Personal Statement, Relevant Background, and Future Goals
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My long-term career goal is to conduct cutting-edge research in the area of computer graphics and human perception in virtual environments, so I can help improve the usefulness of virtual and augmented reality technologies, especially in the fields of education and medicine.

I became interested in the intersection between computer graphics and education during my undergraduate studies, in my role as a teaching fellow in the "EAST" (Embedded Alliance for Science Teaching) program, a partnership between the University of Utah and the Salt Lake City School District to promote science education. I taught local middle school students computer programming using several interactive graphical programs I developed (designed to demonstrate science concepts about Newtonian physics, natural selection, and the mechanics of human vision). Along the way, I found that many of my students were visual learners, who embraced these graphical visualizations. As the students altered the programs' code to change the conditions of the simulations, they had immediate, interactive, and visual feedback on the results of their changes, deepening their understanding. As I have continued in my studies and focused on immersive virtual environments as a research interest, I look back at this experience as a demonstration of the power and effectiveness of real-time visual learning which will become even more powerful with the targeted introduction of mature virtual reality (VR) and augmented reality (AR) technology.

I gained further background in computer vision during my undergraduate final project, working with the University of Utah Robotics Club (RoboUtes) to develop and build a "Mars rover" as part of the 2011 RASC-AL Robo-Ops competition. The rover's task was to traverse a desert landscape in Texas under remote control from the team's home campus, while identifying and collecting specially-colored rocks. I helped design the camera system, which needed to wirelessly stream image data with low latency and process the images to quickly find the rocks to approach and collect. The challenges of overcoming latency and of creating effective user interfaces for telepresence also lie at the heart of my research interests with virtual reality, dealing with the technical challenges that prevent full immersion or cause motion sickness in virtual environments. The RoboUtes took second place that year out of eight teams, and my team's camera system was integral to its success. Being part of that project gave me experience working effectively in an interdisciplinary team. This is an important quality in computer science, a field known for linking together experts from many different fields.

After graduating from the University of Utah, I took what seemed at the time to be a sharp departure from my existing work and spent a year teaching English as a second language at a university in southern China. I did this out of both an interest in Chinese culture and also a desire to broaden my horizons early in life, and I gained international experience and a practiced ability to work long-term and effectively with people with different cultural and linguistic backgrounds. While teaching in China, I saw firsthand the benefits of a diversity of teaching methods. Many of my students had only had experience with lecture-heavy education that emphasized memorization skills, which disadvantaged students who learned in more visual or interactive ways. This reinforced my understanding of the value of visual and experiential learning in education.

Upon returning to the United States, I became a software engineer at a small company in Kansas City, gaining experience in software development and mobile development in particular. Outside work, I studied independently to hone my theoretical and practical computer science knowledge by taking several computer science "massive open online courses" (MOOCs), provided by prominent universities through educational initiatives like Coursera, edX, and Udacity.

Through this I expanded my knowledge of topics like human-computer interaction, databases, machine learning, networking, functional programming, and most importantly computer graphics.

The turning point that made it clear to me that I should pursue graduate studies was when I first used the Oculus Rift virtual reality head-mounted display to view a simulated tour of the solar system. In this application, I sat in a virtual spacecraft flying between 3D scale-models of celestial bodies. The stereoscopic view from the VR headset gave me a dramatic impression of the relative sizes of planets and stars, a direct experience that could never be replicated by looking up the diameters of these bodies in astronomical charts or even viewing images on a conventional monitor. For a brief moment, it felt as if I were really there and not viewing it on a screen a few inches from my eyes.

This was an undeniably powerful experience for me, and immediately afterward I started focusing on just what it was about the simulation that had made it so compelling. How had it given me a sense of "presence"? For example, I noticed that in the simulation, I had a virtual avatar body, such that when I looked over my shoulder to see the massive Sun behind me, there was a virtual shoulder for me to look over. Both technical and creative choices led to an effective, educational, and profound experience for me, and it was then that I knew that I needed to get involved in this field.

The main takeaway I had from that experience was that virtual reality technology had great potential, but needed improvement; virtual reality's strength came from particular choices in how to present and visualize a virtual world. This meant that it was a fertile area for research, and I knew that I needed to understand the state of the art to be able to push it forward. The advances I could contribute to the field would come not from simply reimplementing existing concepts but by creating new knowledge.

As a result, I began applying to graduate schools, and redoubled my efforts in increasing my computer graphics knowledge and experience. I began developing simple virtual environments for the Oculus Rift system, while also focusing my choice of MOOCs towards computer graphics, teaching myself OpenGL, WebGL and the mathematics and principles at the core of modern graphics programming. In my software engineering job, I took the initiative in designing and developing a set of augmented reality mobile applications for a local arts charity in Kansas City, gaining additional experience while also helping broaden the impact of computer graphics by introducing it into areas unfamiliar with augmented reality, learning what makes these technologies useful for different demographics.

At the same time, I led an interdisciplinary team of fellow University of Utah alumni with backgrounds in computer science, medicine and law, as part of the university's 2014 "Bench-to-Bedside" competition, in which teams quickly design, prototype, and market new tools and devices for use in the medical world. We developed a Web-browser-based system that uses a VR headset to display medical scan data in a stereoscopic virtual environment for medical professionals to analyze. Our motivation was that virtually moving inside a patient and viewing MRI data from that perspective would offer unique educational and medical benefits. My primary contribution was a software component that allows live head-tracking data from the Oculus Rift to interface with a browser-based 3D visualization with lower latency than was available at the time, leading to a more immersive experience.

I chose to attend Purdue University because of the research of Dr Voicu Popescu, my advisor, whose research interests in augmented and simulated reality align closely with my own. Eager to start research, I arranged with him to start graduate school at Purdue early, i.e. in May 2014 as opposed to August 2014, so I could spend the summer jump-starting my PhD research.

My PhD research, described further in the Graduate Research Proposal, investigates a novel approach for surgical telementoring in which graphical annotations provided by a remote expert are integrated into the visual field of a trainee through an augmented reality transparent display. Using mobile development and augmented reality experience I had gained from my time in the software industry, I rapidly developed over the summer a prototype system that helps illustrate the concept. As a result, we were able to solicit formative feedback from actual surgical mentors and trainees during an operative trauma management course in Indianapolis in August 2014.

After completing my graduate studies, I plan to continue as a researcher, focusing my efforts on studying and improving immersive virtual/augmented reality technologies. It is important to me that I continually work on new problems that have not yet been solved, researching and enhancing the educational potential of VR and AR for virtual skill acquisition. My time in graduate school is one step toward advancing the field, and an NSF fellowship would help support me as I study the state of the art and find ways to advance it through my research.

Intellectual Merit

Virtual reality and augmented reality are hard problems; there still remain a large number of intellectual challenges to overcome. Practical augmented reality depends on robust and efficient computer vision algorithms, and immersive virtual reality requires addressing the numerous ways that a user's perception of a virtual environment can conflict with what the user's body feels in the real world, any one of which can cause severe discomfort.

It is the difficulty of achieving these goals that attracts me, because there is ample room for new discovery. I am a self-driven individual who has experience in self-learning, which is a vital skill for anyone in a research-focused field. I have specifically applied my industry experience to current research problems. I have worked on projects related to computer vision and graphics, especially regarding optimization, which has prepared me for the tasks I want to accomplish in improving immersion in virtual and augmented reality. I have an ambitious, innovative, yet clearly defined research plan for my PhD thesis that includes solving fundamental computer science research problems and integrating their solutions into a system that fulfills a great societal need.

Broader Impact

Virtual reality and augmented reality have existed as research fields for decades, but only recently have costs decreased to the point that compelling VR/AR experiences can enter widespread use. This is why I am so passionate about these fields. These technologies need not be constrained to those with access to a laboratory or expensive simulator system. By furthering the state of the art to make educational VR/AR experiences more immersive, I can help a broad audience of students have direct experiential understanding of concepts that would otherwise remain abstract or unapproachable. In the same way that the Web has improved humanity's access to information and learning, these visualization technologies can improve how people receive the knowledge and how deeply they learn it.