Virtual reality environments for cognitive and motor rehabilitation

Yaiza Álvarez
PhD Student
Dept. of Statistics, Computer Science and Mathematics
Public University of Navarre
Pamplona, Spain
yaiza.alvarez@unavarra.es

Jose Javier Astrain
Dept. of Statistics, Computer Science and Mathematics
Public University of Navarre
Pamplona, Spain
josej.astrain@unavarra.es

***Abstract*—Virtual reality (VR) consists of the sensory immersion of the user in an artificially generated environment. Head mounted Displays (HMDs) are usually used to introduce the user into these VR environments. Although the most common use of VR is more focused on video games, it has been also researched for its use in learning environments, focusing on cognitive and functional rehabilitation. The benefit of this is that multiple customizable environments or situations can be created, without the limitations of real physical scenarios. Real-life situations can be simulated, helping the user to enhance learning and skill development to everyday circumstances, without the risks or resources present in real life circumstances.**

***Keywords*—virtual reality (VR), rehabilitation, intellectual disabilities, physical disabilities.**

I. Introduction

Virtual reality (VR) is a set of digital computer-generated scenes able to simulate real environments. VR generates in the user the sensation of immersion in these virtual environments. These scenarios can be provided to the user through devices known as virtual reality glasses or headsets.

Stereoscopic Head-mounted Displays consist of two screens on which the user can see a different video sequence in each eye. By means of stereoscopic vision, the user perceives it as a three-dimensional space. VR environments do also enhance dynamic and interactive perception. In addition, the glasses include inertial and positioning sensors to be able to react to the movements made by the user and thus offer an immersive interactive experience. Therefore, when the user walks or moves his head or hands in the real world, his virtual avatar also does so in the virtual world.

II. Examples Of Virtual Reality In Rehabilitation

Virtual Reality is an innovative and promising technology for motor and cognitive rehabilitation. Wu, T. proposes a study analyzing the usability of an easy-to-use adaptation of the ”Virtual Reality Vocational Skills Training System” in high school students with intellectual disabilities [1]. Two differences between the original and easy-to-use versions were reported: added voice prompts and simplified the control buttons. Eight students with intellectual disabilities were chosen to participate in the study. The results were very positive, indicating that the easy-to-use version had good usability. The students were able to reduce the operation time and the number of wrong actions, as well, their accuracy was enhanced.

Brooks, B. evaluates the efficiency of using a virtual kitchen for vocational training of people with intellectual disabilities [2]. The results showed that virtual learning was as beneficial as real physical learning and that it was also better than learning through a book. The users were able to use the virtual kitchen environment and were motivated to learn with this training method.

Apart from learning, VR can be applied for functional rehabilitation. Pereira, M. propose a VR game to improve hand rehabilitation [3]. It evaluates the usability of the Oculus Quest for participants undergoing functional rehabilitation. Results were very favorable in terms of usability.

Choi, J. published an article in which VR games were used to promote wrist and forearm joint movements [4]. The results displayed significant improvements in upper extremity dexterity functions, in the performance of activities of daily living, and in forearm supination by kinematic analysis.

Mathews, M. developed a therapy that consisted of teaching users memory techniques using a computer [5]. Then, they practiced them in VR environments. This allowed the user’s actions to be recorded and individual instant feedback to be provided to the user. The final results indicated that this therapy was very effective.

III. Methodology

In order to define the working methodology of the PhD, the Brainsens collaborative research project (Fig. 1) has been taken as a reference. This project has been carried out at the Public University of Navarre by Álvarez, Y.

A. Participants

An important aspect of the project is user testing. To gather enough user data, it will be required to contact centers or institutions that might be interested in physical and cognitive rehabilitation. At least two kinds of user groups will be studied. Users with functional disabilities as ictus or strokes, and cognitive impairment as down syndrome or intellectual disabilities.

Figure 1. Brainsens project: kitchen and supermarket environment.

B. *Devices*

Priorly, a study will be made to choose the most suitable VR devices for carrying out the exercises. This decision will be made based on the usability and immersion capabilities of the HMD.

C. *Environment design*

Once the right device has been chosen and there is a clear understanding of how the environments and exercises will be structured, the development stage of the VR system will begin.

Figure 2. An example of VR scenario from the Brainsens project.

The proposal is to set up exercises using hand controls and to study the potential application of hand tracking. This is a technique in which the user's hands are the controls used to interact with the environment. However, it is something that is still under development, although simple exercises focused more on functional rehabilitation could be proposed. In order to collect useful user feedback, user testing about usability and subjective perceived workload will be carried out to check the implemented functions, so problems can be detected quickly and readjustments can be made in time.

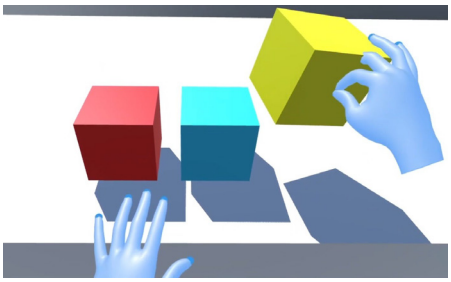

Figure 3. An example of VR scenario with hand tracking.

D. *Data collecting*

During the development of the exercises, the data that the healthcare workers or social-health workers consider necessary

will be collected. These data will be evaluation parameters to analyze if the patient is progressing favorably or not. Thanks to the wifi connection that the virtual reality devices have, the data collected could be sent to a specific application, allowing analyzing the results obtained for each exercise.

IV. Discussion

Technological advances in the area of virtual reality open up new possibilities in the development of applications in the health sector. From the rehabilitation approach, virtual reality provides the opportunity to practice activities that are not, or cannot be, practiced in a clinical setting. In addition, virtual reality environments can be designed to be more interesting and visually appealing than traditional therapy techniques, thus encouraging user participation and repetitiveness, which can lead to better progress [6].

V. Future work

The proposal of this PhD is to develop a software tool that allows virtual rehabilitation exercises to be performed independently of the limitations of the real environment. The only requirements would be: to have a VR device with which to do the exercises and to adapt the environment of the session to the activity (e.g.: clear the room, or define constraints as the users being seated, having a table in front of they or not, etc.).

The challenge posed in this PhD is to improve the most important cognitive and physical functions in patients undergoing rehabilitation, such as attention, orientation, memory, motor functions, and visuospatial skills (ability to represent, analyze and manipulate objects mentally).

This project is intended not only to help patients with some kind of disability but also to help those who are responsible for the rehabilitation sessions, providing them a software tool with scenarios or exercises that, due to the limitations of the installations or the center, cannot be carried out.

Acknowledgment

The Brainsens (0011-1365-2019-000076) research was funded by the Government of Navarre and the European Union with FEDER funds.

References

[1] Wu, T. (2020) "Usability of Virtual Reality Vocational Skills Training System for Students with Intellectual Disabilities", International Conference on Computers Helping People with Special Needs, pp. 123-129, Springer, Cham.

[2] Brooks, B (2002) "An evaluation of the efficacy of training people with learning disabilities in a virtual environment", Disabil. Rehabil., vol. 24, no. 11-12, pp. 627-633.

[3] Pereira, M. (2020) "A Virtual Reality Serious Game for Hand Rehabilitation Therapy", 2020 IEEE 8th Int. Conf. Serious Games Appl. Heal. SeGAH.

[4] Choi, J. (2021) "Virtual reality rehabilitation in children with brain injury: a randomized controlled trial", Dev. Med. Child Neurol., vol. 63, no. 4, pp. 480-487.

[5] Mathews, M. (2016) "A Virtual Reality Environment for Rehabilitation of Prospective Memory in Stroke Patients", Procedia Comput. Sci., vol. 96, pp. 7-15.

[6] Laver, K. (2012) "Virtual reality for stroke rehabilitation", Stroke, vol. 43, no. 2, pp. 20-21.