



# REAL-TIME INTERACTIVE GRAPHICS

## How Real-Time Technology Can Improve the Quality of Life

In the February issue, we looked at an application of interactive real-time graphics systems for entertainment. Previous columns have dealt with interactive gaming, simulation and other areas. In this column, we present two articles about ways in which the same kind of real-time technology can be applied with the goal of improving quality of life.

"How's your health?"

There is no doubt that physical and mental health help form a foundation on which to build a happy, satisfying life. People who suffer from phobias or other "anxiety disorders" are often painfully aware of the impact these can have on their happiness and their lives. For some, activities which most of us don't think twice about — like driving a car to work or being flown to a favorite vacation spot — can be seemingly insurmountable obstacles to personal fulfillment. Could it be that computer technology can help people surmount some of these fears? In our first article, Mark and Brenda Wiederhold — both medical professionals from southern California — give us a look at some of the work being done in this area.

Sometimes mental stress, fatigue and depression are caused by physical pain. Cancer patients frequently suffer excessive pain and this only adds to the psychological trauma of the whole experience. In Japan, Dr. Hiroshi Oyama and others at the National Cancer Center Hospital and the Mitsubishi Electric Corporation are working to help relieve some of this stress. They are developing a "wellness system" to try to ease some of the anxiety and stress that cancer patients experience, by allowing them to virtually experience a natural environment, from the convenience of their bedside. Our second article describes this ongoing effort, and some of their initial findings.

A reminder — we are very interested in hearing from our readers. In particular, if you are involved in a new (real-time, interactive) application, or have a related topic that you think might be interesting to share with the SIGGRAPH membership through our column, please let us know. Also, if you have feedback to offer on current or past columns, we would be more than glad to hear it!

— Glen Fraser, Scott S. Fisher

### The Use of Virtual Reality Therapy for the Treatment of Anxiety Disorders and Phobias

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Twenty-three million Americans will be diagnosed with an anxiety disorder during their lifetime. Anxiety disorders are the most common group of mental disorders in the United States and the fifth most common diagnosis seen by primary care physicians.

In 1990, \$147.8 billion mental health care dollars were spent in the United States, with \$46.6 billion dollars (32 percent) spent on the treatment of anxiety disorders.

Although virtual reality (VR) has been available for more than 20 years, most applications include use by the military and the entertainment industries. VR is now being used to train

surgeons and plan complex surgical approaches in three dimensions. The use of virtual reality to treat and diagnose mental health disorders is still relatively new.

#### Fear of Heights

The first study by Hodges, Rothbaum and North in Atlanta used VR exposure to treat fear of heights. Seventeen subjects were exposed to virtual height situations — a glass elevator, a series of bridges with varying heights and degrees of stability and a series of balconies with varying heights. Participants' subjective ratings of fear, anxiety and avoidance decreased significantly for all participants in the VR exposure group, but remained unchanged for the control group.

In another study, Lamson exposed 30 participants to simulated height situations. A total of 90 percent were able to experience height situations in the real world after one week of exposure. Thirty months after therapy, 90 percent were able to ride in a glass elevator.

To follow-up on these studies, which did not include a group receiving any other treatment, Huang and associates in Michigan are now conducting a study to compare in vivo exposure and virtual reality exposure to treat fear of heights. They are modeling a virtual world to exactly duplicate a staircase at the University of Michigan.

#### Fear of Flying

Characterized by an unreasonable or excessive fear of flying or the anticipation of flying, this specific phobia affects 10 to 20 percent of persons in the U.S.

An initial study treating fear of flying, done by Hodges and Rothbaum in Atlanta, involved a subject who had not flown for two years prior to treatment. She had become progressively more anxious about flying and had finally discontinued flying for business or pleasure. After seven sessions of anxiety management techniques, such as relaxation skills and six sessions of VR exposure, she was able to fly again with her family on vacation, self-reporting less fear upon exposure.



Figure 1: VR simulation to treat fear of driving.



Figure 2: Treating fear of flying.

North et al also did a case study with one of the subjects who had been treated for fear of heights in the first VR study. After five VR exposure sessions in a virtual helicopter, he successfully completed a flight.

Research is now underway at the Center for Advanced Multimedia Psychotherapy in San Diego to look at VRGET vs. imaginal exposure to treat fear of flying. During the exposure sessions, vital signs are monitored for all patients. Based on studies initiated by Carl Jung in 1907 — which revealed that skin resistance correlated with emotional tones previously thought to be invisible — resistance levels are shown to patients as an indicator of arousal and anxiety. Physiological measures being monitored include heart rate, respiration rate, peripheral skin temperature and brain wave activity. Data analysis will reveal whether other physiological data may be important to note as patients become desensitized to the phobic stimuli. Emotional processing theory suggests that in order to change a fear structure, it must be activated and information incompatible with the fear must be provided. According to Foa and Kozak, there are three indications that emotional processing is occurring: physiological arousal and self-reported fear during exposure; diminution of fear responses within sessions; and a decline of arousal across sessions. This study will examine how physiology, self-report measures and behavioral indices correlate.

#### Fear of Spiders

Hoffman, at University of Washington, has completed a case study to treat fear of spiders using both virtual reality and augmented reality. The subject had a severe fear of spiders for 20 years. Treatment involved exposure to a tarantula and a black widow in the virtual world, then touching a furry toy spider while viewing a corresponding virtual spider. After 12, one-hour sessions, the patient was able to go camping in the woods and survived a spider encounter in her home. One-year follow-up indicates that treatment is still successful.

#### Claustrophobia

Bullinger has begun to explore virtual reality for the treatment of claustrophobia, using a head-mounted display and a 3D joystick. During virtual exposure, the patient is allowed to increase or decrease the size of a virtual room, bringing the walls closer and closer as desensitization continues. The patient can exit at any time via a virtual door at one end of the virtual room to escape if necessary. Patients in the initial study have received three sessions per week for four weeks (12 sessions), and initial results show a decrease in overall anxiety scores.

#### Fear of Driving

Berger and others at Hoffstra University are currently conducting a study on the treatment of fear of driving. The study will compare imaginal exposure therapy and virtual reality exposure treatment. Since a fear of driving may occur as part of a simple phobia or as part of agoraphobia, and since driving deficits are often seen after head trauma, stroke or other physical insult, this area has a wide range of potential applications for VR technology.

#### Social Phobia

North and colleagues have begun using virtual reality to treat fear of public speaking. Initially subjects were exposed to a virtual audience and experienced similar symptoms when in front of a real audience — dry mouth, sweaty palms and increased heart rate. Self-reported anxiety (SUDs) as well as scores on an Attitude Toward Public Speaking Questionnaire were found to be decreased after treatment.

#### Obsessive-Compulsive Disorder

A group in Georgia is now exploring the efficacy of treating OCD with VRGET. The program has nine steps — four of which prepare the patient, two that set them on a therapeutic course, and three that continue them through their therapy. The steps involve education, behavioral assessment, a treatment plan, treatment and relapse prevention. An interactive voice response system using a prerecorded

voice responds to the caller's answers to several questions. During the first controlled study, 17 subjects completed at least two sessions using the system. Of those completing the sessions, a decrease in discomfort of over 50 percent was obtained. Eighty-five percent of patients subjectively rated themselves as very much or much improved.

#### Posttraumatic Stress Disorder (PTSD)

Since most studies have used some form of exposure therapy as part of the treatment regimen, a group led by Hodges and Rothbaum in Atlanta is exploring VRGET at the Atlanta Veteran's Administration Hospital to treat PTSD. Treatment involves exposing the veterans to virtual Huey helicopters which will fly them over the jungles of Vietnam.

#### Conclusion

The advantages of virtual reality therapy compared to in vivo exposure include:

- *No loss of patient confidentiality.* The patient and therapist do not have to venture out into public and risk exposing the patient to possible embarrassment if they would prefer their treatment remain confidential.
- *No safety issues.* The patient is in the safety of the therapist's office, and the VR system can be turned off at any time the patient might request.
- *More flexibility of the session.* If a patient has a fear of one aspect of exposure, for example the actual experience of standing in a grocery checkout line, then this can be practiced over and over in the virtual world. In the real world, a patient may feel conspicuous checking out over and over again at the grocery store.
- *Just "unreal" enough that many patients who have resisted therapy due to in vivo approaches are willing to try it.* They know they can stop the virtual experience vs. being "trapped" in a real-life scenario.
- *Less time involved.* The cost advantages here are obvious.

Advantages of virtual reality when compared to imaginal exposure include:

- *The highly immersive nature of VR.* Some patients can't visualize and therefore imaginal exposure doesn't work as well for them. VR should work better for this group of individuals due to providing several sensory modalities.
- *The therapist sees what the patient sees.* Emotional processing theory purports that, in order to successfully treat a phobia, the patient's fear structure must be activated and modified. With VR, the therapist has a chance to see exactly what stimuli is activating the patient's fear structure and will then be better able to work on reducing the fear.
- *The therapy is more realistic than imaginal for most people,* which should allow for fewer treatment sessions, and therefore less cost for treatment.

Virtual environments clearly show promise for the future. It is important that controlled studies and outcomes analysis continue, so that true cost/benefit analysis can be done. Additionally, a variety of other disorders may respond to the use of virtual worlds. One new development will allow the therapist to accompany the patient into the virtual world, allowing additional flexibility and new approaches in the therapy session.

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## VR Reproduces Wellness for Cancer Patients

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VR technology may be used to construct virtual, yet realistic, environments that patients can enjoy, experience and feel refreshed in without being caused additional stress or fatigue. Our medical virtual reality (MedVR) project has several goals. One is to improve the quality of life (QOL) of cancer patients with a wellness support system incorporating virtual reality (VR) technology [6]. It is expected that the beautiful scenery, in conjunction with wind, scents and sounds, will refresh patients, and that the interactive changes in the natural world evoked will relax and refresh them.

Although we have already demonstrated the possible use of such technology in mental health care, we still have improvements to make in the VR technology, and in investigating how to utilize it in the most effective way. VR sickness is a potential side effect [1], for example. On the other hand, VR immersion techniques may improve the emotional condition of cancer patients suffering anxiety, insomnia or depression [5]. Five years ago, we developed a prototype VR system to research the possibility of psycho-oncological VR therapy (POVRT), and started to apply the VR immersion technique to relieve anxiety, reduce cancer pain, encourage patients to fight with their cancer and prevent disuse atrophy [6]. We have been researching and developing wellness support systems that use VR technology. One of these systems is called the virtual forest walk system (Bedside Wellness System) [2]. We have already

reported that, for a healthy person, the system increased the pain threshold, reduced the level of stress and increased satisfaction [3, 4]. We report on how effective the Bedside Wellness System is in supporting cancer patients.

### System Configuration

The Bedside Wellness System stimulates the patients' senses of sight, sound, touch and smell (Figure 3). The system consists of a wide-view three-screen LCD with stereo sound (from speakers and headphone), a walking-system for the bedridden, a scent system with a gentle breeze and a system for monitoring vital signs (Figure 4) [2]. Walking is simulated to enhance the reality of the experience and to promote early rehabilitation. Actual photographs were taken and later synchronized with a walking pace [2], and we used step-wise changes of the viewpoint in the imagery to produce a more natural feeling of walking, and to prevent virtual reality sickness. We have three different scenarios — the walk can be in a typical park, on a beautiful plateau or along an avenue of cherry trees in blossom. The scents, wind and sound (background sound and own footstep) will be matched with each scenario to make the effect more realistic. A vital signs unit measures electrocardiogram, blood pressure and respiration in real time to evaluate the effect of the treatment and to secure patients' safety.

### Method

We performed a clinical trial which was designed to be one arm of a pilot study to confirm the efficacy of the Bedside Wellness System in the psycho-oncological care of female cancer patients. Twenty-two female patients aged 33-75 were studied after giving informed consent. There were 18 patients with breast cancer and four with ovarian cancer. The patients were given the Hospital Anx-

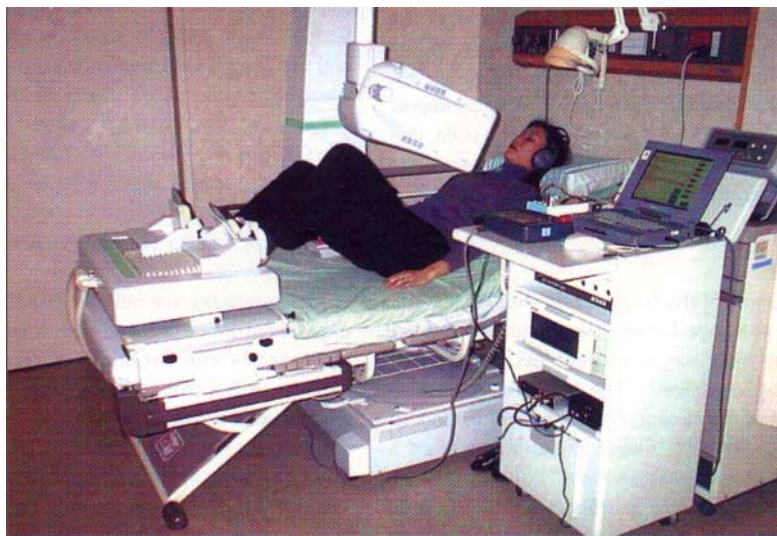


Figure 3: The "Bedside Wellness System" stimulates patients' senses of sight, sound, touch and smell.

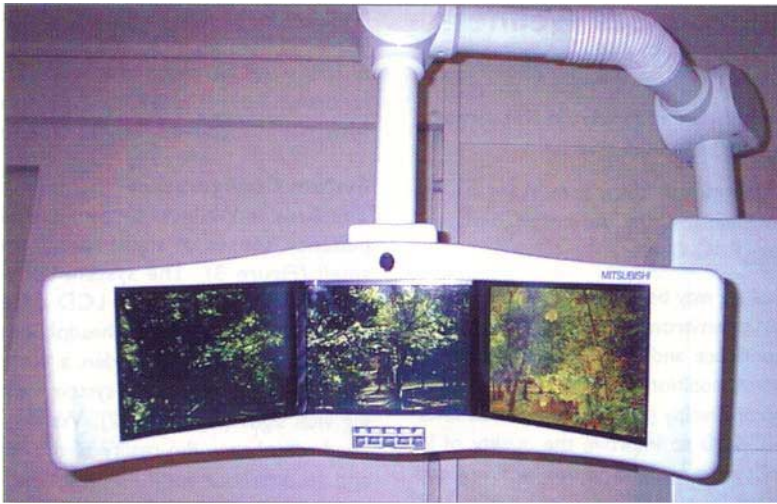


Figure 4: The system's wide-view, three-screen LCD display with stereo sound.

xiety and Depression Scale test (HADS: four-point, 14-item self-assessment questionnaire) before the VR experience to evaluate their emotional baseline. The fatigue scale, which was developed at our institute, and the VAS (visual analogue scale) were assessed before and after the experience. Moreover, we used the patients' subjective feelings to evaluate the system, just as we did in our previous research project. A questionnaire with five graded responses was used to subjectively assess each patient's mental state. After their virtual experience, we interviewed all of the patients about their impressions of the system.

Each of the patients received one experimental VR session, which consisted of a six to seven minute trial. At the end of the session, subjective ratings were obtained from the subject verbally, using a set of adjectives (relaxed, refreshed, calmed, vivid, strained, depressed, displeased, sleepy and tired). After finishing the trial, the subjects were required to answer a written questionnaire (post questionnaire), on both positive (satisfaction and pain reduction), negative (fatigue and pain) effects of the system and the degree of expectation of the effectiveness and the hope of repeated trials. We also gave out four sets of questionnaires which included VAS and the fatigue scale, and asked patients to fill them out each day after the experimental VR session (for a total of four days).

### Results

The results of the fatigue scale showed a significant difference between pre and post scores ( $p < .05$ ). Post scores showed less fatigue compared to pre-session. The post VAS score also indicated significant difference compared to pre VAS ( $p < .05$ ). Eleven patients reported a better mood post session. Four out of 22 patients were very satisfied with the system, five were slightly satisfied, 10 satisfied a little and three were slightly dissatisfied. None

were very dissatisfied. When asked about fatigue, 16 were not fatigued, four were a little fatigued, one was fairly fatigued and one did not answer. Sixteen patients expected positive effects, while five did not. Seventeen patients desired a repeat trial, and four did not. Of the eight cases with cancer pain before the session, two forgot their pain and it was reduced in four others. After the session, most patients showed an increase in positive emotions and a decrease in negative emotions. Most patients became more animated after the system trial. Thirteen patients improved in their HADS scores. There were too few cases to evaluate changes in the vital signs.

### Summary

This study showed that our virtual forest system has a significant effect in the mental support of cancer patients: reducing anxiety and increasing refreshed feeling. Almost all of the patients were happy with the treatment and had positive impressions about their experience. In addition, some patients reported that their cancer pain decreased during the trial. Some cancer patients remember the nausea and vomiting they experience during their first treatment with chemotherapy, and develop these symptoms in their second treatment, even before it begins. This is called anticipatory emesis, and it is resilient to treatment with anti-emetic drugs. We hope to use the virtual forest walk system to treat or prevent anticipatory emesis.

Improvements are still needed to make the experience more natural. We especially need to improve the technology, to allow the patients to feel that they are controlling where they walk. Patients' more active involvement should be considered.

Virtual environments should have enhanced reality. Moreover, a method to have the patient control the state of the virtual environment should be developed. A quantitative

method of assessing the effects of this treatment also has to be established. Ultimately, a more compact system for home use and a multi-user system connected to a network should be developed.

### Acknowledgments

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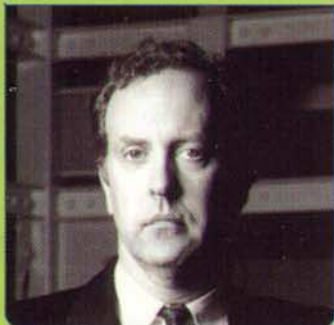
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## About the Columnists



**Scott S. Fisher** is a Media Artist, Producer and Director whose work focuses primarily on immersive environments and technologies of presence. He is President of Telepresence Media, a company focusing on the art and design of virtual environment and remote presence experiences; Visiting Professor in the School of the Arts and Architecture at UCLA; and

Visiting Scholar and Director of the Virtual Explorer Project in the Department of Chemistry and Biochemistry at the University of California, San Diego.

Fisher attended the Massachusetts Institute of Technology, where he held a research fellowship at the Center for Advanced Visual Studies from 1974 to 1976 and was a member of the Architecture Machine Group from 1978 to 1982. There he participated in development of the Aspen Movie Map, a surrogate travel videodisc project, and several stereoscopic display systems for teleconferencing and telepresence applications. He received the Master of Science degree in media technology from MIT in 1981 under thesis advisor Nicholas Negroponte. His research interests focus primarily in stereoscopic imaging, immersive display environments and the development of interactive art installations and media technology for representing first-person sensory experience.

From 1985 to 1990, Fisher was Founder and Director of the Virtual Environment Workstation Project (VIEW) at NASA's Ames Research Center in which the objective was to develop a multi-sensory virtual environment workstation for use in space station teleoperation, telepresence and automation activities. The VIEW Project pioneered the development of many key VR technologies including head-coupled displays, datagloves and 3D audio technology. In 1990, he cofounded Telepresence Research to continue research on first-person media, and to develop virtual environment and remote presence experiences, systems and applications.

Prior to the Ames Research Center, Fisher served as Research Scientist under Dr. Alan Kay with Atari Corporation's Sunnyvale Research Laboratory and provided consulting services for several other corporations in the areas of spatial imaging and interactive display technology. He has taught numerous classes and seminars on interactive media, photography and stereoscopic displays and has been an artist in residence at MIT's Center for Advanced Visual Studies. His work has been recognized internationally through numerous invited presentations, professional publications and in the popular media with articles in publications such as the *Wall Street Journal*, *Time*, *New Media*, *Computerworld*, *Byte*, *Scientific American*, *VR World*, *Funworld*, *TDR*, *Liberation*, *Le Monde*, *InterCommunication*, *Media Report*, *Nikkei Entertainment*, *Nikkei Computer Graphics*, *Login*, *Trigger*, *Asahi Shimbun*, *Asahi Pasocom*, *Designer's Workshop*, *Newton*, *Virtual*, and many others. In addition, his stereoscopic imagery and artwork has been exhibited in the U.S., Europe and Japan. Most recently, his works have been shown in Paris at the Galeries Contemporaines of the Centre Georges Pompidou, and in the InfoArt Pavilion at the '95 Kwanju Biennale in Korea.

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Who are you?  
the editor queried,  
It's for our readers to know.  
Extra-long bio in this quarter's CG,  
Show them what you've got to show.

I'm a computer guy — "graphic" computer guy,  
Seems pretty simple to me.  
My keenness on real-time springs from my history,  
Making VR for money.

Not just for money! (my "second I" says),  
Creative pursuit's at least half.  
It seems that the stereotypes aren't so simple,  
I do the art and do the math.

More recently, though (counting back five years now),  
I've slowly expanded my view.  
Interaction and viewing are still a big part,  
But another love — animation — is new.

[And, for the poetically challenged]

**Glen Fraser** is a Computer Engineer with a passion for virtual reality and other forms of real-time visual computing. He currently works at SOFTIMAGE, developing interactive viewing and animation tools. That part you already knew, from diligently reading right to the end of this column each issue. What else? He loves (listening to and trying to make) music. He enjoys editing, but loves writing. He loves special effects, but not at the expense of a good story or creative cinematography. He loves discovering, expressing and appreciating the absurd (yes, in that order). He loves Jessica.

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