Siming He

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EDUCATION

University of Pennsylvania | School of Engineering and Applied Science, The Wharton School *May 2024*
Candidate for Bachelor of Science in Engineering (Computer Science with Mathematics Minor), **Bachelor of Science in Economics** (Statistics), **Master of Science in Engineering** (Robotics)

- Cumulative GPA: 3.90 / 4.0 Major GPA: 3.96 / 4.0
- Selected Math Courses: Probability Theory (ESE 5300), Advanced Linear Algebra (MATH 5140), Mathematical Statistics (STAT 4320), Real Analysis (MATH 3600), Math Foundation for Reinforcement Learning (STAT 9910), Game-theoretic Learning (CIS 6200)
- Selected Engineering Courses: Learning in Robotics (ESE 6500), Convex Optimization (ESE 6050), Computer Vision (CIS 5810), Deep Learning (ESE 5460), Machine Learning (CIS 5200), Linear System Theory (ESE 5000), Bayesian Statistics (STAT 4420), Algorithm (CIS 3200), Operating Systems (CIS 3800), Information Theory (ESE 0099)

RESEARCH PROJECTS

Active Perception using Neural Radiance Field | University of Pennsylvania *June 2021 – Present*

- In 2021 summer, I studied the theory and algorithms for state estimation, mapping, planning, control, and learning since combining those algorithms creates modern robots. Then, I created a full-stack robotic system on my custom-built quadrotor in 2022 summer. The system allowed an agent to explore its surroundings and build a geometric map autonomously. I extended the idea in 2023 summer and formulated active perception as maximizing the mutual information between past and future observations. We identified the necessary parts of an active perceiver, including 1) an online algorithm to summarize past observations into a compact representation, 2) a generative model for synthesizing future observations, and 3) a mechanism to select trajectories with maximal mutual information. We implemented the first two parts with a bootstrapped ensemble of neural radiance fields, which captures the scene's photometric, geometric, and semantic properties. Based on the ensemble, a sampling-based planner can find dynamically feasible trajectories that maximize the mutual information. We considered the number of objects localized and the quality of scene reconstruction over the traveled distance as evaluation metrics. Our method outperformed standard exploration methods in simulations of realistic 3D indoor environments. We envision that robots capable of autonomously collecting evidence in complex environments will provide a new approach for science research and discovery.
- *Mentor*: Prof. Pratik Chaudhari
- *Manuscript* has been submitted to the 2024 American Control Conference: **Siming He**, Christopher D. Hsu[*], Dexter Ong[*], Yifei Simon Shao, Pratik Chaudhari, *Active Perception using Neural Radiance Field*.

Penn Campus Tree Mapping Project | University of Pennsylvania *January 2023 – Present*

- The project develops algorithms and hardware to enable large-scale, high-resolution tree data collection that current data collection methods cannot do. We can extract rich information like tree volume, species, and health from the data. It would inspire new sciences in which forestry experts, ecologists, and botanists could holistically analyze carbon capture, biodiversity, and ecosystems based on the data. I led the development of the remote sensing technology stack and collected tree data across the campus. Then, I generated geometric and semantic maps from the data as a fine-grained representation of the urban ecosystem for further investigation. Additionally, I took on the role of mentoring first-year student, guiding them in acquiring proficiency in the robotic technology stack.
- *Mentors*: Fernando Cladera, Prof. Pratik Chaudhari, Prof. Vijay Kumar

Robotic System for Automated Experiments on C. Elegans | University of Pennsylvania *September 2021 – May 2022*

- The project developed a robotic platform capable of conducting and analyzing experiments on C. Elegans, accelerating scientific discovery and freeing researchers from time-consuming, repetitive tasks. Take a typical genetic-cross experiment as an example. The robot's imaging system move and searches in an array of agar plates to identify C. Elegans with specific phenotypes. Then, the robot arm picks and transfers those C. Elegans to a new agar plate to mate. And, the imaging system monitors the plates and pick out the descendants with desired phenotypes. The system can tirelessly conduct many similar experiments over multiple generations of C. Elegans in parallel. I designed an algorithm to decode barcode labels on Petri dishes. It allowed the robot to organize experiments and save details based on the labels so researchers can analyze the experiments afterward. I also created an automatic lens calibration algorithm to ensure the cameras' precise focus on C. Elegans because precise focus is essential for detecting various phenotypes accurately.
- *Mentors*: Zihao (John) Li, Prof. Christopher Fang-Yen
- *Publication*: Zihao Li, Anthony D Fouad, Peter D Bowlin, Yuying Fan, **Siming He**, Meng-Chuan Chang, Angelica Du, Christopher Teng, Alexander Kassouni, Hongfei Ji, David M Raizen, Christopher Fang-Yen, *A robotic system for automated genetic manipulation and analysis of Caenorhabditis elegans*, PNAS Nexus, Volume 2, Issue 7, July 2023, pgad197, https://doi.org/10.1093/pnasnexus/pgad197

Information Theory and Learning Theory | University of Pennsylvania *January 2023 – May 2023*

- I explored the mathematics of information theory and learning theory with extensive reading and problem-solving because I'd like to approach challenges in robotics through those theories. For example, information theory provides measures of the complexity of physical systems, which could be important for understanding robot perception and decision-making. Learning theory formalizes convergence and generalization of learning processes, which can be further developed in the robotics context. I started by learning most of the chapters in the famous *Elements of Information Theory* by Cover & Thomas. Then, I studied some more theoretical results from *The Theory of Probability: Explorations and Applications* by my mentor, including axiomatic derivation of information measure, proof of Gaussian channel capacity by concentration of measure, proof of Glivenko–Cantelli theorem, and Vapnik–Chervonenkis theory. After learning these foundations, I studied papers on recent results in information theory and learning theory, including *A sharp concentration inequality with applications* (e.g., in Vapnik-Chervonenkis entropies), *Temporal Dynamics of Generalization in Neural Networks*, and *Deep Reference Priors: What is the best way to pretrain a model?* And I presented the proof of the first paper to my mentor.
- *Mentor:* Prof. Santosh Venkatesh

Benchmarking Heterogeneous Graph Neural Networks | Tsinghua University *January 2021 – March 2021*

- The project aimed to accelerate research progress on heterogeneous graph neural networks (HGNN) by standardizing the evaluation of HGNN models. It constructed the Heterogeneous Graph Benchmark (HGB) with a performance evaluation pipeline and 11 diverse datasets. Based on the pipeline, we systematically assessed 12 existing HGNN models. I contributed to this project by thoroughly evaluating three existing models based on their official implementation.
- *Mentors*: Dr. Ming Ding, Prof. Jie Tang
- *Publication*: Qingsong Lv[*], Ming Ding[*], Qiang Liu, Yuxiang Chen, Wenzheng Feng, **Siming He**, Chang Zhou, Jianguo Jiang, Yuxiao Dong, and Jie Tang. 2021. *Are we really making much progress? Revisiting, benchmarking and refining heterogeneous graph neural networks*. In Proceedings of the 27th ACM SIGKDD Conference on Knowledge Discovery & Data Mining (KDD '21). Association for Computing Machinery, New York, NY, USA, 1150–1160. https://doi.org/10.1145/3447548.3467350

OTHER EXPERIENCE

Resident Advisor, *Kings Court English College House* | Philadelphia, U.S. *August 2023 – Present*

- As a resident advisor in a first-year students' dorm, I counsel my residents on various aspects of academic and residential life and support them through the challenges of first-year college life.
- I organize information sessions to connect residents with the abundant research resources on campus. Additionally, I host lunch sessions where faculty members join residents for conversations spanning academic, research, and daily life topics.

Peer Research Advisor, *Penn Center for Undergraduate Research & Fellowships* | Philadelphia, U.S. *October 2022 – Present*

- I counsel undergraduate researchers regarding research opportunities, faculty mentors, and grants.
- I mentor 20 1st and 2nd year students interested in doing computer science, robotics, and statistics research. I make weekly research talk lists to inform them about talks on campus in their interest areas.
- I design and conduct annual Python Programming for Research Workshops to introduce Python and common Python packages.

Teaching Assistant, *Machine Learning and Deep Learning Courses* | Philadelphia, U.S. *August 2022 – Present*

- I'm a teaching assistant for graduate-level machine learning and deep learning courses. I designed and led weekly recitations on machine learning concepts. To effectively support the students, I created online surveys for students to provide feedback. Based on the feedback, I improved my teaching style and aligned the focus of my recitation to their need.
- 18 out of 22 students rated my recitation as "awesome/good ". Students' comments included: "Clear and explicit, with detailed examples", "TA is always well-prepared, good timing", and "He reviews all the questions! Great TA".

Founder, *Rykert After School Science Program* | St. Catharines, Canada *August 2018 – May 2020*

- I organized the program to engage underprivileged middle school students in science experiments in a laboratory environment often beyond their regular access. I led the development of the curriculum, which focuses on hands-on experience. We designed intriguing experiments, including building electric wheels, building water rockets, and making slime (non-Newtonian fluid). I believe these experiments foster their understanding of physics concepts and inspire their curiosity in science.

Intramural Soccer, *Player* | Philadelphia, U.S. *August 2017 – Present*

- I participate in weekly soccer training sessions and played UPenn and inter-school intramural games.