BY USING A MIXED REALITY GAME IMPROVING THE FUNCTIONS OF THE ARM AND HAND MOTIONS OF REHABILITATION PATIENTS

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ABSTRACT

Recently, Health Technologies are developed very quickly. Medical requirements of the health organizations trigger the development of new applications for this area. The field of physical therapy and rehabilitation also requires more efficient medical treatment than traditional ones for their patients. As they declare, to shorten the treatment for patients, motivation is the major factor. According to the doctors, patients, who have full motivation, complete their half of the treatment. Especially the patients, who losses the abilities of their hand and arm motion because of an injury or a stroke, need to apply exercises more frequently and regularly. Nowadays, some special games have been started to be used for many of the hospitals for the physical therapy. In this research, a virtual reality game is developed specific for the physical therapy patients. Main features of the developed game and its effects on the patients are discussed in this study.

1. INTRODUCTION

A large percentage of the population suffers from injuries and neuromuscular disorders which require physical rehabilitation exercises. During this rehabilitation, the patient must perform the same, often monotonous, routine for days, if not months. Expectedly, a large number of patients who require this form of therapy do not comply. In order to keep motivation and morale high, patients must not dread their therapy, and not find it boring or redundant. Therefore, it is important to investigate alternative methods of therapy and to compare their compliance and efficacy to conventional approaches [7].

Games are used to treat many diseases for years. All the age of patients can get better by playing the games because it is motivated and entertaining. Some hospitals makes a game center for their rehabilitation patients in the abroad. They use the games which are improving the functioning of hand, arm, leg, head, waist and etc. motion of the people (See also Figure1, Figure2, Figure3).

Figure1-Cycling Game

Figure2-Whack a Mole game

Figure3-Taico Drum Master game

However, it is difficult for the patients who can not walk. And if the any breakdown is occured for the games, the repairment is costly and also needs time. The use of computer technology has gerat potential in the physical rehabilitation. For this reason, medical authorithy wants find an efficient way to handle the treatment which is long lived and also technological, for all types of patients.

Virtual Reality, is an interactive , computer generated environment that simulates the real world. VR can be use many aspects; education, health, sports activities, entertainment (video games), in scientific world to simulate a variety of complex situations and etc.

From the point of this perspective, Studies are expanded in that field day by day in the world. Then the term Virtual Rehabilitation is born. Virtual Rehabilitation was coined in 2002 by Professor Daniel Thalman of EPFL (Switzerland) and Professor Grigore Burdea of Rutgers University. In their view, the term applies to both physical therapy and cognitive interventions[2]. It offers numbers of advantages; it is entertaining, so motivating and can be performed by patient's home and monitored at a distance (becoming telerehabilitation) and the cost is cheap. The main aim of the virtual rehabilitation, patients can react the virtual environment by their real senses.

The studies about this topic is drawed an attention to make a study about Virtual-Rehabilitation area. A game which is developed in a virtual environment and based on motion capture techniques with using a graphic program and a webcam, suitable for rehabilitation patients[1]. After the thinking of the subject, a meeting is organized with the medical authorization of Hacettepe University Physical Therapy and Rehabilitation Department. The game is presented to them and they are very excited and interested in the topic with that game. First of all, the type of the patient group is determined, who lossed some functionalities of their bodies not the patients who lossed full functionalities, because the patients who lossed full functionalities needs some special treatments. And then some ideas and contributions are added by the help of medical auhority and by the think of right motions. Then the game for improving arm and hand functionalities is developed. The content of the game is; first of all, the patient's view is monitored by using a web camera. Then colored balls are falling into the environment from the left-side, right-side and up-to-down. The patients try to catch by using their own hands and put the balls into the baskets which are located at the bottom of the game. Each balls which are putted in a true colored basket gives the 5 point score to the player. Finger, arm and hand muscle are worked by playing the game. Actually, there are diffrent kind of patients, that means diffrent kind of game can be developed. But this game is covered most typical and major motion of the rehabilitation patients. Furthermore, the time is holding by the form of minutes.

2. LITERATURE INVESTIGATIONS AND RESULTS

There are some aspects of virtual reality based physical therapy in the world beginning from the year 2002. First of all, there two types of environment applications; 2D applications and 3D applications. After determining the improvement area and needed exercises, application type will be chosen.

One of the point, from the studies about this subject is Wii-based virtual reality systems. In this system, patient interacts with the system by moving the object for getting support from the object[3]. The main features of the Wii Remote are its motion sensing capabilities that enable the clinician to measure end-point motion of the hand held controller and, thus, the patient's abilitiy to manipulate the object. (See also Figure4)
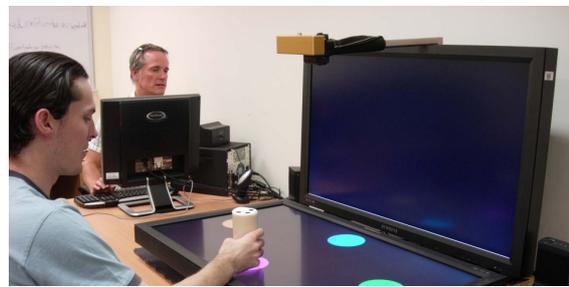

Figure4

By using the Wii Remote systems, the measured variables are; the speed, precision, distance moved and accuracy of target selection data recorded by the program. And also program will allow motor performance to be monitored[3].

The motivated factor is also occured for the rehabilitation patients. The use the system is very simple and the cost is also cheap. Searchers found that patients that play the Wii increase duration participating in therapy and are able to participate in dynamic standing or sitting for longer periods of time[4]. An other type of virtual-reality based physical therapy is simulation type therapy. That is included haptic gloves to percieve the all the knuckles of the body of a patient's hand, arm or leg which is needed. This type of systems are much more advanced than Wii-Remotes. Mostly these systems simulates the activities of daily livings, such as; driving cooking, cleaning, self-care and sports[5]. (See also Figure5, Figure6).
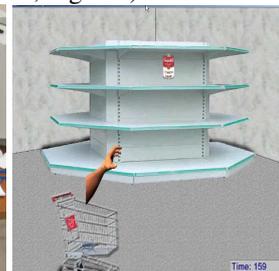

Figure5   Figure6

In these simulations are mostly developed in a 3D environment, because of to implement the daily life activities. In most cases of our daily life activities, people uses their hands; getting dressed, self-grooming, picking up and handling objects from food to books to toys.

Patients who have problem with their hands needs these type of simulations. For example; children with hemiplegia which is occured after any injury in one side of the brain, struggle with the activities of daily living from the time they get up in the morning to the time they go to bed. By fitting a sensing glove to their hand to connect to the video game encourages the children and improve their hand's activities.

In traditional exercises, speed of the area which needs the theraphy, also measured. Therefore, some of the games is developed by thinking the speed factor. Forexample; in a game, there are butterflies which patients should catch to get points, fly fast. This in turn reaquires faster reaction time from the patient[6].(See also Figure7, Figure8, Figure9)
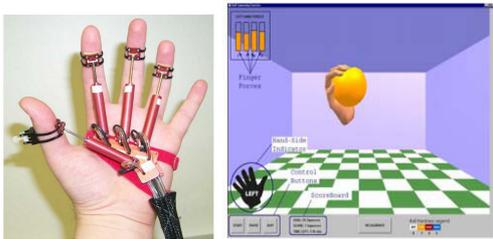
Figure7

Figure8

Figure9

By changing the postion of the web camera, this type of games can be applied to different part the bodies of patients. Some brain injuries affets the foot step of the pateints, so a new game can be developed by new direction of a web-cam and this time the foot step motions and speed can be measured.

There is one more technic in virtual-rehabilitation which only needs a web-cam. Actually it can be called mix-reality. In that environment, there is only a web-cam game and a web-cam. Mostly, the games in that technic in 2D applications. This approach is especially used for the upper-limb rehabilitations. In these games, to emphasize reaching activities, the user is seated at a table in front of a15 cm computer screen. According to the reports in the study currently, underway, children exposed to the VE tended to use their affected upper limb more spontaneously than before.

This feature seperates this tehnic from the other types of virtual rehabilitation therapy. In addition to this, the technic not only used for the rehabilitation patients, also it can be used for obesity treatment for children and development of children's bodies[8]. (See also Figure10)
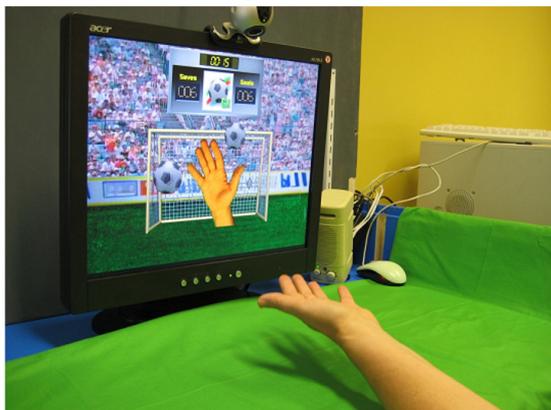

Figure10

In the evaluation of the all types of virtual rehabilitation technics. The first is Wii-Remote based rehabilitation technic, and then simulated type of virtual rehabilitation is observed. Finally, mixed-reality based virtual rehabilitation is investigated.

From the first technics, Wii-Remote based, that is developed in the first studies of the virtual rehabilitation field. That helps the patients with using an object, they can play the game and make their exercises with a movitivated way. However, if the specific motion exercises need for the patient, that method can not be enough for the patients. For example; if the patients takes hand knuckle improvement treatment, this game can only be used for the motivation factor and main activities improvement.

The second one is simulated based virtual rehabilitation. As mentioned before, this type of applications mostly made in 3D environment. The most important advantages of this type is, all the specific motions; can be treated, because of the haptic gloves.

These gloves includes some specific tags for the specific areas. In addition to this, it is motivated factor is fewer than other 2 type of technics, because to play the game patients should wear some editional apparatus. When they wear these extra units, their motivation can not be effected because they think that all these units are taken because of their ilnesses. Moreover, there is one more point for the simulated-based treatment. If the medicel authrithy want to use a new game for new type of patients. It needs time to prepare a game for the patient. Because the coding is complex, not simple.

The final view is mixed-reality based virtual-rehabilitation. The application of that type of rehabilitation, do not use any extra units for the patients. The patient only plays the game with the real appreance's of him/her hands or any other part of their body. Patients can be sensed that, thay are the part of the game with real appreances.

Therefore, motivation is very high in that type of games. In everywhere, the game can be played. These games improved for the major activities of the patients. In that game, it is difficult to improved some specific motions. However, if new type game is needed for the different types of patients. Applying new game is faster than all other types of technics.

According to the research, the most effective technic is the final one, mixed-reality based virtual reality. Because it is suitable for all types of patients in physical therapy and rehabilitation field and the motivation of that game is much more efficient than the all other type of technics. In addition to this, by using this technology applying home-based virtual rehabilitation is much more successful and gives right feedbacks to the authorizations.

3. RESEARCHES

Researches show that by the use of the literature investigation data, the mixed-reality based technology is chosen to developed a game for the rehabilitation field. As it is mentioned before, by the help of the Hacettepe University Department of Physical Therapy and Rehabilitation, the game is improved for the patients. The medical authorithies in the department are very excited about the topic. Because they said that, thay want to purchase a mechanism in a few years ago, which is an IREX system, the expensive costs embarrassed them. In

Turkey, virtual reality based studies mostly uses in education, in simulation-based science projects. In the area of health there is not any studies in virtual rehabilitation. After the topic and the future works are disscussed by the department authorithy in Hacettepe University. Game is started to take shape. The most effective exercises which are performed by the patients will be chosen and then the content of the game is started to prepare. First of all, web cam games which is improved for the aim of entertainment to the children are investigated. Mostly, games are include playing soccer, breaking balloons and snowboarding.

The features, the tools which used for applying the games are all observed. Meetings are still continued in periodicly with the medical authorization.

4. DEVELOPMENT

Game includes the colored balls which can be falling from the right-side, left-side and up-to-down. Some images also included into game to make a enjoyable environment for the people who needs physical therapy. Patients try to put the balls to the baskets which at the bottom of the game. If the patients can be successfull putting the balls to the basket gets the points. Sound effects are also embeded to the game.Balls are falling dowm from the opposite direction of the basket. So, patients react the balls to change their direction. The time information is also taken to control the patients improvement. For example; in the first days, the paients takes the score of 100 in a 12 minutes and the following day the time of the getting the score of 100 is decreased or not. That information must be controlled by the doctors. The game can be use in the hospital, rehabilitation center or can be use in the homes of the patients, whenever it is needed. In the future work, the game is also send an e-mail to the doctors about the time and score informations. Therefore, patients never lies the doctors about their performance and also making their exercises or not.

Flash 8 and action-script and Deplhi programming labguages are mostly use in the type of web cam games. In the coding phase of the game there are some challanges. For example; it is difficult to handle the action of the hand. In action-script part, the motion of the hand is perceived by the color of it. From that points, some aspect is occurred. By the helpof a colored small glove not an apparatus, the grasping motion in by using the handful can be occurred. According to that data, some specific motion controls can also preapared in the mixed-reality based virtual rehabilitation. The searches of the capacitiy of the tool are continuing. The game now makes the specific motion controls and it is applied some of the patients. Implementation of the game is surviving according to the feedbacks of the patients and the doctors. (See also Figure11)

Figure11

5. RESULTS

The game which is developed up to the present, applied to the patients in Hacettepe University Department of Physical Theraphy and Rehabilition. Patients try catch the balls and put them into the baskets. There are two type of baskets. One of them is wide edge basket, if the ball can be putted there, it adds 1 point to the score. Then an other basket is narrow edge, that gets 5 point, if the user can put the ball there. Some of the patients have problems in their arm muscles, so by playing the game they

should erect their arm and give a motion to that area. On the other hand, some patients have a problem with their hands. They can not use their fingers smoothly. By playing the game they should catch the ball, by using their hands and put them into the baskets. The most effective part is, patients playing the with a smile in their faces, because it is enjoyable and very different from the traditional boring exercises. Therefore, doctors said that motivation is an inevitable part of all treatments. So in that field, it is also very significant. In traditional exercises, doctors give some objects to the patients to change their postions, however patients make this theraphy only twice a day. Doctors said that they must do that kind of exercises as much as possible. By playing games they can make the exercises as much as possible and whenever they want with an amusing way and also without they feel tired. Because it is much more enjoyable to changing an funny objects position than a simple common objects. An other complaints of the patients are while they are making traditional exercises, they feel tired themselves, and then they do not want to continue to doing exercises.

Medical authorities said that by applying the game in a while of a time, it shortens the time of get better of the patients. There is an example for that; there is a patient who has a problem with her right arm, she does not erect that arm any time for any thing. Doctors tried to erect her arm by using exercises, theraphies and etc., but they could not succeeded. Futhermore, doctors think that this game can overcome the problem, because it is motivated and people always curious about the games. Everybody wants to try the game.

To sum up, day by day the game is applying to the patients and more results can be gathered according to the time and score relations. And also doctors controls the motion of the areas which have the problems. In addition to this, game can be shapen according to the results, actually according to the needs of the patients and doctors. In addition to this, the cost of the system enormously low.

6. CONCLUSION AND FUTURE WORK

The study presents that, it is a neccesity developing and applying VR based Virtual Rehabilition Systems to the Turkey. Because the studies are received with great deal of excitement from the medical authorities. In abroad, some company produce VR-based systems for the rehabilitation illnesses and the they purchase them to the hospitals and patients (such as IREX). However, purchase of the systems are incrediblely expensive. Therefore,

studies must raise in that areas and much more improvements should presents to the patients.

Investigations shows that patients prefer simple understandable systems rather than complicated applications. The game has very low system requirements. That means that, the majority of the patients will not need to wear or purchase any additional apparatus, units and equipments. Therefore, the system applied more effectively than the other systems.

In this study, there will be some additions for the home-based rehabilitation. The system will sends an email to the doctor or medical authorization after the game is over. It sends the information about time and score, because it shows the improvement of the patient. Form that point, in the future a database can be added to the system which holds the datas about all the rehabilitation patients who plays that game. And then the results can be hiden in a more systematically way.

Researches about the system and system functionalities show that, in the future all the small part of the hand or arm can be perceived from the system by only specifying the color. That means, in the future this type games includes more and different type of exercises. In that tool, motions are understood from the color. So in the future, mixed-reality based applications can be improved like simulation based VR applications without wearing or using any extra units.

Finally, current version of the system helps the treatment of the rehabilitation patients. After applying more and different types of patients, there will be varied findings. Then all these indication are evaluated.

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