

# Guoquan (Paul) Huang

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## Research Interests

- Robotics** Sensing, localization, mapping, SLAM, perception, navigation, locomotion  
**Control** State estimation, nonlinear programming, optimal control, reinforcement learning  
**Vision/AI** SFM, 3D reconstruction, scene understanding, spatial computing, deep learning

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## Education & Training

- 2012 – 2014 **Postdoctoral Associate**, *MIT CSAIL*, Cambridge, MA.  
Advisor: John J. Leonard
- 2012 **PhD Computer Science**, *University of Minnesota*, Minneapolis, MN.  
Advisor: Stergios I. Roumeliotis
- 2009 **MS Computer Science**, *University of Minnesota*, Minneapolis, MN.
- 2005 **Research Assistant (Electrical Engineering)**, *Hong Kong Polytechnic University*.  
Advisors: Ahmad B. Rad and Yiu-Kwong Wong
- 2002 **BS Automation (Electrical Engineering)**, *University of Science and Technology Beijing*.

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## Appointments & Positions

- 2020 – now **Associate Professor**, *University of Delaware (UD)*, Newark, DE.
- 2014 – 2020 **Assistant Professor**, *University of Delaware (UD)*, Newark, DE.  
Dept. of Mechanical Engineering  
Dept. of Computer and Information Sciences  
Dept. of Electrical and Computer Engineering  
**Research Lab: Robot Perception and Navigation Group (RPNG)**.  
Web: <https://sites.udel.edu/robot>  
GitHub: <https://github.com/rpng>  
YouTube: <https://www.youtube.com/c/rpng-ud>
- 2020 – now **Principal Scientist**, *Meituan*, Santa Clara, CA.
- 2017 – 2022 **Adjunct Professor**, *Zhejiang University (ZJU)*, Hangzhou, China.
- 2016 – 2018 **Senior Consultant**, *Huawei 2012 Laboratories*, Toronto, Canada.
- 2014 – 2015 **Technical Consultant**, *DAQRI*, Los Angeles, CA.
- 2012 – 2014 **Postdoctoral Associate**, *MIT, CSAIL (Marine Robotics)*, Cambridge, MA.
- 2005 – 2012 **Research Assistant**, *University of Minnesota (UMN), MARS Lab*, Minneapolis, MN.
- 2003 – 2005 **Research Assistant**, *Hong Kong Polytechnic University (HKPU), EE Dept*, Hong Kong.

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## Teaching

- Spring 2024 **UD MEEG 677: Estimation I**.  
Fall 2023 **UD MEEG 311: Control Systems**.

Spring 2023 **UD MEEG 677: Estimation I.**  
 Fall 2022 **UD MEEG 877: Estimation II (Visual-Inertial Navigation).**  
 Spring 2020 **UD MEEG 677: Estimation I.**  
 Fall 2019 **UD MEEG 311: Vibration and Control.**  
 Spring 2019 **UD MEEG 677: Estimation I.**  
 Fall 2018 **UD MEEG 621: Linear Systems.**  
 Summer 2018 **ZJU CSC 3204006: Estimation Theory.**  
 Spring 2018 **UD MEEG 678: Introduction to Autonomous Driving.**  
 Fall 2017 **UD MEEG 311: Vibration and Control.**  
 Spring 2017 **UD MEEG 877: Optimal State Estimation.**  
 Spring 2017 **UD MEEG 467: Applied Controls, (co-teach).**  
 Fall 2016 **UD MEEG 311: Vibration and Control.**  
 Spring 2016 **UD MEEG 467: Applied Controls, (co-teach).**  
 Fall 2015 **UD MEEG 311: Vibration and Control.**  
 Spring 2015 **UD MEEG 624: Control of Dynamical Systems.**  
 Spring 2015 **UD MEEG 467: Applied Controls, (co-teach).**  
 Spring 2013 **MIT 2.004: Dynamics and Control II, (co-teach).**  
 2005 – 2009 UMN CS 2031: Introduction to Numerical Computing (TA)  
 Fall 2006 UMN CS 4011: Formal Languages and Automata Theory (TA)

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## Advising

### PhD Students.

2014 – 2019 **Kevin Eckenhoff, ME PhD**, Towards robust visual-inertial navigation.  
 Helwig Fellowship (2014-2019). Current: Research Scientist at Meta (Reality Labs).

2015 – 2021 **Yulin Yang, ME PhD**, Aided Inertial Navigation System: Analysis and Algorithms.  
 University Doctoral Fellowship (2019-2020), Current: Computer Vision Engineer at Apple.

2016 – 2021 **Xingxing Zuo, ZJU CSC PhD (co-advised with Liu)**, Lidar-inertial-camera fusion.  
 Current: Post-doc at TUM, Google, and Caltech.

2015 – 2022 **Zheng Huai, ME PhD**, Robocentric visual-inertial localization and mapping.  
 Current: Software Engineer at Google (ARCore).

2017 – 2023 **Patrick Geneva, CS PhD**, Visual-inertial navigation, NASA DE Space Grant Graduate Fellowship (2019-2021), University Doctoral Fellowship (2021-2022).  
 Current: Computer Vision Engineer at Apple.

2017 – 2023 **Woosik Lee, ME PhD**, Multisensor-aided inertial navigation, UD Summer Doctoral Award (2018).  
 Current: TBD.

2015 – now **James Maley, ECE PhD (part-time, co-advised with Zurakowski)**, Visual-inertial navigation.  
 Current: ARL Aerospace Engineer

2019 – now **Nathaniel Merrill, CS PhD**, Fast visual-inertial navigation.  
 AAUP-UD Student Award (2019)

2020 – now **Chuchu Chen, ME PhD**, Consistent visual-inertial estimation.

2021 – now **Yuxiang Peng, ME PhD**, Visual-inertial estimation and perception.

2021 – now **Chinmay Burgul, ME PhD**, Estimation and calibration for legged robots.

- 2021 – now **Abhijeet Kulkarni**, *ME PhD (co-advised with Poulakakis)*, Perceptive locomotion.
- 2022 – now **Saimouli Katragadda**, *CS PhD*, Visual-inertial perception.
- 2023 – now **Shenghao Zhou**, *CS PhD*, Multi-modal perception.

#### MS Students.

- 2017 – 2019 **Jesse Bloecker**, *ME MS*, Multi-camera visual-inertial odometry.  
Thereafter: Research Engineer at ARL Autonomous System Divisions
- 2020 – 2022 **Wenxuan (Owen) Li**, *MS Robotics*, Sensor calibration.  
Thereafter: Algorithm Engineer at Pimax

#### Visiting Scholars.

- 2020 – 2022 **Pengxiang Zhu**, *UC-Riverside*, Cooperative VINS.  
Thereafter: Applied Scientist at Amazon 126 Lab
- 2017 **Wanlong Li**, *Huawei Noah's Ark Lab*, SLAM.  
Thereafter: Engineer at Huawei
- 2016 **Dongxuan Li**, *Zhejiang University*, Camera-odometer calibration.  
Thereafter: Senior Project Engineer at NetEase

#### Undergraduates and HS Interns.

- 2023 – now **Jayden Thomas**, *ME BS*, Micro aerial vehicles.
- Summer 2023 **Jonas Ho**, *UPenn ME BS*, Micro aerial vehicles.
- 2021 – 2022 **Frank Doyle**, *ME BS*, Visual-inertial navigation.  
Thereafter: Engineer at ARL
- 2020 – 2021 **Zachary Zarett**, *ME BS*, Visual-inertial navigation.
- 2018 – 2019 **Tianyi Weng**, *ME BS*, LiDAR SLAM.  
Thereafter: MS at John Hopkins University
- 2016 – 2019 **Nate Merrill**, *CS BS*, Deep learning for visual SLAM.  
Outstanding CIS Senior Award (2019); Thereafter: PhD in my group
- Summer 2018 **Sybil Roosen**, *High-School Intern*, Autonomous driving.
- Summer 2018 **Christa Mumley**, *High-School Intern*, Autonomous driving.
- Summer 2017 **Louise Victoria Cancino**, *ME BS*, Autonomous driving.
- Summer 2017 **Grace Gong**, *High-School Intern*, Autonomous driving.  
Thereafter: Undergraduate at Princeton
- 2015 – 2017 **Patrick Geneva**, *ME/CS/Math BS*, Robot perception and navigation.  
Thereafter: PhD in my group
- 2016 – 2017 **Jesse Bloecker**, *ME BS*, MAV navigation.  
Thereafter: MS in my group
- Winter 2017 **Cory Dodd**, *ME BS*, UGV navigation.
- Winter 2017 **Parth Modi**, *ME BS*, MAV navigation.
- Winter 2017 **Sahil Parikh**, *ME BS*, UGV navigation.
- Winter 2017 **Joseph Koch**, *ME BS*, UGV navigation.
- Summer 2016 **Joel Tylecki**, *ME BS*, MAV navigation.

- 2015 – 2016 **Huayu Fu**, *ECE BS*, SLAM on Turtlebots.  
Thereafter: MS at USC
- 2015 – 2016 **Junpeng Zhu**, *ECE/ME MS (4+1)*, SLAM on Turtlebots.  
Thereafter: Engineer at Ladder Education Group
- Summer 2015 **Arnav Prasad**, *High-School Intern*, Visual SLAM.  
Thereafter: Undergraduate at UD

### Students Mentored at MIT.

- 2014 **Mukul Singh**, *ME undergraduate*, Dense visual localization and mapping.
- 2014 **Henry Nassif**, *EECS undergraduate*, Multi-robot cooperative SLAM.
- 2013 **Robert Truax**, *ME MS graduate*, Cooperative localization and target tracking.
- 2013 **Yasir Latif**, *Visiting PhD (Univ. of Zaragoza)*, Loop closure of visual navigation.
- 2013 **Hongchuan Wei**, *Visiting PhD (Duke)*, Decentralized motion planning.

## Publications

**Google Scholar:** <https://scholar.google.com/citations?user=trMUyZIAAAAJ>

**ORCID:** <https://orcid.org/0000-0001-9932-0685>

Note: ‡ refers to students or advisees and † to visiting scholars who perform research in my group.

### arXiv Preprints.

- [P2] Z. Wen, Y. Zhang, B. He, Z. Cui, W. Dai, L. Zhou<sup>‡</sup>, and **G. Huang**, “Selection Enhances Accuracy: Residual Classification by Sensitivity and Uncertainty Theory”, <https://arxiv.org/abs/2111.07723>
- [P1] P. Yin, S. Zhao, I. Cisneros, A. Abuduweili, **G. Huang**, M. Milford, C. Liu, H. Choset, and S. Scherer, “General Place Recognition Survey: Towards the Real-world Autonomy Age”, <https://arxiv.org/abs/2209.04497>

### Journal Articles.

- [J31] W. Lee<sup>‡</sup>, P. Geneva<sup>‡</sup>, C. Chen<sup>‡</sup>, and **G. Huang**, “MINS: Efficient and Robust Multisensor-aided Inertial Navigation System”, *International Journal of Robotics Research (IJRR)*, September 2023. [submitted]. <https://github.com/rpng/MINS>
- [J30] Z. Huai<sup>‡</sup>, and **G. Huang**, “A Consistent Parallel Estimation Framework for Visual-Inertial SLAM”, *IEEE Transactions on Robotics (TRO)*, December 2023. [revised].
- [J29] Y. Yang<sup>‡</sup>, P. Geneva<sup>‡</sup>, and **G. Huang**, “Multi-Visual-Inertial System: Analysis, Calibration and Estimation”, *International Journal of Robotics Research (IJRR)*, November 2023. [revised]. <https://arxiv.org/abs/2308.05303>
- [J28] Y. Yang<sup>‡</sup>, P. Geneva<sup>‡</sup>, X. Zuo<sup>‡</sup>, and **G. Huang**, “Online Self-Calibration for Visual-Inertial Navigation: Models, Analysis and Degeneracy”, *IEEE Transactions on Robotics (TRO)*, June 2023. doi:[10.1109/TRO.2023.3275878](https://doi.org/10.1109/TRO.2023.3275878)
- [J27] K. Baxevani<sup>‡</sup>, I. Yadav<sup>‡</sup>, Y. Yang<sup>‡</sup>, M. Sebok, H. Tanner, and **G. Huang**, “Resilient Ground Vehicle Autonomous Navigation in GPS-denied Environments”, *Guidance, Navigation and Control (GNC)*, November 2022. doi:<https://doi.org/10.1142/S2737480722500200> **[Best Overseas Paper Award]**
- [J26] X. Zuo<sup>‡</sup>, M. Zhang, Y. Chen, **G. Huang**, Y. Liu, and M. Li, “Visual-based Lifelong Kinematics and Pose Estimation for Skid-Steering Robots”, *IEEE Transactions on Automation Science and Engineering (TASE)*, October 2022. doi:[10.1109/TASE.2022.3214984](https://doi.org/10.1109/TASE.2022.3214984)

- [J25] Z. Huai<sup>‡</sup>, and **G. Huang**, “Square-Root Robocentric Visual-Inertial Odometry with On-line Spatiotemporal Calibration”, *IEEE Robotics and Automation Letters (RA-L)*, July 2022. doi:[10.1109/LRA.2022.3191209](https://doi.org/10.1109/LRA.2022.3191209)
- [J24] J. Lv, X. Zuo<sup>‡</sup>, K. Hu, J. Xu, **G. Huang**, and Y. Liu, “Observability-Aware Intrinsic and Extrinsic Calibration of LiDAR-IMU Systems”, *IEEE Transactions on Robotics (TRO)*, June 2022. doi:[10.1109/TRO.2022.3174476](https://doi.org/10.1109/TRO.2022.3174476)
- [J23] L. Zhou<sup>‡</sup>, S. Wang, J. Yu, **G. Huang**, and M. Kaess, “PLC-LiSLAM: LiDAR SLAM with Planes, Lines and Cylinders”, *IEEE Robotics and Automation Letters (RA-L)*, June 2022. doi:[10.1109/LRA.2022.3180116](https://doi.org/10.1109/LRA.2022.3180116)
- [J22] Y. Yang<sup>‡</sup>, C. Chu<sup>‡</sup>, W. Lee<sup>‡</sup>, and **G. Huang**, “Decoupled Right Invariant Error States for Consistent Visual-Inertial Navigation”, *IEEE Robotics and Automation Letters (RA-L)*, January 2022. doi:[10.1109/LRA.2021.3140054](https://doi.org/10.1109/LRA.2021.3140054)
- [J21] K. Eickenhoff<sup>‡</sup>, P. Geneva<sup>‡</sup>, and **G. Huang**, “MIMC-VINS: A Versatile and Resilient Multi-IMU Multi-Camera Visual-Inertial Navigation System”, *IEEE Transactions on Robotics (TRO)*, February 2021. doi:[10.1109/TRO.2021.3049445](https://doi.org/10.1109/TRO.2021.3049445)
- [J20] X. Zuo<sup>‡</sup>, W. Ye, Y. Yang<sup>‡</sup>, R. Zheng, T. Vidal-Calleja, **G. Huang**, and Y. Liu, “Multi-modal Localization: Stereo over LiDAR Map”, *Journal of Field Robotics (JFR)*, January 2020. doi:[10.1002/rob.21936](https://doi.org/10.1002/rob.21936)
- [J19] X. Zuo<sup>‡</sup>, P. Geneva<sup>‡</sup>, Y. Yang<sup>‡</sup>, W. Ye, Y. Liu, and **G. Huang**, “Visual-Inertial Localization with Prior LiDAR Map Constraints”, *IEEE Robotics and Automation Letters (RA-L)*, 4(4): 3394–3401, 2019. doi:[10.1109/LRA.2019.2927123](https://doi.org/10.1109/LRA.2019.2927123)
- [J18] Y. Yang<sup>‡</sup>, and **G. Huang**, “Observability Analysis of Aided Inertial Navigation with Heterogeneous Features of Points, Lines and Planes”, *IEEE Transactions on Robotics (TRO)*, 35(6): 1399–1418, December 2019. doi:[10.1109/TRO.2019.2927835](https://doi.org/10.1109/TRO.2019.2927835)
- [J17] K. Eickenhoff<sup>‡</sup>, Y. Yang<sup>‡</sup>, P. Geneva<sup>‡</sup>, and **G. Huang**, “Tightly-Coupled Visual-Inertial Localization and 3D Rigid-Body Target Tracking”, *IEEE Robotics and Automation Letters (RA-L)*, 4(2): 1541–1548, 2019. doi:[10.1109/LRA.2019.2896472](https://doi.org/10.1109/LRA.2019.2896472)
- [J16] Y. Yang<sup>‡</sup>, P. Geneva<sup>‡</sup>, K. Eickenhoff<sup>‡</sup>, and **G. Huang**, “Degenerate Motion Analysis for Aided INS with Online Spatial and Temporal Sensor Calibration”, *IEEE Robotics and Automation Letters (RA-L)*, 4(2): 2070–2077, 2019. doi:[10.1109/LRA.2019.2893803](https://doi.org/10.1109/LRA.2019.2893803)
- [J15] Z. Huai<sup>‡</sup>, and **G. Huang**, “Robocentric Visual-Inertial Odometry”, *International Journal of Robotics Research (IJRR)*, 41(7): 667–689, 2022. doi:[10.1177/0278364919853361](https://doi.org/10.1177/0278364919853361)
- [J14] K. Eickenhoff<sup>‡</sup>, P. Geneva<sup>‡</sup>, and **G. Huang**, “Closed-form Preintegration Methods for Graph-based Visual-Inertial Navigation”, *International Journal of Robotics Research (IJRR)*, 38(5): 563–586, 2019. doi:[10.1177/0278364919835021](https://doi.org/10.1177/0278364919835021)
- [J13] F. Han, H. Wang, **G. Huang**, and H. Zhang, “Sequence-Based Sparse Optimization Methods for Long-Term Loop Closure Detection in Visual SLAM”, *Autonomous Robots (AURO)*, 42(7): 1323–1335, 2018. doi:[10.1007/s10514-018-9736-3](https://doi.org/10.1007/s10514-018-9736-3)
- [J12] **G. Huang**, “Particle Filtering with Analytically Guided Sampling”, *Advanced Robotics (AR)*, 31(17): 932–945, 2017. doi:[10.1080/01691864.2017.1378592](https://doi.org/10.1080/01691864.2017.1378592)
- [J11] **G. Huang**, “Towards Consistent Filtering for Discrete-Time Partially-Observable Nonlinear Systems”, *Systems & Control Letters (SCL)*, 106: 87–95, 2017. doi:[10.1016/j.sysconle.2017.06.006](https://doi.org/10.1016/j.sysconle.2017.06.006)
- [J10] Y. Latif, **G. Huang**, J. Leonard, and J. Neira, “Sparse Optimization for Robust and Efficient Loop Closing”, *Robotics and Autonomous Systems (RAS)*, 93: 13–26, 2017. doi:[10.1016/j.robot.2017.03.016](https://doi.org/10.1016/j.robot.2017.03.016)

- [J9] X. Z. Zhang, A. B. Rad, **G. Huang**, and Y. K. Wong, “An Optimal Data Association Method Based on the Minimum Weighted Bipartite Perfect Matching”, *Autonomous Robots (AURO)*, 40(1): 77–91, 2016. doi:[10.1007/s10514-015-9439-y](https://doi.org/10.1007/s10514-015-9439-y)
- [J8] **G. Huang**, K. Zhou, N. Trawny, and S. I. Roumeliotis, “A Bank of Maximum A Posteriori (MAP) Estimators for Target Tracking”, *IEEE Transactions on Robotics (TRO)*, 31(1): 85–103, 2015. doi:[10.1109/TRO.2014.2378432](https://doi.org/10.1109/TRO.2014.2378432)
- [J7] **G. Huang**, M. Kaess, and J. Leonard, “Consistent Unscented Incremental Smoothing for Multi-robot Cooperative Target Tracking”, *Robotics and Autonomous Systems (RAS)*, 69: 52–67, 2015. doi:[10.1016/j.robot.2014.08.007](https://doi.org/10.1016/j.robot.2014.08.007)
- [J6] **G. Huang**, A. I. Mourikis, and S. I. Roumeliotis, “A Quadratic-Complexity Observability-Constrained Unscented Kalman Filter for SLAM”, *IEEE Transactions on Robotics (TRO)*, 29(5): 1226–1243, 2013. doi:[10.1109/TRO.2013.2267991](https://doi.org/10.1109/TRO.2013.2267991)
- [J5] **G. Huang**, N. Trawny, A. I. Mourikis, and S. I. Roumeliotis, “Observability-based Consistent EKF Estimators for Multi-robot Cooperative Localization”, *Autonomous Robots (AURO)*, 30(1): 99–122, 2011. doi:[10.1007/s10514-010-9207-y](https://doi.org/10.1007/s10514-010-9207-y)
- [J4] **G. Huang**, A. I. Mourikis, and S. I. Roumeliotis, “Observability-based Rules for Designing Consistent EKF SLAM Estimators”, *International Journal of Robotics Research (IJRR)*, 29(5): 502–528, 2010. doi:[10.1177/0278364909353640](https://doi.org/10.1177/0278364909353640)
- [J3] **G. Huang**, A. B. Rad, Y. K. Wong, and Y. L. Ip, “Heterogeneous Multisensor Fusion for Mapping Dynamic Environments”, *Advanced Robotics (AR)*, 21(5): 661–688, 2007. doi:[10.1163/156855307780108268](https://doi.org/10.1163/156855307780108268)
- [J2] X. Z. Zhang, A. B. Rad, Y. K. Wong, **G. Huang**, Y. L. Ip, and K. M. Chow, “A Comparative Study of Three Mapping Methodologies”, *Journal of Intelligent and Robotic Systems (JIRS)*, 49(4): 385–395, 2007. doi:[10.1007/s10846-007-9143-z](https://doi.org/10.1007/s10846-007-9143-z)
- [J1] **G. Huang**, A. B. Rad, and Y. K. Wong, “A New Solution to Map Building in Dynamic Indoor Environments”, *International Journal of Advanced Robotic Systems (IJARS)*, 3(3): 199–210, 2006. doi:[10.5772/5737](https://doi.org/10.5772/5737)

### Book Chapters.

- [B5] X. Zuo<sup>‡</sup>, M. Zhang, Y. Chen, Y. Liu, **G. Huang**, and M. Li, “Visual-Inertial Localization for Skid-steering Robots with Kinematic Constraints”, In *Robotics Research*, Springer Proceedings in Advanced Robotics. T. Asfour, E. Yoshida, J. Park, H. Christensen, O. Khatib (Eds.), Springer, 2022. doi:[10.1007/978-3-030-95459-8\\_45](https://doi.org/10.1007/978-3-030-95459-8_45)
- [B4] K. Eickenhoff<sup>‡</sup>, P. Geneva<sup>‡</sup> and **G. Huang**, “High-Accuracy Preintegration for Visual-Inertial Navigation”, In *Algorithmic Foundations of Robotics XII*, Springer Proceedings in Advanced Robotics. K. Goldberg, P. Abbeel, K. Bekris, and L. Miller (Eds.), Springer, 2020. doi:[10.1007/978-3-030-43089-4](https://doi.org/10.1007/978-3-030-43089-4)
- [B3] Y. Yang<sup>‡</sup>, and **G. Huang**, “Map-based Localization under Adversary Attacks”, In *Robotics Research*, Springer Proceedings in Advanced Robotics. N.M. Amato, G. Hager, S. Thomas, M. Torres-Torriti (Eds.), Springer, 2020. doi:[10.1007/978-3-030-28619-4\\_54](https://doi.org/10.1007/978-3-030-28619-4_54)
- [B2] **G. Huang**, K. Eickenhoff<sup>‡</sup>, and J. Leonard, “Optimal-State-Constraint EKF for Visual-Inertial Navigation”, In *Robotics Research*, Springer Proceedings in Advanced Robotics. A. Bicchi and W. Burgard (eds.), Springer, 2018. doi:[10.1007/978-3-319-51532-8\\_8](https://doi.org/10.1007/978-3-319-51532-8_8)
- [B1] **G. Huang**, A. I. Mourikis, and S. I. Roumeliotis, “A First-Estimates Jacobian EKF for Improving SLAM Consistency”, In *Experimental Robotics*, Vol. 54, Ser. Springer Tracts in Advanced Robotics, O., Khatib, V. Kumar, and G. Pappas (eds.), Springer, 2009. doi:[10.1007/978-3-642-00196-3\\_43](https://doi.org/10.1007/978-3-642-00196-3_43)

## Conference Papers.

- [C85] W. Lee<sup>‡</sup>, C. Chu<sup>‡</sup>, and **G. Huang**, “Degenerate Motions of Multisensor Fusion-based Navigation”, *International Conference on Robotics and Automation (ICRA)*, 2024. [submitted]
- [C84] S. Katragadda<sup>‡</sup>, W. Lee<sup>‡</sup>, Y. Peng<sup>‡</sup>, P. Geneva<sup>‡</sup>, C. Chu<sup>‡</sup>, C. Guo, M. Li, and **G. Huang**, “NeRF-VINS: A Real-time Neural Radiance Field Map-based Visual-Inertial Navigation System”, *International Conference on Robotics and Automation (ICRA)*, 2024. [submitted]
- [C83] Y. Peng<sup>‡</sup>, C. Chu<sup>‡</sup>, and **G. Huang**, “Quantized Visual-Inertial Odometry”, *International Conference on Robotics and Automation (ICRA)*, 2024. [submitted]
- [C82] Y. Peng<sup>‡</sup>, C. Chu<sup>‡</sup>, and **G. Huang**, “Ultrafast Square-Root Filter-based VINS”, *International Conference on Robotics and Automation (ICRA)*, 2024. [submitted]
- [C81] C. Chu<sup>‡</sup>, Y. Peng<sup>‡</sup>, and **G. Huang**, “Fast and Consistent Covariance Recovery for Sliding-window Optimization-based VINS”, *International Conference on Robotics and Automation (ICRA)*, 2024. [submitted]
- [C80] J. Hu<sup>‡</sup>, X. Lang<sup>‡</sup>, F. Zhang<sup>‡</sup>, Y. Mao, and **G. Huang**, “Square-Root Inverse Filter-based GNSS-Visual-Inertial Navigation”, *International Conference on Robotics and Automation (ICRA)*, 2024. [submitted]
- [C79] C. Chu<sup>‡</sup>, P. Geneva<sup>‡</sup>, Y. Peng<sup>‡</sup>, W. Lee<sup>‡</sup>, and **G. Huang**, “Optimization-based VINS: Consistency, Marginalization, and FEJ”, *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2023.
- [C78] N. Merrill<sup>‡</sup>, P. Geneva<sup>‡</sup>, S. Katragadda<sup>‡</sup>, C. Chu<sup>‡</sup>, and **G. Huang**, “Fast Monocular Visual-Inertial Initialization Leveraging Learned Single-View Depth”, *Robotics: Science and Systems (RSS)*, 2023. <https://roboticsconference.org/program/papers/072/> [Best Student Paper Award Finalist].
- [C77] C. Chu<sup>‡</sup>, P. Geneva<sup>‡</sup>, Y. Peng<sup>‡</sup>, W. Lee<sup>‡</sup>, and **G. Huang**, “Monocular Visual-Inertial Odometry with Planar Regularities”, *International Conference on Robotics and Automation (ICRA)*, 2023. doi:[10.1109/ICRA48891.2023.10160620](https://doi.org/10.1109/ICRA48891.2023.10160620)
- [C76] L. Zhou<sup>‡</sup>, J. Sun, P. Ai<sup>‡</sup>, F. Zhai<sup>‡</sup>, K. Ren<sup>‡</sup>, Y. Mao, **G. Huang**, Z. Meng, and M. Kaess, “Efficient Bundle Adjustment for Coplanar Points and Lines”, *International Conference on Robotics and Automation (ICRA)*, 2023. doi:[10.1109/ICRA48891.2023.10160834](https://doi.org/10.1109/ICRA48891.2023.10160834)
- [C75] J. Hu<sup>‡</sup>, K. Ren<sup>‡</sup>, X. Xu<sup>‡</sup>, L. Zhou<sup>‡</sup>, X. Lang<sup>‡</sup>, Y. Mao, and **G. Huang**, “Efficient Visual-Inertial Navigation with Point-Plane Map”, *International Conference on Robotics and Automation (ICRA)*, 2023. doi:[10.1109/ICRA48891.2023.10160393](https://doi.org/10.1109/ICRA48891.2023.10160393)
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- [C1] **G. Huang**, A. B. Rad, and Y. K. Wong, “Incorporate Motion Tracking into Map Building in Dynamic Indoor Environments”, *International Conference on Computational Intelligence for Modeling Control and Automation (CICMA)*, 2004. pp. 241–251. <http://people.csail.mit.edu/ghuang/paper/hk/cimca04.pdf>

#### **Workshop Papers.**

- [W8] Y. Yang<sup>‡</sup>, W. Lee<sup>‡</sup>, P. Osteen, P. Geneva<sup>‡</sup>, X. Zuo<sup>‡</sup>, and **G. Huang**, “iCalib: Inertial Aided Multi-Sensor Calibration”, *ICRA Workshop on Visual-Inertial Navigation Systems*, 2021. <http://udel.edu/~ghuang/icra21-vins-workshop>
- [W7] P. Geneva<sup>‡</sup>, K. Eickenhoff<sup>‡</sup>, W. Lee<sup>‡</sup>, Y. Yang<sup>‡</sup>, and **G. Huang**, “OpenVINS: An Open Platform for Visual-Inertial Research”, *IROS Workshop on Visual-Inertial Navigation: Challenges and Applications*, 2019. <http://udel.edu/~ghuang/iros19-vins-workshop>
- [W6] Y. Yang<sup>‡</sup>, and **G. Huang**, “Attack-Resilient Map-based Localization”, *RSS Workshop on Adversarial Robotics*, 2018. [http://hcr.mines.edu/2018-rss-workshop/abstracts/RSS18WS\\_attack-resilient\\_map-based\\_localization.pdf](http://hcr.mines.edu/2018-rss-workshop/abstracts/RSS18WS_attack-resilient_map-based_localization.pdf)
- [W5] K. Eickenhoff<sup>‡</sup>, I. Yadav, **G. Huang**, and H. Tanner, “Dynamic Target Interception in Cluttered Environments”, *ICRA RT-DUNE Workshop*, 2018. [https://manihsieh.com/wp-content/uploads/2018/06/UD\\_main.pdf](https://manihsieh.com/wp-content/uploads/2018/06/UD_main.pdf)
- [W4] P. Geneva<sup>‡</sup>, K. Eickenhoff<sup>‡</sup>, and **G. Huang**, “Asynchronous Multi-Sensor Fusion for 3D Mapping and Localization”, *Workshop on Planning, Perception and Navigation for Intelligent Vehicles*, 2017. <http://ppniv17.irccyn.ec-nantes.fr/session4/Geneva/paper.pdf>

- [W3] K. Eickenhoff<sup>‡</sup>, P. Geneva<sup>‡</sup>, and **G. Huang**, “High-Accuracy Preintegration for Visual Inertial Navigation”, *IROS Late Breaking Results (Poster)*, 2016. [https://ras.papercept.net/conferences/conferences/IROS16/program/IROS16\\_ContentListWeb\\_3.html](https://ras.papercept.net/conferences/conferences/IROS16/program/IROS16_ContentListWeb_3.html)
- [W2] K. Eickenhoff<sup>‡</sup>, L. Paull, and **G. Huang**, “Decoupled, Consistent Node Removal and Edge Sparsification for Graph-based SLAM”, *RSS Workshop on Geometry and Beyond: Representations, Physics, and Scene Understanding for Robotics*, 2016. <https://rss16-representations.mit.edu/>
- [W1] Y. Latif, **G. Huang**, J. Leonard, and J. Neira, “Applying Sparse  $\ell_1$ -Optimization to Problems in Robotics”, *ICRA Long-Term Autonomy Workshop*, 2014. <https://sites.google.com/site/icra2014ltaworkshop/>

### Dissertations.

- [D2] **G. Huang**, “Improving the Consistency of Nonlinear Estimators: Analysis, Algorithms, and Applications”, PhD Thesis, Department of Computer Science and Engineering, University of Minnesota - Twin Cities, Sep 2012. <https://conservancy.umn.edu/handle/11299/146717>
- [D1] **G. Huang**, “Dynamic Data Transmission in Industrial Control Systems”, BS Thesis (in Chinese), Department of Automation, School of Information Engineering, University of Science and Technology Beijing, China, Jul 2002.

### Open Sources (selected)

- MVIS **Multi-Visual-Inertial System: Analysis, Calibration and Estimation**, *IJRR 2023*.  
<https://openmvis.com>
- MINS **Efficient and Robust Multisensor-aided Inertial Navigation System**, *IJRR 2023*.  
<https://github.com/rpng/mins>
- OV\_PLANE **Monocular Visual-Inertial Odometry with Planar Regularities**, *ICRA 2023*.  
[https://github.com/rpng/ov\\_plane](https://github.com/rpng/ov_plane)
- OpenVINS **An Open Research Platform for Visual-Inertial Estimation**, *ICRA 2020, IROS-WS 2019*.  
[https://github.com/rpng/open\\_vins](https://github.com/rpng/open_vins)
- CPI **Closed-form Preintegration for Graph-based VINS**, *WAFR 2016, IJRR 2019*.  
<https://github.com/rpng/cpi>
- R-VIO **Robocentric Visual-Inertial Odometry**, *IROS 2018, IJRR 2022, RA-L 2022*.  
<https://github.com/rpng/r-vio>  
<https://github.com/rpng/r-vio2>
- SUO-SLAM **Symmetry and Uncertainty-Aware Object SLAM**, *CVPR 2022*.  
<https://github.com/rpng/suo-slam>
- CALC **Deep Learning for Loop Closure**, *RSS 2018, IROS 2019*.  
<https://github.com/rpng/calc>  
<https://github.com/rpng/calc2.0>
- OC-EKF **Observability-Constrained (OC)-EKF for 2D SLAM**, *IJRR 2010*.  
<https://github.com/rpng/ocekf-slam>

### Invited Talks

- [T63] “Visual-Inertial Estimation and Learning”, Mohamed bin Zayed University of Artificial Intelligence (MBZUAI) Workshop on Reuniting AI Research in NLP, CV, and Robotics, February 2024

- [T62] “Visual-Inertial Systems: Sensing, Estimation, Perception, and Navigation”, HK PolyU, June 2023
- [T61] “Visual-Inertial Systems: Sensing, Estimation, Perception, and Navigation”, Tesla, February 2023
- [T60] “Visual-Inertial Systems: Sensing, Estimation, Perception, and Navigation”, Wing, February 2023
- [T59] “Visual-Inertial Systems: Sensing, Estimation, Perception, and Navigation”, UD Mobility Forum, January 2023
- [T58] “Visual-Inertial Estimation and Perception for Autonomous Vehicles”, IEEE ITSC 2022 Workshop: Intelligent Vehicle Meets Urban: Safe and Certifiable Navigation and Control for Intelligent Vehicles in Complex Urban Scenarios, October 2022
- [T57] “Visual-Inertial Systems: Sensing, Estimation, Perception and Navigation”, Amazon Computer Vision Conference, August 2022
- [T56] “Visual-Inertial Systems: Sensing, Estimation, Perception and Navigation”, China SLAM Tech Forum, July 2022
- [T55] “Visual-Inertial Systems: Estimation, Perception and Navigation”, International Summit Forum of Engineering Science and Technology on Beidou Navigation and Location Service in Intelligent Era and Beidou Intelligent Application Conference, July 2022
- [T54] “Visual-Inertial Estimation and Perception”, ICRA Workshop on Robotic Perception and Mapping: Emerging Techniques, May 2022
- [T53] “Visual-Inertial Systems: Estimation, Perception and Navigation”, Nankai Univ., Dec. 2021
- [T52] “Visual-Inertial SLAM and Spatial AI”, CAA Youth e-Summit, Jul. 2021
- [T51] “Visual-Inertial SLAM and Spatial AI”, China 3DV, Jul. 2021
- [T50] “Visual-Inertial Estimation and Perception”, CMU Robotics (AirLab SLAM Seminar), Jul. 2021
- [T49] “Visual-Inertial Estimation and Perception”, CAS Institute of Automation, May 2021
- [T48] “Visual-Inertial Estimation and Perception”, Shanghai Tech, April 2021
- [T47] “Visual-Inertial State Estimation and Perception for Autonomous Vehicles”, UC Berkeley (Semi-autonomous Seminar), Mar. 2021
- [T46] “Visual-Inertial SLAM”, Tsinghua University, Feb. 2021
- [T45] “Visual-Inertial State Estimation and Perception for Autonomous Vehicles”, HEU, Dec. 2020
- [T44] “Visual-Inertial Navigation”, The 3rd Chinese SLAM Summer School, Aug 2020 [Instructor]
- [T43] “Visual-Inertial State Estimation and Perception for Autonomous Vehicles”, UBTECH North America R&D Center, Jun 2020
- [T42] “Visual-Inertial State Estimation and Perception for Autonomous Vehicles”, UT Austin, Apr 2020
- [T41] “Visual-Inertial State Estimation and Perception for Autonomous Vehicles”, Georgia Tech, Mar 2020
- [T40] “Visual-Inertial State Estimation and Perception for Autonomous Vehicles”, Yale, Mar 2020
- [T39] “Visual-Inertial State Estimation and Perception for Autonomous Vehicles”, Purdue, Feb 2020
- [T38] “Visual-Inertial State Estimation and Perception for Autonomous Vehicles”, UIUC, Feb 2020
- [T37] “Visual-Inertial State Estimation and Perception for Autonomous Vehicles”, Google, Jan 2020
- [T36] “Visual-Inertial State Estimation and Perception”, John Hopkins Univ. (LCSR Seminar), Nov 2019
- [T35] “Visual-Inertial State Estimation”, UBTECH Robotics, Nov 2019
- [T34] “Visual-Inertial State Estimation”, Tsinghua University (Dept. Precision Instrument), Oct 2019
- [T33] “State Estimation and SLAM”, Chinese SLAM Tech Forum, Jul 2019 [Key Speaker]
- [T32] “Visual-Inertial State Estimation”, The 2nd Chinese SLAM Summer School, Jul 2019 [Instructor]
- [T31] “State Estimation and Autonomous Navigation”, Geekplus, Jun 2019

- [T30] “State Estimation and Autonomous Navigation”, Trifo, Apr 2019.
- [T29] “State Estimation and Autonomous Navigation”, Google ARCore, Apr 2019.
- [T28] “State Estimation and Autonomous Navigation”, Bosch Research, Apr 2019.
- [T27] “Towards Autonomous Navigation in the Wild”, Beijing Sineva, Dec 2018.
- [T26] “Towards Autonomous Navigation in the Wild”, Zhejiang University (CS), Jul 2018.
- [T25] “Towards Autonomous Navigation in the Wild”, HK Univ. of Science and Technology (RI), Jun 2018.
- [T24] “Towards Autonomous Navigation in the Wild”, Zhejiang University (CSC), Jun 2018.
- [T23] “Towards Autonomous Navigation in the Wild”, Zhejiang Sci-Tech University, Jun 2018.
- [T22] “Towards Secure, Efficient and Consistent Robot Navigation”, University of Michigan, Mar 2018.
- [T21] “Localization and Mapping for Autonomous Driving”, UD IDEA Network Faculty Social, Oct 2017.
- [T20] “Visual-Inertial Navigation”, NetEase Inc., Aug 2017.
- [T19] “Mapping and Localization in the Wild”, Zhejiang University (CSC), Aug 2017.
- [T18] “Visual-Inertial Perception”, Huawei Canada Research Center, Aug 2016.
- [T17] “Consistent Visual-Inertial Navigation”, Zhejiang University (CSC), Jul 2016.
- [T16] “Towards Consistent Robot Navigation”, Beijing Institute of Technology, Jan 2016.
- [T15] “Towards Consistent Robot Navigation”, Zhejiang University (CSC), Dec 2015.
- [T14] “Towards Consistent Robot Navigation”, University of Delaware (ECE), Dec 2015.
- [T13] “Towards Consistent Robot Navigation”, Army Research Laboratory (APG), Oct 2015.
- [T12] “Towards Consistent Robot Navigation”, University of Texas at Austin, Mar 2014.
- [T11] “Towards Consistent Robot Navigation”, University of Delaware, Mar 2014.
- [T10] “Towards Consistent Robot Navigation”, SUNY - Buffalo, Mar 2014.
- [T9] “Towards Consistent Robot Navigation”, University of Nevada, Mar 2014.
- [T8] “Towards Consistent Robot Navigation”, University of Michigan, Mar 2014.
- [T7] “Towards Consistent Robot Navigation”, Duke University, Feb 2014.
- [T6] “Towards Consistent Robot Navigation”, Google, Mountain View, CA, Dec 2013.
- [T5] “Improving the Consistency of Nonlinear Estimators: Analysis, Algorithms, and Applications”, MIT CSAIL Marine Robotics Group, Nov 2012.
- [T4] “Consistency of Nonlinear Estimation in Robotics: Analysis, Algorithms, and Applications”, University of Macau, Jun 2012.
- [T3] “Consistency of Nonlinear Estimation in Robotics: Analysis, Algorithms, and Applications”, University of Michigan – Shanghai Jiao Tong University Joint Institute (UM-SJTU JI), May 2012.
- [T2] “Consistency of Nonlinear Estimation in Robotics: Analysis, Algorithms, and Applications”, University of Tennessee, Mar 2012.
- [T1] “Observability-Constrained Consistent Estimators for Robot Localization”, Peking University, State Key Lab of Machine Perception, Jun 2011.

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## Awards & Honors

- 2023 **Meta Faculty Research Award**, *Meta (Reality Labs, Project Aria)*.
- 2023 **World Top 2% Scientists (26,686/210,198)**, [Stanford University](#).
- 2023 **Best Student Paper Award Finalist**, *RSS 2023*.
- 2023 **Best Overseas Paper Award**, *Journal of Guidance, Navigation, and Control (GNC)*.
- 2022 **Google AI Faculty Research Award**, *Google*.

- 2022 **Best Paper Award (Navigation)**, *ICRA 2022*.
- 2021 **Faculty Award for Excellence in Research and Entrepreneurship, Honorable Mention**, *University of Delaware, College of Engineering*.
- 2021 **Best Paper Award Finalist (Robot Vision)**, *ICRA 2021*.
- 2020 **ARL SARA Award**, *US Army Research Laboratory*.
- 2020 **Nominated for Blavatnik National Awards for Young Scientists**, *New York Academy of Sciences*.
- 2020 **IEEE Senior Member**, *IEEE*.
- 2020 **Sigma Xi (Scientific Research Honor Society) Member**, *Sigma Xi*.
- 2019 **Champion for FPV Drone Racing VIO Competition**, *IROS 2019*.
- 2019 **Google AR/VR Faculty Research Award**, *Google*.
- 2018 **Google Daydream Faculty Research Award**, *Google*.
- 2018 **SATEC Robotics Delegation**, *Sino-American Technology & Engineering Conference (SATEC)*.
- 2017 **UD MakerGym Faculty Fellows**, *University of Delaware*.
- 2016 **NSF Research Initiation (CRII) Award**, *NSF*.
- 2015, 2023 **NASA DE Space Research Seed Award**, *NASA DE Space Grant Consortium*.
- 2015 **UDRF Research Award**, *University of Delaware Research Foundation*.
- 2013 **MIT Postdoctoral Association Travel Award**, *Office of MIT Vice President for Research*.
- 2012 **Chinese Government Award for Outstanding Self-Financed Students Abroad**, *CSC*.
- 2009 **Best Paper Award Finalist**, *RSS 2009*.
- 2006 **Academic Excellence Fellowship**, *University of Minnesota*.

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## Professional Service

- 2023 Mentor for FIRST Tech Challenge (Team: Green Lemons)
- 2023 Dutch Research Council (NWO) Reviewer
- 2015 – 2023 U.S. National Science Foundation (NSF) Panelist
- 2017 Canada Foundation for Innovation Reviewer
- 2016, 2018 Israeli Ministry of Science and Technology Reviewer
- 2014 – 2019 DE Homeland Security Advisory Council Unmanned Aerial Vehicle (UAV) Subcommittee

### Main Organizer:

- 2021 [ICRA 2021 Workshop on Visual-Inertial Navigation Systems](#)
- 2019 [ISMAR 2019 SLAM for AR Competition](#)
- 2019 [IROS 2019 Workshop on Visual-Inertial Navigation](#)

### Associate Editor:

- 2022 – now IEEE Transactions on Robotics (T-RO)
- 2018 – now IET Cyber-Systems and Robotics (CSR)
- 2019 – 2022 IEEE Robotics and Automation Letters (RA-L)
- 2017 – 2022 IROS (International Conference on Intelligent Robots and Systems)
- 2015 – 2022 ICRA (International Conference on Robotics and Automation)

### Guest Editor:

- 2021 – 2022 Sensors ([Special Issue on “State Estimation for Mobile Robotics”](#))



### **Editorial Board:**

- 2018 – now Virtual Reality and Intelligent Hardware
- 2016 – now Frontiers in Multi-Robot Systems

### **Program Committee:**

- 2014 – 2020 RSS (Robotics: Science and Systems Conference)
- 2017, 2019 IJCAI (International Joint Conference on Artificial Intelligence)
- 2018 AAAI (AAAI Conference on Artificial Intelligence)

### **Session Chair:**

- 2018 – 2023 IROS (International Conference on Intelligent Robots and Systems)
- 2018 – 2023 ICRA (International Conference on Robotics and Automation)
- 2013 ECMR (European Conference on Mobile Robots)
- 2004 RAM (IEEE Conference on Robotics, Automation and Mechatronics)

### **Reviewer:**

- Journal Reviewer Science Robotics, TRO (IEEE Transactions on Robotics), IJRR (International Journal of Robotics Research), TPAMI (IEEE Transactions on Pattern Analysis and Machine Intelligence), TASE (IEEE Transactions on Automation Science and Engineering), TAC (IEEE Transactions on Automatic Control), AURO (Autonomous Robots), JFR (Journal of Field Robotics) RAS (Robotics and Autonomous Systems), CVIU (Computer Vision and Image Understanding), SCL (Systems and Control Letters), JOE (IEEE Journal of Oceanic Engineering), etc.
- Conference Reviewer ICRA (IEEE International Conference on Robotics and Automation), IROS (IEEE/RSJ International Conference on Intelligent Robots and Systems), RSS (Robotics: Science and Systems Conference), ACC (American Control Conference), CDC (IEEE Conference on Decision and Control), MED (Mediterranean Conference on Control and Automation), ICCV (International Conference on Computer Vision), ECCV (European Conference on Computer Vision), CVPR (Computer Vision and Pattern Recognition), AAAI (AAAI Conference on Artificial Intelligence), IJCAI (International Joint Conference on Artificial Intelligence), etc.

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## **University Service**

- 2023 [UD AI Symposium](#) Planning Committee
- 2022 – 2023 ME Department Graduate Recruitment Committee
- 2015 – 2020 ME Department Undergraduate Curriculum Committee
- 2016 – now ME Graduate Admission Committee
- 2017 – now ME Faculty Search Committee
- 2014 – 2017 ME Department Publicity Committee
- 2015 – 2016 ME Department Seminar Committee (*chair*)
- PhD Thesis Committee Konstantinos Karydis (UD ME 2015, Advisor: Tanner), Jianxin Sun (UD ME 2016, Advisor: Tanner), Prasanna Kannappan (UD ME 2016, Advisor: Tanner), Yiyi Liao (ZJU CSC 2018, Advisor: Liu), Sushant Veer (UD ME 2018, Advisor: Poulakakis), Qiaosong Wang (UD CS 2019, Advisor: Rasmussen), Adam Stager (UD ME 2020, Advisor: Tanner), Bilin Sun (UD CS 2020, Advisor: Rasmussen), Chunbo Song (UD CS 2021, Advisor: Rasmussen), Indrajeet Yadav (UD ME 2020, Advisor: Tanner), Marc-Andre Begin (MIT AA 2022, Advisor: Hunter), Ashkan Zehfroosh (UD ME 2022, Advisor: Tanner), Hao Xu (HKUST ECE 2022, Advisor: Shen), Kunal Narkhede (UD ME 2023, Advisor: Poulakakis)

MS Thesis Saurabh Arora (UD ME 2016, Advisor: Tanner), Caili Li (UD ME 2017, Advisor: Tanner), Dian Jiao  
Committee (UD ME 2017, Advisor: Tanner), Anthony Rossi (UD ME 2018, Advisor: Poulakakis), Benjamin  
Remer (UD ME 2019, Advisor: Malikopoulos), GilHwan Kim (UD ME 2020, Advisor: Poulakakis)

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## Professional Membership

2006 – now IEEE, IEEE Senior Member (2020)  
2020 – now Sigma Xi (Scientific Research Honor Society)  
2020 – now ACM  
2020 – now AAAI

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## References

Available upon request.