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Statement of Purpose

When I was a junior in high school, I designed and built a circuit that changed my life. That one circuit has since evolved into entire robots, and my passion has expanded to include human-robot interaction, computer vision, control systems and robotic grasping. I am now continuing the evolution of my passion, seeking a way to improve the technology we have now.

That life changing project was given to me by my wonderful FIRST Robotics Competition (FRC) mentor, Art Waldenville. My decision to be a part of the pre-engineering course and FRC team that he led, is one of my proudest decisions. What I gained from this time period was an attachment to and experience in Robotics. I enjoyed working with my team members: looking at our budget, machining metals, and solving difficult problems through meticulous designs. This careful planning and hours of hard work allowed us to win the General Motors Industrial Design Award, along with our other accolades. Before this course, I wished to create something new that would change the world. I have since realized that the most effective way to advance technology is through innovation. I am proud to have taken a course that helped me realize this while feeding my desire to learn more. I want to be a part of the generation that discovers new ground truths in robotics and uses those truths to integrate robots further into our society. These new discoveries are what I believe research is all about.

My initial seed of curiosity has grown through my experiences at the University of Oklahoma. Here I have been given the opportunity to take thought-provoking classes that are strengthening my educational foundation. I have also gained more experience in robotics by conducting research under Dr. Sesh Commuri. The research I conducted towards the end of my freshman year involved transforming an electric ATV into a semi-autonomous vehicle. To do this, a 24v DC motor was added to the base of the handlebars, along with a Victor 888 speed controller and a potentiometer to keep track of the steering angle. Generating a pulse width modulation (PWM) signal using Matlab Simulink and using feedback from the potentiometer to account for error in real time, I transformed a regular ATV into a machine capable of steering itself given a specific angle. Then, using the speed controller already attached to the ATV for the electric motor, I was able to control the speed of the ATV via remote control. Seeing the ATV steer itself internally by detecting its incorrect position and correcting itself was captivating. Because my research carried through the summer of 2014, I was able to share my work with a group of incoming underrepresented engineering freshman students of whom I was a camp counselor for. It was not only rewarding to see my hard work progress but to share this work with students just starting their engineering discipline. As a counselor, I had to prepare them for the adversities that come with a STEM major, but I was also thrilled to show and motivate them first hand as to why engineering is worth it and the impact it can have on society.

As I moved on to my sophomore year, while finishing my research, I became team leader of one of the robotic competition teams at OU. The goal of our competition was to autonomously collect 12 different colored objects and distribute them in their corresponding colored bins within two minutes. I had an amazing experience working with my teammates to accomplish this task. As a group of underclassmen, we were enthusiastic yet nervous for the task ahead. We made mistakes and bled for them, but never stopped. Our final robot used a gyroscope and an accelerometer to navigate while using a Pixy camera to identify the objects and their color. With knowledge I gained doing research with Dr. Commuri, we were able to incorporate proportionalintegral-derivate (PID) controls to tune our navigation both around the field and to each object. The opportunity my team and I had to compete in Seattle, Washington was both thrilling and immensely satisfying. I am proud to have won 4th place out of the 15 other national contestants. It frightens me that I almost allowed the fear of failing keep me from the confidence and increased knowledge of Robotics that I gained though this position. It was this experience that affirmed my decision to become the Vice President of all robotic competition teams at OU during my junior year. I wanted to ensure that all students at OU had the same opportunity as I did. To this end, I organized technical talks and business lunches with companies such as Microsoft, ABB, and AT&T in order to raise sponsorship for the organization and benefit our members.

While these experiences were amazing, being able to do research with Dr. Cindy Grimm and Dr. Ravi Balasubramanian on Robotic Grasping has been the turning point of my academic career. This wonderful opportunity was given to me the summer of 2015, right before my junior year, as part of a NSF funded Research Experience for Undergraduates at Oregon State University. The research I helped conduct was centered on improving the way robots grasp objects. Our approach involved conducting a user study by which we could learn from humans and apply those same grasp techniques to a robotic hand. While helping to set up the user study for data collection, my primary task was to create a system that allowed numerous grasps to be tested semi-independent of a human experimenter. This would allow us to acquire larger amounts of data for analysis more efficiently than before. To do this, two interns and I designed a physical box that used a combination of a Raspberry Pi, stepper motors, and pulley system to ensure objects were reset correctly after each test. Having never used a Linux based system before, it was fascinating learning to use Vim in the Ubuntu terminal along with the Robot Operating System (ROS). I am thrilled to have learned Python and written the code for the system that allowed the Barrett Hand and Adept Viper s650 arm to automatically grasp a given object while saving key data from the trials.

I enjoyed my time in Oregon, being fully immersed in my research and learning as much as I could from the resources all around me. It solidified my decision to further my knowledge of control theory and robotic grasping as well as continue to explore my interests in the areas of human-robot interaction and computer vision in a Ph.D. program. I aim to use the theoretical knowledge acquired through school and transform it into real applications that will improve the world. I am glad to have worked with Dr. Grimm and the other professors who were equally passionate about building robots that can operate robustly within our society. I have come to realize that what I have gained from doing research, apart from experience, is a greater aptitude for problem solving and critical thinking. I saw a similar mindset in my fellow interns as I interacted with them, discussing one another's research as well as topics on society, faith, new discoveries, and different theories. This was again highlighted through my experience this past summer as a NSF Robotic Institute Summer Scholar at Carnegie Mellon University.

My experience at Carnegie Mellon was nothing short of remarkable. Every nook and corner of the RI was filled with robots and roboticists alike. I once again had the opportunity to interact with people who thought at such deeply intricate levels both within and outside of the robotic discourse. I was thrilled to invoke discussions and understand the viewpoint of my scholars from across the globe while adding my own perspective. I was also enthralled to once again be completely immersed in such a research-centered atmosphere; constantly surrounded by some of the leading experts in robotics, I could not help but seek them out and learn from them. While these meetings and simply this environment was edifying, I ultimately learned the most from my individual research and the mentorship I received from Dr. Christoph Mertz.

My research expanded a previous project of Dr. Mertz where a smartphone placed in city vehicles such as buses and garbage trucks, could be used to detect cracks and potholes in roadways via an app. Our goal was to increase the capabilities of the system to estimate the size of detected traffic signs. To do this, another intern and I modified the basic Pinhole Camera Model to include a second 2D image plan. This additional information allowed us to relate the intrinsic parameters of our smartphone's camera to real world measurements that could be used to scale the image pixels. After verifying that our model was reliable and accurate once given the needed parameters, we worked to autonomously acquire these values using a combination of Visual Structure from Motion, sensor fusion using a Kalman filter, and Visual Odometry. Our work directly impacts the DOT by allowing them to regulate traffic sign sizes without the tedious and slow process of manual inspection. While robots that can run, grasp, and fit the iconic imagination of humanoids are what I dream about creating, there is a very real need for robotic systems that can simply ease the day to day lives of workers and the general public. I got to relay this message to a group of high school teachers as I lead a tour of the facilities at CMU. The purpose of the tour was to show the teachers what robotic research is all about and how they can equip their students to be a part of it.

I have grown from my time as an undergraduate and have come to understand Robotics in an uncommon way. I have had the opportunity to be mentored by and rub elbows with, current and future leaders of robotics. They have become a catalyst for who I want to be as an individual, researcher, and future mentor. I am excited at the work being done at Carnegie Mellon and at Oregon State, as well as all the graduate programs I am applying to. I resolved to purse my Ph.D at one of these programs then work for a company, such as Boston Dynamics or Willow Garage, that actively researches to improve robotics and make them a thing of the present rather than the future. After this, I plan to become a professor so I can conduct research of my own and have the opportunity to mentor others students as I have been mentored. I have kept in touch with the students I mentored the summer before my sophomore year and the robotic team organization members I led my junior year. Seeing them, now juniors and sophomores themselves, gaining internships and conducting research at OU and elsewhere is inspiring. I am glad to have been a mentor for them and want to continue to do so. I remember once while in Pittsburgh, I met a fellow black male and told him I was an intern at CMU. He said "That's really cool man. You don't see a lot of black folks up there. Keep up the good work." What he said was true and that is why it resonated with me so much. I am proud to have gone to CMU and have done good work while there. I have constantly been inspired by the role models in my life and realize that I have been given the unique opportunity to become a role model myself, particularly to African Americans in STEM.

I want to improve the current technology we have on robotics in order to advance the quality of life in society. I want to do this while encouraging others like myself to do the same. To do this, I need to be involved in practical and advanced research. I know that I can do this within any of the graduate schools I am applying to with the NSF Graduate Research Fellowship.

Increasing the Capabilities of Assistive Caregiving Robots

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Abstract: In 2014, an estimated 43.5 million adults provided unpaid care for an adult or child in need[1]. This included helping both the elderly and people with high spinal cord injuries, such as paraplegics and quadriplegics, preform activities of daily living (ADLs). Of these care providers, 10% provided care for their spouse and 85% provided care for relatives. On average, caregivers spent up to 24.4 hours a week providing care. High time-intensive caregivers, primarily those with a disabled spouse, spent up to 44.4 hours a week providing care. When caregivers were asked if they felt they had a choice in the responsibilities for caretaking, 49% responded with a no. For both the individuals and families affected by a disability, the task of caretaking and being taken care of can lead to significant emotional and physical strain[2]. Feelings of guilt and loss of independence on both sides often follow and can lead to severe depression. This presents the need for a robotic assistive caretakers such as the PR2[3]. A robotic caretaker that can be with an individual 24/7, will allow them to regain more of their independence while also alleviating some of the stress put on family members. Current robotic caretakers are cable of providing care but are slow and limited in the tasks they can perform. This work aims to use tactical sensors to increase the autonomous abilities of robotic caretakers.

Goals: The primary goal of this research is to help assistive robotic caretakers attain a level of proficiency that allows them to moderately replace human caretakers. Current human caretakers primarily assist those in need with ADLs more than any other need. Since the goal of the research is not to fully replace humans, the focus will be to improve the abilities of a robotic caretakers in regard to basic ADLs such as eating, grooming, transportation (to or from a bed or chair), and grasping needed objects. This will allow both the individuals, as well as their human caretakers, to regain a sense of independence. While the PR2 will be used as the primary robot for testing, a secondary goal will be to apply such improved autonomous abilities to other robotic arm and vision systems, such as those that can be attached to a wheelchair.

Methods: The PR2 is equipped with a Microsoft Kinect sensor and Environment Stereo Camera as well as two arms and grippers. In order for the PR2 to assist in the basic ADLs described above, it must first be able to detect and grasp objects around the household. Its grasp must also be robust enough to effectively aid an individual's needs as a human could. While the use of specialized markers to detect objects is a promising approach, it is limited in that the robot does not continue to learn new objects the individual may need unless a new maker is added. An additional drawback is that the users may feel a greater sense of invasion as the markers are placed on objects around the house. Instead, for this study, the PR2 will use an approach similarly used by Collet[4] where meta-data about an objects characteristic, such as shape and size, can be given to the PR2. This will allow the PR2 to quickly detect familiar household objects while still able to recognize and categorize new object a user might need. All programing on the PR2 will be done with the use of the Robotic Operating System (ROS), an open source library that allows preexisting modules for the PR2 to be added and modified as need.

The next task in the research would be to utilize the tactile pressure sensors on the grippers of the PR2 to help understand and bridge the gap between human and robotic grasp. Romano[5] shows that the use of these tactile sensors has promising results on the PR2's ability to manipulate objects. While others rely on pre-defined "grasp forces" or "positions", they use feedback from the tactical sensors to try and match the capabilities of humans. Expanding on the Romano's work, the PR2 will be able to accomplish tasks such as feeding, in a way that feels more human to the individual. Another example is in the case of transportation; although the PR2 is not strong enough to lift individuals, it can provide support for users such as the elderly, in getting in and out of beds and chairs. We want to allow the grip of the PR2 to be such that it can hold the hand of the user much like a human care provider would. Actions like this help the individual to perceive the PR2 as less of a robot and more like a human companion and helper.

Evaluation: Simple grasping and object utilization tests can be administered to evaluate the capabilities of the PR2 and quantify its improvement after our research. Ultimately, to gauge the success of our work, the PR2 must be tested by the individuals it is intended for. After IRB approval, willing participants found from a university's health center can be asked to participate in a study. The next step would be to have the individuals use the PR2 for a set period of time and rate the level of independence and emotional strain they feel as compared to before as well as the level of comfort they feel around the PR2. The human care provider can also be asked the first two questions in order to evaluate the effect that these improvements have on the disabled and their helper, who for the large majority is a relative or spouse. These responses can then be compared to the same criteria when using a system different from the PR2 as well as a PR2 without the improvements made through our research.

Intelligent Merit and Broader Impacts: This research is meant to improve the quality of life for the disabled as well as alleviate some of the strain that comes to both the individual and their care provider as a result. The improvements to the capabilities of the PR2 increase the general knowledge in robotics, and can be used in many other applications of both health care and general robotic grasping.

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