# Exploring Virtual Reality for Neural Rehabilitation and Phobia Treatment

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**Abstract.** The principal objective of neural rehabilitation therapies is helping affected people to recover their mobility and reduce their dependency to other people in personal and occupational life. The way neural rehabilitation therapies are applied used to be based on the experience of the therapists and the epidemiological data available. Meanwhile, computer games (serious games), specially, based on virtual reality, are already used to treat exclusively certain types of phobia considering that an effective therapy consists on exposing patients to the source of their pathological fear within a controlled and safe environment. At present, at National Autonomous University of Mexico we are developing a set of applications based on videogames technology, programming them by the Unity SDK. The idea is helping patients to recover their mobility, which was lost by a neurological accident, or to confront their phobia. In this work we present the corresponding advances. In the case of neural rehabilitation, we focus the applications for ocular, head and neck recovery, developing some 3D scenarios for the Oculus Rift device. Respect to phobia treatment we consider attending arachnophobia, acrophobia and aviophobia, developing some 3D scenarios for Card Boards and also the Oculus Rift.

**Keywords:** Virtual reality · Videogames technologies · Neurorehabilitation · Phobia treatment

## 1 Introduction

According the World Health Organization, in the world exists about one thousand million people presenting some type of disability, and most of them do not have access to medical attention and rehabilitation services according their disability, in particular in countries with low and medium income [1]. That means this group does not have the chance to get the necessary autonomy and health required for a dignified life.

Habilitation and rehabilitation are medical processes, which can help people with an illness to recover independency or become independent in all senses and consist of a group of activities such as medical attention; physical, psychological, occupational and language therapy and support. Moreover, in [2] we find The Convention on the Rights of Persons with Disabilities has established a compromise where countries must guarantee to people with disability the access to satisfactory medical services


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(including sanitary attention, habilitation and rehabilitation services), without any kind of discrimination during attention [2].

In the other hand, we find that the Annual Health Report 2001 [3] of the World Health Organization was dedicated to Mental Health, the objective was to put in consideration the problems emerged from the mental health attention in the programs of global health and development agendas. Along with this enterprise, governments were invited to collaborate in the WHO 2000 initiative on Mental Health gathering information on the nature and extent of the problem, using the cross culturally validated Diagnostic Interview Schedule. In Mexico, the results of this effort were published in [4], where we find that the most commons mental disorders are specific phobia: 7.1% of population in Mexico presents one of these disorders.

At present, the use of interactive, 3D and video games technologies make possible to impact on the problems mentioned above, especially because it is possible to increase the number of patients that can receive attention at public specialized centers or at home. Also, the virtues of these technologies allow to check several human signals and activities avoiding the employ of a personal caregiver. Another virtue is that their use makes less difficult the doctor labor, helping them to monitor the therapy and control the patient activities. It means more patients can be attended by the same number of doctors.

The facts mentioned above where enough to begin to develop different interactive technologies in ours group. In this work we present some of the advances, in particular, the ones corresponding to the development of 3D scenarios for Virtual Reality systems. These scenarios were developed for motor rehabilitation of head, neck and eyes [5]; and also, for the treatment of different phobias: arachnophobia, acrophobia and aviophobia.

## 2 Academic Exploration

The development technologies applied to neurology since a scientific point of view are referred to 50 year ago. However, in this century is when the most important advances are presented. We find there is a high potential in the use of technologies for neurology due the possibility to improve human activities, these technologies were found applied in areas such as neural rehabilitation, diagnostic and neural monitoring, mental disorders, and other combinations of neurological and biomedical knowledge.

About five years ago we start to look for advances and projects corresponding to the development of interactive technologies and serious games applied to neuronal rehabilitation, and we find a few of these technologies, which were employed in hospitals by doctors and therapists as a reinforcement tool for conventional treatments and therapies [6–8], in particular they were using videogames. However, the user objective of most of these videogames were healthy people, in consequence they were not totally suitable for people with a disability. At present, we find projects sharing the same objectives and goals that to ours.

The next step after we laid the foundations for the development of videogames and virtual reality software for neural rehabilitation was exploring the use of these technologies in phobia treatment and we find in [9] some interesting works in the area.

At present, we can note the fast growing of interactive projects for rehabilitation and phobia treatment, this means we are introducing our workgroup in a promissory field of technological development with an encouraging benefit for patients with some grade of disability or mental disorder.

Finally, concerning the hardware, we decided to develop the virtual reality software (using the Unity SDK) for the Oculus Rift [10] (including the Leap Motion device in some cases), Google Cardboard [11] and recently for MetaVision [12] and Fove O [13].

## 3 Rehabilitation of Head, Neck and Eyes

A disability can be produced by a neural accident, leaving the person with cognitive and motor impairments, which affect its capability to live with total independency. The next action to take posterior to the accident is starting a therapy for an intensive rehabilitation, looking for the maximum recovery of the cognitive and motor functionalities.

After the neurological accident many patients will experience some type of visual disfunction. The visual effects associated with this accident can be categorized as sensory, motor and perceptual. In many cases, these disfunctions can be addressed by simple and effective therapies. However, in case of more severe accidents, patients are limited to move only their eyes or even not.

When patients are limited to eye movements, it is necessary to start a gradual motor rehabilitation therapy, where the first step is beginning with the ocular rehabilitation, followed by the head and neck motor recovery and then the arms, hands, and so on.

At present, the virtual reality technologies are employed in some therapies, but they are not considered as part integral part of them. The principal reason is that not always is possible to have the complete medical history of the patient, which is necessary to know if the use of the technology is acceptable for the patient.

In [14] is presented a study where is evaluated the employ of different user interfaces (2D, 3D, traditional and natural) with both stroke survivors and healthy participants. The results show that 3D interfaces exhibit better results in the motor domain versus a lower performance in the cognitive domain, suggesting the use of 2D natural user interfaces as a trade-off.

After considering these observations, as mentioned above, initially we decided to develop some 3D scenes for the Oculus Rift device to be used in rehabilitation therapies as an auxiliary tool always following the medical directions, instructions and considerations.

### 3.1 The Visual Field

The visual field is the observable space that is seen at any given moment, it is also defined as the restriction to what is visible. We note that when are performing eye movements the area of the visual field does not change, while when we are performing

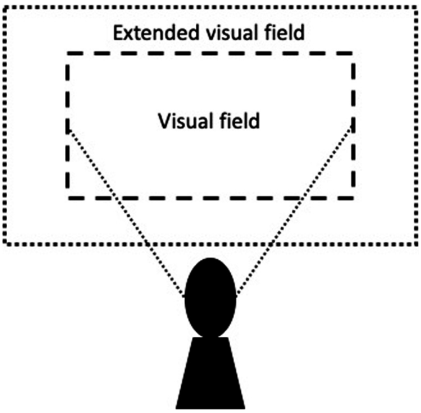


**Fig. 1.** The visual field.

the head or neck movements, the area is widen. In Fig. 1 we note the areas of the visual field for each case. In this work, we develop the dimension of the scenes according the type of therapy that will be performed by the patient.

### 3.2 Eyes, Head and Neck Training

The design of therapies for rehabilitation includes a group of movements or trajectory paths and the number of repetitions of each exercise according the patient necessities.

The scenes developed for eyes, head and neck training contain an attractive object, which is moving according the trajectory paths previously defined or programmed including a specific repetitions number. The trajectory paths are the arrange of different basic movements:

1. From ceil to floor vice versa.
2. From left to right and vice versa.
3. From the horizon to the proximity and vice versa.
4. From any upper corner to the opposite lower corner and vice versa.

During the trajectory of the object, it makes a pause at the middle of the path to have a softy tracking. By default, the patient carries out sets of ten repetitions for each trajectory. However, the number of repetitions and speed of displacement can be set via software.

When we are dealing with ocular rehabilitation, the trajectory paths that eyes follow are limited to the visual field due the head is fixed, meanwhile, when dealing with head or neck rehabilitation it is used the extended visual field because there are not limitations for the head movement.

The objective in ocular rehabilitation is the eyes of the patient follow the displacement of the object; no matter if the head is fixed. In the case of head or neck rehabilitation, the patient will also try to follow the object, which disappears of the field of view forcing to turn the head. Unconsciously, the patient must begin to recover their eyes, head or neck mobility gradually.

### 3.3 The 3D Scenes

We developed three different 3D scenarios for both cases of mobility recover training. As mentioned above, the scenarios where developed using Unity SDK for the Oculus Rift.

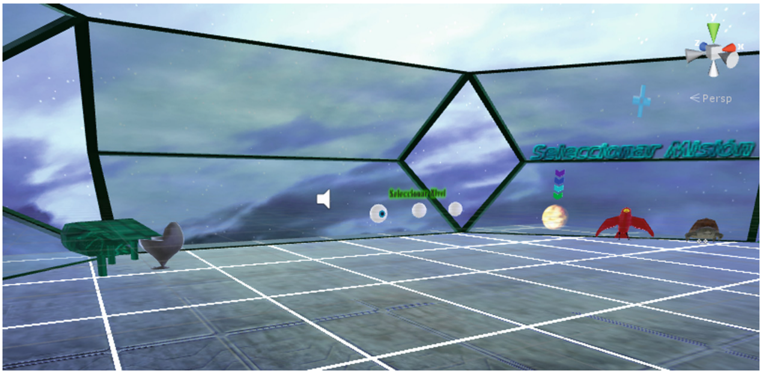


**Fig. 2.** Presentation of the menu to select scenario and type of training rehabilitation.


**Fig. 3.** Planet and Galaxy scenes. The planet is moving around the space according a previously determined path.

At first, when the user puts on the Oculus Rift, an initial scene appears exhibiting the menu where can select the scenario that will be used, and the type of training as illustrated in Fig. 2. In case the user is not able to select any option, another people can make the selection for him using the mouse. Once the type of training and scene are selected the user can begin the exercises.

Figure 3 shows the first scenario, which is a planet moving around the space. Before the planet starts to move around, a 3D arrow appears showing the direction of the next movement of the planet. The movements are performed according the trajectory paths defined by the therapist and were previously programmed. The user must follow with their eyes, head or neck the planet trajectory during some time or according the number of repetitions defined.

Figure 4 corresponds to the second scenario, which is a macaw flying in a jungle. Also, a 3D arrow is appearing in scene to show the direction of the flying of the macaw, this allows the user to know the training movements in advance.

Finally, Fig. 5 shows the third scenario, where a turtle is swimming under the sea, and the characteristics described above concerning movements are also exhibited.

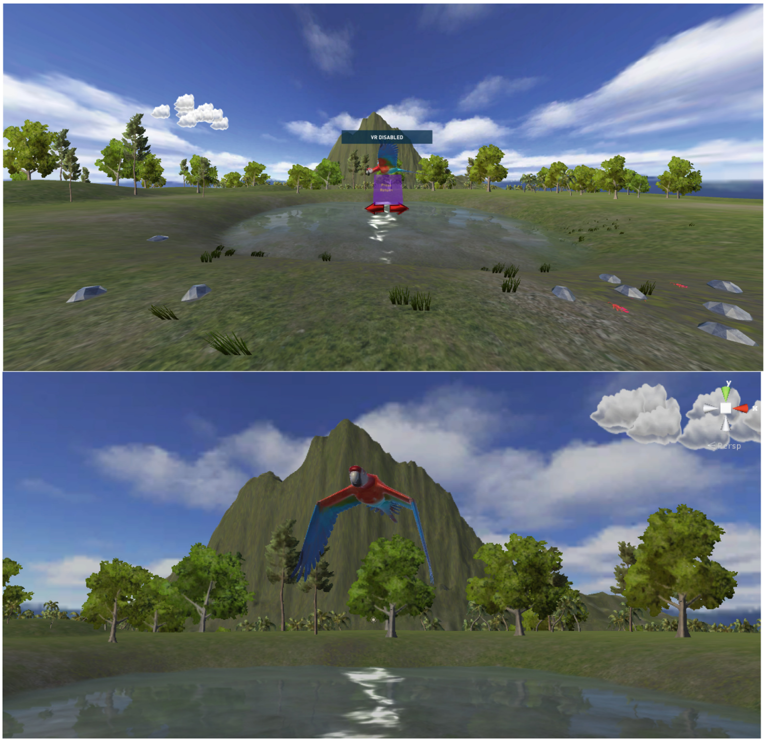


**Fig. 4.** Macaw and Jungle scenes. The macaw flies around according a previously determined path.

**Fig. 5.** Turtle and Deep-Sea scenes.

## 4 Phobia Treatment Using Virtual Reality

Phobia treatment is an area where virtual reality has not been totally exploited. In particular, we have not found a virtual reality system with features such as engagement or motivation, designed and developed for phobia treatments. This fact motivates us to try to implement some simple prototypes that could be used by therapists to enhance the experience of the patients during their treatment.

In [15] is reported the strong preference by patients to use virtual reality instead of in-vivo exposure in phobia treatments. The inclusion of virtual reality in phobia treatments presents some benefits after being tested with patients who suffered from a particular phobia [16]. Moreover, the introduction of head-mounted displays such as Oculus Rift, Metavision or Fove-O, provokes an increase of interest in people to use virtual reality in phobia treatment schemes. Moreover, since these devices are sufficiently portable and economically accessible, there is a good chance for patients to undertake phobia treatments at home. In this work we are presenting three different virtual reality computer programs, one for each specific phobia treatment: arachnophobia, acrophobia and aviophobia.

## 4.1 Arachnophobia

Arachnophobia corresponds to a very strong fear to spiders, it affects between 3.5% and 6.1% of the population [17]. Meanwhile, claustrophobia and arachnophobia need therapy help to cure them because political action is not enough.

A pilot study was presented in [18] and reports the potential effectiveness of virtual reality in the treatment of arachnophobia. In this study is observed a significant difference on self-report cognitive and behavioral metrics of spider phobia between pre-test and post-test. On arachnophobia questionnaires, the scores of participants significantly decreased. On the behavioral avoidance test, participants were able to go significantly further through the different steps after treatment.

Considering virtual reality technologies are attractive, one could wonder whether touching a virtual spider could increase the effectiveness of the treatment. Especially since therapists usually encourage the patients to touch the spider during in vivo exposure and modeling exercises.

Figure 6 presents the scenarios we developed for Oculus Rift and Google Cardboard. The reason to develop 3D environments for a cardboard is because actually almost all students (and people) have a smartphone and they will be able to use them.

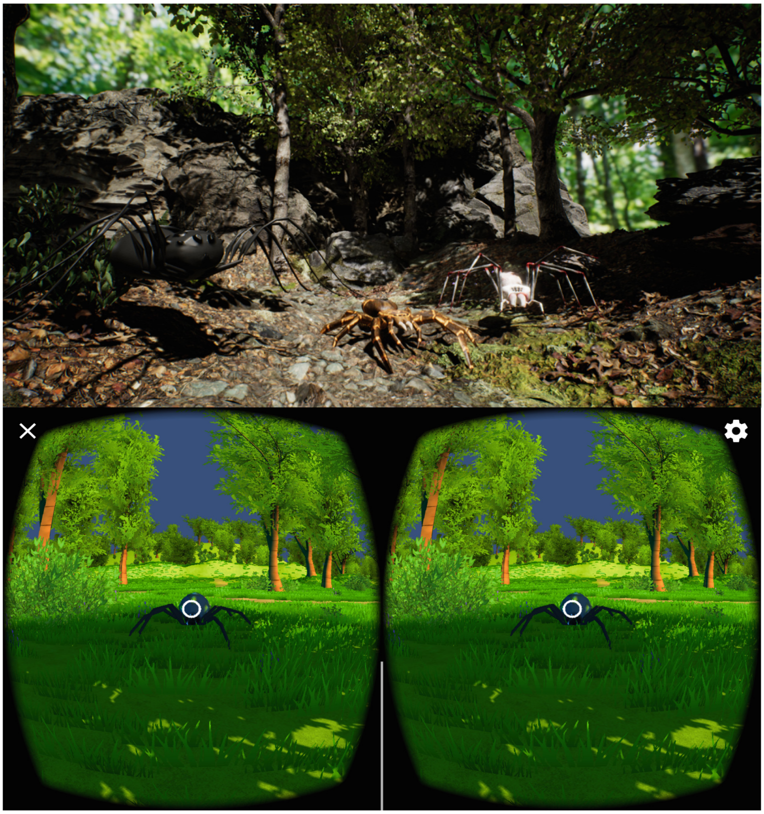

**Fig. 6.** Oculus Rift and Google cardboard environments for arachnophobia treatment.

We can check that the environment for Oculus Rift has more details and resolution that the ones for cardboard.

### 4.2 Acrophobia

Acrophobia is defined as an irrational fear of heights, especially when one is not particularly high up. Acrophobia belongs to a category of specific phobias, presenting a space and motion discomfort. About 5% of the general population suffer from acrophobia [19].

The combined benefits (flexibility and confidentiality, possibility to create and control, etc.) of virtual reality approaches suggest that it holds great promise as a therapeutic tool for enhancing acrophobia treatment outcomes [19].

Figure 7 shows the environment we developed for Oculus Rift. The theme of the scenarios is an amusement park, where different situations concerning to heights are presented. The environment also includes auditive stimuli.

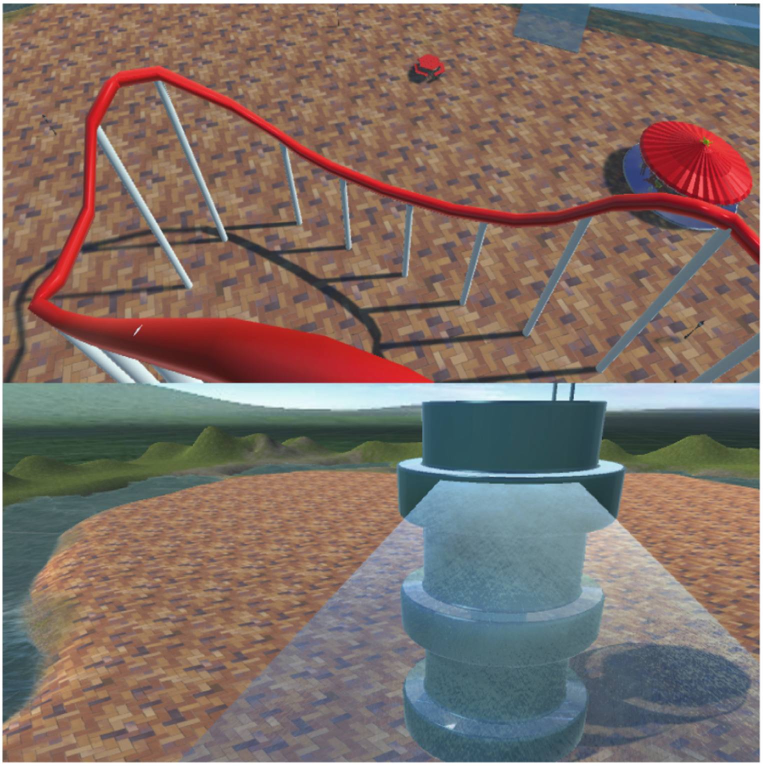

**Fig. 7.** Oculus Rift environments for agoraphobia treatment.

## 4.3 Aviophobia

Aviophobia is a fear of being on an airplane, or other flying vehicle, such as a helicopter, while in flight. It is also referred to as flying phobia, flight phobia or fear of flying.

It is a serious problem that affects millions of individuals. It has been estimated that 10–25% of the general population suffer this phobia [20].

The exposure therapy for aviophobia used to be an effective technique. However, this therapy is expensive, logistically difficult, and presents significant problems of patient confidentiality and potential embarrassment. The exposure therapy is usually provided in stages with patients first practicing going to an airport, seeing and hearing the sights and sounds of airplanes taking off and landing. Subsequently they might actually enter and sit in a stationary airplane. Ideally a flight experience would be the capstone of the therapy program.

The virtual reality exposure has been shown in a controlled study to be an effective treatment approach [20] because the patient is exposed to a virtual environment containing the feared stimulus. For that reason, we decided to develop an airport environment for a cardboard that could act as a tool for aviophobia treatment.

Figure 8 shows the environment we developed corresponding to Terminal 2 of Mexico City Airport. The idea is the user arrives to airport and moves around it until finds its seat on an airplane.

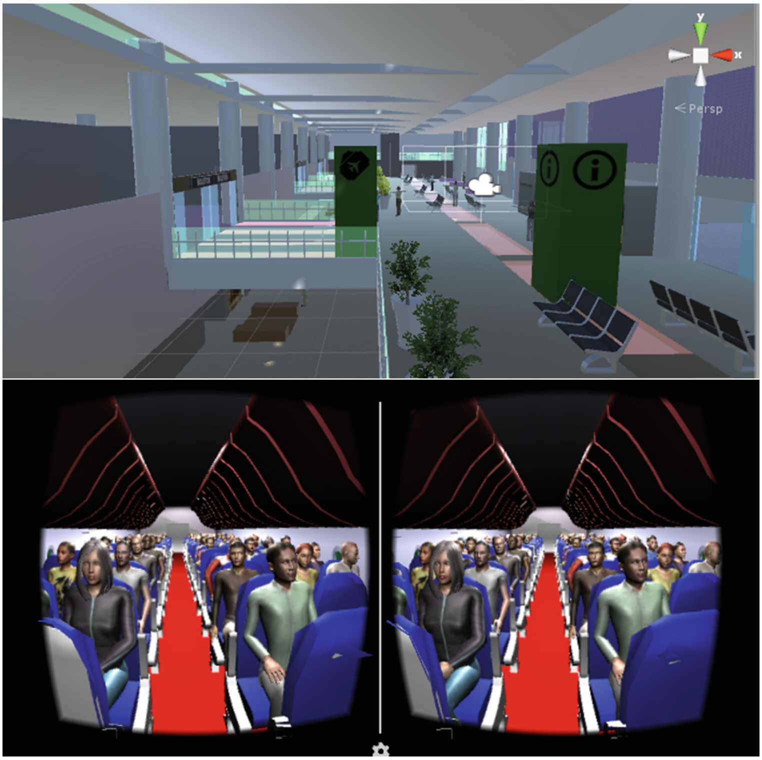


**Fig. 8.** Airport and airplane scenes for aviophobia treatment.

## 5 Conclusions and Further Work

We have presented some advances in virtual reality we have carried out in last five years. The environments we have developed are intended for neural rehabilitation and phobia treatments, both activities are concerned the neurology area.

We have used the Unity SDK as a standard platform in conjunction with Google cardboard, Oculus Rift and Leap Motion SDK. We are actually exploring Metavision and Fove-O for future works.

At this point we are more interested in academic use of these technologies than in clinical application. Virtual reality is very attractive and motivational to computer engineering students. The use of devices such as Oculus Rift, Leap Motion, Metavision, Fove-O and Google cardboard, and the development of scenes and programs on the Unity platform gives them another abilities, perspectives and opportunities for their professional life.

We pretend that the software developed for cardboard can be used for students of neurology, biology, psychology and biomedical engineering considering the extended use of smartphones and a cardboard is cheap or can be easily developed.

Finally, the use of virtual reality for some cases of neural rehabilitation and phobia treatment is innovative in Mexico. The expectation is to transfer our developments to a public health center to take notes about their advantages and disadvantages to could improve them. The final goal of this work is to provide new tools for neural rehabilitation that improve such task and offer new alternatives in the medical field.

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