Applications of Virtual Reality in Medical Fields

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Abstract

This article discusses the many uses of virtual reality in the medical field. It also goes over the results of experiments done to measures the effectiveness of virtual reality being used in the medical field. Most of the experiments found that virtual reality brought great benefits to increasing the medical practice. Haptic and other devices to increase realism are also discussed and how they contribute to experiments.

Keywords: medical education; Virtual reality; Anatomy; Serious games; Natural interfaces; Medical operators training; Haptic systems; Computers; VR; Augmented reality; Patient care; DataGlove; virtual; surgery; Advance medicine; Virtual medicine;

Applications of Virtual Reality in Medical Fields

This review covers what work has been done with virtual reality to improve medical education and medical practice. This review provides researchers with a quick summary of the many uses and effectiveness that virtual reality provides. Effective uses have been found in teaching anatomy, emergency medical training, medical device assembly training, surgical training, and therapy sessions, helping the handicapped, pain reduction and surgery. This summary of information can help medical schools, hospitals, research labs and clinics know how to make advancements in their fields with virtual reality. Zajtchuk and Satava (1997) claimed more than 20 years ago that Virtual reality is being used to enhance medicine in many ways. Scerbo et al. (2006) found in their research that the first virtual reality medical simulator was completed in the 1990s. Soon after, virtual systems were able to simulate specific operations such as knee, eye, and sinus surgery. Virtual reality technology has advanced in the last 20 years by using stronger computers and algorithms to produce realistic imagery and haptic sensory. This article will first cover the many ways virtal reality is being used in education and its effectiveness. Then it will go over how it is being used in medical practice and its effectiveness. It will then conclude by comparing the general advantages of virtual reality found by each article in this review.

Medical Education

Virtual medical education has the potential to be used anywhere in the world, by anyone, and at any time said Zajtchuk and Satava (1997). Salsabeel et al. (2018) also reasoned that medical students need to develop clinical skills before dealing with real patients. Students can develop skills without the risk of harming a patient by working with artificial models. However, the current models need to be updated due to the changing complexities of Medical knowledge and student demand for modern teaching methods. Virtual reality is a model that can be used and has already been being used to enhance medical education. Salsabeel et al. (2018) also explained that minimizing errors in medical learning is crucial for patient safety. Virtual reality provides a way to measure learning outcomes to ensure students are ready to perform on real patients. Djukic et al. (2013) believes the current education model can be drastically improved by virtual reality technologies. Scerbo et al. (2006) agree with many of the researcher in this article that medical training is out of date and better training can be found through virtual reality. Zajtchuk and Satava (1997) have already found Helene Hoffman of the University of California’s virtual courses in anatomy, pathology, and radiology to be effective learning experiences. The following sections are a summary of studies done to test virtual reality learning in the medical field.

Anatomy

A study conducted by Salsabeel ect al. (2018) allowed students to interact with a realistic looking three-dimensional model of a heart in virtual reality. Students were able to dissect and explore different parts of the heart and access description about those parts. These students also used the traditional method for learning about the heart so they would be able to compare the experience. After the student finished the run through, they were given a questionnaire to assess their experience. Twenty-three of the questions asked the student to assess their experience with the physical model and twenty-three other questions asked them to assess their experience with the virtual model.

Another study conducted by Jan-Maarten, Vorstenbosch, and Kooloos (2017) compared students ability to identify cross sections of the neck, which is used to identify cross-sections resulting from an x-ray or histological imaging. The study compared three methods for studying cross-sections of the neck. The first method had students immersed in a three-dimensional virtual environment with the ability to navigate a model of the neck. The second group could navigate the same model but in a two-dimensional environment. The third group was a control group allowed to explore a virtual sea world. Participants were given 150 seconds to navigate their environment. Participants were then given a test to assess their ability to identify cross sections of the neck.

Salsabeel et al. (2018) found that students felt like they learned more and preferred using the virtual reality model over the physical model. This lead to the conclusion that virtual reality is an efficient teaching tool. However, Jan-Maarten et al. (2017) found no difference in assessment scores for any of the three test groups. Both studies found using virtual reality to lower overall teaching costs compared to the traditional teaching method of using dissection facilities.

Patient care

Dyer et al. (2018) created a virtual reality simulation that gave the user the feeling of being a person with age related problems. They hoped this would help user develop empathy towards those with these disabilities. Participants experience conditions such as bad vision and hearing loss. Results showed that participants felt more empathy towards older people with these symptoms by the end of the experiment. They concluded that virtual reality can be used to increase patient care by help participants develop empathy for different disabilities.

Phlebotomy training

Scerbo et al. (2006) tested a virtual system for practicing drawing blood with a needle(phlebotomy) called CathSim. Haptic interfaces provided the ability for users to feel objects in the virtual world because of force feedback devices. Haptic devices provide more realistic training for virtual reality. The CathSim system uses haptic sensors to produce the force feedback needed to simulate sticking a needle into an arm. The system also provides users with multiple circumstances as well as immediate feedback on their performance. There is no current standard of skill tested for phlebotomy which has led to many injuries. Test were performed between the traditional method of practicing on plastic simulated limbs and the virtual method. However, those that trained on the plastic limb had a higher skill rating than those that used the virtual model. However, this could be due to both groups being tested on simulated plastic limbs which would give the group that work with the plastic limbs and advantage. The research still believe virtual reality could bring great benefits as fidelity increases.

Nasogastric tube placement

Choi et al. (2015) explained Nasogastric tube placement or inserting a plastic tube into the body for feeding or drainage, is an important medical skill. So, they created a virtual training to help teach this skill. Professional nurses assessed the training and found it realistic.

Emergency medical training

Simulation is an important training method for medical personnel says Ferracani, Pezzatini, Seidenari, and Del Bimbo (2015). However, unlike virtual reality, many of the simulations available are expensive and lack the ability to create diverse situations. Pezzatini et al. (2015) created an emergency medical virtual training system called EMERGENZA and tested its teaching abilities. Found not as real. EMERGENZA uses the KinectTM SDK to track participant body movements. However, the KinectTM SDK system was not accurate in tracking hand positions. The team found using a temporal Kalman filter increased tracking accuracy to basically 100%. For the experiment, four medical operators and 6 researchers used the

EMERGENZA training system and evaluated their experience using a questionnaire. The evaluator's results show they were highly engaged by the virtual experience.

Diagnosing patients

Holland et al. (2004) explained haptic technology allows users to feel objects in the virtual world because of force feedback sensors. They used this to create an artificial back to see if they could have it produce the forces similar to a real back for diagnostic training purposes. Palpation is the process of diagnosing a patient through touch; this model would help teach students this skill.

Manufacturing medical devices training

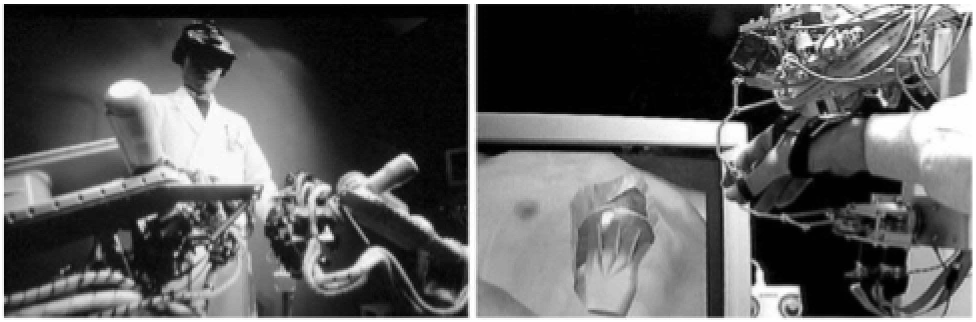
Ho, Wong, Chua, and Chee-Kong (2018) indicated that putting together hybrid medical devices is difficult and time consuming. Current training methods require an experienced instructor, long class room hours, and high training costs. To reduce costs, trainees share work cell with actual workers leading to potential contaminations or real products or safety risks within the work cell. Ho et al. (2018) created a virtual reality training program called VRAGTS to combat these issues. The VRAGTS is an intelligent, game based virtual reality training program. The VRAGTS provides the trainee with a virtual supervisor to help them know when they made a mistake and give hint to the next step in the procedure. A tutorial, practice and assessment phases were identified levels to maximize trainee learning. Trainees are required to pass each level based on a score they are given at the end of the level. They must repeat the level if scores are not high enough. After running experiments Ho et al. (2018) found the new virtual training to significantly decrease training time. They also found trainees preferred using the new system and were better trained on assembling the hybrid medical devices.

Surgical training

Zajtchuk and Satava (1997) explained that virtual reality allows surgeons to train on difficult procedures by performing the procedure on a virtual organ that move, behave and feel like real organs. They only say that they do not currently look like real organs. Also, further testing is needed to determine if this method improves learning. Stern (1998) explains typically surgical learning has student watch professional multiple time before being given their own trial under supervision. With virtual reality, students can practice multiple time before getting familiar with different instruments and procedures. It will also help identify weak areas the potential surgeon can improve upon. A variety of circumstance and unexpected events can be programed into the system to help training surgeons become more prepared. Djukic et al. (2013) also agree that virtual reality has the potential to allow medical student to perform treatments to virtual patients with not risk of harm to patient or equipment. It is also able to produce rare operations that the normal student or trainee would probably not experience.

Carroll and Messenger (2008) also observed that virtual reality can be used to assess medical personnel. It allows them to be tested and trained on such skill as pre-assessments, decision-making, hand skill, following procedure, and managing unexpected events.

Stern (1998) has researched many simulators that accomplish this task but are currently too expensive. A decade later Djukic et al. (2013) observed powerful virtual reality technologies in that time to become inexpensive. They believed it was cheap enough to decrease medical training costs. Carroll and Messenger (2008) found many company that make such simulators and most of these simulators are now FDA approved. However, the main challenge preventing virtual simulation technology to be present in the medical field is the acceptance of the medical community. Hospital and medical school need to see the advantages of these simulations to invest their money into funding simulation programs.



Medical Practice

Therapy

Weghorst et al. (2018) stated that People with Parkinson’s disease can acquire Akinesia which means their steps become small and shuffled and patients with akinesia will experience difficulty moving across doorways or in narrow hallways. Kinesia paradox is a treatment for Akinesia in which perpendicular lines are placed in front of the patient at equal intervals. These lines help the patient walk normally. Weghorst et al. (2018) used augmented reality googles to produce these lines in the patient’s vision so they can walk normally in public.

Weghorst et al. (2018) did an experiment to see if virtual reality could be used to cure the fear of spiders. Spider phobic participants were exposed to virtual spider for four one-hour sessions. After, participants filled out a questionnaire, researchers then measured how close they were willing to get to a real spider, and a doctor rated their fear. The results showed that 83% of the participants showed significant improvements.

Weghorst et al. (2018) also used virtual reality to help those with post-traumatic stress disorder. Those traumatized by the world trade center attack on September 11, were exposed to a virtual rendition of that event. The researcher found this treatment to be successful.

Helping Handicapped

Weghorst et al. (2018) stated people with poor vision that can't be corrected as glasses are categorized as having "low vision." A wearable low vision aid, using augmented reality principles, was invented to detect and notify the user of obstacles in their path. The user is notified by having a virtual image of the obstacles projected onto their retina. This device improves the awareness of those with low vision.

Pain reduction

Weghorst et al. (2018) used virtual reality to reduce pain during painful burn treatments. Those undergoing the painful procedure were put in a virtual snow world where they could shoot snowballs and snowmen. Participants and MRI scans showed a significant increase in pain tolerance.

Surgery

Suzuki and Hattori (2008) created a virtual soft tissue organ that would provide force and tactile feedback in response to touching the virtual organ. This provides a realistic way for surgeons to push, grasp, and preform incisions and resections on the virtual organ. The program is also able to assess the performance of the surgeon.

Suzuki and Hattori (2008) liked the idea of a surgeon using robots to perform a surgery many miles from the patient. This technology was not invented at that time, but researcher thought the first step towards this would be to give surgeons three-dimensional imagery of the internal organs. They accomplished this by using endoscopic robots that were able to render three-dimensional models or the organ they were inserted into.

Carroll and Messenger (2008) observed that virtual reality simulations can allow surgeons to practice newly discovered treatments, so they are ready when they need to apply one to a patient.

Collaboration

Liang and Grady (2003) argues that three-dimensional models received from radiologists should be able to be explored and interacted with to make fast accurate diagnosis. There also would be great advantages if this model could be used remotely by doctors for consulting purposes. This should be possible according to their research on current virtual reality technology. Liang and Grady (2003) have come up with mathematical algorithms to demonstrate how medical data of organs can be used to reproduce three-dimensional images on the internet. The algorithms first focuses on calculating object boundaries of two-dimensional segmentations then uses those to calculate the three-dimensional segmentations. The following formula is used to remove any noise in the pixel values.

$$V_x(P_{x,y,z}) = \mathrm{ABS}((\mathrm{MEAN}(P_{x-p,y,z};\ldots,P_{x-2,y,z},P_{x-1,y,z}) - \mathrm{MEAN}(P_{x+1,y,z};P_{x+2,y,z};\ldots,P_{x+p,y,z}))$$

This is the general explanation of the equations but added equations can be found in Liang and Grady (2003)'s article. Liang and Grady (2003) state that their formalism provides the steps to creating a virtual, internet based, three-dimensional world for doctors to collaborate.

Diagnosing patients

Djukic et al. (2013) have found the medical personnel prefer using two-dimensional cross sections over a three-dimensional image on a screen. So, they have used virtual reality to display these three-dimensional models to see if medical personnel would find the virtual model useful. They also added fluid flow simulation to show medical experts stresses on artery walls. Their hope is that the virtual model will provide experts a quicker and more accurate way of diagnosing issues related to the virtual model. Djukic et al. (2013) medical personnel can move, rotate and scale the three-dimensional images in order to find anomalies in tissues or organs. In order to give personnel a more immersive experience, the 5DT DataGlove was used to allow the user to easily manipulate the model. Djukic et al. (2013) states that virtual models can easily be changed to represent other things like organs and tumors. Djukic et al. (2013) conducted no experiment but concluded that their system along with other virtual reality systems could advance the medical world. By reducing education cost, improving diagnostics, and surgical operation planning.

Conclusion

All researcher agree that virtual reality has and will significantly improve the medical world. Virtual trainings provide training on virtual patients instead of actual ones. It also allows for many repetitions to identify and correct weaknesses and mistakes. With advances in technology current virtual reality devices are inexpensive and easily accessible, helping to reduce schooling costs. Computer and algorithms are being improved daily to increase the virtual imagery to have realistic qualities. Despite these advantages, the medical community have not yet spent the money or time to add virtual simulations to their facilities. Researcher believe this is due to a lack of studies showing the effects of these simulation. While current studies show positive result from virtual reality, more studies need to be done to convince the medical community of the important advancement that can be made by virtual reality programs.

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