

WOOSIK LEE

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EDUCATION

- University of Delaware, USA** *August 2017 – Present*
Ph.D. candidate in Mechanical Engineering
- Korea University, Republic of Korea** *August 2015 – July 2017*
M. A. in Mechanical Engineering
- Korea University, Republic of Korea** *August 2009 – July 2015*
B. S. in Mechanical Engineering

RESEARCH EXPERIENCE

- Robot Perception and Navigation Group, University of Delaware** *August 2017 – Present*
Research Assistant *Newark, DE*
- Simultaneous localization and mapping with multi-sensors (IMU, camera, GNSS, LiDAR, wheel)
 - Sensor calibration, system initialization, observability analysis, efficient estimator design
 - Machine learning technique application in robot perception and navigation
- Intelligent Systems and Robotics Laboratory, Korea University** *March 2015 - July 2017*
Research Assistant *Seoul, Korea*
- Map-based GNSS error modeling in urban environment for autonomous vehicles localization
 - Wheel intrinsic calibration for autonomous vehicles
- Telerobotics and Control Laboratory, KAIST** *May 2014 - August 2014*
Summer Internship *Daejeon, Korea*
- Human emotion classification with vision and machine-learning

PUBLICATIONS

[J] Journal Papers

- [J4] **Lee, W.**, Geneva, P., Chen, C., Huang, G., “MINS: Efficient and Robust Multi-sensor-aided Inertial Navigation System”. (Preprint, 2023).
- [J3] Geneva, P., Eckenhoff, K, **Lee, W.**, Huang, G., “Efficient and Consistent Filter-based Visual-Inertial SLAM”. (Preprint, 2023).
- [J2] Yang Y., Chen, C., **Lee, W.**, Huang, G., “Decoupled Right Invariant Error States for Consistent Visual-Inertial Navigation”. IEEE Robotics and Automation Letters (RA-L), 2022.
- [J1] **Lee, W.**, Cho, H., Hyeong, S., and Chung, W., “Practical Modeling of GNSS for Autonomous Vehicles in Urban Environments”. Sensors, 19(19), 4236. (2019).

[C] Conference Proceedings

- [C15] Katragadda, S., **Lee, W.**, Huang, G., “NeRF-VINS: A Real-time Neural Radiance Field Map-based Visual-Inertial Navigation System”. In: Proc. of the IEEE International Conference on Robotics and Automation. Yokohama, Japan, 2024. (Preprint).
- [C14] **Lee, W.**, Huang, G., “Degenerate Motion Analysis, Detection, and Constraint”. In: Proc. of the IEEE International Conference on Robotics and Automation. Yokohama, Japan, 2024. (Preprint).

- [C13] Chen, C., Geneva, P., Peng, Y., **Lee, W.**, Huang, G., “Optimization-based VINS: Consistency, Marginalization, and FEJ”. In: Proc. of the IEEE International Conference on Intelligent Robots and Systems. Michigan, USA. 2023
- [C12] Chen, C., Geneva, P., Peng, Y., **Lee, W.**, Huang, G., “Monocular Visual-Inertial odometry with Planar Regularities”. In: Proc. of the IEEE International Conference on Robotics and Automation. London, UK, 2023.
- [C11] Chen, C., Yang, Y., Geneva, P., **Lee, W.**, Huang, G., “Visual-Inertial-aided Online MAV System Identification”. In: Proc. of the IEEE International Conference on Intelligent Robots and Systems. Kyoto, Japan, 2022.
- [C10] **Lee, W.**, Geneva, P., Yang Y., Huang, G., “Tightly-coupled GNSS-aided Visual-Inertial Localization”. In: Proc. of the IEEE International Conference on Robotics and Automation. Philadelphia, USA, 2022.
- [C9] **Lee, W.**, Yang Y., Huang, G., “Efficient Multi-sensor Aided Inertial Navigation with Online Calibration”. In: Proc. of the IEEE International Conference on Robotics and Automation. Xi’an, China, 2021.
- [C8] **Lee, W.**, Eckenhoff K., Yang Y., Geneva, P., Huang, G., Visual-Inertial-Wheel Odometry with Online Calibration. In: Proc. of the IEEE International Conference on Intelligent Robots and Systems. Las Vegas, USA, 2020.
- [C7] Geneva, P., Merrill, N., Yang, Y., Chen, C., **Lee, W.**, Huang, G., “Versatile 3D Multi-Sensor Fusion for Lightweight 2D Localization”. In: Proc. of the IEEE International Conference on Intelligent Robots and Systems. Las Vegas, USA, 2020.
- [C6] **Lee, W.**, Eckenhoff, K., Geneva, P., Huang, G., “Intermittent GPS-aided VIO: Online Initialization and Calibration. In: Proc. of the IEEE International Conference on Robotics and Automation. Paris, France, 2020.
- [C5] Geneva, P., Eckenhoff, K., **Lee, W.**, Yang, Y., Huang, G., “OpenVINS: A Research Platform for Visual-Inertial Estimation. In: Proc. of the IEEE International Conference on Robotics and Automation. Paris, France, 2020.
- [C4] Zuo, X., Geneva, P., **Lee, W.**, Liu, Y., Huang, G., “LIC-Fusion: LiDAR-Inertial-Camera Odometry. IEEE/RSJ International Conference on Intelligent Robots and Systems, Macau, China, November 2019.
- [C3] **Lee, W.**, Chung, W., “Position estimation using multiple low-cost GPS receivers for outdoor mobile robots”. In 2015 12th International Conference on Ubiquitous Robots and Ambient Intelligence (pp. 460-461). IEEE.
- [C2] Jeon, J., **Lee, W.**, Cho, H. J., Lee, H., “A big data system design to predict the vehicle slip”. In 2015 15th International Conference on Control, Automation and Systems (pp. 592-596).
- [C1] Lee, H., **Lee, W.**, Kim, J., Jin, J., Kwon, H., Cha, D., Shin, Y., Moon, C., Chung, W., “Drivable Road Region Detection and autonomous navigation of a Surveillance Robot”. In International Conference on Engineering and Applied Science, Hokkaido, Japan, June 2015.

[W] Workshop Papers

- [W2] Yang, Y., **Lee, W.**, Osteen, P., Geneva, P., Zuo, X., Huang, G. iCalib: Inertial Aided Multi-Sensor Calibration. In ICRA 2021 Workshop on Visual-Inertial Navigation Systems, Xi’an, China.
- [W1] Geneva, P., Eckenhoff, K., **Lee, W.**, Yang, Y., Huang, G. Openvins: A research platform for visual-inertial estimation. In IROS 2019 Workshop on Visual-Inertial Navigation: Challenges

and Applications, Macau, China.

[R] Technical Reports

- [R4] Yang Y., Chen, C., **Lee, W.**, Huang, G., Supplementary Materials: Decoupled Right Invariant Error States for Consistent Visual-Inertial Navigation. Tech. rep. RPNG-2021-DRI. University of Delaware, 2021.
- [R3] **Lee, W.**, Eckenhoff, K., Yang, Y., Geneva, P., Huang, G., Visual-Inertial-Wheel Odometry with Online Calibration. Tech. rep. RPNG-2020-VIWO. University of Delaware, 2020.
- [R2] Geneva, P., Eckenhoff, K., **Lee, W.**, Yang, Y., Huang, G., OpenVINS Performance Evaluation on 2019 FPV Drone Racing VIO Dataset. IROS 2019 FPV Drone Racing VIO Competition, 2020.
- [R1] **Lee, W.**, Eckenhoff, K., Geneva, P., Huang, G., GPS-aided Visual-Inertial Navigation in Large-scale Environments. Tech. rep. RPNG-2019-GPS. University of Delaware, 2019.

PROFESSIONAL ACTIVITIES

- **Membership**

- Graduate student member of IEEE
- Graduate student member of Robotics & Automation Society

- **Reviewer**

- IEEE Transactions On Robotics (TR-O)
- IEEE Transactions on Aerospace and Electronic Systems (TAES)
- IEEE Robotics and Automation Letters (RA-L)
- IEEE International Conference on Robotics and Automation (ICRA)
- IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)

INVITED TALKS

- **Multi-Sensor Systems and Degenerate Motions**

Motion2Ai, Korea

August, 2022

- Multi-sensor fusion (IMU, camera, LiDAR, GNSS, and wheel).
- General degenerate motions of multi-sensor systems.

- **Efficient Multi-Sensor-aided INS**

Center for Autonomous & Robotic Systems, USA

March, 2022

- Multi-sensor fusion with linear interpolation.
- Efficient estimator update with measurement abstraction.

- **Visual-Inertial Navigation Systems: An Introduction**

Motion2Ai, Korea

November, 2021

- Visual-inertial navigation system.
- Core algorithms of OpenVINS.

EXTRACURRICULAR ACTIVITIES

- The University of Delaware Korean Graduate Student Association

President

July 2019 - June 2021

Vice President

July 2018 - June 2019

PATENTS

- Variable drive apparatus capable of traveling on the ground and flying in the air, Korea patent 10-1320464 (**Awarded by the Korean Intellectual Property Office in October 2013**)
- Method for measuring uncertainty of GNSS based localization, Korea patent 10-1921483
- Method for measuring uncertainty of GNSS based localization(pending), The Patent Cooperation Treaty

ACADEMIC SCHOLARSHIPS AND AWARDS

- **Summer Doctoral Fellowship:** University of Delaware 2018
- **Outstanding Graduate Student Scholarship:** Dr. Chung's Food Co., Ltd. 2015

TECHNICAL STRENGTHS

- **Mathematical** Linear algebra, Graph theory, Probability theory, Optimization
- **Robotics** Computer Vision, Nonlinear Programming, Machine Learning, Dynamics
- **Programming** C/C++, python, Git, Eigen, PyTorch, CUDA
- **Data Processing** MATLAB, Microsoft Excel
- **Operating System** Linux, Windows, Robot Operating System (ROS), Docker, AWS
- **Hardware** Clearpath Robotics(Warthog, Husky, Jackal), Optitrack, Qualcomm RB5

OPEN SOURCE RESEARCH CODE

- **MINS: Efficient and Robust Multisensor-aided Inertial Navigation System**
 - Source repository: <https://github.com/rpng/mins>
 - An efficient, robust, and tightly-coupled Multisensor-aided Inertial Navigation System (MINS) which is capable of flexibly fusing all five sensing modalities (IMU, wheel encoders, camera, GNSS, and LiDAR) in a filtering fashion by overcoming the hurdles of computational complexity, sensor asynchronicity, and intra-sensor calibration.
- **OpenVINS: An open source platform for visual-inertial navigation research**
 - Source repository: https://github.com/rpng/open_vins
 - Open-source modular on-manifold visual-inertial sliding window extended Kalman filter
 - Supports monocular and stereo, SLAM features, First-Estimates Jacobians, visual-inertial simulator, evaluate suite, camera intrinsic and extrinsic calibration and IMU-camera time offset.
 - Heavy documentation to support rapid development and research on top of the codebase and detailed derivations of implementation: <https://docs.openvins.com/>
- **Monocular Visual-Inertial Odometry with Planar Regularities**
 - Source repository: https://github.com/rpng/ov_plane
 - A real-time monocular visual-inertial odometry (VIO) system leverage environmental planes.
 - Real-time regularization of point features to environmental planes in both in-state SLAM and out-of-state MSCKF point features enabling long-term point-to-plane loop-closures.