Virtual Reality in the Medical Field

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Abstract

The objective is to analyze the use of the emerging 3D computer technology of Virtual Reality in the use of relieving pain in physically impaired conditions such as burn victims, amputees, and phantom limb patients, during therapy and medical procedures. Virtual technology generates a three dimensional visual virtual world in which enables interaction. Comparison will be made between the emerging technology of the Virtual Reality and methods usually used, which are the use of medicine. Medicine have been the main use in relieving pain in these surgical and medical procedures, however since people gain tolerance to the medicine and higher dosage could lead to addiction, therefore this method of Virtual Reality Technology have been developed in order to lessen the harmful effect and possibly improve in relieving the pain. The review will present the notable researches, clinical trials, and developments of the technology in the medical area. This paper will outline the research and current technology of Virtual Reality technology and the role in modern health care. The review showed that the Virtual Reality technology is applicable in the modern healthcare and showed significant improvement in pain reduction during the procedure. From the fast-paced development of new technology, much more improvements could be observed in the future.

Introduction

Severe pains, during medical surgery or during wound treatment, is often at times life threatening and the pain itself may even cause death-threatening situations. The use of medicine is often a major choice preferred; however, there are possibilities that patients might gain a tolerance, which could lead to higher dosage that may lead to a possible addiction. An alternative method to medicine treatment is Virtual Reality Treatment. Virtual Reality (VR) may lessen the

harmful effect and possibly improve in relieving the pain. The aim of the paper is to analyze the use of the emerging 3D computer technology of VR in the use of relieving pain during therapy and medical procedures in patients with physically impaired conditions such as burn victims, amputees, and phantom limb patients. The VR systems are used in two fields: (1) surgeons for visual planning for surgeries (2) physicians and clinical psychologists for immersing the patients within the 3D world created by the VR as an active participant. It will mainly be analyzing of the VR Technology that is used for clinical psychologist and physicians. The studies have shown that the use of VR technologies have proven to be successful in relieving the pain during the medical procedures. VR technology works by simulating and immerge the patients with virtual reality and diverting the attention from pain by interacting with 3D imagery and sound. In this paper, it outlines the research and current technology of VR technology and the role in modern health care. VR is programmable and enables environmental control and controlled stimuli, which generates a three-dimensional world in which enables interaction.

VR as Analgesic for Acute Burn Pain

The title of the first article review was "Virtual Reality as an Adjunctive Non-pharmacologic Analgesic for Acute Burn Pain during Medical Procedures." (Hoffman et al., 2011) The researchers from The Society of Behavioral Medicine use data from the clinical and laboratory experiments to test their hypothesis that the Virtual Reality technology may be used on patients who have suffered from severe burn pains during medical surgery or during wound treatment. Though effective, medicine could become harmful if taken repeatedly until the patient gain tolerance or become addicted to the medicine. Especially, to a child, medicine is not favorable due to its side effects.

The brain activity was measured by fMRI scanning and using a program called “Snow World”. Before the treatment is conducted, the researchers have asked the patients to rate their pain level. The program “Snow World” was specifically made for burn patients, since the program enables the patients to look at virtual reality images that have a correlation to the sensation or feeling of coldness. The patients would see images of the frosting atmosphere with snow and glaciers that reminds them of the feeling of coldness. Patients are also able to interact with the virtual reality, as they are able to use a mouse to click and move an object or throw snowballs at the snowman. In these clinical trials, patients have reported significant and medically meaningful reduction in pain by using the VR. After the clinical trials, the researchers have once again asked the patients to rate their pain levels. By comparing the rating before and after the treatment, the patients have reported 30-50% reduction in pain during the treatment process. It was shown that the patients who identified themselves in the most intense pain levels have had the most effect of pain reduction during the treatment process.

From the comparison made of the brain activity using fMRI, of clinical trials using immersive VR and clinical trials not using the technology, they were able to conclude that the brain activity showed significantly more reduction in pain when using VR and are concurrent with the patient’s pain rating. Researchers have found their hypothesis strongly supported in patients who have used the high-technology 3D helmet and interacted with the virtual reality environment. Effects were lower to those who had the low technology and those who did not interact with the virtual reality environment.

Treatment of Phantom Limb Pain using VR

In the article, "The Treatment of Phantom Limb Pain Using Immersive Virtual Reality: Three Case Studies,” (Murray et al., 2007) data was used from clinical experiments to test their hypothesis that the VR used on patients with severe trauma and burns may be applicable to

phantom limb patients to ease their pain. This article describes the theory and design to investigate the use of VR for treating the Phantom Limb (PL) patients and relieve their pain. Their goals were "to produce virtual facsimiles of amputees phantom limbs; to obtain appropriate measurements that enable conclusions to be reached about the efficacy of VR in the treatment of phantom pain; and to obtain appropriate measurements that enable conclusions to be reached about the efficacy of VR in decreasing body image dissatisfaction and encouraging and enabling successful prosthesis use" (Murray et al., 2007) The method was compared to the Mirror box method, which consists of a box with two holes that are divided with an mirror. The patients are to put both arms, the actual existing arm and the phantom arm into each hole. Due to the angle of the mirror, patient's mind is tricked in seeing their phantom limb existing; it relieves the pain from the amputated arm.

The clinical trials were performed every two weeks, for 30 minutes, over a ten-week period. From the data obtained, it showed that the hypothesis was strongly supported among recent amputees. In general, patients reported a decrease in pain during the VR environment exposure. They found their hypothesis strongly supported to the more recent amputees, while the long-term amputees had less of an effect. In general, patients reported the ease of pain during the VR treatment environment.

Training with VR to Ease Phantom Limb Pain

The article "Training with Virtual Visual Feedback to Alleviate Phantom Limb Pain "(Mercier, Sirigu, 2009) used data from clinical experiments to test their hypothesis that training with VR may alleviate phantom limb pain. They hypothesized that maladaptive plasticity underlies PL pain and that by mobilizing the phantom limb by the use of VR, it could reverse the maladaptive plasticity within sensorimotor cortex in order to reduce pain. The method showed

the patients their

VR Therapy and the Treatment of Complex Regional Pain Syndrome

In the article "Nonimmersive Virtual Reality Mirror Visual Feedback Therapy and Its Application for the Treatment of Complex Regional Pain Syndrome: An Open-Label Pilot Study," (Sato et al., 2010) researchers used data from clinical experiments to test their hypothesis that using virtual reality mirror visual feedback technology could be a more effective solution to conditions such as PL pain and complex regional pain syndrome. The sessions were limited to once a week; however the duration of the sessions was conducted without a time limit. The movement of the virtually created hand was created by Cyber-Glove on the non-affected hand, since it is possible that the affected hand could induce the pain. In these experiments, the researchers created and developed a personal computer-based desktop VR system. In these experiments, the researchers have created and developed a personal computer-based desktop virtual reality system.

“The system contains a personal computer (operating system: Windows XP Professional SP2; central processing unit: Intel Core2 Duo 3.16 GHz; graphics: Radeon HD 4679), CyberGlove (Immersion Co., San Jose, CA) as a hand input device, FASTRAK (Polhems Co., Colchester, VT) as a real-time position and motion tracker, and a 20-inch desktop monitor (EIZO FlexScan SX2761W, EIZO Nanao MS Corp., Japan). A virtual environment (VE) was developed using commercially available software, Autodesk 3DS Max (San Rafael, CA). The original system of the present study, including the VE, was produced by a virtual reality specialty company (Asahi Electronics Corp., Japan) and named the Okayama University Simulator for chronic pain treatment.” (Sato et al., 2010)

Since this research was conducted at a Japanese university, Japanese companies provided most of the equipment. They found the hypothesis was strongly supported in all five of the conducted cases. In addition, the results showed that participants experienced short-term pain reduction and a decrease in pain with consecutive treatment sessions.

VR Compared to Conventional Exercise Programs for Rehabilitation

Another article review was, "Experimental Studies of Virtual Reality-Delivered Compared to Conventional Exercise Programs for Rehabilitation"(Sveistrup et al., 2003). The researchers from The Society of Behavioral Medicine used data from the clinical trials to test their hypothesis that using flat screen VR may provide safer and motivating physical rehabilitation for patients. The strength in using the VR in the physical rehabilitation is that it could process and visualize full range of human gestures and also monitor movements of any or many body parts at the same time. The virtual reality environment is controlled and there is no interference of the "outside world" and, therefore, the patients are able to feel safe in conducting the exercises in the sheltered environment. The program can be adjusted to the patient's needs and creates an environment where the patient is able to produce the full potential. The patients were to rate the pain and the outcomes and the range of motion were also recorded.

They find their hypothesis strongly supported by patients in both the virtual reality and the conventional exercise group, as they have shown improvement on the Community Balance and Mobility Scale after the six-intervention period. Additional benefits were reported during the focus group sessions held with the two groups of exercise participant. The clinical trials proved that the virtual reality technology helped professionals have the ability to precisely deliver and control complex and interactive virtual reality- three dimensional stimulus treatments. Since

there are many patients who, due to the severe injuries, need home-based care patients are able to use this method and therefore create an easier environment for the patients to undergo therapy.

VR with the use of prosthetics

The title of the article reviewed was “Sensory feedback prosthesis reduces phantom limb pain: proof of a principle” (Dietrich et al., 2012). The researchers used data from clinical experiments to test their hypothesis that the use of hand prosthesis that provides somatosensory feedback, help improve prosthesis functionality and reduce PL pain. With incorporating the prosthetics and the VR technology, the patients are able to actually feel the movement of the phantom limbs. The patients will be able to feel sensations in the prosthetic that they had not felt since before their arm was amputated. In this article, eight forearm amputees with PL pain were trained for two weeks to use hand prosthesis with somatosensory feedback on grip strength. After being equipped with the prosthetic, the participants begin the test trials. The results of the experiment was that the “Ten daily training sessions with the feedback prosthesis induced a median reduction of PL pain intensity of 50% (range 6–92%)”(Dietrich et al., 2012). The researchers found their hypothesis to be strongly supported as the results have shown that the prosthetic can be used in an everyday setting to both decrease their pain and to increase their ability to perform everyday tasks.

There are many advantages to the prosthetic limb with somatosensory feedback experiment. Participants will not only be able to reduce PL pain, but also develop skills for manipulating objects using the prosthetic. However, this experiment proves to be disadvantageous in that it can currently only be used to treat arm amputees. If further studies are able to get positive results of this treatment of PL pain, scientists aims to work on developing a similar prosthetic for other parts of the body.

Human Factor Consideration in Clinical Applications of VR

Lastly, the review article is titled "Cognitive, Clinical and Methodological Issues in Assessment and Rehabilitation." The researchers reviewed the side effects of VR technology in order to further develop and improve its use. The article states that, "There are well-documented side-effects of exposures to virtual reality environments which could lead to problems including: symptoms of motion sickness; strain on the ocular system; degraded limb and postural control; reduced sense of presence; the development of responses inappropriate for the real-world which might lead to negative training" (Riva, 1997). The virtual reality technology is still improving and is still limited.

The article states, "Many of the adverse side-effects of virtual reality environments can be attributed to time delays and other spatial and temporal distortions due to limitations in hardware and software. There remains a need for fundamental and systematic research so as to improve understanding of the influence of the spatio-temporal characteristics of virtual reality systems on both normal users and those with disabilities"(Riva, 1997). These limitations may be due to the need for a fully dedicated staff and computer technician to keep the program running and to fix any problems that arise. The resolutions needed for the clinical trials are not those of the everyday computer and could affect the performance and low quality rendering scenes. The articles reviewed show that higher resolutions and higher quality images closer to the "real world" have a better effect. The lack of adequate or conflicting hardware could also occur. Another thing to consider is the cost. To hire staff and to obtain all the resources needed, it requires quite an amount of money. Therefore, in order to conduct more research and to provide towards the treatment, could be limited due to the unavailability of funds.

Conclusion

This review has highlighted the new and improving technology of Virtual Reality (VR) technology used in the medical field. Since the VR is very flexible and programmable, much more improvements could be observed in the future. It is also seen that the harm done to the patients are less and the patients who would most gain from this technology would be children who suffered severe injuries. Since the children are more affected by the effect of the medicine, awareness and more exact caution is needed since there could be aftereffects of the medicine and may experience greater side effects than most adults. In order to help people who have had other limbs amputated, scientists' aim is to create better treatment methods. These treatments are beneficial in that less harm is done to the patients, in overall was beneficial to the patients in many ways. Since the technology for both methods has advanced so vastly in the last decade, many more improvements could be observed in the future. It is reasonable to conclude that the VR technology could improve the modern healthcare by reducing the use of medications and help patients experience less pain during medical procedures.

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Haruka Motomatsu is a senior year undergraduate student at the University of California, Merced pursuing a Bachelor degree in Cognitive Science. Originally from the city of Tokyo, Japan, Haruka have finally gotten used to the rural areas of Merced. Haruka have taken interest in this field of study since she wanted to know more about the human brain and how it could be applied to society and technology. After attending University of California, Merced, she gained motivation for attending medical school where her knowledge may help save more lives. After Haruka graduates in 2015, she plans to continue her interest and proceed to medical school. Outside of academics, she devotes her time in tutoring children and enjoys snowboarding, ice skating, basketball, and swimming.