

Lei He

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RESEARCH PROFILE

Autonomous Aerial Robotics, Learning-Based Control, and Real-World Flight Systems

- Develop autonomous flight systems that combine learning-based planning, trajectory optimization, and MPC-based control.
- Conduct real-world flight experiments across quadrotors, VTOL aircraft, flapping-wing UAVs, aerial manipulators, and TVC rockets.
- Research interests include UAV navigation and control, deep reinforcement learning, explainable AI, and bio-inspired 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 20th of 76
- Awarded Direct Admission to Ph.D. Program
- **Undergraduate Thesis:** Research on Autonomous Flight Experiments of a Hexacopter UAV Based on Pixhawk Open-Source Flight Controller

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

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

PROJECTS

- TVC Rocket Control and Flight Test** May 2025 – Present
- Designed the thrust vector control (TVC) control system for rocket attitude stabilization and trajectory tracking.
 - Developed software-in-the-loop simulation for control algorithm verification and system-level testing.
 - Conducted real flight tests and investigated optimal trajectory planning for rocket ascent and recovery.
- 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 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.
 - Designed a bio-inspired monocular vision system for obstacle detection.
 - Trained the avoidance policy in simulation and deployed it to a real flapping-wing UAV for flight tests.
 - 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

Journal Articles

1. **Lei He**, Nabil Aouf, Bifeng Song. Explainable Deep Reinforcement Learning for UAV autonomous path planning. *Aerospace Science and Technology*, 118:107052, 2021. **Google Scholar citations: 246; Scopus top 1% paper.**
2. Zichen Yan, Rui Huang, **Lei He**, Shao Guo, Lin Zhao. SIGN: Safety-Aware Image-Goal Navigation for Autonomous Drones via Reinforcement Learning. *IEEE Robotics and Automation Letters*, 11(2):1962–1969, 2026.
3. Yueyang Guo, Wenqing Yang, Jiaqi Liu, **Lei He**, Jianlin Xuan. Fluid structure interaction mechanisms of wings with membrane-skeleton structures under low Reynolds number conditions. *Physics of Fluids*, 37(12):124116, 2025.
4. Duarte Rondao, **Lei He**, Nabil Aouf. AI-based monocular pose estimation for autonomous space refuelling. *Acta Astronautica*, 220:126–140, 2024.
5. Changhao Chen, Bifeng Song, Qiang Fu, Dong Xue, **Lei He**. Event-Triggered Hierarchical Planner for Autonomous Navigation in Unknown Environment. *Drones*, 7(12):690, 2023.
6. Changhao Chen, Bifeng Song, Shuhui Bu, **Lei He**. An improved point feature-based sparse stereo vision. *IET Image Processing*, 2022.
7. Shi Qian Liu, James F. Whidborne, **Lei He**. Backstepping sliding-mode control of stratospheric airships using disturbance-observer. *Advances in Space Research*, 2021.

Conference Papers and Preprints

1. Fenglan Wang, Xinguo Shu, **Lei He**, Lin Zhao. Learning Distributed Safe Multi-Agent Navigation via Infinite-Horizon Optimal Graph Control. *Accepted by Robotics: Science and Systems (RSS)*, 2026.
2. Rui Huang, Zhiyu Gao, Siyu Tang, Jialin Zhang, **Lei He**, Ziqian Zhang, Lin Zhao. TransforMARS: Fault-Tolerant Self-Reconfiguration for Arbitrarily Shaped Modular Aerial Robot Systems. *Accepted by IEEE International Conference on Robotics and Automation (ICRA)*, 2026.
3. Yiming Dai, Yanhui Zhang, **Lei He**, Changju Wu, Weifang Chen, Liang Zhuo. Reinforcement Learning-Based Motion Control for Successive Extremely Narrow Gate Traversal with a Quadrotor Tilt-Rotor. *International Conference on Robotics, Automation, and Artificial Intelligence (RAAI)*, 917–922, 2025.
4. **Lei He**, Duarte Rondao, Nabil Aouf. A Novel Mechanism for Orbital AI-based Autonomous Refuelling. *AIAA SCITECH Forum*, 2023.
5. **Lei He**, Nabil Aouf, James F. Whidborne, Bifeng Song. Deep Reinforcement Learning based Local Planner for UAV Obstacle Avoidance using Demonstration Data. *arXiv preprint arXiv:2008.02521*, 2020.
6. **Lei He**, Nabil Aouf, James F. Whidborne, Bifeng Song. Integrated moment-based LGMD and deep reinforcement learning for UAV obstacle avoidance. *IEEE International Conference on Robotics and Automation (ICRA)*, 2020.
7. 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.
8. 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.

Patents

1. 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 Testing

- Python, C++, MATLAB, Simulink
- PX4 open-source flight stack development
- Optimal trajectory planning, trajectory optimization, and model predictive control (MPC) for UAVs/aerial robots
- ROS and Linux programming
- 8 years of UAV operation experience, including fixed-wing, flapping-wing, quadrotor, and VTOL platforms.

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.

OPEN-SOURCE PROJECTS

UAV_Navigation_DRL_AirSim

560+ stars / 69 forks

- Built and shared a Python/AirSim framework for training UAV local path-planning policies with deep reinforcement learning.
- Packaged simulation, training scripts, and example environments to help others reproduce UAV navigation experiments.
- Used by students and researchers as a starting point for DRL-based UAV obstacle avoidance and sim-to-real studies.

px4_avoidance_airsim

44 stars / 8 forks

- Connected PX4-Avoidance and Fast-Planner with AirSim, making obstacle-avoidance experiments easier to reproduce.
- Provided a bridge between PX4 SITL and photorealistic AirSim scenes for testing planning and avoidance algorithms.
- Documented the setup workflow for researchers who want to test PX4-based navigation without immediate hardware access.

UAV-navigation-papers

41 stars / 6 forks

- Maintained a practical reading list for UAV navigation in unknown and cluttered environments.
- Grouped papers around perception, planning, reinforcement learning, obstacle avoidance, and real-world flight tests.
- Created as a quick entry point for new students starting research on autonomous UAV navigation.

HOBBIES

Sports, aviation spotting, and photography

REFEREES

Prof. Bifeng Song
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