Virtual Reality and Medicine

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Professor
Grand Challenge Overview

- Enhance Virtual Reality

MATRIX is a virtual world Neo moves into this world leaving real world

AVATAR Transportation from one body to another
Definition of Virtual Reality

Howard Rhinegold:

“VR might be described as an environment in which the brain is coupled so tightly with the computer that the awareness of the user seems to be moving around inside the computer-created world the way people move around the natural environment.”
Components of VR

• Immersion
  – Coupling of visual, auditory and haptic senses
• Real-time visualization
  – Compelling visuals in real time
• Interaction
  – methods of interacting with the models or VR World
• Modeling of real world or physical systems in a simulated virtual environment
Immersion

See

Hear

Smell

Touch

a

b

c
Haptics: Touch and Force Feedback

Sarcos Dexterous Arm - Utah

Exoskeleton by Bergamasco

Full Arm and Full Body by Serbine
CyberGrasp™ Force Feedback Glove

Tactile Gaming Systems
3D Visualization

Stereo Glasses
Case Study: Application in Medicine
Medical Education

Dr. C. Everett Koop - Former US Surgeon General

“The medical knowledge we have today is 20 times as great as when I went to medical school, but in that time, the teaching methods haven’t changed much”

“We must stop Practicing on humans”
“Experiment on a Bird in an Air Pump” where the bird is deprived of oxygen by Joseph Wright of Derby, 1768.
Use of Cadavers

Herophilus performed the first recorded dissection around 300 B.C.

Artists such as Leonardo da Vinci and Michelangelo also performed dissection to enhance their artistic displays.
Physical Simulators – Limited Application

Peritoneal Dialysis Simulator
Phacoemulsification Simulator for eyes
Endospine Surgical Simulator

Sigmoidoscopic Examination Simulator
Arthroscopic Shoulder Simulator
Diagnostic Peritoneal Lavage Trainer

Courtesy: Simulation
SimMan 3G
Medical Needs for VR

- Training on Patients
- Lack of Physical Realism
  - Mannequins are no humans
  - Cadavers are not perfect medium
Advantages of VR

- No patient involved
- Repeated practice
- Evaluate doctors
Procedures and Applications

- Procedures Training
- Assisting in the Operating Theatre
- Rehabilitation
- Pre-operative planning
- Patient Education
- Telemedicine
Technical Challenges

Software and Mathematics
- Real Time Visualization
- Deformable tissue modeling
- Tool Tissue Interactions
- Computing Forces in Interaction
- Developing Medical procedures

Hardware
- Haptics Hardware
- Visual Hardware
- Tracking, Motion
- Task specific computers
Laparoscopic Simulator

Visualization

Interactive Device
Endovascular Virtual Trainer

Pre Op Endovascular Trainer (Angioplasty, angiography's etc)
Pace maker lead placement
Virtual Endotrachial Intubation Simulator

VR based training Residents, Paramedics, Emergency Medicine Personnel
Modeling

Realistic
Simulator

Haptic Device
da Vinci Surgical Robot

- Minimally Invasive Surgery with Robotic Technology
- Surgeon seated at console, viewing 3D image of surgical field, grasps master controls which translate hand, wrist & finger movements to surgical instruments inside patient
Da Vinci Si System
Da Vinci – Dr. Guru on Console
RoSS:
Dr. Kesavadas - UB
Dr. Guru – Roswell Park
RoSS Version 1.0

- Touchscreen display for proctoring
- Adjustable height
- Stereo HD display
- Kinematic chain Input (6 d.o.f)
- Pincers and Pedals:
- Portable Option

RoSS

da Vinci
RoSS Training Software

Orientation Module:

Surgical Skill Module:

Advanced Surgical Skill Module:

Motor Skill Module:
Knot Tying Algorithm

- Read the user input and move the surgical tools.
- Detect collision to check if the tool interacted with the thread.
- Update the thread accordingly based on Follow the Leader Algorithm.
- Thread is checked for self-collision and is corrected for it mathematically.

<table>
<thead>
<tr>
<th>Reidemeister move</th>
<th>Action performed</th>
<th>MDN after move</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I</td>
<td>Delete crossing 5</td>
<td>(1+, 2-, 3-, 4+, 2+, 1-, 4-, 6+, 6-, 3+)</td>
</tr>
<tr>
<td>Type I</td>
<td>Delete crossing 6</td>
<td>(1+, 2-, 3-, 4+, 2+, 1-, 4-, 3+)</td>
</tr>
<tr>
<td>Type III</td>
<td>Move crossing 2 to the right of thread joining crossing 1 and 4</td>
<td>(2-, 4+, 3-, 2+, 1+, 1-, 4+, 3+)</td>
</tr>
<tr>
<td>Type I</td>
<td>Delete crossing 1</td>
<td>(2-, 4+, 3-, 2+, 4-, 3+)</td>
</tr>
</tbody>
</table>

Follow the Leader (FLT)

FTL2(leader1, leader2)
{  
Copy \(N_{\text{leader1}}\) to \(N_{\text{leader2}}\) into array \(B_n\)
FTL1(leader1, leader2-1)
Copy \(N_{\text{leader1}}\) to \(N_{\text{leader2}}\) into array \(L_1\)
Copy \(B\) into \(N_{\text{leader1}}\) to \(N_{\text{leader2}}\)
FTL1(leader2, leader2+1)
Update \(N_{\text{leader1}}\) to \(N_{\text{leader2}}\) as average of \(N_i\) and \(L_{1_i}\)

Alexander Briggs
• Video
Virtual Prostatectomy (video)
Design of simulators

**Need?**
Is there a need or advantage of using VR in the application? Consider societal benefits e.g. better training, keeping out of harms way, improve quality of life, make process safer, better driver, fewer accidents, better health etc.

**Model?**
How will the proposed application be modeled - e.g. math or physics based systems, lessons, multimedia environment, from observation, videos, interview experts etc.

**Interface?**
What interface and systems will be used to simulate the proposed virtual environment. eg. cockpit of an aircraft to simulate a flight simultaneous.

**Evaluate?**
How will you evaluate if the proposed system works? - e.g. Human subject study, proficiency test, quiz, on the job performance etc - compare traditional way to virtual environment based approach.
How would you use VR?

- Surgery
- Skill Training
- Team training
- Nursing, Emergency Medicine