Kaixin Chai

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Main Experience

City University of Hong Kong | Research Assistant Sep. 2023 – Jun. 2024

Mobile manipulation, manipulation based on foundation model, and wheel-legged robot control

Zhejiang University | Research Assistant Jun. 2022 – Sep. 2023

Perception-aware planning, SLAM, quadrotor control, and relevant commercialized R&D projects

Xi'an Jiaotong University | Bachelor in Energy and Power Engineering Sep. 2018 – Jun. 2022

Average grade: 91.25/100. Participated in multiple competitions and research projects

Current focus

Data generation based on foundation models

Current policies for manipulation, such as Imitation Learning and Reinforcement Learning, have shown effectiveness in guiding low-level tasks. Additionally, recent advancements in Visual-Language-Action models, such as RT-2(-X) and OpenVLA, are promising in terms of generalization with positive transfer. However, these powerful models are data-intensive, requiring vast amounts of data to be available. I'm seeking a cost-efficient way to collect data by automating both the action generation and labeling processes.

In order to autonomously collect data, robots need both high- and low-level understanding of the task. Fortunately, recent foundation models can provide substantial common sense to facilitate the understanding, reasoning, and grounding processes. I'm confident that with the proper use of common sense (guidance and reflection based on LLMs and VLMs) and RL (utilizing Real2Sim to make environments resettable), robots can effectively bridge the data gap one day.

Academic Research

Execute Long-Horizon Tasks with Mobile Manipulator Jan. 2024 – May. 2024

We build the hardware for a mobile manipulator and developed Inverse Kinematics (IK) code to control the arm's movement. The manipulator executes long-horizon tasks using pre-trained skills. Additionally, we design a mechanism to adjust the robot's initial position at the beginning of each sub-task to better align observations with the skills' training data distribution, thereby increasing the success rate of each sub-task.

Improving Localization Reliability with Path Planning Mar. 2023 – Sep. 2023

Derive a new metric for localization reliability through perturbation analysis and apply the metric to path planning, which enables the robot to avoid degraded areas in advance. Accepted by *IROS2024* [1].

Ground Effect-Aware Modeling and Control for Multicopters Sep. 2022 – Sep. 2023

Set up a mathematical model for ground effect prediction based on flown field simulation and experiments, making the drones fly safer and more stable near the ground. *Submitted to T-RO* [2].

Motion Planning for Car-like Robots on Uneven Terrain Sep. 2022 – Mar. 2023

We propose a planning framework for wheeled robot movement on uneven terrain, which is efficient and allows robots to move safely. Accepted by *IROS2023* [3].

A Deep Sea Turbine Power Generation System (Senior Project) Aug. 2021 – Jul. 2022

Design a novel energy generation system that maintains the turbine at optimal power conversion efficiency in changing water flow. My undergraduate thesis received an A+ grade (1^{st} / 25). Accepted by *Energy* [4].

Engineering Project

Lightweight Multi-Robot LiDAR SLAM Framework with Loop Closure Sep. 2024 – Nov. 2024

Consistent mapping and localization are crucial for multi-robot tasks. Existing open-source multi-robot SLAM solutions are limited. In this project, I developed a lightweight multi-robot localization framework, comprising: GICP module for inter-frame estimation; BTC descriptors for loop detection; GTSAM for constructing loop factor graphs. The system supports intra-loop closures within individual trajectories and inter-loop closures

between overlapping trajectories. To address communication instability, a prior loop mechanism enables single robots to close loops with a pre-existing map. This system efficiently runs on Orin-NX using only two threads.

Target Following Framework for Wheel-legged Robot Mar. 2023 – Jul. 2023

Enable a wheel-legged robot equipped with LiDAR and cameras to identify and follow specific targets. This project was completed with Huawei Shenzhen Application Scenario and Innovation Laboratory.

Helium-Assisted Drone for Flight Time Enhancement Dec. 2022 – Mar. 2023

Design a Helium-Assisted drone for floating advertisements in shopping malls. The buoyancy generated by the helium balloon offsets around 95% of the weight, extending the flight time from ten minutes to nearly an hour.

Motion planning for Drones to Avoid Collisions in Complex Structures Sep. 2022 – Dec. 2022

Build a drone using an onboard computer equipped with HiSilicon chips for Huawei. Deploy obstacle avoidance algorithms enabling the drone to fly safely in complex and dynamic environments.

Design of An Energy-efficient Heat Loading System Dec. 2021 – Jul. 2022

Design a new thermal simulation device to generate an even temperature field. To obtain better control strategies, we model the whole heat transfer process and utilize deep reinforcement learning technology.

Automatic detection of Surface Defects in Metal Product Apr. 2020 – Apr. 2021

We designed a system for a metal processing plant to monitor the production quality of products. With the help of industrial cameras and convolutional neural networks, we achieved a recognition recall rate of 94%.

PUBLICATION

[1] **Chai, K.**, Xu, L., Wang, Q., Xu, C., Sun, H.& Gao, F. (2024). LF-3PM: a LiDAR-based Framework for Perception-aware Planning with Perturbation-induced Metric. IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2024). STATUS: Accepted.

[2] Yang, T., **Chai, K.**, Xu, L. & Gao, F. (2024). Ground Effect-Aware Modeling and Control for Multicopters: Enhanced Precision and Energy Efficiency. IEEE/ASME Transactions on Robotics (T-RO). STATUS: Under Review.

[3] Xu, L., **Chai, K.**, Han, Z., Liu, H., Xu, C., Cao, Y., & Gao, F. (2024). An Efficient Trajectory Planner for Car-like Robots on Uneven Terrain. IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). arXiv preprint arXiv:2309.06115. STATUS: Published.

[4] Zhang, D., **Chai, K.**, Guo, P., Hu, Q., Li, J., & Shams, A. (2024). A novel full-process test bench for deep-sea in-situ power generation systems. Energy, 297, 131341. STATUS: Published.

[5] Chen, Y., Guo, P., Zhang, D., **Chai, K.**, Zhao, C., & Li, J. (2022). Power improvement of a cluster of three Savonius wind turbines using the variable-speed control method. Renewable Energy, 193, 832-842. STATUS: Published.

PATENT

[1] Zhou, Z., **Chai, K.**, Qiu, Z., Shu, H., Zhu, Y., Xing, H., Ye, S., Shen, Y. & Liu, B. (2021). A fast and uniform static load heating device and control method for high-speed aircraft. China National Intellectual Property Administration. CN202110462447.0. STATUS: Published.

[2] Guo, P., **Chai, K.**, Wang, J., Yin, Y., Zhang, D. & Chen, Y. (2022). A deep sea power generation system and its control method. China National Intellectual Property Administration. CN202210663338.X. STATUS: Published.

[3] Chen, Y., Li, J., **Chai, K.**, Zhou, J. & Xu, X. (2022). A passively regulated bidirectional tidal current energy generation device. China National Intellectual Property Administration. CN202210545692.2. STATUS: Published.

[4] Guo, P., **Chai, K.**, Chen, Y., Zhang, D., Wang, J., Qian, Y. & Liu, C. (2022). A land-based test platform and control method for deep sea power generation system. China National Intellectual Property Administration. CN202210662549.1. STATUS: Published.