DR. JIANHAO JIAO

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EMPLOYMENT

Deputy Director, Intelligent and Autonomous Driving Center, HKUST(GZ)	*September 2022 - Now*
Research Associate, The Hong Kong University of Science and Technology	*January 2022 - Now*
Internship, Shenzhen Unity-Drive Innovation Ltd.	*June 2018 - September 2018*
Research Assistant, CityU Hong Kong, Shenzhen Research Institute	*December 2016 - April 2017*
Internship, RoboMaster, Shenzhen DJI Ltd.	*July 2016 - August 2016*

EDUCATION

The Hong Kong University of Science and Technology   Hong Kong SAR, CHINA

Ph.D. in Electronic & Computer Engineering   *September 2017 - January 2022*

Robotics and Multi-perception Lab, Robotics Institute

Advisor: Prof. Ming Liu

Thesis: LiDAR Perception Systems for Autonomous Robots: from Calibration to Localization, Mapping, and Recognition.[1]

Zhejiang University   Hangzhou, CHINA

B.Eng. in Electronic Engineering   *Sept. 2013 - June 2017*

Advisors: Prof. Xiang Tian

Thesis: Towards a Cloud-Based Visual SLAM Framework for Low-Cost Agents

RESEARCH

1. **Sensor Calibration for Mobile Robots**
   Code 1: `https://github.com/ram-lab/MLC`
   Code 2: `https://github.com/HKUSTGZ-IADC/LCECalib`
   Sensor calibration is essential to any sensor fusion systems for autonomous robots. I have proposed the first online method for multi-LiDAR extrinsic calibration and the first calibration approach for the LiDAR-frame camera-event camera pair. Especially, the multi-LiDAR calibration method was integrated into the MATLAB LiDAR Toolbox[2] (Accepted by IEEE IV 2019, IEEE IROS 2019, minor revision to IEEE/ASME Transactions on Mechatronics 2022).

2. **LiDAR SLAM for Mobile Robots and Handheld Devices**
   Code: `https://github.com/gogojjh/M-LOAM`
   We propose **the first multi-LiDAR system** that achieves robust and simultaneous extrinsic calibration, odometry, and mapping. We additionally propose a novel compression method to reduce the storage burden of LiDAR data. (Accepted by IEEE ICRA 2021, IEEE Transactions on Robotics 2022, IEEE ICRA 2022, and IEEE/ASME Transactions on Mechatronics 2022)

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[1]`https://repository.ust.hk/ir/Record/1783.1-116580`

[2]`https://www.mathworks.com/help/lidar/ug/multi-lidar-calibration-workflow.html`

3. **3D Object Detection for Autonomous Vehicles**
   Code: `http://143.89.78.112:5000/sharing/90BpyDIuq`
   Extrinsic perturbation always exists in multiple sensors. This project focuses on the extrinsic uncertainty in multi-LiDAR systems for 3D object detection. We propose **the first multi-LiDAR 3D object detector** that takes multiple point clouds as input and predicts the 3D states of key objects under extreme extrinsic perturbation. (Accepted by IEEE IROS 2020)

PROJECTS & EXPERIENCES

I have mainly finished several projects which are listed below:

1. **Trials of Autonomous Logistic Vehicle in HKUST**   *May 2020 - July 2022*
   I am the **co-PI** of this project. The project goal is to deploy Hercules (check our RAM paper) in UST to deliver food and goods between restaurants and offices. My main responsibility is to design and conduct a series of tests on the csampus to demonstrate that the autonomous vehicle is safe, reliable, and intelligent. **I was one of the authors who drafted the testing standard for AVs in Hong Kong.** Tests include 95 specific testing items on closed and open road, and 500-km road tests without any accident (we have finished more than $500km$ by 2022-08). Another responsibility for me is to arrange the complete task and test plan, which required me to coordinate service office, management office, public affairs office as well as the electronics and computer engineering department in HKUST and Hong Kong Transport Department (HKTD).

   We have obtained the stage0, stage0.5, and stage1 moving permits from HKTD. This project has gained support from HKUST, KAISA, and HKTD. We appreciate TD's appreciation: "HKUST has been advancing the trials and becoming the **first** trialing organization in Hong Kong to varry out AVs without a driver/operator on board". A series of demo videos can be found: `https://okt.ust.hk/node/5462`.

   This project represented HKUST to be shown to VIPs including Chief Executive of Hong Kong[3], ASEAN Counsuls, MTR, Airport Authority, and president of Asia Pacific Research Institute of Huawei.

2. **Multi-sensor Handheld Devices for Various Robotic Applications**   *June 2020 - Now*
   I am the **co-PI** of this project. This project is sponsored by KAISA. It will develop a handheld device[4] with multiple sensors (e.g., one LiDAR, two cameras, one IMU, one GPS, one micro-processor) for various robotic applications (e.g., large-scale mapping in HKUST and robotic navigation). We have used this device to collect datasets on the campus[5], and developed a multi-sensor SLAM system to build up the 3D map of HKUST. The map was post-processed (e.g., noise reduction, human label) as a HD map[6] of the autonomous vehicle which is introduced above.

3. **Deep Learning Based Defect Inspection of Smartphone Glass**   *May 2018 - April 2020*
   This project developed a defect detection system[7] for figuring out smartphone glass with small defect. This system consists of a hardware (one LED-base light source, one line-based camera, and one conveyor for scanning) for high-resolution (16384×24576 pixel) glass image and deep-learning-based defect segmentation algorithm. My main responsibility is to develop the hardware and collaborate colleagues

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[3] `https://hkust.edu.hk/zh-hant/news/institutional-advancement/chief-executive-visits-hkust`

[4] Device visualization: `https://github.com/gogojjh/gogojjh.github.io/blob/master/images/project/handheld_device_1.png`

[5] Data collection: `https://github.com/gogojjh/gogojjh.github.io/blob/master/images/project/handheld_device_1_vehicle.jpg`

[6] Map visualization: `https://github.com/gogojjh/gogojjh.github.io/blob/master/images/project/map_hkust.png`

[7] Device: `https://github.com/gogojjh/gogojjh.github.io/blob/master/images/project/glass_device.png`

who develop algorithms for system integration. We worked closed the UCB Mechanical and Systems Control Lab (lead by Prof.Masayoshi Tomizuka). Besides the system, this project also outputed two patents and one IROS paper.

PUBLICATIONS

*: Equal Contribution. $^+$: Corresponding Author.

IN SUBMISSION

[1] **Jianhao Jiao**, Ruoyu Geng, Ren Xin, Yuanhang Li, etc., Lujia Wang, Ming Liu, Real-Time Metric-Semantic Mapping for Autonomous Navigation in Outdoor Unstructured Environments, submitted to *IEEE Transactions on Automation Science and Engineering (TASE)*.

[2] Xiangcheng Hu, Linwei Zheng, Ruoyu Geng, Jin Wu, Hexiang Wei, Yang Yu, Xiaoyu Tang, Lujia Wang, **Jianhao Jiao**$^+$, Ming Liu, PA-SLAM: Robust Prior-Assisted Ground Truth Trajectory Generation for Benchmarking, submitted to *IEEE/ASME Transactions on Mechatronics (T-Mech)*.

BOOK CHAPTER

[1] **Jianhao Jiao**, Xiangcheng Hu, Xupeng Xie, Jin Wu, Hexiang Wei, Lu Fan, Ming Liu, Enabling Robust SLAM for Mobile Robots with Sensor Fusion, Autonomous Driving Perception: Fundamentals and Applications. Springer, 2023.

[2] **Jianhao Jiao**, Peng Yun and Ming Liu (2017) A Cloud-Based Visual SLAM Framework for Low-Cost Agents. In: Liu M., Chen H., Vincze M. (eds) Computer Vision Systems. ICVS 2017. Lecture Notes in Computer Science, vol 10528. Springer, Cham.

JOURNAL

[1] **Jianhao Jiao**, Feiyi Chen, Hexiang Wei, Jin Wu, Ming Liu, LCE-Calib: Automatic LiDAR-Frame/Event Camera Extrinsic Calibration With a Globally Optimal Solution, *IEEE/ASME Transactions on Mechatronics (T-Mech)*, 2023.

[2] Shuyang Zhang, Qingwen Zhang, Feiyi Chen, Jin Wu, **Jianhao Jiao**, Lujia Wang, A VT-HMM-based Framework for Countdown Timer Traffic Light State Estimation, *IEEE Transactions on Intelligent Transportation Systems (TITS)*, 2023.

[3] Yang Yu, Peng Yun, Bohuan Xue, **Jianhao Jiao**, Ming Liu, Accurate and Robust Visual Localization System in Large-scale Dynamic Environments, *IEEE/ASME Transactions on Mechatronics*, 2022.

[4] Jin Wu, Yu Zheng, Zhi Gao, Yi Jiang, Xiangcheng Hu, Yilong Zhu, **Jianhao Jiao**, Ming Liu, Quadratic Pose Estimation Problems: Globally Optimal Solutions, Solvability/Observability Analysis and Uncertainty Description, *IEEE Transaction on Robotics (TRO)*, 2022.

[5] Huaiyang Huang, Yuxiang Sun, Wu Jin, **Jianhao Jiao**, Xiangcheng Hu, Linwei Zheng, Lujia Wang, Ming Liu, On Bundle Adjustment for Multiview Point Cloud Registration, *IEEE Robotics and Automation Letters (RAL)*, 2021.

[6] **Jianhao Jiao**, Haoyang Ye, Yilong Zhu, Ming Liu, Robust Odometry and Mapping for Multi-LiDAR Systems with Online Extrinsic Calibration, *IEEE Transaction on Robotics (TRO)*, 2021. **TRO Popular Article in April, 2022**.

[7] Tianyu Liu, Qinghai Liao, etc, **Jianhao Jiao**, Ming Liu, Hercules: An Autonomous Logistic Vehicle for Contact-less Goods Transportation During the COVID-19 Outbreak, *IEEE Robotics and Magazine (RAM)*, 2020.

CONFERENCE

[1] Wu Jin, Soheil Sarabandi, **Jianhao Jiao**, Huaiyang Huang, Bohuan Xue, Ruoyu Geng, Lujia Wang, Ming Liu, Completely Rational SO(n) Orthonormalization, *IEEE International Conference on Robotics and Automation (ICRA)*, 2023.

[2] **Jianhao Jiao***, Hexiang Wei*, Tianshuai Hu*, Xiangcheng Hu*, Yilong Zhu, Zhijian He, Jin Wu, Jingwen Yu, Xupeng Xie, Lujia Wang, Ming Liu, FusionPortable: A Multi-Sensor Campus-Scene Dataset for Evaluation of Localization and Mapping Accuracy on Diverse Platforms, *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2022.

[3] Bowen Yang, **Jianhao Jiao**, Lujia Wang, Ming Liu, Game-Theoretic Local Planner for Interactive Crowd Navigation, *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2022.

[4] Feiyi Chen, Shuyang Zhang, Yutong Wang, Xupeng Xie, Qingwen Zhang, **Jianhao Jiao**, Ming Liu, Automatic Extrinsic Calibration for Multiple Cameras and LiDARs using a Checkerboard, *IEEE Intelligent Transportation Systems Conference (ITSC)*, 2022.

[5] Sukai Wang, **Jianhao Jiao**, Peide Cai, Ming Liu, R-PCC: A Baseline for Range Image-based Point Cloud Compression, *IEEE International Conference on Robotics and Automation (ICRA)*, 2022.

[6] **Jianhao Jiao**, Yilong Zhu, Haoyang Ye, etc, Ming Liu, Greedy-Based Feature Selection for Efficient LiDAR SLAM, *IEEE International Conference on Robotics and Automation (ICRA)*, 2021.

[7] **Jianhao Jiao***, Peng Yun*, Lei Tai, Ming Liu, MLOD: Awareness of Extrinsic Perturbation in Multi-LiDAR 3D Object Detection for Autonomous Driving, *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2020.

[8] M Usman Maqbool Bhutta, Shoaib Aslam, Peng Yun, **Jianhao Jiao**, Ming Liu, Smart-Inspect: Micro Scale Localization and Classification of Smart Phone Glass Defects for Industrial Automation, *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2020.

[9] Yilong Zhu, Dong Han, **Jianhao Jiao**, etc, Ming Liu, Rui Fan, Road Curb Detection Using A Novel Tensor Voting Algorithm, *IEEE International Conference on Robotics and Biomimetics (ROBIO)*, 2019. **Best Paper Finalist**.

[10] Bohuan Xue, **Jianhao Jiao**, Yilong Zhu, etc, Ming Liu, Automatic Calibration of Dual-LiDARs Using Two Poles Stickered with Retro-Reflective Tape, *IEEE International Conference on Imaging Systems and Techniques (IST)*, 2019.

[11] **Jianhao Jiao**, Yang Yu, Qinghai Liao, Haoyang Ye, Ming Liu, Automatic Calibration of Multiple 3D LiDARs in Urban Environments, *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2019. **This work was integrated into MATLAB**.

[12] **Jianhao Jiao***, Qinghai Liao*, Ming Liu, et al, A Novel Dual-Lidar Calibration Algorithm Using Planar Surfaces, *IEEE Intelligent Vehicles Symposium (IV)*, 2019.

[13] Rui Fan, Mohammud Bocus, **Jianhao Jiao**, Ming Liu, et al, Road Crack Detection Using Deep Convolutional Neural Network and Adaptive Thresholding, *IEEE Intelligent Vehicles Symposium (IV)*, 2019.

[14] **Jianhao Jiao**, Rui Fan, Han Ma, Ming Liu, Using DP Towards A Shortest Path Problem-Related Application, *IEEE International Conference on Robotics and Automation (ICRA)*, 2019.

[15] Han Ma, Yixin Ma, **Jianhao Jiao**, Rui Fan, Ming Liu, et al, Multiple lane detection algorithm based on optimised dense disparity map estimation, *IEEE International Conference on Imaging Systems and Techniques (IST)*, 2019.

[16] **Jianhao Jiao**, Peng Yun, and Ming Liu, A Cloud-Based Visual SLAM Framework for Low-Cost Agents, *International Conference on Computer Vision Systems (ICVS)*, 2017.

[17] Yun, Peng, **Jianhao Jiao**, and Ming Liu, Towards a Cloud Robotics Platform for Distributed Visual SLAM, *International Conference on Computer Vision Systems (ICVS)*, 2017.

WORKSHOP PAPER

[1] Xiangcheng Hu, Jin Wu, **Jianhao Jiao**, Ruoyu Geng, Ming Liu, PA-SLAM: Robust Prior-assisted Ground Truth Trajectory Generation for Benchmarking, *IEEE International Conference on Robotics and Automation Workshop* (*ICRAW*), 2023.

[2] **Jianhao Jiao**, Huaiyang Huang, Liang Li, Zhijian He, Yilong Zhu, Ming Liu, Comparing Representations in Tracking for Event Camera-based SLAM, *IEEE/CVF Conference on Computer Vision and Pattern Recognition, Event-based Vision Workshop* (*CVPRW*), 2021.

[3] Rui Fan, **Jianhao Jiao**, Jie Pan, Huaiyang Huang, Shaojie Shen, Ming Liu, Real-Time Dense Stereo Embedded in An UAV for Road Inspection, *IEEE/CVF Conference on Computer Vision and Pattern Recognition, UAV Vision Workshop* (*CVPRW*), 2019.

*Equal contribution

PATENTS

[1] 中国专利：**焦健浩**，云鹏，刘明；一种定位方法、系统及介质, 2021-1-29, 中国, 4228721

[2] 中国专利：王恒立，**焦健浩**，云鹏，孙宇翔，刘明；路径规划模型训练方法、路径规划方法、设备和系统；2020-12-3, 中国, CN202011405403.6

[3] 中国专利：穆罕默德·奥斯曼·布塔，**焦健浩**，云鹏，王远，孙学斌，刘明；基于半监督学习的缺陷检测方法和装置；2020-4-26, CN202010338415.5

[4] 中国专利：王远，**焦健浩**，云鹏，穆罕默德·奥斯曼·布塔，孙学斌，刘明；基于深度学习的缺陷检测方法和系统；2020-4-20, 中国, CN202010312201.0

INVITED TALKS

[1] Academic Seminar:

    (a) Invited to give a talk at the 2nd workshop, Intelligent Vehicle Meets Urban: Safe and Certifiable Navigation and Control for Intelligent Vehicles in Complex Urban Scenarios, IEEE ITSC, September 2023.

(b) **Enabling Robust Perception System for Autonomous Navigation**, The Hong Kong University of Science and Technology (Guangzhou), Robotics and Autonomous Systems Thrust, Invited by Professor Lei Zhu, February 2022.

(c) **LiDAR Perception System for Autonomous Robots: from Calibration to Localization, Mapping, and Recognition**, Southern University of Science and Technology, Invited by Professor Hong Zhang, December 2021.

(d) **LiDAR Perception System for Autonomous Robots: from Calibration to Localization, Mapping, and Recognition**, Zhejiang University, November 2021.

(e) **Extending Multi-LiDAR Fusion to LiDAR-Inertial-Event Fusion for Robust SLAM**, The Hong Kong University of Science and Technology (Guangzhou), Robotics and Autonomous Systems Thrust, April 2021.

AWARDS

IEEE ROBIO, Best Paper Finalist	*2019*
HKUST Postgraduate Student Scholarship	*2017-2021*
The 2nd runner-up in DJI RoboMaster summer camp.	*2017*
The Second-Class Scholarship for outstanding student, Zhejiang University (Top 10%)	*2017*
Zhejiang Province Scholarship	*2017*
Best Team Award, ZhongKong Robotics Competition, Zhejiang University	*2016*

TEACHING

Teaching Assistant   *January 2018 - December 2018*

[1] ELEC 1030: The Rise of Autonomous Robots. Instructor: Prof. WANG, Michael Yu, IEEE/ASME Fellow

Supervised Ph.D. and Master Students

[1] Ph.D. students: Shuyang Zhang, Hexiang Wei, Xiangcheng Hu, Tianshuai Hu, Jingwen Yu, Jinhao He, Ruoyu Geng, Mingkai Jia, Yilong Zhu

[2] Master students: Feiyi Chen (now in DJI), Xupeng Xie, Kai Zhang, Chengyang Li

ACADEMIC ACTIVITIES

Workshop and Challenge Committee

- ECCV-AVVision workshop[8], 2022

- The Conference on Pattern Recognition and Computer Vision (PRCV)-AGEP Challenge[9], 2022

Review Services

- Journal

  - *IEEE Transaction on Robotics (TRO).*

  - *IEEE Robotics and Automation Magazine (RAM).*

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[8] https://avvision.xyz/eccv22
[9] http://www.prcv.cn/?list_92

- *IEEE Robotics and Automation Letters (RA-L).*

- *Autonomous Robots (AURO).*

- *IEEE/ASME Transactions on Mechatronics (TMECH).*

- *IEEE Transactions on Intelligent Transportation Systems (TITS).*

- *IEEE Transactions on Instrumentation and Measurement (TIM).*

- *Neurocomputing.*

- Conference

  - *Robotics: Science and Systems (RSS).*

  - *International Conference on Intelligent Robots and Systems (IROS).*

  - *International Conference on Robotics and Automation (ICRA).*

  - *IEEE Intelligent Vehicles Symposium (IV).*

  - *IEEE International Conference on Intelligent Transportation Systems (ITSC).*

  - *IEEE/CVF Conference on Computer Vision and Pattern Recognition Workshop (CVPRW).*

  - *European Conference on Computer Vision Workshop (ECCVW).*