Undergraduate Thesis Prospectus

Live Facial Expression Tracking with Partially Occluded Faces
(technical research project in Computer Engineering)

The Self: A Threshold between Simulated Experiences and Virtual Reality
(STS research project)

by

Cody Robertson

November 3, 2016

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

signed: _____ date: _____

approved: _____ date: _____
Peter Norton, Department of Engineering and Society

approved: _____ date: _____
Connolly Barnes, Department of Computer Engineering

word count: 1,127

General Research Problem

In virtual reality environments, how can poor user experiences be prevented?

In virtual reality, optical tricks create the illusion of three-dimensional space on a two-dimensional and a feeling of presence in the environment, called immersion. Any number of small defects can derail the illusion, breaking a user's immersion in the virtual environment and at worst even making a user physically ill. For example, a small drop in latency of the system below the ideal minimum of 15 milliseconds produces severe motion sickness in most users (Orland, 2013). Inventive software practices, such as adding a virtual nose as a stationary focal point or creative avatar locomotion techniques, can avert these defects (Goodall, 2016). With such preventative measures, virtual reality can serve as a medium for diverse academic, entertainment, and professional applications.

Live Facial Expression Tracking of Partially Occluded Faces

How can a system tracking the live facial expressions of a partially occluded face be improved?

When a subject's actions are mirrored in their virtual counterpart, immersion is enhanced. When a user and their avatar experience a disconnect between their actions and sense of self, a cognitive schism occurs, breaking immersion and occasionally causing nausea. Through this independent research, I seek to improve upon the current state of expression tracking with a system that can add on to current virtual reality headsets without requiring sensors to be attached to a subject's face. Connolly Barnes of the SEAS Computer Science Department will advise, due to his experience in computer vision and graphics.

The State of the Art

Hao Li, an assistant professor at the University of Southern California, has led several projects aimed at solving this very problem. Li used a combination of strain sensors on the subject's face to track expressions on the portion of the face obscured by the headset and a Kinect. In Li's system, the Kinect's color camera and depth camera captures expressions formed by the mouth (Li et al., 2015). The data are interpreted mathematically and applied to a generic virtual face. Later attempts, including those not yet formally presented at the time of writing, exchange the facial sensors for an infrared camera to track ocular motion and mathematical interpretation for artificial intelligence based interpretation (Olszewski, et al., 2016).

Outside of purely academic prototyping, companies are raising funds to release products solving aspects to portions of the problem. SMI, a company experienced in eye-tracking hardware, offers a development kit for eye-tracking with infrared cameras with the HTC Vive headset (Durbin, 2016). BinaryVR is a company producing a depth-sensing camera system for tracking expressions formed with the lower jaw (Hamilton 2016). Both cases make no mention of the types of software they use to exploit the power of their respective hardware.

Project Goals

I intend to find an unanalyzed portion of the data provided with current systems of eye and mouth tracking, such as motion of the eyelid or tongue, and prototype a system that can apply the motion onto a virtual avatar. I will add a tracking system to existing Oculus Rift or HTC Vive head mounted displays to capture test data. Utilizing that data along with elements of artificial intelligence and computer vision, a program that can approximate a subject's motion can be developed and trained on the captured data. I will ensure that the program developed will work with current development tools for character creation and animation.

If successful, I will have a prototype of a program that will work with currently developing systems for expression tracking to translate user motion more naturally onto a virtual face. This will allow for more nuanced expression of user emotion in a virtual environment and enhance feelings of immersion in the environment. Further steps to refine the system could be taken until the accuracy of the system is one-to-one with user emotion.

The Self: A Threshold between Simulated Experiences and Virtual Reality

How does the experience of virtual reality compare other simulated experiences?

The recent advent of in-home virtual reality extends to this medium to far more people. This access outside of a formally controlled environment means that many people will "get their sea-legs" and get used to the environment on their own without the gentle guidance of experienced live help. To ease this transition, the effects of virtual reality relative to other simulated environments like video games needs to be explored before it proliferate.

Research

Virtual reality in the home was not possible before the first development kits of the Oculus Rift were shipped in March 2013. The two major consumer-ready systems of the Oculus Rift and HTC Vive became widely available in late March to early April of 2016.Researchers have studied virtual reality as a tool for education or rehabilitation. For example, according to Rose et al. (2000), "virtual training … resulted in equivalent or even better real world performance than real training".

Major Participants

Many individuals are making the leap from video games to virtual reality for the sake of entertainment. Participants on this threshold of virtual reality and other experiences are

"converts": those who "pretty much lost interest in games in general" yet "walked away convinced … that virtual reality is the defining technology for the next era" (Bishop 2016). While a virtual reality experience is a solitary experience physically as one eschews reality for an alternate, many are excited for multiplayer games enhanced by this technology once fully embraced by the masses.

Is virtual reality merely an extension of the video game experience? Even the manufacturers of the HTC Vive market to businesses in design visualization, "offer[ing] unlimited perspectives to inspire product ideation and creation" (HTC 2016). They cite the immediate sense of visual scale as a revolutionary tool for feedback in architecture, perhaps seeking demonstrate that virtual reality is not just an expensive toy from a joint venture with a video game company.

Others value virtual reality as a means to immerse the visual sense completely, providing new experiences and a way to understand more people. The sense of self in a virtual environment is fluid, letting users, for example, to experience their own fears with a surrogate body form (Sanchez-Vives & Slater, 2005). The artists at The Machine to Be Another use a virtual reality and camera system to simulate how other people perceive their surroundings and even own bodies ("The Machine"). To such users, VR is a way to understand the sense of self and others in a purely social way.

The Virtual Reality Society is a British group that publicizes the benefits and hazards of virtual reality. They warn that VR users may suffer real tramua through virtual traumatic experiences and that the anonymity of other users may compound the trauma (VRS). Users have reported psychological stress from witnessing virtual traumatic events (Buckley, 2016)

References

Bishop, T. (2016, September 06). 4 Days of Virtual Reality: Takeaways from a total immersion in the future of video games. http://www.geekwire.com/2016/4-days-in-virtual-reality-lessons-from-my-vr-immersion-and-why-you-should-care-about-video-games-again/

Buckley, S. (2016, January 28). I watched someone commit suicide in VR and it freaked me out. https://www.engadget.com/2016/01/28/i-watched-someone-commit-suicide-in-vr-and-it-freaked-me-out/

Durbin, J. (2016, July 23). SMI Releases Eye Tracking Developer Kit For The HTC Vive. http://uploadvr.com/smi-releases-eye-tracking-dev-kit-htc-vive/

Goodall, L. (2016). Motion Sickness in Virtual Reality and How to prevent it | TruVision VR. http://truvisionvr.com/blog/motion-sickness-in-virtual-reality-and-how-to-prevent-it/

Hamilton, I. (2016, August 08). Face-Tracking VR Headset Camera From BinaryVR Launches Pre-Orders Today. http://uploadvr.com/face-tracking-pre-order/

Li, H., Trutoiu, L., Olszewski, K., Wei, L., Trutna, T., Hsieh, P., . . . Ma, C. (2015). Facial performance sensing head-mounted display. *TOG ACM Tranactions on Graphics. ACM Transactions on Graphics, 34*(4).

Olszewski, K., Lim, J. J., Saito, S., & Li, H. (2016). High-fidelity facial and speech animation for VR HMDs. *ACM Transactions on Graphics, 35*(6), 1-14.

Orland, K. (2013). How fast does "virtual reality" have to be to look like "actual reality"? http://arstechnica.com/gaming/2013/01/how-fast-does-virtual-reality-have-to-be-to-look-like-actual-reality/

Rose, F. D., Attree, E. A., Brooks, B. M., Parslow, D. M., & Penn, P. R. (2000, April). Training in virtual environments: Transfer to real world tasks and equivalence to real task training [Abstract]. *Ergonomics, 43*(4), 494-511.

Sanchez-Vives, M. V., & Slater, M. (2005). Opinion: From presence to consciousness through virtual reality. *Nature Reviews Neuroscience, 6*(4), 332-339. doi:10.1038/nrn1651

Veeso: SDK for Face Tracking in Virtual Reality. (n.d.).https://www.indiegogo.com/projects/veeso-sdk-for-face-tracking-in-virtual-reality-social-technology

VRS. Virtual Reality and Ethical Issues - Virtual Reality. (2016). http://www.vrs.org.uk/virtual-reality/ethical-issues.html