Shizhuang Wang

PhD candidate, Shanghai Jiao Tong University
Mobile : +86-131-2783-1090
Email : sz.wang@sjtu.edu.cn
ResearchGate; Google Scholar; LinkedIn; Website

Education

- **Shanghai Jiao Tong University** — Shanghai, China
  Ph.D. in Aerospace Engineering; GPA: 3.93 / 4.0 — *Sep 2019 - Dec 2023*
  Research Topic: *Navigation system integrity monitoring for safety-critical applications*
  Supervisors: Prof.Xingqun Zhan, Dr.Yawei Zhai
- **Shanghai Jiao Tong University** — Shanghai, China
  B.S. in Aerospace Engineering; GPA: 3.95 / 4.3 (First in class of 28) — *Sep 2014 - Jul 2018*

Experience

- **Shanghai Jiao Tong University** — Shanghai, China
  Research Assistant at Guidance Navigation and Control (GNC) Laboratory — *May 2016 - Dec 2023*
  Research Interests: integrity monitoring; multi-sensor integrated navigation; cooperative navigation

Publications

- **Publications as the first author**

1. **Wang, S.**, Zhan, X., Zhai, Y., and Gao, Z. (2023) "Solution Separation-Based Integrity Monitoring for Integer Ambiguity Resolution-Enabled GNSS Positioning," *Proceedings of the 2023 International Technical Meeting of The Institute of Navigation* (ION ITM 2023), Long Beach, CA, 2023. [PDF] [video]
2. **Wang, S.**, Zhai, Y., and Zhan, X. (2023) "Implementation of Solution Separation based Kalman Filter Integrity Monitoring Against All-Source Faults for Multi-Sensor Integrated Navigation," *GPS Solutions* (SCI), 27(103): 1-18, 2023. [PDF]
3. **Wang, S.**, Zhai Y, Chi C, Zhan X, and Jiang Y. (2023) "Implementation and Analysis of Fault Grouping for Multi-Constellation Advanced RAIM," *Advances in Space Research* (SCI), 2023, 71 (11): 4765-4786. [PDF]
4. **Wang, S.**, Zhan, X., Zhai Y., Zheng, L., and Liu, B. (2022), "Enhancing Navigation Integrity for Urban Air Mobility with Redundant Inertial Sensors," *Aerospace Science and Technology* (SCI), 2022, 126: 107631. [PDF]
5. **Wang, S.**, Zhai, Y., and Zhan, X. (2021) "Characterizing Beidou Signal-In-Space Range Errors from Integrity Perspective," *NAVIGATION: Journal of the Institute of Navigation* (SCI), 2021, 68 (1): 157-183. [PDF]
6. **Wang, S.**, Zhan, X., Zhai, Y., Chi, C., Shen, J. (2021) "Highly Reliable Relative Navigation for Multi-UAV Formation Flight in Urban Environments," *Chinese Journal of Aeronautics* (SCI), 2021, 34 (7): 257-270. [PDF]
7. **Wang, S.**, Zhan, X., Zhai, Y., Shen, J., and Wang, H. (2021) "Performance Estimation for Kalman Filter based Multi-Agent Cooperative Navigation by Employing Graph Theory," *Aerospace Science and Technology* (SCI), 2021. [PDF]
8. **Wang, S.**, Zhan, X., Zhai, Y., and Liu, B. (2020) "Fault Detection and Exclusion for Tightly Coupled GNSS/INS System Considering Fault in State Prediction," *Sensors* (SCI), 2020, 20 (3): 590. [PDF]
9. **Wang, S.**, Zhan, X, Xiao, Y., and Zhai Y. (2022) "Integrity Monitoring of PPP-RTK based on Multiple Hypothesis Solution Separation," *Proceedings of China Satellite Navigation Conference 2022* (CSNC 2022), Beijing, 2022. [PDF]
10. **Wang, S.**, Zhan, X., Zhai, Y., and Fu, Y. (2020) "Feature-Based Visual Navigation Integrity Monitoring for Urban Autonomous Platforms," *Aerospace Systems*, 2020, 3: 167-179. [PDF]
11. **Wang, S.**, Zhan, X., Zhai, Y., Chi, C., Liu, X. (2020) "Ensuring High Navigation Integrity for Urban Air Mobility Using Tightly Coupled GNSS/INS System," *Journal of Aeronautics, Astronautics and Aviation*, 2020, 52 (4): 429-442. [PDF]
12. **Wang, S.**, Zhan, X., and Pan, W. (2018) "GNSS/INS Tightly Coupling System Integrity Monitoring by Robust Estimation," *Journal of Aeronautics, Astronautics and Aviation*, 2018, 50 (1): 61-80. [PDF]
13. **Wang, S.**, Zhan, X., Zhai, Y., and Wang, H. (2023) "Bayesian Tight Upper Bound on GNSS Posterior Integrity Risk", *submitted to IEEE Transactions on Aerospace and Electronic Systems* (SCI), under review, 2023. [paper]

- **Publications as a co-supervisor**

14. Fu, Y., **Wang, S.**, Zhai, Y., Zhan, X., and Zhang X. (2022) "Measurement Error Detection for Stereo Visual Odometry Integrity," *NAVIGATION: Journal of the Institute of Navigation* (SCI), 2022, 69 (4): 1-32. [PDF]

15. Xiao, Y., **Wang, S.**, Zhan, X., and Zhai, Y. (2022) "Research on Integrity Evaluation Method for PPP-RTK Service End," *Proceedings of China Satellite Navigation Conference 2022* (CSNC 2022), Beijing, 2022. [PDF]
16. Shen, J., **Wang, S.**, and Zhan, X. (2022) "Multi-UAV Cluster-based Cooperative Navigation with Fault Detection and Exclusion Capability," *Aerospace Science and Technology* (SCI), 2022, 124: 107570. [PDF]
17. Wang, H., **Wang, S.**, Zhan, X., and Shen, J. (2022) "Offline Optimization of Sensor Configuration and Integration Architecture for Efficient Cooperative Navigation," *Aerospace Science and Technology* (SCI), 2022, 123: 107491. [PDF]
18. Shen, J., **Wang, S.,** Zhai, Y., and Zhan, X. (2021) "Cooperative Relative Navigation for Multi-UAV Systems by Exploiting GNSS and Peer-to-Peer Ranging Measurements," *IET Radar, Sonar and Navigation* (SCI), 2021, 15 (1): 21-36. [PDF]
19. Fu, Y., **Wang, S.,** Zhai, Y., and Zhan, X. (2020) "Visual Odometry Errors and Fault Distinction for Integrity Monitoring," *Aerospace Systems*, 2020, 3: 265-274. [PDF]
20. Liu, X., Zhan, X., **Wang, S.,** and Zhai, Y. (2020) "Measurement-Domain Cooperative Navigation for Multi-UAV Systems Augmented by Relative Positions," *Journal of Aeronautics, Astronautics and Aviation*, 2020, 52 (4): 403-416. [PDF]

• **Publications as a co-author**

21. Chang, J., Zhan, X., Zhai, Y., **Wang, S.**, and Yang, R., "Vector Angle Grouping-based Solution Separation for Multipath/NLOS Detection and Exclusion with the Enhancement of Doppler Test," GPS Solutions (SCI), 2022, 26(121). [PDF]
22. Liu, B., Gao Y., Gao, Y., and **Wang, S.** (2022) "HPL Calculation Improvement for Chi-squared Residual-based ARAIM," *GPS Solutions* (SCI), 2022, 26:45. [PDF]
23. Chang, J., Zhan, X., Zhai, Y. **Wang, S.,** and Lin, K. (2021) "Analysis of BDS GEO Satellite Multipath Effect for GNSS Integrity Monitoring in Civil Aviation", *Aerospace Systems*, 2021, 4: 133-141. [PDF]
24. Zhai, Y., Fu, Y., **Wang, S.,** and Zhan, X. (2021) "Mechanism Analysis and Mitigation of Visual Navigation System Vulnerability," *Proceedings of China Satellite Navigation Conference 2021* (CSNC 2021), Nanchang, Jiangsu, China, 2021. [PDF]
25. Zheng, L., Zhan, X., Zhang, X., **Wang, S.,** and Yuan, W. (2020) "Heading Estimation for Multi-Mode Pedestrian Dead Reckoning," *IEEE Sensors Journal* (SCI), 2020, 20 (15): 8731-8739. [PDF]
26. Chi, C., Zhan, X., **Wang, S.,** and Zhai, Y. (2020) "Enabling robust and accurate navigation for UAVs using real-time GNSS precise point positioning and IMU integration," *The Aeronautical Journal* (SCI), 2020, 125 (1283): 87-108. [PDF]
27. Pan, W., Zhan, X., Zhang, X., and **Wang, S.** (2019) "A Subset-Reduced Method for FDE ARAIM of Tightly-Coupled GNSS/INS," *Sensors* (SCI), 2019, 19 (22): 4847. [PDF]

Patents

1. Zhan, X., **Wang, S.,** Shen, J., Liu, X., Zhai, Y., Cooperative Relative Navigation Algorithm for Multi-UAV Systems based on GNSS Observations and Peer-to-Peer Ranging Measurements. CN111273687A, June 12, 2020.
2. Zhan, X., **Wang, S.,** Liu, X., Shen, J., Zhai, Y., A Cooperative Navigation Algorithm for Multi-Receiver Systems based on Virtual Centroid. CN111175797A, May 19, 2020.

Projects

• **Research Projects from Industry**

1. Design and Evaluation of Integrity Monitoring Algorithms for GNSS Precise Point Positioning - Real-time Kinematic (PPP-RTK). **Geely**, RMB 1,500,000, **Subtask Student Leader** *Aug 2021 - Dec 2022*

   Contributions: design integrity monitoring algorithms for PPP-RTK and implement them using C/C++; conduct experimental evaluation with over 50,000-kilometer data; write technical reports.
2. Performance Monitoring and Evaluation System for BeiDou/GPS Navigation Services at Shanghai Pudong Airport. **CAAC East China Regional Administration**, RMB 1,500,000, **Group Member** *Oct 2021 - Oct 2022*

   Contributions: revise the proposal; guide students for SISRE evaluation
3. Multi-Sensor Integrated Navigation System with High Integrity for Autonomous Urban Air Mobility. **Honeywell Technology Solution China**, RMB 400,000, **Student Leader** *Aug 2019 - Dec 2020*

   Contributions: design and validate integrity monitoring schemes for visual navigation system; design integrity monitoring algorithm for GNSS/INS/Vision integrated navigation systems; write reports.
4. Multi-UAV Cooperative Navigation and Control for Urban Applications. **SJTU Global Strategic Partnership Fund (2019 SJTU-University of Toronto)**, RMB 75,000, **Group Member** *Jun 2019 - Jun 2020*

   Contributions: prototype a multi-UAV test platform with GNSS, IMU, and UWB; write technical reports.

5. Multi-Constellation GNSS Integrity for Aviation. **Honeywell Technology Solution China**, RMB 300,000, **Group Member** *Aug 2016 - Oct 2017*

   Contributions: evaluate the advanced receiver autonomous integrity monitoring algorithm; design fault detection and exclusion algorithms for GNSS/INS tight integration; establish flight test platform; write reports.

- **Research Projects from Governments**

1. Research on Time Sequential Integrity Monitoring for GNSS/INS/VO Integrated Navigation. **Natural Science Foundation of China**, RMB 300,000, **Student Leader** *Jan 2022 - Dec 2024*

   Contributions: review the proposal; investigate multi-sensor integrity monitoring algorithms; guide students.

2. Event-Driven Dynamic Programming of Fusion Topology for Large-Scale Swarm Cooperative Navigation. **Natural Science Foundation of China**, RMB 570,000, **Student Leader** *Jan 2022 — Dec 2025*

   Contributions: write and revise the proposal; provide technical road map; guide students.

3. Trustworthy Navigation Services for Wide-Area Intelligent Transportation Systems. **National Key Research and Development Program**, RMB 3,000,000, **Group Member** *Sep 2022 - Sep 2025*

   Contributions: review the proposal; design the multi-sensor integrity monitoring algorithm.

- **Research Projects from Our Laboratory**

1. Implementation of a Pose Reference System for Demonstrating Multi-Sensor Integrated Navigation Algorithms. GNC Laboratory, **Leader** *May 2021 - Jul 2021*

   Contributions: establish a platform to collect data from GNSS, IMUs, and cameras with hardware time synchronization (sync error is below 1ms)

2. Design and Implementation of a MATLAB-Unreal Engine Simulation Platform for Multi-Agent Cooperative Navigation. GNC Laboratory, **Leader** *Jun 2021 - Sep 2021*

   Contributions: provide a simulation platform to simulate the observation data from multiple sensors (including GNSS, IMU, cameras, and UWB) in multi-agent systems under different 3D scenarios.

- **Undergraduate Projects**

1. Localization-based Service Systems for Ships by Employing Beidou Short Messages and WeChat Mini Programs. Undergraduate Research Programs of SJTU, **Group Leader**, Score: Excellent. *Jan 2017 - Dec 2017*
2. Enabling Indoor Navigation for Unmanned Aerial Vehicles based on Optical Flow. The 13th National Undergraduate Innovation Program, **Group Leader**, Score: Excellent *Jun 2016 - Jun 2017*
3. Prototyping Vertical Take-off and Landing Unmanned Aerial Vehicles. Shanghai Undergraduate Innovation Program, **Group Member**, Score: Excellent *Jan 2015 - Jan 2016*

Professional Activities

- **Membership:** IEEE student member, student member of Chinese Society of Aeronautics and Astronautics, student member of Chinese Association of Automation
- **Peer Review:** Submitted about 50 peer-review reports to journals and conferences, including (1) Aerospace Science and Technology, (2) IEEE Transactions on Aerospace and Electronic Systems, (3) Journal of Navigation, (4) International Journal of Distributed Sensor Networks, (5) IET Radar Sonar and Navigation, (6) IEEE Sensors Journal, (7) Measurement Science and Technology (**Outstanding Reviewer Award 2022**), (8) Geo-spatial Information Science, (9) Aerospace Systems, and (10) Chinese Automation Congress.
- **Supervising Students:**
  1. **Jiawen Shen: M.S.**, supervising her research on cooperative navigation and integrity, *Sep 2019 - Mar 2023*
     Excellent Bachelor Thesis Award (Top 1%);
     Master thesis: *Multi-UAV Cooperative Navigation Based on Clustering Fusion Structure*
  2. **Xiyu Liu: M.S.**, supervising her research on cooperative navigation, *Sep 2019 - Mar 2023*
     Master thesis: *Distributed Multi-Agent Cooperative Navigation Based on Kalman Consensus Filter*
  3. **Hanyu Wang: Ph.D. student**, supervising his research on cooperative navigation, *Sep 2019 - Present*
     Bachelor's thesis: *Optimal Sensor Configuration of Cooperative Navigation Based on Required Performance*

Research Summary

Background: My research goal is achieving high-accuracy and high-integrity navigation for safety-critical applications. Integrity measures the trust that can be placed on the navigation solution. Integrity monitoring is a technique to ensure navigation integrity. It includes the fault detection & exclusion (FDE) capability and offers an upper bound on the navigation error with a high confidence level (e.g., 99.99999%).

My contributions are:

1. Characterizing signal-in-space range errors of Beidou from an integrity perspective.
2. Designing FDE and integrity monitoring algorithms for multi-sensor navigation against all sources of faults and implementing them for (a) GNSS (including RTK and PPP-RTK), (b) visual navigation, (c) GNSS/INS tight integration, (d) GNSS/INS with redundant IMUs, (e) GNSS/INS/VO integration, etc.
3. Developing a Bayesian receiver autonomous integrity monitoring approach with the state-of-the-art performance.
4. Leading the research on efficient and reliable multi-agent cooperative navigation in our lab.
5. Prototyping a multi-sensor integrated navigation platform with GNSS, IMU, and Cameras.

Skills Summary

- **Personality**: Responsible and Highly Efficient, Self-Motivated Quick Learner, Good Team Player and Leader
- **Navigation Fundamentals**: Satellite Navigation (SPP/PPP/RTK/PPP-RTK), Inertial Navigation, Visual Navigation, Multi-Sensor integrated Navigation (e.g., GNSS/INS), Cooperative Navigation, Kalman Filter, Factor Graph Optimization
- **Mathematical Skills**: Probability (A+), Statistics (A+), Calculus (A), Matrix (A), Computational Method (A)
- **Coding and Hands-on Experience**: MATLAB, Python, C, Linux, ROS, STM32, PCB Design, UAV
- **Languages**: Chinese(native speaker); English

Honors and Awards

• Scholarships

1. Excellent Graduate Student Scholarship, *Shanghai Jiao Tong University*, 2022.
2. Zhao Zhu Mulan Scholarship, *Shanghai Jiao Tong University*, 2021.
3. National Scholarship for Graduate Students (ranked 1st among about 300 graduate students), *Ministry of Education of China*, 2020.
4. Leo Ko-guan Scholarship, *Shanghai Jiao Tong University*, 2018.
5. Luo Mai Scholarship, *Shanghai Jiao Tong University*, 2017.
6. Fan Hsu-chi Scholarship (only 10 students per year), *Shanghai Jiao Tong University*, 2016

• Honors

1. IOPP Outstanding Reviewer Award (top 30 over thousands of reviewers), *Measurement Science and Technology*, 2022.
2. Best Student Paper Award (third prize), *China Satellite Navigation Conference*, 2022.
3. Excellent Undergraduate Student Award of Shanghai (top 1%), *Shanghai Municipal Education Commission*, 2018.
4. Excellent Bachelor Thesis Award (ranked top 39 among 5000 students), *Shanghai Jiao Tong University*, 2018.
5. Excellent Student Award, *Shanghai Jiao Tong University*, 2016, 2017, 2020.

• Competition Awards

1. Special Award (Ranked 1st among hundreds of teams) of the College Student AI+ Self-Driving Car Contest, *Chinese Association for Artificial Intelligence*, 2018.
   Task: developing an autonomous lane-tracking algorithm and deploying it in a toy car.
2. The Most Creative Award in Honeywell's Aerospace Innovation Competition, *Honeywell Technology Solution China*, 2016.
   Submission: Autonomous Navigation and Control of UAV based on Optical Flow.
3. Honorable Mention in *American Mathematical Contest in Modeling*, 2017.
4. Second Prize in *Chinese Mathematical Contest in Modeling*, 2016.
5. First Prize in *Shanghai Undergraduate Physics Competition*, 2015.