I live with Dysgraphia, a transcription disability associated with impaired handwriting. Even with immense effort and concentration, my handwriting, after years of therapy, is nearly illegible. In the fourth grade, I began using computers to type homework assignments, including my math homework. This proximity to computers, in school and out, grew into love and appreciation for them. I was thankful that I grew up in a world with machines that made my Dysgraphia less of a hurdle in my education and communication. As I grew older, I became interested in how computers worked. By the end of high school, I regularly spent time writing simple programs and games, repairing computers for money, and building drones with my brother. I decided to pursue a career in computing, and enrolled at Miami University to study computer science.

Intellectual Contributions @Miami: As a Freshman at Miami University, I started working working with Dr. DJ Rao. Together with his graduate students, we worked on problems in parallel discrete event simulation. The focus of the research was on improving the efficiency of the time warp algorithm. The time warp algorithm is a method for assuring that agents in a parallel simulation are on the same clock time when interacting. One node in a cluster may be processing the simulation faster than another, and when agents in different nodes interact, they must assure they are interacting at the same time in the simulation. When two agents are on different timelines, the timewarp algorithm dials back the events generated by the future agent to the time of the past one. Time warps are effective but costly, and can be minimized if agents who interact often are located in the same node of the cluster (colocated), where they will have less of a disparity between clock times. Our intellectual contribution was creating a mechanism for colocating agents that communicated most often to avoid time warps. I helped organize code, ran experiments, attended meetings, and presented a poster on the project at the Miami University undergraduate research forum.

My work with Dr. Rao gave me a continued appreciation for efficiency and parallelism in computing. Through my work with him, and after taking his excellent High Performance Computing class at Miami, I developed a fondness for systems programming and research that influences my work today.

Intellectual Contributions @AFIT: After my work with Dr. Rao concluded, I was able to find a research position at the Air Force Institute of Technology, working on topics like discrete event simulation, autonomy, and unmanned aerial systems with many excellent researchers. Over my four years at AFIT, I performed research with my main mentor, Dr. Christina Rusnock, and collaborated with many other professors, researchers, and students.

As a SOCHE intern and later ORISE Fellow at AFIT, I was able to create posters and publish papers on a number of topics, but the most impactful to my current research interests was my work on autonomy. With Dr. Rusnock, I studied the interactions between autonomous machines and humans. Our work centered around the ability for machines to build trust with human operators. We built autonomous software systems and ran human subject tests to determine automation patterns which humans could more easily trust. We designed automation actions that humans are predisposed to trust, and developed statistical processes to empirically determine the effectiveness of human-automation teams. **This work has been used in masters and PhD theses at AFIT and Ohio State, and has generated numerous publications and posters.**

My last summer at AFIT, I worked with Dr. Michael Miller researching test and evaluation of unmanned aerial vehicles (UAV). At AFIT, I was able to apply prior UAV knowledge from my hobbies to create a testing suite for our research UAV. My testing suite, FaultInjector, leveraged extant simulation software to test UAV firmware failure procedures, assuring any in-flight UAV would fail gracefully under all but the most extraordinary conditions. This project introduced me to the UAV research space, allowing me to familiarize myself with the literature, as well as the technologies that were used in UAV research. **My application is still used and developed by USAF researchers today.**

My time at AFIT with Dr. Rusnock and Dr. Miller helped me mature as a researcher. I learned how to properly identify research problems, design experiments, analyze data, and convey my research to a scholarly audience. I also developed research interests in autonomy and UAV that inspire my work today.

Intellectual Contributions @Ohio State: I am now a PhD student at Ohio State studying under Dr. Chris Stewart. In Dr. Stewart's ReRoutlab, we create and analyze Fully Autonomous Aerial Systems (FAAS). FAAS consist of UAV and edge systems that execute complex autonomous missions without human interaction. Autonomy in this context requires the abilities to plan missions, sense data, and adapt to a changing environment in real time. FAAS expand the concept of unmanned aerial systems, allowing users to specify high level goals, push start, and allow the FAAS to do the work. By combining approaches from computer vision, robotics, and computer systems, we seek to create systems of the future. We want to create FAAS that are capable of managing and maintaining farms, surveiling disaster areas, inspecting buildings and infrastructure, and possibly constructing buildings with little more than the push of a button from the end user.

FAAS require considerable compute power for real time vision and route planning, have small batteries, and operate in resource constrained environments like farms and disaster areas. These constraints require application and study of high performance computing concepts to decrease runtimes and increase energy efficiency. My work on FAAS allows me to combine my principal research interests (autonomy, high performance computing, and UAV) to create novel systems that solve the problems of the future and today.

My first project with Dr. Stewart was the creation of a UAV benchmark for facial recognition. I helped create the Reroutlab FAAS middleware, included real time facial recognition, and used it to create an autonomous photography benchmark. My photography benchmark is able to autonomously fly through a room and scan for faces using a number of facial recognition techniques. This benchmark represents a kernel at the heart of many FAAS applications (autonomous target recognition and photography) that can benefit from analysis. Using our benchmark, we were able to test hardware devices suitability as edge devices for simple FAAS applications based on edge and UAV battery consumption, application execution time, and responsiveness. **This form of my photography benchmark was the subject of a poster I presented at IoTDI 2018.**

Over the last spring and summer, I extended our benchmark further to study optimization on autonomous photography. We wanted to be able to use recognition algorithms and feature extraction to take the highest quality image possible of a target in the FAAS state space. This ability is useful in areas like agriculture, where problems with crops are easy to recognize but require high quality images to diagnose. To enable this, I added the capability to extract features from images to our FAAS middleware, as well as the ability to determine utility of facial images.

FAAS pathfinding is difficult in this context. We want the highest utility images possible, but FAAS explore unpredictable environments making it difficult to know which flight path will provide the most benefit. To improve FAAS search, Dr. Stewart and I introduced the concept of autonomy cubes. The autonomy cube is a data structure containing all data that can be sensed during an FAAS mission. During autonomous missions, our FAAS can access a database of autonomy cubes and find similar cubes to its current state space, using them to infer the best possible movement from the utility gains of each possible motion in those cubes. Using this approach, we were able to decrease mission throughput by up to 2.25X over competing approaches.

Using a database of over 100 autonomy cubes, almost 10,000 images collected from real FAAS missions, I studied the effects that parallel architectures and GPUs, goal driven autonomy policies, search algorithms, and adaptive model switching had on the mission throughput of our facial recognition FAAS. Each of these techniques yielded throughput improvements which will be useful for designing future FAAS. **Combined, our approaches yielded a 10X improvement in throughput. The results of this work have been submitted to ASPLOS 2019 as a full paper.**

Broader Impact and Future Goals: My FAAS work has direct connections to a number of important domains, most prominently agriculture, search and rescue, and infrastructure inspection. I seek to create FAAS benchmarks for these domains, particularly agriculture. I am concerned about the documented effects that climate change and population growth will have on our food supply. I feel that it is my duty as a researcher to help target my efforts towards closing the yield gap and increasing the productivity of individual farmers. Using FAAS, farmers will be able to detect and neutralize crop diseases and pests, monitor crop health, and actively manage their farms like never before. I have already begun working with farmers in Ohio to develop FAAS applications to improve crop yield, and seek to continue my work until these goals are realized.

In the near future, I will be releasing my FAAS middleware and benchmarks as an open source software package. I intend to actively manage and update this package throughout my PhD and after. I believe in the open culture of the computer science field, and seek to disseminate my software in an effort to encourage others to create FAAS benchmarks and applications in important domains. Over the next three years, I plan to engage with collaborators at Miami, Ohio State, Denison, and AFIT, giving talks and demonstrations of my software in an effort to introduce undergraduate developers to open source software as well as find developers for my own research.

I also intend to continue outreach. In the spring of 2018, my colleagues and I got the opportunity to use our FAAS to teach young women about robotics and computer science at Ohio State's Buck-I-Code workshop, an event sponsored by Ohio State and our ACM-W chapter that seeks to teach young women about computer science through hands on programming exercises and demonstrations. My colleague Shiqi Zhang and I modified the photography benchmark to play a facial recognition game with the girls, and gave a presentation on the computational thinking and its relationship with computer science using UAV as an example application.

I will continue to reach out to my community by presenting and demonstrating my work at outreach events in an effort to close the gender gap and increase minority representation in computer science. Along with my Rerout lab colleagues I will create new demonstrations for Buck-I-Code and similar events this year and the future to reach out underrepresented groups in my community. I would also like to educate farmers in and around Ohio about the power of farm automation. As I create my agriculture benchmarks, I will create educational demonstrations of FAAS for the farm, and continue to work with farmers in my area to develop the applications they need to increase crop yield in Ohio and around the world.

After completing my PhD, I plan to become a tenured professor at a research university here in the United States. I want to continue researching FAAS, creating novel architectures and techniques to solve difficult problems with autonomous systems. The NSF Graduate Research Fellowship will allow me to spend more time on research, outreach, and open source development as I continue my PhD.