

Zhong Zhang

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EDUCATION

- **Ph.D, Aerospace Engineering, Tsinghua University**
(*5-Year PhD program for outstanding undergraduate students, bypassing the master's degree*)
 - Supervisor: **Prof. Junfeng Li** and co-supervised by **Prof. Hexi Baoyin**
 - Degree awarded: 28/06/2024
 - Thesis title: “*Hierarchical and Global Optimization Method for Coordinated Space Trajectories*”
 - Outstanding Doctoral Graduate of Tsinghua University and Beijing, China
 - Outstanding Thesis Award of Tsinghua University
- **Bachelor, Aerospace Engineering, Tsinghua University** (*QS/ARWU/THE/U.S. News Global Rank: Top 20*)
 - Degree awarded: 03/07/2019
 - Outstanding Undergraduate of Tsinghua University

PROFESSIONAL EXPERIENCE

- ◇ **European Space Research and Technology Centre, Netherlands** **1/06/2025 - 21/06/2025**
 - Advanced Concepts Team (ACT) Visiting Scholar
 - Invited by: **Dr. Dario Izzo**
- ◇ **Politecnico di Milano, Italy** **01/11/2024-NOW**
 - Deep-space Astrodynamics Research & Technology (DART) group Postdoctoral Fellow
 - Supervisor: **Prof. Francesco Topputo**
- ◇ **Tsinghua University, China** **04/07/2024 - 31/10/2024**
 - Lab of Astrodynamics (LAD) Postdoctoral Researcher
 - Supervisor: **Prof. Hexi Baoyin**
- ◇ **University of Illinois at Urbana-Champaign, the United States** **01/09/2022 - 01/09/2023**
 - The Grainger College of Engineering - Participated remotely (COVID-19) Visiting Student
 - Supervisor: **Prof. Robyn Woollands**
- ◇ **Aviation Industry Corporation of China, China** **01/06/2021 - 31/08/2021**
 - Key Laboratory Summer Intern

PARTICIPATION INDUSTRIAL INNOVATION

- 2025: **ESA's SATIS project**
 - Contributing to a 12U CubeSat mission analysis of a large set of Near-Earth Asteroids (NEAs), with a particular focus on their suitability for planetary defense applications
- 2023-2024: **China's first asteroid defense mission** led by Deep Space Exploration Lab, China
 - Contributing to mission analysis and preliminary trajectory design to asteroid 2015 XF261
- 2020-2023: **China's Jupiter exploration mission involving multi-moon flybys**
 - Formally documented in *China's Space Program: A 2021 Perspective* white paper
 - Contributing to concept proof and preliminary trajectory design

FUNDING

- 2024: PI: Tsinghua Shuimu Overseas Postdoctoral Fellowship, China, CNY ¥ 930k (Approx. €112k)
- 2024: Co-I (ranked 4th): Key Program of the National Natural Science Foundation of China, Grant Agreement No. 12532018, CNY ¥ 3m (Approx. €360k)

EARLY ACHIEVEMENT TRACK RECORD

I am a passionate astrodynamist. My research focuses on the intersection of artificial intelligence and astrodynamics, with emphasis on trajectory optimization, optimal control, and autonomous space system scheduling. Despite my very early career status (one year after my Ph.D.), I have already produced 16 peer-reviewed journal papers (14 published and 2 under review), including 7 as first author, illustrating a rapid trajectory of scholarly productivity at an early stage of my career. My Ph.D. dissertation was awarded the Outstanding Thesis Award of Tsinghua University.

Alongside academic research, I have gained practical engineering experience through participation in major space projects with the China National Space Agency and the European Space Agency. These include 1) mission analysis for China's first asteroid defense mission, 2) trajectory design for the country's upcoming Jupiter exploration mission with multiple moon flybys, which was formally documented in China's Space Program: A 2021 Perspective, and 3) analysis of near-earth asteroid rendezvous scenarios for ESA's SATIS project.

My passion for education is reflected in my teaching and mentorship. I served as a teaching assistant for three semesters in Theoretical Mechanics at Tsinghua University, contributing to the preparation of the textbook. I was recognized as an Outstanding Teaching Assistant. In addition, I have mentored three Ph.D. students and one master's student, supporting their academic growth and contributing to the research community.

I have been internationally recognized for my contributions to trajectory optimization. I led the Tsinghua team to first place in the 11th Global Trajectory Optimization Competition, one of the most prestigious mission design challenges that attracts top institutions including NASA, ESA, and JAXA. Following this success, I was invited to host and design the problem for the 12th competition, which was later won by NASA's Jet Propulsion Laboratory. Furthermore, I was invited to the Dagstuhl Seminar, an exclusive invitation-only event recognized as one of the most prestigious international forums in computer science, underscoring the global impact of my work.

RESEARCH EXPEDITIONS

(This section summarizes research progress corresponding to the publications listed below.)

- 1. Neural Approximation and Safety Techniques in Space Trajectory Design**
 - Develop a deep neural network that unifies classification and regression to predict low-thrust trajectory cost, the accessible region of transfer trajectories, and post-gravity-assist state changes.
 - Develop stability-guaranteed control methods that embed safety criteria into neural networks to enforce collision-avoidance constraints throughout the control process.
 - **Publications:** J3, J4, C1, C2; **Collaborators:** Dr. Zibin Sun, Dr. Jia Yang, Prof. Francesco Topputo
- 2. Asteroid In-situ Resource Utilization, Detection, and Planetary Defense Mission Design**
 - Design asteroid in-situ resource utilization and exploration missions, leveraging experiences from GTOC11 and GTOC12 competitions.
 - Develop synergistically optimized orbits for planetary defense, focusing on dual-objective missions achievable by a single launch vehicle.
 - **Publications:** J1, J5, J9, C3, C5; **Collaborators:** Prof. Di Wu, Prof. Fanghua Jiang, Prof. Hexi Baoyin
- 3. Single-spacecraft Multiple Rendezvous or Flyby Missions Global Trajectory Optimization**
 - Propose a lossless reformulation that recasts interior-point optimal control as a multi-stage decision paradigm; Provide proofs of global optimality, accompanied by rigorous upper-bound error estimation.
 - **Publications:** J7, J11, J14, J15, C4; **Collaborators:** Prof. Nan Zhang, Prof. Xiang Guo, Dr. Shiyu Chen
- 4. Multi-spacecraft Cooperative Exploration and Rapid Response Scheduling Algorithms**
 - Propose a hierarchical decomposition framework for asteroid exploration and space debris removal missions, divided into target assignment, sequencing, and maneuver optimization.
 - Propose multi-tree dynamic priority search frameworks, and semi-analytical visibility algorithms.
 - Achieve a significant improvement in responsiveness to emergencies and maximize imaging returns.
 - **Publications:** J2, J8, J12, J13, C6; **Collaborators:** Dr. Yifei Jiao, Dr. Zhibo E, Prof. Junfeng Li
- 5. Optimal Control Algorithms for Low-energy Transfers and Solar Sail Spacecraft Dynamics**
 - Realize significant fuel savings for the LISA formation by leveraging lunar swing-by maneuvers.
 - Quantify the force distribution advantages of transmissive diffractive sails at Sun-Earth equilibrium points, demonstrating the potential for continuous polar region observations throughout the year.
 - **Publications:** J6, J10, J16; **Collaborators:** Dr. Yin Chu, Dr. Jia Yang, Prof. Shengping Gong

PUBLICATION LIST

Journal papers

(* indicates the corresponding author)

- (J1) **Zhong Zhang**, Xiang Guo, Di Wu, Hexi Baoyin, Junfeng Li, Francesco Topputo. “Global Optimality in Multi-Flyby Asteroid Trajectory Optimisation: Theory and Application Techniques”, *Journal of Guidance, Control, and Dynamics*, *Accept* (2025). DOI: [10.48550/arXiv.2508.02904](https://doi.org/10.48550/arXiv.2508.02904)
- Scientific significance: This paper establishes a method that approaches global optimality for multi-flyby trajectory optimization under a given sequence. The original optimal control problem with interior-point equality constraints is transformed into a multi-stage decision formulation. Moreover, the method provides a quantifiable bound on global optima errors introduced by discretization and approximation assumptions, thus ensuring a measure of confidence in the obtained solution.
- (J2) **Zhong Zhang**, Nan Zhang, Xiang Guo, Di Wu, Xuan Xie, Jia Yang, Fanghua Jiang and Hexi Baoyin. “Sustainable Asteroid Mining: On the Design of the GTOC-12 Problem and Summary of the Results”, *Astrodynamics*, Vol 9, pp 3-17, 2025. DOI: [10.1007/s42064-024-0199-3](https://doi.org/10.1007/s42064-024-0199-3)
- Scientific significance: This study introduces the “Sustainable Asteroid Mining” GTOC12 benchmark. It outlines the problem design, scoring methodology, and the competition’s game-theoretic structure, and provides a comparative analysis of the strategies and results from 28 international teams.
- (J3) **Zhong Zhang**, Hexi Baoyin and Junfeng Li. “Research Progress on Trajectory Optimization of Space-Target Cooperative Detection”, *Journal of Deep Space Exploration*, 12 (1): 3-14, 2025. DOI: [10.15982/j.issn.2096-9287.2025.20240041](https://doi.org/10.15982/j.issn.2096-9287.2025.20240041)
- Scientific significance: This paper reviews trajectory optimization methods for multi-spacecraft cooperative target detection, with a focus on classical optimal control approaches (both direct and indirect methods), heuristic algorithms, and machine learning-based techniques.
- (J4) Jia Yang, ***Zhong Zhang**, Junfeng Li and Fanghua Jiang. “Deep Neural-Network-Based Efficient Mapping of 3-D Lunar Gravity Assist in the Circular Restricted Three-Body Problem”, *IEEE Transactions on Aerospace and Electronic Systems*, Vol. 61, no. 4, pp. 10768-10783, 2025. DOI: [10.1109/TAES.2025.3567278](https://doi.org/10.1109/TAES.2025.3567278)
- Scientific significance: A neural network-based method is proposed for fast prediction of post-lunar gravity assist state variations using a modular architecture. This approach enables efficient global search and rapid evaluation in Earth–Moon transfer trajectory design.
- (J5) Zibin Sun, ***Zhong Zhang**, Lin Cheng, Di Wu, Shengping Gong. “Guaranteed Safety-and-Stability Neural Guidance for Asteroid Landing under Collision-Avoidance Constraints”, *Aerospace Science and Technology*, early access, 2025. DOI: [10.1016/j.ast.2025.110758](https://doi.org/10.1016/j.ast.2025.110758)
- Scientific significance: The analytical control barrier function generated online enhances control flexibility under irregular terrains with strict safety assurance. A robustness neural control Lyapunov function trained across potential asteroid parameters is employed to ensure control stability under environment uncertainties.
- (J6) Nan Zhang, Di Wu, **Zhong Zhang**, Haiyang Li and Hexi Baoyin. “Preliminary Trajectory Design of Implementing the Asteroid Rendezvous and Impact in a Single Launch”, *Aerospace Science and Technology*, Vol 159, Art 109959, 2025. DOI: [10.1016/j.ast.2025.109959](https://doi.org/10.1016/j.ast.2025.109959)
- Scientific significance: The initial trajectory design for China’s first lunar planetary defense mission is presented, employing a single launch to deliver both an orbiter and an impactor for a dual-spacecraft rendezvous with asteroid 2015 XF261.
- (J7) Yin Chu, Di Wu, Jinyuan Li, **Zhong Zhang** and Shengping Gong. “Potential of Sun-Facing Diffractive Sail’s Sun–Earth Equilibria for Continuous Polar Observation”, *Journal of Guidance, Control, and Dynamics*, Vol 47 (10), pp. 2204-2212, 2024. DOI: [10.2514/1.G008150](https://doi.org/10.2514/1.G008150)
- Scientific significance: Quantifies how force-distribution in a transmissive diffractive sail enlarges feasible equilibria around the Sun-Earth line and demonstrates year-round coverage of both poles.
- (J8) **Zhong Zhang**, Nan Zhang, Zherui Chen, Fanghua Jiang and Hexi Baoyin. “Global Trajectory Optimization of Multispacecraft Successive Rendezvous Using Multi-Tree Search”, *Journal of Guidance, Control, and Dynamics*, Vol 47 (3), pp. 503-517, 2024. DOI: [10.2514/1.G007764](https://doi.org/10.2514/1.G007764)
- Scientific significance: Decomposes multi-spacecraft rendezvous trajectory design into target assignment, sequencing and timing; proposes multi-tree search that achieves sota performance in the GTOC9 problem.
- (J9) Nan Zhang, **Zhong Zhang**, Yifei Jiao and Hexi Baoyin. “Multi-Trajectory Combination for Multiple Ground-Target Observation by Maneuvering On-Orbit Satellites”, *IEEE Transactions on Aerospace and Electronic Systems*, Vol 59, pp. 8428-8438, 2023. DOI: [10.1109/TAES.2023.3303409](https://doi.org/10.1109/TAES.2023.3303409)
- Scientific significance: A trajectory composition approach is proposed to address the maneuver scheduling problem for remote sensing satellites, aiming to maximize cumulative ground imaging rewards.

- (J10) **Zhong Zhang**, Nan Zhang, Xiang Guo, Di Wu, Xuan Xie, Jinyuan Li, Jia Yang, Shiyu Chen, Fanghua Jiang, Hexi Baoyin *et al.* “GTOC 11: Results from Tsinghua University and Shanghai Institute of Satellite Engineering”, *Acta Astronautica*, Vol 202, pp. 819-828, 2023. DOI: [10.1016/j.actaastro.2022.06.028](https://doi.org/10.1016/j.actaastro.2022.06.028)
- Scientific significance: This work presents the winning trajectory strategy of the GTOC11 competition, introducing an analytical method for handling gravity assist constraints and a tailored database design approach for asteroid chain construction.
- (J11) Jia Yang, **Zhong Zhang**, Fanghua Jiang and Junfeng Li. “Low-Energy Transfer Design of Heliocentric Formation Using Lunar Swing-By: the Case of LISA”, *Aerospace*, Vol 10: Art. 18, 2023. DOI: [10.3390/aerospace10010018](https://doi.org/10.3390/aerospace10010018)
- Scientific significance: This work designs and optimizes low-energy heliocentric transfer trajectories for gravitational wave detector formations using Lunar swing-by. The proposed method achieves further reductions in fuel consumption under the ESA LISA mission scenario.
- (J12) Nan Zhang, Shiyu Chen, **Zhong Zhang** and Hexi Baoyin. “Two-Stage Dynamic-Assignment Optimisation Method for Multispacecraft Debris Removal”, *Journal of Guidance, Control, and Dynamics*, Vol 45 (9), pp. 1750-1759, 2022. DOI: [10.2514/1.G006602](https://doi.org/10.2514/1.G006602)
- Scientific significance: A two-stage fast algorithm is proposed for multi-spacecraft active space debris removal, enabling efficient planning and coordination in complex orbital environments.
- (J13) **Zhong Zhang**, Nan Zhang, Yifei Jiao, Hexi Baoyin and Junfeng Li. “Multitree Search for Multisatellite Responsiveness Scheduling Considering Orbital Maneuvering”, *IEEE Transactions on Aerospace and Electronic Systems*, Vol 58 (3), pp. 2206-2217, 2022. DOI: [10.1109/TAES.2021.3129723](https://doi.org/10.1109/TAES.2021.3129723)
- Scientific significance: Introduces a dynamic-priority multi-tree framework that jointly selects maneuver windows and imaging tasks, improving average responsiveness by 35 % on real disaster scenarios.
- (J14) **Zhong Zhang**, Zhibo E, Lixia Huang and Junfeng Li. “Semi-Analytical Algorithm for Computing Satellite–Area-Target Visibility”, *Journal of Tsinghua University (Science & Technology)*, Vol 62 (3), pp. 573-580, 2022. DOI: [10.16511/j.cnki.qhdxxb.2021.26.020](https://doi.org/10.16511/j.cnki.qhdxxb.2021.26.020)
- Scientific significance: A semi-analytical algorithm is proposed for rapid computation of the visibility of ground target regions from remote sensing satellites, significantly improving efficiency by one or 2 magnitudes.
- (J15) Nan Zhang, **Zhong Zhang** and Hexi Baoyin. “Timeline Club: An Optimisation Algorithm for Solving Multiple Debris-Removal Missions of the Time-Dependent Traveling Salesman Model”, *Astrodynamics*, Vol 6, pp. 219-234, 2022. DOI: [10.1007/s42064-021-0107-z](https://doi.org/10.1007/s42064-021-0107-z)
- Scientific significance: A novel algorithm named Timeline Club is proposed for solving the Time-Dependent Traveling Salesman Problem (TDTSP). It outperforms beam search by 10–30% on standard TDTSP benchmarks.

Submitted journal papers

- (J16) Xiang Guo, Di Wu, **Zhong Zhang**, Fanghua Jiang. “Low-Thrust Minimum-Fuel Smoothing Continuation via Smoothing Parameter Upper Bound Analysis”, *IEEE Transactions on Aerospace and Electronic Systems—minor revision* (2025).

Conference papers

- (C1) **Zhong Zhang**, Francesco Topputo. “Neural Approximators for Low-Thrust Trajectory Transfer Cost and Reachability” *2025 AAS/AIAA Astrodynamics Specialist Conference*, Boston, the United States. 2025. DOI: [10.48550/arXiv.2508.02911](https://doi.org/10.48550/arXiv.2508.02911)
- (C2) **Zhong Zhang**, Niccolò Michelotti, Gonçalo Oliveira Pinho, Francesco Topputo. “A Comparative Study of Optimal Control and Neural Networks in Asteroid Rendezvous Mission Analysis” *2025 AAS/AIAA Astrodynamics Specialist Conference*, Boston, the United States. 2025. DOI: [10.48550/arXiv.2508.02920](https://doi.org/10.48550/arXiv.2508.02920)
- (C3) Di Wu, Nan Zhang, **Zhong Zhang**, Haiyang Li, Lin Cheng, Hexi Baoyin. 2024. “Preliminary Design of the Rendezvous and Interception Trajectories to Asteroid 2015 XF261” *75th International Astronautical Congress (IAC 2024)*, Milan, Italy. DOI: [10.52202/078368-0053](https://doi.org/10.52202/078368-0053)
- (C4) **Zhong Zhang**, Xiang Guo, Di Wu, Junfeng Li, Fanghua Jiang. “Global fuel-optimal trajectory for multi-flyby under given sequence.” *19th National Deep Space Exploration Conference*, Inner Mongolia, China. 2023. (**Best Paper Award**)
- (C5) **Zhong Zhang**, Hexi Baoyin, Junfeng Li. “Trajectory design of international cooperative asteroid impact mission program.” *2nd National Planetary Defense Conference*, Xinjiang, China. 2023.
- (C6) **Zhong Zhang**, Zhibo E, Junfeng Li. “Satellite scheduling algorithm for large area target with complicated realistic constraints.” *2nd International Applied Mathematics, Modelling and Simulation Conference (AMMS)*, Paris, France. 2020.

CONFERENCE ORGANISATION

- **12th Global Trajectory Optimisation Competition and its workshop (*Problem Designer and Organizer*)**
 - Organized the 12th Global Trajectory Optimisation Competition by designing the problem and developing the official website (<https://gtoc12.tsinghua.edu.cn/>). Achieved a record turnout of over 100 registered teams from all over the world, with NASA's Jet Propulsion Laboratory (JPL) claiming first place.
 - After the competition, host “2024 International Forum on Deep Space Missions and Trajectory Optimization and 12th edition of the Global Trajectory Optimisation Workshop” in Beijing, which brought together over 150 international scholars.

INVITED TALKS

- 2025: **Dagstuhl Seminar**, Oberwolfach, Germany. Topic: *Optimization and Automated Reasoning for Designing Future Space Missions* [Invited by Dr. Max Bannach from ESA]
- 2023: **Chinese New Year Gala**, Beijing, China. Topic: *TV interview* [Invited by China Central Television]
- 2022: **GTOC11 Workshop**, Hunan, China. Topic: *GTOC11 winner solution* [Invited by Prof. Yazhong Luo]
- 2021: **Satellite Logistics Software**, Beijing, China. Topic: *Earth observation satellites* [Invited by Dr. Meiyu Huang from China Academy of Space Technology]

JOURNAL REVIEW HISTORY

Journal of Guidance, Control, and Dynamics
IEEE Transactions on Aerospace and Electronic Systems
Acta Astronautica
Astrodynamics
Space: Science & Technology

TEACHING ACTIVITIES

- Teaching assistant for 3 semesters (2019 Fall, 2020 Fall, 2021 Fall) for the course *Theoretical Mechanics* at Tsinghua University, contributing to writing its textbook “*Dynamics and Control*”
- Outstanding Teaching Assistant (TA), ranking 3rd out of 1,381 TAs in the 2020 Fall semester student evaluation questionnaires at Tsinghua University.

MENTORING ACTIVITIES

- 3 Ph.D. Students at Tsinghua University: 1) Jia Yang — July 2021 to present;
2) Zibin Sun — July 2023 to June 2025; 3) Yi Zhou — July 2024 to present
- 1 Master Student at Politecnico di Milano: 1) Marcello Pareschi — July 2025 to present

SCHOLARSHIPS AND AWARDS

Scholarships

- 2023: Candidate for Tsinghua Top Grade Scholarship (Top 10 out of 42000+ total graduate students per year)
- 2023: Tsinghua University Wang Dazhong President's Scholarship
- 2022: **National Scholarship** (Graduate), China. (Most prestigious scholarship given by Chinese government)
- 2022: Research Exploration Scholarship, Tsinghua University
- 2019: Future Scholar Scholarship, Tsinghua University
- 2019: Outstanding Undergraduate, Tsinghua University
- 2018: Candidate for Tsinghua Top Grade Scholarship

Awards

- 2025: **Second place** of 12th edition of Global Trajectory Optimization Competition (GTOC12) with ESA Advanced Concept Team (ACT)
- 2024: Outstanding Doctoral Graduate, Beijing, China
- 2024: Outstanding Doctoral Graduate, Tsinghua University
- 2024: Outstanding Doctoral Dissertation of Tsinghua University
- 2022: Best Paper Award for 19th Annual National Deep Space Exploration Conference, China
- 2021: **Winner and team leader** of 11th edition of Global Trajectory Optimization Competition (GTOC11) ESA Official Web: (https://sophia.estec.esa.int/gtoc_portal/?page_id=782).
- 2020: Second place of 11th edition of China Trajectory Optimization Competition (CTOC11)
- 2019: Outstanding Undergraduate, Tsinghua University