Serious Games for Virtual Rehabilitation in a Large Scale Virtual Reality Environment

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Overview

• Why serious Games?
• Related works
• First Person vs Third Person
• CAVE2
• RehabJim
• CAVEChef
• User study
Motivation

• Rehabilitation usually consists of some repetitive tasks
• Repetition is necessary, but at the same time often annoys patients

• How to create a better rehabilitation experience?
  • Virtual rehabilitation
  • Serious Games
Serious Games

- Computer applications which not only contains entertaining features, but also aspects of teaching and learning
- Go beyond mere entertainment
- Edutainment Category
- Very powerful tools:
  - Learner centered approach
Related Works

• Ma et al. developed 3 different games for virtual rehabilitation using a HMD to create an immersive experience:
  • Catch the orange
  • Fishing game
  • Whack a mouse

• VOTA (Virtual Occupational Therapist Assistant):
  • Upper limbs rehabilitation
  • Activity of daily living
  • No immersive environment
  • Microsoft Kinect

Related Works

• The Sorcerer’s apprentice:
  • Fantasy game for shoulder rehabilitation
  • Microsoft kinect
  • LCD display
  • Navigation using a controller and rehabilitation exercises with Kinect

• RehaLabyrinth:
  • Wii Fit balance board
  • Patient controls ball inside a labyrinth

First person vs Third person

• Our application can help domain scientists to understand which perspective is more effective in rehabilitation

• First person:
  • Only avatar arms are visible

• Third person:
  • Avatar body seen from behind at a certain distance
CAVE2

• Hybrid reality immersive environment
• 320 degree panoramic environment
• 72 displays
• 10 infra-red cameras
• 1 Microsoft Kinect
• 36 megapixel resolution per eye
RehabJim - Demo
RehabJim - Design

• Application design
  • Immersive experience
  • Simple natural features, minimalistic environment
  • Cartoon avatar both for therapists and patient
  • Avatar virtually situated in front of the user
  • Shadows on the ground

• User interaction
  • Wand controller
  • Speech recognition
RehabJim – Training Modes

• Tutorial

• Random objects

• Progressive distance

• Custom training
RehabJim – Additional Mode

• Distorted Reality
  • Swap left and right
  • Useful to see how users adapt to this situation
  • Could help patients with phantom pain

• Trajectory
  • Show the best path to reach object
  • Show the difference between the best path and the actual path
RehabJim - Tracking

- Microsoft Kinect v2
- Can track up to 6 users at the same time
- X, Y, Z position of the joints
- Only one is the patient, all the others are therapists
- System records position with a frequency of 30Hz
RehabJim – Patient Therapists Interaction

Therapist and patient can interact in virtual reality. This adds an additional training mode: the therapist can perform some movements with his/her avatar that the patient should reproduce with his/her avatar.
CAVEChef - Demo
CAVEChef – Game Description

• Main Level:
  • Composed by a series of tasks
  • Each task can be decomposed in several subtasks

• Minigames:
  • To make the experience more enjoyable

• Obstacles
  • To keep the attention on the screens
  • To perform particular movements
CAVEChef - Design

- Tried to keep the environment as simple as possible
- Activity of daily living
- Kitchen adapted to the CAVE shape
- Light and shadows to help users
- Cartoonish avatar
CAVEChef - Tracking

- Kinect range not enough for this application
- CAVE2 tracking system to track the user
- Users wear markers on their joints
CAVEChef – Highly Motivational Environment

• Meaningful play
• Sound effects to increase immersion
• Scoring system and rewards to increase users’ motivation
  • Point assigned when task, subtask or minigame completed successfully
  • Penalty assigned when obstacles hit or meal is burning
Innovative aspects

• RehabJim
  • Most of the approaches use a first person perspective
  • Therapists in virtual reality

• CAVEChef
  • Walking in CAVE
  • Walking rehabilitation without using external devices
User Study
User study - Overview

• 10 single user sessions performed
• Compare user experiences and performances when using a first person perspective and a third person perspective
• Compare Wand Controller and speech recognition when interacting with menus
User study - Structure

• Complete training session with first person perspective and third person perspective
• Interact with menus using Wand Controller
• Complete training session with first person perspective and third person perspective in distorted reality
• Interact with menus using Speech recognition
• Complete training session with first person perspective and third person perspective with trajectories enabled
User study - Measurements

- Number of objects caught
- Time to complete a training session
- Number of errors
- Time to activate the right command
- Number of errors
User study - Assumptions

• Not real patients, but useful insights about the experience in third person vs first person
• Didn’t check the stereo vision of subjects
• Used default eye separation values for all subjects
Results – Object Caught

• No significant differences
Results - Time

• Third person almost always faster than first person
Results - Time

• Field of view:
  • Human binocular vision, which is in charge of depth perception, covers only 110 degrees

• Under the previous assumptions and adding the fact that Unity worlds are not scientifically accurate:
  • Shadows on the floor help understanding the position of the object
  • In first person shadows are not visible causing a greater number of depth perception errors
Results – Perspective Errors

• 1 error if one or more corrections were performed to reach the object
• 2 errors if object not caught in time
• 0 errors if no corrections

![Average number of depth mistakes](image)
Results – Trajectory Mode

• Most of the users didn’t follow the suggested path, especially when the object was on one side of the screen and the nearest hand was on the other side.
Results – Help functionality

• When users use speech recognition they are more inclined to ask for help
Results – User interaction

- Voice more efficient but more error prone
- Speech recognition can’t be the only way to interact with the interface, a backup controller is necessary
Results - Questionnaire

- Evaluation of ease of use of the application
- Evaluation of first person
- Evaluation of third person
- Usefulness of tutorial
- Wand vs Voice
Results – Box Plot

• Scale from 0 to 10. 0 means difficult and 10 means easy
Conclusions

• Serious games can help people to adhere better to their rehabilitation routine
• With Rehabjim you can perform a rehabilitation training session using a first person perspective or a third person perspective
• CAVEChef allows only third person perspective and is based on the so-called activity of daily living
• The user study suggested that users feel comfortable when using a third person perspective
Thanks!