Low Cost System for Mobility Recovery and Gait Analysis Based on Inertial Navigation and Virtual Reality Techniques

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Abstract: Mobility in people is a critical factor for their physical and emotional development, having any impairment that prevents their mobilization can have detrimental effects on the person, these deficiencies in most cases are caused by diseases and accidents. Their recovery depends in most cases on physical therapies and rehabilitation exercises in adults. In the present work a recovery mechanism is proposed through recreational activities, the proposal consists of the use of gaming technology, based on the Minecraft game, added to virtual reality technology, in which the patient will perform the proposed exercises, but will perceive that he is playing, the results are related to the measurements of biomechanical variables that occur with the use of sensors such as the gyroscope, where the registration of movement is presented graphically, through which you can identify any of the pathologies related to the process of walking.

1 INTRODUCTION

Medicine is one of the areas where technology is applied, in this sense we have equipment that perform the recording of physiological variables, such as equipment that record signals of EEG, EOG, EMG and others, to highly complex equipment such as magnetic resonators and a great variety. For this reason, we always pay attention to the technological development applied to the design of new devices, based on the application of hardware and software.

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Reviewing the literature, we found several works related to the application of technologies to solve problems related to the health field, such as the case of proposing mechanisms to send biomedical signals in telemedicine applications, ensuring data integrity (Rojas, 2022). Among the works related to ensuring the exchange of information, we find works related to being able to interact between different devices, with the intention of ensuring interoperability between devices (Herrera, 2021).

Works related to the use of the techniques provided by virtual reality, we find works that recommend the use of different mechanisms to exploit these techniques to improve the performance of the new solutions, as is the case of the use of the WIFI 6 network (Auccahuasi, 2021), the use of these techniques allows the maximum exploitation of computational resources for the benefit of the execution of virtual simulation techniques (Auccahuasi, 2021).

When we apply virtual reality techniques, we find works related to the exploitation of these techniques, one of these areas where they are being used more frequently is the case of education, with the presentation of works where virtual reality techniques are applied (Auccahuasi, 2021).

We found works related to the exploitation of technology for the benefit of the recovery of the mobility of the upper and lower limbs, by performing rehabilitation exercises, using IOT technologies (Auccahuasi, 2021). These processes are achieved thanks to the exploitation of images and video, all these taken to a virtual environment (Auccahuasi, 2020). The use of these technologies is complemented by the use of various devices such as gyroscopes and inertial navigators that help to increase the data in order to be analyzed (Auccahuasi, 2021).

One of the techniques related to muscle recovery, are those dedicated to train the brain to be able to relearn how the movement of the course is and how its extremities interact in order to perform it (Auccahuasi, 2019). These techniques are complemented by the use of various devices such as those that evaluate the signal of the muscle, where the recovery of the muscle is tested using different techniques and technologies (Auccahuasi, 2019). These works are complemented with the use of other techniques, as is the case of the brain-computer interface to evaluate the behavior of the brain when the rehabilitation exercises are being performed (Auccahuasi, 2019).

Our proposal is based on having a low cost system for the recovery of mobility under gait analysis, using inertial navigation technology and virtual reality, based on the popular game that most children know, as is the case of Minecraft, this game used by designing a virtual environment, where patients as a game performs rehabilitation exercises, such as walking in a straight line, dodging obstacles, jumping in others, the control of the virtual scenarios are performed by recording the movements and the movement by the patient based on a gyroscope, giving the patient the feeling that he is playing in real time, these electronic components are housed in a support that the patient is placed on the chest, managing to record the movement of the patient, the most outstanding is to involve the patient who are mostly children in performing the exercises as it is more interesting to play than to exercise.

2 MATERIALS AND METHODS

Working with children has a special task, which is to understand what they like that attracts them and these requirements lead us to analyze what videogame can lead us to do rehabilitation exercises without them being stressed in thinking they are doing their therapies, the chosen one is the Minecraft, for its practicality in designing virtual scenarios and the sensation of walking that one has when navigating the stage, we eliminate all types of visual interference if we submit it to a virtual environment, eliminating all kinds of distraction, this feature is achieved with the use of virtual reality lenses, with this we have ensured that the child is involved in the therapy exercises, we would lack as we can give the integration to the game as if the child was involved in the game without The need for a jostick or keyboard, this requirement was solved with the incorporation of a gyroscope which is going We sent the game to the game and we achieved that the game is mobilized with the action of walking patient, completed the mechanisms of integration into the game, the movement recorded by the patient is represented in a displacement graph that tells us how is the patient's march, then we develop each component described.

2.1 Analysis of the March

The analysis of the gait is characterized in that the patient can move without problems, we call normal movement to the movement performed in a patient without difficulty, moving without problems, taking the foot forward one after the other, this exercise has to perform without causing some kind of physical exhaustion or presenting some type of muscular

fatigue. When this displacement is done with some extra effort, caused by an additional effort, by presenting difficulty of accompanying the foot and in some cases by performing an abnormal movement of the body such as moving the hip in a non-uniform way, each of these movements can be represent by means of standard graphs, where the registry determines if the patient presents some graphic deviation which would indicate a pathology of the march.

2.2 Recovery of Mobility

When we talk about recovery of mobility, we are referring to the patient can perform a normal march in cases when there is some immobilization of some lower limb, for different reasons, by an operation or immobilization, brings unfavorable effects on the joints which causes The patient walks poorly, such as dragging the foot, not bending the knee, which causes him not to be able to move in a straight line, among other deficiencies that can be observed at the moment he walks.

2.3 Component of Inertial Navigation Techniques

Among the components that make up the inertial navigator, we have an Altimu-10 gyroscope that will register the movements in the three axes in order to identify the movement when the patient is walking, the gyroscope values are sent to the data acquisition card, in our case the arduino lilypad, we chose this card because it provides us the facility to be able to attach to our support, having the values of the gyroscope we use the bluetooth module model HC-60 with what we can transmit to the computer the movement of the patient.

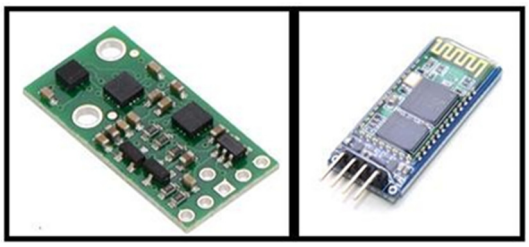

Figure 1: Altimi-10 gyroscope module and Bluetooth HC-60.

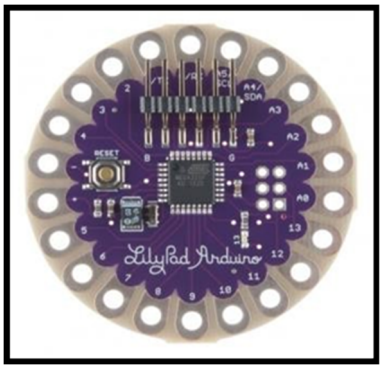

Figure 2: Arduino Lilypad data acquisition module.

2.4 Component Virtual Reality

The virtual reality component is made up of the Minecraft video game and virtual reality lenses, which works through the use of a cell phone that connects to the computer to view the video game.

Figure 3: Minecraft video game.

Figure 4: Virtual reality lenses.

2.5 Proposal

The proposal is characterized in being able to use the gyroscope and its components, but we will give emphasis to the development of the virtual scenarios,

which is the mechanism where the patient performed the interaction, developed four levels each with a particular exercise, and increased the degree of difficulty.

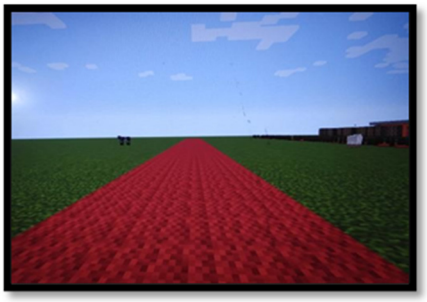

Figure 5: First level of exercise.

The first level is characterized by presenting an exercise where the patient tries to walk in a straight line following the red path without stepping on the garden.

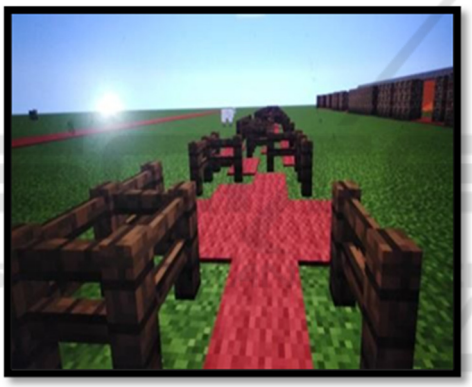

Figure 6: Second First level of exercise.

The second level is characterized by red obstacles in the path, the patient has to walk on the red path without hitting the wooden obstacles.

Figure 7: Third level of exercise.

The third level, is characterized by increasing the complexity of the exercise, at this level the patient has to walk in fine form, the path is presented in a narrow way and does not have to hit the walls.

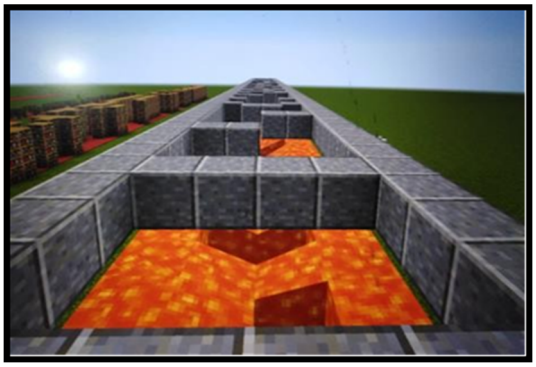

Figure 8: Fourth level of exercise.

The fourth level is the most complex, presents a greater challenge where the patient has to jump simulating that the floor is lava, with this exercise you can verify that the patient can walk and jump without problems.

The fifth level is characterized in being able to perform the exercise of being able to choose one of the boxes that are at the end of the room, with this exercise we can identify that the patient controls the direction when walking, with these exercises we can recover the patient being able to control their steps, to be able to jump, to be able to walk without tripping, the exercises can be performed consecutively until the patient regains mobility.

Figure 9: Fifth level of exercise.

3 RESULTS

The results presented are the result of an evaluation of the system, based on three concepts, the first is the patient's record when it is stopped, the second corresponds to the record when the patient walks normally and the third corresponds when the patient

presents a difficulty when walking, these three records can be seen in the following graphs:

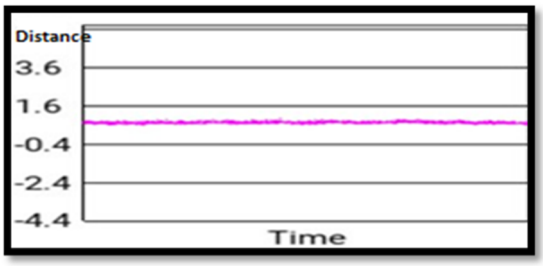

Figure 10: Registration when the patient is stopped.

In the record of figure 10, it can be seen that the value remains constant as time passes, so it can be deduced that the patient is stopped.

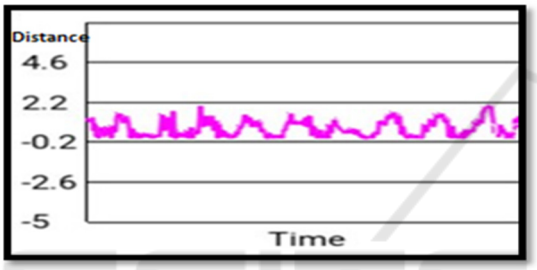

Figure 11: Record when the patient walks normally.

In the record of figure 11, it can be observed that the data form a wave that repeats in a constant way, with which it can be deduced that the patient walks in a normal and consecutive way, some alteration in the shape of the wave, represents Some difficulty at the moment you walk.

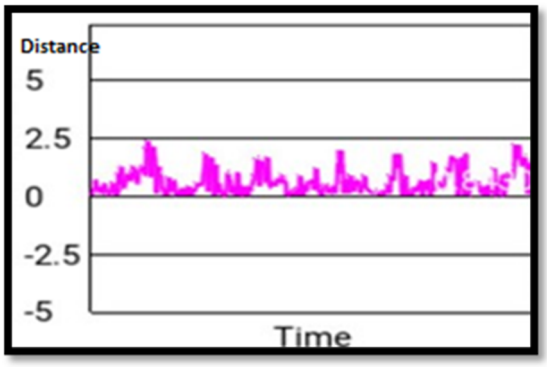

Figure 12: Record when the patient walks poorly.

In the record of figure 12, it can be observed that the data form a wave that is not constant, presenting a variety of waves of different width, which corresponds to a patient who has problems when walking through the irregularity of the signal.

Figure 13: Front and back view of the system, with the components placed on the patient.

Figure 13 shows the virtual reality lenses placed on the patient, as well as the gyroscope placed in the navel of the patient, because it is the center of gravity of the patient and is where the registration and graphic analysis will be performed. On the back of the stand, you can see the acquisition card as the wireless transmission module.

4 CONCLUSIONS

Among the conclusions that we can describe, at the time of finalizing the design and carrying out the first field tests, we are given the degree of acceptance that the system has on the part of the children, because they get excited when presenting the game instead of the exercise to be performed, with this we eliminate the classic problems that arise in children by their very nature of being distracted at the time of performing the exercise. From the point of view of design, it was possible to couple the components, in such a way that the interaction between the acquisition mechanism and the computer where the videogame is installed is achieved, this wireless connection allows the patient to feel total control of the game. mobilize in a natural way, and technically it is possible to have the register of the variables that you want to analyze, in the practical case the variable center of gravity was registered recording the movement that occurs in the navel, so the movement originates a continuous wave indicating the continuity of the steps at the time of walking. A recording and visualization different from the characteristic wave correspond to a deficiency at the time of walking. The system can be scaled, increasing the number of gyros in other parts of the body that it

is necessary to analyze and be able to better describe the pathology.

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