Method to Improve Recovery Through Rehabilitation Techniques Using Virtual Reality with Motor Imaging Techniques

Christian Ovalle[1][a], Sandra Meza[2][b], Wilver Auccahuasi[3][c], Oscar Linares[4][d], Kitty Urbano[5][e], Gabriel Aiquipa[6][f], Yoni Nicolas-Rojas[7][g], Aly Auccahuasi[8][h], Tamara Pando-Ezcurra[9][i] and Karin Rojas[10][j]

[1]*Universidad Tecnológica del Perú, Lima, Peru*
[2]*Universidad ESAN, Lima, Peru*
[3]*Universidad Privada del Norte, Lima, Peru*
[4]*Universidad Continental, Huancayo, Peru*
[5]*Universidad Científica del Sur, Lima, Peru*
[6]*Universidad Tecnológica de los Andes, Apurimac, Peru*
[7]*Escuela superior la Pontificia, Ayacucho, Peru*
[8]*Universidad de Ingeniería y Tecnología, Lima, Peru*
[9]*Universidad Privada Peruano Alemana, Lima, Peru*
[10]*Universidad César Vallejo, Lima, Peru*

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Abstract: The new technological tools provided by information and communication technologies are changing the concepts and ways to perform certain actions, in the field of health, it is being applied to a great extent, we can note that one of them is the Virtual Reality technology, in its different equipment and applications, one of the related areas where you can take advantage of the immersion and abstraction, is related to rehabilitation procedures, In this case we can indicate if you have any immobilization or absence of these members, the rehabilitation processes of these situations, is highly aggressive in order to walk again in a coordinated manner or a more serious case is when resorting to the use of a prosthesis, we must indicate that when we walk, there is a harmony in the movement of the arms and legs, any absence or immobilization of these, will affect the movement. In the present work we present a method applying Virtual Reality, which uses the techniques of motor imagery, to help in the recovery through virtual therapies, the proposed method uses three main elements, such as Virtual Reality glasses, which will be used by the patient and where he will visualize the movements and images of the feet, arms, legs, among other images or videos to strengthen self-confidence in the recovery process, Then we need a computer, which will be responsible for issuing and controlling the sequence of images, a third element that is responsible for making possible the connectivity and the ability to share images and videos, is the Virtual Desktop application, through this tool you can share the computer screen to visualize the virtual reality glasses, we must consider that the equipment must be connected to the same network.

[a] https://orcid.org/0000-0002-5559-5684
[b] https://orcid.org/0000-0002-4650-1340
[c] https://orcid.org/0000-0001-8820-4013
[d] https://orcid.org/0000-0002-7952-9518
[e] https://orcid.org/0000-0003-2009-000X
[f] https://orcid.org/0000-0002-3755-7393
[g] https://orcid.org/0000-0001-6493-6084
[h] https://orcid.org/0000-0001-5069-0415
[i] https://orcid.org/0000-0003-0301-3440
[j] https://orcid.org/0000-0002-6867-0778

Ovalle, C., Meza, S., Auccahuasi, W., Linares, O., Urbano, K., Aiquipa, G., Nicolas-Rojas, Y., Auccahuasi, A., Pando-Ezcurra, T. and Rojas, K.
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1 INTRODUCTION

Performing a literature review, we found works related to the application of technological tools in favor of patients, where it is evidenced that presenting related images as the way of walking, patients begin the retraining process (Auccahuasi, et al. 2019). In rehabilitation procedures we can evidence the level of behavior of patients, managing to measure the level of concentration when they are performing rehabilitation exercises, these measurements are made thanks to techniques related to the use of brain-computer interface (Auccahuasi, et al. 2019). The use of technology is used for the benefit of evaluating the gait aspect, seen in this way, we find that gait is one of the main mechanisms of the human being, so there is much concern that people who have been affected, manage to recover the ability to walk, for this opportunity through inertial navigation systems can evaluate the behavior of the center of gravity (Auccahuasi, et al. 2021).

We found works referred to robot-assisted manual training applied to people who have suffered stroke, with which you can perform practical activities, with the use of a VR environment, so it has been used to analyze about the robotic device on the final effects of hand Amadeo used by improving cognitive performance which is compared with the amount of treatment that focuses on the hand which is applied to 48 people with an average age 54.3 ± 10.5 years and the amount of women was 62, 5% who have suffered an ischemic or hemorrhagic stroke, which have been separated into 2 groups called experimental group (GE) which were applied the Amadeo Robotic Training and the control group (CG) were subjected to occupational therapy involving the upper limb, maintaining an evaluation at the beginning and end of rehabilitation with a neuropsychological battery, and motor function tests, obtaining the results that in GE has been obtained improvements in cognitive domains including attention skills and executive functions, hand motor, however robotic rehabilitation based on VR showed improvements in both motor function in the paretic arm and global cognitive skills in cerebrovascular patients (Torrisi, et al. 2021).

We found works referred to VR technology used in rehabilitation applied to people who have suffered strokes, in order to analyze the effectiveness of VR training without the use of glasses to improve motor functions of the upper extremities applied to patients who have suffered strokes for which 12 patients with stroke have been considered for the process for 3 weeks, For this purpose, examinations were taken at the beginning and end of the process in which the evaluation was performed twice, including the Fugl-Meyer upper extremity scale (FMS-UE), the measurement of transcranial magnetic stimulation (TMS) and the evaluation of movement from which the results were obtained, which showed no differences between the groups in the initial evaluation, where after the intervention the FMS-UE score showed superior improvement for the VR group than for the control group, the TMS had a significant difference on the latency of the cortex, on motor conduction after the intervention, no differences were shown on the amplitude of the motor event potential (Xie, et al. 2021).

We found works referred to IT applied in patient care and rehabilitation. We found works referring to IT applied to patient care and rehabilitation, so a review of the literature on games based on VR used for motor rehabilitation was carried out. The objective is to propose a methodology used to improve the design and reporting process of clinical trials using the search for publications on this type of experiments, which were carried out in databases such as Science and Medline (PubMed), which have been evaluated. The publications about this type of experiments were searched in databases such as Science and Medline (PubMed), which have been evaluated with the Downs and Black checklist, and the following results were obtained: 86 studies were identified in which the main tool used was the Kinect, the EyeToy system and GestureTek IREX based on VR games for rehabilitation which have been tested in patients with cerebral palsy and stroke focusing on posture control, limb exercises (Ayed, et al. 2019).

We found works referred to multiple sclerosis (MS) and diseases of the central nervous system which affect motor, sensory, visual and cognitive activities for which a review is made about the virtual reality tools that can be used to perform cognitive and motor rehabilitation for which an analysis of studies between 2010 and 2017 searched in PubMed databases is used, Scopus, Cochrane and Web of Sciences with keywords such as "VR rehabilitation" and "MS", where the results obtained after the use of VR for rehabilitation can be seen an improvement in motor and cognitive function, which confirms the positive results about the improvement of the outcomes of patients with MS (Maggio, et al. 2019).

We found works referred to advanced robotic technologies (RT), virtual reality (VR) and transcranial direct stimulation (TDC), in order to make a combination of devices and apply them to

the recovery of hand-arm function based on the hypothesis of functional reorganization of the undamaged motor system, while early and intensive motor treatment according to the patient's potential, thus demonstrating that the application of new technologies for rehabilitation is giving more effective results in patients with cognitive deficits, Therefore, the aim is to declare the application criteria, limits and application procedures for which a search and registration of post-stroke patients will be used to undergo conventional rehabilitation and rehabilitation with RT and TDC to then compare them, which will be supported with virtual reality (VR) methodology in the treatment of the paretic upper limb after a stroke, obtaining the results of superiority of VR methods compared to the classical methodology (Pistarini & Maggioni, 2019).

We found works referred about VR applied in the restoration of motor function in stroke patients where the analysis was used in 45 patients with acute stroke diagnosis, which were randomly divided into 2 groups where the first group received standard rehabilitation and neuro-trainer classes while the other group only received standard rehabilitation classes. Both groups were evaluated according to Berg's balance test where the results about the neurotransmitter showed an efficacy on the 15th to 19th day after the stroke, where re-sults can be found superior to the beginning of training with a neurotransmitter within days 5 to 9 after stroke ($p = 0.022$), with a degree of recovery about the neurotransmitter ($p = 0.001$), reached within 3 to 5 sessions (Kate, et al. 2019).

We found works referred about VR exercises implemented in motor rehabilitation on the lower extremities applied in a Spinal Cord Injury (SCI) rehabilitation center where 12 patients with SCI and 10 control patients have been used, for which heart rate and electromyographic activity of both legs have been recorded, obtaining results about the interactivity considered as the main interaction of the participants, where it is considered that the feedback is of vital importance for the improvement of the patient assisted by robot (Steadman, et al. 2015).

We can indicate that within the rehabilitation techniques, we find those related to the exercises that are performed with a health personnel, this is a traditional mechanism, one of the disadvantages is the need to be able to travel to the health center, to perform rehabilitation exercises, depending on the resources available to patients, you can have access to a health personnel to perform rehabilitation exercises in a personalized way. We also have the mechanisms where technology is applied, as is the case of being able to use automated devices to perform rehabilitation exercises, in this sense not all patients can count on them, as well as health centers do not have the necessary resources to be able to acquire this equipment.

In retraining related to walking, involves relearning how the movements of the arms and legs are performed when the movement is being performed, this technique uses videos and images of the affected limbs to get to know them again, as well as how they interact when walking, this technique is known as motor imagery, which can be implemented with the visualization of photographs or videos.

Having made a description of the state of the art regarding the use of techniques related to the use of technology in the health sector, as is the case of virtual reality with emphasis on rehabilitation issues, this paper develops a method that uses virtual reality techniques to develop the technique of motor imagery, organizing images and videos of the components of the arms and legs and their interaction in walking, through the projection of these in the virtual reality glasses, with which you can get patients to increase the level of concentration and thus to recover their skills in the shortest time.

2 MATERIALS AND METHODS

The materials and methods that we are presenting have an important particularity, which is their dynamics, based on being able to create different scenarios according to the particularity and preference of the patients, we can indicate that it is a modular method organized with the intention of being able to be replicated, for which we describe the necessary components as well as their respective integration plan and we end with previous results:

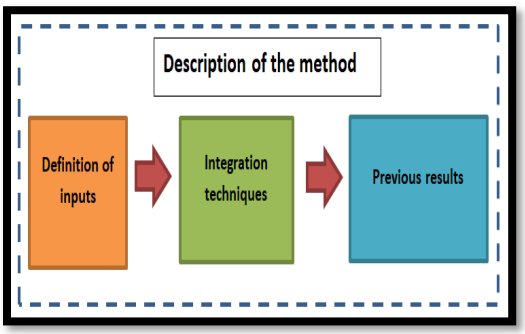

Figure 1: Description of the methodology.

In Figure 1, we present the description of the methods to be developed, starting with the definition of the inputs, followed by the integration of techniques and ending with the previous results, then we develop the details:

2.1 Description of the Inputs

The inputs that we describe in the development of the methodology, is characterized by the description of the needs, we can indicate that in a real situation we have two possible situations, the first in an environment of a rehabilitation center, where we have many patients, of different types of ailments and rehabilitation therapies, as well as different ages and a second environment can indicate that we are in performing rehabilitation therapies performed in the homes of patients, where we try to reinforce the exercises performed in rehabilitation centers, or also managing to have a particular staff to be able to perform rehabilitation exercises.

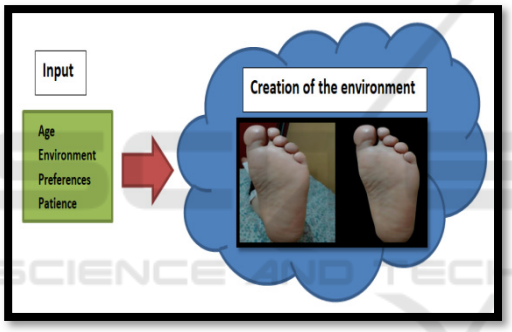

Figure 2: Description of the inputs and creation of the environment.

Figure 2 shows the approach of the inputs, which result in the creation of the environment where the sequence of images is represented, as well as the representation of the background, this is one of the characteristics of using virtual reality glasses, because it not only presents the sequence of images, but also a view of the depth, allowing the patient to isolate himself from the physical place where he is and can only visualize the scenarios provided by the glasses, then we present what each of the inputs consists of:

- The years, as the environment where it will be presented will be implemented, to have a better reception by the patient, the background of the environment should be developed according to themes related to the patient's age, we must indicate that the Virtual Desktop tool, allows us to select different topics to be configured as background of the scenario.
- In the environment, it is recommended that the images and the environment are related to the patient's activities, for example sports, educational, work environments, these help because they motivate the patient in the recovery process.
- Preference is a very important aspect in the process of personalizing the environment, it would be ideal to know the preferences of patients so we get a greater commitment of the patient which would lead us to have better results.
- Patience, one of the factors to take into account and is related to age, this aspect is very important to time the sequence in which the images appear giving the sensation that the patient is watching a video.

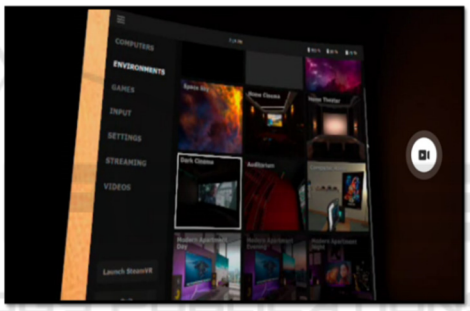

Figure 3: Virtual Desktop application configuration mode.

In Figure 3, we present the screen to configure the environment where the images corresponding to the motor imagery technique are presented, where the recommendations of the 4 described inputs are applied, managing to select the environment according to the tastes and preferences of the patients, to achieve a better response from the patients.

2.2 Integration Techniques

The integration that must be considered is related to the necessary equipment to implement the model, as hardware a computer is needed that has the task of being able to present the sequence of images and to control the sequence of images, it is necessary and virtual reality device, such as glasses, for the demonstration we use a virtual reality glasses model Oculus Gest II, The function of the glasses is to be able to replicate what is observed on the computer screen, the total control is in the computer, an

additional mobile device can be considered, which can be a cell phone, where you can replicate what is displayed on the glasses, it also fulfills the function of quality control to verify the operation of the glasses.

As a software component, the Virtual Desktop application is required, which provides connectivity tools, with which we can share computer resources and virtual reality glasses, we must indicate that it is necessary that all devices are connected to the same network, with which the application works as an integrating agent, all devices must be registered with the application that is installed on the computer. One of the functionalities that this configuration allows us, is to be able to work in a multiple configuration, managing to configure several virtual reality glasses connected to the same computer, with which the therapy can be performed to several patients.

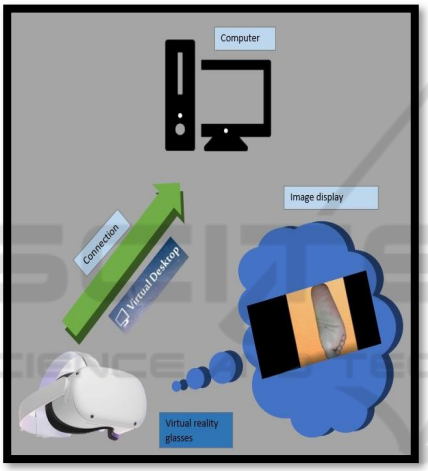

Figure 4: Description of the integration mode.

Figure 4 shows the integration mode between the different components through the Virtual Desktop application, the integration requirement is to be connected to the same network and to be able to register in the application installed in the computer.

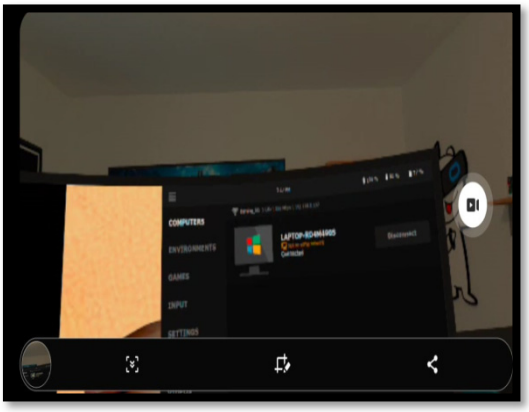

Figure 5: Device connectivity.

Figure 5 shows the configuration in the Virtual Desktop application, in the virtual reality glasses, the virtual desktop client must be installed, when the application is opened, it searches for the server that can be connected in the same network, in our case, we are connected in a laptop, so the application finds and connects us to share resources.

2.3 Previus Results

For the case of the previous results, we present the results that are observed in the virtual reality glasses, as well as in the cellular equipment, we must consider that what we observe in the cellular equipment is the same image that is observed in the glasses, so we can recommend as a quality control mechanism, to only place the glasses on the patient without any other action that may cause discomfort to patients.

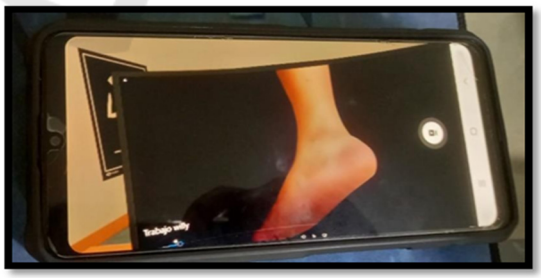

Figure 6: Verification of the connection with the simulated cellular device.

In Figure 6, we present the connection of the cellular device, where connectivity and access to the computer is verified, what is displayed on the cellular device is the same as what is displayed on the virtual reality glasses.

Figure 7: Virtual reality lens configuration.

Figure 7 shows the configuration of the Oculus Gest II lenses, where the connection with the Virtual Desktop application is shown, by means of which it is possible to connect to the equipment as well as to select the environment. The mode of use is through the controls of the lenses, in the case of patient use, the configuration is done before placing the lenses on the patients.

3 RESULTS

The results that we present are related to the implementation of the method and the results that we obtain in each of the processes, the fundamental idea of the publication is to explain how the method can be implemented, as well as the results in each of the stages. The results will explain the resulting images in each process, similarly when replicated the images can be used as a reference.

Figure 8: Generation of lower limb imaging sequence.

In Figure 8, we present the image generation process, in this case we generate the images corresponding to the feet, first we register the image of the foot and then we eliminate the outline of the foot, leaving the foot with a black background.

One of the recommended ways is to be able to create your own sequence of images, the recommended method is to be able to take pictures of the limbs as appropriate, for a better reception of patients, you can take images of the patient himself, this way you have a better reception of the patient to the therapy.

Figure 9: Generation of upper limb imaging sequence.

In Figure 9, we present, analogously to Figure 8, how we generate the images of the hand, having the hand with a commonly used background, and the image of the hand with a black background.

Just as we made the collection of images of the lower limbs, we present the sequence of images of the upper limbs, for which we also recommend that the image is of the same patient, you can take several images as well as to rotate them in both cases, to be able to reproduce them in sequential form, so we can have more images.

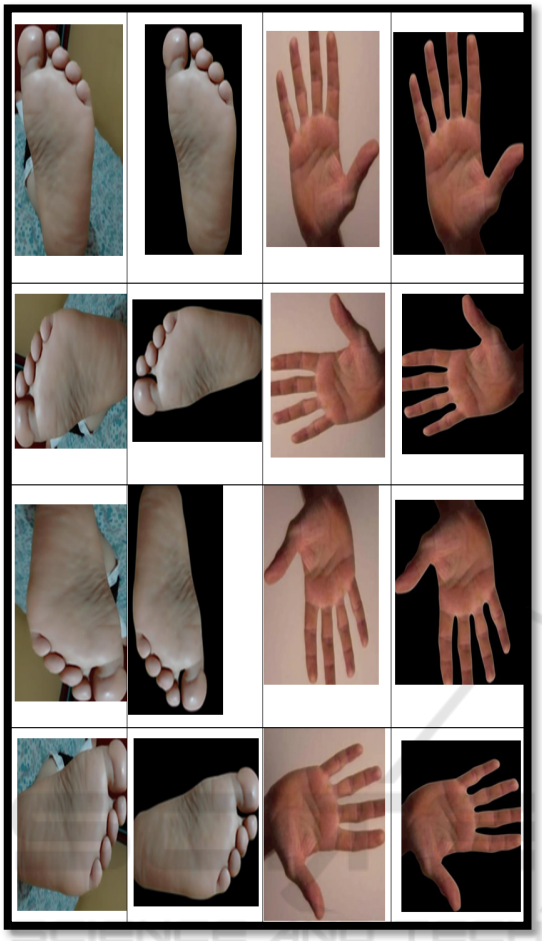

Figure 10: Generation of image sequence.

The images shown in Figure 10 correspond to the sequence of images generated, starting from the same image we can add backgrounds, rotate them, so that we can have a greater number of images.

Figure 11: Performance of motor imagery exercises.

In Figure 11, we present an example of the application of the method, in which the patient is a teenager who is performing the exercises, we can observe the application of the method, by connecting the computer, the virtual reality glasses and the mobile device, the same image that is observed on the computer is observed on the glasses and on the cellular equipment.

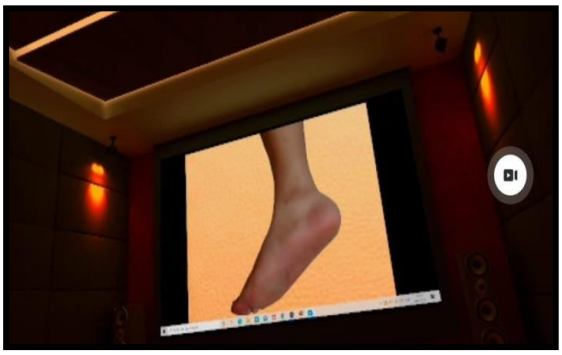

Figure 12: Final visualization of the exercise.

In Figure 12, we present the final work mode, where the recommendations of the method were applied, the patient indicated is an adolescent who likes movies, so the virtual environment was configured to simulate a movie theater, the patient visualizes the sequence of images as if he were in a movie theater, improving the patient's perception, which would help in their collaboration and thus improve rehabilitation therapies.

4 CONCLUSIONS

The conclusions we reached at the end of the research, is related to the implementation of the method, as well as the benefits of the application, we indicate from the perspective of the implementation method, that the method is applicable because you can perform exercises using the technique of remote imaging, it is scalable, because it can be scaled towards improvements in the images and replicable because we present the procedures to implement the method. The method can be applied in rehabilitation centers using different equipment that provide a virtual reality scenario, all of them connecting to the same computer, and replicating it in all devices.

The benefits of using the motor imagery techniques are related to the benefit of the patients by reducing the recovery time, thus improving self-confidence and eliminating all kinds of anxiety that

is typical of patients, who try to recover as soon as possible. Being able to control anxiety is very important, increasing the motivation of the patients themselves and generating confidence in their recovery, using the method concentrating the patient increases learning and performance at the time of evaluating the patient's recovery.

The application of the method is related to different types of patients, in which case they require certain exercises to recover and perform daily activities, can be applied to all types of patients, adults, children, adolescents, workers, athletes, although the technique of remote imagery helps in recovery, to be complemented with the techniques and advantages that provide us with virtual reality helps to benefit the patient, using the proposed method helps in the strategy for the recovery of the patient.

Comparing traditional techniques with the present proposal, they are related to the use and exploitation of the different tools and techniques provided by virtual reality, applied in the process of learning how the arms and legs interact when walking, known as motor imagery, being able to provide patients with these images and videos in a virtual environment, improve the perception and attitude of patients, helping their recovery for the benefit of recovering the mobility of patients, after being immobilized by various factors.

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