Chengyuan ZHANG

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CONTACT

- Homepage: https://chengyuan-zhang.github.io; Google Scholar: [Link]
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RESEARCH INTERESTS

My research focuses on Bayesian inference, spatiotemporal modeling, traffic flow theory, and multi-agent interaction modeling within intelligent transportation systems, with an emphasis on bridging the gap between theoretical modeling and practical traffic simulation through advanced statistical techniques with appropriate uncertainty quantification. My motivation lies in advancing the understanding of human driving behaviors to improve microscopic traffic simulations, ultimately contributing to safer and more efficient transportation systems. I'm currently interested in the following topics:

- Traffic Flow Theory & Traffic Simulations;
- Multi-Agent Social Interactions & Human Driving Behaviors;
- Spatiotemporal Modeling & Interpretable Pattern Discovery;

EDUCATION

McGill University — Montréal, Québec, Canada
Ph.D. Candidate (20'-26'), supervised by Prof. Lijun Sun — Sept. 2020 - May 2026 (expected)

· **Dissertation**: "From Micro Interactions to Traffic Flow: Stochastic Driver Models for Realistic Traffic Simulation"
· **Cumulative GPA: 4.00/4.00**;
· **Courses:** COMP588@McGill, IFT6135@UdeM, ECSE683@McGill, COMP540@McGill, CIV1532H@UofT
· Fast tracked to the Ph.D. program in 2022 winter with 4.00/4.00 Master's GPA;

Chongqing University — Chongqing, China
BEng in Vehicle Engineering — Sept. 2015 – June 2019

· **Thesis**: "Recognition of Multi-Vehicle Interaction Patterns Based on Probabilistic Velocity Fields"
· **Selected scholarships and awards:** National Scholarship, 2017; Outstanding Undergraduate Thesis Award, 2019; Outstanding Graduate of Chongqing University, 2019; Outstanding Student Award (top 3%), 2018 and 2017;
· Selected to **Excellent Student Program** (top 5%, on basis of outstanding academic performance;)
· Completed extensive coursework in **Electronics Science and Technology** (2015-2016.)

University of Pennsylvania — Philadelphia, Pennsylvania, USA
Visiting Student — Jan. 2018 – Feb. 2018

ACADEMIC EXPERIENCE

Carnegie Mellon University (Robotics Institute) — Pittsburgh, Pennsylvania, USA
Visiting Student Researcher (supervised by Prof. Changliu Liu) — Jan. 2023 – Aug. 2023

University of California, Berkeley (Department of Mechanical Engineering) — Berkeley, California, USA
Visiting Student Researcher (supervised by Prof. Masayoshi Tomizuka) — Sept. 2019 – Jan. 2020

Carnegie Mellon University (Department of Mechanical Engineering) — Pittsburgh, Pennsylvania, USA
Visiting Student Researcher (supervised by Prof. Ding Zhao) — July 2018 – Oct. 2018

PREPRINTS

- ***Zhang, C.***, Wu, C., & Sun, L. (2025). Markov Regime-Switching Intelligent Driver Model for Interpretable Car-Following Behavior. arXiv preprint arXiv:2506.14762. [arXiv]
- ***Zhang, C.***, He, Z., Wu, C., & Sun, L. (2025). When Context Is Not Enough: Modeling Unexplained Variability in Car-Following Behavior. arXiv preprint arXiv:2507.07012. *(Accepted at ISTTT26)* [arXiv]

JOURNAL PUBLICATIONS

- Chen, X., ***Zhang, C.***, Zhao, X. L., Saunier, N., & Sun, L. (2025). Forecasting Sparse Movement Speed of Urban Road Networks with Nonstationary Temporal Matrix Factorization. *Transportation Science*. [TranSci] [arXiv] [slides] [Github] [blog]
- ***Zhang, C.***, Wang, W., & Sun, L. (2024). Calibrating Car-Following Models via Bayesian Dynamic Regression. *Transportation research part C: emerging technologies. (ISTTT25 Special Issue)* [TR PartC] [arXiv] [Github]
- ***Zhang, C.***, & Sun, L. (2024). Bayesian Calibration of the Intelligent Driver Model. *IEEE Transactions on Intelligent Transportation Systems*. [IEEE TITS][arXiv] [Github] [presentation] [poster]
- Chen, X., ***Zhang, C.***, Cheng, Z., Hou, Y., & Sun, L. (2023). A Bayesian Gaussian Mixture Model for Probabilistic Modeling of Car-Following Behaviors. *IEEE Transactions on Intelligent Transportation Systems*. [IEEE TITS]
- Chen, X., ***Zhang, C.*** (equal contributions), Chen, X., Saunier, N., & Sun, L. (2022). Discovering dynamic patterns from spatiotemporal data with time-varying low-rank autoregression. *IEEE Transactions on Knowledge and Data Engineering*, 36(2), 504-517.[IEEE TKDE] [arXiv] [data & code] [blog]
- ***Zhang, C.***, Zhu, J., Wang, W., & Xi, J. (2020). Spatiotemporal Learning of Multivehicle Interaction Patterns in Lane-Change Scenarios. *IEEE Transactions on Intelligent Transportation Systems*. [demo] [IEEE TITS] [project website] [Github]
- ***Zhang, C.***, Zhang, X., Ye, H., Wei, M., & Ning, X. (2019). An Efficient Parking Solution: A Cam-Linkage Double-Parallelogram Mechanism Based 1-Degrees of Freedom Stack Parking System. *Journal of Mechanisms and Robotics, 11*(4), 045001. [demo] [ASME JMR]
- ***Zhang, C.***, & Xiao, J. (2018). Chaotic Behavior and Feedback Control of Magnetorheological Suspension System with Fractional-Order Derivative. *Journal of Computational and Nonlinear Dynamics, 13*(2), 021007. [ASME JCND]

CONFERENCE PUBLICATIONS

- ***Zhang, C.***, Chen, K. (equal contributions), Zhu, M., Yang, H., & Sun, L. (2024). Learning Car-Following Behaviors Using Bayesian Matrix Normal Mixture Regression. *2024 IEEE Intelligent Vehicles Symposium (IV)*. [arXiv][IEEE IV]
- ***Zhang, C.***, Chen, R., Zhu, J., Wang, W., Liu, C., & Sun, L. (2023). Interactive Car-Following: Matters but NOT Always. *2023 IEEE Intelligent Transportation Systems Conference (ITSC)*. [arXiv][IEEE ITSC]
- Wang, W., ***Zhang, C.***, Wang, P., & Chan, C. (2020). Learning Representations for Multi-Vehicle Spatiotemporal Interactions with Semi-Stochastic Potential Fields. *2020 IEEE Intelligent Vehicles Symposium (IV)*. [IEEE IV]
- ***Zhang, C.***, Zhu, J., Wang, W., & Zhao, D. (2019). A General Framework of Learning Multi-Vehicle Interaction Patterns from Videos. *2019 IEEE Intelligent Transportation Systems Conference (ITSC)*. [IEEE ITSC]

BOOKS

- Wang, W., Wang, L., ***Zhang, C.***, Liu, C., & Sun, L. (2022). Social Interactions for Autonomous Driving: A Review and Perspectives. *Foundations and Trends in Robotics: Vol. 10, No. 3-4, pp 197–376.* [ebook] [arXiv]
- Chen, X., Jin, J., Liao, Q., ***Zhang, C.***, Chen, X. Academic Writing with LaTeX (in Chinese), 2023. [ebook] [link]

PATENT

- CN108222589B, Cam-connecting rod type mechanical three-dimensional parking device. ***Zhang, C.***, Zhang, X., Ye, H., Shi, J., Wang, M., & Ning, X. *Chongqing University*.

FUNDING PROGRAM

- "Quantitative Evaluation and Modeling of Action-Reaction Cycles in Interactive Human Driving Behaviors", NSERC Alliance International Catalyst Grant, $25,000, trainee, 2022-2023.
- "Quantitative Evaluation and Modeling of Action-Reaction Cycles in Interactive Human Driving Behaviors", FRQNT Fellowship, $100,000, 2023-2026.
- "Discovering Spatiotemporal Interactive Driving Behaviours in Traffic Scenes", FRQNT Fellowship, $17,500, 2022-2023.
- "Statistical Modeling Framework to Understand Dynamic Traffic Patterns from Video Data", IVADO Fellowship, $40,000, 2020-2022.

TEACHING EXPERIENCE

Traffic Engineering and Simulation (by Prof. Lijun Sun) *2022 Fall, 2023 Fall, 2025 Fall*
Teaching Assistant, Department of Civil Engineering, McGill University

- TA Tutorials: traffic flow fundamentals and simulation; fundamental diagrams and shockwaves.

Basics of Machine Learning and Data Analysis (by Prof. Pradeep Ravikumar) *2022 Fall*
Teaching Assistant (Online), Department of Computer Science, Carnegie Mellon University

- TA Tutorials: ordinary/generalized least squares (OLS/GLS), logistic regression, Bayesian inference, Gaussian processes.

Statistical Machine Learning (by Prof. Dino Sejdinovic) *2020 Spring, 2020 Summer, and 2022 Summer*
Teaching Assistant (Online), Department of Statistics, Oxford University

- TA Tutorials: LSE, MLE, Linear Regression, PCA, SVM, kernel methods, Deep Neural Network.

ACADEMIC ACTIVITIES

· (Co-)Chair/(Co-)Organizer:
  - 2nd SIAM workshop on IEEE IV24', Jeju Shinhwa World, Jeju Island, Korea, 2024. [Website]
  - 1st SIAM workshop on IEEE IV23', Anchorage, Alaska, USA, 2023. [Website]

· Journal Reviewer:
  - Transportation Science;
  - Transportation Research Part B: Methodological;
  - Transportation Research Part C: Emerging Technologies;
  - Artificial Intelligence for Transportation;
  - IEEE Transactions on Intelligent Transportation Systems;
  - IEEE Transactions on Intelligent Vehicles;
  - IEEE Transactions on Consumer Electronics;
  - IEEE Transactions on Cybernetics;
  - IEEE Sensors Journal;
  - European Journal of Operational Research;
  - Travel Behaviour and Society;
  - ASME Journal of Mechanism and Robotics;
  - ASME Journal of Mechanism Design;
  - Physica A: Statistical Mechanics and its Applications;
  - Automotive Innovation;
  - Advanced Engineering Informatics;
  - Journal of Traffic and Transportation Engineering;
  - Nonlinear Dynamics;

· Conference Reviewer:
  - IEEE International Conference on Intelligent Transportation Systems (ITSC), 22-24;
  - IEEE Intelligent Vehicles Symposium (IV), 23-24;
  - Symposium on Machine Learning for Autonomous Driving; [NeurIPS'23] [AAAI'25]
  - Transportation Research Board Annual Meeting;
  - The 5th Symposium on Management of Future Motorway and Urban Traffic Systems (MFTS), 2024;
  - RSS 2024 Workshop on Autonomous Vehicles Across Scales (AVAS), 2024; [RSS'24]
  - Bayesian Decision-making and Uncertainty Workshop; [NeurIPS'24]
  - International Symposium on Transportation Data & Modelling (ISTDM), 2025;

· IEEE Graduate Student member;

· IEEE Intelligent Transportation Systems Society (ITSS) Student member;

· Student member of Chinese Overseas Transportation Association (COTA);

· Student member of Interuniversity Research Centre on Enterprise Networks, Logistics and Transportation (CIRRELT);

· Member of the Society of Automotive Engineers (SAE) of China;

AWARDS & COMPETITIVE FELLOWSHIPS/SCHOLARSHIPS

· The Honorable Mention Award for the 2024 Clifford Spiegelman Student Paper Competition, 2024 [Link]

· Graduate Mobility Award, McGill University, 2022-2023

· Graduate Research Enhancement and Travel Awards, McGill University, 2023

· Ron Rice Memorial Award, McGill University, 2023

· Mitacs Globalink Research Award - Abroad, 2022-2023

· McGill Engineering Doctoral Award (MEDA), CAD $111,000, McGill University, 2022-2025

· FRQNT Master's Scholarship (B1X), CAD $17,500, 2022-2023 [Link]

· FRQNT Doctoral Scholarship (B2X), CAD $100,000, 2023-2027 [Link]

· CIRRELT Doctoral Scholarship of Excellence - Final Stages, CAD $7,500, 2025 [Link]

· CIRRELT Doctoral Scholarship of Excellence - Early Stages, CAD $4,000, 2023 [Link]

· CIRRELT Master's Scholarship of Excellence, CAD $3,500, 2022

· Graduate Excellence Fellowship Awards, McGill University, 2020

· IVADO Excellence Scholarships - Msc, CAD $40,000, 2020-2022

· Outstanding Team Award & Best Application Award at DeeCamp, China, 2019

· Outstanding Graduate of Chongqing University, 2019

· First Prize in the 2018 National College Mechanical Innovation Competition (TOP #10 in China), 2018

· National Scholarship, China, 2017

· First Prize in the Chongqing University Physics Contest (#1/500 in Chongqing University), 2015

OPEN-SOURCED PACKAGES/NOTES

- https://github.com/Chengyuan-Zhang/IDM_Bayesian_Calibration;
- https://github.com/Chengyuan-Zhang/Gaussian_Velocity_Field;
- Research Notes: https://chengyuan-zhang.github.io/notes/;

SELECTED TALKS & PRESENTATIONS

- Invited Online Talk. From Micro Interactions to Traffic Flow: Stochastic Driver Models for Realistic Traffic Simulation. MIT Wu Lab, Massachusetts Institute of Technology. Oct. 2025.
- Invited Online Talk. Stochastic Modeling and Simulations of Car-Following Behaviors. JTL Research Seminar, Massachusetts Institute of Technology. Feb. 2025.
- Invited Podium Talk. Bayesian Calibration of Car-Following Models. Department of Mechanical Engineering, Beijing Institute of Technology, Beijing. Nov. 2024.
- Invited Podium Talk. Bayesian Calibration of Car-Following Models. Artificial Intelligence Institute, Shanghai Jiao Tong University, Shanghai. Oct. 2024.
- Podium Presentation. Calibrating Car-Following Models via Bayesian Dynamic Regression. The 25th International Symposium on Transportation and Traffic Theory (ISTTT25). University of Michigan, Ann Arbor. July 2024.

- Invited Online Talk. Bayesian Calibration of the IDM. Traffic Flow Theory and Characteristics (ACP50) general webinar series. Feb. 2023.
- Poster Presentation. Bayesian Calibration of the IDM. Transportation Research Board Annual Meeting. Washington, DC. Jan. 2023.
- Invited Podium Talk. Learning to Drive: Imitating How Human Drivers Make Decisions in Complicated Urban Scenarios. Department of Mechanical Engineering, UC Berkeley, Berkeley. Dec. 2019.
- Invited Podium Talk. Design of a Novel Cam-Linkage Mechanism. The 1st Workshop for SAILER at CMU. Department of Mechanical Engineering, Carnegie Mellon University, Pittsburgh. Aug. 2018.

My PhD Research Summary:

From Micro Interactions to Traffic Flow: Stochastic Driver Models for Realistic Traffic Simulation
(Chengyuan Zhang, Ph.D. Candidate @ McGill University, *enzozcy@gmail.com*)

- **Goal:** Model and simulate human driving behaviors with heterogeneity and stochasticity.
- **Challenge:** Traditional models learn a *one-to-one mapping*

$$f_{\text{CF}} : (s_t, \Delta v_t, v_t) \mapsto a_t \quad \text{(deterministic)} \ \text{✗}$$

but real drivers induce a *one-to-many mapping* with uncertainty

$$f_{\text{CF}} : (s_t, \Delta v_t, v_t) \mapsto \{a_t^{(1)}, a_t^{(2)}, \dots\} \quad \text{(stochastic)} \ \text{✓}$$

- **Solutions:**

1 Explicit Uncertainty Modeling (Heterogeneity as Identity)

$$a_t \approx f_{\text{CF}}(\boldsymbol{x}_t; \boldsymbol{\theta}_d) + \delta_t, \quad \text{(Zhang and Sun 2024, Zhang et al. 2024, Zhang et al. 2025a)}$$

Table 1: Modeling of temporal correlations in my previous work.

Reference	$f_{\text{CF}}(\boldsymbol{x}_t; \boldsymbol{\theta}_d)$	δ_t	Inference Method
Zhang and Sun (2024)	IDM	Gaussian processes (GPs)	Full Bayesian (MCMC)
Zhang et al. (2024)	IDM	Autoregressive (AR) processes	Full Bayesian (MCMC)
Zhang et al. (2025a)	NN	Nonstationary GPs	Point estimate (gradient descent)
Kong et al. (2026)	IDM	GPs	Likelihood-free (SBI)

1. Chengyuan Zhang and Lijun Sun. (2024). Bayesian calibration of the intelligent driver model. *IEEE Transactions on Intelligent Transportation Systems*.
2. Chengyuan Zhang, Wenshuo Wang, and Lijun Sun. Calibrating car-following models via Bayesian dynamic regression. (ISTTT25 Special Issue) Transportation Research Part C: Emerging Technologies 168 (2024): 104719.
3. Chengyuan Zhang, Zhengbing He, Cathy Wu, and Lijun Sun. (2025a). When Context Is Not Enough: Modeling Unexplained Variability in Car-Following Behavior. arXiv preprint arXiv:2507.07012 *(Accepted at ISTTT26 and TR Part B)*.
4. Menglin Kong, Chengyuan Zhang, and Lijun Sun. (2026). Active Simulation-Based Calibration of Car-Following Models via Amortized Bayesian Inference. *(under review)*

2 Latent Variable Modeling (Heterogeneity as Composition)

$$a_t \approx f_{\text{CF}}(\boldsymbol{x}_t; \boldsymbol{\theta}_{z_t}), \ z_t \sim \begin{cases} \text{Gaussian Mixture} & \textit{(i.i.d.)} \\ & \text{(Chen et al. 2023 , Zhang et al. 2023, 2024)} \\ \text{Markov Chain} & \textit{(temporal dependence)} \\ & \text{(Zhang et al. 2025b)} \end{cases}$$

5. Xiaoxu Chen, Chengyuan Zhang, Zhanhong Cheng, Yuang Hou, and Lijun Sun. A bayesian gaussian mixture model for probabilistic modeling of car-following behaviors. IEEE Transactions on Intelligent Transportation Systems 25, no. 6 (2023): 5880-5891.
6. Chengyuan Zhang, Rui Chen, Jiacheng Zhu, Wenshuo Wang, Changliu Liu, and Lijun Sun. "Interactive car-following: Matters but not always." In 2023 IEEE 26th International Conference on Intelligent Transportation Systems (ITSC), pp. 5120-5125. IEEE, 2023.
7. Chengyuan Zhang, Kehua Chen, Meixin Zhu, Hai Yang, and Lijun Sun. Learning car-following behaviors using bayesian matrix normal mixture regression. In 2024 IEEE Intelligent Vehicles Symposium (IV), pp. 608-613. IEEE, 2024.
8. Chengyuan Zhang, Cathy Wu, and Lijun Sun. (2025b). Markov Regime-Switching Intelligent Driver Model for Interpretable Car-Following Behavior. arXiv preprint arXiv:2506.14762 (2025b). (*under review*).

→ stochastic, interpretable human-like simulators

McGill NSERC CRSNG Fonds de recherche Québec CIRRELT IVADO