

GUOXIANG ZHAO

9580 Carroll Canyon Rd, San Diego, CA 92126

+1(765)237-2160 ◊ zhaoguoxiang999@gmail.com ◊ <https://gxzzhao.github.io>

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, motion planning, distributed control, optimal control, reinforcement learning, deep learning

RESEARCH EXPERIENCES

Distributed optimal motion planning with dependent goals

March 2019 - Present

- A distributed algorithm is proposed to command mobile robots in a constrained space to goals with minimal cost;
- Asynchronous policy iterations are executed where robots only share value functions and policies without disclosing local information and convergence to optimal policy in the continuous state space is formally guaranteed;
- 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. (2022). 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. (2021). 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 with dependent goals.**

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, Linux, Git, Docker, MATLAB, PyTorch, Java/Quarkus, Javascript/Typescript/React/Ant Design, Looker, Airflow, MongoDB, PostgreSQL, AWS suites

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

Teaching Assistant

August 2020 - May 2021

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

Teaching Assistant

August 2015 - May 2016

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.

WORK EXPERIENCES

TuSimple, Inc.

Software Engineer

January 2022 - Present

San Diego, CA

- Worked in **Map Platform Team** to develop and maintain tools and services to produce high-definition maps. Supported all Map Ecosystem partners from fixing operational issues to improving user experiences/production efficiencies. Developed new features and optimized applications/infrastructures in catering to needs from map users.
- Designed and developed **Map Renovation Detector** that checks live videos of operational vehicles to identify road condition changes in an event-driven and stream-processing fashion, visualizes changes on UI and requests users to verify if maps need updates. Developed **CNN/PCA-based** road marker detectors to identify road changes. Developed pipeline filter to eliminate redundant examinations and reduced computations and cost by **40%**. Led a **team of 4** to migrate deployments to AWS EC2 using **Kubernetes**, refactored backend and reduced pipeline cost **from ~\$800/wk to <\$60/wk** and UI's response time **from ~20s to <1s**. Refactored the whole platform to execute examination in a **real-time fashion**.
- Developed **Map Production V2 UI** that visualizes routes on **Mapbox**, allows users to copy/partition/append/merge desired routes collected from operational vehicles, manages and monitors map production pipelines that merge edits into released maps. Refactored UI to support **2 more times** route types and reduced redundant steps by **80%** to improve user experience. Supplied **>30** map specialists with **3 more** GPS-based interactions to increase input efficiency and they dominated all others. Maintained different versions in **>20** environments in catering to more than **4 teams'** development/research needs. Migrated from monolithic server-based application to **cloud-based microservices** that speed up development and deployment;
- Developed **Assignment Management Platform** that dispatches event-triggered tasks to assignees with email/Slack messages, tracks task progress and controls access of different roles. Leveraged **OpenAPI** to support frontend/third-party queries and **PostgreSQL** to manage data. Integrated within **all map services** used by **>40 colleagues** and is being promoted company wise.
- Developed **Business Analytics Services** that collects production statistics/service deployments/git commits using **Java** for company-wise repositories. The Services stores data in **PostgreSQL** and visualizes statistics of service developments and deployments using **Looker**. Integrated with production platform/GitHub/CICD platform to periodically extract service production/development progress and operational health. Established a scalable framework providing **>10 families of tailored metrics** with potential expansions to more criteria.

- Maintained **Map Production Platform V1** while transiting to V2. Answered on-calls from users and resolved all within-scope issues **within one day**. Developed a blacklist of unusable clusters for users together with a pod health monitor so that user can remove failed clusters to **instantly unblock productions** when identified and file on-call tickets for further diagnosis.

Shanghai FANUC Robotics, Co., Ltd

Field Engineer Intern

July 2014 - August 2014

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

University Representative of National Student Loan Affairs

April, 2011 - December, 2012

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)