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VIRTUAL REALITY SYSTEM - USE CASE SCENARIO FOR POST-TRAUMATIC STRESS DISORDER SYMPTOMS TREATMENT

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This scientific paper presents and focuses on analyzing a system based on virtual reality. The system can be used in multiple fields (such as medicine, art, tourism, archeology, etc.). In this article, we present, as a use case scenario, a medical implementation (with remote secure communication) designed to help and used for people who are affected by post-traumatic stress disorder (PTSD).

1. INTRODUCTION – VIRTUAL REALITY

Stress is a well-known and debated topic in medical science, mostly today, when almost everyone is stressed. Stress is one of the main factors for many diseases, such as psychiatric disorders, high cholesterol, ulcers, sudden increase or decrease in weight, heart disease, diabetes, Alzheimer's, and the list can go on. Virtual reality (VR) is a constantly evolving subject that can be introduced to study in almost every field. Also, the medical field is starting to use VR. It is mainly used to treat various psychological and psychiatric disorders. For example, treating various phobias: fear of water, fear of the dark, claustrophobia, fear of noise, etc. Besides the treatment of phobias, VR is used both to relieve and treat various types of stress caused by multiple factors: unpleasant past events, watching terrifying scenes that triggered a shock, etc. The disorder in which these types of stressful or underlying events are called SSTP or "post-traumatic stress disorder". In this case, the applications developed using VR come to the aid of those concerned: the user meets different types of scenes and stimuli, which resemble those of the terrifying event, to help him get used to it and overcome the trauma more easily. One category of people who are deeply affected by this syndrome, PTSD, are the military and veterans. These, having harsh conditions to endure during missions and scenes challenging to watch, remain deeply affected. In this paper, we will underline the benefits of using VR for treating PTSD [1]. One of the most effective treatments for PTSD, proven so far, has been that of exposure treatment combined with appropriate medication.

PTSD is a complex emotional and sensory experience that varies in duration, intensity, and factors and can also be different for everyone. Therefore, situational and emotional factors that coexist with this experience of trauma can alter the intensity of the other elements present for analyzing the user's behavior, such as attention, cognitive control, expectations, or aversive behavior.

This paper presents a potential efficacious method to facilitate post-traumatic stress disorder (PTSD), with a particular emphasis on the advantages of enhanced accessibility. The discussion elucidates the benefits of virtual reality from a cost perspective for patients, with specific consideration of the advantages for those with disabilities, regardless of their level of economic affluence.

Advanced technologies have successfully connected VR and the medical field to benefit doctors and patients. There are many studies [2] dedicated to the implementation of VR in the medical field. For example, the Creative Technologies Institute at the University of Southern California. The fields of medicine, in which VR and augmented reality have been most applied are for educational purposes, students, residents, helping Alzheimer's patients, training in operations, dealing with motor disorders, dentist, patient distraction. The VR systems could be employed for the evaluation of real-life scenarios and the execution of performance assessments [3].

The article presents a discussion of the creation and utilization of a treatment system via VR, which has the potential to be advantageous for individuals seeking remote access to medical recovery treatment. Another section of this paper presents a redundant remote access solution.

VR technology has been proven to be very useful in different affections, such as: stress (i.e. anxiety, anger), pain, in a very wide array of situations: radiology, chemotherapy, burn wound care, dental care, dental procedures. These studies showed that also the level of stress and also the level of pain is reduced, and the patient has a better overall experience. The capability of VR to reduce the level of stress is based on two important points: distraction and focus shifting mechanisms. Mechanisms that are behind all VR actions are not yet identified, but there is a large number of investigations referred to the complex interaction of cortical activity, associated with immersive VR. Using many technologies specific for VR, such as joysticks, controllers, data gloves and headsets, the VR applications give users a multisensorial experience [4] and help them get the attention away from stress stimuli [5].

The use of VR in the context of recovery or education offers a number of advantages, making the process more accessible to all participants.

The potential cost savings for participants through the utilisation of virtual reality technologies, including those from disadvantaged backgrounds (economically or otherwise), are outlined in the following section.

- The adoption of this technology has the potential to reduce the financial burden associated with field trips, including transportation, admission fees, and other related expenses.
- It offers access to high-quality treatment experiences, utilizing realistic 3D models and complex abstract concepts.
- All participants are assigned the same treatment level, regardless of their economic status or the extent of their disabilities (control variables can be modified).

2. MEDICAL APPROACH

PTSD is a disorder that is characterized by the re-experience of a traumatic event that comes from outside. In addition, PTSD can be accompanied by some symptoms: grade arousal and avoid stimuli associated with trauma. Medical specialists diagnose a person as PTSD-positive if the person has

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experienced, witnessed, or also faced an event that they are afraid of. The main factors that trigger PTSD are the actual death that means the moment when the person in question sees another person losing their life and the threat of death. Other factors that can trigger PTSD are sexual victimization, sexual abuse. Another very common factor, encountered in people who have problems with this syndrome are the military, because they are exposed to various causes (serious injury, threat of death, sight of a dying person, very strong and incessant noises). [6]

Medical field specialists defin 4 categories of PTSD, such as:

- Victim related trauma. - People diagnosed with this type of PTSD have witnessed a criminal attack and saw the scene in detail or were victims of the attack. Assaults of this type involve physical, verbal, sexual abuse or even rape. This form of trauma can also be triggered by a theft, burglary, kidnapping or terrorist attack.
- Trauma triggered by natural disasters. - The causes of this trauma are natural disasters, for example: tornadoes, hurricanes, hurricanes, and floods. Survivors of these natural disasters can be affected, and their PTSD trauma can be triggered.
- Survivor trauma - In this scenario, a victim and an antagonist are involved. Sometimes there can be multiple victims and only one person survives the incident. When this happens, people can have very specific PTSD trauma. This is related to the fact that they survived the incident, while the others lost their lives.
- Trauma triggered by perpetrator's guilt. - This trauma of PTSD is the most common. This type of trauma involves the negative feelings and thoughts of a person who was powerless over a factor that triggered the fear. In this type of scenario, it is possible that the person in question planned to participate in the scenario, realizing, later, only after the backlash, of the mistake he had made. They can be caught in the act either then or days or months after the incident [7]. Instead of the conventional allopathic medical approach, which often entails the use of addictive pharmaceuticals, virtual reality (VR) could serve as an alternative technique for pain management. [8]

3. STATE OF THE ART AND EXISTING APPS

In this section, we will list and describe some of the existing applications to treat PTSD, in the military field, with the help of VR and augmented reality. Specialists of the medical field have found 4 categories of PTSD:

- 3MDR "Modular Motion - Assets Memory Desensitization Reconsolidation" application is developed using VR as a result of a Cardiff University study. Preliminary studies have shown that the app can be an effective treatment for PTSD in military and veterans. Studies carried out demonstrate that these people have not been helped so much by the treatments that exist so far, with the exception of exposure treatment. Studies conducted on soldiers and military personnel affected by post-traumatic stress syndrome demonstrate an obvious improvement [9].

3MDR is a new treatment designed specifically for PTSD. It is based on therapy, through exposure to VR. The treatment also uses eye movement desensitization and reprocessing. Being a complex treatment, the patient walks on a treadmill, during which he interacts with a series of specially selected images. These images are projected in front of him and depict key moments that triggered his trauma [9].

- Bravemind - is VR software, powered by the USC Institute for Creative Technologies. This software is designed to help veterans and military personnel get rid of post-traumatic stress caused by the conditions they experienced during the war. According to a study by researchers involved in development, 2.7 million US military personnel have been involved in 5,400 military delegations to defend the party since September 11, 2001. These delegations have created many young soldiers suffering from PTSD. According to other studies, an average of 20 US soldiers commit suicide every day due to symptoms of PTSD [7]. To fight against PTSD and care for the military facing this problem, the partner, “SoldierStrong”, in collaboration with the administration “WarVeterans”, created “BraveMind”. Bravemind uses state-of-the-art technology to implement this exposure therapy. The system is defined as one with effective therapy, which has both results regarding the relief of post-traumatic stress symptoms, as well as an attractive interface, to attract people and provide a pleasant state, during the treatment. Albert Rizzo is Ph.D. and the Director of Medical Virtual Reality at the Institute for Creative Technology at the University of Southern California. According to the observed experiences over time with patients, he affirms the fact that the soldiers severely affected by this post-traumatic stress syndrome do not want to communicate with anyone about this problem, nor do they even consider that they would he had a problem [10].

This VR software is designed to adopt the exposure method: the patient is subjected to different scenarios, like those of war, to use his imagination. The patient, in this way, will recall the traumatic event and can talk about it with a therapist. This type of treatment is a strategy to combat PTSD. The therapy is adopted to force the patient to remember because a large part of the veterans say that they have very bad memory problems and they hardly remember the scenarios they have been through [11].

- Caren - The Caren system is a system developed using VR, which is an advanced platform for treating mental and physical problems. The word "Caren" is formed by merging two words: "CARE" and "DETECT." The system is designed to detect, cure and treat problems. The APT Center was instrumental in securing and installing new $3.8 million high-tech Ohio State research equipment in two projects (Clinically Applied Rehabilitation Engineering CARE and: Diagnostic Engineering Technologies for Evaluating Connective Tissues DETECT) at the LSCVAMC and its partner institutions (CWRU, CCF and Austen BioInnovation). An essential element that makes up the equipment is a 3D biotracer, manufactured by EnvisionTEC. It is able to create biocompatible tissue scaffolds, which can be made from a variety of materials, such as: soft hydrogels, molten polymers, or even very hard materials, for example, ceramics. The system presents new facilities, which include state-of-the-art equipment in terms of tissue processing, but also histology, real-time PCR, microfabrication [12].

4. USE CASE SCENARIOS FOR PTSD

To eliminate PTSD symptoms, medical specialists strongly recommend at least one of the following interventions to reduce and eliminate the PTSD symptoms:

- Cognitive-behavioral therapy (CBT) includes: thoughts, feeling and behavior. This therapy proposes to change the way in which the individual perceives the thoughts, the feelings he has and also the behavior he exhibits.
- Cognitive Processing Therapy (CPT) - is a therapy to aid of patients to teach them and make them change certain thoughts and beliefs, related to a certain traumatic event [13]
- Cognitive therapy - is derived from CBT by changing pessimistic areas and memories that cause trauma. [14]
- Prolongs exposure - is a specific type of cognitive therapy behavioral approach that teaches individuals to progressively manage memories, feelings and traumatic situations. [15]
- Eclectic brief psychotherapy - Short eclectic therapy is a type

of therapy that combines cognitive behavioral therapy, combined with a psychodynamic approach. The therapy aims to change the patient feeling of guilt or shame. [16]

• Eye Movement Desensitization and Reprocessing (EMDR) is a structured therapy type that encourage the patient to focus on a short sequence, from the entire trauma film, from memory. [17]

• Narrative Exposure Therapy (NET) - is intended for people who come in contact with one or more traumatic events. These experiences must contextualize and resemble the traumatic ones they felt at a given moment [18] combined with various medications, prescribed by the doctors. [19]

5. SYSTEM ARCHITECTURE

In Fig. 1 is presented the system remote connections. The connection are secured using SSL or IPsec VPNs [20]. Multiple medical doctors can treat the same patient. Fig. 2 presents the entity components system diagram. Entity represents an object, in the scope of the entire game. In the application, the entity can be described as any graphic object that is included in the game. Therefore, these objects are also called entities. Usually, these objects are unique, that is, they each have a unique ID.

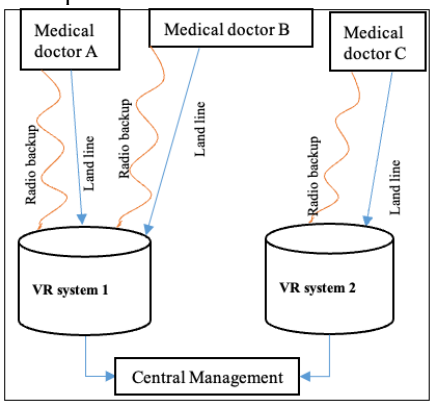

Fig. 1 – System overview

Component is another element that we find within the ECS type architecture. It has the role of giving the entity, the unique object, the property of being private and also gives it a certain label. Also, this component has the role of storing data related to an entity.

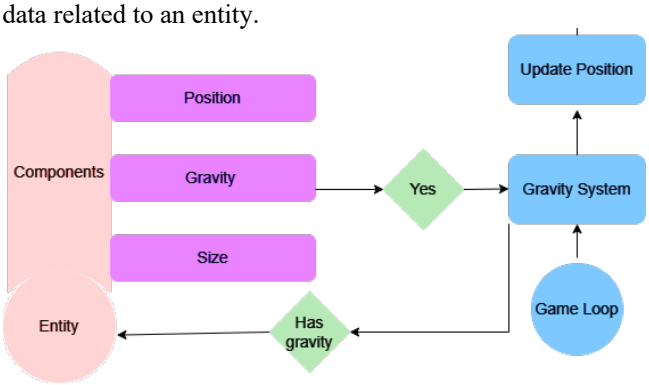

Fig. 2 – Entity component system diagram

For example, within our project, any entity, game object is defined by color, texture, size or, if it is an object that is characterized by movement, it will have attributes such as: size, position, gravity. These properties are stored within the component, which stores all the data of a range object. The system is the most important part of the ECS type architecture, within which there are both the entities and the components that describe them. A game can be described as a virtual physical system, in which different types of interactions take place between the elements found in that game. The system deals with interrogating the entities that are in the game, to find out data, which are needed to perform the calculations: for example, the system deals with retrieving the data of an object, such as its mass, speed or its position in space and with the related calculations to determine the new position of the object, after the displacement is completed. This architecture is not object-oriented programming, not about objects, but about components and about the actions that take place at the level of each element, which are described as a system. The entity object in the game card has the role of grouping the components, which have similarities, to be later analyzed by the system [21].

Fig. 3 – Unity Engine game print screen

Today, games have many elements that are inside the system, such as: elements that change their state, players, different graphic objects that make up the entire graphic system: houses, cars, balls, animals, characters and, of course, also elements that define all these elements. In this category of elements, we include position, rotation, speed, acceleration, mass, color, size, elasticity coefficient, etc. In every second of a game, there is a certain state of the game, which is stored in the ECS database, i.e. ECS central database. More precisely, it defines and stores the way in which game data changes. In a game, however simple it may be, it has many operations that occur inside it. Take, for example, a soldier who is in our PTSD treatment system using VR. This player, which is defined as an entity, is stored, through a component, in the database of the ECS architecture. The player is considered as an empty capsule, to which are attributed different elements that describe him: render system, which draws the player in the game plane, camera system, which positions the camera on the player, input system, which will change the position of the character depending on the input on which receives it from the user, the physical system, which changes the position of the character depending on the physics that is implemented in the game and the collision system, which describes whether or not the object collides with each other in the game plane [22].

An entire game can integrate many game objects inside them, which, in turn, encapsulate different characteristics necessary for their illustration in the game plan.

Another benefit that is specific to the component-entity architecture is that it facilitates game save mode. Due to the fact that the structure of this system is a core type and integrates several sub-systems inside, we can save the status of each sub-system much more easily. Often, saving a game object in the system is simple: simply Json-encode each component, which has certain characteristics, so that we can save the status of the game. [21]

To illustrate how the component entity type architecture works, we can see, on the left side of the image (Fig. 3), some

of the objects in the scene, which contain different specifications, such as: size, colors, etc.

Fig. 4 – Scenario with different tasks (app print screen)

The game places the user, a person affected by PTSD, in a first scenario, which illustrates a war scene. To integrate the user into the scene and to create a more realistic setting, a certain animation is attached to the soldiers. To complete the end of the game scene, the user must complete the tasks that are displayed on the screen (Fig. 4).

6. APPLICATION FUNCTIONALITIES

The current paper describes the entire development of the application (Fig 5). This system is a gamified VR application to relieve stress and traumas for militaries. The participant for the application is an adult, potentially from the military. During the game, his mission is to confront different tasks, in order to accomplish them. The application is mainly focused on exposure therapy: by definition, the exposure therapy means that the user has direct contact with stress factors. For the user to have an experience as close as possible to reality, we have implemented in the application a series of factors with which he can have contact [22].

Fig. 5 – Beginning of the scenario

For the user to go through these scenarios, we have implemented a series of critical points to help the user guide himself. In the exposure-specific treatments, it is recommended by the specialists that the user subjected to the test have contact with situations that increase in difficulty, from an easy level to something more difficult: the same principle is applied in this application as well. The points through which the user must pass have tasks that increase in difficulty and also that have more and more aggressive stimuli. UML diagrams are technical elements that describe all the functionalities that a system has. They are made up of simple graphic elements: they describe actions that take place in that application, states, auxiliary points. The working mode of the application in VR for the treatment of post-traumatic stress in the military field is illustrated with the help of two UML diagrams: an activity diagram (Fig. 6) and a use case diagram (Fig. 8, Fig. 9) [23]. In the first one, the activity diagram, we can observe the entire process of developing the application: the user enters the game and contacts the main menu of the application. In this menu, the user has many elements that he can access, namely: he can read the game instructions, he can change the game settings, or he can configure his options (volume, intensity, etc.). From any of these points, the user can enter the game and start with the first scene of the game. Randomly, by moving him on the game map, certain instructions will appear randomly to guide his path, for certain objectives. After these objectives are met, the user can proceed to the next scene.

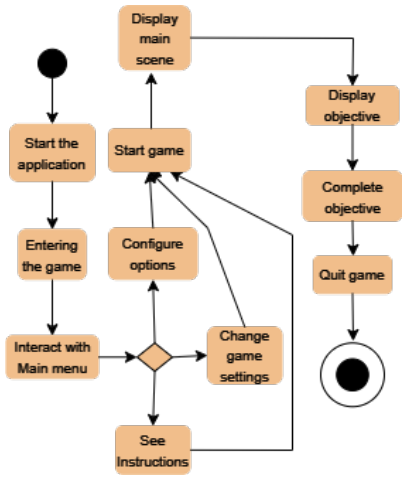

Fig. 6 – Activity diagram

From a technical point of view, this project is not built according to a normal application development process. In this project, the classic development elements of a project are not applied. As far as this application is concerned, it is a game type, it relies on graphic elements. To build a game-type application, the following steps are necessary, which we also applied in developing this application: testing, animations, and tests for each animation, interface graphics with the user, analysis of all scripts, *etc*. An essential feature of the games is the game creation engine. In our case, this is "Unity", which offers us a very good organization of elements (see Fig. 7 where all aspects of the game built in Unity are organized in folders and subfolders [24]).

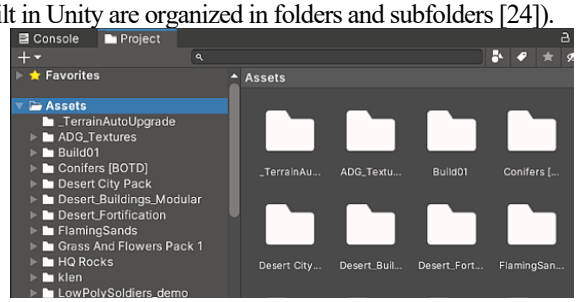

Fig. 7 – Organization of elements in folders and subfolders

The scenario that the user must go through consists of 3 scenes. The first scene consists of a war frame, with details specific to a battlefield, including elements particular to a war. Soldiers are illustrated in different poses (training, fighting), tanks, destroyed houses, fire, and sounds specific to a war setting. Studies show that an application built for an exposure treatment, to have the best possible results and for the user to have a greater capacity for reception, must-have elements of calmness and serenity [25].

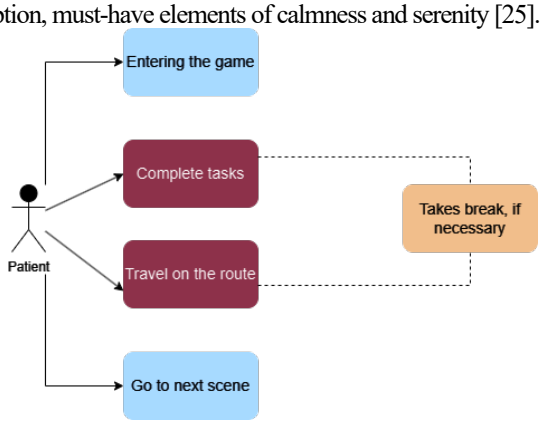

Fig. 8 – Use case diagram for patient

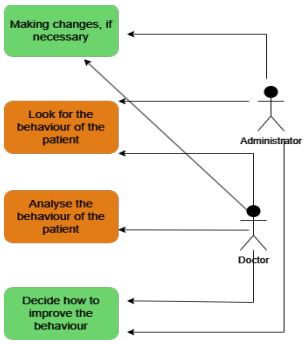

Fig. 9 – Use case diagram for administrator and doctor

These are distracting elements, which are found in all 3 scenarios, mainly in Scenario 2 which illustrates a calming scene, a walk through the forest, illustrated in Fig. 10.

Fig. 10 – Scene of the walk through the forest

This is intended to relax the user after he has had contact with the elements of the war, which brings him stress. Forest bathing is a practice that reduces stress and restores mental resources using immersion in nature. Also, people who don't have access to nature are the people who need it the most. This includes the case of soldiers who had poor contact with nature. Currently, research in VRE focuses on the qualities of a natural virtual environment for the highest possible quality and restorative impact. Research has also shown that multisensory VRE therapy has the most significant effect, which should be combined with at least one external stimulus: sound or smell. From a technical point of view, it is tough to black out smells in VR applications, which are still in the research stage. However, it has been shown that a multisensory VRE experience combined with sounds is much more effective. The trench scene represents the last scene of the game, illustrated in Fig. 11. The user meets another stimulus-specific to the war, the trenches. It is guided to perform tasks with the help of elements that appear progressively on the screen [26,27].

Fig. 11 – Trenches scene

IMPLEMENTATION

To create realistic scenarios, the majority of VR-based applications are designed as first-person controllers [28]. This was the approach that we adopted in our implementation. Game physics: physical elements are critical components in a 3D game. The objects in the scene of a 3D game must have a property, that of moving. To move, it is necessary to have specific physical quantities attached, namely speed and acceleration, that can decrease or increase with the change in speed. Also, besides these elements, another essential thing in the 3D world is collisions: objects in motion in a game suffer collisions with the ground when interacting with other objects in the game. Many of the collisions are operated by gravity. The person who is part of this application and who has control over the world is built on the "first person" principle: thus, the scenario is seen as through the eyes of the viewer. For the user to interact both with the ground and with the other objects, I have attached a "rigid body" object. In designing a 3d game, this is the most important element that defines all physical activity, namely: speed, acceleration, and gravity (collision with the ground). In case of adding collisions in the scene, an additional element is needed: collider. A game is closer to reality if character behavior implemented in the application has the behavior of a real physical person. This can be achieved using a "rigid body" and a "collider". If the object did not have these two elements attached, it can easily pass through the other objects in the scene, which leads to something far from reality. In unity, to attach a collider to a character, we can choose between several elements and shapes: sphere, cylinder, capsule or even a mesh type collider. In addition, within a game, we need to implement movement for our character. It needs physical elements to function and to move within normal parameters. Before implementing the character and its movement, the options were a first-person or third-person character. The first-person controller [29] [30] makes the game closer to reality and induces the user's "sense of presence" (Fig. 12).

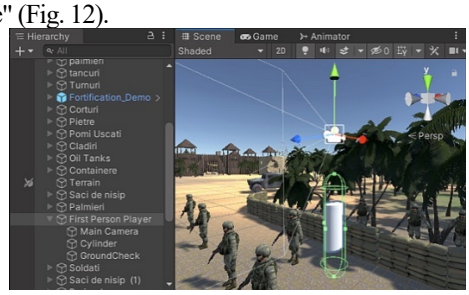

Fig. 12 – First-person controller capsule

GRAPHICS

Graphics is a characteristic element of Unity that offers many advantages. With its help, we can create many elements specific to 3D games: scenes, lights, cameras, textures on objects, and materials.

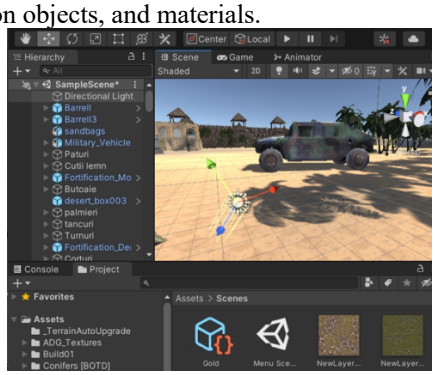

Fig. 13 – Representation of directional light

Light is an essential element in graphics, and it is also found within the Unity game engine. To set the light, we can choose different directions, intensities, or numbers of beams according to preference. Fig. 13 presents how the light is attached to the game. In our case, this is called unidirectional light, which is a predefined element within Unity. Using this unidirectional light, we can also represent the shadows of the objects in the scene, as seen in the figure. In creating a game as close as possible to reality, Unity offers us another graphic element, the skybox. Skybox is a predefined object in game creation engines, which is used, in general, to create a general atmosphere for the scene.

7. CONCLUSIONS

This research paper presents a VR-based system that is useful in multiple activities, such as medicine, archeology, history studies, and even art and tourism.

As a use case scenario, we present the improvement and treatment, together with the necessary medication, of people affected by post-traumatic syndrome. The application is intended for individuals who have experienced physical or psychological abuse or persons in the military who require specialized treatment and who are seeking an improvement in their symptoms. To create this VR system, we relied on the specific architecture of an infographic system, namely the component entity system. It facilitates both the work and the manipulation of objects and game objects in the system and their efficient saving.

Our next step is to create multiple scenes and interactions between the user and the panic state triggering factor to provide a greater scope for analyzing its symptoms. Software modeling using VR for real-time applications on distributed web systems may be limited. These limitations primarily concern the following areas: concurrently executed tasks, asynchronous events modeling (which includes a more comprehensive depiction of the mechanism that manages hardware interrupts), scheduling policies, modeling of temporal constraints, communication between tasks, and modeling of concurrent activities [31].

The system will be expanded to present VR scenarios for art and tourism (museums visiting), and archeological and history studies (archeological sites visiting, artifacts presentation and interaction).

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