Virtual Reality: Applications in Medicine and Psychiatry

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Virtual reality (VR) is a coined description of a new computer-based technology that allows the user to enter a 3-D artificial world. Inside this world, the user can look around, move around and interact within computer worlds. The user can fly, visit exotic lands, play with molecules, "enter" cardiac chambers and watch blood swirl or do simulated surgery. The possibilities are staggering and it is important that physicians become literate in this visual experience. In this article I will introduce the technology in the field, discuss some medical applications already in use, and speculate on some potential uses in my field of interest: psychiatry.

The Concept

Virtual reality systems are different because of 3 inherent properties: Immersion, navigation and manipulation.

Immersion is experiencing an alternate reality from the inside instead of observing it through a computer screen and is primarily a function of hardware. Most systems use a head-mounted display (HMD) to create a 3-D effect, which also stimulates the auditory senses through stereo headphones. The cycle starts when a participant reacts to the visual and auditory data provided by the HMD. Head movements are input as signals to a reality engine. The reality engine is the computer system that processes

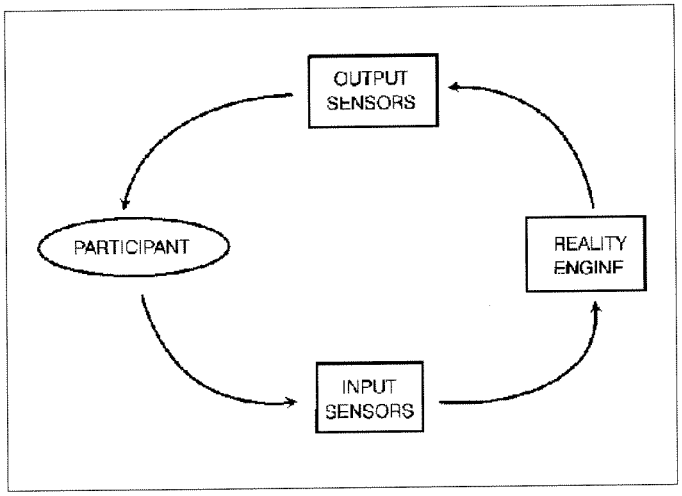

Figure 1: Block diagram of VR sensory feedback loop

these data and continuously pumps out sensory information to keep the illusion alive (Fig. 1).

Additional input devices that increase immersion include wired gloves that sense hand orientation and position and force balls that measure the amount of force applied to them.

Immersion creates the experience of an alternate reality, navigation and manipulation allow the user to explore and move within this world. Geometry is the term used to denote stored information describing the physical attributes of objects such as their shape, color and placement. Accurate geometry gives the user the ability to manipulate the artificial environment and have it respond appropriately. For example, the user might put on a data glove and reach out and rotate an object in his or her virtual field of vision. The object would then respond as if it were a real object being rotated in the real world. The user would feel the virtual object as it is rotated by means of little tactile stimulators embedded in the glove. Anatomical dissection, for example, is quite possible in a virtual world.

Current Medical Applications

At the University of North Carolina, Chapel Hill, virtual reality goggles were developed to work with an ultrasound scanner allowing an obstetrician to examine a pregnant woman (men cannot get pregnant even in virtual reality!) and talk with her while watching her fetus.

Wired gloves are being used to aid in the rehabilitation of injuries and as a new kind of prosthesis.

A virtual reality gastrointestinal endoscopy simulator has been developed to help train physicians.

At Dartmouth Medical School in Hanover, New Hampshire, a team is working on a computer graphics-based model of skeletal muscle in a patient. The team is hoping this virtual patient will accurately reflect the geometry of the body and the biomechanical behavior of the physiological systems under study. Such a virtual patient can be used by future surgeons to train others.

A team in Germany is working on simulating the functions of the heart, and their goal is to be able to tour the interior of the heart as it pumps and to study the dynamics of blood flow from inside the heart.

In the future, more and more computer-aided imagery will be used to explain to and educate patients about what is happening inside them. Home imaging systems will allow patients to monitor and keep track of developments inside their own bodies much like taking their own blood pressure or checking blood glucose levels.

Medicine has come a long way—from the days of x-rays, all the way to ultrasound and to magnetic resonance imaging (MRI). When coupled with virtual reality techniques, MRI can give rise to fascinating applications. For instance, virtual reality can make it possible for a physician, moving around in an HMD, to move the MRI sensor to different parts of a patient's body sending a stream of data to the HMD displays. To the doctor, it would seem as though he or she is actually looking through x-ray glasses at the patient. He or she would be able to look at the patient's internal organs first from the front, then from the side and finally from the back, thus getting a complete, continuous picture in real time and in 3 dimensions. Every adolescent boy's dream to own a pair of x-ray glasses now can be realized.

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Potential Applications in Psychiatry

The potential uses of the technology of virtual reality go beyond the improvement in imaging studies; these will help all medical specialties. Specifically, the technology will change the way anxiety disorders are treated and perhaps help us understand the world of the schizophrenic.

I predict that in the future most behavioral therapy for anxiety disorders will take place in virtual worlds. If a patient suffers from a specific phobia, social phobia or agoraphobia, it will be possible to desensitize him or her by exposing him or her to the feared stimulus in a virtual world. The interaction with the program will allow the patient to titrate his or her exposure to the stimulus and work through a gradation of fears. In current practice, most of the desensitization occurs through in vivo exposure, which causes a lot of inconvenience and could be costly (eg, getting desensitized to riding in planes). In addition the therapist will be able to join the patient in the virtual world and help navigate him or her through the minefield of fears.

Likewise, a patient with an obsessive-compulsive disorder can be exposed to avoided activities (eg, using public phones) in a virtual world and be guided away from the usual response (eg, hand washing). Again, a therapist can help the patient by being inside this world with the patient.

Schizophrenia, itself perhaps a virtual reality inside a patient's mind, offers many paradigms that can be recreated and examined with VR technology. In the process, an understanding is gained about how schizophrenics process information. If we can understand how the world out there looks to them (and how it got that way), it will certainly be easier to plan interventions that target specific deficits or excesses.

The ethics of therapist-patient interaction in a virtual world will have to be redefined. Does a patient-therapist sexual encounter in a virtual world (as played out in a recreation of a patient's fantasy) constitute boundary violations? This and other issues will need to be clarified before widespread use of virtual reality-enhanced psychotherapy will be undertaken.

Conclusion

The technology of the future as described above is already available today (see recommended readings). In the same way we adapted to x-rays, ultrasounds, CT-scans and MRIs, so will we have to become comfortable with virtual reality, lest we miss the chance of becoming virtual doctors.

References

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5. Sense8 Corp. 4000 Bridgeway Suite 101, Sausalito, Calif. 94965. tel: (415)331-6318 (sells hardware and programs in virtual world building.)
6. VPL Research. 950 Tower Lane 14th Flr, Foster City, Calif. 94004. tel: (415)312-9356 (Sells a full-line of virtual reality technology including RB2: Reality built for two).

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