Lei He

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Research Interest

- UAV autonomous navigation and control
- Deep Reinforcement Learning for Robotics
- Explainable AI for robotics applications
- Bio-inspired Computer Vision

Education

School of Aeronautics, Northwestern Polytechnical University Xi'an, China
Ph.D. in Aircraft Design *Aug 2015 – Dec 2023*

- Direct Ph.D. project without master degree
- Supervisor: Prof. Bifeng Song (The Changjiang Scholars Program award)
- **Ph.D. Thesis:** Autonomous Obstacle Avoidance Flight of Bird-like Flapping Wing Micro Aerial Vehicle based on Deep Reinforcement Learning
  - Developed a deep reinforcement learning framework for flapping-wing UAV obstacle avoidance.
  - Designed a bio-inspired monocular vision system.
  - Validated in real-world flight experiments, achieved 10 m/s flight speed.

Center for Aeronautics, Cranfield University Bedford, UK
Visiting Ph.D. student *Feb 2019 – Dec 2020*

- Supervisor: Prof. Nabil Aouf and Prof. James Whidborne
- Research area: UAV autonomous flight using deep reinforcement learning
- Supported by China Scholarship Council (CSC)

Honors College, Northwestern Polytechnical University Xi'an, China
B.E. in Aircraft Design and Engineering *Aug 2011 – Jun 2015*

- Overall GPA 86/100, ranking 20^{th} of 76
- Awarded Direct Admission to Ph.D. Program

Experience

Research Fellow Jan 2024 – Present
National University of Singapore *Singapore*

- Designed and implemented an adaptive whole-body control framework for aerial manipulation.
- Developed a real-time MPC-based trajectory tracking algorithm.
- Conducted flight experiments on a customized aerial manipulator.
- Supervised by Assistant Prof. Lin Zhao

Research Assistant (Part-time) Apr 2020 – Oct 2020
City, University of London *London, UK*

- Conducted research on Orbital AI-based Autonomous Refuelling (OIBAR) project, supported by European Space Agency (ESA).
- Designed a 3D monocular pose estimation algorithm for spacecraft docking using deep learning.
- Finished simulation for autonomous docking using a robotic arm and our docking mechanism.
- Supervised by Prof. Nabil Aouf

Assistant Flight Control Engineer (Part-time) Aug 2016 – Dec 2018
Sanyi UAS Co. Ltd *Xi'an, China*

- Working on flight control system design for various novel UAV concepts.
- Performed system debugging and flight testing to validate performance in real-world conditions.

Projects

Aerial Manipulator Aug 2024 – Present

- Investigated the integration of Model Predictive Control (MPC) and Adaptive Control for aerial manipulation.
- Designed and built a prototype, followed by initial flight tests.
- Implemented simulation software for system evaluation and algorithm verification.

Swarm UAV Flight in Cluttered Environment Jan 2024 – Dec 2024

- Conducted indoor and outdoor flight experiments for multi-agent coordination and collision avoidance.
- Contributed to the simulation and debugging of swarm algorithms.
- Developed a visualization software for the system.

Flapping Wing Autonomous Obstacle Avoidance Flight May 2021 – Dec 2023

- Developed an obstacle avoidance system for a bird-like flapping wing micro UAV.
- Using bio-inspired monocular vision for obstacle detection.
- Avoidance policy is trained in the simulation environment and deployed to real flapping wing UAV for flight test.
- Finished my PhD thesis based on this project.

Orbital AI-based Autonomous Refuelling Apr 2020 – Dec 2020

- Designed an AI-based 3D target position and pose estimation algorithm for autonomous docking.
- Developed a physical docking mechanism, creating prototypes using 3D printing and CNC machining.
- Simulated a microgravity environment using a robotic arm and successfully demonstrated autonomous docking.

UAV Autonomous Flight using Deep Reinforcement Learning Feb 2019 – May 2021

- Developed a simulation framework using AirSim to simulate UAV flight scenarios.
- Implemented deep reinforcement learning (DRL) algorithms for autonomous obstacle avoidance and navigation.
- Transferred the trained policy from simulation to a real quadrotor UAV and successfully conducted outdoor flight experiments.

VTOL Fixed-Wing UAV Design and Flight Test Jan 2016 – Dec 2018

- Designed and built various VTOL fixed-wing UAVs, including quadrotor VTOL, tail-sitter VTOL, and tilt-wing UAVs.
- Developed and customized flight control systems based on the PX4 open-source autopilot.
- Performed hardware integration, software tuning, and extensive flight testing to ensure stability and transition performance.

Internships

Undergraduate Research Student Aug 2013 – Mar 2015

Intelligent Car Lab, Northwestern Polytechnical University *Xi'an, China*

- Automatic driving and tracking system for intelligent car using computer vision
- Supported by China National Innovation Experiment Program for college students
- Supervised by Prof. Shiru Qu

Summer Research Intern May 2014 – Aug 2014

Shaanxi Province Key Lab of Speech and Image Information Processing (SAIIP) *Xi'an, China*

- Audio, speech and language processing using machine learning
- Supervised by Prof. Lei Xie

Exchange Student Aug 2013 – Jan 2014

National Taiwan University of Science and Technology *Taipei*

- Exchange student in Department of Computer Science and Information Engineering
- Major in Computer Science and Software Engineering

Publications

1. **Lei He**, Aouf Nabil, and Bifeng Song. Explainable Deep Reinforcement Learning for UAV Autonomous Navigation. *Aerospace science and technology*, 2021.
2. **Lei He**, Nabil Aouf, James Whidborne, Bifeng Song. Integrated moment-based LGMD and deep reinforcement learning for UAV obstacle avoidance. *IEEE International Conference on Robotics and Automation (ICRA)*, 2020.
3. **Lei He**, Duarte Rondao, Nabil Aouf. A Novel Mechanism for Orbital AI-based Autonomous Refueling. *AIAA SCITECH Forum*, 2023.
4. **Lei He**, Nabil Aouf, James Whidborne, Bifeng Song. Deep Reinforcement Learning based Local Planner for UAV Obstacle Avoidance using Demonstration Data. *preprint*, 2020.
5. Duarte Rondao, **Lei He**, Nabil Aouf. AI-based monocular pose estimation for autonomous space refuelling. *Acta Astronautica*, 2024
6. Changhao Chen, Bifeng Song, Shuhui Bu, **Lei He**. An improved point feature-based sparse stereo vision. *IET Image Processing*, 2020.
7. Shi Qian Liu, James F Whidborne, **Lei He**. Backstepping sliding-mode control of stratospheric airships using disturbance-observer. *Advances in Space Research*, 2021.
8. Siqi Wang, Bifeng Song, **Lei He**, Xinyu Lang. Modeling and robust attitude controller design of a distributed propulsion tilt-wing UAV in hovering flight. *Chinese Control And Decision Conference (CCDC)*, 2019
9. Siqi Wang, Bifeng Song, **Lei He**. Robust attitude control system design for a distributed propulsion tilt-wing uav in flight state transition. *Asia-Pacific International Symposium on Aerospace Technology*, 2018
10. Bifeng Song, **Lei He**, Chen Wang, Wenqing Yang, A multi power fusion flight control system applied to micro UAV. *Chinese Patent (ZL 2015 1 0990837.X)*, 2015

Technical Skills

UAV control system design, simulation and real flight test

- Python, C++, MATLAB, Simulink
- PX4 open-source flight stack development
- ROS and Linux programming
- UAV operation for 8 years, including fixed-wing, flapping-wing, quadrotor and VTOL.

Learning-based control and planning

- TensorFlow, PyTorch
- Experienced in implementing deep reinforcement learning algorithms for UAV applications.
- Familiar with common UAV and robotics simulators, such as Gazebo, AirSim, and MuJoCo.

Hobbies

Sports, aviation spot and photography

Referees

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