My goal is to leverage the unprecedented recent growth in robotics technology to automate the construction, inspection, and maintenance of our nation's aging large-scale civil infrastructure, as a way to enhance the safety and sustainability of public services (e.g., transit, housing, water). To achieve this goal, I plan to become a Professor of Computer Science and to build a program of research, education, and entrepreneurship in the area of computer vision for robotics. As a first step, I am working toward a PhD in Computer Science at the University of Illinois Urbana-Champaign (UIUC), where I am deriving new methods of vision-based material recognition and robot localization that will be applied to construction site monitoring. My interest in this field stems from the work I did as an undergraduate researcher and teaching assistant, which I will proceed to describe.

I first began conducting research during the summer of 2009 when I elected to participate in Virginia Tech's Computer Science NSF Research Experience for Undergraduates (REU) program. Working under the guidance of Dr. Scott McCrickard and his graduate student, Shahtab Wahid, I implemented an interactive online tool called PIC-UP that provided users with a drag-and-drop interface to create storyboards. These storyboards consisted of claims (an image depicting a design element for a system with an accompanying description, and pros and cons) and scenario cards (text areas for the user to provide context for the storyboard), which my system saved and presented to future users as a method of idea sharing. I then demoed my system for the other summer participants and presented my system at the end of program symposium. After the program ended, I continued to collaborate with Dr. McCrickard and Shahtab, and we deployed PIC-UP for a semester long user study. Our study showed that PIC-UP effectively encouraged the sharing of ideas for both experience and inexperienced designers. We then published these results in our 2011 ACM CHI paper [1] for which my contributions included writing the section detailing PIC-UP and presenting at ACM CHI 2011 in Vancouver. In the end, my work with PIC-UP was particularly meaningful because I was first introduced to a research environment where, through experimentation and the sharing of ideas, I was able to produce and disseminate knowledge that is now available to people around the world

Because of the positive research experience I had at Virginia Tech, I sought additional opportunities and participated in summer research programs at Georgia Tech (2010) and the University of Michigan (2011). At Georgia Tech, I worked under the guidance of Dr. Patricio Vela to classify flight trajectories for modeling activity in the northern Atlanta airspace. Airspace models enable immediate recognition of abnormal behavior in the airspace, resulting in quicker response times to potential emergencies and a safer environment for flying. The massive number of flight trajectories and the fact that planes have no set pathways through a given airspace make flight data particularly difficult to analyze conventionally. To solve the analysis problem, I implemented unsupervised learning techniques such as principal component analysis and mean-shift and used these methods to analyze thousands of flights through the airspace. In the end, I was able to successfully cluster the data into specific classes of trajectories and build a model of normal daily activity in the airspace. I finished my work at Georgia Tech by writing a paper [2] detailing my method and results and giving an oral presentation at the Georgia Tech SURE symposium. At the University of Michigan, my research, led by Dr. Ryan Eustice, was part of a larger effort to control an autonomous helicopter to land on a moving landing pad. Autonomous

landing control directly applies to the Fire Scout, an unmanned helicopter used by the United States Navy, and represents an ongoing effort to perform missions while ensuring the safety of military personnel and the preservation of civilian lives. One challenge of autonomous landing is having the helicopter perceive the landing zone on a moving Navy ship using an onboard camera. To solve the perception problem, I implemented a planar pattern detector that was able to track a model helicopter pad in a real-time video sequence while also calculating the relative pose of the helicopter to the tracked landing pad. From the calculated pose, it becomes possible to calculate the necessary control instructions to perform a safe landing. To conclude my work at Michigan, I presented at both the University of Michigan SROP symposium and the CIC SROP Symposium at the Ohio State University. In addition, I made a publicly available video of my work: www.youtube.com/watch?v=MKNxUi17xXQ.

Interwoven within my summer research experiences, I also worked with Dr. Robert Collins at the Pennsylvania State University on developing a method for tracking multiple targets simultaneously. Being able to track multiple groups of people offers significant benefits for surveillance applications: facilitating quicker reaction to potential emergencies in public environments and overall improved safety for the general public. To address the tracking problem, I extended the capabilities of an existing algorithm called mean-shift belief propagation (MSBP) and experimented with my implementation for tracking tens of people in crowded scenes. From my results, I was able to demonstrate that MSBP is capable of tracking multiple people simultaneously in any configuration and despite partial occlusion. In addition, my results showed that incorporating information about each person's neighbors improved the stability of the tracker over time. I concluded my MSBP work by writing a paper [3] that was published by the Schreyer Honors College and fulfilled my final requirement to become a Schreyer Honors Scholar. Influenced by all of my undergraduate research experiences, I learned how to apply the scientific method to my research and how to present my findings effectively. In addition, I came to appreciate the challenging, yet rewarding career path of being a professor: conducting research to create knowledge, disseminating work through publications and presentations, and teaching students in the hopes that they have a positive impact on future generations.

Motivated by my career aspiration of becoming an academic, I wanted to assume another important professorial role: teacher. Thus, I chose to become an undergraduate teaching assistant for the iPhone programming class taught by Dr. John Hannan at Penn State. I instructed fellow students through lecturing, holding office hours, and designing assignments to emphasize specific topics. I have continued mentoring students in graduate school, where I have been a PURE (Pursuing Undergraduate Research in Engineering) mentor since my inception. Through the PURE program, I have mentored and continue to mentor four undergraduate students. One group of two students has been building a mobile application to interface with the sensor on board a quadrotor robot. Using this technology, a user can provide guidance to a semi-autonomous system through the use of a tablet pc. The other group of two students has been running experiments with different image feature techniques often used for computer vision applications. Their goal is to provide a comprehensive comparison of the different image features for use in justification of choosing an image feature for a given application. As a group, my mentees and I meet weekly for them to present their current progress. We analyze any challenges

they are facing and discuss new ideas to guide the project. I then give a brief lecture on a topic of interest within the field of computer vision or robotics. My teaching and mentoring experiences have been enjoyable and continue to validate my career goal of becoming a professor.

I am currently working closely with Dr. Derek Hoiem (CS-Computer Vision), Dr. Tim Bretl (Aero. Eng. -Robotics and Control), and Dr. Mani Golparvar-Fard (Civil Eng. -Construction Management) and in conjunction with Dr. Myra Nam (Image Processing) from MIT Lincoln Laboratory. Through their guidance and individual expertise, I have been building an autonomous quadrotor system that is capable of inspecting large-scale civil structure systems (e.g., bridges, tunnels, rail roads) while looking for structural deficiencies. An autonomous inspection system would enable more frequent inspections, providing Departments of Transportation with knowledge of the most-updated states so that they can better prioritize expenditure to rehabilitate our nation's aging infrastructure systems. So far, I have focused on the material recognition, quadrotor localization, and motion detection aspects of this problem. For material recognition, I am devising a method to detect and classify a large number of common construction materials. My preliminary results show that we can effectively classify construction materials from close range, forward facing views; however, I hope to extend my method to leverage geometry and perspective information for improved classification. Furthermore, I am building a new fiducial marker system that enables efficient onboard localization of the quadrotor. While fiducial marker systems already exist, my experimentation has showed that these current systems are too inefficient to be run in real time onboard a quadrotor. Thus, I hope to realign current methods to cater a system to the low computational needs of a quadrotor. Moreover, I have implemented a system for motion detection from video captured onboard a moving aerial vehicle. My results show that by leveraging in plane camera motion, it is possible to differentiate stationary objects from moving objects. I presented this research at the conclusion of summer 2013 at MIT Lincoln Lab and have submitted my work for publication to ICASSP 2014 [4]. Because my interests are interdisciplinary, I work with several professors that each provide necessary expertise. Having the NSF GRF would allow me the freedom to pursue this work without having to worry about funding limitations.

Intellectual Merit: My research contributes to the body of knowledge in areas of computer vision (material recognition, Pose Estimation), construction management (model-based monitoring, and automated defect assessment), and robotics (marker-based localization and control mechanisms) while forwarding the overarching goal of devising systematic methods that can frequently and systematically inspect infrastructure systems. Additionally, I was awarded the **NSF GRFP Honorable Mention** and the 3M Fellowship Award in 2012-13. I am currently pursuing my Ph.D. with a **3.8** GPA at UIUC. I graduated with a B.S. in Computer Eng. and a B.S. in Mathematics from Penn State. My cumulative GPA was a **3.92**, and I was the Computer Eng. Student Marshal (Highest GPA in major) for my graduating class (Spring 2012). I am also a Schreyer Honors Scholar with an approved thesis on "Detection and Tracking of Multiple Targets in Crowded Scenes." I have several additional publications and presentations from research at Virginia Tech, Georgia Tech, University of Michigan, and MIT Lincoln Lab. I also spent a summer abroad in Bangalore India interning with Western India PROducts (WIPRO).

Broader Impacts: As a current graduate student and future professor, I plan to continue making social impacts through mentoring and knowledge dissemination on a topic that can impact safety and sustainability of our aging infrastructure systems. In particular, I plan to build on my previous experiences and continue presenting through forums meant to reach general audiences such as Illinois Engineering Open House, Beckman Open House, and YouTube. I spent the summer of 2012 working for Western India Products (WIPRO) in Bangalore, India as Software Eng. intern. I was the leader of a team implementing an iPad application that displayed data from a server in a dynamically growing map. This international experience speaks to my communication and leadership skills: not only was I leading a small team, but I was also communicating with employees with a diverse range of English proficiencies. Furthermore, as a PURE mentor, I have guided undergraduate research and promoted future research. In addition, I have communicated my work through several mediums to reach a general audience. Besides conferences, papers, and symposiums, I have also condensed my work from Michigan into a YouTube video that is publicly available. This is particularly relevant because I present the work using demonstrations and straightforward language; making it appropriate for a diverse audience.

References

[1] S. Wahid, D. S. McCrickard, **Joseph DeGol**, N. Elias, and S. Harrison. *Don't drop it! Pick it up and storyboard.* 2011 ACM Conference on Human Factors in Computing Systems (CHI '11), Vancouver Canada, May 2011.

[2] **Joseph DeGol***,* Patricio Vela, *Data Clustering for Spatial Analysis of Flight Trajectories,* The Georgia Institute of Technology SURE Program, Paper and Presentation, 2010.

[3] **Joseph DeGol***, Detection and Tracking of Multiple Targets in Crowded Scenes,* Pennsylvania State University Schreyer Honors College. Electronic Honors Theses: https://honors.libraries.psu.edu/paper/14160/. May 2012.

[4] **Joseph DeGol**, R. Phillips, M. Nam, "A Clustering Approach for Detecting Moving Objects Captured by a Moving Aerial Camera, IEEE Intl Conf on Acoustics, Speech, and Signal Processing (ICASSP), Submitted 2014.