XIAO CAI

+852-5515-0699 | +86-156-8604-8828

Xiao.Cai@my.cityu.edu.hk | xiaocai96.github.io | Google Scholar

83 Tat Chee Avenue, Kowloon, Hong Kong SAR

Research Interests

Scientific Machine Learning; Knowledge-informed and Physics-informed Deep Learning; Remaining Useful Life (RUL) Prediction; Health Monitoring and Prognostics; Graph-based Neural Networks; Intelligent Manufacturing.

Education

- **City University of Hong Kong** — *Sep. 2022 – Jun. 2026(expected)*, Hong Kong SAR
  Ph.D. degree in systems engineering | *GPA: 4.1/4.3*
  ◦ Supervisor: Prof. Min Xie
- **University of Cambridge** — *Jun. 2025 – Dec. 2025*, Cambridge, U.K.
  Visiting Ph.D, Institute for Manufacturing | *Topic: network-level alarm propagation*
  ◦ Host: Prof. Ajith Parlikad
- **Xi'an Jiaotong University** — *Sep. 2019 – Jun. 2022*, Xi'an, China
  M.E. degree in mechanical engineering | *GPA: 3.7/4.0, Rank: 20/285*
  ◦ Supervisor: Prof. Yaguo Lei
- **Xi'an Jiaotong University** — *Sep. 2015 – Jun. 2019*, Xi'an, China
  B.E. degree in mechanical engineering | *GPA: 3.8/4.3, Rank: 12/212*

Research Experience

- **Prior-informed RUL Prediction for Two-phase Degrading Cutting Tools**
  ◦ Developed a RUL prediction framework for two-phase degrading systems considering prior information.
  ◦ Incorporated physical damage observations from offline inspections and optimally selected sensors to improve prediction accuracy and interpretability.
- **Physics- and Knowledge-informed Prognostics for Aero-engines**
  ◦ Developed a knowledge-embedded spatiotemporal GNN for RUL prediction of aero-engines.
  ◦ Incorporated system topology and sensor spatial layout as structured priors to improve accuracy and robustness.
- **Time-aware and Mechanism-informed Graph Learning for Radio Access Networks**
  ◦ Constructed inter-base-station graphs from raw alarm timestamps using co-occurrence analysis and time-decay weighting to encode prior knowledge of alarm propagation into adjacency matrix.
  ◦ Used the resulting adjacency matrix to constrain GAT for learning latent cross-site influence pathways.
  ◦ Achieved AUC up to 0.97 and AP up to 0.95 on large-scale real-world data of radio access networks.
- **Self-data-driven method for Large-scale Wind Turbine Monitoring**
  ◦ Developed self-data-driven fault diagnosis and RUL prediction algorithms integrated into industrial software.
  ◦ Monitored the wind turbine driven by its own condition monitoring data without depending on failure event data.
  ◦ Deployed the method on over 1000 wind turbines and successfully predicted failures of critical units in advance.
- **Trustworthy Data Engineering for Scientific Machine Learning**
  ◦ Developed outlier detection and missing data recovery pipelines to ensure data quality for machine learning.

Publications and Patents

C=Conference, J=Journal, P=Patent, S=In Submission

[S.1] **Cai, X.**, Mukherjeeb, A., Wang, Q., Parekh, A., Parlikad, A., & Xie, M. (2026). Topology-Agnostic Inference of Alarm Influence Pathways using Time-Aware Graph Attention Networks in Cellular Networks. Manuscript submitted for publication in *IEEE Transactions on Industrial Informatics*.

[S.2] Wang, Q., Dhada, M., **Cai, X.**, Parlikad, A., & Xie, M. (2026). Compute-Efficient Online Bayesian Inference for Hierarchical Weibull Models under Streaming Failures. Manuscript submitted for publication in *Reliability Engineering & System Safety*.

[J.1] **Cai, X.**, Zhang, D., Yu, Y., & Xie, M. (2025). Knowledge embedded spatial-temporal graph convolutional networks for remaining useful life prediction. *Reliability Engineering & System Safety*, DOI: 10.1016/j.ress.2025.110928.

[J.2] Sun, Q., Chen, C., **Cai, X.**, Gao, J., Ye, X., Zhai, G., & Xie, M. (2025). Small-sample prediction validation testing: Uncertainty-aware design and robust maintenance strategy for power electronic converters. *IEEE Transactions on Power Electronics*, DOI: 10.1109/TPEL.2025.3587316.

[J.3] Xu, P., Lei, Y., Wang, Z., Li, N., **Cai, X.**, & Feng, K. (2025). A self-data-driven approach for online remaining useful life prediction of machinery using a recursive update strategy. *Mechanical Systems and Signal Processing*, DOI: 10.1016/j.ymssp.2025.112541.

[J.4] **Cai, X.**, Li, N., & Xie, M. (2024).RUL prediction for two-phase degrading systems considering physical damage observations. *Reliability Engineering & System Safety*, 244, 109926. DOI: 10.1016/j.ress.2024.109926.

[J.5] Li, N., Xu, P., Lei, Y., **Cai, X.**, & Kong, D. (2022). A self-data-driven method for remaining useful life prediction of wind turbines considering continuously varying speeds. *Mechanical Systems and Signal Processing*, 165, 108315. DOI: 10.1016/j.ymssp.2021.108315.

[J.6] Lei, Y., Xu, X., **Cai, X.**, Li, N., Kong, D., & Zhang, Y. (2021). Research on Data Quality Assurance for Health Condition Monitoring of Machinery. *Journal of Mechanical Engineering*, 2021,57(4): 1-9. DOI: 10.3901/JME.2021.04.001.

[J.7] Li, N., **Cai, X.**, Lei, Y., Xu, P., Wang, W., & Wang, B. (2021). A Model-data-fusion Remaining Useful Life Prediction Method with Multi-sensor Fusion for Machinery. *Journal of Mechanical Engineering*, 2021, 57(20): 29-37,46. DOI: 10.3901/JME.2021.20.029.

[J.8] Li, N., Gebraeel, N., Lei, Y., Fang, X., **Cai, X.**, & Yan, T. (2021). Remaining useful life prediction based on a multi-sensor data fusion model. *Reliability Engineering & System Safety*, 208, 107249. DOI: 10.1016/j.ress.2020.107249.

[J.9] Li, N., Lei, Y., Gebraeel, N., Wang, Z., **Cai, X.**, Xu, P., & Wang, B. (2020). Multi-sensor data-driven remaining useful life prediction of semi-observable systems. *IEEE Transactions on Industrial Electronics*, 68(11), 11482-11491. DOI: 10.1109/TIE.2020.3038069.

[P.1] Lei, Y., Xu, P., Li, N., **Cai, X.**, Liu, X., Zhao, J. A Self-Data-Driven Remaining Useful Life Prediction Method for Rolling Bearing. CN112949204A, 2021-06-11.

[P.2] Lei, Y., **Cai, X.**, Li, N., Xu, P., Liu, X., Zhao, J. A Baseline-speed Transformation Algorithm for Wind Turbine. CN112855467A, 2021-05-28.

[P.3] Li, N., **Cai, X.**, Lei, Y., Han, T., Wang, B. A Remaining Useful Life Prediction Method for Machine Tools Based on Informative Sensors Selection and Fusion Algorithm. CN111143990A, 2020-05-12.

Skills

- **Research Skills:** Scientific Machine Learning; Physics- and Knowledge-informed Deep Learning; Spatiotemporal Graph Neural Networks; Foundation Models for Time-series Systems; Model–Data Fusion; Multi-sensor Prognostics; Trustworthy AI
- **Methodological Expertise:** Degradation Modeling; Wiener Processes; Optimal Sensor Selection; Anomaly Detection and Data Quality Assurance; Multi-modal Data Fusion
- **Programming & Data:** Python, MATLAB, C; Time-series Modeling; Large-scale Industrial Data Processing
- **Engineering Platforms:** SolidWorks, AutoCAD, Arduino; Industrial Condition Monitoring Systems
- **Application Domains:** Aero-engines; Wind Turbines; Cutting tools; Intelligent Manufacturing; Cellular Networks

Honors and Awards

- National Scholarship (Top 0.2%)
- Excellent Graduation Thesis (Top 1%)
- Outstanding Graduate
- First Prize, China Undergraduate Mathematical Contest in Modeling
- Second Prize, China Postgraduate Mathematical Contest in Modeling
- SKF Scholarship
- SiYuan Scholarship (Rank 1st)
- Multiple University Excellence Awards