# Liangkai Liu

+1-313-212-9388 | liangkai@umich.edu | liangkai.org

in LinkedIn | ◯ Torreskai0722 | g Google Scholar |

Ann Arbor, Michigan - 48109, USA

## RESEARCH INTERESTS

**Area: real-time cyber-physical systems**, **autonomous driving**, **edge computing**, **robotics**.

**Topics**:
- **Predictability:** DNN inference time variations; Predictable perception for autonomous vehicles.
- **Efficiency:** Energy-efficient autonomous mobile robots; Fuel-efficient autonomous trucking.
- **Safety:** Edge computing-enabled real-time systems for public safety.

## EXPERIENCE

- **University of Michigan** *September 2023 - Present*
  *Research Fellow* Ann Arbor, MI, USA
  ◦ **Mentor: Prof. Kang Shin**

- **University of Delaware** *May 2023 - August 2023*
  *Postdoctoral Researcher* Newark, DE, USA
  ◦ **Mentor: Prof. Weisong Shi**

- **Argonne National Laboratory** *May 2021 - August 2021*
  *Research Intern* Lemont, IL, USA

- **Argonne National Laboratory** *May 2020 - August 2020*
  *Research Intern* Lemont, IL, USA

## EDUCATION

- **Wayne State University** *January 2018 - May 2023*
  *Ph.D. in Computer Science* (GPA: 3.98/4.00) Detroit, MI, USA
  ◦ **Advisor:** Prof. Weisong Shi
  ◦ **Dissertation:** *Predictable DNN Inference for Autonomous Driving.*

- **Xidian University** *August 2013 - June 2017*
  *B.S. in Telecommunication Engineering* (GPA: 3.25/4.00) Xi'an, China

## GRANT AS PI/CO-PI

- **Predictable Multi-Tenant DNN Inference for Autonomous Driving, 2024**
  **National Science Foundation CSR: Small**
  **My Role:** Co-Principal Investigator
  Awarded to: University of Delaware
  PI: Weisong Shi
  Awarded amount: $600,000 (10/1/2024 - 9/30/2027)
  Grant number: **2343601**

## FULL LIST OF PUBLICATIONS

**Google Scholar** (as of Jan. 6, 2025): **2,015** citations, H-Index: **17**, i10-Index: **20**.

**25** research articles and **1** book, including **15** as first author: **eight** appearing in flagship conferences (two in RTSS, one in ICCAD, two in SEC, one in ICRA, and two in HotEdge) and **three** in premier journals (one each in TITS, IoTJ, and IWC).

## First-Author Publications

**[C18] Liangkai Liu**, Jinkyu Lee, and Kang G. Shin, "RT-BEV: Enhancing Real-Time BEV Perception for Autonomous Vehicles," in *Proceedings of the IEEE Real-Time Systems Symposium (**RTSS**)*, 2024.

**[C17]** Chao Wu*, Yifan Gong*, **Liangkai Liu***, Mengquan Li, Yushu Wu, Xuan Shen, Zhimin Li, Geng Yuan, Weisong Shi, and Yanzhi Wang, "AyE-Edge: Automated Deployment Space Search Empowering Accuracy yet Efficient Real-Time Object Detection on the Edge," in *International Conference on Computer-Aided Design (**ICCAD**)*, 2024. (*Equal contribution)

**[C16] Liangkai Liu**, Ren Zhong, Aaron Willcock, Nathan Fisher, and Weisong Shi, "An Open Approach to Energy-Efficient Autonomous Mobile Robots," in *Proceedings of the IEEE International Conference on Robotics and Automation (**ICRA**)*, 2023.

**[C15] Liangkai Liu**, Yanzhi Wang, and Weisong Shi, "Understanding Time Variations of DNN Inference in Autonomous Driving," in *MLSys Workshop on Benchmarking Machine Learning Workloads on Emerging Hardware (**MLBench**)*, 2023.

**[C14] Liangkai Liu**, Zheng Dong, Yanzhi Wang, and Weisong Shi, "Prophet: Realizing a Predictable Real-time Perception Pipeline for Autonomous Vehicles," in *Proceedings of the IEEE Real-Time Systems Symposium (**RTSS**)*, 2022.

**[C13] Liangkai Liu**, Baofu Wu, and Weisong Shi, "A Comparison of Communication Mechanisms in Vehicular Edge Computing," in *USENIX Workshop on Hot Topics in Edge Computing (**HotEdge**)*, 2020.

**[C12] Liangkai Liu**, Yongtao Yao, Ruijun Wang, Baofu Wu, and Weisong Shi, "Poster: Equinox: A Road-Side Edge Computing Experimental Platform for CAVs," in *Proceedings of the IEEE International Conference on Connected and Autonomous Driving (**MetroCAD**)*, 2020.

**[C11] Liangkai Liu**, Jiamin Chen, Marco Brocanelli, and Weisong Shi, "E2M: An Energy-Efficient Middleware for Computer Vision Applications on Autonomous Mobile Robots," in *ACM/IEEE Symposium on Edge Computing (**SEC**)*, 2019.

**[C10] Liangkai Liu**, Xingzhou Zhang, Qingyang Zhang, Andrew Weinert, Yifan Wang, and Weisong Shi, "AutoVAPS: an IoT-Enabled Public Safety Service on Vehicles," in *CPSWEEK Workshop on Science of Smart City Operations and Platforms Engineering*, 2019.

**[C9] Liangkai Liu**, Xingzhou Zhang, Mu Qiao, and Weisong Shi, "SafeShareRide: Edge-based Attack Detection in Ridesharing Services," in *ACM/IEEE Symposium on Edge Computing (**SEC**)*, 2018.

**[C8] Liangkai Liu**, Xingzhou Zhang, Mu Qiao, and Weisong Shi, "SafeShareRide: Edge-based Attack Detection in Ridesharing Services," in *USENIX Workshop on Hot Topics in Edge Computing (**HotEdge**)*, 2018.

**[J7] Liangkai Liu**, Yanzhi Wang, and Weisong Shi, "CPT: A Configurable Predictability Testbed for DNN Inference in AVs," in *Tsinghua Science and Technology*, September 2024.

**[J6] Liangkai Liu**, Wei Li, Dawei Wang, Yi Wu, Ruigang Yang, and Weisong Shi, "Fuel Rate Prediction for Autonomous Heavy-Duty Trucks," in *IEEE Transactions on Intelligent Transportation Systems (**TITS**), 2023*.

**[J5] Liangkai Liu**, Shaoshan Liu, and Weisong Shi, "4*C*: A Computation, Communication, and Control Co-Design Framework for CAVs," in *IEEE Wireless Communications (IWC)*, Vol. 28, No. 4, pp. 42-48, August 2021.

**[J4] Liangkai Liu**, Sidi Lu, Ren Zhong, Baofu Wu, Yongtao Yao, Qingyang Zhang, and Weisong Shi, "Computing Systems for Autonomous Driving: State-of-the-Art and Challenges", in *IEEE Internet of Things Journal (IoTJ)*, Vol. 8, No. 8, pp. 6469-6486, December 2020.

## Books

**[B1]** Weisong Shi and **Liangkai Liu**. *Computing Systems for Autonomous Driving*. November 2021, Springer.

## In Submission

**[S4] Liangkai Liu** and Kang G. Shin, "PIE: Patch-based Inference Engine for Predictable Deep Learning", Submitted to **MobiSys 2025**.

**[S3] Liangkai Liu** and Kang G. Shin, "eXR: A Power-Efficient Framework For XR", Submitted to **EuroSys 2025**.

**[S2] Liangkai Liu**, Weisong Shi, and Kang G. Shin, "Power-Efficient Navigation of Autonomous Mobile Robots", Submitted to **SenSys 2025**.

**[S1] Liangkai Liu**, Kang G. Shin, Chengmo Yang, and Weisong Shi, "Predictable DNN Inference for Autonomous Vehicles", Submitted to **RTAS 2025**.

## Co-Author Publications

**[C7]** Noah T. Curran, Minkyoung Cho, Ryan Feng, **Liangkai Liu**, Brian Jay Tang, Pedram MohajerAnsari, Alkim Domeke, Mert D. Pesé, and Kang G. Shin, "Achieving the Safety and Security of the End-to-End AV Pipeline", in *the 1st Cyber Security in Cars Workshop (CSCS '24)*, Salt Lake City, UT, October 2024.

**[C6]** Yifan Gong, Yushu Wu, Zheng Zhan, **Liangkai Liu**, Chao Wu, Xulong Tang, and Yanzhi Wang, "LOTUS: Learning-Based Online Thermal and Latency Variation Management for Two-Stage Detectors on Edge Devices," in *Design Automation Conference (DAC)*, 2024.

**[C5]** Abdullah Al Arafat, Sudharsan Vaidhun, **Liangkai Liu**, Kecheng Yang, and Zhishan Guo, "Compositional Mixed-Criticality Systems with Multiple Executions and Resource-Budgets Model," in *Proceedings of the IEEE Real-Time and Embedded Technology and Applications Symposium (RTAS)*, 2023.

**[C4]** Yifan Wang, **Liangkai Liu**, Xingzhou Zhang, and Weisong Shi, "HydraOne: An Indoor Experimental Research and Education Platform for CAVs," in *USENIX Workshop on Hot Topics in Edge Computing (HotEdge)*, 2019.

**[C3]** Xingzhou Zhang, Yifan Wang, Sidi Lu, **Liangkai Liu**, Lanyu Xu, and Weisong Shi, "OpenEI: An Open Framework for Edge Intelligence," in *Proceedings of the IEEE International Conference on Distributed Computing Systems (ICDCS)*, 2019.

**[C2]** Xingzhou Zhang, Mu Qiao, **Liangkai Liu**, and Weisong Shi, "Collaborative Cloud-Edge Computation for Personalized Driving Behavior Modeling," in *ACM/IEEE Symposium on Edge Computing (SEC)*, 2019.

**[C1]** Qingyang Zhang, Yifan Wang, Xingzhou Zhang, **Liangkai Liu**, Xiaopei Wu, Weisong Shi, and Hong Zhong, "OpenVDAP: An Open Vehicular Data Analytics Platform for CAVs," in *Proceedings of the IEEE International Conference on Distributed Computing Systems (ICDCS)*, 2018.

**[J3]** Tianze Wu, Baofu Wu, Sa Wang, **Liangkai Liu**, Shaoshan Liu, Yungang Bao, and Weisong Shi, "Oops! It's Too Late. Your Autonomous Driving System Needs a Faster Middleware," *IEEE Robotics and Automation Letters (**RA-L**)*, Vol. 6, No. 4, pp. 7301-7308, July 2021.

**[J2]** Congfeng Jiang, Tiantian Fan, Honghao Gao, Weisong Shi, **Liangkai Liu**, Christophe Cerin, and Jian Wan, "Energy-Aware Edge Computing: A Survey," *Computer Communications*, Vol. 151, No. 1, pp. 556-580, February 2020.

**[J1]** Shaoshan Liu, **Liangkai Liu**, Jie Tang, Bo Yu, Yifan Wang, and Weisong Shi, "Edge Computing for Autonomous Driving: Opportunities and Challenges," *Proceedings of the IEEE*, Vol. 107, No. 8, pp. 1697-1716, August 2019.

## RESEARCH PROJECTS

- **Safe and Predictable Perception Pipeline for Autonomous Vehicles**          *September 2023 - present*
  *University of Michigan*                                                                    **Mentor:** Kang G. Shin
  - RT-BEV: the first framework co-optimizes message communication and object detection with dynamic region of interests (ROIs) for improving real-time e2e BEV perception without sacrificing accuracy. (RTSS'24)
  - PP-DNN: models critical regions into variable sizes ROIs to achieve predictable perception pipeline. (under review by RTAS'25)

- **Energy-Efficient Cyber Physical Systems**                                          *September 2023 - present*
  *University of Michigan*                                                                    **Mentor:** Kang G. Shin
  - pNav: a novel power-management system designed to enhance the power/energy-efficiency of Autonomous Mobile Robots (AMRs) by jointly optimizing their physical/mechanical and cyber subsystems. (under review by SenSys'25)
  - eXR: an energy-efficient middleware designed for extended reality applciation based on coordianted management of feature extraction, resource scheduling, and DVFS configurations. (under review by EuroSys'25)

- **DNN Inference Time Variations for Autonomous Vehicles**                          *January 2020 - August 2023*
  *Wayne State University, University of Delaware*                                          **Mentor:** Weisong Shi
  - PDNN Grant: Awarded a research grant from NSF for studying predictable multi-tenant DNNs inferece time variations for autonomous vehicles. (**NSF Grant**)
  - Prophet: identify root causes for DNN inference time variations and propose an early-exit cooridnation system to optimization the inference pipeline for autonomous vehicles. (RTSS'22, RTAS'23)
  - CPT: propose a reconfigurable testbed for profiling the DNN inference time and accuracy variations for autonomous vehicles under various traffic environments. (Tsinghua Science and Technology, 2023)
  - Analyze the time variation in DNN inference in fine granularity from six perspectives: data, I/O, model, runtime, hardware, and end-to-end perception system. (MLBench'23)

- **Energy/Fuel Efficient Autonomous Trucking/Driving**                               *May 2019 - May 2023*
  *Wayne State University*                                                                    **Mentor:** Weisong Shi
  - Create a fuel dataset using the truck's engine management system (EMS) and Instant Fuel Meter (IFM) and propose ML-based prediction model for real-time fuel prediction and integrated into predictive planning for autonomous trucking. (IEEE TITS, 2023)
  - Develop a customized AMR called Donkey, which has the capability for millisecond-level end-to-end power profiling. Propose a comprehensive energy prediction model that provides real-time energy consumption for each component of the autonomous mobile robots. (ICRA'23)
  - E2M: an energy-efficient middleware software stack for optimizing the computing stack of autonomous mobile robots. (SEC'19)

- **Open Platforms for Connected and Autonomous Vehicles**                          *May 2018 - December 2021*
  *Wayne State University*                                                                    **Mentor:** Weisong Shi

○ Led the development of a level-4 autonomous driving vehicle (**Hydra**) based on Autoware and DriveWorks with a complete sensor suite (LiDAR, camera, radar, GNSS, etc.).

○ Designed and implemented **Equinox**, a Road Side Unit (RSU) with heterogeneous computation and communication resources. Developed a vehicular edge computing (**VEC**) prototype supporting WiFi, DSRC, and LTE; compared their performance using real CAV applications. (HotEdge'20, MeterCAD'20)

○ Designed **HydraOne** from scratch, an indoor research and education platform. (HotEdge'19)

• **Edge Computing Enabled Applications for Public Safety**       *January 2018 - December 2018*
*Wayne State University*                                            **Mentor:** Weisong Shi

○ SafeShareRide: an edge-based real-time attack detection system in ridesharing services. (HotEdge'18, SEC'18)

○ AutoVAPS, an edge-based reference architecture for privacy-preserving data sharing and access on law enforcement vehicles. (CPSWEEK'18 Workshop)

## Honors and Awards

• **Department Travel Award for Outstanding Conference Publications**             *2023*
*Wayne State University*

• **RTSS Student Travel Grant**                                                   *2022*
*IEEE Real-Time Systems Symposium*

• **Department Travel Award for Outstanding Conference Publications**             *2022*
*Wayne State University*

• **NSF ACM/IEEE Symposium on Edge Computing Student Travel Grant**     *2019, 2018, 2021*
*National Science Foundation*

• **Top Ten Seniors Award**                                                       *2016*
*Xidian University*

• **First Prize, CETC-10 Literature Review Contest**                              *2016*
*CETC-10, Xidian University*

## Teaching Experience

• **Guest lecture, Building Predictable and Power-Efficient Autonomous Cyber-Physical Systems** *2024*
*University of Michigan, Oakland University*

• **Guest lecture, Robot Platforms for CPS Research**                             *2024*
*University of Michigan, EECS-571*

• **Guest lecture, Building Predictable and Efficient System for Autonomous Vehicles/Robots**   *2024*
*University of Michigan, University of North Texas, California Polytechnic State University*

• **Seminar talk: Introduction to Autonomous Driving**                            *2023*
*HensHack at University of Delaware*

• **Computing systems for connected and autonomous driving**                      *2022*
*UIUC physical AI group*

• **Teaching Assistant, Introduction to Java Programming**                        *2018*
*Wayne State University*

## MENTORING EXPERIENCE

- **Sanjith Udupa**                                                                    *Mentored: 2022/2023*
  *Novi High School student; now undergraduate at MIT*                         **first-authored paper**

- **Mingyu Guo**                                                                           *Mentored: 2023*
  *Undergraduate at the University of Wisconsin–Madison; now Ph.D. at University of Delaware*

- **Yuchen Chueh**                                                                         *Mentored: 2020*
  *Admitted to Master's Program at Carnegie Mellon University, now at Nvidia*

- **Justin Baskaran**                                                                      *Mentored: 2018*
  *Backend Software Engineer at General Motors*

## PROFESSIONAL SERVICES

- **Publication Chair**, ACM/IEEE Symposium on Edge Computing, 2025.

- **Program Committee**, The 3rd IEEE International Conference on Mobility: Operations, Services, and Technologies (MOST), 2024/2025

- **Program Committee**, Workshop on Compute Platforms for Autonomous Vehicles (CAV), ASPLOS 2024

- **Program Committee**, The 21th ACM Conference on Embedded Networked Sensor Systems (SenSys 2023) Posters & Demos

- **Reviewer**, IEEE/CVF Computer Vision and Pattern Recognition Conference (CVPR), 2024/2025

- **Reviewer**, IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2022/2023/2024

- **Reviewer**, IEEE International Conference on Robotics and Automation (ICRA), 2023

- **Web Chair**, The 30th Annual International Conference on Mobile Computing and Networking (MobiCom 2024)

- **Committee Member**, Technical Steering Committee of the Autoware Foundation, October 2022 - December 2023

- **Verified and Recognized Reviewer:** IEEE Communications Magazine, Proceedings of the IEEE, IEEE Transactions on Vehicular Technology, IEEE Vehicular Technology Magazine, IEEE Transactions on Services Computing, IEEE Internet of Things Journal, IEEE Network Magazine, IEEE Internet Computing, IEEE Open Journal of Circuits and Systems, IEEE Transactions on Network Science and Engineering, IEEE Transactions on Intelligent Transportation Systems, and IEEE Robotics and Automation Letters.

## REFERENCES

1. **Kang G. Shin**
   Kevin and Nancy O'Connor Professor of Computer Science
   University of Michigan
   Email: kgshin@umich.edu
   Phone: +1-734-763-0391
   *Relationship: Postdoc Mentor*

2. **Weisong Shi**
   Alumni Distinguished Professor and Chair, Department of Computer and Information Sciences
   University of Delaware
   Email: weisong@udel.edu
   Phone: +1-302-831-7603
   *Relationship: PhD Advisor*

3. **Chengmo Yang**
   Professor, Department of Electrical and Computer Engineering
   University of Delaware
   Email: chengmo@udel.edu
   Phone: +1-302-831–4997
   *Relationship: Collaborator*

4. **Yanzhi Wang**
   Associate Professor, Electrical and Computer Engineering
   Northeastern University
   Email: yanz.wang@northeastern.edu
   Phone: +1-617-373-8805
   *Relationship: Collaborator*

5. **Marco Brocanelli**
   Assistant Professor, Electrical and Computer Engineering
   Ohio State University
   Email: brocanelli.1@osu.edu
   *Relationship: Collaborator*