

Zengxiang Lei

Transportation AI, Simulation, and Cyber-Physical Systems Researcher

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Current	Focus	Signature Work	Record
Postdoctoral Associate, Purdue University	Transportation AI, simulation, and cybersecurity	METS-R SIM open-source mobility simulator	17 journal publications; lead-author TRB/TRC work
Research profile. I build scalable models and decision systems for ride-hailing, shared autonomous electric fleets, evacuation, and transportation security. My long-term goal is simulation-supported reasoning: using machine learning to make large-scale simulation more realistic and efficient, while using simulation to stress-test, verify, and improve control policies for socio-cyber-physical systems.			

Appointments

Postdoctoral Associate
Transportation Cybersecurity and Resiliency Center, Purdue University

January 2025–Present
West Lafayette, IN

- **Simulation-based verification:** Lead research connecting METS-R SIM, CARLA, and an autonomous driving stack for controlled, repeatable scenario testing.
- **Scenario search:** Develop amortized samplers for policy and control verification in simulated environments, with emphasis on rare, high-impact scenarios.
- **Transportation security:** Study adversarial risks in autonomous mobility systems, including booking attacks, emergent adversarial driving maneuvers, and broader cybersecurity challenges for next-generation road transportation.

Graduate Research Assistant
Urban Mobility, Network and Intelligence Lab, Purdue University

August 2018–December 2024
West Lafayette, IN

- **Ride-hailing control:** Conducted research on pricing and fleet relocation, leading to publications in *Transportation Research Part B* and *Transportation Research Part C*.
- **Open-source simulation:** Served as student lead for the U.S. Department of Energy METS-R project, building a city-scale multimodal electric vehicle simulator. Major contributor of the METS-R SIM.
- **Mobility analytics:** Analyzed large-scale GPS and trajectory data to study evacuation, return, pandemic-era mobility, and transportation hub operations.

Education

Purdue University

2018–2024

Ph.D. in Transportation and Infrastructure Systems Engineering. Dissertation: *Towards an Efficient and Secure Ride-hailing Service*. Selected coursework: Reinforcement Learning, Real Analysis and Measure Theory, Security Analytics.

Tongji University

2011–2018

M.S.E. in Transportation Planning and Management; B.S. in Transportation Engineering.

Selected Research and Open-Source Leadership

METS-R SIM: Open-Source Multimodal Electric Mobility Simulator

U.S. Department of Energy project

- Led development of a city-scale simulation platform for Multi-modal Energy-optimal Trip Scheduling in Real-time, supporting shared autonomous electric vehicles, taxis, buses, charging operations, routing, and service evaluation.
- Used the platform to evaluate energy, congestion, and service impacts of operational algorithms for electric mobility services and transportation hubs.

Secure and Efficient Ride-Hailing Systems

Ph.D. research

- Designed scalable reinforcement learning approaches for dynamic pricing and data-driven relocation policies for mobility-on-demand systems.
- Quantified the network-level risk of adversarial booking attacks against autonomous mobility-on-demand services.

Large-Scale Mobility Analytics for Disasters and Recovery

Interdisciplinary research

- Modeled evacuation and return behavior during Hurricane Ida under compound risks with COVID-19.
- Built evidence from smartphone GPS and trajectory data to study transportation resilience, demand recovery, and traveler response.

Honors and Awards

1. Eldon J. Yoder Memorial Award, Purdue University, 2024–2025 academic year.
2. NSF Innovation Corps (I-Corps) Midwest Industry Connect Grant on social ride-sharing, 2019.
3. Chinese Patent: A Method for Evaluating Reserve Capacity of Urban Metro Networks, 2018.
4. Peikun Transportation Talent Fund Award, Tongji University, 2017.
5. 13th Competition of Transport Science, First Prize, project: Research on Spatial Activity Patterns Based on Smartphone Data, 2014.

Journal Publications

1. Li, H., Lei, Z., Qian, X., & Ukkusuri, S. V. (2026). Anticipatory demand planning for microtransit with strategic use of latent capacity at fixed stops. *Transportation Research Part E: Logistics and Transportation Review*, 212, 104939
2. Lei, Z., & Ukkusuri, S. V. (2025). Assessing the risks of adversarial booking attack to autonomous mobility-on-demand services. *Transportation Research Part C: Emerging Technologies*, 178, 105218
3. Yabe, T., Hamim, O. F., Lei, Z., Ka, E., Salek, M. S., Chowdhury, M., Amini, M. H., Cardenas, A. A., & Thuraishingham, B. (2025). Cybersecurity for next-generation road transportation: A review. *ACM Journal on Autonomous Transportation Systems*, 3(2), 1–42
4. Lei, Z., Verma, R., Siebeneck, L. K., & Ukkusuri, S. V. (2024). Modeling hurricane evacuation/return under compound risks: Evidence from Hurricane Ida. *International Journal of Disaster Risk Reduction*, 114, 104977
5. Siebeneck, L. K., Lei, Z., Sharma, P., Verma, R., Osazuwa-Peters, M., & Ukkusuri, S. V. (2024). Household evacuation decision making during simultaneous events: Hurricane Ida and the COVID-19 pandemic. *International Journal of Disaster Risk Reduction*, 114, 104914
6. Liu, X., Lei, Z., & Duan, Z. (2024). Assessing metro network vulnerability with turn-back operations: A Monte Carlo method. *Physica A: Statistical Mechanics and its Applications*, 646, 129923
7. Lei, Z., Xue, J., Chen, X., Qian, X., Saumya, C., He, M., Sobolevsky, S., Kulkarni, M., & Ukkusuri, S. V. (2024). METS-R SIM: A simulator for multi-modal Energy-optimal Trip Scheduling in Real-time with shared autonomous electric vehicles. *Simulation Modelling Practice and Theory*, 132, 102898
8. Chen, X., Lei, Z., & Ukkusuri, S. V. (2024). Modeling the influence of charging cost on electric ride-hailing vehicles. *Transportation Research Part C: Emerging Technologies*, 160, 104514
9. Verma, R., Mittal, S., Lei, Z., Chen, X., & Ukkusuri, S. V. (2024). Comparison of home detection algorithms using smartphone GPS data. *EPJ Data Science*, 13(1), 6
10. Lei, Z., & Ukkusuri, S. V. (2023). Scalable reinforcement learning approaches for dynamic pricing in ride-hailing systems. *Transportation Research Part B: Methodological*, 178, 102848
11. Chen, X., Xue, J., Lei, Z., Qian, X., & Ukkusuri, S. V. (2022). Online eco-routing for electric vehicles using combinatorial multi-armed bandit with estimated covariance. *Transportation Research Part D: Transport and Environment*, 111, 103447
12. Lei, Z., & Ukkusuri, S. V. (2022). Understanding the recovery of on-demand mobility services in the COVID-19 era. *Journal of Big Data Analytics in Transportation*, 4(1), 1–21
13. He, M., Muaz, U., Jiang, H., Lei, Z., Chen, X., Ukkusuri, S. V., & Sobolevsky, S. (2022). Ridership prediction and anomaly detection in transportation hubs: An application to New York City. *The European Physical Journal Special Topics*, 231(9), 1655–1671
14. Qian, X., Lei, T., Xue, J., Lei, Z., & Ukkusuri, S. V. (2020a). Impact of transportation network companies on urban congestion: Evidence from large-scale trajectory data. *Sustainable Cities and Society*, 55, 102053
15. Lei, Z., Qian, X., & Ukkusuri, S. V. (2020). Efficient proactive vehicle relocation for on-demand mobility service with recurrent neural networks. *Transportation Research Part C: Emerging Technologies*, 117, 102678
16. Duan, Z., Lei, Z., Zhang, M. H., Li, W., Fang, J., & Li, J. (2017). Understanding evacuation and impact of a metro collision on ridership using large-scale mobile phone data. *IET Intelligent Transport Systems*, 11(8), 511–520
17. Duan, Z., Wang, C., Zhang, H. M., Lei, Z., Li, H., & Yang, D. (2017). Using longitudinal mobile phone data to understand the stability of individual travel patterns: Case study of three communities in Shanghai, China. *Transportation*

Conference Papers

1. Barbosa, D. O., Burbano, L., Hernandez, C., Lei, Z., Park, Y., Ukkusuri, S. V., & Cardenas, A. A. (2025). D4+: Emergent adversarial driving maneuvers with approximate functional optimization [arXiv preprint arXiv:2505.13942]
2. Li, H., Lei, Z., & Ukkusuri, S. V. (2024). Flexible microtransit scheduling with time sensitive travelers. *2024 IEEE 27th International Conference on Intelligent Transportation Systems (ITSC)*, 2832–2837
3. Chen, X., Lei, Z., & Ukkusuri, S. V. (2022). Prediction of road-level energy consumption of battery electric vehicles. *2022 IEEE 25th International Conference on Intelligent Transportation Systems (ITSC)*, 2550–2555
4. Lei, Z., Xue, J., Chen, X., Saumya, C., Qian, X., He, M., Sobolevsky, S., & Ukkusuri, S. V. (2021). ADDS-EVS: An agent-based deployment decision-support system for electric vehicle services. *2021 IEEE International Intelligent Transportation Systems Conference (ITSC)*, 1658–1663
5. Verma, R., Lei, Z., Xue, J., Shen, J., Gehlot, H., Ukkusuri, S. V., & Murray-Tuite, P. (2021). How information heterogeneity influences traffic congestion during hurricane evacuation. *2021 IEEE International Intelligent Transportation Systems Conference (ITSC)*, 1833–1838
6. Lei, Z., Qian, X., Chen, X., & Ukkusuri, S. V. (2021). Real-time ridesharing for transportation hubs with demand and supply uncertainty [Paper No. 21-04371]. *Transportation Research Board Annual Meeting*
7. Lei, Z., Qian, X., Chen, X., & Ukkusuri, S. V. (2020). Efficient subspace clustering for road traffic pattern and anomaly analysis [Paper No. 20-01664]. *Transportation Research Board Annual Meeting*
8. Qian, X., Xue, J., Lei, Z., Suarez, J., & Ukkusuri, S. V. (2020). Demand-adaptive transit design for urban transportation hubs [Paper No. 20-01285]. *Transportation Research Board Annual Meeting*
9. Qian, X., Lei, T., Xue, J., Lei, Z., & Ukkusuri, S. V. (2020b). Impact of transportation network companies on urban congestion [Paper No. 20-02381]. *Transportation Research Board Annual Meeting*
10. Lei, Z., Qian, X., & Ukkusuri, S. V. (2019). Optimal proactive vehicle relocation for on-demand mobility service with deep Convolution-LSTM network. *2019 IEEE Intelligent Transportation Systems Conference (ITSC)*, 3373–3378
11. Duan, Z., Lei, Z., Zhang, H. M., Li, H., & Yang, D. (2018). Using matrix decomposition method to understand the structure of metro travel demand [Paper No. 18-02468]. *Transportation Research Board Annual Meeting*
12. Duan, Z., Lei, Z., Li, H., Wang, K., & Yang, D. (2018). Understanding the structure of taxi travel demand via stable principal component pursuit: A case study in Xiamen, China [Paper No. 18-04753]. *Transportation Research Board Annual Meeting*
13. Chang, Y., Duan, Z., Yang, D., & Lei, Z. (2018). Using ALPR data to analyze the impact of TDM policy on vehicle users' travel behaviors [Paper No. 18-02765]. *Transportation Research Board Annual Meeting*
14. Duan, Z., Lei, Z., Zhang, M. H., Li, W., Fang, J., & Li, J. (2016). Understanding evacuation patterns of a metro collision accident using large-scale mobile phone data [Paper No. 16-3207]. *Transportation Research Board Annual Meeting*

Invited Talks and Seminars

- “Transportation Cybersecurity: A Network-Level Perspective.” *TraCR Scholar Webinar Series*, August 27, 2025.
- “Adversarial Booking Attacks for On-Demand Mobility Services.” *Purdue Institute of Transportation Engineers Student Chapter Seminar*, November 28, 2023.

Teaching and Mentorship

Co-Instructor

Purdue University

CE564: Data Science for Smart Cities. Delivered four weeks of lectures and developed instructional materials on deep learning and reinforcement learning for transportation systems.

Research Mentorship

Purdue University

Mentored seven students and junior collaborators: Mithun Debnath (2022), Ruichen Tan (2023–Present), Hongli Li (2024–Present), and Zhiyu Cai, Ziyuan Yang, Shiveswarran Ratneswaran, and Yufan Zhang (2025–Present). Advised projects in transportation simulation, mobility analytics, and security-focused research, contributing to a *Transportation Research Part E* publication and manuscripts submitted to competitive AI and systems venues.

Professional Service

Journal Reviewer.

- *Security and intelligent systems: IEEE Transactions on Information Forensics and Security; IEEE Transactions on Intelligent Transportation Systems.*
- *Transportation systems: Transportation Research Part B; Transportation Research Part C; Transportation Research Part D; Transportation Research Part E; Transportation; Multimodal Transportation; Transportation Research Record; Data Science for Transportation.*
- *Operations, energy, and interdisciplinary science: European Journal of Operational Research; Operations Research Perspectives; Scientific Reports; Energy.*

Conference Reviewer.

- *AI and data mining venues: AAAI Conference on Artificial Intelligence; Conference on Neural Information Processing Systems; ACM SIGKDD Conference on Knowledge Discovery and Data Mining.*
- *Intelligent transportation venues: IEEE Intelligent Vehicles Symposium; IEEE Intelligent Transportation Systems Conference; IEEE International Conference on Vehicular Electronics and Safety.*

Event Coordinator. *ITE Special Seminar (2025): "Interdisciplinary Intelligent Transportation Systems: Traffic Control and Travel Time Dynamics."* Speaker: Dr. Pushkin Kachroo.