Wenhan Cao
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RESEARCH INTERESTS

My research vision is to establish a probabilistic foundation for physical intelligence, enabling AI agents to reason, learn, and act reliably under real-world constraints.

WORK EXPERIENCE

National University of Singapore September 2025-Present
Research Fellow in Robot Learning *Singapore*

EDUCATION

Tsinghua University September 2019-June 2025
Ph.D student in Intelligent Vehicle Engineering *Beijing, China*
Supervisor: Prof. Shengbo Eben Li, Intelligent Driving Laboratory
Co-supervisor: Prof. Chang Liu, Autonomous Robots Lab

University of Manchester *January 2023-June 2024*
Visiting Ph.D. Student in Computer Science *Manchester, UK*
Supervisor: Prof. Wei Pan, Robotics and Embodied AI Lab

Technical University of Munich *September 2023-December 2023*
Visiting Ph.D. Student in Control and Optimization *Munich, Germany*
Supervisor: Prof. Sandra Hirche, Chair of Information-Oriented Control

Beijing Jiaotong University *September 2015-June 2019*
Bachelor of Electrical Engineering *Beijing, China*
GPA ranking: 1/305

ONGOING PROJECTS

Foundation Priors for RL Navigation: Reinforcement learning (RL) for navigation is hindered by sparse rewards, inefficient exploration, and weak generalization beyond simulation. We tackle these challenges by casting navigation as probabilistic inference, where pretrained VLN models provide policy priors instead of starting from scratch. These priors capture spatial reasoning, goal-directed behavior, and language-grounded strategies, guiding RL agents toward faster learning and stronger semantic grounding. The result is compact navigation policies that transfer reliably to the real world and remain efficient enough for deployment on edge devices.

SELECTED PUBLISHED PAPERS (* denotes equal contribution)[1]

Shiqi Liu*, **Wenhan Cao***, Chang Liu, Zeyu He, Tianyi Zhang & Shengbo Eben Li. *One Filters All: A Generalist Filter for State Estimation*. In 2025 Annual Conference on Neural Information Processing Systems (NeurIPS). [Paper] [Poster]

Wenhan Cao, Alexandre Capone, Rishabh Yadav, Sandra Hirche & Wei Pan. *Computation-Aware Learning for Stable Control with Gaussian Process.* In 2024 Robotics: Science and Systems (RSS). [Paper] [Poster] [Recording]

[1] An updated list of publications can be found in this link.

Wenhan Cao & Wei Pan. *Impact of Computation in Integral Reinforcement Learning for Continuous-Time Control.* In 2024 International Conference on Learning Representations (ICLR). **(Spotlight)** [Paper] [Poster] [Code]

Wenhan Cao, Chang Liu, Zhiqian Lan, Shengbo Eben Li, Wei Pan & Angelo Alessandri. *Robust Bayesian Inference for Moving Horizon Estimation.* Automatica, 173, 112108. [Paper] [Code]

Tianyi Zhang, **Wenhan Cao**, Chang Liu, Tao Zhang, Jiangtao Li & Shengbo Eben Li. *Robust State Estimation for Legged Robots with Dual Beta Kalman Filter.* IEEE Robotics and Automation Letters (RA-L), 10(8), 7955–7962. [Paper]

Jingliang Duan, **Wenhan Cao**, Yang Zheng & Lin Zhao. *On the Optimization Landscape of Dynamic Output Feedback Linear Quadratic Control.* IEEE Transactions on Automatic Control (TAC), 69(2):920–935, 2024. [Paper] [Code]

Shiqi Liu, **Wenhan Cao**, Chang Liu, Tianyi Zhang & Shengbo Eben Li. *Convolutional Unscented Kalman Filter for Multi-Object Tracking with Outliers.* IEEE Transactions on Intelligent Vehicles (TIV), pp. 1–12, 2024. [Paper]

Tianyi Zhang, **Wenhan Cao**, Chang Liu, Feihong Zhang, Wei Wu & Shengbo Eben Li. *NANO-SLAM: Natural Gradient Gaussian Approximation for Vehicle SLAM.* In 2025 IEEE International Conference on Intelligent Transportation Systems (ITSC). [Paper]

Tianyi Zhang, **Wenhan Cao** & Shengbo Eben Li. *Natural Gradient Gaussian Approximation Filter with Positive Definiteness Guarantee.* In 2026 American Control Conference (ACC).

Wenhan Cao, Chang Liu, Zhiqian Lan, Yingxi Piao & Shengbo Eben Li. *Generalized Moving Horizon Estimation for Nonlinear Systems with Robustness to Measurement Outliers.* In 2023 American Control Conference (ACC). [Paper] [Code] [Slides]

Wenhan Cao, Jingliang Duan, Shengbo Eben Li, Chen Chen, Chang Liu, & Yu Wang. *Primal-Dual Estimator Learning Method with Feasibility and Near-Optimality Guarantees*. In 2022 IEEE Conference on Decision and Control (CDC). [Paper] [Slides]

Wenhan Cao, Jianyu Chen, Jingliang Duan, Shengbo Eben Li & Yao Lyu. *Reinforced Optimal Estimator*. In 2021 Modeling, Estimation and Control Conference (MECC). **(Student Best Paper Finalist)** [Paper] [Slides]

PREPRINTS

Wenhan Cao, Shiqi Liu, Chang Liu, Zeyu He, Stephen S.-T. Yau & Shengbo Eben Li. *Convolutional Bayesian Filtering.* Under Review in IEEE Transactions on Automatic Control. [Paper] [Slides]

Wenhan Cao, Tianyi Zhang, Zeju Sun, Chang Liu, Stephen S.-T. Yau & Shengbo Eben Li. *Nonlinear Bayesian Filtering with Natural Gradient Gaussian Approximation.* Under Review in IEEE Transactions on Pattern Analysis and Machine Intelligence. [Paper] [Code] [Slides]

Xuyang Chen, Keyu Yan, **Wenhan Cao** & Lin Zhao. *Discriminating Out-of-Distribution Actions in Offline Reinforcement Learning via Quantile Advantage.* Under Review in IJCAI 2026. [Paper] [Code]

Rui Huang, Xin Chen, **Wenhan Cao**, Lidong Li, Yizhe Xiao, Yichao Gao, Yuqi Shi & Lin Zhao. *Agile Modular Aerial Robot Load Transport with Arbitrary Configurations.* Under Review in RSS 2026.

HONORS & AWARDS

Study Abroad Fund from Tsinghua University	2022
Student Best Paper Finalist of Modeling, Estimation and Control Conference	2021
China National Scholarship	2016
The First Prize Scholarship from Beijing Jiaotong University	2016, 2017 & 2018

SOFTWARE

I contributed to the General Optimal Control Problem Solver (GOPS), an easy-to-use reinforcement learning (RL) solver package designed to build real-time, high-performance controllers for industrial applications. I was primarily responsible for the core design and implementation of the trainer, sampler, and buffer modules. [Docs] [Paper]

PROJECTS PARTICIPATED

Networked Modeling and Cooperative Control of Connected and Automated Vehicles

Project Leader	Supported by MOST	Nov 2020

State Estimation for Warehouse Automated Logistics Vehicles

Project Leader	Supported by Geek+	May 2022

Reinforcement Learning for Autonomous Driving Decision and Control on Open Roads

Project Member	Supported by Toyota & IdriverPlus	May 2024

RL Post-Training of MindGPT

Project Member	Internship at Li Auto	November 2024

INVITED TALKS

NANO filter: Bayesian Filtering with Natural Gradient Gaussian Approximation at the Department of Astronomy, Tsinghua University, Beijing, China, hosted by Prof. Zheng Cai, August 2024.

Convolutional Bayesian Filtering at the Department of Mathematical Sciences, Tsinghua University, Beijing, China, hosted by Prof. Stephen Shing-Toung Yau, February 2024.

Learning-based State Estimation Methods at the Technical University of Munich, Munich, Germany (Online Presentation), hosted by Prof. Sandra Hirche, February 2023.

TEACHING EXPERIENCE

School of Vehicle and Engineering, Tsinghua University *February 2022-May 2022*
Teaching Assistant, 150051 Intelligent Vehicles

PROFESSIONAL SERVICES

Conference Reviewer: ICLR, NeurIPS, CDC, ACC, L4DC, AAMAS & IFAC NMPC
Journal Reviewer: T-RO, T-ITS, TII, Automatica, TAC, T-ASE, TNNLS & RA-L