Personal Statement – Jessica Yin

Immediately demonstrates initiative and passion for research

Before my first day at Carnegie Mellon University (CMU), I had already emailed ten professors expressing my interest in their research. Despite my lack of engineering background at the time, [redacted] of the Soft Machines Lab (SML) invited me to attend their weekly lab meetings, during which graduate students presented their work and received feedback. Throughout the semester, I dove headfirst into soft robotics and gained a familiarity with cutting-edge ideas, fundamental concepts, and fabrication techniques. My vocabulary grew to include words like "eutectic gallium-indium" and "polydimethylsiloxane", and I began to pick up on the elements of an exemplary technical presentation.

introduction to communication skills

Quick description of research project and author's own technical contributions

As part of CMU's Undergraduate Research Apprenticeship program, I spent the summer after my freshman year contributing to an elastic sensor skin for a soft robotic gripper. I undertook tasks ranging from sensor data visualization to soft circuit fabrication with liquid-metal, microelectronics, and elastomers. Beyond technical skills, I learned how to teach myself and work independently, but also recognize when I should seek assistance. My first project in the SML revealed a then-novel facet of engineering research to me: how all the abstract theory that I had been studying came alive in a tangible system.

What the author learned from this experience

Motivation of the author to continue doing research

Captivated by the interdisciplinary nature of robotics, I continued my research in the SML the following school year. In contrast to my coursework, which was largely restricted to only what is considered relevant to mechanical engineers, my research gave me freedom to integrate electrical engineering and computer science into my work. I learned to view robotics from a broad perspective, understanding its connection to almost all disciplines, from chemistry to linguistics to psychology. I was fascinated by the opportunities for collaboration and creativity within this field, and quickly realized my drive to pursue this path further.

What the author learned from this experience highlighting non-technical research skills

Clearly labeled required section

Intellectual Merit: To complement my coursework and research with industry experience, I interned at P&G in R&D Packaging Development in the summer after my sophomore year. My project was to identify and collect data for developing a finite element analysis (FEA) model of a cardboard package. Existing tests such as three point bending capture certain material behaviors well, but they lack information on the locations and magnitudes of where failure (buckling) can occur in the context of the entire package structure. I realized that developing a testing framework to collect buckling data would be valuable, not only for my specific package design, but for all of P&G's cardboard packaging. I presented my analysis to my management along with my proposed solution: using an RGB-Depth camera to identify and collect data on the magnitudes and locations of buckling during top load compression tests.

Complete but succinct description of the motivating problem

demonstrates initiative and describes clear outcome

After securing support and funding for my proposal, I began my first foray into computer vision. Using an RGB-Depth camera with OpenCV, I implemented a motion detection algorithm that collected the necessary data to inform the FEA model about buckling behavior. I also created a user-friendly interface and automatic data output for other employees, who were unfamiliar with programming, to be able to use the test after my internship was over.

author's specific contributions - shows great initiative and independence and ability to deliver concrete impacts

By the end of my summer at P&G, I had identified an area for innovation, designed my own research plan, obtained funding, and delivered results for the company. I had developed a testing pipeline to collect data for simulations that could be generalized to other cardboard packaging. These simulations led to a reduction of about 70% of physical testing while also expanding the number of iterations and different potential designs being tested, leading to a **cost savings of over $500,000 per year** alone for the specific package I focused on.

quantitative descriptions of project outcomes

When I returned to the SML for the school year, I turned my attention to sharing my soft robotics research. The soft sensor skin I had been working on for the past 1.5 years demonstrated

novel multimodal sensing capabilities with proximity, temperature, pressure, and orientation sensing processed on-board a soft robotic system. I was awarded over $2000 in grants to attend the **2018 IEEE International Conference of Intelligent Robots and Systems (IROS)** in Madrid, Spain and present in the interactive poster session. Working with the lead author, I learned how to successfully prepare a research publication and give a technical presentation to an audience of graduate students and professors.

If I had any doubts about my decision to pursue a PhD, they vanished after attending IROS. Being surrounded by the vast global community of robotics researchers, sharing ideas, having discussions, and meeting the people behind the papers I had read was a phenomenal experience. This experience, I realized, would be the norm in my future graduate school career.

Shortly after IROS, I presented the soft robotic gripper skin at the **2018 Society of Women Engineers National Conference as one of the 10 national finalists** in the research poster competition. With a larger scope of audience members, ranging from high school students to parents to professors, I was challenged to find the appropriate level of technical content to include in my presentation. In this process, I learned how to distill my work into big-picture concepts that require minimal background to understand, while still conveying the significance and motivation behind the research, by focusing on visual examples and familiar analogies. I **placed third in the competition** after presenting to a panel of graduate students and professors.

After the conference presentations, I embarked on three research projects to explore my interests in robotics: soft robotics, haptics, and interactive interfaces. I continued my involvement in the SML with a bio-inspired soft robotic fish project. I worked towards developing a shape memory alloy actuated locomotion system for 3-axis underwater movement, consisting of a ballast and caudal fin. With this project, I experienced the full process of developing an original research idea: beginning with a literature review, then analyzing different approaches and identifying areas for innovation, and finally design, iteration, and testing. I also learned how to conduct interdisciplinary research, drawing inspiration for my design of the caudal fin from papers characterizing the swimming movements and anatomy of fish from biology-focused journals.

To explore my interest in haptics, I worked with two other undergraduate students to win a $1000 grant for the development of a haptic device for the Oculus Rift to provide feedback in virtual reality interactions, supervised by [redacted]. By shifting the device's center of mass when attached to an Oculus Rift controller, reaction forces could be generated that corresponded with users' interactions with virtual objects, thus providing a more realistic virtual reality experience. I designed and prototyped the mechanical components that provided the necessary range of motion to generate the appropriate reaction forces. This experience taught me how to design for integration with an existing platform. **We presented this project at the 2019 CMU Undergraduate Research Symposium.**

In my exploration of interactive interfaces, I collaborated with another undergraduate student to develop an interactive tangible representation of a neural network to promote a better understanding of machine learning to students without technical backgrounds. By representing neural network nodes as modular building blocks, students could physically rearrange the structure of the neural network and see how it affects performance in real time. Creating tangible and interactive embodiments of abstract neural network components reduced the threshold of background knowledge required to understand how neural networks operate. Broadening my experience with system design, I handled the integration of both mechanical and electrical components and the design of the user interface. I also discovered my interest in applying

quantitative measure of success

return to communication skills mentioned earlier

What the author learned from this experience

more quantitative measures of success

Demonstrates knowledge and ability to communicate well using specific techniques

What the author learned from this experience

author's specific contributions and what they learned

return to collaboration skills mentioned earlier

author's specific contributions, what they learned, and communication outcome

Explicitly stated broader impact of project

author's specific contributions and what they learned

technology to teaching. **We presented this paper at the 2019 IEEE Integrated STEM Education Conference (ISEC)**.

communication outcome

Through these projects, I increased my responsibilities and ownership of my research by operating under less supervision and guidance and working with peers rather than mentors. These projects also reaffirmed my research interests in soft robotics, haptics, and interactive interfaces, empowering a clear vision for my future graduate-level research.

Skills the author developed - return to earlier themes of independence and collaboration

Connections between past/ current experiences and future research

To challenge myself in the computer science aspect of robotics, I worked on autonomous systems as a robotics research intern at MIT Lincoln Laboratory this past summer. Working with three other interns, I led the 3D LiDAR sensor and NVIDIA Jetson TX2 computer-on-module integration for our successful implementation of SLAM on an autonomous ground vehicle. As an individual project, I developed a sensor-based control system of a ground vehicle using a microcontroller and 1D LiDAR sensors. Throughout the summer, I learned about autonomous system architectures and feedback controls. **We presented our work to our sponsors from the Department of Defense and the leadership of MIT Lincoln Laboratory.**

author's specific contributions and communication outcome

This year, I am continuing my research in the SML for my Honors Engineering Research thesis. I have begun to explore the implementation of sensor-based control in a soft robotic system to build a foundation for future work in my graduate studies.

Clearly labeled required section

Broader Impacts: Because I have personally experienced the powerful impact that a strong mentor can make, in both my decisions to pursue a PhD and continued involvement in research, I actively seek to develop mentoring relationships with younger students. Through campus organizations such as the Society of Women Engineers, I serve as a mentor to four undergraduate engineering students. In graduate school, I look forward to continuing to mentor undergraduate students interested in research and inspire them to pursue research-based careers as well.

current mentorship tied to future goals

I have also been involved with educational outreach efforts to recruit a diverse generation of future engineers and scientists. I have contributed to the SML's participation in STEM fair days at the Jeron X. Greyson Center serving underrepresented middle school students. In addition to designing engaging posters that explain basic STEM concepts, I also help lead the activity and teach the concepts at our lab's booth in the fair.

specific outreach project, including author's specific contributions

My enthusiasm for STEM educational efforts extend to creating better tools for teachers to use in the classroom. The device I presented at ISEC that aims to explain the basics of machine learning to students is low-cost, open-source, and built from common materials. I strongly believe in the potential of accessible educational devices, and I am eager to develop additional tools in my graduate school career.

broader impact goal with example of past work

By choosing a research direction incorporating soft robotics, haptics, and interactive interfaces, I will contribute to the development of devices that will increase the everyday quality-of-life by enabling applications in elderly care and personal robots. My goal is to build a career in industry R&D and ensure that these advances in research will benefit society.

broader impact goal

long-term career ambition

Future Goals: My undergraduate years have undoubtedly been transformative in my growth as an engineer, researcher, and person. My experiences in academia and industry have given me both the technical and interpersonal skills for a promising research-based career. My enthusiasm for STEM has led to an earnest desire to educate and share it with as many communities as possible. Receiving the NSF Graduate Research Fellowship would elevate my future research contributions by affording the flexibility to pursue the research I am most passionate about in my doctoral degree, while allowing for the freedom to actualize the core values of NSF: advancing the field of robotics, sharing knowledge with society, and recruiting and guiding the next generation of scientists.

Closes with connection of this author's experiences and goals to the fellowship