Research Statement

My research focuses on leveraging imitation learning, reinforcement learning, LLMs, and diffusion models to empower autonomous robots to understand and carry out human instructions while navigating safely and in compliance with social norms within human environments.

Education

Ph.D. in Artificial Intelligence and Robotics

Advisor: Joydeep Biswas, Autonomous Mobile Robotics Lab

Research Areas: LLMs for Code Generation, Language-conditioned Diffusion Policies, Social Robot Navigation Relevant Courses: Robot Learning, Planning and Reasoning Under Uncertainty, Predictive Machine Learning

B.Science in Computer Engineering

Advisor: Samira Khan, Shift Lab

Research Areas: Simultaneous Localization and Mapping (SLAM)

Relevant Courses: Data Structures and Program Representations, Advanced Algorithms, Machine Learning, Advanced Human-Computer Interaction

Research Projects

Composable Diffusion-based Planner for Instruction-Following Navigation

Co-supervised by Joydeep Biswas, Peter Stone

- Generated large-scale synthetic robot trajectory datasets to pre-train a diffusion policy for producing collision-free trajectories in dynamic environments.
- Applied reinforcement learning from AI feedback (RLAIF) to finetune diffusion policies for generating specialized social navigation behaviors, including overtaking and following.
- Leveraged the compositional properties of diffusion models to synthesize complex navigation behaviors from specialized behaviors (e.g., deriving merging behavior from overtaking and following) based on languageconditioned instructions at inference time.

LLM-Powered Code Generation for Autonomous Service Robots

Co-supervised by Joydeep Biswas, Arjun Guha, Jessy Junyi Li

- [Thrust 1] Developed CodeBotler, a system integrating large language models (LLMs) with the Robot Operating System (ROS), enabling end-users to command a service robot through natural language instructions for performing open-world tasks.
- [Thrust 1] Created RoboEval, a robot code generation benchmark that utilizes linear temporal logic (LTL) to verify the correctness of robot actions generated by the program.
- [Thrust 1] Published in RA-L 2024, [Project Website: https://amrl.cs.utexas.edu/codebotler/]
- [Thrust 2] Generated synthetic service robot programs to fine-tune small open-weight LLMs (e.g., Llama), closing the code generation performance gap with large proprietary models (e.g., GPT, Gemini).
- [Thrust 2] Proposed Robo-Instruct, an extension of Self-Instruct that verifies the correctness of generated instructions and robot programs. It dynamically infers the relevant simulation environment during program execution and filters out invalid robot programs from the training dataset.
- [Thrust 2] Under review, [Project Website: https://amrl.cs.utexas.edu/robo-instruct/]

Social Robot Navigation

Co-supervised by Joydeep Biswas, Xuesu Xiao, Peter Stone

 Conducted a case study on the Socially CompliAnt Navigation Dataset (SCAND) using the ROS Navigation Stack on playback data, discovering that human-demonstrated trajectories only occasionally deviate from general-purpose planner outputs. Addressing these rare deviations is essential for solving social robot navigation.

University of Virginia, VA, USA August 2018 – May 2022

University of Texas at Austin, TX, USA

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August 2022 – Present

Austin, TX

June 2024 – Present

Austin. TX

April 2023 – May 2024

Austin, TX January 2023 – September 2023

Journals

• Zichao Hu, Francesca Lucchetti, Claire Schlesinger, Yash Saxena, Anders Freeman, Sadanand Modak, Arjun Guha, Joydeep Biswas. "Deploying and Evaluating LLMs to Program Service Mobile Robots", *Robotics and Automation Letters, (RA-L 2024).* [Paper]

Conference Proceedings

- Amir Hossain Raj*, Zichao Hu*, Haresh Karnan, Rohan Chandra, Amirreza Payandeh, Luisa Mao, Peter Stone, Joydeep Biswas, Xuesu Xiao. "Rethinking Social Robot Navigation: Leveraging the Best of Two Worlds", IEEE International Conference on Robotics and Automation (ICRA 2024). Joint first Author. [Paper]
- Hanzhi Zhou*, **Zichao Hu***, Sihang Liu, Samira Khan. "Efficient 2D Graph SLAM for Sparse Sensing", *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2022). Joint first Author.* [Paper]

Under Review

- **Zichao Hu**, Junyi Jessy Li, Arjun Guha, Joydeep Biswas. "Robo-Instruct: Simulator-Augmented Instruction Alignment For Finetuning CodeLLMs", *Under Review*.
- Jeahn Han, **Zichao Hu**, Seonmo Yang, Minji Kim, Pyojin Kim. "SoMaSLAM: 2D Graph SLAM for Sparse Range Sensing with Soft Manhattan World Constraints", *Under Review*.
- Yunhao Yang, William Ward, **Zichao Hu**, Joydeep Biswas, Ufuk Topcu. "Joint Verification and Refinement of Language Models for Safety-Constrained Planning", *Under Review*.

Workshops & Symposiums

- Zichao Hu, Francesca Lucchetti, Claire Schlesinger, Yash Saxena, Anders Freeman, Sadanand Modak, Arjun Guha, Joydeep Biswas. "Deploying and Evaluating LLMs to Program Service Mobile Robots", *Vision-Language Models for Navigation and Manipulation Workshop (ICRA 2024)*. Spotlight Paper [Paper]
- Zichao Hu, Francesca Lucchetti, Claire Schlesinger, Yash Saxena, Anders Freeman, Sadanand Modak, Arjun Guha, Joydeep Biswas. "Deploying and Evaluating LLMs to Program Service Mobile Robots", AAAI 2024 Spring Symposium. [Paper]
- Divyanshu Saxena, et al. "On a Foundation Model for Operating Systems", *Machine Learning for Systems Workshop (NeurIPS 2023).* [Paper]

Technical skills

Programming Languages	Python, C++
Libraries, Frameworks, Softwares	Pytorch, Huggingface, ROS1/2, ROS Navigation Stack, Docker
Algorithms	Imitation Learning, Reinforcement Learning, RLAIF, Diffusion Mod- els, Planning Algorithms (A*, RRT), Control Algorithms (DWA, MPC)

Services and Professional Activities

Reviewer Community Outreach	RA-L, ICRA, IROS, ICLR, HRI. Robot demo and public engagement at South by Southwest Conference & Festivals (SXSW).
NSF Expedition in Computing	Graduate student researcher as a part of the Learning Directed Operat- ing System (LDOS) project under the NSE Expedition in Computing.
Undergraduate Mentorship	Mentored Alex Liu in completing his undergraduate research thesis.