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Building a National Research & Education Program in Virtual Reality

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Building a National Research & Education Program in Virtual Reality

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Talk Outline

What is VR & why should we care?

The research scope for VR

Is VR computer science or what?

*The NPS Modeling, Virtual Environments
& Simulation Program*

Some video

What is VR & why should we care?

Virtual reality is the synthesis of the technology for moving through and interacting with a computer-generated three-dimensional model of a world in real-time such that the experience is almost real or a near-believable or usable simulation of the real.

Additional Terms

Artificial reality

Augmented reality

Virtual environments

Metaverse

***Synthetic
environments***

The matrix

...

Cyberspace

Telepresence

Synthesis of technology

The key point from the definition is the “synthesis of technology”.

- It is the application of that synthesis to very interesting applications that is VR’s promise.
- I mean, what could be more exciting than developing a world through which a human can move and interact in a natural way, with that feedback being a computer-generated image?

VR - should we care?

Yes - lots of very interesting computer science and other areas to research, with the possibility of some very useful outcomes.

If you care about the computer interface of the future, this is where the action is.

VR Technology - Research & Application

I hope to show you today that VR is a rich area for intellectual pursuit and show you how universities can adapt to build national VR programs.

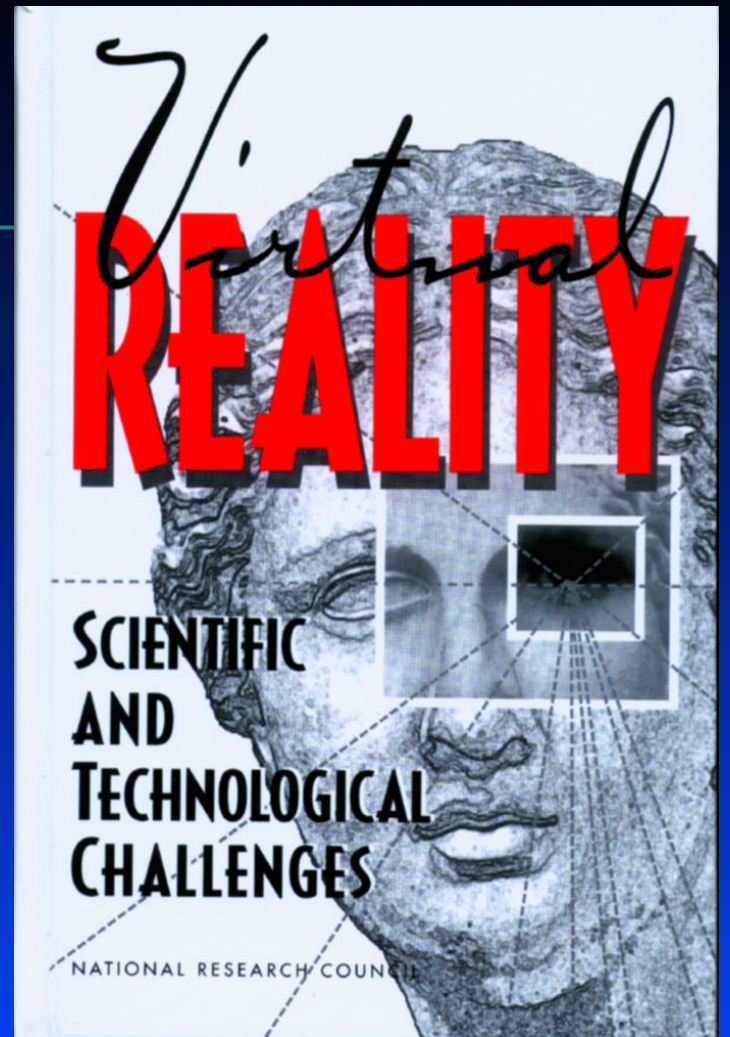
- To do this, I need to describe for you the breadth of research in VR, especially with respect to required support technologies and the proposed applications for that technology.

The Research Scope of VR

Virtual Reality Research Scope

*The research scope
in the following
section is taken from
the NRC report, with
some enhancements*

...



Purpose of the Report Committee

The NRC Committee on Virtual Reality Research & Development

- The purpose of the committee was to “recommend a national research and development agenda in the area of virtual reality”.
- Committee consisted of 17 university, corporate and governmental experts in the field of virtual reality & telerobotics.

Criteria Used to Construct the Research Agenda

Science and technology criteria.

- Research areas that could advance the state-of-the-art.

Practical applications criteria.

- Research areas likely to have practical application in the not-too-distant future.

Leverage criteria.

- Leverage, cost-effectiveness & ratio of payoff to effort.

Categories of Proposed Research Agenda

- *Application domains.*
- *Some psychological considerations.*
- *Development of improved synthetic environment technology.*
- *Evaluation of synthetic environment systems.*

Application Domains of Synthetic Environment Systems

Recommendations

Application Domains Recommendation

Four application domains show the most promise for SE:

- Design, manufacturing and marketing.
- Medicine & health care.
- Hazardous operations.
- Training.

Application Domains Recommendation

Research needs in these domains should be used as one of the principal means to focus SE technology development & testing.

Application Domains - Special Project Recommendation

Two projects should receive special attention:

- Modeling the human body for purposes of medical education, surgical planning and providing explanations of procedures and outcomes to patients.
- Studying the transfer of knowledge and skill gained in training in a VE to performance in a real-world task environment.

Psychological Considerations

Recommendations

Psychological Considerations - Recommendations

Support for psychological studies organized around the following objectives:

- Development of a comprehensive, coherently organized review of theory and data on human performance characteristics from the viewpoint of SE systems.
 - Including basic sensorimotor resolution, perceptual illusions, info. transfer rate & manual tracking.

Psychological Considerations

- Recommendations

- Development of a theory that facilitates quantitative predictions of human responses to alterations in sensorimotor loops for all channels, with special emphasis on:
 - Degradations in performance resulting from deficiencies in SE technology (e.g. in the form of distortions, time delays and system noise).

Psychological Considerations

- Recommendations

- Supernormal performance achievable through introduction of purposeful enhancing distortions.
- Radical sensorimotor transformations that arise, for example, in connection with the use of sensory substitution or strongly non-anthropomorphic telerobots.
- Methods of accelerating both adaptation to various types of alterations and readaptation to normal conditions.

Psychological Considerations

- Recommendations

- Channel interaction effects that occur with multimodal interfaces.
- Factors governing the occurrence, kind and magnitude of space sickness from SE exposure.
- Factors governing the strength of subjective telepresence and its relationship to objective performance.

Psychological Considerations - Recommendations

Development of cognitive models that will facilitate effective design of VE systems for purposes of education, training and information visualization.

Psychological Considerations

- Recommendations

Development of improved understanding of the possible deleterious effects of spending substantial portions of time in SE systems.

Development of Improved Synthetic Environment Technology

Recommendations

Human-Machine Recommendations

*Support of research on visual displays,
haptic interfaces and locomotion
interfaces.*

- HMDs.
- Tool-handle interfaces.
- Locomotion interfaces.

Position Tracking & Mapping Recommendations

A multiphase research & development approach:

- Conduct research & development on mechanical & inertial trackers.
- Explore the possibility of obtaining improved cost-effectiveness in tracking by using hybrid systems.

Position Tracking & Mapping Recommendations

- Carefully monitor commercial developments in magnetic, acoustical and optical trackers, in eye trackers, and in trackers directed toward registration problems in augmented reality.

If market forces do not drive the development of these trackers, federal research support is urged.

Testing & Evaluation Recommendation

The establishment of a set of standards or an independent laboratory to evaluate SE interface devices.

Computer Hardware Recommendation

No aggressive federal involvement in computer hardware development in the SE area at this time.

- Hardware development remain largely a private-sector activity.
- Should serious lags in development occur, the gov't might then consider strategies for leveraging private-sector development efforts.

Software Recommendation

A major unified research program be created that focuses on those areas of development directly related to the generation, implementation, and application of VEs.

Topics to be considered

- *Multimodal human-computer interactions.*
- *Rapid specification & rendering of visual, auditory and haptic images.*

Topics to be considered

- *Models & tools for representing & interacting with physical objects under multimodal conditions (including automated model acquisition from the real world).*

Topics to be considered

- *Simulation frameworks.*
- *A new time-critical, real-time operating system suitable for VEs.*
- *Registration of real and virtual images in augmented-reality applications.*

Topics to be considered

- *Navigational cues in virtual space.*
- *Behavior of autonomous agents.*
- *Computer generation of auditory and haptic images.*

Networking Recommendation

The federal government provide funding for a program (to be conducted with industry & academia in collaboration) aimed at developing network standards that support the requirements for implementing distributed VEs on a large scale.

Networking Recommendation

Funding of an open VE network that can be used by researchers, at a reasonable cost, to experiment with various VE network software developments and applications.

Evaluation of Synthetic Environment Systems

Recommendations

Evaluation Recommendations

The federal government encourage the SE system developers it supports to include a comprehensive evaluation plan in the early design stages of their research projects.

Evaluation Recommendations

The federal government help coordinate the development of standardized testing procedures for use across studies, systems and laboratories, particularly in those areas in which the private sector has not acted.

Recommendations ...

Now, these are all the recommendations to the government by the NRC Committee...

- The purpose of the report is to advise the government how to spend its research dollars.**
- It is up to the responsible program managers to actually implement the recommendations...**

Is VR computer science or what?

VR has come very interesting computer science in it, some of it in computer graphics, HCI, networking, systems, ...

Or what?

VR technology development also has a significant requirement for cognitive psychology (understanding & modeling the human), mathematical modeling, physically-based modeling, electrical engineering, mechanical engineering, ...

So its interdisciplinary ...

***And let's not forget the Applications of VR
that can take place all over ...***

***So the word Interdisciplinary is written all
over VR ...***

How can we build national VR programs?

Well we can do this if we somehow provide a focused educational program that feeds the backend research.

- Our current crops of students are coming from other disciplines, with only part of the training they need (computer science, cognitive psychology, electrical engineering, ...). They need more directed, focused education.

How can we build national VR programs?

- We need to offer degrees in VR, most likely MS and PhD degrees at first, with perhaps a much later offering of undergraduate programs.
- These degrees need to cover a broad range of courses, courses not all in one department.
- A mechanism for interdisciplinary participation in the VR program needs to be established.

NPS Modeling, Virtual Environments & Simulation (MOVES) Program

- The Naval Postgraduate School has put together a degree program that fits this mold - the Modeling, Virtual Environments & Simulation (MOVES) program.
 - That program offers MS and PhD degrees in MOVES.
 - We did not create a department but rather a degree program comprised of existing courses from two departments

MOVES Tracks

Two tracks in MOVES -

- Visual Simulation - technology development for VEs.
- Human Computer Interaction - technology utilization and evaluation for VEs.
- We plan additional tracks at a later date, with Physically-Based Modeling being perhaps the next.

MOVES Common Courses

- Computer Science
 - CS-2971 Introduction to Object-Oriented Programming in C++
 - CS-3010 Computer Systems Principles
 - CS-3700 Data Structures
 - CS-3200 Introduction to Computer Architecture
 - CS-3310 Artificial Intelligence
 - CS-3472 Introduction to Physically-Based Modeling
 - CS-3450 Operating Systems
 - CS-3502 Computer Communications & Networks

MOVES Common Courses

- Computer Science
 - CS-4112 Distributed Operating Systems
 - CS-4202 Computer Graphics
 - CS-4314 Symbolic Computing
 - CS-4473 Virtual World & Simulation Systems

MOVES Common Courses

- Operations Research
 - OA-3101 Probability
 - OA-3102 Probability & Statistics
 - OA-3103 Statistics
 - OA-3104 Data Analysis
 - OA-3301 Stochastic Models I
 - OA-3302 System Simulation
 - OA-3401 Human Performance Measurement

MOVES Visual Simulation Track Courses

- CS-3202 Introduction to Multimedia Production
- CS-4470 Image Synthesis
- CS-4471 Computer Animation
- CS-4472 Physically-Based Modeling
- CS-4474 Virtual Environment Network & Software Architectures
- OA-4401 Human Performance Evaluation

MOVES Human Computer Interaction Track Courses

- CS-3130 Mobile Computing Systems
- OA-3402 Human Performance Measurement II
- OA-4333 Simulation Methodology
- OA-4401 Human Performance Evaluation
- OA-4404 Operations Research in Man-Machine Systems
- MV-4xxx Designing Virtual Environments I, II & III
- MV-4xxx Training in Virtual Environments
- MV-4xxx Human Performance Analysis in the VE I, II & III

Student Theses

Video

- Here is a video of the type of work our students do for their dissertations ...
- We also have a very large web site (see next slide).

Web Sites

MOVES Page:

- <http://www-npsnet.cs.nps.navy.mil/moves>

NPSNET Page:

- <http://www-npsnet.cs.nps.navy.mil/npsnet>

Michael Zyda Page:

- <http://www.cs.nps.navy.mil/people/faculty/zyda>