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Virtual Reality Haptic Device for Mental Illness Treatment

Leonel D. Deusdado[a], Alexandre F. J. Antunes[a]*

[a]*Research Centre in Digitalization and Intelligent Robotics (CeDRI), Polytechnic Institute of Bragança (IPB), Campus de Santa Apolónia, Bragança 5300-253, Portugal*

Abstract

Schizophrenia is a mental disorder that alters mental functioning and can cause hallucinations, mental disorientation, and a variety of other symptoms, which results in a separation of schizophrenics from society. Despite the fact that the condition has been known about for a long time, there is still an urgent need for research and testing to develop better therapies.

Virtual reality (VR) has had interesting outcomes when used to treat illnesses, and it is gradually emerging as a viable technical choice for the healthcare sector due to its immersion, which offers better and more intense user experiences. Once linked to a serious game, it can introduce the user to a number of situations that, when combined with medical assistance, aid in their rehabilitation and treatment.

The use of haptic devices enhances VR immersion by enabling users to comprehend virtual environments with greater nuance, which increases their level of believing in the new environment they are in. When used in conjunction with VR, it can improve the efficacy of the treatment, making its use viable for the treatment of psychic diseases.

The goal of this research is to develop haptic vest interactions using a three-dimensional virtual testing scenario to support and improve the use of VR for rehabilitation and therapy for schizophrenia. The established functionalities can be applied to a further serious game with the same focus.

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* Leonel D. Deusdado. ORCID: 0000−0002−9944−4386.
E-mail address: leodeus@ipb.pt
* Alexandre F. J. Antunes. ORCID: 0000−0001−6988−8237.
E-mail address: alexandrejarosz@ipb.pt

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1. Introduction

Schizophrenia is a psychiatric disorder which, despite the fact of it has been researched since the 19th century and with the evolution of technology, has not yet found a cure. In the past, there was a lack of information about this mental illness, and people were considered insane and committed to psychiatric centers [1]. With the advance of research, some types of schizophrenia have been identified, each with its own particular symptoms.

Treatment processes were done through electroconvulsive therapy, a technique that applied shocks to the patient in order to obtain an antipsychotic response, with research until these days to analyze its effectiveness. Another alternative was the use of antipsychotic medicines, but their effect was partially functional [2]. Schizophrenia can be hereditary or environmental, but it is known that the earlier it is discovered, the better the effectiveness of the treatment, because as time goes by the symptoms get worse.

Technology has been a great helper in the healthcare field for mental illness. Various systems are used as aids in sharing information, treatments, and therapies. Apps, websites, serious games, and various technical gadgets enable more effective and accurate results [3]. With the principle of making information about mental illnesses more accessible, people can have a better comprehension of the details of a patient with psychological problems, as well as the patients can understand better their particularly difficulties.

The current effort intends to optimize the circumstances of a testing scenario for a further serious game, and enhance its immersion, by customizing a haptic device and making it work in real-time with a VR application. This will enable better control over the experience and, consecutively, the treatment of a patient. As a result, studies are still being conducted to see how VR and haptic technologies may be enhanced and effectively used to treat schizophrenia. The GreenHealth (European Regional Development Fund) Project[1], which consists of digital strategies based on biological resources to enhance wellbeing and promote green health, includes this work.

2. State of the art

Since the 1990s, VR has been a great helper in the treatment process of patients with psychological problems. This is due to the great immersiveness provided, placing the patient in various scenarios so that, with medical monitoring, the user is exposed to situations that stimulate the brain to make decisions. With training in everyday tasks, the patient is proposed to accomplish simple goals and with the tranquility of being in a controlled environment.

It has been performing a fascinating role with studies when the focus is on rehabilitation. In their studies and results, Bortone et al. claim that serious games can be utilized as an effective treatment when combined with tactile gadgets [4].

A possibility of using VR applications is with serious games that enable a robust, immersive and secure experience. Studies prove the effectiveness of using VR games for people with schizophrenia for their motor and cognitive stimulation [5]. A major goal of advancing research and development in the treatment of people with mental illness is to reintroduce them back into society, interacting and contributing with others [6].

Using haptic devices, a technology that enables people to sense virtual items through touch, is one technique to further enhance immersion when using VR. Currently, there are various haptic device kinds for various body areas [7]. It is expected that, consecutively, the outcomes improve when rehabilitation is the target. This is a significant difficulty since it is crucial that the device configuration closely matches what is occurring in the virtual environment.

[1] The GreenHealth Project will focus on digital and biological technologies and their interaction with human health, environmental sustainability and economic development, based on assets from the territory.

It is becoming more popular to employ haptic devices in conjunction with VR, and there are numerous different sorts of studies that can be found. Many projects have been published over the years, such as the one by Sarac et al. that investigates the uses of a haptic bracelet for research in interaction with virtual objects [8]. Also, research on using a haptic pillow to improve sleep, reduce stress, and promote relaxation is presented by Kampa et al. [9]. A library for haptic devices with sound feedback stimuli was created by Artizzu et al. [10]. Nilson et al. also looked at the use of haptic proxies, which involved connecting virtual senses with actual items [11].

The vibro-tactile feedback from a haptic vest is used in an interesting experiment by Lee et al. to identify potentially dangerous objects in a real environment for those with vision impairment [12]. It is similar to the one being used to construct this project, which will be covered in more detail in the following part.

3. Test scenario

Reintegrating the patient into society is one of the main objectives. In consideration of this, creating diverse virtual scenarios based on actual locals and offering a safe virtual experience while presenting challenges that may be found in each real environment area, is one strategy to lead people into social experiences.

The user will encounter a variety of situations and be able to move through the scenario by teleporting, using the buttons on the controls, or walking in the real world, which makes movements into the application. That is possible with the recognition of the environment by the cameras attached to the VR glasses, passing the real movements into the scenario. For this project, we are using the Oculus Meta Quest 2, developed by Meta (Facebook) [13], which immerses the user in the environment and allows interaction through its controls.

We developed a scenario that serves as a testing environment where new features are developed and tested. It is possible that these researched technologies will be integrated in a serious game, in its final and improved version. The project is Open-Source and accessible on GitHub [14].

3.1. Metro scenario

The Marquês station in Porto, Portugal, served as the inspiration for the initial virtual setting (Fig. 1, a). It was chosen in previous works [1] for being in an important tourist city in the country, having a high possibility of recognition of the environment by numerous people, and being useful as a scenery idea for the project due to the wide range of possibilities to be explored.

Fig. 1. (a) Porto Marquês virtual metro scenario; (b) Several NPC; (c) Walking NPC.

Blender [15] was used to generate the 3D modeling, while Unity [16] was used to build the other features, such as VR integration. Seats, lighting objects, route maps, Non-Player Characters (NPC) (Fig. 1, b), among other objects, in conjunction with the train with four carriages, and the station itself are all included in the scenario.

The NPC are crucial because they add more wealth of details to the application and give the user interaction experiences. Each one has its own standby movement, which gives the scene more similarity with the reality. Although a character can move around the scene (Fig. 1, c), this may invade the space where the user is standing or moving.

This can be difficult for patients with schizophrenia, and it may take several sessions of therapy to help them feel comfortable and realize that it is a common occurrence. As a result, medical monitoring is essential. There are more than ten NPC distributed throughout the scenario, either in the station or inside the metro carriages (Fig. 1, b).

3.2. Tactsuit haptic vest

The usage of a haptic vest is an interesting aspect of the research, as haptic gadgets significantly boost immersiveness, which benefits the project and leads to better patient treatment outcomes [17]. The project is using the TactSuit X40 model [18], built by bHaptics [19], and includes 40 vibro-tactile motors, twenty in front and twenty behind, arranged in five rows by four columns, which enable us to combine these vibration motors in different ways to produce different patterns.

With this technology, there is the ability to develop several interesting attributes for the application. One of these, is to be able to sense in the haptic vest every time there is contact with an object within the scenario. For this, each of the vibro-tactile motors has been given a collision sensor within Unity [16], which when colliding, starts or stops the respective motor. The C# programming language [20] is being used, based on a simple interaction model posted by the vest developer bHaptics [21], being each actuation motor's identification, rotation in patterns, intensity, and duration adjustable.

Two haptic device interactions were inserted and tested for the project. The collision with the wall is one of them. The vibro-tactile motors in the vest will activate when the user pushes against the wall from behind, for instance, giving the impression that is leaning on a real wall. This approach can be viewed in the application's screenshot together with the appropriate vest illustration in the Fig. 2, a. The blue circles are the vest's motors, and the red balls are the motors that vibrate to create the interaction.

The second one, is the interaction that occurs when an NPC runs into a user, which also triggers the vest, and it is demonstrated in Fig. 2, b. What is remarkable about the size of the red balls is the intensity that can be configured depending on the intensity of interaction with the other objects in the scene, being the small ones are the lower intensities, and the big ones the higher.

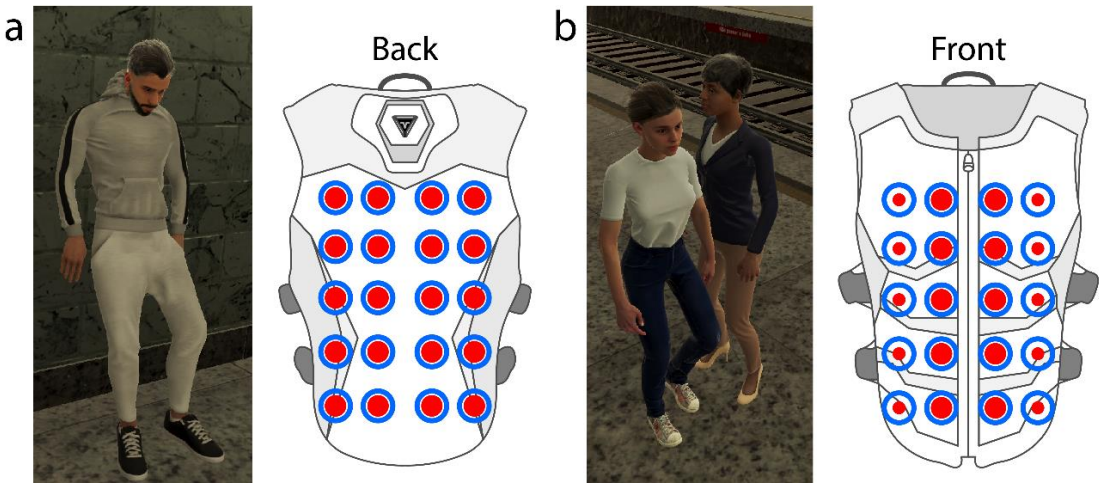

Fig. 2. (a) Wall interaction; (b) NPC interaction.

The metro scenario was tested, as is described in more detail in the Test and validation section below, in order to determine if the use of the haptic vest was appropriate for the experience and increased immersion.

4. Testing and validation

The test experiment, which some images are shown in Fig 3, was done with twelve people without schizophrenia, among students and professors, who participated in using our application; nine of them ranged in age from 18 to 30, and the remaining four from 31 to 50; there were also 10 women and two men, representing six different nationalities. Four of these students were using VR for the first time; seven had previously used VR with less sophisticated equipment; and the remaining students had previously used VR with similar equipment. They were instructed to try the movements, teleportation, haptic vest experiments, wait for the metro, boarding it, and traveling to the subsequent station.

Ten users said they felt no discomfort while wearing the haptic vest, whereas two others said they did. When using the application, these users felt a range of emotions that can be seen in the table 1, given that the numbers reflect the overall number from who experienced those emotions. The haptic vest's feedback level of realism efficiency was also questioned, and the table 2 shows the response, ranging from 1 (very bad) to 10 (very good), and in the body of the table there are how many people chose that level of realism (column), together with the subject (row).

Fig. 3. Test experiment.

Table 1. Emotions felt.

Emotion	Anxiety	Confusion	Fear	Claustrophobia	Impatient	Apprehension	Tranquility	Happiness	Relaxion
People amount	1	1	0	3	2	4	1	4	2

Table 2. Level of realism.

	1	2	3	4	5	6	7	8	9	10
Inside metro carriage					2	1	1	5	1	2
Navigation	1		1			4	3	2		1
Outside metro station							3	5	3	1
NPC animation				1	2	2	3	3	1	
Sound				2			1	4	3	2

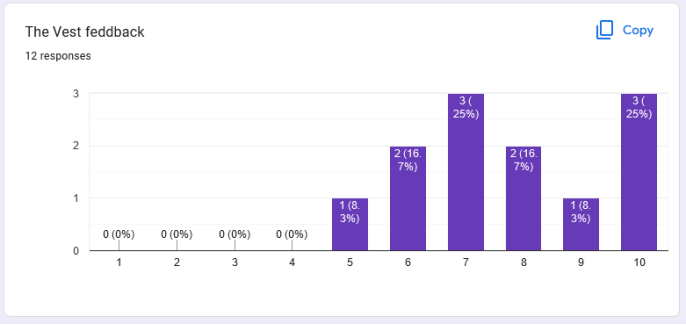

Fig. 4. The vest feedbacks.

The vest feedback is a highlight test (Fig. 4), and it is the most important information this project requires to realize the effectiveness of using a haptic vest to increase the level of realism. It is clear that the vest improves immersion, but it still needs to be improved.

5. Additions to the scenario after testing

One of the ways humans express affection and wish for the well-being of others is through the hug and embrace. Hugging, in addition to greeting others, can convey greater affection and companionship. Because it causes positive psychological and biochemical responses, hugging another person can be used to treat certain emotional problems [22].

With that in mind, this project seeks to investigate the use of hugging as a means of improving treatment for schizophrenics, as there is a lack of studies in this correlation. A new feature in the development and testing stages is an NPC that simulates a virtual hug, just like in real life.

Each type of hug can elicit a variety of emotions, which differ depending on the person and gender. Duaren et al. [23] show some hug tests between people of the same and different genders, using the hugs called crisscross and neck-waist. The crisscross hug was found to be more acceptable, especially between two males, and it was viewed as a more egalitarian, familiar, and pleasant hug. In view of Fig. 5, a, which shows two people hugging crisscross--style, Fig. 5, b, shows the same hug style that is being used to design this feature of the application.

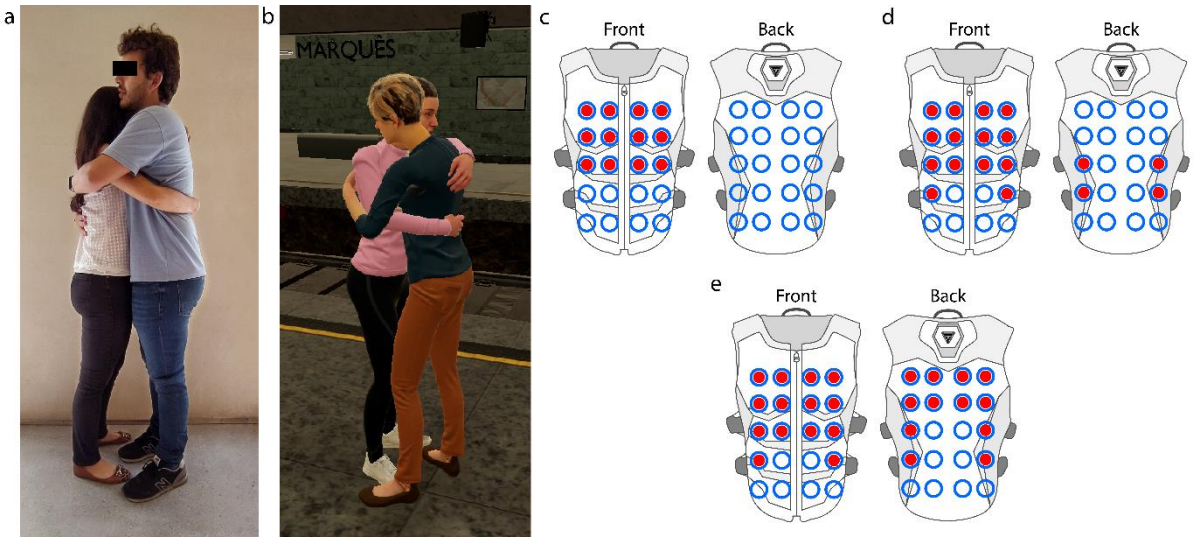

Fig. 5. (a) Human hug; (b) NPC hug; (c) First motors set; (d) Second motors set; (e) Third motors set.

The haptic vest is being used to increase the immersiveness and perception of the hug given by the NPC, conveying a better experience to the user. The haptic vest will trigger a set of vibro-tactile motors in a progressive sequence, beginning with Fig. 5, c, simulating the touch of the chests, progressing to the second set of motors in Fig. 5, d, simulating the touch of the forearm on the front and back, and ending with Fig. 5, e, simulating the complete hug.

Unlike the previous interactions with the wall and an NPC, the actuation of the vibro-tactile motors is done as a ready-made animation instead of in real-time via the sensors, as developed on the haptic vest design site made available to developers by the device developer [24].

6. Conclusions and future works

There is still not enough research about schizophrenia, despite the passage of time and technological advancement. Such a mental disorder requires constant scientific development in order to find more effective treatments that are always individualized for each patient. Reintegrating schizophrenics into society is admirable, but more research is required to make it happen more naturally.

Additionally, people need to be better informed about this illness so that they can understand the importance of providing care for the ill. Furthermore, providing schizophrenics with understanding of their problems and demonstrating a successful treatment course.

VR is also undergoing a rapid evolution and is proving to be an efficient technology across a wide range of goals and market areas. Due to its immersiveness, it can produce strong experiences, which call for prudence and responsibility. This is proving to be a more effective rehabilitation method for patients suffering from numerous disorders, including schizophrenia.

For the majority of people, the vest and other haptic devices boost how immersive VR is. It is crucial that it reacts appropriately to the application's events, because it is possible for it to produce results that are undesirable. When properly set up and thoroughly tested, the study of integration with rehabilitation-focused serious games can be helpful.

People experienced a variety of emotions, both positive and negative, while using the application, highlighting the need for further improvements to what was created as well as the addition of new features useful for the goal. There is also a need for more research linking VR and schizophrenia, and it is critical to focus on serious in-game interactions like hugging. Integrating all of these goals with haptic devices increases the need for research, tests, and new goals to boost effective treatment, primarily having a specialized medical follow-up to ensure schizophrenics' safety, always with responsibility and respect.

The test shows that the application has achieved a high level of reality comparison and clarifies areas for improvement. With this in mind, the application will be updated with a greater emphasis on the data obtained, and once it has reached a higher level of quality and safety, it will be tested with schizophrenics.

Other essential aspects for future works include methods for collecting data from users before, during, and after the experience. One of them is to use a smartwatch to measure the user's heart rate. The data will be saved in a real--time database and used by the application to personalize the experience based on the user's needs. In addition, use cameras to record the user's motions on video and examine if their body movements indicate any discomfort. When these new features are combined with haptic devices, new tests are required to ensure good results. Additionally, adjustments are being made to the NPC movement, lighting, sounds, different scene objects, gameplay, and user experience, together with the enhancement of the teleport control, which the participants found difficult to understand in the initial test experiment.

The goal is to create new surroundings and methods for helping schizophrenia patients overcome obstacles in their daily lives and reintegrate into society. Moreover, to exploring ways to use VR to elicit curiosity and positive feelings in those who use it, consequently advancing technology and health-related sectors.

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