Academic Statement of Purpose

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Applying for Ph.D. in Robotics [U-M ID: (Applicant's ID)]

Introduction

My research objective is in the area of multi-robot systems and task and motion plannings. Through my research, I would like to leverage my understanding in higher intelligence to make robots that I could transform robots to smart partners that blend into our society from tools people need to study for years to utilize. From my experience in DARPA Robotics Challenge, I started having a long-term goal of completing a robotics system where robots interact with other agents to assist in tasks that are currently done by humans as partners. To this end, I hope to pursue a Ph.D. in Robotics at the University of Michigan.

Research Goal

I believe the most effective way to reach the goal and bring it to the real world is in the study of intelligence models. Recent studies in robotics made critical advancements in many areas, such as perception models, but most of them are staying in labs as they need decision-making models that should link them together for real-world use. With my experiences in both algorithmic studies and the implementation of perception models into factory automation, I am sure I will complete making robots our partners toward a better world through the Ph.D. program at the University of Michigan.

The fields of interest that constitute my research goal are Task and Motion Planning (TAMP), Multi-Robot System, and Human-Robot Interaction (HRI). My previous research works on TAMP and Multi-Robot are focused on sizing down the complexity of problems known to be NP-hard/complete into simpler formulations. They have been proven to be effective ways to tackle those problems, and I aspire to move on to studies in discovering more generalized decision-making models. My previous works assume fixed costs and known agents in planning, but I seek to extend the model to effectively determine the costs for unknown events as humans are heterogeneous agents; it would be a key in the formation of a human-autonomy nature. To this end, I would like to explore the use of multi-agent interactions and discover a planning model integrated with them.

Research Experience

I am currently conducting research in multi-robot coordination at AI Robotics Lab at Sogang University. I previously worked at Korea Institute of Science and Technology, a national research institution in South Korea, and have experience in the factory automation industry as well as the field of Virtual Reality as a research engineer.

Task and Motion Planning I published a paper on the task and motion planning of a manipulator in retrieving an object in a clutter the targeting object is occluded by other objects [1]. I proposed a search-based method to relocate objects to secure physical space for the robot to reach the target object guided by admissible heuristics. The method significantly reduced the task and motion planning time at most 74.9% compared to a state-of-the-art method as of 2020, and it was presented at ICRA 2021. I also joined related research where the work on manipulation planning is undergoing revision for IEEE Transactions on Systems, Man, and Cybernetics: Systems.

Multi-Robot Coordination I published a paper leveraging my previous work [1] on task and motion planning by extending the scope to multiple manipulators coordinating to retrieve an object faster [2]. The two proposed models on the paper are scalable to number of robots larger than two, and they were presented at ICRA 2022. This year, I submitted a paper on the coordination of multiple mobile manipulators in sorting objects in a given order [3], which is currently under review for ICRA 2023. For both works, I designed simulation tools on Unity.

Mobile Robot Navigation & SLAM During my master's program, my works were predominantly on mobile robot navigation and related perception models. I focused on studies to improve the feasibility of conventional search-based pathfinders. My thesis is on a method to generate via points that can not only improve the efficiency of the heuristic search but also lead it to result in a more natural path using Convolutional Neural Network (CNN). In this research, I generated a training dataset out of popular indoor 3D map datasets, such as TUM RGB-D, with a small number of manually and a large number of automatically labeled data based on the vector field histogram (VFH) of each grid. I also participated in a project where I implemented an autonomous navigation system that utilizes SLAM, and I joined in publishing a study on neuro-symbolic task planning [4] at Korea Institue of Science and Technology as an intern and a researcher, respectively.

Vision-Centered Factory Automation During my career at a startup company as a research engineer, I focused on designing systems the industry has rarely seen using perception models I studied during my master's program. I designed a fully automated assembly system of a large-sized curved vehicle display using 3D perception algorithms, such as iterative closest point or feature extraction models, and delivered it to LG Electronics for large-scale production. It was a first in the industry, and my team was the only one bidding for the project. The components from the production line are currently being supplied to major motor companies. I also participated in an automation project to develop an adaptive teaching system for the sealant dispensing process in vehicle manufacturing. Our team devised a model to handle the deviations of the actual bodies from the nominal CAD design using correction methods in 3D vision. In this project, I developed a manipulation simulator on Unity.

Concluding Remarks

With my ambition and broad experience in robotics research, the University of Michigan would be an ideal place to pursue my doctoral study. In particular, I hope to work with **Professor Christoforos Mavrogiannis**, who is joining the Robotics Department from Fall 2023. My most recent works on coordination of multiple mobile manipulators fit well in line with his recent works on multi-agent interactions/coordination using topological braids. Specifically, his work on the framework for navigation in a dynamic multi-agent environment aligns perfectly with my goal of making robots our partners through interactions [5]. Also, the research in HRI by **Professor Chad Jenkins** toward the facilitation of the use of robots in assisting people's lives comes to me as a strong motivation in research.

I dream of bringing intelligence models to pragmatic uses through entrepreneurship after the program. As I worked at a factory automation startup, I witnessed the worker displaced from the technology at manufacturing sites; the workers cannot interact with robots. I am optimistic that filling the gap should drastically foster the use of robots at industrial scenes and in other parts of our daily lives.

References

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[2] J. Ahn, C. Kim, and C. Nam, "Coordination of two robotic manipulators for object retrieval in clutter," in *2022 International Conference on Robotics and Automation (ICRA)*, 2022, pp. 1039–1045.

[3] J. Ahn, S. Lee, and C. Nam, "Ordered sorting of cluttered objects using multiple mobile manipulators," *arXiv preprint arXiv:2211.13175*, 2022.

[4] U. Rakhman, J. Ahn, and C. Nam, "Fully automatic data collection for neuro-symbolic task planning for mobile robot navigation," in *2021 IEEE International Conference on Systems, Man, and Cybernetics (SMC)*, 2021, pp. 450–455.

[5] C. I. Mavrogiannis, W. B. Thomason, and R. A. Knepper, "Social momentum: A framework for legible navigation in dynamic multi-agent environments," in *Proceedings of the 2018 ACM/IEEE International Conference on Human-Robot Interaction*, 2018, pp. 361–369.