My research experiences have strengthened my intellectual ability, and my leadership and communication skills have been bolstered by working with teams of other researchers. I have published several articles as an undergraduate, which taught me how to effectively convey my research to the community. The topics of my research have varied in computer graphics and computer vision, and the breadth of these topics will facilitate my future research. The research I have produced can impact society in fields such as medicine and defense. These experiences have prepared me to complete my proposed research, but most importantly, this has given me the confidence and knowledge to excel in academia. As an academic, I will continue to positively affect society through research and teaching while satisfying my interest of learning and solving difficult problems.

Undergraduate Research. My first exposure to research was at Washington University, where I independently developed a paperless documentation system to increase the efficiency of treatments performed by the Gamma Knife, a non-invasive radiation device to treat brain tumors. FDA software restrictions posed numerous complications during my research, but I persevered through these issues and produced a completed, robust product that allows for more patients to undergo radiation therapy each day. Additionally, I worked with a team of PhD students to create an algorithm that is currently used to evaluate the accuracy and efficacy of Gamma Knife treatments. We were able to use our algorithm to collect and analyze data about treatments performed by the Gamma Knife before my internship concluded. My work in these areas culminated in two papers published and presented at the *50th Annual American Association of Physicists in Medicine* conference [9, 10]. I was the first author and second author on these works respectively.

At the University of Missouri, I pursued image segmentation and image processing research with Prof. Duan as part of my honors undergraduate research project. This research was geared towards identifying brain structure characteristics associated with autism. Collaborating with a team of graduate students from my research group, we created a more efficient and robust method than the current manual segmentation methods used in most medical treatment software packages. This algorithm was soon published in the *Proceedings of the 4th International Symposium of Visual Computing* in which I was a second author [5]. Unfortunately, this method was limited to 2D MRI slices and only worked well for certain brain structures.

I spent the next several semesters extending this algorithm into a framework for general 3D brain structure segmentation. I was also able to improve the accuracy and efficiency of state-of-the-art methods, including our previous 2D algorithm, allowing for rapid and more precise data collection. Recently, a comprehensive paper describing this framework has been accepted in the *Proceedings of the IEEE International Conference on Bioinformatics and Biomedicine* [2]. I am the first author on this paper, and I will be giving an oral presentation at the conference.

While working on this segmentation algorithm, I found that robust, automatic brain volume calculation remained an open research problem. Prof. Duan explained that this tool would be crucial for analyzing segmentation data. I led a team of graduate students to implement such an algorithm, and I published this work at the *30th Annual International Conference of the IEEE Engineering in Medicine and Biology Society* as the first author [7].

Utilizing the tools we developed for data collection and analysis [2, 5, 7], my research group and I made significant discoveries about autism. Analyzing these results strengthened my background in statistics and machine learning. Much of this work is ongoing, and I have assisted with the analysis and publication of these results in international conferences and journals [1, 3, 4, 6, 8].

I also spent over a year researching a method to reduce wartime casualties with Prof. Duan, funded by the Department of Defense. Our goal was to develop an algorithm for unmanned terrain visualization which can alert soldiers of traps and enemies that occupy a building. Last year, I

attended the *National Defense Industrial Association Annual Maneuver Support and Technology Summit* to present the progress of the research. The project has since concluded with a deliverable that is in use as a prototype by the military.

I worked last summer at the Naval Research Laboratory researching improvements to an augmented reality (AR) system for the military. For AR, the concept of providing "X-ray vision" - the ability to see virtual representations of occluded objects which are registered to the real environment - has often been cited as a desired feature. One aspect lacking in much of the literature is an evaluation of modern X-ray techniques. With the guidance of my advisor, Dr. Mark Livingston, I designed and conducted a user study. I devised a new X-ray technique and implemented existing approaches for the study. The results conclusively favored one procedure over the rest, and our conclusions are under review for *IEEE Virtual Reality* 2010 in which I am the second author [11].

Graduate Research. In only two months as a graduate student, I have started working on two new, distinct research projects. With Prof. David Forsyth and Prof. Derek Hoiem, I have created an interface to create a 3D representation of a room automatically with a single photograph assuming a cuboid parameterization. In the proposed plan of research, I describe an ambitious extension to this preliminary work. Also, under the guidance of Prof. John Hart, I am examining procedures to automatically deduce the most aesthetically appealing poses for objects in images. I have already achieved results which automatically position a 3D mesh in artistic poses, such as the 3/4, 2/3, and 7/8 views, and I am now implementing similar a method for 2D images with no prior information about the objects in the scene. Our goal, albeit a challenging one, is to publish results from both of these projects at the *ACM SIGGRAPH* 2010 conference. I have had the opportunity to work with these two groups due to the one-year fellowship I received for this academic year, and the NSF GRF will allow me the freedom to continue researching in the areas I am most passionate about.

Intellectual Merit. My previous research has undoubtedly eased my transition into graduate coursework and research, and I believe it has enhanced my ability to produce profound research. I have published new computer graphics and computer vision algorithms, including image segmentation and image processing techniques, topics that are consistent with the research that I am currently involved with. These experiences have strengthened my aptitude for presenting my research to the community in the form of papers and talks. I have worked with many research teams on varying topics, giving me a broader sense of related research in these fields.

Broader Impact. At Washington University, I produced two applications that increase the efficiency of patient treatments and that also improve the accuracy of current clinical procedures, potentially prolonging the lives of those in need of treatment. My medical imaging work with Prof. Duan's research group has provided further insight on autism and possibly accelerated the rate at which a cure will be discovered. The 3D segmentation framework I created allows for more accurate clinical and non-clinical brain structure classification. Additionally, the projects developed for the DoD as well as the Naval Research Laboratory can reduce the number of soldier casualties.

The research that I have begun in graduate school will influence digital image understanding and manipulation across many fields such as animation, surveillance and security, and household robotics. These projects can contribute to education through tutorials and courses, as well as the ability to excite and attract potential students interested in visual media to computer science.

I have created a publicly available web interface for my brain volume calculation work (http://kevinkarsch.com/BrainExplorer). In the future, I will offer other applications, tutorials, and code in the same online format to promote the technology transfer. I hope that other institutions can in turn extend these works, enhancing not only the field of computer science research, but society as well.

References correspond to those listed in the "honors and publications" section of the application