Jingxuan Wu

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Research Interest

My research focuses on building data-efficient, adaptive learning systems across three fronts: (1) online learning with LLMs—leveraging LLMs' reasoning and learning abilities, combined with online algorithms, to solve scenario-driven problems from streaming data and human/implicit feedback; (2) reinforcement learning—developing methods and applications to tackle agentic RL problems, turning feedback into reliable decision-making and controllable behaviors; and (3) diversity in graph generative models, where I study both RL-trained and training-free approaches to broaden coverage, mitigate mode collapse, and enable fine-grained control.

Education

The University of North Carolina at Chapel Hill Aug. 2025 – Dec. 2026 (Expected)
M.S. in Statistics *Chapel Hill, NC, USA*

The Chinese University of Hong Kong, Shenzhen Sep. 2021 – May 2025
B.S. (Hons) in Data Science and Big Data Technology *Shenzhen, China*

Publications

(∗ indicates equal contribution)

Conference & Workshop Papers

Journal Papers

[J1] Chi Li, Jianfeng Mao, Lingyi Li, **Wu, Jingxuan**, Lianmin Zhang, Jianyu Zhu, and Zibin Pan. **"Flight delay propagation modeling: Data, Methods, and Future opportunities"**. In: *Transportation Research Part E: Logistics and Transportation Review* 185 (2024), p. 103525.

Preprints & Technical Reports

[P1] **Jingxuan Wu**, Zhenglin Wan, Xingrui Yu, Yuzhe Yang, Yiqiao Huang, Ivor Tsang, and Yang You. **"Time-Annealed Perturbation Sampling: Diverse Generation for Diffusion Language Models"**. 2026.

[P2] **Jingxuan Wu**, Zhenglin Wan, Xingrui Yu, Yuzhe Yang, Bo An, and Ivor Tsang. **"OSCAR: Orthogonal Stochastic Control for Alignment-Respecting Diversity in Flow Matching"**. 2025.
Under Review at ICML 2026.

[P3] Zhenglin Wan, **Jingxuan Wu**, Xingrui Yu, Chubin Zhang, Mingcong Lei, Bo An, and Ivor Tsang. **"FM-IRL: Flow-Matching for Reward Modeling and Policy Regularization in Reinforcement Learning"**. 2025.
Under Review at ICML 2026.

[P4] Maohao Ran, Zhenglin Wan, Cooper Lin, Yanting Zhang, Hongyu Xin, et al. **"CaveAgent: Transforming LLMs into Stateful Runtime Operators"**. 2026.
Technical Report.

[P5] Wang, Hanzhao*, **Wu, Jingxuan***, Pan, Yu, Li, Yumeng, Wang, Yansong, Liu, Helang, Wang, Fuqiang, and Chen, Guanting. **"LLM-Powered Predictive Decision-Making for Sustainable Data Center Operations"**. OpenReview. 2024.
In Preparation for *Manufacturing & Service Operations Management*.

[P6] Chi Li, Mingcong Lei, **Jingxuan Wu**, Yuzhe Yang, Zibin Pan, Xiongwen Qian, and Jianfeng Mao. **"Integrative Mean-Field Epidemic Model and Adaptive Graph Learning for Network-wide Delay Propagation Dynamics Prediction"**. 2024.
In Preparation for *Transportation Research Part B*.

Research Experience

Latent Prompt Optimization for Diffusion Models Jan. 2026 – Present
Advisors: Guanting Chen (Dept. of Statistics & Operations Research, UNC)
Wenjia Ba (Sauder School of Business, University of British Columbia) *Chapel Hill, NC, USA*

Controllable and Modular Generation for Diversity in Large Language Models Dec. 2025 – Present
Advisors: Guanting Chen (Dept. of Statistics & Operations Research, UNC)
Chudi Zhong (Dept. of Statistics & Operations Research, UNC) *Chapel Hill, NC, USA*

Time-Annealed Perturbation Sampling for Diffusion Language Models Nov. 2025 – Jan. 2026
Advisors: Xingrui Yu (CFAR, A*STAR)
Ivor Tsang (Director, A*STAR CFAR; Adjunct Prof., SCSE, NTU) *Singapore*
• Proposed Time-Annealed Perturbation Sampling (TAPS), a training-free and scalable inference method that improves generation diversity in Diffusion Language Models by exploiting their temporal denoising structure.
• Designed time-dependent context perturbation with annealing and quality-preserving rescaling to encourage early semantic branching while maintaining fluency and instruction adherence.
• Demonstrated consistent improvements in semantic and embedding-level diversity across creative writing and reasoning benchmarks, with little compromising generation quality.
• Validated robustness across non-autoregressive and semi-autoregressive diffusion backbones (LLaDA-8B-Instruct, TraDo-8B-Instruct), outperforming standard decoding baselines

Guidance Mechanisms to Enhance Diversity in Flow Matching Jun. 2025 – Sep. 2025
Advisors: Xingrui Yu (CFAR, A*STAR)
Ivor Tsang (Director, A*STAR CFAR; Adjunct Prof., SCSE, NTU) *Singapore*
• Proposed OSCAR, a training-free, inference-time control framework that generalizes across multiple generation models' backbones, improving set-level diversity while preserving image quality and prompt alignment.
• Designed a feature-space volume maximization objective on predicted endpoints, combined with orthogonal stochastic control that projects both deterministic guidance and time-scheduled noise strictly orthogonal to the base flow, inducing principled repulsive interactions among trajectories to mitigate mode collapse while preserving generation quality.
• Demonstrated consistent improvements in mode coverage, entropy, and Vendi Score across text-to-image benchmarks, outperforming strong diversity baselines under matched computational budgets.
• Validated robustness and portability across multiple diffusion backbones (FM-SD3.5, SDXL-Turbo, SD1.5), encoders (CLIP, DINO, Inception), and sampling budgets.

Flow-Matching Rewards & Policy Regularization Apr. 2025 – Sep. 2025
Advisors: Xingrui Yu (CFAR, A*STAR)
Ivor Tsang (Director, A*STAR CFAR; Adjunct Prof., SCSE, NTU) *Singapore*
Bo An (President's Chair Professor; Head of Division of AI, College of Computing and Data Science, NTU)
• Proposed FM-IRL, a teacher–student framework: a Flow-Matching (FM) teacher provides a reward model and a policy regularizer, while a lightweight MLP student interacts with the environment and is updated online.
• Designed an FM-enhanced discriminator that turns distribution-level FM distances (expert vs. agent, with a binary condition) into rewards via a softmax transform, enabling informative and stable shaping for online RL.
• Regularized the student policy using state–action pairs generated by the FM teacher, balancing exploration and exploitation and stabilizing training under limited or suboptimal demonstrations.
• Demonstrated improved learning efficiency, generalization to perturbed initial/goal states, and robustness to suboptimal expert data across six environments, outperforming DP/FP and IRL baselines.

Resource Allocation Optimization for GPUs using LLMs May 2024 – Dec 2024
Advisors: Guanting Chen (Dept. of Statistics & Operations Research, UNC)
Xiaocheng Li (School of Business & Analytics and Operations, IC) *Remote*

• Predicted job runtime and energy across GPU types by encoding program code into embedding vectors and training a lightweight linear probe.
• Modeled time-varying job arrivals with a non-homogeneous Poisson process and estimated parameters via maximum likelihood.
• Designed an online scheduling algorithm that uses predictions to allocate GPUs and route jobs.
• Built a simulation environment using data-center traces; outperformed a greedy baseline in throughput and energy efficiency.

Research on Network-wide Delay Propagation Dynamics Prediction Dec. 2023 – Present
Supervisor: Prof. Jianfeng Mao, School of Data Science, CUHK-Shenzhen *Shenzhen, China*

• Adapted a heterogeneous Susceptible–Infected–Susceptible (SIS) contagion process to model airport congestion spreading across a network.
• Upgraded SIS by turning transmission parameters into time-dependent functions; learned them via an *adaptive graph learning* (AdapGL) structure with GAT.
• Introduced heterogeneous, dynamic, and negative recovery states; used AdapGL to predict infection and recovery trajectories.
• Benchmarked against ODE-based methods, LSTM, STGCN, and ASTGCN, where the adaptive graph approach (GAT+AdapGL) achieved superior delay-status prediction.
• Provided theoretical conditions under which delay propagation converges even with node-varying infection/recovery rates.
• Integrated a Kalman filter to enhance multi-step forecasts, significantly improving multi-horizon performance.
• Ran simulations with realistic infection rates and transmission processes to validate model correctness and the theoretical derivations.

Study on Flight Delay Propagation Modeling Oct. 2023 – Mar. 2024
Advisor: Jianfeng Mao, School of Data Science, CUHK-Shenzhen *Shenzhen, China*

• Reviewed 40 + studies on airport delay propagation across statistical, econometric, and queueing models; organized findings by model family and data scale.
• Synthesized each approach's assumptions, strengths/limitations, and suitable problem settings; drafted a comprehensive survey manuscript.

Projects

CaveAgent | Python, LLM, AST, LiteLLM, Asyncio, Security Validation Oct. 2025 – Jan. 2026

A tool-augmented agent framework enabling stateful runtime management and code-based function calling.

• Contributed to the development of the **persistent Python runtime** modules, supporting seamless object injection and retrieval across multi-turn LLM interactions.
• Implemented specific **AST-based security rules** (e.g., ImportRule, FunctionRule) to validate and sanitize LLM-generated code before execution.
• Developed discovery and registry mechanisms for the **Agent Skills** open standard, allowing modular injection of functions and types into the runtime.
• Participated in benchmarking and performance evaluation across multiple LLM backends (OpenAI, Claude, Gemini) to validate framework robustness.

Handwriting Recognition | PyTorch, OpenCV, OCR, Transformers, LSTM, GAN Feb. 2024 – Apr. 2024

End-to-end pipeline for handwriting dataset curation, auto-labeling, and robust recognition.

• Collected and cleaned ∼10k handwriting images by suppressing page background and guideline artifacts for higher signal-to-noise.
• Applied OCR-based word boundary detection to auto-label images and organized them into a structured corpus for downstream training.

• Trained transformer/LSTM recognizers and validated labels post-recognition, yielding a +4% accuracy improvement.
• Modified a GAN-based recognition/generation setup to better capture font/style characteristics, improving robustness to handwriting variability.

References available upon request.