

Liang Cao

Department of Chemical and Biological Engineering University of British Columbia liang.cao@ubc.ca

Research Interests

Machine Learning, Fault Diagnosis, Process Control, Process Modeling, Alarm Management

Education

- 2025.11 – Present **Postdoc, University of British Columbia/Cornell University**, Chemical and Biological Engineering.
Advisors: Prof. Bhushan Gopaluni (Fellow of the Canadian Academy of Engineering), Prof. Fengqi You (AAAS/AICHe/FRSC Fellow)
- 2024.03 – 2025.11 **Postdoc, Massachusetts Institute of Technology**, Chemical Engineering.
Advisor: Prof. Richard D. Braatz (Member of the US National Academy of Engineering, IEEE/IFAC/AAAS/AICHe Fellow)
- 2019.09 – 2024.02 **Ph.D., University of British Columbia**, Chemical and Biological Engineering.
Advisors: Prof. Bhushan Gopaluni (Fellow of the Canadian Academy of Engineering), Prof. Yankai Cao
Thesis title: *Interpretable and Robust Soft Sensor Modeling for Industrial Applications*
- 2015.09 – 2018.06 **M.S., Beijing University of Chemical Technology**, Control Engineering.
Advisor: Prof. Youqing Wang
Thesis title: *Model-based fault diagnosis and fault-tolerant control of industrial processes*
- 2017.07 – 2018.04 **Joint M.S., University of Duisburg-Essen**, Control Engineering.
Advisor: Prof. Steven X. Ding
- 2011.09 – 2015.06 **B.S., Beijing University of Chemical Technology**, Automation.
Advisor: Prof. Youqing Wang
Thesis title: *Fault diagnosis and fault-tolerant control of intermittent fault*

Experience

- 2018.06-2019.08 **Research Assistant of Tsinghua University**, Department of Automation
Duties included: causal discovery analysis, collaboration with industry partners
Supervisor: Prof. Fan Yang
- 2019.12-2024.02 **Data Scientist Intern of Parkland Corporation**, Department of Process Control
Duties included: data analysis and visualization, model development and implement
- 2020.08-2021.01 **Teaching Assistant of CHBE 474 Process Control Engineering**, Department of Chemical and Biological Engineering, UBC
Duties included: assisting with course materials, conducting tutorials, grading Supervisor: Prof Alireza Bagherzadeh
- 2021.04-2021.07 **Research Assistant of Chinese University of Hong Kong**, School of Data Science
Duties included: matrix factorization/recovery, fault diagnosis, causal discovery analysis.
Supervisor: Prof. Jicong Fan
- 2021.01-2023.12 **Vice President of UBC Society of Petroleum Engineers Chapter**
Duties included: assisting the president,organizing events,communicating with members

Awards and Achievements

- 2025 Outstanding Reviewers of IEEE Transactions on Instrumentation and Measurement (IEEE TIM)
Outstanding Reviewers of Control Engineering Practice (CEP)
- 2024 **Second Prize of the 2024 IEEE/CAA JAS Conference on Automation for Industry 5.0, IEEE/CAA JAS**
Outstanding Reviewers of IEEE Transactions on Instrumentation and Measurement (IEEE TIM)
- 2023 A. J. Shaw Graduate Scholarship in Engineering, UBC
- 2023/2022 President's Academic Excellence Initiative Ph.D. Award, UBC
- 2022 **Finalists of the 2022 SICE Annual Conference Young Author's Award, Society of Instrument and Control Engineers (SICE)**
Petrov Family Graduate Scholarship, UBC
- 2021 CHBE Awards in Breakthrough Innovations and Engineering Leadership, UBC
- 2019 Mitacs Accelerate Award, UBC, Parkland Corporation
Faculty of Applied Science Graduate Award, UBC
- 2018 Outstanding Graduate Student of Beijing, Beijing
Excellent Master Thesis, Beijing University of Chemical Technology
- 2017 Graduate Mathematical Contest in Modeling, 2nd prize, China Society for Industrial and Applied Mathematics
Outstanding Graduate Student, Beijing University of Chemical Technology
- 2017/2016 National Scholarship for Graduates Student, Ministry of Education of the People's Republic of China
- 2015 Outstanding Undergraduate Student, Beijing University of Chemical Technology

Journal Articles

1. **Liang Cao**, Weide Liu, Yang Liu, Yan Qin. **2026**. Condition-Dependent Causal Discovery: A Polynomial Chaos Framework for Systems with Parametric Uncertainty. *IEEE Transactions on Industrial Informatics*, 1–10, , DOI: 10.1109/TII.2026.3672049, **Q1, top**, (IF=9.9).
2. **Liang Cao**, Weide Liu, Yan Qin. **2026**. Causal Discovery in Dynamic Industrial Systems Under Parametric Uncertainty: A Polynomial Chaos Approach. *IEEE Transactions on Automation Science and Engineering*, 1–12, , DOI: 10.1109/TASE.2026.3672332, **Q1**, (IF=6.4).
3. Yan Qin, Shan Yin, Wenbin Qian, Wei Dai, **Liang Cao***. **2026**. Slow-fast Dynamics-Assisted Koopman Network for Anomaly Detection in Nonstationary Industrial Processes with Time-lagged Variables. *Journal of Process Control*. **Q1**, (IF=3.3)
4. **Liang Cao**, Yixiu Wang, Jianping Su. **2026**. A Systematic Framework for Data Quality Assessment in Industrial Process Monitoring. *IEEE Journal of Emerging and Selected Topics in Industrial Electronics*, DOI: 10.1109/JESTIE.2026.3667011, **Q1**, (IF=4)
5. Yan Qin, Zhiqing Luo, Yunhong Che, **Liang Cao***. **2026**. False Data Injection Attacks Against UAV Battery State of Health Estimation with A Capacity-informed Latent Diffusion Model. *Green Energy and Intelligent Transportation*, accepted, 1–16., **Q1**, (IF=16.4).
6. **Liang Cao**, Youqing Wang, Yan Qin, Yankai Cao, Bhushan Gopaluni, Richard Braatz. **2026**. Attack Detection for Cyber-Physical Systems Based on Causal Representation. *IEEE Transactions on Systems, Man, and Cybernetics: Systems*, 1–11, **Q1, top**, (IF=8.7).
7. **Liang Cao**, Jianping Su, Yi Luo. **2026**. Causal Structure Discovery for Industrial Process Monitoring: A Novel Approach for Nonlinear Systems with Complex Noise. *IEEE Internet of Things Journal*, DOI: 10.1109/JIOT.2026.3653158, **Q1, top**, (IF=8.9).

8. **Liang Cao**, Fan Yang, Youqing Wang. 2025. Causal Representation Learning for Trustworthy Industrial Process Modeling. *IEEE/CAA Journal of Automatica Sinica*, DOI: 11109/JAS.2025.135470, **Q1, top**, (IF=19.2)
9. **Liang Cao**, Jianping Su, Fan Yang, Yankai Cao, R Bhushan Gopaluni. 2025. Interpretable and Reliable Soft Sensor Development in Industry 5.0. *IEEE/CAA Journal of Automatica Sinica*, DOI: 11109/JAS.2025.125420, **Q1, top**, (IF=19.2)
10. **Liang Cao**, Jianping Su, Jack Saddler, Yankai Cao, Yixiu Wang, Gary Lee, Lim C Siang, Yi Luo, Robert Pinchuk, Jin Li, R Bhushan Gopaluni. 2025. Machine learning for real-time green carbon dioxide tracking in refinery processes. *Renewable and Sustainable Energy Reviews*, 115417. **Q1, top**, (IF=16.3)
11. **Liang Cao**, Jianping Su, Yang Liu, Jin Liu. 2025. Physics-informed dynamic hybrid modeling for real-time renewable CO₂ tracking in refinery co-processing. *ISA Transactions*, DOI:10.1016/j.isatra.2025.10.035, **Q1, top**, (IF=6.5)
12. **Liang Cao**, Jingyi Wang, Jianping Su, Yi Luo, Yankai Cao, Richard D. Braatz, R Bhushan Gopaluni. 2025. Comprehensive analysis on machine learning approaches for interpretable and stable soft sensors. *IEEE Transactions on Instrumentation and Measurement*, 74,1-17, **Q1**, (IF=5.9)
13. **Liang Cao**, Jianping Su, Emilio Conde, Lim Siang, Yankai Cao, Bhushan Gopaluni. 2025. A novel automated soft sensor design tool for industrial applications based on machine learning. *Control Engineering Practice*, 160, 106322, **Q1**, (IF=4.6)
14. **Liang Cao**, Jianping Su, Yankai Cao, Lim C. Siang, Gary Lee, Jin Li, R. Bhushan Gopaluni. 2025. Data-Driven Dynamic Modeling of Renewable CO₂ Emissions in Multimode Industrial Co-processing Processes. *Control Engineering Practice*, 164,106424, **Q1**, (IF=4.6)
15. **Liang Cao**, Xiaolu Ji, Yankai Cao, R Bhushan Gopaluni. 2025. Adaptive Process Monitoring for Multimode Industrial Processes through Machine Learning. *IEEE Journal of Emerging and Selected Topics in Industrial Electronics*, 6,4,1819-1827, **Q1**, (IF=4)
16. **Liang Cao**, Jianping Su, Jack Saddler, Yankai Cao, Yixiu Wang, Gary Lee, Lim C Siang, Robert Pinchuk, Jin Li, R Bhushan Gopaluni. 2024. Real-time tracking of renewable carbon content with AI-aided approaches during co-processing of biofeedstocks. *Applied Energy*, 360,122815. **Q1, top**, (IF=11)
17. **Liang Cao**, Jianping Su, Yixiu Wang, Yankai Cao, Lim C. Siang, Jin Li, Jack Nicholas Saddler, Bhushan Gopaluni. 2022. Causal Discovery Based on Observational Data and Process Knowledge in Industrial Processes. *Industrial & Engineering Chemistry Research*, 61,38, 14272-14283. **Q1**, (IF=3.9)
18. **Liang Cao**, Feng Yu, Fan Yang, Yankai Cao, R Bhushan Gopaluni. 2020. Data-driven dynamic inferential sensors based on causality analysis. *Control Engineering Practice*, 104, 104626. **Q1**, (IF=4.6)
19. **Liang Cao**, Dong Zhao, Youqing Wang, Steven X Ding. 2019. Existence and design of observers for two-dimensional linear systems with multiple channel faults. *Multidimensional Systems and Signal Processing*, 30(2), 641-660. **Q2**, (IF=1.8)
20. **Liang Cao**, Youqing Wang. 2018. Fault-tolerant control for nonlinear systems with multiple intermittent faults and time-varying delays. *International Journal of Control, Automation and Systems*, 16(2), 609-621. **Q2**, (IF=2.9)
21. **Liang Cao**, Dong Zhao, Youqing Wang. 2017. Simultaneous estimation of multiple channel faults for two-dimensional linear systems. *International Journal of Systems Science*, 48(13), 2838-2849. **Q1**, (IF=4.6)
22. **Liang Cao**, Yuan Tao, Youqing Wang, Juan Li, Biao Huang. 2016. Reliable H_{∞} control for nonlinear discrete-time systems with multiple intermittent faults in sensors or actuators. *International Journal of Systems Science*, 47, 302-315. **Q1**, (IF=4.6)
23. Jiang Liu, Wei Dai, **Liang Cao**, Yan Qin, Chau Yuen. 2026. Ensemble Domain Adaptation with Constructive Incremental Learning for Fault Diagnosis of UAV Actuators. *IEEE Internet of Things Journal*, DOI: 10.1109/JIOT.2026.3667670, **Q1, top**, (IF=8.9).

24. Jing Liu, Yang Liu, Jieyu Lin, Jieli Li, **Liang Cao**, Peng Sun, Bo Hu, Liang Song, Azzedine Boukerche, Victor CM Leung. **2025**. Networking systems for video anomaly detection: A tutorial and survey. *ACM Computing Surveys*, 57(10), 1-37. **Q1, top**, (IF=28)
25. Yixiu Wang, Qiyue Luo, **Liang Cao**, Arpan Seth, Jianfeng Liu, Bhushan Gopaluni, Yankai Cao. **2024**. Data-driven battery capacity estimation using support vector regression and model bagging under fast-charging conditions. *The Canadian Journal of Chemical Engineering*, 102(10), 3322-3332. **Q2, Issue Highlights**, (IF=1.6)
26. Yixiu Wang, Jiangong Zhu, **Liang Cao**, Yankai Cao, Bhushan Gopaluni. **2023**. Long short-term memory network with transfer learning for lithium-ion battery capacity fade and cycle life prediction. *Applied Energy*, 350, 121660. **Q1, top**, (IF=11)
27. Yi Luo, Bhushan Gopaluni, **Liang Cao**, Yongjian Wang, Jian Cheng. **2023**. Adaptive online optimization of alarm thresholds using multilayer Bayesian networks and active transfer entropy. *Control Engineering Practice*, 137, 105534. **Q1**, (IF=4.6)
28. Yupeng Li, Weihua Cao, R. Bhushan Gopaluni, Wenkai Hua, **Liang Cao**, Min Wu. **2023**. False alarm reduction in drilling process monitoring using virtual sample generation and qualitative trend analysis. *Control Engineering Practice*, 133, 105457. **Q1**, (IF=4.6)
29. Jianping Su, **Liang Cao**, Gary Lee, Bhushan Gopaluni, Lim C. Siang, Yankai Cao, Susan van Dyk, Robert Pinchuk, Jack Saddler. **2022**. Tracking the green coke production when co-processing lipids at a commercial fluid catalytic cracker (FCC): combining isotope C₁₄ and causal discovery analysis. *Sustainable Energy and Fuels*, 6, 5600-5607, **Co-first author, Q1**, (IF=4.1)
30. Jianping Su, **Liang Cao**, Gary Lee, Bhushan Gopaluni, Don O'Connor, Susan van Dyk, Robert Pinchuk, Jack Saddler. **2022**. Determining the amount of 'green' coke generated when co-processing lipids commercially by fluid catalytic cracking. *Biofuels, Bioproducts and Biorefining*, 16 (2), 325-334. **Q2**, (IF=2.9)
31. Feng Yu, Qiluo Xiong, **Liang Cao**, Fan Yang. **2022**. Stable soft sensor modelling based on causality analysis. *Control Engineering Practice*, 122, 105109. **Q1**, (IF=4.6)
32. Jianping Su, **Liang Cao**, Gary Lee, Jonathan Tyler, Anna Ringsred, Michael Rensing, Susan van Dyk, Don O'Connor, Robert Pinchuk, Jack John Saddler. **2021**. Challenges in determining the renewable content of the final fuels after co-processing biogenic feedstocks in the fluid catalytic cracker (FCC) of a commercial oil refinery. *Fuel*, 294, 120526. **Q1, top**, (IF=7.5)
33. Yi Luo, Bhushan Gopaluni, Yuan Xu, **Liang Cao**, Qun-Xiong Zhu. **2020**. A novel approach to alarm causality analysis using active dynamic transfer entropy. *Industrial & Engineering Chemistry Research*, 59(18), 8661-8673. **Q1**, (IF=3.8)
34. Shiqi Lai, Fan Yang, Tongwen Chen, **Liang Cao**. **2019**. Accelerated multiple alarm flood sequence alignment for abnormality pattern mining. *Journal of Process Control*, 82, 44-57. **Q1**, (IF=3.3)

Conference Articles

1. **Liang Cao**. **2026**. A Polynomial Chaos Framework for Causal Discovery in Nonlinear Uncertain Systems. *The IEEE/CVF Conference on Computer Vision and Pattern Recognition 2026 (IEEE/CVF CVPR 2026)*, 1-9. CCF A, Denver, USA
2. **Liang Cao**. **2026**. Learning Dynamic Causal Graphs Under Parametric Uncertainty via Polynomial Chaos Expansions. *14th International Conference on Learning Representations (ICLR 2026)*, 1-19. CCF A, Rio de Janeiro, Brazil
3. **Liang Cao**. **2026**. A Natural-Gradient Approach for Nonlinear Stochastic Systems with Parameter Uncertainty. *The Fortieth AAAI Conference on Artificial Intelligence (AAAI 2026)*, 1-8. CCF A, Singapore
4. **Liang Cao**, Weide Liu, Yan Qin, Zhenghua Chen, Zhuo Chen, and Bhushan Gopaluni. **2026**. Sparse Causal Latent Features for Robust Multimodal Learning under Distribution Shifts. **Companion**

Proceedings of the ACM Web Conference 2026 (WWW 26), 1–7. CCF A, Dubai, United Arab Emirates

5. **Liang Cao**, Xiaolu Ji, Yankai Cao, Yi Luo, Yixiu Wang, Lim C. Siang, Jin Li, R. Bhushan Gopaluni. **2024**. Interpretable Industrial Soft Sensor Design Based on Informer and SHAP. **The 12th IFAC Symposium on Advanced Control of Chemical Processes (ADCHEM 2024)**, Toronto, ON, Canada
6. **Liang Cao**, Yankai Cao, R Bhushan Gopaluni. **2024**. Stable Soft Sensor Modeling for Industrial Systems. **2024 IEEE 7th International Conference on Industrial Cyber-Physical Systems (ICPS)**, St. Louis, MO, USA.
7. **Liang Cao**, Xiaolu Ji, Yankai Cao, Yupeng Li, Lim C Siang, Jin Li, Vijay Kumar Pediredla, R Bhushan Gopaluni. **2023**. Interpretable Soft Sensors using Extremely Randomized Trees and SHAP. **IFAC World Congress 2023**, Yokohama, Japan.
8. **Liang Cao**, R Bhushan Gopaluni, Lim C Siang, Yankai Cao, Jin Li. **2022**. Soft Sensor Change Point Detection and Root Cause Analysis. **Society of Instrument and Control Engineers (SICE) Annual Conference**, Kumamoto, Japan.
Finalists of SICE Annual Conference Young Author's Award
9. **Liang Cao**, Dong Zhao, Youqing Wang. **2017**. Integrated fault/state estimation for two-dimensional linear time-varying systems. **Chinese Automation Congress (CAC) 2017**, Jinan, China.
10. **Liang Cao**, Changqing Liu, Youqing Wang. **2017**. Asymptotically stable observer for two-dimensional systems with multiple-channel faults. **36th Chinese Control Conference (CCC)**, Dalian, China.
11. **Liang Cao**, Youqing Wang, Lina Xu. **2016**. Fault-tolerant control of stochastic systems with intermittent faults and time-varying delays. **35th Chinese Control Conference (CCC)**, Chengdu, China.
12. Yupeng Li, Weihua Cao, R. Bhushan Gopaluni, Wenkai Hua, **Liang Cao**, Min Wu. **2023**. Alarm Event Pattern Extraction of Drilling Time Series Using Change Point Detection and Event Sequence Generation. **IFAC World Congress 2023**, Yokohama, Japan.
13. Feng Yu, **Liang Cao**, Weiyang Li, Fan Yang, Chao Shang. **2021**. Feature based causality analysis and its applications in soft sensor modelling. **IFAC World Congress 2020**, Berlin, Germany. 53(2), 138-143.
14. Chao Wu, **Liang Cao**, Youqing Wang. **2018**. Fault estimation and compensation for two-dimensional linear systems with actuator/sensor faults. **37th Chinese Control Conference (CCC)**. Wuhan, China.

Patent

1. Han Jing, Yang Fan, **Liang Cao**, etc. **2021**. Root Cause Analysis Method, System and Computer Storage Medium for Communication System Faults. Patent No.: ZL2019109751210,20210316

Book

1. Bhushan Gopaluni, **Liang Cao**, Yankai Cao. **2023**. Modelling of Chemical Process Systems, Chapter 11: Large-scale Process Models Using Deep Learning, Elsevier, ISBN: 9780128238691

Project

2024.03-Present	Continuous mRNA Manufacturing of Massachusetts Institute of Technology <i>Funding: US FDA, Amount: 82 Million USD, Role: Core Participant</i>
2022.11-2024.02	Smart Energy Modeling and Optimization of University of British Columbia <i>Funding: Rogers Canada, Amount: 4.8 Million CAD, Role: Core Participant</i>
2020.06-2023.06	Modeling and Control of Refining Process of University of British Columbia <i>Funding: Mitacs Accelerate Award, Amount: 120,000 CAD, Role: Principal Investigator</i>

Community Service

Editor Service

Associate Editor: IEEE Transactions on Industrial Informatics (IF: 9.9)

Early Career Advisory Editorial Board Member: Control Engineering Practice (IF: 4.6)

Early Career Advisory Editorial Board Member: The Innovation Informatics

Conference Organization

Spring 2026 - Joint International Conference on Automation-Intelligence-Safety (ICAIS) & International Symposium on Autonomous Systems (ISAS)

Organizers for the Session Industrial Process Intelligence Operation Control and Data Analysis

Summer 2025 - The 4th IEEE International Conference on Industrial Electronics for Sustainable Energy Systems

Organizers for the Session Advanced Monitoring and Control for Industrial Systems

Spring 2025 - The 23rd IEEE International Conference on Industrial Informatics

Program Committee for the Technical Track of Renewable Energy

Winter 2022 - Canadian Chemical Engineering Conference

Session Chair of Artificial Intelligence and Machine Learning in Process session

Session Chair of Systems Engineering session

Reviewers

IEEE Transactions on Automatic Control, Automatic, IEEE Transactions on Industrial Informatics, IEEE Transactions on Industrial Electronics, IEEE Transactions on Automation Science and Engineering, Journal of Process Control, IEEE Systems, Man and Cybernetics: Systems, Nonlinear Dynamics, Control Engineering Practice, Neurocomputing, IEEE Transactions on Instrumentation & Measurement, Engineering Applications of Artificial Intelligence, Chemical Engineering Journal, ISA Transactions, Journal of the Franklin Institute, Chemometrics and Intelligent Laboratory Systems, IFAC World Congress, American Control Conference, IEEE Conference on Decision and Control, etc.

References

Richard D. Braatz, Edwin R. Gilliland Professor, Department of Chemical Engineering, Massachusetts Institute of Technology, braatz@mit.edu

Bhushan Gopaluni, Professor, Department of Chemical and Biological Engineering, The University of British Columbia, bhushan.gopaluni@ubc.ca

Yankai Cao, Associate Professor, Department of Chemical and Biological Engineering, The University of British Columbia, yankai.cao@ubc.ca

Fan Yang, Professor, Department of Automation, Tsinghua University, yangfan@tsinghua.edu.cn