Personal, Background, and Future Goals Statement **Alex Yen**

Personal Background: I come from a privileged background. I lived very comfortably and had access to great education. However, although I am currently enrolled in a PhD program, my current academic standing does not tell my story of how I got here. I grew up in a competitive K-12 environment – while my peers excelled at academics, I succumbed to the pressures of "success." I grew up with my parents telling me that I was different; that I was not "normal." The various labels—"SpEd (Special Education) Kid," for example—in addition to taunts and boasts from my classmates became a heavy burden. Ironically, this is what probably shaped the rest of my life. When my transition from high school to college resulted in alleviated academic pressure, I took off running. I developed an obsession with fixing my past mistakes; I regretted a lot of things.

In college, I had to learn how to "succeed" to achieve my personal goals. While learning to work hard played a factor, I owe a lot to embracing uncomfortable situations. I pushed myself to participate in hackathon organization. I started my own mentorship organization. I engaged myself with a diverse body of students amongst my participation in a selective Research Experience for Undergraduates (REU) program. Putting myself in these (once) uncomfortable situations made me realize that I can experience many opportunities if I just get out of my own skin.

I grew to love research and the academic environment. Following my first publication, I felt impassioned by the ways we imagine novel ideas and develop solutions for tough problems; I wanted to pursue research as a career. As the first person to pursue a doctoral degree amongst my extended family, I currently tread uncharted waters. But I cherish every part of the process – from all the exhausting effort put into solving a difficult problem to the euphoric feeling of achieving a solution, I have no regrets. After graduating Summa Cum Laude and being awarded our departmental "Award of Excellence"—an award only given to three exceptional students from a class of 100+ people—I knew that I was capable of "success" and that I would continue to work towards new goals. Following high school, I was afraid that I would not measure up to the goals I wanted to pursue. Yet here I am.

Broader Impacts: There are many people without (reliable) electricity in developing countries. While I continued my undergraduate research project—GridInSight—into graduate school to build a new collaboration between my new and old advisors, I primarily continued GridInSight because its impact will affect the lives of millions of people. GridInSight will serve as a methodology to autonomously monitor the electric grid, providing the means to deliver reliable power to customers at the avoidance of costly modern technology. This result will enable societal and economical growth, accelerating development in developing countries.

Beyond research and academia, I want to have broader impacts amongst students too. In college, I talked with multiple professors regarding my insecurities as a student and a researcher; from imposter syndrome to my own lack of confidence, I owe a lot to my mentors for encouraging me to go further. Like my mentors, I want to be that person for other students, and I have acquired the experience, qualities, and skills of someone who can accomplish this. I organized two successful hackathons which led to an offer to lead my third hackathon as the head director. I initialized a college-level mentorship organization to prepare high school students for science competitions. I exerted my abilities to make these programs successful and was recognized by my peers as a leader. These skills and qualities will not only allow me to empathize with students like me but also offer advice towards success.

I was not a leader by nature. Yet, my extracurricular and research experiences taught me that I am capable of taking initiative and leading others around me. I hope to use my experiences as a way to change and encourage the way students think about their own capabilities because I truly believe that every person possesses the ability to do amazing things.

Research Projects and Background

GridInSight. I researched on the application of monitoring the grid via commodity cameras. The **broader impact** of this work influenced my research trajectory – throughout this work, I became interested in understanding the things we take for granted in society. The world contains information that

we can readily sense, collect, and apply for various applications. From my undergraduate project, I realized what excites me: impactful applications that can solve real-world, large-scale problems. This influenced my interest into pursuing the topic of ubiquitous and interconnected sensing devices in my graduate studies. The idea that we can use commodity cameras—or sensors in general—to collect widespread information fascinated my imagination of smart societies embedded with sensing technology.

The **intellectual merit** of GridInSight regards the information we can extract about electricity from the electric grid. Electricity can be measured and quantized indirectly through light, namely street lights and house lights. Through various literature review, I studied and reverse-engineered the method to quantize a light bulb's light emittance—called a Bulb Response Function (BRF)—which we use to extract electric grid phase and frequency information. From this, I created a key-value database of BRF data and associated metadata, forming the crux of our first publication to which I was second author [1].

LightsCameraGrid. Continuing off of GridInSight, the focus of this project was to research on the components needed to form a grid mapping of electricity information. The **broader impact** of this work is enabling infrastructure documentation and electricity monitoring. Many grid mappings in developing countries are outdated or lacking – this results in perfunctory efforts to immediately fix problems that arise, as well as the addition of new, unplanned, and undocumented infrastructure to provide electricity access to new (and old) customers; these immediate fixes do not provide long term solutions. Establishing a grid mapping through automated and affordable methods ensures up-to-date information of the grid infrastructure, avoiding information ambiguity while enabling efficient expansion and timely solutions to grid failures.

The **intellectual merit** of LightsCameraGrid is the new interdisciplinary developments. I tackled two components of this research for the larger vision of mapping the electric grid: (1) BRF classification and (2) feature geolocation, namely the Global Positioning System (GPS) estimation of light bulbs with mere images and smartphones. I first explored methods to classify BRF signals. The solution was surprisingly nontrivial – I exhausted classic signal processing techniques and even went to my signals and systems professor for advice. I next applied computer vision techniques, where I later found that I (unintentionally yet intuitively) replicated a state-of-the art practice (i.e. feature engineering via Principal Component Analysis); exhausting the obvious solutions allowed me to think more creatively. I learned a lot from this experience, and I realized that perseverance—despite the frequent roadblocks—is a major part of the research process. I spearheaded our eventual solution, which stemmed from a novel hybrid approach of feature engineering and machine learning methods – I designed and weighted features that could describe each BRF, which were then fed into a weighted k-Nearest Neighbor (KNN) classifier for training and testing. This methodology resulted in an *unoptimized* 94.5% accuracy of light bulb classification. Perseverance allowed me to appreciate the feeling of success, and while I felt discouraged after many failed attempts, I achieved solutions as a result of patience and determination.

Since the last publication, I have researched on methods to geolocate features (i.e. lights) in images – the **intellectual merit** of this effort required advanced knowledge of computer vision techniques. I took two graduate computer vision courses, self taught and researched on additional algorithms, and established a mentor-mentee relationship with an expert computer vision scientist. Once ignorant about the fundamentals, I can now conduct computer vision research and can also understand the underlying theory and concepts for new algorithms. I eventually designed and implemented my own stereo vision setup that allowed me to estimate the 3-dimensional GPS location from 2-dimensional image pixel coordinates. To design my custom stereo camera, I researched on the unorthodox usage of smartphone cameras, designed my own CAD model, coordinated with multiple Mechanical and Aerospace Engineer (MAE) staff members for design advice, and pushed through months of code implementation and debugging to establish a fully functional stereo camera. The **broader impact** of this method will allow us to associate image-based information with real-world locations. This vision-based sensing will enable new methods by which researchers can use commodity cameras to associate information—collected via images—with geospatial information. For interdisciplinary communities, my stereo implementation provides broad access to commodity stereo devices and stereo technology for real-world applications.

As a computer *systems* researcher, I not only drove my research to fruition but also instigated my learning of various research subjects. These skills and knowledge expand my ability to conduct interdisciplinary research, and I know I will continue to learn new topics related-to and unrelated-to my background and research interests. I believe that exploring a wide range of subjects will allow me to become a broad and knowledgeable expert. My current work will be submitted to ACM COMPASS in October 2021.

"Sniffing" Helium. The Helium company provides infrastructure—namely hotspots that any person can purchase—to enable long-range, low-power connectivity for commodity embedded devices. I analyzed various aspects of the network through Helium's public blockchain; this blockchain records all hotspot—and hence user—actions, providing insight into the network functionality, behavior, and reliability. The **broader impact** of this analysis was to provide a quantitative measure of this new network's efficacy for anyone deploying Internet-of-Things technology. Our analysis provided incipient insight and takeaways for refining Helium and for future Internet-of-Things networks to come.

As one of the first researchers to conduct a broad measurement study on the Helium network, I provided the **intellectual merit** of producing exploratory research questions, hypotheses, and analyses on Helium's network and infrastructure. I analyzed various user activity, contributed to the assessment of the network coverage and reliability, and designed software to represent and provide visual analysis for hotspot geospatial data. As the primary co-author, I drove this project from start to end; I started "Sniffing" Helium in a graduate computer networks course and propelled this class project into a research publication. Our research was accepted into the 2021 Internet Measurement Conference (IMC); 55 out of 196 papers were accepted. While I greatly appreciated and enjoyed the entirety of the project, there is unfinished work. The network and protocols are constantly changing and evolving, and there are further questions and hypotheses to be challenged. I will continue this work and submit our new research to IMC 2022.

Future Goals: I achieved a wide range of rewarding experiences during my first year of graduate studies. I led and submitted a first author workshop paper [2] and a first co-author research paper [3], I received a best presentation runner-up award, and I learned to persevere through some of the most challenging research problems I ever dealt with. I am capable of self-driven learning, and I am eager to apply this attitude towards the design and development of novel computer systems. My previous and current research projects have confirmed my passion to measure and sense the various things that interact within the world, and I will continue to pursue this passion throughout my graduate studies.

I envision myself becoming an academic professor. I believe that a novel and impactful idea stems from a well motivated application – I will hypothesize, design, and lead projects and students to solve real-world problems with the intent of making a greater impact on society as a whole. I am also particularly keen to mentor diverse, motivated students – I intend to leverage my position as a professor to reach out to student communities about pursuing not only research and academia but also challenging, personal goals. I want to serve as a mentor and guide for those who display drive and potential but carry doubts about themselves.

[1] Z. Shah, **A. Yen**, A. Pandey, J. Taneja. GridInSight: Monitoring Electricity Using Visible Lights. Proceedings of the 6th ACM International Conference on Systems for Energy-Efficient Buildings, Cities, and Transportation, Nov. 2019.

[2] **A. Yen**, B. Flowers, W. Luo, N. Nagesh, P. Tueller, R. Kastner, P. Pannuto. A UCSD view on replication and reproducibility for CPS & IoT. Proceedings of the Workshop on Benchmarking Cyber-Physical Systems and Internet of Things, May 2021.

[3] D. Jagtap*, **A. Yen***, H. Wu, A, Schulman, P. Pannuto. Federated Infrastructure: Usage, Patterns, and Insights from "The People's Network". ACM Internet Measurement Conference (IMC '21), Nov. 2021.