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Guoquan (Paul) Huang

Research Interests

Robotics Sensing, localization, mapping, SLAM, perception, navigation, planning
Estimation Optimal control and estimation, estimation theory, nonlinear programming
CV Structure from motion, motion estimation, 3D reconstruction, scene understanding

Education & Training

2012 – 2014 **Postdoctoral Associate**, *MIT CSAIL (Marine Robotics)*, Cambridge, MA.
Advisor: John J. Leonard

2012 **PhD Computer Science**, *University of Minnesota*, Minneapolis, MN.
Advisor: Stergios I. Roumeliotis
[Thesis was successfully defended in Sep 2012, while the degree was officially awarded in Feb 2013.]

2009 **MS Computer Science**, *University of Minnesota*, Minneapolis, MN.

2002 **BS Automation (Electrical Engineering)**, *University of Science and Technology Beijing*, China.

Appointments

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 (joint)
Dept. of Electrical and Computer Engineering (joint)
Research Lab: Robot Perception and Navigation Group (RPNG).
WWW: https://sites.udel.edu/robot
GitHub: https://github.com/rpng
YouTube: https://www.youtube.com/c/rpng-ud

2017 – now **Adjunct Professor**, *Zhejiang University (ZJU)*, Hangzhou, China.

2020 – now **Principal Scientist**, *Meituan*, Santa Clara, CA.

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.
Advisor: John J. Leonard

2005 – 2012 **Research Assistant**, *University of Minnesota (UMN), MARS Lab*, Minneapolis, MN.
Advisor: Stergios I. Roumeliotis

2003 – 2005 **Research Assistant**, *Hong Kong Polytechnic University (HKPU), EE Dept*, Hong Kong.
Advisors: Ahmad Rad and Yiu-Kwong Wong

Teaching

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 621/421: Linear Systems**.
Summer 2018 **ZJU CSC 3204006: Estimation**.
Spring 2018 **UD MEEG 467/678: Introduction to Autonomous Driving**.
Fall 2017 **UD MEEG 311: Vibration and Control**.
Spring 2017 **UD MEEG 877: Estimation II (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 624/467: 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)
Spring 2004 HKPU EE: Control Laboratory Course (TA)

Student Advisement

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 of Stefan Leutenegger at TUM.

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

2017 – now **Patrick Geneva**, *CS PhD*, Visual-inertial estimation.
NASA DE Space Grant Graduate Fellowship (2019-2021), University Doctoral Fellowship (2021-2022)

2017 – now **Woosik Lee**, *ME PhD*, Multi-sensor fusion.
University Summer Doctoral Award (2018)

2019 – now **Nate Merrill**, *CS PhD*, Semantic mapping and localization.
AAUP-UD Student Award (2019)

2019 – now **Chuchu Chen**, *ME PhD*, State estimation and SLAM.

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

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

2022 – now **Saimouli Katragadda**, *CS PhD*, State estimation and spatial perception.

MS Students.

2017 – 2019 **Jesse Bloecker**, *ME MS*, Multi-camera visual-inertial odometry.
Current: Research Engineer at ARL Autonomous System Divisions

2020 – 2022 **Wenxuan (Owen) Li**, *MS Robotics*, Sensor calibration.
Current: Algorithm Engineer at Pimax

Visiting Scholars.

2020 – 2022 **Pengxiang Zhu**, *UC-Riverside*, Cooperative VINS.
Current: Applied Scientist at Amazon 126 Lab

2017 **Wanlong Li**, *Huawei Noah's Ark Lab*, SLAM.

2016 **Dongxuan Li**, *Zhejiang University*, Camera-odometer calibration.
Current: Senior Project Engineer at NetEase

Undergraduates and HS Interns.

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 **Yasir Latif**, *Visiting PhD student from Univ. of Zaragoza*, Loop closure of visual navigation.

2013 **Hongchuan Wei**, *Visiting PhD student from Duke*, Decentralized motion planning.

2013 **Robert Truax**, *ME MS student*, Cooperative localization and target tracking.

Publications

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

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

Journal Articles.

[J29] Y. Yang‡, P. Geneva‡, X. Zuo‡, and **G. Huang**, "Online Self-Calibration for Visual-Inertial Navigation: Models, Analysis and Degeneracy", *IEEE Transactions on Robotics (TRO)*, October 2022. [submitted]. https://arxiv.org/abs/2201.09170

[J28] 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", *IEEE Transactions on Robotics (TRO)*, September 2022. [submitted]. https://arxiv.org/abs/2209.04497

[J27] K. Baxevani, I. Yadav, Y. Yang‡, M. Sebok, H. Tanner, and **G. Huang**, "Resilient Ground Vehicle Autonomous Navigation in GPS-denied Environments", *Guidance, Navigation and Control (GNC)*, September 2022. [submitted].

[J26] X. Zuo‡, 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

[J25] Z. Huai‡, and **G. Huang**, "Square-Root Robocentric Visual-Inertial Odometry with Online Spatiotemporal Calibration", *IEEE Robotics and Automation Letters (RA-L)*, July 2022. doi:10.1109/LRA.2022.3191209

[J24] J. Lv, X. Zuo‡, 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

[J23] L. Zhou‡, 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

[J22] Y. Yang‡, C. Chu‡, W. Lee‡, 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

[J21] K. Eckenhoff‡, P. Geneva‡, 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

[J20] X. Zuo‡, W. Ye, Y. Yang‡, R. Zheng, T. Vidal-Calleja, **G. Huang**, and Y. Liu, "Multimodal Localization: Stereo over LiDAR Map", *Journal of Field Robotics (JFR)*, January 2020. doi:10.1002/rob.21936

[J19] X. Zuo‡, P. Geneva‡, Y. Yang‡, 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

[J18] Y. Yang[‡], 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

[J17] K. Eckenhoff[‡], Y. Yang[‡], P. Geneva[‡], 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

[J16] Y. Yang[‡], P. Geneva[‡], K. Eckenhoff[‡], 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

[J15] Z. Huai[‡], and **G. Huang**, "Robocentric Visual-Inertial Odometry", *International Journal of Robotics Research (IJRR)*, 41(7): 667–689, 2022. doi:10.1177/0278364919853361

[J14] K. Eckenhoff[‡], P. Geneva[‡], 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

[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

[J12] **G. Huang**, "Particle Filtering with Analytically Guided Sampling", *Advanced Robotics (AR)*, 31(17): 932–945, 2017. doi: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

[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

[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

[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

[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

[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

[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

[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

[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

[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

[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

Book Chapters.

[B5] X. Zuo‡, 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

[B4] K. Eckenhoff‡, P. Geneva‡ 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

[B3] Y. Yang‡, 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

[B2] **G. Huang**, K. Eckenhoff‡, 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

[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

Conference Papers.

[C75] C. Chu‡, P. Geneva‡, Y. Peng‡, W. Lee‡, and **G. Huang**, "Monocular Visual-Inertial Odometry with Planar Regularities", *International Conference on Robotics and Automation (ICRA)*, 2023. [submitted]

[C74] C. Chu‡, Y. Yang‡, P. Geneva‡, W. Lee‡, and **G. Huang**, "Visual-Inertial-aided Online MAV System Identification", *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2022.

[C73] N. Merrill‡, L. Guo, X. Huang, X. Zuo, S. Leutenegger, L. Ren, and **G. Huang**, "Symmetry and Uncertainty-Aware Object SLAM for 6DoF Object Pose Estimation", *Conference on Computer Vision and Pattern Recognition (CVPR)*, 2022. doi:10.1109/CVPR52688.2022.01448

[C72] J. Hu, J. Hu, Y-J. Shen, X. Lang, B. Zang, **G. Huang**, and Y. Mao, "1D-LRF Aided Visual-Inertial Odometry for High-Altitude MAV Flight", *International Conference on Robotics and Automation (ICRA)*, 2022. doi:10.1109/ICRA46639.2022.9811757

[C71] L. Zhou‡, **G. Huang**, Y. Mao, S. Wang, and M. Kaess, "EDPLVO: Efficient Direct Point-Line Visual Odometry", *International Conference on Robotics and Automation (ICRA)*, 2022. doi:10.1109/ICRA46639.2022.9812133 **[Outstanding Navigation Paper Award]**.

[C70] P. Geneva‡, and **G. Huang**, "Map-based Visual-Inertial Localization: A Numerical Study", *International Conference on Robotics and Automation (ICRA)*, 2022. doi:10.1109/ICRA46639.2022.9811829

[C69] W. Lee‡, Y. Yang‡, P. Geneva‡, and **G. Huang**, "Tightly-coupled GNSS-aided Visual-Inertial Localization", *International Conference on Robotics and Automation (ICRA)*, 2022. doi:10.1109/ICRA46639.2022.9811362

[C68] C. Chu[‡], Y. Yang[‡], P. Geneva[‡], and **G. Huang**, "FEJ2: A Consistent Visual-Inertial State Estimator Design", *International Conference on Robotics and Automation (ICRA)*, 2022. doi:10.1109/ICRA46639.2022.9811831

[C67] P. Zhu[†], P. Geneva[‡], W. Ren, and **G. Huang**, "Distributed Visual-Inertial Cooperative Localization", *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2021. doi:10.1109/IROS51168.2021.9636031

[C66] P. Zhu[†], Y. Yang[‡], W. Ren, and **G. Huang**, "Cooperative Visual-Inertial Odometry", *International Conference on Robotics and Automation (ICRA)*, 2021. doi:10.1109/ICRA48506.2021.9561674

[C65] W. Lee[‡], Y. Yang[‡], and **G. Huang**, "Efficient Multi-sensor Aided Inertial Navigation with Online Calibration", *International Conference on Robotics and Automation (ICRA)*, 2021. doi:10.1109/ICRA48506.2021.9561254

[C64] N. Merrill[‡], P. Geneva[‡], and **G. Huang**, "Robust Monocular Visual-Inertial Depth Completion for Embedded Systems", *International Conference on Robotics and Automation (ICRA)*, 2021. doi:10.1109/ICRA48506.2021.9561174

[C63] Z. Huai, and **G. Huang**, "Markov Parallel Tracking and Mapping for Probabilistic SLAM", *International Conference on Robotics and Automation (ICRA)*, 2021. doi:10.1109/ICRA48506.2021.9561238

[C62] X. Zuo[‡], N. Merrill[‡], W. Li, Y. Liu, M. Pollefeys, and **G. Huang**, "CodeVIO: Visual-Inertial Odometry with Learned Optimizable Dense Depth", *International Conference on Robotics and Automation (ICRA)*, 2021. **[Best Paper Finalist in Robot Vision]**. doi:10.1109/ICRA48506.2021.9560792

[C61] P. Geneva[‡], N. Merrill[‡], Y. Yang[‡], C. Chen[‡], W. Lee[‡], and **G. Huang**, "Versatile 3D Multi-Sensor Fusion for Lightweight 2D Localization", *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2020. doi:10.1109/IROS45743.2020.9341264

[C60] X. Zuo[‡], Y. Yang[‡], P. Geneva[‡], J. Lv, Y. Liu, **G. Huang**, and M. Pollefeys, "LIC-Fusion 2.0: LiDAR-Inertial-Camera Odometry with Sliding-Window Plane-Feature Tracking", *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2020. doi:10.1109/IROS45743.2020.9340704

[C59] W. Lee[‡], K. Eckenhoff[‡], Y. Yang[‡], P. Geneva[‡], and **G. Huang**, "Visual-Inertial-Wheel Odometry with Online Calibration", *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2020. doi:10.1109/IROS45743.2020.9341161

[C58] Y. Yang[‡], P. Geneva[‡], X. Zuo[‡], and **G. Huang**, "Online IMU Intrinsic Calibration: Is It Necessary?", *Robotics: Science and Systems (RSS)*, 2020. http://www.roboticsproceedings.org/rss16/p026.pdf

[C57] I. Yadav[‡], K. Eckenhoff[‡], **G. Huang**, and H. Tanner, "Motion Planning and Visual-Inertial Target Tracking for UAV-based Radiation Detection", *Mediterranean Conference on Control and Automation (MED)*, 2020. doi:10.1109/MED48518.2020.9183297

[C56] Y. Yang[‡], B. P. W. Babu, C. Chen[‡], **G. Huang**, and L. Ren, "Analytic Combined IMU Integrator for Visual-Inertial Navigation", *International Conference on Robotics and Automation (ICRA)*, 2020. doi:10.1109/ICRA40945.2020.9197280

[C55] W. Lee[‡], K. Eckenhoff[‡], P. Geneva[‡], and **G. Huang**, "Intermittent GPS-aided VIO: Online Initialization and Calibration", *International Conference on Robotics and Automation (ICRA)*, 2020. doi:10.1109/ICRA40945.2020.9197029

[C54] K. Eckenhoff[‡], P. Geneva[‡], N. Merrill[‡], and **G. Huang**, "Schmidt-EKF-based Visual-Inertial Moving Object Tracking", *International Conference on Robotics and Automation (ICRA)*, 2020. doi:10.1109/ICRA40945.2020.9197352

[C53] P. Geneva[‡], K. Eckenhoff[‡], W. Lee[‡], Y. Yang[‡], and **G. Huang**, "OpenVINS: An Open Platform for Visual-Inertial Research", *International Conference on Robotics and Automation (ICRA)*, 2020. doi:10.1109/ICRA40945.2020.9196524

[C52] X. Zuo[‡], M. Zhang, Y. Chen, Y. Liu, **G. Huang**, and M. Li, "Visual-Inertial Localization for Skid-steering Robots with Kinematic Constraints", *International Symposium on Robotics Research (ISRR)*, 2019. https://arxiv.org/abs/1911.05787

[C51] N. Merrill[‡], and **G. Huang**, "CALC2.0: Combining Appearance, Semantic and Geometric Information for Robust and Efficient Visual Loop Closure", *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2019. doi:10.1109/IROS40897.2019.8968159

[C50] X. Zuo[‡], P. Geneva[‡], W. Lee[‡], Y. Liu, and **G. Huang**, "LIC-Fusion: LiDAR-Inertial-Camera Odometry", *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2019. doi:10.1109/IROS40897.2019.8967746

[C49] Y. Yang[‡], P. Geneva[‡], K. Eckenhoff[‡], and **G. Huang**, "Visual-Inertial Navigation with Point and Line Features", *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2019. doi:10.1109/IROS40897.2019.8967905

[C48] P. Geneva[‡], J. Maley[‡], and **G. Huang**, "An Efficient Schmidt-EKF for 3D Visual-Inertial SLAM", *Conference on Computer Vision and Pattern Recognition (CVPR)*, 2019. pp. 12097–12107. doi:10.1109/CVPR.2019.01238

[C47] **G. Huang**, "Visual-Inertial Navigation: A Concise Review", *International Conference on Robotics and Automation (ICRA)*, 2019. pp. 9572–9582. doi:10.1109/ICRA.2019.8793604

[C46] Y. Yang[‡], P. Geneva[‡], X. Zuo[‡], K. Eckenhoff[‡], Y. Liu, and **G. Huang**, "Tightly-Coupled Aided Inertial Navigation with Point and Plane Features", *International Conference on Robotics and Automation (ICRA)*, 2019. pp. 6094–6100. doi:10.1109/ICRA.2019.8794078

[C45] K. Eckenhoff[‡], P. Geneva[‡], J. Bloecker[‡], and **G. Huang**, "Multi-Camera Visual-Inertial Navigation with Online Intrinsic and Extrinsic Calibration", *International Conference on Robotics and Automation (ICRA)*, 2019. pp. 3158–3164. doi:10.1109/ICRA.2019.8793886

[C44] K. Eckenhoff[‡], P. Geneva[‡], and **G. Huang**, "Sensor-Failue-Resilient Multi-IMU Visual-Inertial Navigation", *International Conference on Robotics and Automation (ICRA)*, 2019. pp. 3542–3548. doi:10.1109/ICRA.2019.8794295

[C43] P. Geneva[‡], K. Eckenhoff[‡], and **G. Huang**, " A Linear-Complexity EKF for Visual-Inertial Navigation with Loop Closures", *International Conference on Robotics and Automation (ICRA)*, 2019. pp. 3535–3541. doi:10.1109/ICRA.2019.8793836

[C42] Y. Yang[‡], and **G. Huang**, "Aided Inertial Navigation: Unified Feature Representations and Observability Analysis", *International Conference on Robotics and Automation (ICRA)*, 2019. pp. 3528–3534. doi:10.1109/ICRA.2019.8793507

[C41] J. Maley[‡], and **G. Huang**, "Unit Quaternion-based Parameterization for Point Features in Visual Navigation", *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2018. pp. 6880–6886. doi:10.1109/IROS.2018.8594206

[C40] P. Geneva[‡], K. Eckenhoff[‡], Y. Yang[‡], and **G. Huang**, "LIPS: LiDAR-Inertial 3D Plane SLAM", *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2018. pp. 123–130. doi:10.1109/IROS.2018.8594463

[C39] Z. Huai[‡], and **G. Huang**, "Robocentric Visual-Inertial Odometry", *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2018. pp. 6319–6326. doi:10.1109/IROS.2018.8593643

[C38] N. Merrill[‡], and **G. Huang**, "Lightweight Unsupervised Deep Loop Closure", *Robotics: Science and Systems (RSS)*, 2018. pp. 1–10. doi:10.15607/RSS.2018.XIV.032

[C37] P. Geneva[‡], K. Eckenhoff[‡], and **G. Huang**, "Asynchronous Multi-Sensor Fusion for 3D Mapping and Localization", *International Conference on Robotics and Automation (ICRA)*, 2018. pp. 5994–5999. doi:10.1109/ICRA.2018.8460204

[C36] Y. Yang[‡], and **G. Huang**, "Aided Inertial Navigation with Geometric Features: Observability Analysis", *International Conference on Robotics and Automation (ICRA)*, 2018. pp. 2334–2340. doi:10.1109/ICRA.2018.8460670

[C35] Y. Yang[‡], and **G. Huang**, "Map-based Localization under Adversary Attacks", *International Symposium on Robotics Research (ISRR)*, 2017. pp. 1–16. https://parasol.tamu.edu/isrr/isrr2017/papers/paper057.pdf

[C34] Y. Yang[‡], J. Maley[‡], and **G. Huang**, "Null-Space-based Marginalization: Analysis and Algorithm", *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2017. pp. 1775–1782. doi:10.1109/IROS.2017.8206592

[C33] X. Zuo[‡], J. Xie, Y. Liu, and **G. Huang**, "Robust Visual SLAM with Point and Line Features", *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2017. doi:10.1109/IROS.2017.8205991

[C32] D. Li[†], K. Eckenhoff[‡], K. Wu, Y. Wang, R. Xiong, and **G. Huang**, "Gyro-Aided Camera-Odometer Online Calibration and Localization", *American Control Conference (ACC)*, 2017. pp. 3579–3586. doi:10.23919/ACC.2017.7963501

[C31] K. Eckenhoff[‡], P. Geneva[‡], and **G. Huang**, "Direct Visual-Inertial Navigation with Analytical Preintegration", *IEEE International Conference on Robotics and Automation (ICRA)*, 2017. pp. 1429–1435. doi:10.1109/ICRA.2017.7989171

[C30] Y. Yang[‡], and **G. Huang**, "Acoustic-Inertial Underwater Navigation", *IEEE International Conference on Robotics and Automation (ICRA)*, 2017. pp. 4927–4933. doi:10.1109/ICRA.2017.7989571

[C29] K. Eckenhoff[‡], P. Geneva[‡], and **G. Huang**, "High-Accuracy Preintegration for Visual Inertial Navigation", *International Workshop on the Algorithmic Foundations of Robotics (WAFR)*, 2016. pp. 1–16. http://wafr2016.berkeley.edu/papers/WAFR_2016_paper_95.pdf

[C28] K. Eckenhoff[‡], L. Paull, and **G. Huang**, "Decoupled, Consistent Node Removal and Edge Sparsification for Graph-based SLAM", *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2016. pp. 3275–3282. doi:10.1109/IROS.2016.7759505

[C27] L. Paull, **G. Huang**, and J. Leonard, "A Unified Resource-Constrained Framework for Graph SLAM", *IEEE International Conference on Robotics and Automation (ICRA)*, 2016. pp. 1346–1353. doi:10.1109/ICRA.2016.7487268

[C26] P. Corcoran, P. Mooney, and **G. Huang**, "Unsupervised Trajectory Compression", *IEEE International Conference on Robotics and Automation (ICRA)*, 2016. pp. 3126–3132. doi:10.1109/ICRA.2016.7487479

[C25] **G. Huang**, K. Eckenhoff[‡], and J. Leonard, "Optimal-State-Constraint EKF for Visual-Inertial Navigation", *International Symposium on Robotics Research (ISRR)*, 2015. pp. 125–139. doi:10.1007/978-3-319-51532-8_8

[C24] K. Eckenhoff[‡], and **G. Huang**, "State-Transition and Observability Constrained EKF for Multi-robot Cooperative Localization", *Chinese Control Conference (CCC)*, 2015. pp. 7404–7410. doi:10.1109/ChiCC.2015.7260813

[C23] T. Steiner, **G. Huang**, and J. Leonard, "Location Utility-based Map Reduction", *IEEE International Conference on Robotics and Automation (ICRA)*, 2015. pp. 479–486. doi:10.1109/ICRA.2015.7139223

[C22] L. Paull, **G. Huang**, M. Seto, and J. Leonard, "Communication-Constrained Multi-AUV Cooperative SLAM", *IEEE International Conference on Robotics and Automation (ICRA)*, 2015. pp. 509–516. doi:10.1109/ICRA.2015.7139227

[C21] H. Wei, W. Lu, P. Zhu, **G. Huang**, J. Leonard, and S. Ferrari, "Visibility-based Motion Planning for Active Target Tracking and Localization", *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2014. pp. 76–82. doi:10.1109/IROS.2014.6942543

[C20] Y. Latif, **G. Huang**, J. Leonard, and J. Neira, "An Online Sparsity-Cognizant Loop-Closure Algorithm for Visual Navigation", *Robotics: Science and Systems Conference (RSS)*, 2014. pp. 1–9. doi:10.15607/RSS.2014.X.036

[C19] **G. Huang**, M. Kaess, and J. Leonard, "Towards Consistent Visual-Inertial Navigation", *IEEE International Conference on Robotics and Automation (ICRA)*, 2014. pp. 4926–4933. doi:10.1109/ICRA.2014.6907581

[C18] D. Rosen, **G. Huang**, and J. Leonard, "Inference Over Hybrid Finite-/Infinite-Dimensional Spaces Using Gaussian Processes and Factor Graphs", *IEEE International Conference on Robotics and Automation (ICRA)*, 2014. pp. 1261–1268. doi:10.1109/ICRA.2014.6907015

[C17] **G. Huang**, R. Truax, M. Kaess, and J. Leonard, "Unscented iSAM: A Consistent Incremental Solution to Cooperative Localization and Target Tracking", *European Conference on Mobile Robots (ECMR)*, 2013. pp. 248-254. doi:10.1109/ECMR.2013.6698850

[C16] **G. Huang**, M. Kaess, and J. Leonard, "Consistent Sparsification for Graph Optimization", *European Conference on Mobile Robots (ECMR)*, 2013. pp. 150–157. doi:10.1109/ECMR.2013.6698835

[C15] **G. Huang**, M. Kaess, J. Leonard, and S. I. Roumeliotis, "Analytically-Selected Multi-Hypothesis Incremental MAP Estimation", *International Conference on Acoustics, Speech, and Signal Processing (ICASSP)*, 2013. pp. 6481–6485. doi:10.1109/ICASSP.2013.6638914

[C14] **G. Huang**, and S. I. Roumeliotis, "On Filter Consistency of Discrete-Time Nonlinear Systems with Partial-State Measurements", *American Control Conference (ACC)*, 2013. pp. 5468–5475. doi:10.1109/ACC.2013.6580693

[C13] **G. Huang**, and S. I. Roumeliotis, "Analytically-Guided-Sampling Particle Filter Applied to Range-only Target Tracking", *IEEE International Conference on Robotics and Automation (ICRA)*, 2013. pp. 3168–3175. doi:10.1109/ICRA.2013.6631018

[C12] **G. Huang**, A. I. Mourikis, and S. I. Roumeliotis, "An Observability-Constrained Sliding Window Filter for SLAM", *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2011. pp. 65–72. doi:10.1109/IROS.2011.6095161

[C11] **G. Huang**, K. X. Zhou, N. Trawny, and S. I. Roumeliotis, "Bearing-only Tracking Using a Bank of MAP Estimators", *IEEE International Conference on Robotics and Automation (ICRA)*, 2011. pp. 4998–5005. doi:10.1109/ICRA.2011.5980515

[C10] **G. Huang**, K. X. Zhou, N. Trawny, and S. I. Roumeliotis, "A Bank of MAP Estimators for Single-Sensor Range-only Target Tracking", *American Control Conference (ACC)*, 2010. pp. 6974–6980. doi:10.1109/ACC.2010.5531337

[C9] **G. Huang**, N. Trawny, A. I. Mourikis, and S. I. Roumeliotis, "On the Consistency of Multi-robot Cooperative Localization", *Robotics: Science and Systems Conference (RSS)*, 2009. pp. 1–8. **[Best Paper Finalist]**. doi:10.15607/RSS.2009.V.009

[C8] **G. Huang**, A. I. Mourikis, and S. I. Roumeliotis, "On the Complexity and Consistency of UKF-based SLAM", *IEEE International Conference on Robotics and Automation (ICRA)*, 2009. pp. 4401-4408. doi:10.1109/ROBOT.2009.5152793

[C7] **G. Huang**, A. I. Mourikis, and S. I. Roumeliotis, "A First-Estimates Jacobian EKF for Improving SLAM Consistency", *International Symposium on Experimental Robotics (ISER)*, 2008. pp. 373-382. doi:10.1007/978-3-642-00196-3_43

[C6] **G. Huang**, A. I. Mourikis, and S. I. Roumeliotis, "Analysis and Improvement of the Consistency of Extended Kalman Filter based SLAM", *IEEE International Conference on Robotics and Automation (ICRA)*, 2008. pp. 473–479. doi:10.1109/ROBOT.2008.4543252

[C5] **G. Huang**, X. Z. Zhang, A. B. Rad, and Y. K. Wong, "An Optimal Graph Theoretic Approach to Data Association in SLAM", *IFAC World Congress*, 2008. pp. 14669-14674. doi:10.3182/20080706-5-KR-1001.02484

[C4] **G. Huang**, A. B. Rad, and Y. K. Wong, "Online SLAM in Dynamic Environments", *International Conference on Advanced Robotics (ICAR)*, 2005. pp. 262–267. doi:10.1109/ICAR.2005.1507422

[C3] **G. Huang**, A. B. Rad, and Y. K. Wong, "A Hierachical Hybrid Method for Simultaneous Localization and Mapping", *IFAC World Congress*, 2005. pp. 1–5. http://folk.ntnu.no/skoge/prost/proceedings/ifac2005/Papers/JsPaper2255.html

[C2] **G. Huang**, A. B. Rad, Y. K. Wong, and Y. L. Ip, "SLAM with MTT: Theory and Initial Results", *IEEE Conference on Robotics, Automation and Mechatronics (RAM)*, 2004. pp. 834–839. doi:10.1109/RAMECH.2004.1438026

[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‡, W. Lee‡, P. Osteen, P. Geneva‡, X. Zuo‡, 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‡, K. Eckenhoff‡, W. Lee‡, Y. Yang‡, 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‡, 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

[W5] K. Eckenhoff‡, 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

[W4] P. Geneva‡, K. Eckenhoff‡, 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. Eckenhoff‡, P. Geneva‡, 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

[W2] K. Eckenhoff[‡], 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 ℓ_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 Source

OpenVINS **An Open Research Platform for Visual-Inertial Estimation**, *ICRA 2020, IROS-WS 2019*.
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

[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 (Semiautonomous 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.

Awards and Honors

2022 **Outstanding Paper Award (Navigation)**, *ICRA 2022*.

2021 **Honorable Mention of Faculty Award for Excellence in Research and Entrepreneurship**, *University of Delaware College of Engineering*.

2021 **Best Paper Award Finalist (Robot Vision)**, *ICRA 2021*.

2020 **ARL SARA Award**, *Army Research Laboratory*.

2020 **IEEE Senior Member**, *IEEE*.

2020 **Sigma Xi (Scientific Research Honor Society) Member**, *Sigma Xi*.

2019 **Champion for the FPV Drone Racing VIO Competition**, *IROS 2019*.

2019 **NSF NRI Award**, *National Science Foundation*.

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)*.

[Invited by ASME as *one of ten* robotics experts from US to attend the event organized by China State Administration of Foreign Experts Affairs and Ministry of Science and Technology.]

2017 **UD MakerGym Faculty Fellows**, *University of Delaware*.

2016 **NSF CRII Award**, *NSF Computer and Information Science and Engineering (CISE)*.

2015 **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 the MIT Vice President for Research*.

2012 **Chinese Government Award for Outstanding Self-Financed Students Abroad**, *CSC*.

[This award is established by China Scholarship Council (CSC) to encourage research excellence and to recognize the achievement among Chinese students abroad. It is granted across all fields of study and all countries in the world, and was presented to only 495 out of over 440,000 Chinese oversea students all over the world in 2011.]

2009 **Best Paper Award Finalist**, *RSS 2009*.

2006 **Academic Excellence Fellowship**, *University of Minnesota*.

Academic Services

2015 – 2022 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

[International Conference on Robotics and Automation (ICRA) is one of the two flagship robotics conferences.]

2019 ISMAR 2019 SLAM for AR Competition

[International Symposium on Mixed and Augmented Reality (ISMAR) is the leading international academic conference in the fields of Augmented Reality and Mixed Reality, organized and supported by the IEEE Computer Society and IEEE VGTC.]

2019 IROS 2019 Workshop on Visual-Inertial Navigation

[International Conference on Intelligent Robots and Systems (IROS) is one of the two flagship robotics conferences.]

Associate Editor:

2022 – now IEEE Transactions on Robotics (T-RO)

2019 – now IEEE Robotics and Automation Letters (RA-L)

2018 – now IET Cyber-Systems and Robotics (CSR)

2017 – now IROS (International Conference on Intelligent Robots and Systems)

2015 – now ICRA (International Conference on Robotics and Automation)

Guess 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 – now IROS (International Conference on Intelligent Robots and Systems)

2018 – now 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), JIRS (Journal of Intelligent and Robotic Systems), IJARS (International Journal of Advanced Robotic Systems), IEEE-CYB (IEEE Transactions on Cybernetics), CVIU (Computer Vision and Image Understanding), SCL (Systems and Control Letters), JOE (IEEE Journal of Oceanic Engineering)

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)

University Services

2022 – now ME Department Graduate Recruitment Committee

2015 – 2020 ME Department Undergraduate Curriculum Committee

2016 – 2020 ME Graduate Admission Committee

2017 – 2019 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 , Advisor: Hunter), Ashkan Zehfroosh (UD ME 2022, Advisor: Tanner), Hao Xu (HKUST ECE 2022, Advisor: Shen)

MS Thesis Committee: Saurabh Arora (UD ME 2016, Advisor: Tanner), Caili Li (UD ME 2017, Advisor: Tanner), Dian Jiao (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)

Professional Membership

2006 – now IEEE, IEEE Senior Member (2020)

2020 – now Sigma Xi (Scientific Research Honor Society)

2020 – now ACM

2020 – now AAAI