Statement of Purpose

In my current research lab, I love talking about different ideas with other labmates (or really anyone who wants to throw ideas around) whenever I get the chance. The research process is energizing, and I'm excited to continue working with some of the brightest minds in the field, furthering 3D-recognition /reconstruction and generative modeling techniques. **Specifically, I'm interested in general scene generation as well as 3d recognition/reconstruction.** My research experiences in machine learning theory, uncertainty estimation, bias mitigation, and image synthesis make me well equipped to push the frontier of 3D-recognition and reconstruction/generative modeling during a PhD program. Further, as a four-year TA for undergraduate courses at Carnegie Mellon and a teaching assistant for a high school AI program at CMU, I've continued my love of teaching, empowering the next generation of students to achieve their own dreams. I hope to continue to empower this next generation in machine learning during my PhD and later as a professor. **CMU houses many notable scholars both enthusiastic and knowledgeable in the field and given my strong capability in both research and teaching, I think I am the perfect fit for the PhD program.**

My first academic research project was in machine learning theory, where I worked on improving theoretical algorithms for finding optimal hyperparameters in graph-based semi-supervised learning under Prof. Nina Balcan alongside a PhD student. During this work, I learned how to take a project from an idea to an accepted publication, produce clean open source code, and work with both mathematics and machine learning to produce theoretically sound results that work in practice. We were able to improve time bounds via speedup techniques for these algorithms while still providing similar theoretical guarantees. **I updated, found complexity bounds, and proved convergence for these algorithms, as well as wrote the codebase which is currently released on my github.** This included implementing past work by other authors from scratch, implementing theoretical results from the previous paper from scratch, and **showing that our new methods were both more accurate and multiple orders of magnitude faster than previous algorithms**. I made it a point to write code that makes it easy for anyone to quickly understand and reproduce our results as well as tweak for their own testing. During the project, I particularly enjoyed the process of tinkering with solely theoretical algorithms to make them work in a real world setting, then re-proving the theoretical results for the new, updated versions. Finally, **our work was accepted at UAI 2023 [1]** where I created and helped present our poster. I liked the experiments and implementation aspects of the project more than the theory, leading me to pursue more deep learning based research in vision.

My introduction to computer vision research in industry was at Meta, where I created a streamlined pipeline to benchmark the difference in confidence predictions between normal and probabilistic (bayesian/ensemble networks) models for out of distribution data. Over the course of the summer, I learned valuable skills like running experiments, keeping training/testing logs for reproducibility, and writing clean code that could be used by anyone for similar purposes. We turned testing images into OOD images by performing data augmentations like rotation and random blackout of areas in the image. **Upon completion, I showed that probabilistic networks indeed had higher entropy for OOD data, but it was both surprising and interesting to see that even probabilistic models would get fooled by some adversarial data points.** I enjoyed the process of making/testing hypotheses, as well as digging in deeper when my hypotheses turned out to be incorrect. During my time at Meta, I was particularly inspired by Infinite Nature, a paper that I presented at a reading meeting incorporating both 3D geometric constraints and image generation to produce stunning results.

After these experiences, I sought out research in generative modeling at CMU, and joined the Generative Intelligence Lab under prof. Jun-Yan Zhu. During my time, I've gained insights on

leading a project in deep learning-based computer vision in an academic lab. Currently, I am working on generative model customization for diffusion models. More specifically, given an input pair or pairs of (base image, styled image), we hope to learn this translation using low rank adapters on a pretrained diffusion model and apply the translation to other images, thus allowing us to create more images from the artist's style. With just the styled image as training data, there is no clear way for the model to separate content from style. For instance, a model trained on a portrait of a cat by Van Gogh may be able to correctly create a boat in the style of Van Gogh, but may have trouble creating different cats in the style of Van Gogh, mode collapsing onto the training cat. To alleviate this problem, we can use a base image of the original cat as a content reference to help disentangle the content of the styled image from the style application itself. **We plan to submit our work to SIGGRAPH 2024**. Working in the Generative Intelligence lab on a project that I am leading has given me many valuable skills which I hope to continue improving upon as a PhD student. **I've improved my ability to quickly and correctly reproduce and integrate previous/concurrent works into my own methods, iterate on ideas quickly, and present material clearly to the team.** Finally, During my time with the lab, I've found it immensely interesting and helpful to pick the brains of my fellow labmates, especially those working in the 3D space. Learning about their thinking process when working on their own projects from beginning to completion has been eye-opening, and I hope to continue learning from other great researchers during my PhD.

Teaching has been a consistent passion. For the last four years, I've had the privilege of being a teaching assistant for two mathematics/CS theory classes that new CS/Math students take their first year. **As a three-year head TA, I've been in the unique position to make a difference in the lives of undergraduates through teaching and course development.** I've loved teaching at CMU, and I hope to continue my teaching journey as a PhD student and later as a professor. Furthermore, **I was nominated for and accepted a position on the university leadership student advisory council for the current school year.** As members of the committee, I and a select group of leaders from across CMU will be meeting with the provost and vice dean of student affairs to provide counsel about the student experience. I hope to use this experience to make a positive impact across campus, and continue to augment my skills working effectively with faculty to serve the needs of a diverse community.

Finally, I feel that my team-based extracurriculars equipped me with valuable skills that I can leverage during a PhD. During undergrad, I participated on a team of four in Battlecode, an AI strategy competition held by MIT over the month of January. Hundreds of teams and thousands of students compete internationally each year, and **our team was able to qualify for the finals held at MIT all three years we competed, yielding $2000+ in prize winnings.** This experience helped solidify my ability to work with a team to output high quality solutions and code, which will be extremely valuable for team based projects during a PhD program.

CMU boasts a large number of talented and driven professors who I'd be eager to work with. Specifically, the work of Profs. Zhu, Tulsiani, and Ramanan are all exceptional and I'd be more than happy to work with any.

References

[1] Sharma, Dravyansh, and Maxwell Jones. "Efficiently Learning the Graph for Semi-supervised Learning." *arXiv preprint arXiv:2306.07098* (2023).