Personal, Background, and Future Goals Statement - Alexandra Nisenoff

There are things in our world that don't seem to go together, until they absolutely do: mango and chili powder; music on phones; cats on glass tables. For me, a whimsical and surrealistic combination attracts me, and I find these hidden in plain sight, particularly in my research interests. For example, when taking a class on printed circuit boards, it seemed obvious to me that my final project should be to make electronic knitting needles that can record how many (and what types of) stitches you've done. In a class on social science research methods, why not apply what I am learning to information operations on Twitter? I have always been fascinated with combining the things I am passionate about in unexpected new ways, so when I learned that there was an area of computer science that combined the important subdiscipline of computer security and the complexities of human nature, I was hooked. Individually, both computer security and psychology are of interest to me, but together, I enjoy the combination; the impact of protecting systems and therefore the security and privacy of users, while taking into account that the people who are using these systems have their own priorities, preferences, and mental models that influence how these technical systems are used and perceived.

While this is my passion now, my path towards the study of usable privacy and security was not clear from the beginning because I grew up on the largely rural Island of Hawaii and attended a quirky outdoor public charter school that had a literal shark tank on campus, but no formal computer science classes. The thing that I did have was the freedom to pursue interests that were uniquely my own, making the absolute most out of the resources I could find around me (like creating a crochet coral reef for students to use to explain coral bleaching). My school instilled the importance and joy of scientific discovery and the teachers consistently supported my exploration into the topics that interested me. I can credit this experience with my independent drive to satisfy my curiosity as well as my ability to seek out resources and knowledge on my own, despite access limitations. With this support and mindset, I designed and implemented a psychology research project to study the impact of the project based learning format that I had experienced there. The results were so interesting that the project culminated in a poster presentation at the National Association of School Psychologists Annual Convention where my research team and I were the first high schoolers to present or attend the conference. My love of research and discovery has inspired me to stay involved with research (often in multiple labs at the same time) while completing my undergraduate career with a double major in computer science (with honors) and astrophysics, as well as being involved with STEM outreach in the broader Chicago community.

Broader Impacts: Because I experienced an environment with limited access to computer science education, I have consistently worked to create and improve programs that provide students exposure to computer science and STEM. I first learned about if statements and while loops after joining my school's robotics team that included a senior who offered computer science workshops for interested freshmen. Even then, I recognized how important that opportunity was and felt compelled to make sure that other students would have an even better chance to explore this skill set even though I was just beginning myself. Within a year I was running the same workshops I had enjoyed and, by my senior year, teaching an after school computer science program in my high school, co-teaching a media class at a nearby middle school, helping to organize that school's first Hour of Code event for 200 students, and teaching over 150 elementary and middle school students how to program robots through a local public high school's summer robotics camp. My passion to share these experiences and opportunities has only grown as I have learned more about the field. As an undergrad, I consistently volunteered to help coordinate the Science Olympiad invitationals hosted at UChicago and compileHer hackathons designed to engage young girls from all across Chicago with computer science. I am also an active member of the Expanding Your Horizons (EYH) organizing committee which runs an annual symposium that gives middle school girls hands-on experiences in STEM. For EYH, I primarily focus on recruitment to ensure we reach students who may not have had the opportunities to explore STEM in the past, an initiative that is important and near to my heart.

As a woman in computer science, and particularly computer security, I am sensitive to the isolation of being underrepresented in this area and want to be sure to bridge this divide through my research and mentoring work. I have been the only woman in group projects and lab meetings in which I have experienced having my statements and ideas questioned because of my gender, hearing younger students tell me that people have called them dumb for not being able to figure out bugs instantly, and

noticing female researchers whom I respect deeply be talked over and ignored in professional settings. While I may not be able to completely change that culture (yet), I have worked as a peer tutor for introductory students in computer science and made it a priority to foster a collaborative and inclusive environment. During my time as a tutor, in addition to helping students with course topics, I spent time getting to know them and understanding what they were passionate about. This helped me to suggest resources, summer programs, and promising research opportunities for them. While I may not have known that research in computer science was an option in my first year of college, that wasn't going to be the case for the wonderful students who sought out my tutoring assistance. Working as a course assistant for UChicago's intro to computer security class was another vehicle for me to help other students enjoy the same eye opening experiences that I had when I took the class.

Intellectual Merit:

As an undergraduate student, I became involved in five computer science research projects (across three research labs) and two projects on the physical sciences. None of this was required for my coursework, but instead was the result of my drive to do research and take a deeper dive into my interest areas. Some of these projects are ongoing and are spawning additional research questions this year as well.

Project 1: Vulnerability of University Accounts to Password Guessing Attacks

Under my current advisor, Professor Blase Ur, I am heading up a project to measure the vulnerability of accounts at UChicago to password guessing attacks (where attackers make guesses about a user's password by looking at passwords for other accounts that have been in data breaches). Our group worked with IT Services to run a simulated attack on every password that has been used at the University since 2002. To find potentially valid credentials, I parsed over one terabyte of poorly formatted data breaches and generated transformations based on state of the art heuristics and machine learning methods as well as setting up a password spray attack (where common passwords are guessed for all users) for comparison. The two attacks were able to correctly guess over 13,000 credentials that were used for university accounts, and over 3,800 of them were credentials that were currently valid for real user's accounts. I also created a survey that will be sent to users that were found to be at risk to access information on how users react to their account being at risk. This ongoing project has included considerable logistic and ethical complexity due to IRB approvals, legal considerations, and interdepartmental cooperation. While the project has been progressing, I have given poster presentations on our findings at the Midstates Undergraduate Research Symposium and UCISTEM Undergraduate Research Symposium. This project gives the research community the unique opportunity to understand how the risk of password guessing attacks have changed over time (with UChicago as a case study) and gives IT Services the real world opportunity to make the accounts of users more secure.

Project 2: Security of PIN Upgrades

This project, in collaboration with researchers at George Washington University, was to investigate the security of 6-digit PINs created by users forced to "upgrade" from 4-digit PINs, similar to what companies like Apple have done in the context of smartphone unlocking. We found that having knowledge of a user's 4-digit PIN often allows a user's 6-digit PIN to be easily guessed, calling into question this practice of PIN upgrading. For my part in the project, I built on what I had learned about password reuse and targeted password guessing, to develop heuristics for guessing 6-digit PINs after having upgraded from 4-digit PINs which allowed us to guess the 6-digit PINs of users much more efficiently than guessing without knowledge of the 4-digit PIN. This research led to a paper that is currently under review.

Project 3: Issues in the Interactions Between Password Managers and Websites

Through my work as a research assistant at the Max Planck Institute for Security and Privacy, advised by Dr. Yasemin Acar, I collaborated with researchers at the University of Hannover and CISPA to create a selenium based web crawler design to measure the prevalence of issues that occur between websites and password managers which are currently collecting data. This was an invaluable opportunity to learn about conducting large-scale measurement studies and was a great way to combine my interest in authentication with my interest in browsers.

Project 4: Preserving User Privacy and Website Functionality

Because users (or their browsers) take measures to prevent themselves from being tracked online, sometimes websites stop functioning as intended. Investigation into the existing research on this usability issue led to a project in consultation and collaboration across universities and industry as we design our

particular research effort to mitigate these usability issues. This project has real implications for the field in creating solutions for internet breakage so that users don't circumvent their tracking protection tools for the sake of function while inadvertently opening themselves to further privacy problems. I received a $3,750 Jeff Metcalf Fellowship Grant from the university to help fund my participation in this research. Thus far, I have learned how to use browser automation tools such as Selenium and Puppeteer to begin developing a framework for interacting with websites and developed a browser extension to simulate various forms of tracking protection, while learning about how users are tracked online and the tools that attempt to mitigate those risks for users.

Project 5: Encrypted DNS Settings

In my junior year of college, I took a graduate level class on Internet Censorship and Online Speech with Professor Nick Feamster, in which I designed a small scale study to look into the encrypted DNS interfaces in Firefox and Android. This class project turned into a first author peer reviewed workshop paper at the NDSS DNS Privacy Workshop in 2021. As follow up to that project, I designed a full research project to investigate a wider variety of encrypted DNS browser interfaces and user opinions, which is currently collecting survey responses. I applied for and was awarded $1,500 in the form of a Dean's Fund Grant to pursue this project. Through this project, I have had the opportunity to work with and mentor an incredible high school research assistant, introducing topics and designing tutorials on Qualtrics, LaTeX, and basic computer security concepts like encryption and web security. Combining research and mentoring continues.

Project 6: Availability and Accessibility of Supernova Data

I have worked extensively on making astronomical data more available to researchers while paying special attention to adapting the web interface to be accessible to researchers with visual impairments. While working in Professor Vikram Dwarkadas's lab in the astrophysics department, I migrated the lab's database of X-Ray Supernova data to the most current version of PHP so that it could continue to be accessed. During this process, I fixed existing XSS vulnerabilities and worked with another student to make sure that the site is accessible to visually impaired individuals. In my free time I am also working further to make Radio Supernova data accessible in a similar database.

Project 7: Water Isotopologues in Earth's Atmosphere

While working in a geophysical sciences lab, I added functionality to the lab's custom spectrometer, used for measuring the differences in water isotopologues in the atmosphere, to automatically open the valves that allow air into the instrument, a task that had previously been done manually. When done by hand, the task is slow and if the valves are opened improperly, the instrument can be damaged. Even if the spectrometer isn't damaged, improperly opening the valves can necessitate removing it from the roof of the building, taking it to a lab and cleaning the mirrors, a process that takes several hours and also risks damaging the $20,000 custom mirrors. After being frustrated by the speed of the data processing pipeline and the downside of mistakes in handling the equipment, I took the initiative to learn IDL and rewrite the pipeline. Using my updated code, jobs that used to take over 24 hours to run now take 45 minutes to run, freeing up more time for additional data collection and analysis. This was an obvious need in my view, so that was a task that I undertook for the benefit of the lab.

Future Goals: Having been involved with usable security and privacy research, I have discovered my passion for the field. To continue to explore this area, I am applying to Computer Science PhD programs where I will conduct research on web privacy and system security, combining the hard technical challenges these areas provide with consideration for users' experience. My research interests perfectly lend themselves to being used in a security researcher position in industry. Taking a research position in industry would allow me to apply the findings of my research in a way that could have an immediate and direct positive impact on a large number of users, while remaining involved in collaborations with academic researchers and continuing to publish at conferences. The NSF Graduate Research Fellowship would open up even more possibilities by giving me the opportunity to research the areas of usable security and privacy that I am passionate about while continuing my involvement in outreach to help high schoolers and undergraduates involved in STEM.