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Personal Statement 1: Personal Experience

During my undergraduate career, I realized that I want to create things that are *useful* to real people and *used* by real people. Computer Science is an ideal field for this because the rapid rate of new ideas and innovations sometimes results in human-computer interfaces that leave room for improvement. Initially, I assumed the best place to make computers more useful would be in industry where my work would most likely touch the lives of others. This assumption stemmed from my view of academic research as a dry, abstract pursuit where projects often get "shelved," never being used by real people. My undergraduate research project offered me concrete experience beyond course work and to create something fun and socially beneficial; however it unexpectedly and delightfully changed my view of academic research.

As the lead programmer on the *Adventures Josie True* project, I gained the ability to base design decisions on research and communicate my ideas to artists, media students, and grade school teachers (non-computer scientists). The project was an online math and science game geared toward 5th and 6th grade girls. It wasn't until later that I began to see the value of these activities from an academic research standpoint.

As one of the two programmers building the *EyeDraw* project, an eye-controlled drawing program for children with mobility impairments, I finally realized that the aspects of these projects that I enjoyed (such as collaboration with people of diverse backgrounds, interaction with people affected by my work, and finding empirical and ecological validation for design decisions) were not uncommon in academic research. The project was very "real," in that it would impact the lives of real people with whom I interacted first-hand. My views of boring, abstract research began to transform into interesting, significant, and *fun* research! *EyeDraw* made me realize that a project can simultaneously be scientifically interesting, beneficial to humanity, and personally rewarding.

While I was working on the *EyeDraw* project, a specific event cemented my desire to pursue advanced study in computer science. *EyeDraw* received local and national news coverage during the winter of 2004. During one of the television interviews, a reporter asked Anthony Hornof (my advisor and project manager) about the "market value" of *EyeDraw*. He answered the question with examples of air-traffic control and intricate surgery procedures where users may need to control a computer while their hands are already occupied. However, his answers did not directly relate to *EyeDraw* itself. This made me realize that I may have difficulty in the future finding opportunities in industry to design systems that are targeted toward relatively small communities (less than 10% of the population) because the applications may not be seen as "marketable." While perhaps not initially money-makers, there have been several technological advances that were created for use by people with disabilities, but resulted in new conveniences for the general population. For example, the Americans with Disabilities Act requires that sidewalks have curb cuts so that people who use wheelchairs can access public places, but people with bicycles, baby strollers, and shopping carts benefit from them as well.

The research I am currently pursuing (better video compression methods, allowing people who communicate by American Sign Language to use video cell phones) will give deaf people the convenience of remote communication that hearing people enjoy, but the technology could likely be appreciated by everyone. It seems that sometimes an academic setting is more likely to recognize the future potential of projects that are initially geared toward a smaller population, whereas an industrial setting may be more concerned about an immediate return on its investment.

Experiences in the past two years drastically changed my view of doctoral study. I no longer feel that an academic career would lead me away from the creation of tools that real people can use. In the academic world, I can see countless opportunities for collaboration, community impact, and creation of technology that accounts for the particular needs of humans. I am enjoying a continued educational pursuit and I look forward to concentrating on assistive technology using a knowledge base built through coursework and research. My position at the University of Washington will give me the resources and opportunities to make a powerful impact on my community.

Personal Statement 2: Teaching and Diversity.

My research interests have a very strong educational component because they seek to level the playing field in situations where the field is inherently uneven. My experiences have led me to investigate human learning at several life stages. The *EyeDraw* project focused on the initial stages of learning; the *Josie True* project focused on learning stages that occur during elementary school; and my eMentoring experiences focused on middle school education. Also, the PhD program at the University of Washington offers opportunities to focus on college-level education through teaching assistantships. I believe that I can make an impact at this stage in life as well by participating in the most high-profile means of role-modeling: teaching.

In the *EyeDraw* project, I based design decisions on research findings about the development of child art. *EyeDraw* gives children with mobility impairments, such as cerebral palsy, a means of creative expression through eye movements, as opposed to arm and hand movements. It was important that *EyeDraw* allow for natural progress through drawing stages. Thus, one of my roles was investigating why children draw and ways children learn to draw. I found that children draw mainly because it appeals to basic human esthetics and their own abilities. Also, while learning to draw, children begin to visually recognize their own patterns and structures and this builds skills needed to read, write, and understand math concepts. These stages are typically between the ages of one and four, however children with mobility impairments may not experience creative expression until much later. Even then, they are limited to only the type of art that is expressed by words via eye-typing. If these children were able to draw by moving their eyes, they could develop basic life skills at a rate similar to typically developing children.

The *Adventures of Josie True* project inspires 5th and 6th grade girls to maintain interest in math and science in the hopes that more women will pursue these fields in the future. Divergent test scores indicate that girls begin to lose interest in math and science in late elementary school. Later in life, women are less likely to pursue degrees in technology: the numbers of women awarded bachelors degrees in computer science steadily declined in the past 20 years. The *Josie True* project attempted to mediate these effects with girl-centered games (in contrast to many of today's computer games) that introduce real-world role models. These theories took on new life when *Josie True* was tested at a local elementary school where a room of 6th grade girls, excited about the game, decided they wanted to create computer games themselves, confident their games would be better than *Josie True*!

I was a mentor in the eMentor program for the Julia Morgan School for Girls in Berkeley, California. The eMentor program matches 7th grade girls with women in technology. Through 10 weeks of email exchanges, girls learn how technology fits in the lives of everyday people. The objective is exposing girls to jobs that involve technology and building in them a confidence to pursue the field.

These experiences are motivated by my desire to promote interest in the sciences and to provide tools that will make the sciences more accessible. They have influenced the approach I will take when teaching at the college level. University of Washington PhD computer science students have opportunities to teach in the classroom and I am excited about this challenge. I believe that undergraduates at the introductory level, where the classes are more diverse, will benefit most from real-world examples that apply computer science theories. While I didn't experience teaching during undergraduate, I took a senior-level public speaking course. I presented the environmental effects of the University of Oregon's electrical use during the first ten minutes of undergraduate classes in an attempt to spread the word about campus electrical use. During one presentation (with class size of 250), the classroom microphone malfunctioned, so my talk had to be self-amplified. Afterwards, the instructor told me she hoped she could keep the attention of the class for the remaining hour as well as I had in those first ten minutes.

My research efforts have incorporated education, diversity, and direct benefits to my community. The *EyeDraw* project shows children with mobility impairments that they can make their own mark and use their computer to express themselves. The *Josie True* game gives girls the confidence to pursue fields in science and technology and proves to them that they are capable, and greatly needed, as contributors to the field. I am looking forward to teaching and being an example to those who think they would not "fit-in" in the world of computer science. This would give me excellent preparation should I choose to pursue an academic career.

Previous Research Experience

While studying Computer and Information Science at the University of Oregon, I dedicated my time and effort to research that attempted to open up creative and scientific worlds to those who have historically been locked out. The two research projects I chose, *The Adventures of Josie True* (a web-based game developed during my junior year and *EyeDraw* (developed during my senior year), were well suited to attaining this goal. The *Josie True* project, led by Professor Mary Flanagan, included seven undergraduate students and attempted to combat the gender inequalities currently found in the sciences by encouraging fifth and sixth grade girls to maintain interest in math and science. The *EyeDraw* project, led by Professor Anthony Hornof at the Cognitive Modeling and Eye Tracking Laboratory, gave children with severe mobility impairments the ability to draw by just moving their eyes. Both the science game and the drawing with the eyes program were motivated by a desire to dissolve a societal barrier through software applications and both have motivated my goal to create life-altering software.

The Adventures of Josie True Online Game (Multimedia Lab, University of Oregon)

The *Josie True* project has had a significant impact on girls nationwide by giving them an accessible and fun environment to learn and build confidence in the sciences. The application impacted the Oregon community during my involvement: *Josie True* received television and newspaper coverage as it was tested at local elementary schools. As the computer programmer for the project during its time at UO, I was able to build games by employing research findings (such as the different ways boys and girls play games, the appropriate levels of math and science content, and the best ways to keep users of this age group engaged). The games, set in Ancient Egypt, encourage players to use math and science skills to solve problems ranging from watering crops to astronomy to determining the cause of death in mummies.

The online game was the joint effort of multi-media students, game designers, and grade-school teachers. As a result, it was one of the first opportunities for me to discuss computer programming concepts with people who are not computer scientists. The interaction with different thinking styles was one of the most enjoyable aspects of working on the project. The situation taught me how to convert abstract ideas into concrete processes by formulating a plan, estimating its implementation time, explaining the plan to the other group members, and then explaining my creations so that they could be used by others. Due to the mix of people, weekly meetings with artists and multi-media students gave me insight on different ways to solve a problem. I noticed that artists tend to tackle a problem from the top down (envisioning a game from the player's point of view first, then figuring out how to implement it), whereas the common approach of computer scientists is to tackle the problem from the bottom up (deciding what type of game to build based on the tools that available). I found that the top-down technique used by our group encouraged creative thinking and thus our game ideas were more whimsical. From a programming point of view, whimsical ideas are much more challenging to program and this forced me to come up with creative solutions programmatically.

My work on *Josie True*, which led to a National Science Foundation grant awarded to Mary Flanagan, has attempted to address the low and decreasing numbers of women in computer science by attacking the problem at the source. Because studies have revealed that *Josie*'s target group, fifth and sixth graders, begin to show divergent math and science scores, we created the game to inject new life into the discipline and introduce girls to real life role models like Bessie Coleman and female Pharaoh Hatshepsut. These games show girls that the world of math and science is not an exclusive coterie, but rather an accessible and interesting pursuit.

EyeDraw (Cognitive Modeling and Eye Tracking Lab, University of Oregon)

Similarly, *EyeDraw* opens a whole new world to its users: it enables them to express themselves artistically and to develop creatively in a way that was previously impossible. The *EyeDraw* software system uses an eye tracker (by LC Technologies) as real time input to a drawing program. The program is targeted toward children (aged five to ten) who have severe mobility impairments because artistic and creative development is especially important at that age. For this reason, it is imperative that *EyeDraw* allows for a natural progression through the phases of drawing and, as a result, my research focused on how and why children draw and the ways in which they learn to draw. Because eye movements are a virtually unknown means of producing art, many of the previously discovered difficulties of eye control are being addressed in our user interface, such as the inability of the eye to draw smooth lines and the difficulty in choosing starting and ending points. One of the ideas that I have contributed involves providing millisecond-level visual feedback of the current drawing state through the use of a green-yellow-red metaphor.

Figure 1: An 18-year old woman with cerebral palsy evaluating *EyeDraw*.

The group dynamics of the *EyeDraw* team were quite different from those of the *Josie True* project. The *EyeDraw* designers consisted of one computer science faculty and two undergraduate seniors in computer science. We collaborated with artists, the designer of a software drawing program, caregivers of disabled people, and experts in eye tracking technology, but all of the implementation was done by computer scientists. This time, I had the opportunity to express my ideas with people at a similar level of technical understanding, and I also learned how to speak more formally about these aspects of my work. However, I also learned how to speak about my work in terms that a five-year-old user could understand. The ability to convey concepts to very different audiences is especially important in the field of computer science: a skill I will use in my future research, in my teaching, and in my encounters with many different user groups.

We conducted usability studies of the EyeDraw software system during the winter and again in the summer of 2004. The studies included both local children without disabilities and remote children with disabilities. We separated our studies in this way because we wanted to first test the functionality of the program with children who could come to our lab and easily describe difficulties and possible improvements to the program. After the initial local study, EyeDraw was shipped to four separate locations nationwide. Some of the locations were the homes of children who use an eye tracker as their primary communication device; others were clinics where several different people share a common eye tracker. These studies were extremely helpful from a designer's point of view: many improvements to the software were made as a result of the studies and I discovered unforeseen issues that I resolved in subsequent versions. The studies were also extremely important to me as a researcher. Close contact with my actual user population taught me that different groups of people (such as people who rely on an eye tracker as their sole means of communication with the world) view technology in very different ways. Taking account these different views is essential to the creation of technology that will be accepted and useful to populations that differ from the main stream.

I have co-authored two papers describing this project that have been accepted to the CHI2004 Conference on Human Factors in Computing System (where I presented the project in a Short Paper Session) and the ASSETS2004 Conference on Computers and Accessibility. *EyeDraw* received local and national news coverage, which aided in the recruitment of remote, disabled users who have been willing to participate in usability studies. My work has been funded by an NSF Research Experiences for Undergraduates grant awarded to Anthony Hornof. *EyeDraw* has great potential for improving the lives of those who are very much restricted in their expressive and communicative abilities by allowing them access to the world of art and drawing.

Conclusion

In both *EyeDraw* and *Josie True*, I have developed software systems that have encouraged others to do what they previously thought impossible. Both have made significant contributions to computing, to the community, and also to my own personal aspirations. These experiences will positively influence my future research and projects because they have reaffirmed my beliefs in the importance of reconciling unmet needs through technology.

Research Proposal

Graduate students in Computer Science and Engineering (CSE) at the University of Washington (UW) receive immediate research experience because qualifying exams require work on a substantial project. I am fortunate to have the opportunity to participate in a research project in my first year at UW. The following project is in collaboration with Richard Ladner and Eve Riskin of the Data Compression Lab at UW, Michael Cohen at Microsoft Research, and Sheila Hemami at Cornell University. While my role in the project is unique, the collaboration with an experienced group of people will allow substantial work to take place and greatly increase the chances of real-world implementation.

Introduction and Motivation

As computers are becoming ubiquitous in American life, development often targets specific users, sometimes at the exclusion of other groups. While universal usability is not always a realistic expectation, practicing inclusive development often improves technology. The wireless telephone network is an example of a technology that has inadvertently excluded over one million deaf or hard of hearing Americans. While the Deaf Community uses text messaging or video relay services (where a remote interpreter translates video sign language to spoken English), neither service offers the portable convenience of the wireless phone network.

With the advent of cell phone PDAs with larger screens and photo/video capture, people who communicate by American Sign Language (ASL) could utilize these new technologies. However, due to the low bandwidth of the wireless telephone network, even today's best video encoders likely cannot produce the quality video needed for intelligible ASL. Instead, a new real time video compression scheme is needed to transmit within the existing wireless network. In addition to bandwidth and real-time constraints, video quality must allow users to understand semantics of ASL with ease. For this technology to exist in the immediate future, we are designing new ASL encoders that are compatible with the new H.264/AVC compression standard (nearly doubling compression ratios of MPEG-2) that can eventually be used on video cell phones. The challenge will be designing an encoder that works in real-time and yields intelligible ASL at low bit rates. *The focus of my research will be the development of a video compression metric that takes into account empirically validated visual and perceptual processes that occur during conversations in American Sign Language.*

Methodology

Technology does not have a perfect track record as a benefit (or hindrance) to society. Often new technologies do not help, or are not accepted by, the intended audience. My main role as the only project member with a Human-Computer Interaction (HCI) background is ensuring the proposed technology is acceptable, comfortable to use, and appropriate for our target audience. This has been a major concern of my research advisors and they are excited to have the insight that my background and the usability studies that I conduct will bring to the project.

My specific contribution to this project will be twofold: (1) the conduction of usability studies that will (2) inform the ASL-specific video compression metric and methods.

I plan to conduct two separate usability studies. The preliminary user study will expand on a previous study by [1], where they found that while observing sign language, deaf people visually focus on the face and mouth with only short and infrequent diversions toward the hands and arms. My intuition is that changes in video quality due to variations in compression rates and bit allocation will result in altered viewing habits. When signing, deaf people rely on peripheral vision to gather conversational content, but focus on the face to better interpret personal meaning. As video quality decreases, I image that interpreting movements in the periphery will be more difficult and viewers will focus more visual attention on video regions containing semantic information, which will require more concentration. My initial studies will attempt to validate these assumptions. Through use of an eye tracker that Michael Cohen at Microsoft Research has generously provided access to, the eye movements of fluent ASL users will be tracked while watching ASL videos in talking head format. Videos of varying bit rates compressed with both standard H.264 encoder and a "Wizard-of-Oz encoding" which produces video that looks similar to our vision of ASL-specific encoding.

These studies will inform the metric, which we call the objective intelligibility metric (OIM-ASL) for the new video coder. By gaining insight into important areas of ASL video, we can train an encoder to exploit human perception in this highly constrained setting. Interframe head-tracking and hand-tracking can be used by the encoder to segment important regions and allocate more bits there, sacrificing bits in less important regions.

The next user studies will occur after compression techniques using OIM-ASL are developed. Video encoded with OIM-ASL will replace "Wizard-of-Oz" and the study will be more ecologically valid as the video will not be pre-recorded, but rather real-time conversations between two separate ASL signers will take place.

Other HCI issues I foresee include the use of camera cell phones as both input and output devices. We image an external camera will allow easy transitions of signing and viewing. This setup may seem cumbersome, but the tradeoff is small for the increased communication gained. This is a potential area for empirical validation.

Related Personal Experience

This research is surprisingly related to my previous work, my personal experiences, and my research interests. My goal in research is creating technology that opens doors for people previously locked out. With this project, an entire sub-community (one million Americans) stands to benefit. My experience with human visual perception and eye tracking technology will play an important role and my HCI background will assist in the usability aspects of these devices.

Institutional Appropriateness

The UW, with its wealth of resources and knowledgeable people interested in this area, is the ideal place for me to conduct this research. Professor Richard Ladner, PI and the hearing child of deaf parents, is (to the best of our knowledge) possibly the only video compression researcher fluent in ASL and active in the Deaf Community. Through him, I will be able to interact with members of the Deaf Community and have already begun to attend informal signing groups at UW. This connection will also aid in participant recruitment for user studies. Professor Eve Riskin, PI, is the director of the National Science Foundation-funded ADVANCE Center for Institutional Change at UW, which focuses on the advancement of women faculty in science, engineering, and math. The Center very much promotes my interest in parity in the sciences. Every summer, Richard Ladner and his students participate in UW's Disabilities, Opportunities, Internetworking, and Technology (DO-IT) program to encourage high school students with disabilities to pursue higher education through one-to-one computer science related workshops with undergraduate and graduate students. UW and Seattle are also ideal places for the technical resources needed to conduct this research. Michael Cohen of Microsoft Research has given me access to an eye tracker for usability studies. CSE students Gidon Shavit, Matt Renzelmann, and Dane Barney have already developed an embedded video encoder based on group testing that we can use to quantify the effects of different H.264 features on video quality and complexity.

Conclusion

The ultimate goal of this research is to create encoding algorithms that could be implemented on video cell phones for real-time ASL encoding. This research fits extremely well with my interests and goals, because it is intended for use by real people who have previously been left out of the freedom and comfort afforded by the wireless telephone network. Everyday people stand to benefit from this technology as well and might use it to view news broadcasts, sports videos, or teleconferencing on their cell phones. The research is also culturally important because it will give deaf people a means of communication, in their indigenous language, and remote accessibility. Also, because my role in this project is very unique due to my HCI background, it will be a great springboard to start creating projects that are based on my own ideas and my own interests.

References

[1] L. Muir, I. Richardson, and S. Leaper. Gaze tracking and its application to video coding for sign language. *Picture Coding Symposium*, April 2003.