Qingzhao Liu

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Research Interests: Motion planning for aerial swarm robotics, Formation control

EDUCATION

Tianjin University Tianjin, China
Master of Control Engineering *Sep.2022-Present*

- GPA:**3.81**/4.0
- Research with **Prof. Bailing Tian**

Tianjin University Tianjin, China
Bachelor of Automation *Sep.2018-Jun.2022*

- GPA:**3.82**/4.0
- A+ subjects: Signal Analysis and Processing(97), Advanced Mathematics(96), Autocontrol Theory(95) et al.

PUBLICATIONS (* Denotes the Corresponding Author) & PATENTS

☆ **Q. Liu**, B. Tian, X. Zhang, J. Lu, and Z. Li*, "Sampling-Based Hierarchical Trajectory Planning for Formation Flight," in *IEEE Transactions on Intelligent Transportation Systems*, 2024. (Under Review)

☆ X. Zhang*, **Q. Liu**, H. Cao, B. Tian, "A Gradient-free and Parallel Hierarchical Motion Planning Framework for Quadrotor Swarm", *The International Conference on Control, Automation, Robotics and Vision*, 2024. (Submitted)

☆ B. Tian, **Q. Liu**, L. Dou, K. Wang, D, Wang, Distributed Active Collaborative Detection Method for Multiple Unmanned Aerial Vehicles [P]. Tianjin: ZL 2023 1 0013673.X, 2023-09-22.

RESEARCH EXPERIENCE

☆ **Gradient-free Trajectory Planning**: The traditional trajectory planning problem is typically solved through gradient-based optimization methods, which rely on the continuous assumption of the cost functions, and may be unsuitable for non-continuous trajectory planning problems. ***To overcome this limitation, a gradient-free planner has been proposed that optimizes trajectories in parallel, solving non-continuous optimization problems through model predictive path integral control.*** The approach has been used to develop a small quadrotor capable of real-time autonomous flight with limited onboard computation resources.

☆ **Multi-UAV Formation Planning:** Formation flight of unmanned aerial vehicles (UAVs) poses significant challenges in terms of safety and formation keeping, particularly in cluttered environments. The conflicts between formation keeping and obstacles avoidance can occur in dense obstacle environments, which can distort the formation for the sake of safety. Moreover, the data volume shared between UAVs is limited, restricting the type of transmitted environment information. ***To enable a formation with some UAVs navigate safely with the desired shape in a clustered environment, a hierarchical formation trajectory planning method is proposed.*** The formation connectivity is utilized in the front-end formation guidance paths generation algorithm, deconflicting the formation keeping and obstacles avoidance. Besides, a back-front trajectory algorithm based on Model Predictive Path Integral (**MPPI**) is developed to generate the executable trajectory in each UAV locally. Comprehensive simulation compares are conducted to validate the efficiency of the developed algorithm. The results show that the proposed method can enhance the ability of formation keeping and safety in clustered scenarios for swarm aerial robots.
Demo video: https://www.youtube.com/watch?v=xSxbUN0tn1M

HONOR and AWARD

☆ Second Prize for Postgraduate Academic Scholarship, Tianjin University
☆ Outstanding Graduates, Excellent Student Cadre in Tianjin University
☆ The North American Alumni Association Scholarship in Tianjin University

RESEARCH SKILL

☆ Software : C/C++; Python; CUDA; Matlab/Simulink; Git; Vim; ROS;
☆ Hardware: Pixhawk; Nvidia Xavier AGX/NX/TX2;
☆ Language: English (**Fluent**, IELTS:**7.0**, CET-4:**651**, CET-6:**600**)

PROJECT EXPERIENCE

2023.03-2023.04 Coaxial Drone Formation Maintenance and Formation Transformation

☆ With the goal of achieving fully autonomous formation flight with six coaxial drones in high-altitude environment, a decentralized formation trajectory planning framework is developed to enable autonomous flight with only onboard computation resource.

Main contribution:

1) The formation keeping cost is designed as a sub-cost of the evaluation of the trajectory.
2) A sampling-based model predictive control framework is developed to generate smooth trajectories, which are dynamically feasible and can steer the formation to form the desired shape.
3) The message sharing between drones and the ground station is realized with the Multi-master library , providing the stable communication between devices in the same local area network.
4) The deployment of the developed planning algorithm is done in Jetson Orin NX.

2022.07 Development of a Virtual Simulation Platform for Real-time Motion Planning of Unmanned Aerial Vehicles in Alleyway Environments

☆ With the goal of achieving safe and fast flight of UAV in alleyway environment, a simulation platform is developed and the proposed trajectory planning method is test in this simulator.

Main contribution:

1) A simulation platform based on Gazebo is constructed, where the UAV model and alleyway environment are placed.
2) A Model Predictive Path Integral (**MPPI**) based trajectory algorithm is developed and a obstacle avoidance cost is designed considering the harsh environment.

2023.08 The Third Air Force "Unmanned Vanguard" Intelligent Swarm System Challenge

☆ With the goal of achieving rapid target search and strike with a swarm of quadrotors and fixed-wing UAVs in a appointed aera, a distributed quadrotor-fixed-wing Intelligent Collaborative System is developed with motion planning module, collaborative decision module, object detection module.

Main contribution:

1) The development of motion planning based on the minimum snap trajectory for quadrotors.
2) Developed the logic for calling various functional modules based on the behavior tree, and designed the logic behavior trees for different phases such as the takeoff assembly phase, patrol phase, and strike phase.

2023.09-2024.03 Intern in Autel Robotics

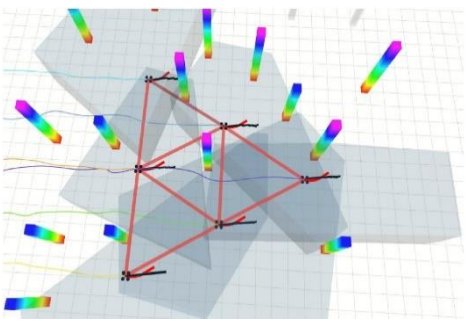
☆ Joined in the development of a multi-UAV project in the motion planning and decision department

Main contribution :

1) A module-scheduling method is developed based on behavior tree.
2) Motion planning and decision algorithms are encapsulated as the rules of constructing the modules in behavior tree.
3) The modules of formation assembly and formation keeping are developed with the leader-follower idea, which drive the formation consisting of 15 UAVs to fly with different shapes.
4) The codes are re-used flexibly with the framework of behavior tree, where new task modules are constructed by logically connecting previously built sub-task modules through the logic of a self-defined behavior tree.

OUTCOMES

Coaxial Drone Formation Flight



Formation Flight in Simulation

Heterogeneous platforms