

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

# 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

Ma, M. and Bechkoum, K.: Serious games for movement therapy after stroke. In Systems, Man and Cybernetics, 2008. SMC 2008. IEEE International Conference on, pages 1872–1877. IEEE, 2008.

Adams, R. J., Lichter, M. D., Krepkovich, E. T., Ellington, A., White, M., and Diamond, P. T.: Assessing upper extremity motor function in practice of virtual activities of daily living. Neural Systems and Rehabilitation Engineering, IEEE Transactions on, 23(2):287–296, 2015.

# 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

Fikar, P., Schoenauer, C., and Kaufmann, H.: The sorcerer's apprentice a serious game aiding rehabilitation in the context of subacromial impingement syndrome. In Pervasive Computing Technologies for Healthcare (PervasiveHealth), 2013 7th International Conference on, pages 327–330. IEEE, 2013.

Baranyi, R., Willinger, R., Lederer, N., Grechenig, T., and Schramm, W.: Chances for serious games in rehabilitation of stroke patients on the example of utilizing the wii fit balance board. In 2013 IEEE 2nd International Conference on Serious Games and Applications for Health (SeGAH), pages 1–7. IEEE, 2013.

# 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

# 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 add an additional training mode: the therapist can perform some movements with his/her avatar that the patient should reproduce with his/her avatar.



CAVEChef



# 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

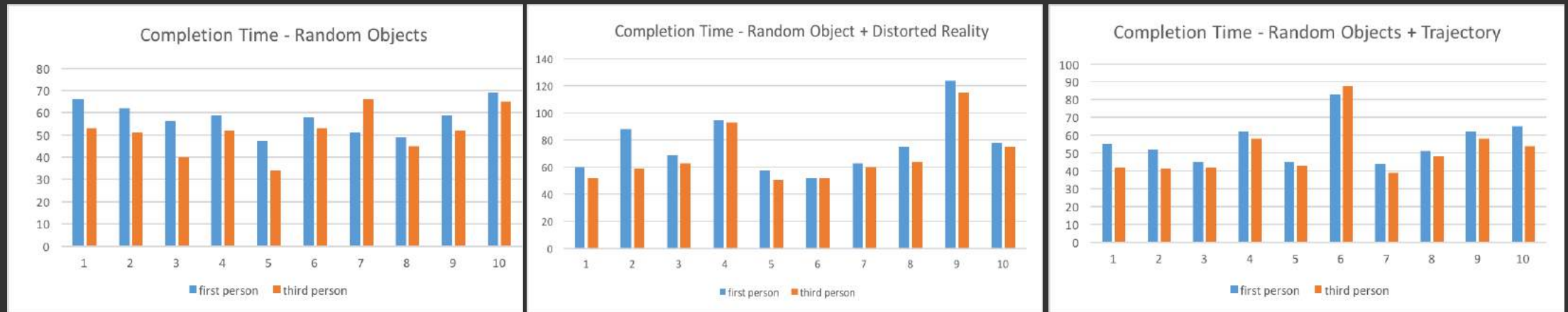
# Results – Object Caught

- No significant differences



# Results - Time

- Third person almost always faster than first person

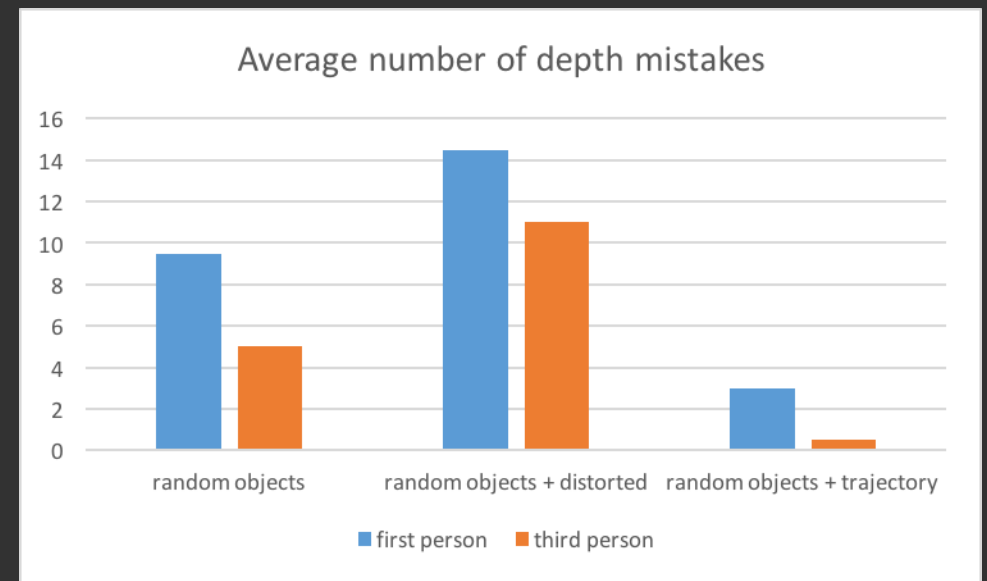


# Results - Time

- 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

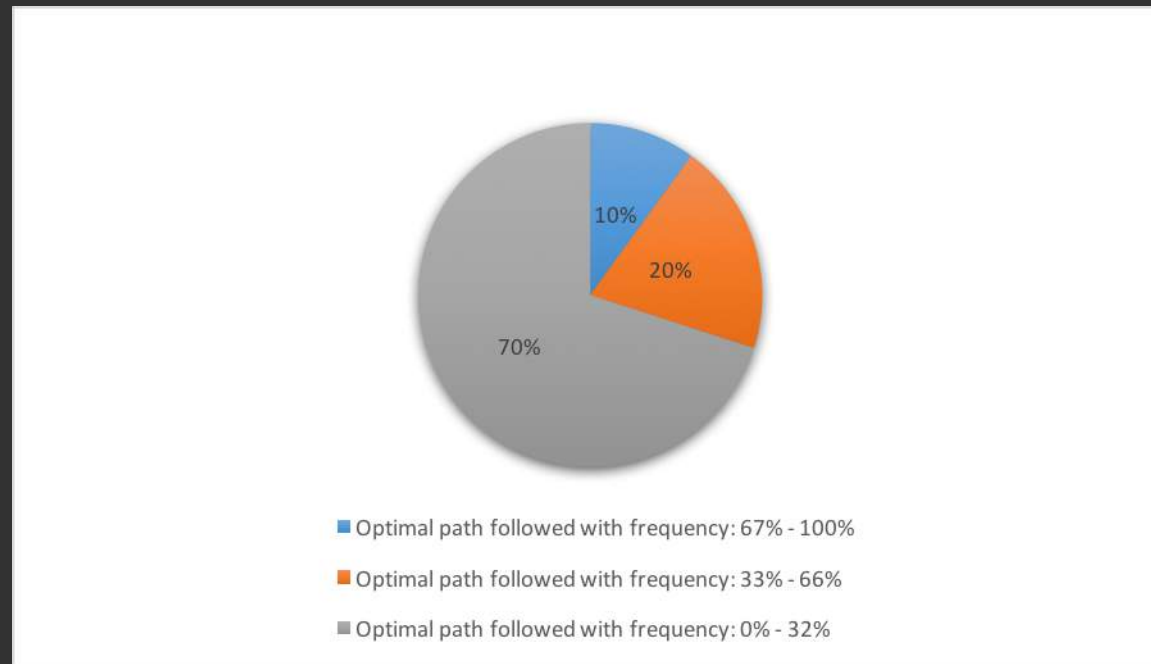
# Results – Perspective Errors

- 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



# 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.

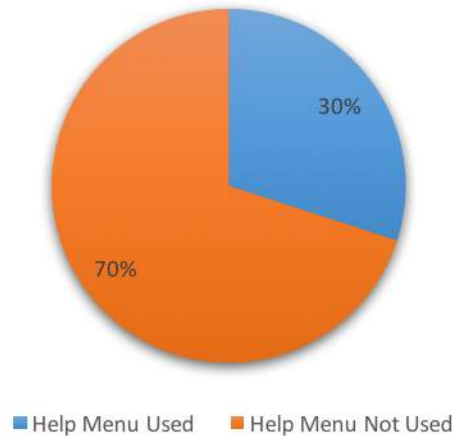




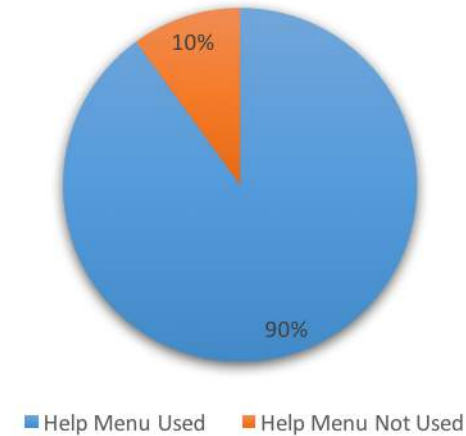
# Results – Help functionality

- When users use speech recognition they are more inclined to ask for help

Help Functionality with Wand Controller

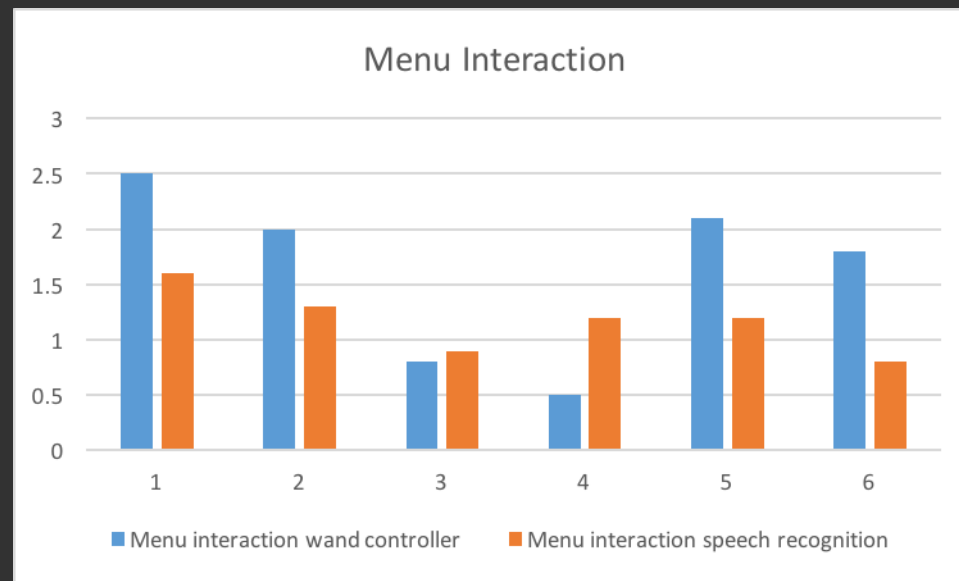


Help Functionality with Speech Recognition



# 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

University of Illinois at Chicago  
Department of Computer Science

Survey questions  
**Evaluation of Serious Games for Virtual Rehabilitation in a Large-Scale Virtual Reality Environment**

1. Please rate the **ease of use** of the RehabJim application on a scale of 1 to 10, with 1 being difficult and 10 being easy.

1 difficult	2	3	4	5	6	7	8	9	10 easy
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2. Please rate **how easy** is to reach the virtual objects on a scale of 1 to 10, with 1 being difficult and 10 being easy using a third person perspective.

1 difficult	2	3	4	5	6	7	8	9	10 easy
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3. Please rate **how easy** is to reach the virtual objects on a scale of 1 to 10, with 1 being difficult and 10 being easy using a first person perspective.

1 difficult	2	3	4	5	6	7	8	9	10 easy
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4. Please describe any difficulties you faced while trying to perform a rehabilitation training session.

5. Please rate the **ease of use** of the user interface on a scale of 1 to 10, with 1 being difficult and 10 being easy.

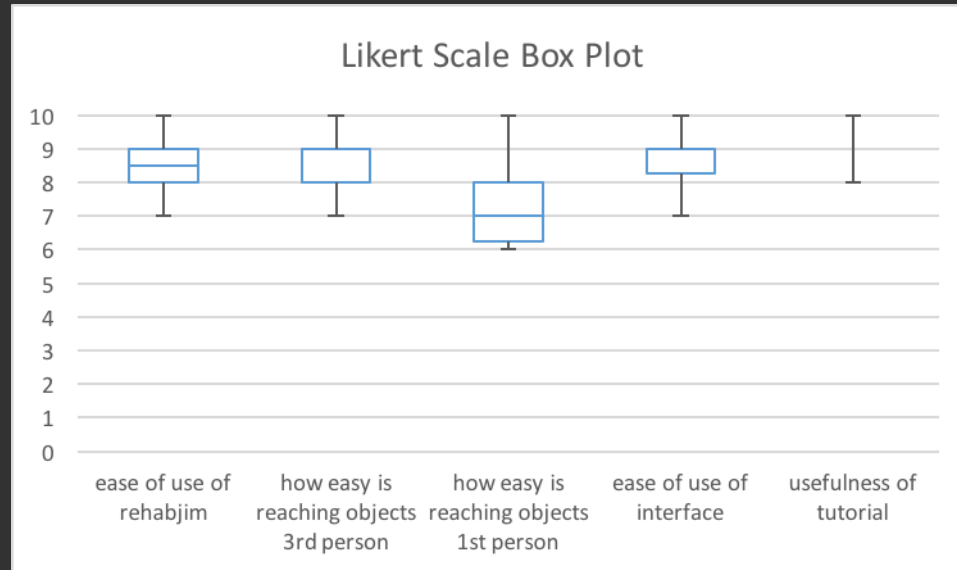
1 difficult	2	3	4	5	6	7	8	9	10 easy
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6. Of the two ways to interact with the user interface, which one did you like better? Please indicate your choice by making a tick mark against the appropriate option.

- Speech Recognition
- Wand Controller

# 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!