

Shibo Zhao

RESEARCH INTEREST · LOCALIZATION AND MAPPING

Robotics Institute, School of Computer Science, CMU, PA

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Education

Carnegie Mellon University

PHD IN ROBOTICS, SCHOOL OF COMPUTER SCIENCE

- Advisor: Sebastian Scherer

[Pittsburgh, USA](#)

Sep. 2021 - Present

Carnegie Mellon University

M.S. IN ROBOTICS, SCHOOL OF COMPUTER SCIENCE

- Advisor: Sebastian Scherer

[Pittsburgh, USA](#)

Sep. 2021 - 2023

Northeastern University

M.S. IN ELECTRONIC AND ENGINEERING

- GPA: 93/100 Rank: 3/286

[Shenyang, China](#)

Sep. 2016 - Sep. 2019

Experience

IMU Foundation Model for Motion Tracking

DEPARTMENT: RESEARCH INTERN, APPLE COMPANY

- Designed a generalizable motion-tracking foundation model applicable across diverse smart devices.
- Investigated domain adaptation methods to bridge gaps between simulated and real-world inertial sensor data.
- Developed a differentiable SLAM pipeline combining data-driven technique with classical optimization to leverage the strengths of both.

[VR Team, Apple, USA](#)

May. 2025 - Present

Tartan IMU: A Light Foundation Model for Inertial Positioning in Robotics

DEPARTMENT: ROBOTICS INSTITUTE, CARNEGIE MELLON UNIVERSITY

- Introduced the first IMU foundation model with a shared backbone, enabling scalable and cross-platform motion estimation.
- Evaluated our IMU foundation model across diverse applications, including ground vehicles, drones, legged robots, and human motion.
- Integrated LoRA into the architecture to allow the pre-trained IMU foundation model to adapt seamlessly to unseen environments.
- Proposed an online adaptation method that actively selects motion patterns from the training buffer, enabling fast training and eliminating the boundary between training and testing phases.
- Accepted in **CVPR 2025** Conference

[Website, Pittsburgh, USA](#)

Dec. 2023 - Present

Super Odometry: Hierarchical Adaptation Enables Robust Odometry Towards All-degraded Environments

DEPARTMENT: CARNEGIE MELLON DARPA SUBTERRANEAN CHALLENGE TEAM

- Developed a hierarchical adaptation strategy to address degradation, scaling responses to maintain both efficiency and robustness.
- Designed a multi-level system incorporating adaptive feature selection, state direction, factor degradation, and learning-based IMU odometry.
- Enabled the system to predict the risk of failed alignment between point clouds and estimate confidence in current scans.
- Pioneered an active sensor fusion approach by estimating observability in the front-end, rather than passively fusing multiple sensors.
- Helped the team won **No.1** in DARPA Tunnel Challenge, **No.2** in DARPA Urban Challenge and **No.4** in DARPA final Challenge.
- To the best of our knowledge, it is the first sensor fusion pipeline capable of operating reliably in **all-weather environments**.
- Under review in **science robotics** journal

[Website, Pittsburgh, USA](#)

Jun. 2019 - Sep. 2023

MSO: Hierarchically Uncertainty-Aware Multispectral Odometry

DEPARTMENT: ROBOTICS INSTITUTE, CARNEGIE MELLON UNIVERSITY

- Proposed a highly robust and versatile multi-spectral inertial state estimator, that seamlessly integrates both thermal and visual data
- Proposed an adaptive fusion pipeline and explored uncertainties from 2D features, 3D landmarks and engines
- Support arbitrary number of thermal and RGB camera setups with various camera models
- Incorporate learning feature with traditional methods to achieve real-time performance
- To the best of our knowledge, it is the **first multispectral odometry** can overcome both darkness and smoke environments
- Prepare submission for **TRO** journal

[Website, Pittsburgh, US](#)

Sep. 2023 - Present

Super Map: 4D Spatial-temporal Representation for Autonomous Robotics

DEPARTMENT: ROBOTICS INSTITUTE, CARNEGIE MELLON UNIVERSITY

- Developed a multi-layer mapping representation, including geometric, semantic, texture, and uncertainty layers.
- Introduced a unified scene graph to track objects over time, which allows a robot to build an abstract metric-semantic representation.
- Leverage open-vocabulary 3D semantics network to support the detection and tracking of both short-term and long-term dynamic objects.
- Under Review **NeurIPS 2025** conference.

[Website, Pittsburgh, US](#)

Jan. 2023 - Sep. 2023

SuperLoc: Key to Robust LiDAR-Inertial Localization Lies in Predicting Alignment Risks

[Website, Pittsburgh, US](#)

DEPARTMENT: ROBOTICS INSTITUTE, CARNEGIE MELLON UNIVERSITY

Jan. 2023 - Sep. 2023

- Our system can not only predict the risk of failed alignment between two point clouds but also estimate the confidence scan.
- Rather than passively fusing multiple sensors, we estimate observability in the front-end and integrate it into the sensor fusion.
- Release our code along with datasets from 8 challenging environments, including ground-truth maps, to push the limits of localization
- Accepted in **ICRA 2025** conference

Super Loop: Distributed Multi-robot SLAM System with Online Place Recognition

[Website, Pittsburgh, US](#)

DEPARTMENT: CARNEGIE MELLON UNIVERSITY

Jan. 2023 - Sep. 2023

- Support fully distributed collaborative framework for the robotic swarm.
- Designed an efficient communication pipeline for transmitting loop closure constraints between robots.
- Supported both inter-loop and intra-loop closures to ensure consistent map generation across robots.
- Prepare submission for **RAL 2025** conference

SubT-MRS: Pushing SLAM Towards All-weather Environments

[Website, Pittsburgh, US](#)

DEPARTMENT: CARNEGIE MELLON UNIVERSITY

Jan. 2023 - Sep. 2023

- Proposed challenging datasets including subterranean, multi-robot, multi-spectral-inertial, and multi-degraded environments
- Proposed a robustness metric to evaluate the reliability of SLAM systems
- Provided the benchmark to evaluate the accuracy, robustness, and real-time performance of existing SLAM system
- Provided the datasets from simulation to real-world scenarios to bridge the gap for sim-real adaptation
- Organize the **ICCV2023** SLAM Challenge and accepted in **CVPR 2024** conference

TP-TIO: A Robust Thermal-Inertial Odometry with Deep ThermalPoint

[Website, Pittsburgh, US](#)

DEPARTMENT: CARNEGIE MELLON UNIVERSITY

Jan. 2019 - Mar. 2020

- Proposed the first tightly coupled deep thermal-inertial odometry algorithm
- Proposed a new feature detection network(ThermalPoint), specifically designed on thermal images
- Proposed a new IMU-aided radiometric feature tracking method establishing robust correspondences
- Summarized the experimental results and published it on **IROS 2020**

LIOM: Laser-Inertial Odometry and Mapping for Large-Scale Highway Environments

[Video, Tecent, China](#)

DEPARTMENT: CARNEGIE MELLON UNIVERSITY

Jan. 2019 - oct. 2019

- Proposed a novel lidar odometry pipeline utilizing both CNN segmentation network and laser-inertial framework
- Implemented a CNN segmentation network and removed the influence of dynamic objects
- Implemented a laser-inertial framework and overcame the aggressive motion and achieved robust pose estimation
- Summarized the experimental results and published it on **IROS 2019**

A Real-Time 3D Perception and Reconstruction System Based on a 2D Laser Scanner

[Video, NEU, China](#)

ROBOTIC SCIENCE AND ENGINEERING INSTITUTE

Dec. 2017 - Feb. 2018

- Investigated the principles of LOAM algorithm and designed 3D reconstruction system based on a 2D laser scanner
- Summarized the experimental results and published it on **Journal of Sensors 2018**

A Real-time Handheld 3D Temperature Field Model Reconstruction System

[Video, NEU, China](#)

ROBOTIC SCIENCE AND ENGINEERING INSTITUTE

Sep. 2017, - Oct. 2018

- Utilized the traditional RGB-D odometry algorithm to add thermal intensity residuals and achieve the robust pose estimation
- Achieved the multi-dimensional perception and reconstruction based on Kintinuuous algorithm
- ummarized the experimental results and published it on CYBER 2017 and won the **best paper finalist (0.2 %)**

Publications

SELECTED FIRST AUTHOR PAPERS

[CVPR] Zhao, Shibo, et al. "Tartan IMU: A Light Foundation Model for Inertial Positioning in Robotics." Proceedings of the Computer Vision and Pattern Recognition Conference. 2025

[CVPR] Zhao, Shibo, et al. SubT-MRS Dataset: Pushing SLAM Towards All-weather Environments. IEEE / CVF Computer Vision and Pattern Recognition Conference (CVPR) 2024.

[IROS] Zhao, Shibo, et al. Super odometry: IMU-centric LiDAR-visual-inertial estimator for challenging environments. 2021 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). IEEE, 2021.

[IROS] Zhao, Shibo, et al. "Tp-tio: A robust thermal-inertial odometry with deep thermalpoint." 2020 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). IEEE, 2020.

[IROS] Zhao, Shibo, et al. "A robust laser-inertial odometry and mapping method for large-scale highway environments." 2019 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). IEEE, 2019.

SELECTED CO-AUTHOR PAPERS

[SLAM Handbook] Luca Carlone, et al. From Localization and Mapping to Spatial Intelligence, Cambridge University Press (2025).

[TRO] Ebadi, Kamak, et al. "Present and Future of SLAM in Extreme Environments: The DARPA SubT Challenge." IEEE Transactions on Robotics (2023).

[CVPR] Wang, Chen, et al. "PyPose: A library for robot learning with physics-based optimization." Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition. 2023.

[ICLR] Xu, Xiaohao, et al. "Scalable benchmarking and robust learning for noise-free ego-motion and 3d reconstruction from noisy video." ICLR (2025)

[CVPR] Xu, Xiaohao, et al. "MAC-Ego3D: Multi-Agent Gaussian Consensus for Real-Time Collaborative Ego-Motion and Photorealistic 3D Reconstruction." Proceedings of Computer Vision and Pattern Recognition Conference. 2025.

Community Service

2025	SLAM Handbook Committee, From Localization and Mapping to Spatial Intelligence	Boston, USA
2023	IROS23 Workshop Committee, Robotic Perception and Mapping: Frontier Vision & Learning Techniques	DETROIT, USA
2023	ICCV23 SLAM Challenge Organizer, Pushing SLAM Towards All-weather Environments	PARIS, France
2021	Main Organizer, Tartan Air SLAM Series	Virtual
2020	CVPR Workshop Committee, Joint Workshop on Long-Term Visual Localization, Visual Odometry and Geometric and Learning-based SLAM	Virtual

Honors & Awards

2019	Shenyang Scholarship Candidates (0.1%), Shenyang Ministry of Education	Shenyang, China
2019	Outstanding Research Scholarship (1%), Northeastern University	Northeastern University
2019	Best Master Thesis (0.5%), Northeastern University	Shenyang, China
2018	National Scholarship (0.1%), The Chinese Ministry of Education	Shenyang, China
2016	National Scholarship (0.1%), The Chinese Ministry of Education	Shenyang, China
2016	Principal Gold Medal (0.1%), Northeastern University	Shenyang, China
2015	Honorable Mention, American College Students Mathematical Modeling Competition	Xian, China

Presentation

Adaptive Fusion from LiDAR to Visual	Video
SPEAKER IN ROBOT LEARNING AND SLAM WORKSHOP	Oct, 2023
• Introduced ICCV SLAM Challenge and Adaptive Fusion Technique from LiDAR to Visual for Robust SLAM System	
Super Odometry: Robust Localization and Mapping in Challenging Environments	Video
SPEAKER ON TARTAN AIR SLAM SERIES	2021
• Introduced Super Odometry in DARPA SubT Challenge	

Skills

Programming	C++, Python, Matlab, Pytorch, Numpy
Library	GTSAM, Ceres, G2o, Sophus, Eigen
Software	LATEX, Git, ROS, CUDA,
Languages	English Toefl(105), Chinese

Teaching

CMU-16825	collaborated with Prof. Shubham Tulsiani and excited to be a TA for learning for 3D
CMU Mentor	Mentor 2 undergraduate students for their research

Reviewer

IJRR: 2023, RAL: 2024, TRO: 2024, TFR:2024, Autonomous Robots: 2023, CVPR: 2024, ICCV: 2024, ECCV: 2024, ICLR: 2024