Qianyi Zhang

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Third year of candidate PH.D. at **Nankai University** under the supervision of Prof. **Jingtai Liu**

Research: Motion planning of mobile robots, Decision-making of autonomous vehicles, Human-robot game theory

EDUCATION

2021.9 – present	Nankai University	Institute of Robotics and Automatic Information System	PHD
2017.9 – 2021.6	Nankai University	Department of Automation	Bachelor

Main courses: Robotics, Motion planning of mobile robot, Swarm intelligence and control, Automatic control principle, Operational research and optimization, Computer composition principles, Reinforcement learning, Deep neural network

ACADEMIC EXPERIENCE

1. Non-homotopic trajectory search and optimization based on environment understanding 2023.1 – present

- For trajectory planning of mobile robots in hotel lobbies, computer graphics are utilized to cluster obstacles and quickly find all feasible trajectories in spatial space.
- An incremental optimization is proposed to derive from the completeness of spatial space to that of spatiotemporal space in the scenario with dynamic pedestrians.
- Reinforcement learning is utilized to estimate the optimization result of numerous initial trajectories so that the optimal initial one can be directly selected and optimized to save computing power by neglecting other initial ones.
- Key technologies: non-homology trajectory, computer graphics, timed elastic band, asymmetric Gaussian distribution

2. Local motion planning considering human-robot-environment interaction 2022.3 – present

- For robots quickly passing through crowded corridors, human gaze information is introduced to portray a unique portrait for each person to adaptively adjust the safe distance between humans and robots so as to realize efficient navigation.
- Local guidance points extracted from the static environment and dynamic pedestrians are projected into the same axes, and RL agent is introduced to secondary analyze the data to conduct safe navigation that is robust to sensory noise.
- Key technologies: gaze estimation, chicken game, limit cycle, reinforcement learning, hybrid loosely coupled projection

3. Decision-making for autonomous vehicles based on human-robot game theory 2021.7 – present

- For autonomous vehicles meeting with oncoming vehicles on narrow roads such as residential areas and villages, a complete mathematical model is established to allow vehicles to identify the potential meeting areas.
- A tentative game theory is proposed to use tentative actions to encourage other drivers to express their intentions as soon as possible, prompting all drivers to reach a consensus so as to realize efficient navigation.
- Key technologies: lattice plan, cooperative game, tentative game, timed elastic band

4. Global path planning in large-scale complex environments 2019.12 – 2021.6

- For path planning in large-scale and obstacle-dense scenes, the completeness of the search-based method and the efficiency of the sampling-based method are combined to achieve fast and complete search.
- For trajectory smoothing, reinforcement learning is introduced to adjust the positions of control points to balance safety, length, and smoothness.
- Key technologies: A*, Bi-RRT, deep deterministic policy gradient, jump point search, B-spline curve

INTERN EXPERIENCE

2012 Lab · Advanced computing and storage department *Motion planning algorithm intern.* 2023.9 – present

- For the motion planning of unmanned delivery vehicles in complex dynamic environments, a hybrid loosely coupled perception-to-planning projection is proposed to make RL agent understand surroundings efficiently and robustly. The related work has been submitted to RAL and deployed to real vehicles.

Meituan group · Unmanned delivery department *Decision-making algorithm intern.* 2021.5 – 2022.3

- For the decision-making of unmanned delivery vehicles in narrow roads, prediction and planning are combined to propose an explorative game theory. The related work was published on IROS2022 and deployed to real vehicles.

PUBLICATIONS

1. **Q. Zhang**, S. Wu, Y. Jia, Y. Xu and J. Liu, "Improve Computing Efficiency and Motion Safety by Analyzing Environment With Graphics," in IEEE Transactions on Automation Science and Engineering (**TASE**), doi: 10.1109/TASE.2023.3299962.
2. **Q. Zhang**, Z. Hu, Y. Song, J. Pei and J. Liu, "The Human Gaze Helps Robots Run Bravely and Efficiently in Crowds," 2023 IEEE International Conference on Robotics and Automation (**ICRA**), London, UK, 2023, pp. 7540-7546.
3. **Q. Zhang**, X. Li, E. He, S. Ding, N. Wang and J. Liu, "P2EG: Prediction and Planning Integrated Robust Decision-Making for Automated Vehicle Negotiating in Narrow Lane with Explorative Game," 2022 IEEE/RSJ International Conference on Intelligent Robots and Systems (**IROS**), Kyoto, Japan, 2022, pp. 4819-4826.
4. **Q. Zhang**, D. Yang, L. Zhou, Z. Hu and J. Liu, "Trajectory Optimization on Safety, Length and Smoothness in Complex Environments with A Locally Trained and Globally Working Agent," 2022 IEEE International Conference on Real-time Computing and Robotics (**RCAR**), Guiyang, China, 2022, pp. 284-289.
5. **Q. Zhang**, L. Zhou, Y. Zhao, R. Cao and J. Liu, "A Parallel Algorithm Combining Improved-Connect-RRT and JPS with Closed-operation," 2020 IEEE 16th International Conference on Automation Science and Engineering (**CASE**), Hong Kong, China, 2020, pp. 359-364.
6. **Q. Zhang**, Z. Cao, J. Guang and J. Liu, "A Time-Optimal Tentative Game for Vehicles to Efficiently Pass through Narrow Roads," 2024, IEEE Transactions on Intelligent Transportation Systems (**TITS**), under review.
7. **Q. Zhang**, W. Luo, and J. Liu, "A Hybrid Loosely Coupled Perception-to-Planning Projection Method for Robust Navigation," 2024, IEEE Robotics and Automation Letters (**RAL**), submitted.
8. Z. Hu, **Q. Zhang**, X. Zhai, S. Wu and J. Liu, "Socially-aware Robot Navigation Considering Human Gaze-related Area Constraints," **ROBOT,** 2023, 45(6): 670-682.
9. Y. Song, **Q, Zhang**, Z, Hu and J. Liu, "Safe and Robust Human Following for Mobile Robots Based on Self-Avoidance MPC in Crowded Corridor Scenarios". In 2023 IEEE International Conference on Robotics and Biomimetics (**ROBIO**).
10. K. Zhao, Z. Hu, **Q. Zhang** and J. Liu, "RTHG: Towards Real- Time Head Detection And Gaze Estimation," 2022 IEEE International Conference on Robotics and Biomimetics (**ROBIO**), Jinghong, China, 2022, pp. 735-740.

COMPETITIONS AND AWARDS

• Chinese Graduate Mathematical Modeling Competition	*Second award (31/621)*	2023.9
• Chinese Graduate Mathematical Modeling Competition	*Third award (182/1134)*	2022.9
• Robot Cup Obstacle Avoidance Challenge	*Third award*	2020.9
• National Undergraduate Mathematical Modeling Competition	*First award (6/59611)*	2019.6

SKILLS

- Languages: Mandarin (mother tongue), English (IELTS 7)
- Coding skills: C++ and Python (master), Matlab (learn)
- Robotics skills: Linux, Git, Ros, and Gazebo (daily use), **Navigation stock** (rewrite most of it, nearly 20000 rows), Reinforcement learning (application of DQN and DDPG in navigation system)
- Funding for visiting PH.D.: China Scholar Council (CSC)

VISITING RESEARCH TOPICS

- **Human-robot-game-based navigation:** As robots become increasingly integrated into human life, it's necessary to build human-robot interaction and to make robots cooperate with humans based on fully understanding of their intentions.
- **Environment understanding:** With the improvement of motion planning and perceptual algorithms, an inevitable challenge is to use methods such as graph theory to perform a secondary analysis of the distribution of objects to aid robot navigation.
- **Combination of intelligent agents and traditional framework:** With the development of LLM and DRL, how to combine intelligent agents with traditional navigation framework to simultaneously leverage their flexibility and robustness will be a valuable future direction.