Virtual Reality for Cognitive Stimulation in the Elderly and Individuals with Disability

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Abstract: The recent advances in virtual reality enable the creation of highly realistic and immersive environments. The purpose of this project is to develop a virtual reality tool for cognitive stimulation in the elderly and people with disabilities through gamification. This tool will feature a range of activities, with adjustable difficulty levels and accessibility options. These activities can be combined with a 360º video to create a gymkhana or a circuit, providing users with an engaging and customized experience to enhance cognitive abilities and mental agility.

1 Introduction

Today, thanks to improvements in quality of life and advancements in the healthcare field (medicine, technology, assistance, etc.), life expectancy has increased, and people are reaching advanced ages in better health conditions. Therefore, active aging should be one of the fundamental pillars of both current and future society. The concept of "active aging" was promoted by the World Health Organization (WHO) in the 1990s. The WHO defined it as the process of optimizing health, participation, and security opportunities to enhance the quality of life as people age (World Health Assembly, 1999).

As part of this improvement in quality of life, cognitive stimulation is a crucial component (Franco-Gómez, Laura and García-González, Laura, 2022), the more stimuli a person receives, the greater their autonomy will be, and they will better cope with the cognitive decline associated with aging. These techniques can also be applicable to individuals with intellectual disabilities.

Taking all of this into account,this project proposes the implementation of a virtual reality (VR) tool that enables cognitive stimulation for both individuals with intellectual disabilities and older adults experiencing cognitive decline. This tool will feature a visually enjoyable and user-friendly design to encourage its utilization by the application's target users. Aspects such as usability, simplicity, and user-friendly controls within the virtual environment will be prioritized to ensure an intuitive and enjoyable user experience, minimizing any potential resistance.

The tool will offer a variety of activities designed to target different cognitive areas, with the flexibility to adjust their difficulty according to the user's preferences. Additionally, a 360º video viewing mode will be available, allowing for the integration of activities within the video, such as an obstacle course or gymkhana.

2 Technologies

The use of virtual reality technologies for this project enables the creation of immersive and interactive environments. In this context, we have opted for the Meta Quest 2 virtual reality headset (Meta, 2023a) this virtual reality solution is driven by its capacity to operate autonomously, negating the requirement for dedicated room setups or computer connections (though the latter is available if needed), as well as its integrated hand-tracking technology.

For its software development, we have chosen the Unity development engine (Unity, 2023), which offers a wide range of libraries for VR development and is one of the primary engines for 3D environments.

3 Description of the application

The Virtual Reality tool currently in development starts with a main menu, allowing the professional to choose from various options and environments for conducting activities.

As depicted in the application's navigation diagram (Figure 1), starting from the main menu, users will have the option to directly select an activity or access the 'Walk Mode' configuration. This mode will also include a random mode and the possibility to save preconfigured walks.

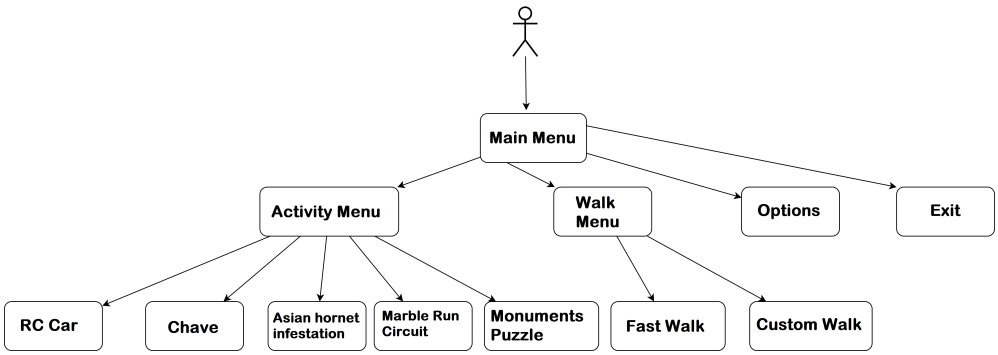

Figure 1: Overall Navigation Diagram

There is a 'Walk Mode,' which involves a 360º video in which various tests or activities are played during its execution, which the user must complete to continue the video playback. Both the video and the displayed activities can be selected in advance before starting the activity. Also, there is the option to perform each activity directly without going through the video process. These activities will be customizable in terms of their difficulty and duration.

We have collaborated with the Adcor Foundation (Adcor, 2023) to develop the following activities:

Asian hornet infestation: It involves a shooting challenge where the user must aim using the controllers at hornets that will appear in the environment.By pressing the primary button, they can shoot a ball, and if it hits the hornet, it will disappear. The difficulty of this challenge can be adjusted by changing the number of hornets to shoot down, their movement speed across the screen, or their stationary presence. Additionally, you can modify the number of hornets present simultaneously. This activity helps the user enhance reflexes, upper body coordination, and stability.

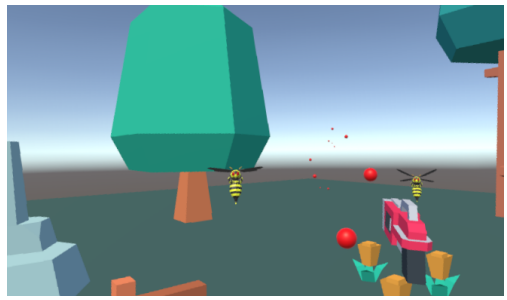

Figure 2: First-Person Screenshot of Asian hornet infestation

RC car: The user will see a radio-controlled car inside a race circuit and will be responsible for controlling it while following a series of waypoints that will appear to complete the course. The time taken to complete the circuit and the time spent off the road will be recorded. The difficulty can be adjusted by increasing or decreasing the length of the circuit. This activity helps improve the user's coordination and reflexes.

Figure 3: First-Person Screenshot of RC car

Chave: An adaptation of the traditional Galician game with the same name (Chave Compostela, 2023), in this activity, the user grabs a 'pello,' either with the controller or using the hand tracking feature, and throws it at the 'chave' with the goal of knocking it down. If needed, the user can approach to the 'chave' as closely as necessary to increase the difficulty. This activity helps improve the user's coordination, balance, and aim.

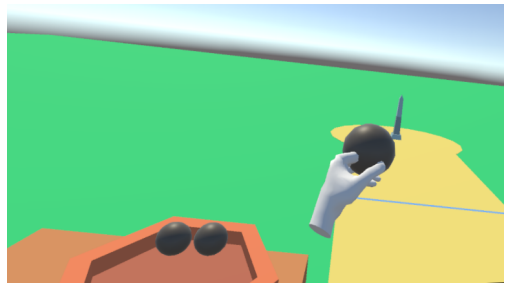

Figure 4: First-Person Screenshot of Chave

Monuments Puzzle: users are tasked with reconstructing various historical monuments that have been broken into pieces within a 3D object. They can use the controllers or their hands as needed. To simplify the task, the pieces don't have to fit perfectly; if the user makes an approximate placement, the program automatically connects them. The difficulty can be adjusted by changing the requirements for when this approximation is needed and the number of puzzles to complete. This activity helps enhance coordination and creativity.

Figure 5: First-Person Screenshot of Monuments Puzzle

Marble Run Circuit: this challenge involves arranging a series of ramp components so that the marble exiting the right square reaches the left square. To assist with this process, guide marks will be placed to indicate where the ramps should be positioned. Similar to the previous activity, if the user brings their position close enough, the ramps will be automatically placed. The ramps can be manipulated using the hands or the controllers. The difficulty can be adjusted by modifying the requirement for approximation or removing it entirely, and the number of puzzles to complete can also be varied. This activity helps improve coordination and creativity.

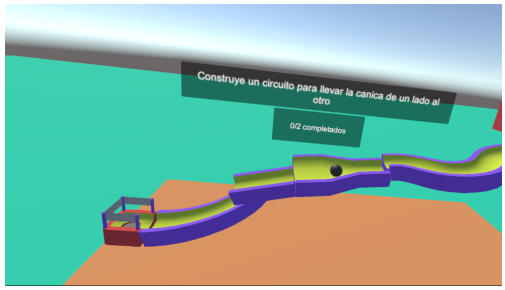

Figure 6: First-Person Screenshot of Marble Run Circuit

4 Discussion

Currently, there are several platforms for selling video games and virtual reality programs, such as Steam (Steam, 2023)] and Meta's own store (Meta, 2023b). The majority of commercial applications are geared towards a more general audience and may not be specialized for individuals with disabilities or the elderly, especially in the context of cognitive stimulation. Additionally, this market often lacks extensive customization options for difficulty levels and controls, as industry standards, while intuitive for those familiar with them, may not be as user-friendly for individuals who are less accustomed to such technologies.

The use of virtual reality for rehabilitation and cognitive stimulation offers numerous advantages, including the high degree of customization for activities, the gamification of physical

tasks that might otherwise be tedious, the safety of performing them in a controlled environment, and the ability to tailor difficulty levels to individual users, among many others.

Therefore, the application being developed in this project can be of significant assistance for cognitive stimulation in elderly individuals and/or those with disabilities. It allows for the adaptation of environments and controls to the user's needs, providing visual and auditory feedback during gameplay.

This tool can be used as a complement to other activities within the center, such as the use of 'Personalized Virtual Reality Environments for Intervention with People with Disability' (Lagos-Rodríguez, Manuel et al., 2022) at the time.

5 Conclusions

The application described in this article is a tool designed for use in the healthcare domain, specifically for cognitive stimulation in the elderly and individuals with disabilities. The utilization of virtual environments tailored to the user's abilities by rehabilitation professionals serves as a motivating factor, encouraging their active participation and commitment to the treatment process.

The environments and activities in this project offer clear advantages. It allows for the adaptation of controls for different user profiles in each of the proposed exercises, enabling the use of controllers and/or hand detection at any time. Additionally, the difficulty level can be adjusted for the various activities in the application.

The proposed tool facilitates gamification of different rehabilitation exercises. Since they take place in a closed and virtual environment, the supervising professional can monitor the user's actions at all times. This application offers a high degree of customization for the various activities and routes, tailoring them to the user's needs.

In the future, it is expected that this application will grow and become a valuable low-cost complement to the activities carried out in various centers involved in the project.

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