ANQI LI

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RESEARCH INTERESTS

My research focuses on providing theoretical guarantees for robot learning using control theoretic tools. Specific research topics include safe reinforcement learning, learning stable dynamical systems/policies, learning from human demonstrations, and planning & control with formal guarantees.

EDUCATION

University of Washington Sept. 2019 –
Ph.D. student in Computer Science & Engineering *Seattle, WA*
· Advisor: Prof. Byron Boots, GPA: 3.96/4.00

Georgia Institute of Technology Aug. 2017 – Aug. 2019
Ph.D. student in Robotics *Atlanta, GA*
· Advisors: Prof. Magnus Egerstedt & Prof. Byron Boots, GPA: 4.00/4.00
· Transferred to the University of Washington in Sept. 2019

Carnegie Mellon University Aug. 2015 – May 2017
Masters in Robotics *Pittsburgh, PA*
· Advisor: Prof. Katia Sycara, GPA: 4.00/4.00

Zhejiang University Sept. 2011 – July 2015
Bachelor of Engineering, Automation Major *Hangzhou, China*
· GPA: 3.93/4.00, Rank: 1/132

RESEARCH EXPERIENCE

University of Washington Sept. 2019 –
Graduate Research Assistant *Seattle, WA*

· *Safe Reinforcement Learning with Structured Policy Classes*

- Introduced a policy class with formal control theoretic guarantees on stability and safety based on the Riemannian Motion Policy (RMP) framework
- Showed that reinforcement learning on the structured policy class is more safe and efficient on reaching tasks with a simulated three-link robot and a simulated Franka Emika robot.

· *Learning Coordinated Riemannian Motion Policies on Multiple Task Spaces*

- Proposed a framework for end-to-end learning of multiple Riemannian Motion Policies (RMPs) on different task spaces from human demonstrations
- Demonstrated the proposed framework on a Rethink Sawyer Robot on multiple placing tasks — the proposed framework outperforms baselines where the policies are learned individually

· *Learning Stable Policies from Demonstrations through Learning Diffeomorphisms*

- Proposed a framework for representing a complex policy as a simple policy on an latent space related to the original space through a diffeomorphism
- Designed a neural network architecture for parameterizing diffeomorphism between spaces and the corresponding loss for learning policies on the latent spaces

Facebook AI Research June – Sept. 2021
Research Intern *Remote*

· *Learning from Expert Demonstrations under Different Dynamics*

- Considered learning policies from demonstrations when the experts have different embodiment and/or actuation modes
- Formulated the learning problem as a bilevel optimization problem, with the inner optimization solving (weighted) imitation learning from observations
- (ongoing) Testing the proposed framework on a set of simulated and real-robot tasks

NVIDIA Research May – Aug. 2019, June – Sept. 2020
Robotics Research Intern *Seattle, WA*

· *RMP^2: Combining Riemannian Motion Policies with Automatic Differentiation Libraries*

- Designed an algorithm that solves the same optimization problem as RMP*flow*, but makes use of the gradient oracles from automatic differentiation libraries, e.g., TensorFlow, Pytorch, etc.
- Achieved a smaller memory footprint than RMP*flow* and a more intuitive user interface

· *Learning Riemannian Motion Policies from Human Demonstrations*

- Introduced a framework to learn stable Riemannian Motion Policies (RMPs) from human demonstrations through learning potential functions and Riemannian metrics
- Demonstrated the effectiveness of the proposed learning framework on door reaching and drawer closing tasks performed by a Franka Emika robot

Georgia Institute of Technology Aug. 2017 – May 2019
Graduate Research Assistant *Atlanta, GA*

· *Multi-objectives Policy Generation for Multi-robot Systems*

- Designed a collection of Riemannian Motion Policies (RMPs) for common multi-robot tasks and showed that many existing potential-based multi-robot controllers can be realized by RMPs
- Proposed decentralized algorithms to generate control policies for multi-robot systems by combining control policies defined for individual tasks

· *Distributed Second-order Optimization for Multi-agent Systems*

- Designed a distributed truncated Newton's method using consensus protocol as building blocks for a class of multi-agent problems

· *Formally Correct Behavior Composition for Teams of Autonomous Robots*

- Proposed a framework that ensures correct-by-construction behavior composition for teams of autonomous robot using Control Barrier Functions (CBFs)

Microsoft Research June 2017 – Aug. 2017
Research Intern, CNTK Group *Redmond, WA*

· *Video Synthesis from Static Images using Generative Adversarial Networks*

- Proposed a deep learning approach to generate videos from static images using Generative Adversarial Networks (GANs)
- Contributed two tutorials on WGANs, LSGANs and BEGANs for Microsoft Cognitive Toolkit. The tutorial on WGANs and LSGANs are available on the Microsoft CNTK github repository

Carnegie Mellon University Oct. 2015 – May 2017
Graduate Research Assistant *Pittsburgh, PA*

· *Topology-Based Coordination for Large Teams of Robots*

- Proposed a decentralized and behavior-based approach for large groups of robots to navigate in unknown environments while preserving connectivity and avoiding collisions

· *State Abstraction for Multi-robot Systems under Uncertainty*

- Designed distributed asynchronous algorithms to abstract high dimensional state information of multi-robot systems with the state information of a subset of robots under state uncertainty

· *Human Action Prediction with Recurrent Neural Networks*

- Developed a Recurrent Neural Network (RNN) model with Long Short-Term Memory (LSTM) architecture to predict human actions in Cyber-physical Systems

PUBLICATIONS

(* indicates equal contribution)

Journal Publication

[J1] P. Pierpaoli, **A. Li**, M. Srinivasan, X. Cai, S. Coogan, and M. Egerstedt, "A Sequential Composition Framework for Coordinating Multi-robot Behaviors." *IEEE Transactions on Robotics (T-RO), 2020*

Conference Publications

[C13] M. A. Rana*, **A. Li***, D. Fox, S. Chernova, B. Boots, and N. Ratliff, "Towards Coordinated Robot Motions: End-to-End Learning of Motion Policies on Transform Trees." *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2021*

[C12] **A. Li***, C.-A. Cheng*, M. A. Rana, M. Xie, K. Van Wyk, N. Ratliff, and B. Boot, "RMP^2: A Structured Composable Policy Class for Robot Learning." *Robotics: Science and Systems (R:SS), 2021*

[C11] J. Urain, **A. Li**, P. Liu, C. D'Eramo, and J. Peters, "Composable Energy Policies for Reactive Motion Generation and Reinforcement Learning." *Robotics: Science and Systems (R:SS), 2021*

[C10] N. Ratliff, K. Van Wyk, M. Xie, **A. Li**, and M. A. Rana, "Generalized Nonlinear and Finsler Geometry for Robotics." *IEEE Conference on Robotics and Automation (ICRA), 2021*

[C9] M. A. Rana, **A. Li**, D. Fox, B. Boots, F. Ramos, and N. Ratliff, "Euclideanizing Flows: Diffeomorphic Reductions for Learning Stable Dynamical Systems." *Conference on Learning for Dynamics and Control (L4DC), 2020*

[C8] **A. Li**, and C.-A. Cheng, B. Boots, and M. Egerstedt, "Stable, Concurrent Controller Composition for Multi-Objective Robotic Tasks." *IEEE Conference on Decision and Control (CDC), 2019*

[C7] M. A. Rana*, **A. Li***, H. Ravichandar, M. Mukadam, S. Chernova, D. Fox, B. Boots, and N. Ratliff, "Learning Reactive Motion Policies in Multiple Task Spaces from Human Demonstrations." *Conference on Robot Learning (CoRL), 2019*

[C6] **A. Li**, M. Mukadam, M. Egerstedt, and B. Boots, "Multi-Objective Policy Generation for Multi-Robot Systems Using Riemannian Motion Policies." *International Symposium on Robotics Research (ISRR), 2019*

[C5] **A. Li**, and M. Egerstedt, "On the Trade-Off Between Communication and Execution Overhead for Control of Multi-Agent Systems." *American Control Conference (ACC), 2019*

[C4] **A. Li**, L. Wang, P. Pierpaoli, and M. Egerstedt, "Formally Correct Composition of Coordinated Behaviors Using Control Barrier Certificates." *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2018*

[C3] **A. Li**, W. Luo, S. Nagavalli, and K. Sycara, "Decentralized Coordinated Motion for a Large Team of Robots Preserving Connectivity and Avoiding Collisions." *IEEE Conference on Robotics and Automation (ICRA), 2017*

[C2] **A. Li**, W. Luo, S. Nagavalli, N. Chakraborty, and K. Sycara, "Handling State Uncertainty in Distributed Information Leader Selection for Robotics Swarms." *IEEE Conference on System, Man and Cybernetics (SMC), 2016*

[C1] **A. Li**, M. Lewis, C. Lebiere, K. Sycara, S. S. Khatib, Y. Tang, M. Siedsma, and D. Morrison, "A Computational Model Based on Human Performance for Fluid Management in Critical Care." *IEEE Symposium Series on Computational Intelligence (SSCI), 2016*

Workshop Paper

[W1] **A. Li***, C.-A. Cheng*, M. A. Rana, N. Ratliff, and B. Boot, "RMP^2: a Differentiable Policy Class for Robotic Systems with Control-Theoretic Guarantees." *3rd NeurIPS Workshop on Robot Learning, 2020; Microsoft Reinforcement Learning Day, 2021*

Preprints & Technical Reports

[TR5] M. Xie, **A. Li**, K. Van Wyk, F. Dellaert, B. Boots, and N. Ratliff, "Imitation Learning via Simultaneous Optimization of Policies and Auxiliary Trajectories.", *arXiv preprint arXiv:2105.03019, 2021*

[TR4] N. Ratliff, K. Van Wyk, M. Xie, **A. Li**, and M. A. Rana, "Optimization Fabrics for Behavioral Design.", *arXiv preprint arXiv:2010.15676, 2020*

[TR3] M. Xie, K. Van Wyk, **A. Li**, M. A. Rana, D. Fox, B. Boots, and N. Ratliff, "Geometric Fabrics for the Acceleration-based Design of Robotic Motion.", *arXiv preprint arXiv:2010.14750, 2020*

[TR2] N. Ratliff, K. Van Wyk, M. Xie, **A. Li**, and M. A. Rana, "Optimization Fabrics.", *arXiv preprint arXiv:2008.02399, 2020*

[TR1] P. Pierpaoli, H. Ravichandar, N. Waytowich, **A. Li**, D. Asher, and M. Egerstedt, "Inferring and Learning Multi-Robot Policies by Observing an Expert.", *arXiv preprint arXiv:1909.07887, 2019*

Thesis

[T1] **A. Li**, "Decentralized Coordinated Motion for Robot Teams Preserving Connectivity and Avoiding Collisions.", *Master's Thesis, Carnegie Mellon University, 2017*

INVITED TALKS & POSTERS

Learning Reactive Robot Motion Policies with Control-theoretic Guarantees

- Microsoft Research AI Breakthroughs, September 2020
- Robotics Colloquium@UW, November 2020
- NVIDIA GTC, April 2021
- Robotics Seminar@UIUC, May 2021

Safe and Efficient Robot Learning Using Riemannian Motion Policies

- R:SS'21 Workshop on Geometry and Topology in Robotics

HONORS

- **NVIDIA Graduate Fellowship (5 worldwide)** 2020
- Georgia Robotics Fellowship 2017
- ICRA RAS Travel Grant 2017
- GSA Conference Funding, CMU 2016, 2017
- **Siebel Scholar Class of 2017 (72 worldwide)** 2016
- Outstanding Graduate (top 5%), ZJU 2015
- Excellent Undergraduate Thesis Award (top 10%), ZJU 2015
- **Chu Kochen Scholarship (top 0.2%, highest honor), ZJU** 2014
- National Scholarship (top 1%), China 2013
- First-Class Scholarship for Outstanding Students (top 3%), ZJU 2013, 2014
- Excellent Student Awards, ZJU 2012, 2013, 2014

LEADERSHIP AND PROFESSIONAL SERVICE

- Research Breakout Room Host, Allen School Women's Research Day 2021
  - Shared research and career development experience with women undergraduate researchers
- Reader, Allen School of Computer Science & Engineering, University of Washington 2020 – 2021
  - Computer Science & Engineering Ph.D. Admissions
  - Pre-Application Review Service (PARS)*
    - Provided feedback on 5 prospective students' Ph.D. application packages

    * The PARS program is especially designed to assist PhD applicants from underrepresented communities and related organizations
- Member of Executive Board, RoboGrads, Georgia Institute of Technology 2018 – 2019
  - President (May – Aug. 2019), Vice-President Academics (May 2018 – May 2019)
  - Initiated faculty-student lunch events in the robotics community
  - Organized student seminars where students present their research to their peers

– Student Volunteer, American Control Conference 2021

– Reviewer

- **Journals:** IEEE Robotics and Automation Letters (RA-L); European Journal of Control (EJC)
- **Conferences:** IEEE International Conference on Robotics and Automation (ICRA); Robotics: Science and Systems (R:SS); Conference on Robot Learning (CoRL); IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS); IEEE Conference on Decision and Control (CDC); IEEE International Conference on Robot & Human Interactive Communication (RO-MAN)
- **Workshop:** NeurIPS Workshop on Imitation Learning and its Challenges in Robotics

TEACHING EXPERIENCE

University of Washington Mar. 2020 – June 2020
Graduate Teaching Assistant *Seattle, WA*
– CSE-599W: Reinforcement Learning, Spring 2020, Instructor: Prof. Byron Boots

Georgia Institute of Technology Jan. 2018 – May 2018
Graduate Teaching Assistant *Atlanta, GA*
– CS-3630: Introduction to Robotics and Perception, Spring 2018, Instructor: Prof. Sonia Chernova

SKILLS

Programming Laguages	Python, MATLAB, C/C++, Java, R
Open Sourse Libraries	PyTorch, Tensorflow, CNTK, Keras, OpenAI Gym, MuJoCo, ROS