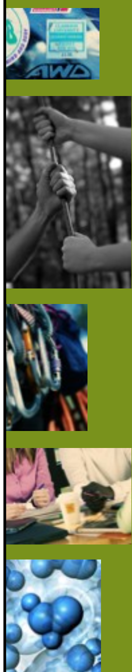

A Virtual Reality Application for Stroke Patient Rehabilitation

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Introduction

- Virtual Reality has shown promise as a physical therapy intervention technique because:
  - Enhances Neuroplasticity
    - Goal oriented and motivating
    - Repetition is important
    - Task oriented
    - At the appropriate level for the patient
  - Augmented feedback
  - Virtual teacher
  - Allows seamless collection of quantitative data to document objective changes

VR Application for Stroke Rehabilitation

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- Customizable to individual client needs
- Provides a highly immersive environment where the client can safely practice common ADLs and improve the motor function required to perform these activities
- Delivery of content is highly scaleable
- Generates quantitative data for the therapist to identify movement limitations and to assess the effectiveness of the intervention

Experimental Setup Hardware

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- Three 8’ by 10’ rear projected screens forming an open ended cube with stereoscopic display
  - VizTek ICUBE display system
  - Six Epson Powerlite 9300i projectors
- Networked PC Cluster
  - Three high-end, dual Xeon processor PCs with genlocked Nvidia FX3000G graphics cards
- Real-time motion capture capability within the visualization space
  - Polhemus FASTRAK system
  - Vicon MX series system

Overview of System Architecture

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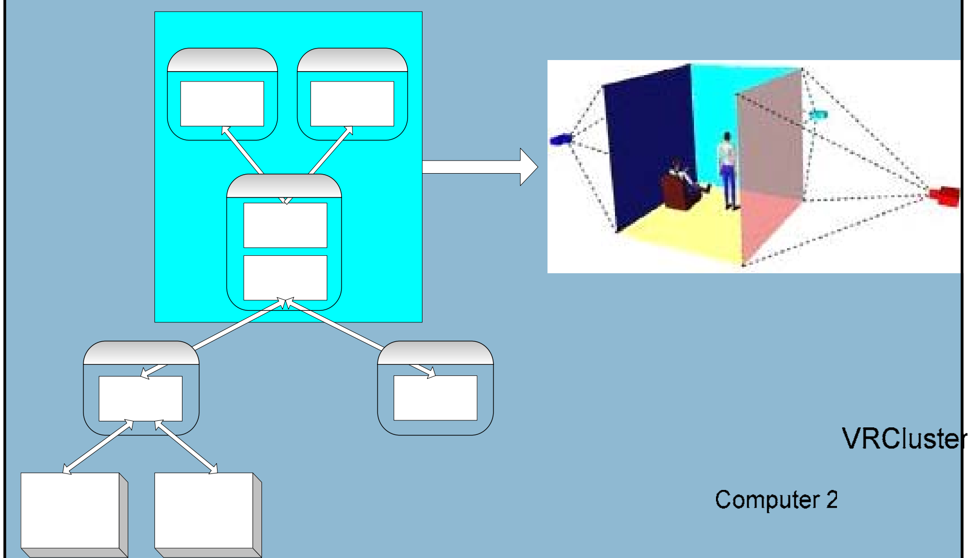

Experimental Setup Software

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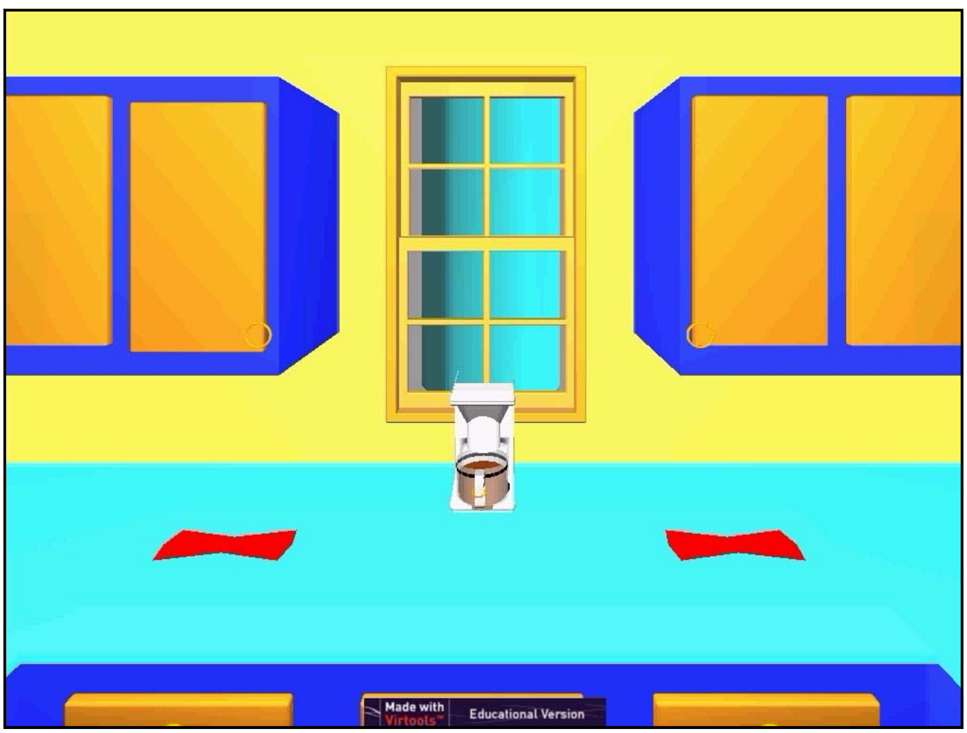
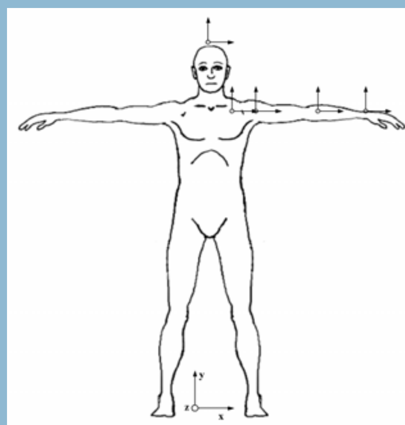
- Five main software components
  - 3D Studio Max 6.0
  - Virtools Dev 3.0
  - Virtual Reality Peripheral Network (VRPN)
  - Network Component Integrator (NCI)
  - C++ (Virtools SDK, Back-end Database)

Initial Virtual Environment

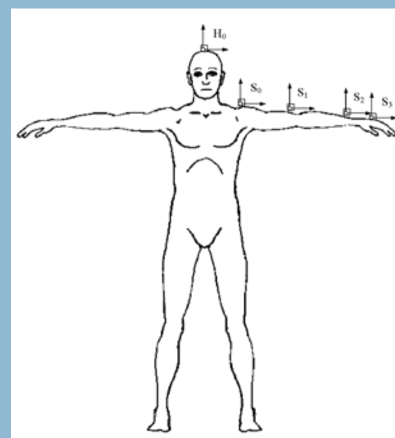
- Three-walled virtual kitchen
- Virtual reference arm
  - Driven by the client's arm motions
- Task can be scaled to the client's abilities



Arm Model and Sensor Locations



Reference Frames



Sensor Locations

Calculating Joint Angles

- Joint angles are calculated at pre-selected time intervals and the data points are stored in a back-end database
- Uses an underlying twist-based representation of the human body commonly used to model robotic systems
- Kinematic data is reconstructed offline using Matlab and analyzed by the therapist

Example Kinematic Data

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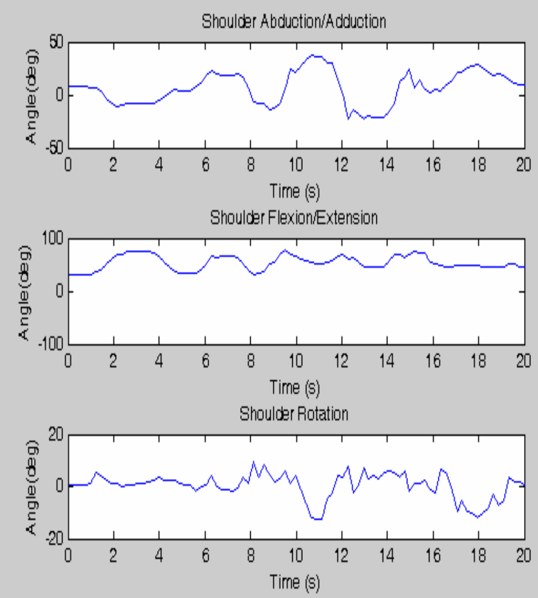

- Shoulder
  - Flexion/Extension
  - Abduction/Adduction
  - Rotation
- Elbow
  - Flexion/Extension
- Forearm
  - Pronation/Supination
- Wrist
  - Flexion/Extension
  - Radial/Ulnar deviation

Conclusions

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- Developed a framework for VR based rehabilitation interventions that permits
  - Shaping the task to the client's abilities
  - Increased practice time
  - Task oriented
  - Seamless collection of kinematic data
  - Immersive environment
  - Scaleable delivery of content
- Work to further develop the environment involves
  - Adding a larger set of scenarios
  - Developing user-friendly front-end application for therapist
  - Remote control of application using a Tablet PC or PDA