Outrageous Technologies in Development

DISTRIBUTED IMMERSIVE VIRTUAL REALITY SIMULATION[1]

Advanced Distributed Learning – The TOUCH Experience

DISTRIBUTED IMMERSIVE VIRTUAL REALITY SIMULATION for TRAINING and PERFORMANCE ASSESSMENT

Dale C. Alverson, MD

Emerging Trends in Medical Simulation:
Identifying the Needs of the Medical Community and Methods to Address Them

MMVR
January 27 , 2004

Project TOUCH

Telehealth Outreach for Unified Community Health

A Hawaii and New Mexico Collaboration

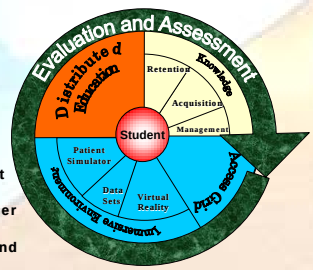
Year 4

Experiential Learning

I hear and I forget

I see and I remember

I do and I understand



Project TOUCH is made possible by grant number 4 D1BTM 00003-03-02 from the Office for the Advancement of Telehealth, Health Resources and Services Administration, DHHS.

Current Contributors

- University of New Mexico
- University of Hawaii
- Pacific Telehealth and Technology Hui (TAMC/VA)
- Uniformed Services University of the Health Sciences

Principal Investigators

- Dale C. Alverson, MD
- Tom Caudell, PhD
- Tim Goldsmith, PhD
- Stan Saiki, Jr, MD
- Mark Bowyer, MD
- Alan Liu, PhD
- Gil Muniz, PhD

Contributors
Interdisciplinary Project

- Edward Aalseth MS
- J Rex Baker MD
- John A. Greenfield MS
- Karen Haines PhD
- James R. Holten IV MS
- Joshua Jacobs MD
- Summers Kalishman PhD
- Marcus F. Keep MD
- Kathleen Kihmm
- Marlene Lindberg PhD
- Stewart Mennin PhD
- Moad Mowafi MS
- Curtis Nakatsu MD
- David Nickles MS
- Jeffrey Norenberg PhD
- Linda Saland PhD
- Andrei Sherstyuk PhD
- Susan Stevens, MS
- Kenneth L. Summers PhD
- Diane Wax MPA
- David Wilks, MD

5

Presentation Table of Contents

6

Motivation

- Errors in medicine (IOM reports) and need to improve methods to train, assess competence and performance in order to decrease errors and improve patient safety

  Each year more than 46,000 people die as a result of medical errors. Medical simulation improves patient safety by offering new ways to "train and maintain" skills.

- Increased demand for simulation in lieu of using animals or actual patients prior to further training
- Responding to new approaches to how people learn by creating interactive experiential training environments

7

Motivation

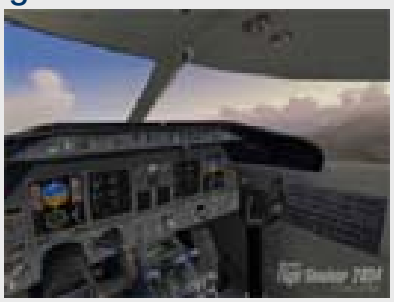
- Creates environment for reification of abstract concepts to improve human understanding
- Opportunities to apply new methods in advanced computing, visualization = "perceptualization" and advanced communication networks
- Complements other methods of simulation training such as standardized patients and robotic simulators
- Allows interaction and collaborative learning and training independent of distance (ADL)

8

Presentation Table of Contents

9

Flight Simulation Metaphor



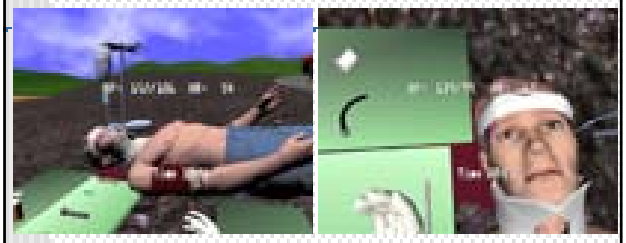
Based on the concept of a distributable flight simulator in which individual trainees and instructors can work together virtually despite physical separation at different locations

Rules-based Artificial Intelligence

- Simulations are driven by rules-based artificial intelligence that are founded in principles of knowledge-based design to meet specific training/learning goals, objectives and requirements

11

Artificial Intelligence



The simulation A. I. engine dynamically governs changes in physiology, physical findings, movement and events, as well as responses to the user

12

Tool: Flatland

- Perceptualization and Virtual Environments development tool
- Developed at ECE & HPC, UNM
- IRIX/Linux/Unix/MacOSX/Windows*
- Open source core

*Ported to Windows in conjunction with NCA SimCenter at USUHS

13

Typical rules

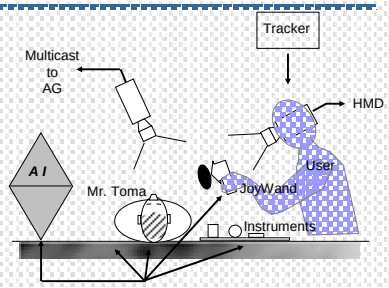
```
/* Bleeding rules ********************************************************/
nantecedents = 1 ;
r = make_rule( nantecedents, 5 * sizeof(float) ) ;
sprintf(r->name,"%s_BP-%d",rs->name,rulecount++) ;
set_antecedent_params( r, 0, prede, "string", "bandage_state", "on_head", "NULL" ) ;
set_antecedent_params( r, 1, prede, "string", "bleeding_state", "TRUE", "NULL" ) ;
r->consequencefunc = bleeding_off_consequence ;
add_rule_to_ruleset(rs, r) ;

nantecedents = 3 ;
r = make_rule( nantecedents, 5 * sizeof(float) ) ;
sprintf(r->name,"%s_BP-%d",rs->name,rulecount++) ;
set_antecedent_params( r, 0, predge, "float", "timeminutes", "0.1", "NULL" ) ;
set_antecedent_params( r, 1, prede, "string", "bandage_state", "on_gurney", "NULL" ) ;
set_antecedent_params( r, 2, prede, "string", "gauze_state", "on_gurney", "NULL" ) ;
r->consequencefunc = bleeding_on_consequence ;
add_rule_to_ruleset(rs, r) ;
```

TOUCH contains approximately 500 rules extracted from three experts. Validation.

14

TOUCH
Patient Simulator Schematic



"Flatland" 3-D Virtual Environment Platform

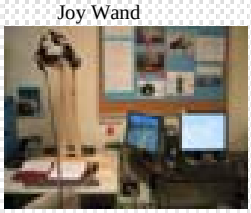
15

16

Flatland I/O for Immersion

Joy Wand

Head Mounted Display (HMD)

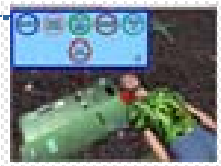


VR Work Station

Full Immersion

17

Inside the Virtual Environment
The Patient Simulator
HMD 1st Person View

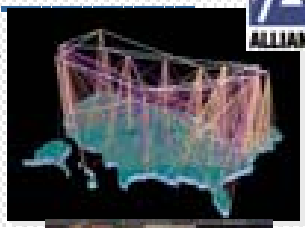


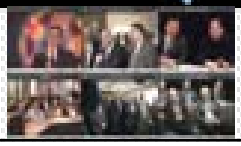
18

Communication Backbone
Access Grid
Next Generation Internet (NGI)

- TCP/IP based video conferencing system using multicasting: simultaneous interactions with multiple sites using multiple applications
- Supports collaborative VR interaction
- Lag time/Latency Minimization
- Open Source Code

Developed by the National Computational Science Alliance and Argonne National Laboratory





19

Internet2 Universities

AG Collaboration

Access Grid Interfaces

21

First Person Collaboration

22

Fully Immersive Interactive Virtual Reality

24

25

26

Safe Environments to Make Mistakes

Presentation Table of Contents

- Motion
- Methods/Tools
- Evaluation Results
- Conclusions
- Next Steps

28

Evaluation Methods

- Usability
- Validation; Face, content, concurrent, construct and predictive
- Changes in Knowledge Acquisition and Knowledge Structure
  1. Comparative Experiments: 4 Comparison Study Groups using medical students and a standardized case; text-based only (“gold standard”) or VR enhanced, with or without distance using the Access Grid
  2. Knowledge structure relatedness ratings using individual students ranging from first year to fourth year in their programs

29

Knowledge Structure & Concept Mapping

Expert knowledge network of the 25 core hematoma concepts

30

Presentation Table of Contents

- Motivation
- Methods/Tools
- Evaluation Results
- Conclusions
- Next Steps

31

Conclusions

1. Virtual collaboration within VR is possible with multiple participants independent of distance
2. Students accept use of VR for education and training
3. Participants felt more engaged in VR
4. Students feel they learned best from their mistakes in VR

Conclusions

1. In comparative experiments, post-testing performance was similar between VR and non-VR Groups, as well as distributed and non-distributed groups, indicating VR or distance distribution "do no harm" and demonstrating concurrent validity with standard PBL-case methods
2. Knowledge structure relatedness ratings were significantly improved in those students with lower pre-VR relatedness ratings ($p = 0.014$)

Lessons learned – what worked, what didn't

- Interdisciplinary and interinstitutional team effort is synergistic and productive
- Requires strong project management to coordinate and insure appropriate progress (Hire a project coordinator)
- Develop an agreed upon timeline and deliverables. Set deadlines. Balance iteration and refinement with progress to completion
- Be realistic about achievement and completion of tasks. Don't try to do more than is likely possible with time and resources allotted (tends to require more time than anticipated)

34

Lessons learned – what worked, what didn't

- Need to assign specific project components and tasks to an individual point of contact (POC) who takes responsibility for organization, planning, implementation and completion of that task
- Find funds to support individual contributors and investigators in order to provide "protected time" and justify effort. This is an ongoing issue for sustainment of effort
- You can't please everyone and meet all needs so prepare for negotiation and possibility of turn-over of participation
- Address intellectual property rights and expectations
- Develop criteria for presentation, publication and authorship and encourage presentation and publishing of results

35

Presentation Table of Contents

- Motivation
- Methods/Tools
- Evaluation Results
- Conclusions
- Next Steps

36

Looking forward: What's for the future?

- Create "library" of simulations that are scalable and modifiable based on level of training, discipline
- Test proof of concept with multiple sites
- Need to validate each simulation scenario and evaluate impact on learning; knowledge structure and concept mapping; comparing trainee to expert

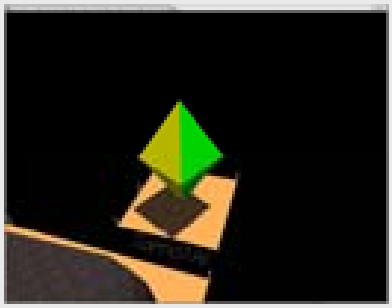
37

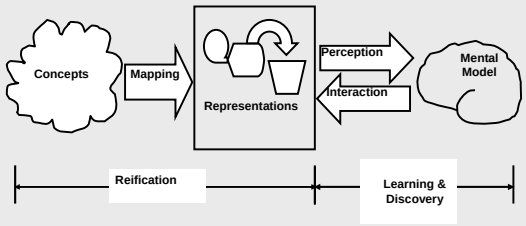
Looking forward: What's for the future?

- Incorporating distributed learning and interactive virtual reality simulation into the curriculum
  - Augments standardized patient actors and other simulators
  - Creates opportunity to teach and learn difficult or complex concepts through "reification" (e.g. renal physiology and the nephron)

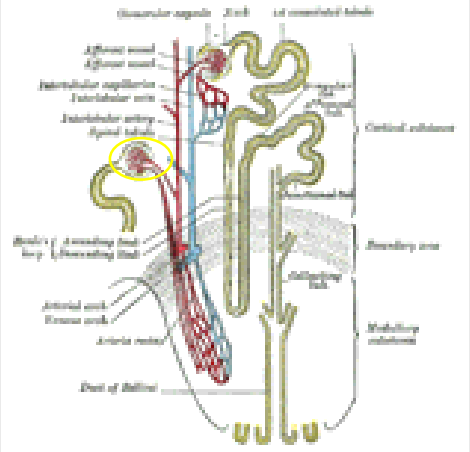
38

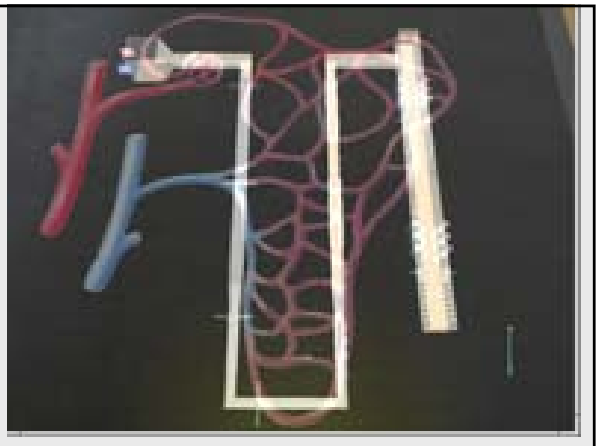
Reification of the AI



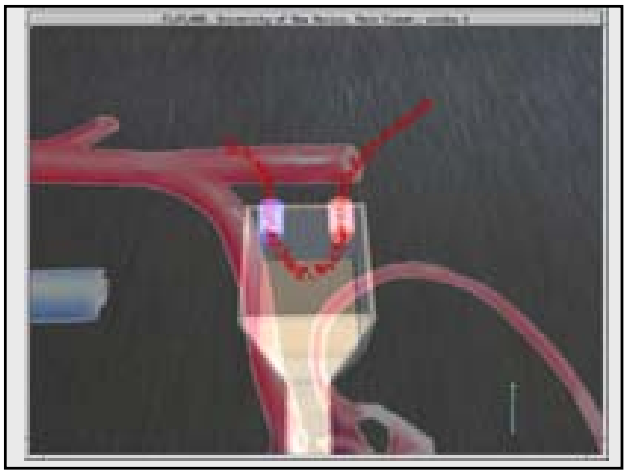


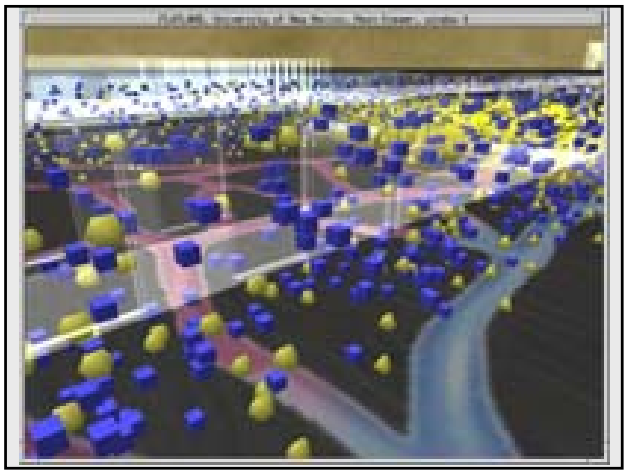
Reification is the mapping of abstract concepts into concrete representations, which are then used in the learning and discovery processes and can be combined with physical and "continuous semantic zooming"





The "Reified" Nephron: *Reification of anatomy and processes*





Reification of gradients and flows

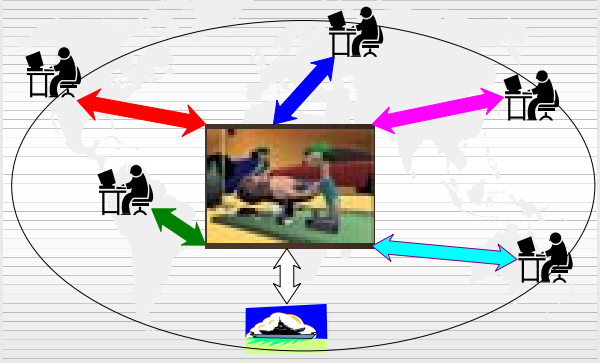
Looking forward: What's for the future?

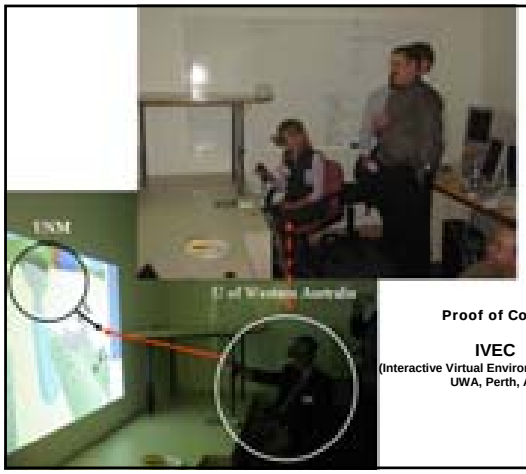
- Provide platform for performance assessment
- Avoid need to travel to a "simulation center" by providing a distributable platform for training and assessment and opportunities for "just-in-time" training

46

Distributed Learning In Interactive Virtual Reality Environments

via Next Generation Internet2 Grid Technology





Proof of Concept

IVEC
(Interactive Virtual Environments Center)
UWA, Perth, AU

Looking forward: What's for the future?

- Setting a national agenda
- Forming partnerships
- Develop additional funding support

49

AIMS

- Part of AIMS (Advanced Initiatives in Medical Simulation):
  designed to set a national strategic agenda and pathway for simulation research, development and implementation

50

Industry Partnerships

- Opportunities to partner with industry; digital entertainment and video-gaming industry to create professional quality, high fidelity 3-D animated models more efficiently

51

The *IMPACT* Model

IMPACT (Integrated Medical Performance Assessment and Credentialing Trainer)

- a model for "just-in-time" training
- a model for Advanced Distributed Learning (ADL)
- Uses distributable, interactive, fully immersive virtual reality and "multi-casting" for collaborative interaction independent of distance
- Designed to create a "library" of simulation scenarios to meet defined training and educational needs

52

Questions / Discussion

http://hsc.unm.edu/telemedicine

53