring together from all over the world researchers, practitioners and educators with interests in the many facets of human-computer interaction, usability and interactive systems.

It is by now almost a truism that the concerns and goals of HCI have shifted over the years from a focus on individual interaction between a human and a computer to understanding, designing, constructing and evaluating complex interactive systems involving many people and many technologies. Developments in software and hardware technologies have pushed applications towards supporting our collaborative and communicative needs as social beings, both at work and at play. At the same time, similar developments are pushing the human-computer interface beyond the desktop and into our pockets, streets and buildings. These developments provide exciting challenges and opportunities for HCI. How do we design for usability when the human-computer interface is dispersed and interwoven throughout our environment? How can we understand and account for the web of influences amongst society, environment and technology?
“The Old Computing is about Computers
The New Computing is about USERS!”

Ben Shneiderman
“There have been a number of significant achievements by the Center in the last year. Of particular note has been its increased emphasis on HCI and user-centered research of various sorts - something, which had been raised as a concern by previous panels. We see the elevation of this area to that of a thrust as a positive development which reflects an important improvement from the previous year. We also urge the Center to continue its efforts in this direction, and caution that the overall task of fully leveraging the significant benefits that this area can bring will be a difficult one - it will require attention, effort, and resources for a number of years. This task will be particularly difficult because it requires the inclusion of significantly different methodologies, approaches, and outlooks (when compared with the other, aspects of the Center, which are primarily rooted in a fairly conventional EE and CS engineering culture).”
‘You’re suffering from sensory overload. Cut down on your intake of media.’
Drawing by Koren; © 1967 The New Yorker Magazine, Inc.
The End for now....

“I have a 300 MHz computer...with 10 MHz fingers.”
Teaching Virtual Reality

IEEE VR 2004
Bill Sherman, NCSA/UIUC
VR Education at UIUC

• CS397-WRS: Introduction to Virtual Reality
• CS490: Graduate Independent Study
• Get a job at NCSA or the Beckman Institute
  – (or with a researcher affiliated with either)
CS397WRS: Intro to VR

• Taught for past 5 academic years
• Prerequisite: Intro to Computer Graphics
  – Homogeneous matrix transformations
  – OpenGL
• Participants
  – Graduate and undergraduate student mixture
  – CS students & Engineering students in labs using the CAVE
  – Circa 85 students over 5 years
CS397WRS: The Students

• Where did they go?
  – 1 to NASA Langley
  – 1 to NCSA
  – ~83 to somewhere else, presumably not doing VR

• Where should I send them?
  – For graduate studies
  – For employment
CS397WRS: The Course

- http://www.ncsa.uiuc.edu/VR/cs397wrs
- 16-24 students
- 5 graded submissions
  - 3 programming assignments (5% each)
  - 1 test (midterm) (25%)
  - Semester project (60%)
- VR Interface
  - NCSA’s CAVE
CS397WRS: The Material

• Presented as standard lecture
  (students follow along on workstations or laptops)
• ½ Overview of VR (“Understanding VR”)
  • Display devices & input devices
  • Selection & manipulation
  • Travel & wayfinding
• ½ VR programming tutorials (freevr.org)
  • OpenGL & Performer
  • Sound libraries
  • VTK visualization toolkit
CS397WRS: Example work

- Assignment 1: 3D painting
CS397WRS: Example Work

• Project Presentations
CS397WRS: Issues

- Grading takes a long time
- CAVE is a limited resource
- CAVE is not an auditorium
- CAVE is part of a research institute, not the Computer Science department

(without a free VR facility, it’s much more difficult to teach VR – unless the course is: “How to build a VR system from scratch”)
A VR Program

- Introduction to Virtual Reality
- Advanced VR programming (for applications)
- VR Cases Studies
- VR application design lab
- Human factors in/of VR
- 3/6-DoF Interface design and analysis
- VR technology development
- ?
FIN
My Background

• Taught graduate/senior level courses in Virtual Environments

• Developer of the Simple Virtual Environment (SVE) toolkit
  – C library and run-time system
  – Used for student projects in the course
  – Designed to get simple VR app done quickly
  – Supports implementing interaction techniques, rendering techniques, device handling, etc.
VEs Should be Taught in Graduate CS Programs

- Current technology allows a computer generated environment to coincide with the real world
- 3D tracking, non-keyboard/mouse input
  - Encumbered (worn receiver, held I/O device)
  - Unencumbered (vision-based object rec., speech)
- 3D displays
  - Encumbered (stereo glasses, HMD)
  - Unencumbered (autostereoscopic)
- Students need to "think outside of the box"
VE Course Should be Hands-on

- Experience head tracked 3D display
- Make an interactive 3D world
- Test out interaction techniques, rendering techniques, etc.
VE Software Tool Requirements

- Cheap (i.e. practically free)
- Well documented
- Easy to install, configure, and run a simple walkthrough app.
- Easy to set up a scene graph of objects
- Easy to program behaviors of objects in the scene
- Easy to program user interaction (navigation, selection, manipulation)
- Easy to switch between display & input device configurations
A Few Free VE toolkits

- Alice (www.alice.org)
- Blender3D (www.blender3d.org)
- DIVE (www.sics.se/dive)
- DIVERSE (diverse.sourceforge.net)
- FreeVR (www.freevr.org)
- Java3D (java.sun.com/products/java-media/3D)
- Panda3D (www.etc.cmu.edu/panda3d)
- Maverik (www.gnu.org/software/maverik)
- VRJuggler (www.vrjuggler.org)
- VIRPI (www.nat.vu.nl/~desmond/VIRPI)
- ...

Tools Intended for Different Purposes

• Creating dynamic, interactive 3D worlds
  – GUI scene builder, behavior scripts
  – *Alice*, *Panda3D*, *Blender3D*

• Converting a 3D application to a VE application
  – Handle VE input devices, displays
  – *VRJuggler*, *DIVERSE*, *FreeVR*

• Comprehensive VE development
  – Geometry loaders, programming library, VE devices
  – *DIVE*, *Maverik*, *Java3D*
Challenge: Describing the 3D world, and its behavior

- Need a scene graph to express reference frames
  - Nodes in graph
- Need methods to relate objects in common coordinates
  - Object-centric operations ("move forward")
  - Conway, 1997
- Movement relative to other objects
Challenge: Defining 3D User Interaction

- Helps to have an *node based* user model
  - Easy to ask where eyes, head, view, etc. are
  - Allows for object relative methods
  - Tracking data can be incorporated directly
Example: Selection

- **Ray casting**
  - Attach ray to hand
  - Shoot ray in hand “forward” direction

- **Occlusion (image plane) selection**
  - Attach ray to hand
  - Shoot ray in opposite direction of eye in hand coordinates
Java3D User Model

View

Canvas3D

Screen3D

ViewPlatform

Scene Graph

PhysicalBody

PhysicalEnvironment

Tracker base

PhysicalBody

→

setHeadToHeadTracker()

PhysicalEnvironment

→

setCoexistenceToTrackerBase()

Screen3D

→

setHeadTrackerToRightImagePlate()

(HMD View)

Screen3D

→

setHeadTrackerToHeadTracker()

PhysicalBody

→

setRightEyePosition()

PhysicalBody

→

setRightEyePosition()

Head

Left eye image

Right eye image

Left eye

Right eye

Tracker base

Head tracker

Head
Challenge: Switching Hardware

- Node based user model also helps with display configuration changes

- Ideally, changed through system-specific config. file
- Eg. Java3D ConfiguredUniverse utility class
<table>
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<th>Alice</th>
<th>Panda3D</th>
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NotSupported ⬤ ⬤ ⬤ ⬤ ⬤ ⬤ ⬤ ⬤ WellSupported

Our Evaluation: Appropriate for VE Coursework?