Jinjie Li

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Education

- **Beihang University** Sept. 2020 – June 2023 (expected)
  M. Sc. Eng. in Control Science and Engineering, GPA: 89.8/100 *Advisors: Prof. Liang Han, Prof. Zhang Ren*
- **Beihang University** Sept. 2016 – June 2020
  B. Eng. in Automation, Shen Yuan Honors College, GPA: 89.7/100 *Advisor: Prof. Lei Guo*

Courses: Matrix Theory, Linear System Theory, Optimal Control and State Estimation, Robot Theory, Embedded Systems, Digital Signal Processing, Pattern Recognition and Machine Learning, Artificial Intelligence Accelerator

Research Interests

My research interests are in the intersection of machine learning and control science, spanning the entire spectrum from algorithm design, large-scale simulation, to real-world applications in robotics and autonomy.

Publications

Papers

1. **[ICRA'22]** Jinjie Li, Liang Han, Zhang Ren, "Indoor Localization for Quadrotors using Invisible Projected Tags", *IEEE International Conference on Robotics and Automation (ICRA)*, 2022. [oral] [pdf] [video]
2. Ziwei Yan, Liang Han, Xiaoduo Li, Jinjie Li, "Event-Triggered Optimal Formation Tracking Control using Reinforcement Learning for Large-Scale UAV Systems", *Submitted to ICRA'23*, 2022. [video]
3. Hui Cao, Dongyu Li, Liang Han, Jinjie Li, Pengkun Hao, "Fully Distributed Dynamic Event-Triggering Formation Control of UAV Swarms under DoS Attacks", *Submitted to ICRA'23*, 2022. [video]
4. Jinjie Li, Haoyang Yu, Yuheng Lin, Liang Han, Qingdong Li, Zhang Ren, "Nonlinear MPC for Quadrotors in Close-Proximity Flight with Neural Network Downwash Prediction", *In Preparation for RA-L*, 2022.

Others

5. Liang Han, Jinjie Li, Zhang Ren, "An Indoor Localization Method based on Invisible Projected Tags", *Chinese Invention Patent*, 202111154577.4. *Substantive Examination Stage.*
6. "A Localization Software based on Invisible Projected Fiducial Tags", *Chinese Software Copyright*, 2022SR0123403.
7. "A Large-Scale Heterogeneous Multi-Agent Simulation Platform V1.0", *Chinese Software Copyright*, 2021SR1039534.

Research Experiences

Starts Lab, Beihang University *Beijing & Hangzhou, China*

- **Development of a 3D Simulator for Large-Scale Heterogeneous Swarm Robots** Sept. 2020 – Present
  Student Software Architect *Advisor: Prof. Liang Han*
  - **Aim**: Developed a simulator that supports (1) over 1000 robot nodes, (2) 6-DoF dynamic models of four model types, including fixed-wing UAVs, quadcopters, tilt-rotor UAVs, and vehicles, (3) range of vision and collision, (4) 3D visualization, and (5) a dataset to build for off-line model training and an interface with Gym for on-line DRL training.
  - **Method**: Implemented the modular simulation for fixed-wing UAVs and quadrotors from scratch, including path planner, path manager, path follower, autopilot, and dynamics. Accelerated the computation for different model types and tasks via *Multiprocessing*. Accelerated the computation for the same model type via *Data-Oriented Programming (DOP)*, which was packaged by PyTorch TorchScript and ran on GPU. Used pandas for OOP and DOP conversion. Utilized Cesium platform for 3D visualization.
  - **Leadership**: Used *Gitee* for version control and code review, *Tencent Docs* for project management.
  - **Achievement**: The simulator has supported two papers, see pub. 2, 3. Simulating 1000 robots on one PC reached an order of magnitude improvement compared with the CPU-based simulator Gazebo, which supported only about 50.
- **Learning-Based MPC for Close Formation Tracking of Quadrotors** Nov. 2021 – Present
  Master's Thesis *Advisor: Prof. Liang Han*
  - **Problem**: The downwash effect caused by other agents is a unique problem for aerial robotics and is hard to model. How could aerial robots observe the downwash effect and integrate it into the state-of-the-art trajectory tracking framework?
  - **Method**: Designed and trained a neural network observer with *Spectral Normalization* to catch the downwash effect in close-proximity flight. Utilized the observer to predict the future disturbances caused by the relative motion of ego and other quadrotors. Integrated the predicted disturbances into *Nonlinear Model Predictive Control (NMPC)* to design a trajectory tracking controller. Implemented *Minimum Snap* method to generate trajectories as the reference.
  - **Experiment**: Identified the inertial parameters and the rotor parameters. Used a TX2 NX for running the algorithm in real time, ROS for communication, PX4 for body rate control, and OptiTrack for state estimation.
  - **Achievement**: The paper is in preparation for RA-L, see pub. 4. Reduced 80% tracking error under downwash effect.

- **Low-Cost Indoor Localization in Augmented Reality Robotic Systems** May 2021 – Feb. 2022
  Researcher *Advisor: Prof. Liang Han*
  - **Problem**: How could robots fully exploit the AR scenarios projected by projectors for low-cost indoor localization?
  - **Method**: Proposed a real-time centimeter-level indoor localization method based on psycho-visually invisible projected tags (IPT), requiring a projector as the sender and quadrotors with high-speed cameras as the receiver. The method includes a modulation process for the sender, as well as demodulation and pose estimation steps for the receiver, where *Screen-Camera Communication* is applied to hide fiducial tags using human vision property. Implemented an AR platform for experiments, demonstrating an accuracy within ten centimeters and a speed of about ten FPS.
  - **Achievement**: The paper has been accepted by ICRA 2022, see pub. 1. The first time screen-camera communication is utilized for AR robot localization.

Academic Projects, Beihang University *Beijing, China*

- **Formation Control for Quadrotors with RL and Visual Fiducial Localization** Dec. 2019 – June 2020
  Bachelor's Thesis *Advisor: Prof. Liang Han*
  - Captured the fiducial tags on the ground for visual localization, and combined it with IMU to improve reliability and accuracy. Implemented the Dyna-Q reinforcement learning algorithm to train a multi-UAV system to achieve a formation. Verified the system on a ROS/Gazebo simulation platform.
  - The thesis was ranked No.1 in my major.
- **Development of a Settable Constant Temperature Controller** Feb. 2018 – June 2018
  Team Leader, Course Project of Fundamentals of Analog Electronics *Advisor: Prof. Yao Tang*
  - Developed a real temperature control system for a water tank from scratch, which could be controlled via Bluetooth and be adjusted to a specified temperature in 5 minutes. Including circuit design and PCB drawing. [video] [blog]
  - Ranked No.1 in my class. Invited by Lunar Palace 1 Lab to design a temperature control system for plant cultivation.

Practical Experiences

Human-Machine Interaction Lab, Huawei Technologies *Shenzhen, China*

- **Development of a Virtual Keyboard Prototype with Force Feedback** Aug. 2020 – Sept. 2020
  Research Intern *Advisor: Dr. Xuan Zhou*
  - Implemented a virtual keyboard prototype based on a raspberry pi, piezoelectric sensors, and acrylic sheets. Created the combination of different vibration waveforms to provide a natural touch feeling for users.

Beihang Aeromodelling Team, Beihang University *Beijing, China*

- **Development of Heavy Load and High Maneuverability Aircrafts** Nov. 2016 – Oct. 2018
  Leader of the Composite Material Team & Pilot *Advisor: Prof. Zhiqiang Wan*
  - Developed the composite part of a heavy-load aircraft. Employed carbon and glass fiber reinforced polymer (CGFRP) to make D-box structures, increasing the torsional rigidity by 161.07%. [blog] Trained to be a pilot as well. [blog]
  - Won the championship in the 2018 China Aeromodelling Design Challenge (Time-limited Airdrop Project), the best record in the history of the event. Reported by *BMFA (British Model Flying Association) News* magazine. [pdf]

Skills Summary

- **Coding:** Python, C/C++, MATLAB, Mathematica, Bash, Git, Data-Oriented Programming, LaTeX
- **Software:** ROS 1&2, Gazebo, PX4, PyTorch, TensorFlow, OpenCV, Pandas, ACADOS, CasADi, Eigen, Docker, OptiTrack
- **Hardware:** NVIDIA Jetson, Raspberry Pi, STM32, Pixhawk, Circuit Design (Altium Designer), CAD (SolidWorks), CNC
- **Hobbies:** Model Airplane (Pilot for Fixed-Wing, Quadrotor, and Glider), Photography [homepage], Table Tennis, Ski

Honors and Awards

- Merit Student Scholarship 2016 ∼ 2018, 2022
- Beihang Scholarship, Freshman Scholarship 2021
- Beihang Outstanding Graduates 2020
- The Champion of "Simulated Search and Rescue Project" in China Aeromodelling Design Challenge (CADC) 2017

References

- **Zhang Ren**
  Chang Jiang Professor of Automation Science and Electrical Engineering at BUAA
  Director of Science and Technology on Aircraft Control Laboratory
  renzhang@buaa.edu.cn
- **Liang Han**
  Associate Professor of Sino-French Engineer School at BUAA
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