

GUOXIANG ZHAO

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EDUCATION

Pennsylvania State University

Ph.D. in Electrical Engineering

GPA: 3.78/4

Dissertation title: Multi-robot optimal motion planning

University Park, PA

May 2022

Purdue University

Master of Science in Mechanical Engineering

GPA: 3.81/4

West Lafayette, IN

May 2015

Shanghai Jiao Tong University

Bachelor of Engineering in Mechanical Engineering & Automation

GPA: 87.4/100

Shanghai, China

June 2014

RESEARCH INTERESTS

Multi-robot systems, robotic motion planning, distributed control, optimal control, nonlinear control, machine learning.

RESEARCH EXPERIENCES

Distributed deep learning for multi-robot optimal motion planning

March 2019 - Present

- A deep-learning-enabled algorithm is proposed to command multiple mobile robots in a constrained state space to their goal sets as soon as possible;
- Deep neural networks efficiently approximate the value function in high-dimensional state space;
- The distributed update fashion relieves the algorithm's dependency of computational complexity on robot number and makes it more flexible about robot dynamics and objectives.

Distributed safe reinforcement learning for multi-robot motion planning

August 2020 - March 2021

- A distributed reinforcement learning algorithm is proposed to coordinate multiple mobile robots;
- Anytime collision avoidance, uniform and ultimate boundedness of system states and convergence of neural network controller weights are formally guaranteed via Lyapunov analysis;
- Simulations show both 10 single integrators and unicycle robots can safely arrive at goal regions.

Distributed multi-robot near-optimal motion planning

March 2018 - February 2019

- A scalable algorithm is designed to navigate a large fleet of unicycle robots to their goal regions in cluttered environment and maintain a safe distance between any two robots and a robot-obstacle pair;
- Computational complexity is independent of robot number and all robots are guaranteed to reach their destinations without causing any collisions;
- Simulations demonstrate the scalability of the algorithm using 25 unicycle robots and also show minor optimality losses compared to globally optimal solutions.

Anytime multi-robot optimal motion planning

June 2016 - February 2018

- A numerical algorithm is proposed to guide a team of mobile robots subject to general nonlinear dynamics arrive at their respective goal sets without causing any collisions in cluttered environment;
- Via set-valued analysis, each robot's safe arrival at goal set with minimal traveling time is ensured;
- Computer simulations and real-world experiments with Khepera III robots and Vicon system on a four-way intersection show that the numerical algorithm has anytime property.

Functional printing control

January 2014 - May 2015

- A printing motion control interface EZPrinting is developed to synthesize a HP Thermal Inkjet Printing System with its motion platform for large size printing tasks;
- It automatically calibrates printing motion platform for user specified missions and evaluates printing quality;
- EZPrinting facilitates inkjet surface-functionalized printing technologies and successfully produces test strips for detecting food-borne pathogens.

PUBLICATIONS

• Journal papers

[J2] **Zhao, G.** & Zhu, M. (2020). **Scalable distributed algorithms for multi-robot near-optimal motion planning.** *Automatica*, vol. 140, Article 108637, June 2022. <https://doi.org/10.1016/j.automatica.2022.110241>

[J1] **Zhao, G.** & Zhu, M. (2020). **Pareto optimal multi-robot motion planning.** *IEEE Transactions on Automatic Control*, vol. 66, no. 9, pp. 3984-3999, Sept. 2021. <https://ieeexplore.ieee.org/document/9204457>

• Conference papers

[C3] Lu, Y., Guo, Y., **Zhao, G.** & Zhu, M. (2021). **Distributed safe reinforcement learning for multi-robot motion planning.** In *29th Mediterranean Conference on Control and Automation*, 1209-1214, Bari, Italy.

[C2] **Zhao, G.** & Zhu, M. (2019). **Scalable distributed algorithms for multi-robot near-optimal motion planning.** In *58th IEEE Conference on Decision and Control*, 226-231, Nice, France.

[C1] **Zhao, G.** & Zhu, M. (2018). **Pareto optimal multi-robot motion planning.** *2018 American Control Conference*, 4020-4025, Milwaukee, WI.

• Working papers

[W1] **Zhao, G.**, Lu, Y., & Zhu, M. (2021). **Distributed optimal motion planning for heterogeneous multi-robot systems.**

HONORS AND AWARDS

- Dean's List and Semester Honors, College of Engineering
Purdue University 2014
- Sun Hung Kai Scholarship
Shanghai Jiao Tong University 2011-2014
- Timken Scholarship
Shanghai Jiao Tong University 2012
- B-Level Merit Scholarship Award
Shanghai Jiao Tong University Top 5%
2013

COMPUTER SKILLS

Python, Javascript/Typescript/React/Ant Design, MATLAB, Tensorflow, MongoDB, AWS CLI, Airflow

COURSEWORK

Control & Optimization	Linear Control Systems, Dynamical Systems and Control, Nonlinear Systems, Adaptive and Learning Systems, System Identification, Convex Optimization, Stochastic Optimization
Robotics & Mechatronics	Microprocessing Electromechanical Systems, Human Motion Kinetics, Robotics, Electromechanical Motion Devices, Control of Functional Printing
Machine Learning	Pattern Recognition and Machine Learning, Reinforcement Learning, Introduction to Deep Learning, Neural Networks
Math	Real Analysis, Stochastic Process, Linear Algebra, Numerical Analysis

ACADEMIC SERVICE

Journal Review

- IEEE Transactions on Automatic Control, IEEE Transactions on Systems, Man and Cybernetics: Systems, IEEE Control Systems Letters, IEEE Open Journal of Control Systems, IET Cyber-Systems and Robotics, International Journal of Aerospace Engineering, Scientific Report - Nature

Conference Review

- CDC 2017, ACC 2018, CDC 2018, ICCA 2018, CDC, 2019, ACC 2020, CDC 2020, ACC 2021, CDC 2021, MED 2021, CDC 2022, ICCA 2022, MECC 2022

TEACHING EXPERIENCE

EE 350 Continuous-Time Linear Systems

August 2020 - May 2021

Teaching Assistant

University Park, PA

- Instructed approximately 20 students weekly to solve recitation exercises and finish MATLAB assignments;
- Designed, proctored and graded monthly exams, held office hours and graded homework.

ME 355 Dynamic Systems Laboratory

August 2015 - May 2016

Teaching Assistant

University Park, PA

- Instructed over 50 students to finish 7 control experiments including robotic arms, magnetic force control and gyroscopes;
- Maintained 8 sets of laboratory apparatus and revised corresponding laboratory manuals.

INTERNSHIP

Shanghai FANUC Robotics, Co., Ltd

July 2014 - August 2014

Field Engineer Intern

Shanghai, China

- Installed robot operation systems and programmed computer vision module of industrial robotic arms;
- Commissioned material handling robotic arms to finish a loading-inspecting-unloading procedure.

LEADERSHIP & SOCIAL SERVICES

Student Affairs Center, Shanghai Jiao Tong University

April, 2011 - December, 2012

University Representative of National Student Loan Affairs

Shanghai, China

- Supervised a team of over 30 members in organizing student loan signing ceremonies semesterly;
- Collaborated with bank representatives on verifying applicants' identities;
- Processed over 1600 student loan applications with a total value over RMB 10M (US\$1.6M).

LANGUAGES

Chinese (native), English (professional proficiency)