BOLUN DAI

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EDUCATION

New York University May 2024
Ph.D. in Electrical Engineering
Honors: Ernst Weber Fellowship | Shiv Panwar Scholarship | SOE Fellows Scholarship

Carnegie Mellon University May 2019
Master of Science in Mechanical Engineering Research Option, GPA: 3.93 / 4.00
Selected Coursework: Deep Reinforcement Learning, Artificial Intelligent and Machine Learning

Huazhong University of Science and Technology May 2017
Bachelor of Engineering: Mechanical Engineering, GPA: 3.83 / 4.00
Honors: Academics Excellence Scholarship | Academics Progress Scholarship

RESEARCH EXPERIENCE

Point Cloud Based Safe Motion Planning for Quadrupedal Robots
New York University *October 2023 – Present*

- Proposed a point cloud based growth distance control barrier functions that utilizes custom GPU kernels for safe robotic motion planning and tested the proposed approach on quadrupedal robots (Unitree B1 and Unitree Go2) in a variety of settings.
- Created a pipeline to read, filter, process, and visualize point cloud measurements, motion capture data, and SLAM outputs using RViZ.
- Deployed code on a Jetson Orins that runs SLAM pipeline and control algorithm on board the robot while utilizing the onboard GPU.

Differentiable Optimization Based Control Barrier Functions for Safe Motion Planning
New York University *October 2022 – Present*

- Proposed a differentiable optimization based control barrier functions for safe robotic motion planning and tested the proposed approach on robot manipulators (Franka Emika Research 3) and quadrupedal robots (Unitree B1).
- Created an easy-to-use robot control pipeline using a C++ API running at 1 KHz and a Python API that communicates with the C++ API using LCM which can be used for controlling the robot at a varying frequency.
- Results from this research project have been published in the RA-L 2023, RA-L 2024, and presented as a poster at IROS 2023. Extend the proposed method to dynamic obstacle avoidance tasks.

Learning-based Control Barrier Function Refinement
New York University *January 2022 – May 2023*

- Proposed an online learning pipeline to learn control barrier functions (CBFs) starting from a handcrafted CBF.
- Proved theoretically that using a prioritized replay buffer (PER) can enhance the learning speed. Empirically shown that PER-based learning pipelines can learn an equally well CBF while using only $\sim 70\%$ data.
- Results from this research project have been published at the CDC 2022 and ACC 2023.

State Constrained Stochastic Optimal Control
New York University *May 2020 – May 2023*

- Proposed a penalty function approach to solving stochastic optimal control problems using LSTM-based deep forward-backward stochastic differential equations.
- Designed neural network architecture and training pipeline such that the proposed approach is effective on continuous and hybrid dynamical systems.
- Results from this research project have been published at the ACC 2021 and Automatica 2023.

WORK EXPERIENCE

Core Contributor of Minigrid & Miniworld May 2022 – Present
Farama Foundation

- Responsible for creating CI/CD pipeline, reviewing pull requests, and creating documentation and tutorials.
- Improved user experience by providing case studies and tutorials for obtaining baseline results for the environments.

Reinforcement Learning in Mining Jun 2019 – Aug 2019
SafeAI Inc, San Jose, CA

- Created a reinforcement learning simulation environment for the load-haul-dump cycle.
- Designed the reward function, state space, and action space to be realistic and speed up training.
- Constructed a behavior tree that orchestrates between reinforcement learning based and traditional controllers.

Adaptive Identification of Robotic Kinematic Structure Jan 2018 – May 2019
Carnegie Mellon University, Robotic Institute, Pittsburgh, PA, under supervision of Prof. Hartmut Geyer

- Derived a six degrees-of-freedom (DOF) joint based kinematic model for a multi-link bipedal robot system
- Developed a 6 DOF joint based kinematic identification algorithm using linear regression and achieved 92.3% accuracy in simulation with white noise polluted data.
- Implemented the kinematic identification algorithm on a real bipedal robot ATRIAS using mocap data.

JOURNAL PAPERS

State constrained stochastic optimal control for continuous and hybrid dynamical systems using DFBSDE
Bolun Dai*, Prashanth Krishnamurthy, Andrew Papanicolaou, Farshad Khorrami*
Automatica, 2023

Safe Navigation and Obstacle Avoidance Using Differentiable Optimization Based Control Barrier Functions
Bolun Dai*, Rooholla Khorrambakht, Prashanth Krishnamurthy, Vincius Gonalves, Anthony Tzes, Farshad Khorrami*
IEEE Robotics and Automation Letters, 2023

DiffOcclusion: Differentiable Optimization Based Control Barrier Functions for Occlusion-Free Visual Servoing
Shiqing Wei, ***Bolun Dai****, Rooholla Khorrambakht, Prashanth Krishnamurthy, Farshad Khorrami*
IEEE Robotics and Automation Letters, 2024

Sailing Through Point Clouds: Safe Navigation Using Point Cloud Based Control Barrier Functions
Bolun Dai*, Rooholla Khorrambakht, Prashanth Krishnamurthy, Farshad Khorrami*
IEEE Robotics and Automation Letters, 2024

CONFERENCE PAPERS

State Constrained Stochastic Optimal Control Using LSTMs
Bolun Dai*, Prashanth Krishnamurthy, Andrew Papanicolaou, Farshad Khorrami*
American Control Conference (ACC), 2021

Learning a Better Control Barrier Function
Bolun Dai*, Prashanth Krishnamurthy, Farshad Khorrami*
IEEE Conference on Decision and Control (CDC), 2022

Data-efficient control barrier function refinement
Bolun Dai*, Heming Huang, Prashanth Krishnamurthy, Farshad Khorrami*
American Control Conference (ACC), 2023

Minigrid & Miniworld: Modular & Customizable Reinforcement Learning Environments for Goal-Oriented Tasks
*Maxime Chevalier-Boisvert, **Bolun Dai**, Mark Towers, Rodrigo de Lazcano, Lucas Willems, Salem Lahlou, Suman Pal, Pablo Samuel Castro, Jordan Terry*
NeurIPS Datasets and Benchmarks Track, 2023

PREPRINTS

Learning locomotion controllers for walking using deep FBSDE
***Bolun Dai**, Virinchi Roy Surabhi, Prashanth Krishnamurthy, Farshad Khorrami*
arXiv, 2021

Learning a Better Control Barrier Function Under Uncertain Dynamics
***Bolun Dai**, Prashanth Krishnamurthy, Farshad Khorrami*
arXiv, 2023

Differentiable Optimization Based Time-Varying Control Barrier Functions for Dynamic Obstacle Avoidance
***Bolun Dai**, Rooholla Khorrambakht, Prashanth Krishnamurthy, Farshad Khorrami*
In submission to Robotics and Autonomous Systems

SKILLS

Programming Skills	Python, C++, Matlab, Julia, HTML, CSS, PyTorch, Jax, Tensorflow, Docker, ROS ROS2, Pinocchio, crocoddyl, ProxSuite, MuJoCo, PyBullet, IsaacSim, OMPL
Languages	English (fluent) and Mandarin (native)