Mengdi Xu

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Education

Carnegie Mellon University
Ph.D. in SafeAI Lab, Mechanical Engineering *2019–present*
MS in Machine Learning, Machine Learning Department *2021–2022*
Advisor: Ding Zhao, GPA: 4.0/4.0

The Johns Hopkins University
Robotics MSE, Laboratory of Computational Sensing and Robotics *2017–2019*
Advisor: Gregory Chirikjian

Tsinghua University
BS, Automotive Engineering, School of Vehicle and Mobility *2013–2017*
Advisor: Jianqiang Wang, Excellent Undergraduate Award
BS, Management, School of Economics and Management *2013–2017*

Research Interests

I am broadly interested in **generalizable robot learning**, especially building robots that generalize to challenging unseen environments with strong adaptability and robustness. My current research highlights the following perspectives: (1) **in-context robot learning** with few-shot demonstrations and robot foundation models, (2) **unsupervised reinforcement learning** to discover task/skill structures in environment dynamics, visual geometries, and agent policies, (3) **distributionally robust reinforcement learning** that balances performance and robustness when facing task uncertainties.

Methods: Reinforcement Learning, Imitation Learning, Probabilistic Graphical Model, Unsupervised Learning

Applications: Robotics, Human-Robot Interaction, Embodied Agents, Intelligent Mobility

Work Experience

Google DeepMind, Robotics Team
Student Researcher, Mentor: Wenhao Yu *2023.2–2023.11*

MIT-IBM Watson AI Lab
Research intern in Machine Learning, Mentor: Chuang Gan *2022.5–2022.12*

Toyota Research Institute
Research intern, Machine Learning Engineering team, Mentor: Chao Fang *2021.6–2021.8*

Honors and Awards

EECS Rising Stars [link] *2023*
Robotics: Science and Systems (RSS) Pioneers [link] *2023*
Rising Stars in Computational and Data Sciences [link] *2023*
Excellent Bachelor Thesis at Tsinghua University (5%) *2017*
National Scholarship at Tsinghua University (5%) *2014, 2015, 2016*
Qualcomm Scholarship at Tsinghua University (0.3%) *2016*
Cummins Dr. Lin Scholarship for excellent female students at Tsinghua University *2014, 2015*

Publications

* *indicates equal contribution.*

Conference Publications

1. [CoRL'23] Shiqi Liu*, **Mengdi Xu***, Peide Huang, Yongkang Liu, Kentaro Oguchi and Ding Zhao. "Continual Reinforcement Learning with Group Symmetries", Conference on Robot Learning (CoRL), 2023. **Oral, 6.6%** [pdf] [website]
2. [CoRL'23] Peide Huang, Xilun Zhang*, Ziang Cao*, Shiqi Liu*, **Mengdi Xu**, Wenhao Ding, Jonathan Francis, Bingqing Chen and Ding Zhao. "What Went Wrong? Closing the Sim-to-Real Gap via Differentiable Causal Discovery", Conference on Robot Learning (CoRL), 2023. [pdf] [website]
3. [ICLR'23] **Mengdi Xu**, Yuchen Lu, Yikang Shen, Shun Zhang, Ding Zhao, and Chuang Gan. "Hyper-Decision Transformer for Efficient Online Policy Adaptation". Eleventh International Conference on Learning Representations (ICLR), 2023. [pdf] [website]
4. [AISTATS'23] **Mengdi Xu**, Peide Huang, Yaru Niu, Visak Kumar, Jielin Qiu, Chao Fang, Kuan-Hui Lee, Xuewei Qi, Henry Lam, Bo Li and Ding Zhao, "Group Distributionally Robust Reinforcement Learning with Hierarchical Latent Variables", The 26th International Conference on Artificial Intelligence and Statistics (AISTATS), 2023. [pdf] [website]
5. [NeurIPS'23] Siyuan Zhou, Yilun Du, Shun Zhang, **Mengdi Xu**, Yikang Shen, Wei Xiao, Dit-Yan Yeung, Chuang Gan, "Adaptive Online Replanning with Diffusion Models", Thirty-seventh Conference on Neural Information Processing Systems, (NeurIPS), 2023. [pdf] [website]
6. [ACL'23] Jielin Qiu, Jiacheng Zhu, **Mengdi Xu**, Franck Dernoncourt, Trung Bui, Zhaowen Wang, Bo Li, Ding Zhao, and Hailin Jin, "Semantics-Consistent Cross-domain Summarization via Optimal Transport Alignment", The 61st Annual Meeting of the Association for Computational Linguistics (ACL), 2023. [pdf]
7. [EACL'23] William Han*, Jielin Qiu*, Jiacheng Zhu, **Mengdi Xu**, Michael Rosenberg, Emerson Liu, Douglas Weber, and Ding Zhao, "Transfer Knowledge from Natural Language to Electrocardiography: Can We Detect Cardiovascular Disease Through Language Models?", The 17th Conference of the European Chapter of the Association for Computational Linguistics (EACL), 2023. [pdf]
8. [UAI'23] Yiqi Wang, **Mengdi Xu**, Laixi Shi and Yuejie Chi, "A Trajectory is Worth Three Sentences: Multimodal Transformer for Offline Reinforcement Learning", The 39th Conference on Uncertainty in Artificial Intelligence (UAI), 2023. [pdf]
9. [ICASSP'23] Jielin Qiu, Jiacheng Zhu, **Mengdi Xu**, Peide Huang, Michael Rosenberg, Douglas Weber, Emerson Liu and Ding Zhao, "Cardiac Disease Diagnosis on Imbalanced Electrocardiography Data Through Optimal Transport Augmentation", 2023 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP). [pdf]
10. [ICML'22] **Mengdi Xu**, Yikang Shen, Shun Zhang, Yuchen Lu, Ding Zhao, Josh Tenenbaum and Chuang Gan, "Prompting Decision Transformer for Few-shot Policy Generalization", Thirty-ninth International Conference on Machine Learning (ICML), 2022. [pdf] [website]
11. [NeurIPS'22] Peide Huang, **Mengdi Xu**, Jiacheng Zhu, Laixi Shi, Fei Fang, Ding Zhao, "Curriculum Reinforcement Learning using Optimal Transport via Gradual Domain Adaptation", Thirty-sixth Conference on Neural Information Processing Systems, (NeurIPS), 2022. [pdf]
12. [IROS'22] **Mengdi Xu**, Peide Huang, Fengpei Li, Jiacheng Zhu, Xuewei Qi, Kentaro Oguchi, Zhiyuan Huang, Henry Lam, and Ding Zhao, "Scalable Safety-Critical Policy Evaluation with Accelerated Rare Event Sampling", IROS. 2022. [pdf]
13. [IJCAI'22] Peide Huang, **Mengdi Xu**, Fei Fang, Ding Zhao, "Robust Reinforcement Learning as a Stackelberg Game via Adaptively-Regularized Adversarial Training", International Joint Conference on Artificial Intelligence (IJCAI), 2022. [pdf]
14. [LivingMachine'22] Wenhuan Sun, **Mengdi Xu**, Jeffrey P. Gill, Peter J. Thomas, Hillel J. Chiel and Victoria A. Webster-Wood, "GymSlug: Deep Reinforcement Learning toward Bio-inspired Control based on *Aplysia californica* Feeding", Living Machines, 2022. [pdf]

15. [ICRA'21] Baiming Chen, Zuxin Liu, Jiacheng Zhu, **Mengdi Xu**, Wenhao Ding, Liang Li and Ding Zhao, "Context-Aware Safe Reinforcement Learning for Non-Stationary Environments", IEEE International Conference on Robotics and Automation (ICRA), 2021. [pdf]
16. [NeurIPS'20] **Mengdi Xu**, Wenhao Ding, Jiacheng Zhu, Zuxin Liu, Baiming Chen, and Ding Zhao, "Task-Agnostic Online Reinforcement Learning with an Infinite Mixture of Gaussian Processes", Thirty-fourth Conference on Neural Information Processing Systems (NeurIPS), 2020. [pdf]
17. [ICRA'20] Wenhao Ding, **Mengdi Xu**, and Ding Zhao, "CMTS: A Conditional Multiple Trajectory Synthesizer for Generating Safety-Critical Driving Scenarios", IEEE International Conference on Robotics and Automation (ICRA), 2020. [pdf]
18. [CASE'19] **Mengdi Xu**, Shengnan Lyu, Yingtian Xu, Can Kocabalkanli, Brian K. Chirikjian et al. "Mosquito staging apparatus for producing PfSPZ malaria vaccines", IEEE 15th International Conference on Automation Science and Engineering (CASE), 2019. [pdf]
19. [CASE'19] Hongtao Wu, Jiteng Mu, Ting Da, **Mengdi Xu**, Russell H. Taylor, Iulian Iordachita, and Gregory S. Chirikjian, "Multi-mosquito object detection and 2D pose estimation for automation of PfSPZ malaria vaccine production", IEEE 15th International Conference on Automation Science and Engineering (CASE), 2019. [pdf]
20. [IDETC'18] **Mengdi Xu**, and Gregory S. Chirikjian, "Recovering a Rotation Matrix From Three Direction Cosines", ASME 2018 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference, 2018. [pdf]

Journal Publications

21. [CBS'23] Zhiyun Ma, Jieliang Zhao, Li Yu, Mengdan Yan, Lulu Liang, Xiangbing Wu, **Mengdi Xu**, Wenzhong Wang, and Shaoze Yan. "A Review of Energy Supply for Biomachine Hybrid Robots." Cyborg and Bionic Systems 4 (2023): 0053. [pdf]
22. [Neurocomputing'21] Baiming Chen, **Mengdi Xu**, Liang Li, and Ding Zhao, "Delay-Aware Model-Based Reinforcement Learning for Continuous Control", Elsevier Neurocomputing, 2021. [pdf]
23. [J. Insect Physiol.'18] Jieliang Zhao*, **Mengdi Xu***, Youjian Liang, Shaoze Yan, and Wendong Niu, "Influence of hydrodynamic pressure and vein strength on the super-elasticity of honeybee wings", Journal of insect physiology 109 (2018): 100-106. [pdf]

Workshop Papers and Preprints

24. **Mengdi Xu***, Peide Huang*, Wenhao Yu*, Shiqi Liu, Xilun Zhang, Yaru Niu, Tingnan Zhang, Fei Xia, Jie Tan, Ding Zhao. "Creative Robot Tool Use with Large Language Models". Workshop on Language and Robot Learning at CoRL 2023. [pdf][website]
25. **Mengdi Xu***, Zuxin Liu*, Peide Huang*, Wenhao Ding, Zhepeng Cen, Bo Li and Ding Zhao. "Trustworthy Reinforcement Learning Against Intrinsic Vulnerabilities: Robustness, Safety, and Generalizability". [pdf]
26. Jielin Qiu*, **Mengdi Xu***, William Han*, Seungwhan Moon, and Ding Zhao. "Embodied Executable Policy Learning with Language-based Scene Summarization", ICML 2023 Workshop on Interactive Learning with Implicit Human Feedback (**spotlight**). [pdf]
27. Jiacheng Zhu, Aritra Guha, **Mengdi Xu**, Yingchen Ma, Rayleigh Lei, Vincenzo Loffredo, XuanLong Nguyen, and Ding Zhao. "Functional Optimal Transport: Mapping Estimation and Domain Adaptation for Functional data", AAAI OT-SDM 2022 workshop (**spotlight**). [pdf]
28. Baiming Chen, **Mengdi Xu**, Zuxin Liu, Liang Li, and Ding Zhao, "Delay-Aware Multi-Agent Reinforcement Learning". [pdf]

Patents

29. Russell H Taylor, Gregory Chirikjian, Iulian Iordachita, Henry Phalen, Hongtao Wu, **Mengdi Xu**, Shengnan Lyu, Michael Aaron Pozin, Jin Seob Kim, Can Kocabalkanli, Balazs Vagvolgyi, Brian K Chirikjian, Joshua Davis, Da Ting, John S Chirikjian, Sumana Chakravarty and Stephen Hoffman, "Apparatus and Method of Use for an Automated Mosquito Salivary Gland Extraction Device", United States Patent 11,503,819, Filed Aug. 17, 2020, Issued Nov. 22, 2022. [link]

Speaking Engagements

- On the Efficiency and Robustness of Generalizable Robot Learning
  - Invited talk at ByteDance AI Lab, November 2023.
  - Invited talk at Microsoft Research Lab - Asia, November 2023.
  - Invited talk at Berkeley Hybrid Robotics Lab, November 2023.
  - Lighting talk at Robotics: Science and Systems (RSS) Pioneers Workshop, July 2023.
  - Contributed talk at Rising Stars in Computational and Data Sciences Workshop, April 2023, April 2023.
  - Lighting talk at CMU Manipulation Reading Group, April 2023.
- Continual Vision-based Reinforcement Learning with Group Symmetries
  - Lighting talk at RSS Workshop about Symmetries in Robot Learning, July 2023.
- Generalizable Robot Learning: The success of GPT4 and its potential in robotics research
  - Guest lecture for 24-784 Trustworthy Intelligent Autonomy at Carnegie Mellon University. April 2023.
- Prompting Decision Transformer for Few-shot Policy Generalization
  - Invited talk at AISOC lab at School of Computer Science, Carnegie Mellon University, April 2022.
- Group Distributionally Robust Reinforcement Learning with Hierarchical Latent Variables
  - Talk at ICRA 2022 the Fresh Perspectives on the Future of Autonomous Driving Workshop, May 2022.
  - Contributed talk at Toyota Research Institute, August 2021.
- Task-Agnostic Online Reinforcement Learning with an Infinite Mixture of Gaussian Processes
  - Invited talk at Department of Statistics, University of Michigan, November 2020.
- Ambiguity-aware Sequential Decision Making for Human-in-the-loop Systems
  - Lighting talk at CMU Symposium on AI and Social Good, February 2020.
- Recovering a Rotation Matrix From Three Direction Cosines
  - Guest Lecture for EN.530.645 Kinematics at The Johns Hopkins University, Fall 2018.

Academic Service and Volunteering

Organization:

- RSS Pioneers workshop, RSS 2024.
- Breakout session leader at 3rd Women in Machine Learning Un-Workshop, ICML 2022

Conference Reviewer:

- International Conference on Learning Representations (ICLR)
- International Conference on Machine Learning (ICML)
- Conference on Neural Information Processing Systems (NeurIPS)
- Conference on Artificial Intelligence and Statistics (AISTATS)
- International Conference on Computer Vision (ICCV)
- IEEE/CVF Computer Vision and Pattern Recognition Conference (CVPR)
- Association for the Advancement of Artificial Intelligence (AAAI)
- The International Conference on Acoustics, Speech, & Signal Processing (ICASSP)
- The International Conference on Robotics and Automation (ICRA)

Journal Reviewer:

- IEEE Transactions on Intelligent Transportation Systems (T-ITS).
- IEEE Transactions on Intelligent Vehicles (T-IV).

Assistant to Associate Chief Editor:

- The Journal of Robotica, 2018.09-2019.05.

Mentor:

- 2020 CMU Robotics Institute Summer Scholars Program (RISS)

Teaching

Teaching Assistant:

- 24-784 Trustworthy Intelligent Autonomy at Carnegie Mellon University, Spring 2023.
- 24-677 Linear Control Systems at Carnegie Mellon University, Fall 2021.
- EN.530.646 Robot Devices, Kinematics, Dynamics, and Control at The Johns Hopkins University, Spring 2019.
- EN.530.645 Kinematics at The Johns Hopkins University, Fall 2018.

Mentored Students

- Beverley-Claire Okogwu, RISS scholar at CMU. Next: Master in Robotics at the CMU Robotics Institute.
- Peide Huang, Ph.D. in Mechanical Engineering at CMU.
- Diana Gomez, Ph.D. in Mechanical Engineering at CMU.
- Shiqi Liu, Ph.D. in Mechanical Engineering at CMU.
- Krishna Dave, Master at CMU. Next: Master in Applied Statistics at UCLA.
- Xilun Zhang, Master in Mechanical Engineering at CMU.
- Yiqi Wang, Master in Electrical and Computer Engineering at CMU.
- Can Kocabalkanli, Master in Robotics at JHU. Next: Engineer at PediaMetrix.
- Jing Jia, visiting undergrad at JHU. Next: Master student at Stanford.
- Bolin He, visiting undergrad at JHU. Next: Master student at University of California, Berkeley.
- Xia Wu, visiting undergrad at JHU. Next: Ph.D. student at Shanghai Jiao Tong University.