Xiaoyu Wang

BA 8292, 40 St George St, Toronto, Ontario, M5S 2E4, Canada

(+1) 647 509 8517 | cnxiaoyu.wang@mail.utoronto.ca | github.com/xxArbiter

Education

Ph.D. in Civil Engineering, University of Toronto Sep. 2019 - present
Supervisors: Baher Abdulhai, Scott Sanner

Master of Science in Control Science, Shanghai Jiao Tong University Sep. 2016 - Mar. 2019

Bachelor of Engineering in Automation, Tianjin University Sep. 2012 - Jul. 2016
Research Focus: Simultaneous Localization And Mapping (SLAM), High Precision Localization

Research Experience

Current Research Focus: Offline Reinforcement Learning, Multi-Agent Reinforcement Learning, Intelligent Transportation Systems, Control Systems.

Research on Model-Based Offline Reinforcement Learning (MB Offline-RL) Jan. 2022 - present

- Background: Offline reinforcement learning is aimed at high-cost testing scenarios, seeking to learn the optimal policy solely from a fixed dataset without online interaction. Compared to model-free methods, model-based methods often offer better generalization performance.
- Challenges: In offline scenarios, MBRL struggles with rapid accumulation of multi-step prediction errors due to the inability to online correct the dynamics model, making it difficult to surpass model-free methods in standard test set performance.
- Leveraging the theory of Model-Based Value Expansion (MVE), a Bayesian multi-step h-step MVE returns (as value function estimators) fusion algorithm is proposed. It dynamically balances the weights of different h-step MVE returns based on the credibility of probabilistic dynamic models and value models within the framework of Generalized Policy Iteration (GPI), achieving an adaptive adjustment of model prediction horizon in the search space.
- To enhance generalization performance, research on meta-learning-based offline model-based reinforcement learning algorithms.

Urban Traffic Signal Control and Coordination Sep. 2019 - Present

- Background and Challenges: Existing research falls short in practical deployment and testing. This study faces several requirements and challenges imposed by existing infrastructure and available resources, including distributed training, updates and deployment, lightweight communication, partially observable problems (low-cost sensing solutions and controller perception distance constraints), and robustness of sensing solutions (minimizing performance loss under low-cost scenarios).
- Based on the framework of Decentralized Partially Observable Markov Decision Processes (Dec-POMDPs), a unified description and classification method is proposed to address the Traffic Signal Control (TSC) problem from different perspectives. This research identifies existing issues and challenges in the field and suggests potential solution paths.
- A set of model-free reinforcement learning-based distributed intersection control algorithms (eMARLIN, eMARLIN+) is introduced. The foundational algorithm is based on DQN design and is easily extensible. This project is conducted in collaboration with local authorities, and the improved algorithms are currently in the early stages of experimental deployment.
- Generalization performance study of model-based Monte Carlo Tree Search (MCTS) algorithms. Various improvements for TSC scenarios are proposed by incorporating domain knowledge, demonstrating that in scenarios where precise calibration of traffic models is achievable, the improved MCTS algorithms can match or even surpass the performance of model-free reinforcement learning.
- Application Extension: Research into the application of the eMARLIN algorithm series in scenarios such as Traveling Salesman Problem (TSP), Parking Control (PC), and Ramp Metering with Variable Speed Limits (RM&VSL). Excellent results are achieved in simulation experiments.

Development, Validation, and Benchmarking of Multi-Agent Traffic Control Algorithms Feb. 2020 - Present

- Compatible with various simulation software: SUMO (Simulation of Urban MObility), Aimsun.
- Applicable to multiple application scenarios: Traffic Signal Control (TSC), Transit Signal Priority (TSP), Perimeter Control (PC), Ramp Metering Control and Variable Speed Limit Control (RM&VSL), Car Following Control.
- Value: Easily scalable, significantly reduces research and development costs in traffic management studies.

Traffic Data Fusion and Prediction Algorithms for Large-Scale Road Network Sep. 2017 - Aug. 2020

- Designed a heterogeneous data fusion algorithm (combining vehicle GPS trajectory data and bus stop arrival data) to mitigate sparsity issues in traffic condition estimation due to a single data source. Proposed a robust regression-based Granger causality analysis test for fusion results to demonstrate the reliability of multi-source fusion.
- For road network-scale traffic condition prediction, introduced the Graph Regression Neural Network (GRNN) algorithm based on the concept of Graph Neural Networks (GNN), leveraging road network connectivity features. This method mined traffic propagation characteristics on the graph, enabling efficient global prediction. Research results garnered attention from industry players (Truck Alliance - Full Truck Alliance Group, Baidu Ventures).

Internship Experience

Associate Engineer | Huawei Technologies Canada ***Markham, Ontario, Canada*** May. 2020 - Sep. 2020

- Explored indicators and evaluation routines for traffic signal coordination
- Developed a graph attention network (GAT) based multi-agent reinforcement learning method for regional traffic signal control

Research Assistant | Shanghai Transportation Information Center ***Shanghai, China*** Aug. 2017 - Jan. 2018

- Database structuring, transportation data processing
- Implemented algorithms matching trajectory data with different sampling rate to the road network
- Designed a data fusion framework to alleviate the sparsity problem in traffic monitoring system

Publications

* Equally Contributed

Wang, X., Taitler, A., Smirnov, I., Sanner, S., and Abdulhai, B. eMARLIN+: Overcoming Partial-Observability Caused by Sensor Limitations and Short Detection Ranges in Traffic Signal Control. 2023 IEEE 26th International Conference on Intelligent Transportation Systems (ITSC).

Jeong, J.*, **Wang, X.***, Gimelfarb, M., Kim, H., Abdulhai, B., and Sanner, S. Conservative Bayesian Model-Based Value Expansion for Offline Policy Optimization. 2023 Eleventh International Conference on Learning Representations (ICLR).

Wang, X., Taitler, A., Smirnov, I., Sanner, S., and Abdulhai, B. eMARLIN: Distributed Coordinated Adaptive Traffic Signal Control with Topology-Embedding Propagation. Transportation Research Record, 2023.

Wang, X., Sanner, S., and Abdulhai, B. A Critical Review of Traffic Signal Control and A Novel Unified View of Reinforcement Learning and Model Predictive Control Approaches for Adaptive Traffic Signal Control. This is a draft chapter/article. The final version is available in Handbook on Artificial Intelligence in Transport, edited by Hussein Dia, forthcoming 2023, Edward Elgar Publishing Ltd.

Li, X., Mercurius, R. C., Taitler, A., **Wang, X.**, Noaeen, M., Sanner, S., and Abdulhai, B. Perimeter Control Using Deep Reinforcement Learning: A Model-free Approach towards Homogeneous Flow Rate Optimization. 2023 IEEE 26th International Conference on Intelligent Transportation Systems (ITSC).

Jaggi, P., **Wang, X.**, Carrara, N., Sanner, S., and Abdulhai, B. Microscopic Model-Based RL Approaches for Traffic Signal Control Generalize Better than Model-Free RL Approaches. 2021 IEEE 24th International Conference on Intelligent Transportation Systems (ITSC).

Ting, T., **Wang, X.**, Taha, I., Sanner, S., and Abdulhai, B. A Comparative Evaluation of Established and Contemporary Deep Learning Traffic Prediction Methods. 2021 Transportation Research Board Annual Meeting.

Min, Y., Chen C., **Wang, X.**, He J., and Zhang, Y. SGM: Seed Growing Map-matching with Trajectory Fitting. 2019 5th International Conference on Big Data Computing and Communications (BIGCOM).

Wang, X., Chen, C., Min, Y„ He, J., Yang, B., and Zhang, Y. Efficient Metropolitan Traffic Prediction Based on Graph Recurrent Neural Network. arXiv preprint, 2018.

Wang, X., Chen, C., Min, Y., He, J., and Zhang, Y. Vehicular transportation system enabling traffic monitoring: A heterogeneous data fusion method. 2018 10th International Conference on Wireless Communications and Signal Processing (WCSP).

Professional Activities

Reviewer

- IEEE Transactions on Systems, Man and Cybernetics: Systems
- IEEE Transactions on Intelligent Transportation Systems
- IEEE Systems Journal
- IEEE International Conference on Intelligent Transportation Systems (ITSC)
- IEEE Conference on Decision and Control
- American Control Conference
- Transportation Research Board Annual Meeting

Others

- Session Chair, IEEE International Conference on Intelligent Transportation Systems (ITSC)
- Session Chair, IEEE International Conference on Big Data and Smart Computing

Honors & Awards

2023	Alan Tonks Scholarship in Transportation Engineering
2022	Fortran Traffic Systems Graduate Scholarship in Transportation Research
2021	Kai Yin Shen Graduate Scholarship
2021	Dr. Mazen Hassounah Graduate Scholarship
2020	Professor Gerald Steuart Graduate Scholarship in Transportation Engineering
2017	Winning Prize, Huawei Software Elite Challenge
2016	Outstanding Graduate Award of Tianjin University
2016	1st Place, RoboCup China Open@Home