



Effective Virtual Environments

Department of Computer Science

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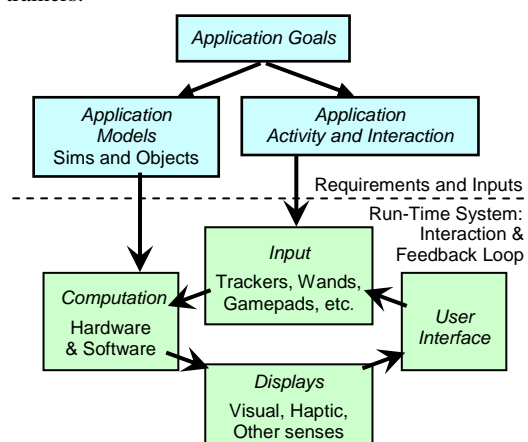
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VE Applications and Challenges

Applications using virtual environment (VE) systems are as diverse as the technologies that enable the systems: They include training; rehabilitation; virtual tours of heritage sites, imaginary places, scientific data, and reconstructed crime scenes; immersive art experiences; and entertainment and games using immersive VEs. Hardware and software technologies include game engines, graphics, trackers, displays, and user input/output devices and techniques. While commodity products are making it easier to build VE systems, there is still research needed to understand how to compute and deliver a VE experience that creates an illusion of being in *another* world and of being in a *plausible* world—one that behaves as you expect it to. Research in the Effective Virtual Environments (EVE) group has addressed most of these topics at one time or another.

The EVE Team's Approach to VEs

At a highest level, EVE approaches VEs as multi-faceted, multi-sensory human-computer interfaces (see figure above). The group's research is usually driven by a collaborator's application problem: We have worked with military trainers and are now working with physical therapists and athletic trainers.



EVE views virtual environment systems as multi-sensory human-computer interfaces designed to create the illusions needed to make applications effective.

EVE builds systems using commercial technology—hardware and software—whenever we can, but develops custom solutions when we must. We use commercial trackers, HMDs, game cards, and a commercial game engine, Emergent Game Technology's Gamebryo, as the foundation of our (current) software. We change hardware and software as technology moves on and projects need the capabilities of new products.

Several of EVE's project areas—haptics, walking-in-place, redirected walking—require an understanding of the psychology of human perception in addition to an understanding of graphics and principles of human-computer interface. Perception and knowing how to fool the senses are often the scientific underpinning for the design of new techniques. We evaluate the new techniques using standard usability engineering techniques, including user studies.

Research Directions and Opportunities

- Develop methodologies to use the new *Place Illusion (PI)* and *Plausibility (Psi)* concepts in evaluation of VE effectiveness.
- Extend the ideas of Gait-Understanding-Driven walking-in-place to address the start-up and stopping phases of walking and application of GUD-WIP to joystick, keyboard, and balance board locomotion.
- Define and implement a game-based VE system for concussion rehabilitation that supports cognitive and motor tasks.
- Develop an automated system to evaluate gait based on the biomechanics definition of normal gait and logs of treadmill and tracker data for users exhibiting pathological gait.
- Develop a scenario generation tool for Physical Therapists training balance and maneuvering.
- Exploit the imprecision of human perception to increase the strength of the VE illusion: haptics (our sense of touch) and redirected walking.
- Apply VE technology in scientific visualization.

New Research Opportunity

Using Place Illusion and Plausibility to Evaluate VEs.

Rick Skarbez

Slater¹ has proposed a new way to think about what makes VE illusions work. Abandoning the concept of *presence* that no longer has a precise definition, Slater proposed that the VE experience is made up of *place illusion (PI)*—feeling that you are in another place, and *plausibility (Psi)*—feeling that actions and reactions in the virtual place are directed at or reacting to you in a consistent manner. We now need to explore and understand PI and Psi and how to measure them. Once we have validated and reliable measures of PI and Psi, we can begin using them to evaluate our systems.



Dual-belt treadmill and three screen VE system in the Human Motion Science laboratory.

¹ Slater, Mel (2009). Place Illusion and Plausibility can lead to realistic behaviour in Immersive Virtual Environments. *Phil. Trans. R. Soc. B* 2009 **364**, 3549-3557

Ongoing Research Areas and Projects

Applying VE in stroke and concussion rehabilitation.

Jeff Feasel

Rehabilitation after traumatic-brain injuries, whether received in a football game, on the battlefield, or from a stroke, is a topic receiving much attention in the medical and VE communities. We are collaborating with the Division of Physical Therapy (PT) and the Human Motion Studies Laboratory in the UNC Medical School to develop a locomotion interface for the dual-belted treadmill + VE system shown in the figure. The challenge is to enable the treadmill users to control the speed and direction of their travel through the VE using only data from the force plates mounted under each belt. This application also needs easy-to-use scenario authoring and evaluation-from-logs tools.

In addition, we are in the planning stages of collaborations in the Department of Exercise and Sports Science. They are outfitting two new laboratories with VEs. One lab will be devoted to games-technology based concussion rehabilitation and the other to avoiding injuries by understanding the movements that cause them.

Understanding optical flow and perceived speed. During development of the treadmill system we found a mismatch between the actual speed of the treadmill belts and the speed of movement through the virtual environment. Most users prefer the visuals to be moving at twice the speed of the belts. We don't know why this is so, but we'd like to find out.

Redirected Touching—Luv Kohli. Not having anything to actually touch and feel in VEs is a big problem. This project is investigating how different the shape-you-see can be from the shape-you-feel without your noticing it. Luv will apply his technique in training where one prop may be used to represent, for instance, several differently shaped cockpit panels.

Improved Redirected Walking Distractors—Ky Waegel. It has been shown that distractors are a promising method for implementing a redirected walking system. Current research seeks a generalizable and minimally-distracting method of inserting distractors into arbitrary virtual environments.

Recent Dissertation Projects

(All EVE dissertations can be found on the EVE web page.)

Improved Redirected Walking—Tabitha Peck. A new *reorientation* technique, distractors, helps eliminate the *waypoints* requirement of previous redirected walking techniques. The goal is an interface that allows real walking in a virtual space of any size, independent of lab size, and neither increases simulator sickness nor interferes with navigation ability.

Real-Walking Models Improve Walking-in-Place Systems—Jeremy Wendt. The goal is to improve the match between the speed VE users moving by walking-in-place think they are moving and their forward progress as they perceive it visually. The methods are based on an understanding of gait derived from the biomechanics literature.

Scene-Motion and Latency Perception Thresholds for Head-Mounted Displays—Jason Jerald. Jason used psychophysics to study how low end-to-end latency must be for the scene motion induced by the latency to remain imperceptible. The work defined and validated a model that relates head rotation frequency to perception of scene motion.

For More Information

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Project Leaders

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Mary Whitton, Research Associate Professor

Current Team Members-Graduate Students

Rick Skarbez (team lead), Jeff Feasel, Luv Kohli, Alexis Chan, & Ky Waegel.

Where EVE alumni work

Sandia National Labs, Digital Artforms, U. Florida CS, NVIDIA, Intel, AMD/ATI, Electronic Arts, 3D Learning Solutions (part of Lockheed Martin), Red Storm Entertainment, InnerOptic Technology, Google.

Research Sponsors

National Institutes of Health / National Institute of Biomedical Imaging and Bioengineering
Office of Naval Research

Selected Recent Publications

Locomotion

Peck, T. M., Fuchs, H., & Whitton, M. (2010). Improved Redirection with Distractors: A Large-Scale-Real-Walking Locomotion Interface and its Effect on Navigation in Virtual Environments. *Proceedings of IEEE Virtual Reality 2010*.

Wendt, J., Whitton, M. C., & Brooks, F. P. (2010). GUD WIP: Gait-Understanding-Driven Walking-In-Place. *Proceedings of IEEE Virtual Reality 2010*.

Peck, Tabitha, M.C. Whitton, H. Fuchs (2008). Evaluation of Reorientation Techniques for Walking in Large Virtual Environments. *Proceedings of IEEE Virtual Reality 2008* (Reno, NV March 2008), 121-127. Honorable Mention in Best Paper Competition.

Feasel, Jeff., M.C. Whitton, J.D. Wendt, (2008). LLCM-WIP: Low-Latency, Continuous-Motion Walking-in-Place. *Proceedings of IEEE Symposium on 3D User Interfaces 2008* (Reno, NV March 2008), 97-104.

Latency

Jerald, J., & Whitton, M. (2009). Relating Scene-Motion Thresholds to Latency Thresholds for Head-Mounted Displays. *Proceedings of IEEE Virtual Reality 2009*, 211-218.

Jerald, J., Peck, T., Steinicke, F., Whitton, M. (2008). Sensitivity to Scene Motion for Phases of Head Yaws, *Proceedings of Applied Perception in Graphics and Visualization 2008* (Los Angeles, August 2008), pp. 155-132.

Haptics

Kohli, L., Whitton, M.C., Brooks, F. P. (2010). Redirected Touching: Warping Space to Remap Passive Haptics. *Proceedings of IEEE Symposium on 3D User Interfaces 2012* (Orange County, CA, March 2012), in press. Runner-up in Best Paper Competition.

Kohli, L. (2010). Redirected Touching: The Effect of Warping Space on Task Performance. Poster presented at the IEEE Symposium on 3D User Interfaces 2010, (Waltham, MA). Best Poster Award.

Kohli, L. (2009). Exploiting Perceptual Illusions to Enhance Passive Haptics. Paper at the IEEE VR Workshop on Perceptual Illusions in Virtual Environments (PIVE), (Lafayette, LA).

Rehabilitation

Feasel, J., Whitton, M. C., Kassler, L., Brooks, F., & Lewek, M. (2011). The Integrated Virtual Environment Rehabilitation Treadmill System. *IEEE Transactions on Neural Systems and Rehabilitation Engineering*.

Kassler, L., J. Feasel, et al. (in preparation). Matching treadmill speed and visually perceived walking speed in associated virtual environment.

Mihalik JP, Whitton MC, & Kohli L. (2008). Do the physical characteristics of a virtual reality device contraindicate its use for balance assessment? *Journal of Sport Rehabilitation*, 2008, 16(38-49).

