Introduction

I found robotics late in my college career. During the fall of my senior year at Brown University, I walked into the computer science (CS) department on my way to class. Through a glass wall, I noticed a student pointing at objects: a cup, a marker, a rubber duck. A robot reacted by pointing back. How could this robot see and act on its belief? As I walked closer to the wall, I knew I had to be on the other side to find out. Searching for the answer has inspired me to dedicate my career to robotics. After years of research experience in academia and industry, I believe the link between interaction and perception is fundamental to create robots that are flexible enough to help people in daily life. Inspired by this viewpoint, **my doctoral research focuses on the intersection of robotics and computer vision. En route to a tenure-track professorship, I also prioritize using my privilege to make CS more accessible to marginalized communities.**

Intellectual Merit

A love for coding and photography brought me to the field of computer vision, where researchers develop algorithms for machines to understand images. After my second year of college at Brown, I **won a Karen T. Romer Undergraduate Teaching and Research Award (UTRA)** for summer 2016. Under the mentorship of Professor Benjamin Kimia, I **wrote code to track cameras** using the videos they capture. Such algorithms have broad implications for self-driving cars and headsets to help visually impaired people navigate. In developing these capabilities, I learned to set up optimization problems and manipulate camera geometry—skills I still use in current research. I **built a real-time system** around these building blocks and worked with a grad student to formulate the core algorithm. At a university poster session, I was excited to **present positive initial results** on the KITTI benchmark that contains street view videos. Retrospectively, creating a visual system primed my passion for developing more complex robot systems.

Curious about how people could communicate programs to robots, I joined the Intelligent Robot Lab (IRL) at Brown during fall 2017. I worked with Professor George Konidaris, whose lab studies robot learning. At IRL, I learned to transform fuzzy research ideas into scientific output. In a preliminary literature review, I discovered augmented reality (AR), which leverages phones and headsets to display graphics layered on the real world. I identified an opportunity for AR to empower people to program robots without writing code. This has the societal impact of **making robots accessible to those who lack programming skills**. Following my intuition, I **implemented an AR interface to specify robot arm trajectories** in a Microsoft HoloLens headset. With my interface, humans can draw paths in free space that a robot can then follow to complete tasks. I overcame varied hurdles, from robot grippers breaking to hologram misalignment with real world objects. I found talking through ideas was the best way to move forward. To this day, I enjoy creating spaces for those around me to discuss ideas, over whiteboards, lunches, and video calls alike. Upon completing the prototype, the **success rate was over 90% for picking-and-placing blocks and cups**. The work led to an **honors thesis**, which I defended for a committee, and a **U.S. patent**.

I was eager to form a deeper empirical understanding of my human-robot AR interface, which I believed was critical to quantify its impact. To do so, I stayed at Brown after graduating during summer 2018. Collaborating with a postdoc, I learned that experiments involving human interaction can be just as important as automated benchmarks to expose core scientific points. We created a user-study comparing the AR system to a keyboard and mouse robot programming baseline. **Pick-and-place task completion time was 82% faster on average** with our system. The work resulted in a **first author paper at a top robotics venue, ICRA 2019**. I presented the work at the conference in Montreal and also as an **invited speaker at the University of Washington Robotics Colloquium**. At these events, I found great joy in positioning my work in a greater societal context. I contributed to discussions about explainable Artificial Intelligence (AI), where AR can be used to visualize the intentions of robots before they act. These moments affirmed that research is a dialog. As a PhD student and eventual professor, I am thrilled to respectfully add my voice to the conversation and make space for others to do the same.

To improve the user experience of working with holograms in AR, I became interested in algorithms for automatically aligning computer-aided design (CAD) models to their real world counterparts. Such perceptual capabilities allow robots to plan actions relative to objects, without low-level human guidance. After joining Microsoft in summer 2018, I transferred to the HoloLens team, determined to contribute to the platform that was so important in my research. I became the only entry level software engineer on an algorithms team of eight. I reported to Dr. Harpreet Sawhney, who investigates 3D computer vision. My work on object representations of CAD models and large scale algorithm benchmarking put me at the intersection of research and engineering. To broaden my impact, I aligned my work with the efforts of product teams, some a few desks away and others as far as Nigeria. The algorithms I developed were incorporated into a computer vision product that brings assembly instructions into AR. Such capabilities will transform the manufacturing industry by strengthening safety checks. My performance was **rewarded with two promotions** and the privilege to co-supervise an intern, which ultimately reaffirmed my desire to advise students. My time at Microsoft taught me the experimental rigor and teamwork needed to deliver reliable computer vision at a global scale. However, I ultimately felt the pull of academia, where I could make the technical details of my work accessible for others to build on. **I was attracted to the intellectual freedom inherent in PhD programs and was excited to engage in teaching and mentorship**, which I find to be most rewarding in academic settings.

Excited to explore how advances in computer vision could help create more general purpose robots, I chose to be a PhD student at the Columbia AI and Robotics (CAIR) lab in fall 2020. I was one of only four incoming students in my CS cohort to **win a Columbia Presidential Fellowship**. I found an incredible advisor in Professor Shuran Song, who works on perception and robot learning. For my first project, I designed an algorithm that learns to interact with articulated objects (e.g., scissors) to discover their parts in images. I worked remotely from Seattle due to the pandemic, but made the best of the situation by collaborating with Dr. Kiana Ehsani from the Allen Institute of Artificial Intelligence (AI2). In leading the project, I gained experience customizing simulators and training neural networks for interaction and perception. Our model was trained in simulation for objects with two parts. However, **my experiments showed performance that exceeded expectations**: the method generalized to new categories of simulated and real world objects with three parts. This outcome reaffirmed my belief in the synergies between interaction and perception. The project led to a **first-author paper at a top computer vision venue, ICCV 2021** and an ongoing **research internship at AI2**, where I work with Drs. Kiana Ehsani and Roozbeh Mottaghi.

Broader Impact

Growing up in the predominantly white suburbs of Louisville, KY, I was often the only kid of Indian descent in the room. This had a profound effect on me, and for most of my life I wished I was white. In college, I became more secure in my identity, in part because I gravitated towards STEM courses where I felt represented. However, I noticed the lack of Black, female, and queer-identifying students. I empathize with peers who express feeling out of place and have resolved to use my privilege to amplify their message. More specifically, I seek to make the CS community more diverse and accessible through **teaching, mentorship, and organization**. I have worked on accessibility as a teaching assistant (TA), but my involvement goes beyond the classroom. I believe targeted mentorship is critical to ensure equitable access to resources. I have also stepped into leadership roles to extend my reach. As I continue graduate work, I look for opportunities to make my work accessible and **encourage others to get involved in AI research**.

Teaching: Motivated by a belief in accessible education, I have **TA'd four CS classes** during my career. At Brown, I TA'd two introductory programming courses with the goal of motivating younger students to pursue CS. In the process, I developed a **guiding pedagogical principle: class difficulty is not fundamentally at odds with accessibility given proper support**. As a graduate TA for upper-level robotics courses at Columbia, I put this principle into practice. During the pandemic, this meant I stayed late during online office hours and scheduled 1-on-1 meetings with students in need.

Mentorship: Outside the university, I have been drawn to **high school STEM education**, which I believe is important to ensure the next generation of academics is more diverse. During my first and second years at Brown, I was a **mentor for the Outdoor Leadership and Environmental Education Program (OLEEP)**. The program took a holistic approach to science education, with an emphasis on project based learning and supplementary outdoor field trips. Through OLEEP, I traveled to the MET high school in Providence with a dozen of my peers to lead weekly after-school STEM workshops. The MET is an alternative charter school that serves minority communities. During a workshop on plate tectonics, we asked students to use household materials to engineer structures that could survive low frequency vibrations. One group predicted tipping was inevitable and built a tower that caught itself, which had never occurred to me. This experience reaffirmed my belief that a diverse STEM community ensures not only a more equitable society, but also potential for more innovative science.

While I believe reaching underrepresented groups pre-college is important, I also feel **continued STEM support** is essential to ensure retention. To this end, I am a **Women in Science at Columbia (WiSC) mentor**. I work with an underrepresented student who transferred to Columbia during the pandemic. Given the student's lack of access to many on-campus career resources, I connected them with software engineers at Microsoft and beyond. **My email introductions lead to internship interviews.** I realized the privilege I have gives me the opportunity to highlight the intellectual merit of others. To this end, I continue to connect mentees with people in my network.

Organization: To empower more underrepresented students to get into PhD programs, I also **co-coordinate the CS Pre-Application Review (PAR) program** at Columbia. The program provides PhD applicants with a round of feedback to align applications with professors' expectations. I coordinate outreach, with a focus on engagement with underrepresented folks in STEM. I believe this is important because underrepresented students tend to have less access to resources on applying to graduate school. I have been in contact with over 20 affinity groups and coordinate with students and faculty running similar programs at other schools to broaden our collective reach.

Research Impact: In the spirit of the robotics demo that molded my career path, I look for opportunities to **create demos of my research** to get others excited about AI. For my most recent ICCV 2021 project, I built a website with an interactive tool so people can probe how my proposed AI responds to different inputs. Such demos make AI systems more transparent to the public. Every system has its failure modes, and often community engagement is the best way to find and fix them. I have received emails from across the globe communicating how inspirational my demo has been. In line with my research proposal on robot navigation, I have begun work on an online robot simulation platform. Such a platform will not only expedite my own research, but will also allow people without access to physical robots to conduct meaningful research in the field. By **developing a pictorial interface to robots** and a corresponding curriculum, I will build a powerful teaching platform for students who do not yet have college-level programming skills. I will use the Scratch block-programing paradigm as inspiration. Such teaching innovations will realize a world where middle and high school students can develop algorithms of their own for robots to navigate homes.

Future Goals

During my PhD, I am excited to develop techniques in robot navigation where agents are required to reason over what they see to find human specified objects. Such techniques will allow for robots to cater to the people they are meant to help, rather than turning into monolithic systems. I will continue my outreach activities, with an added emphasis on reaching Black communities in Harlem through the Community Impact at Columbia volunteer program. Longer term, I will become a professor to build a research group exploring how interaction and perception algorithms can make robots even more customizable and personal. Such capabilities will open the door for robots being more useful in households. The NSF GRFP would be a critical milestone in my journey to achieve these goals.