Ran Tao

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Education

University of Illinois Urbana-Champaign
Ph.D. candidate, M.Sc., B.Sc. in Mechanical Engineering *Expected May 2026*

Research Experience

Advanced Controls Research Lab (PI: Naira Hovakimyan) Fall 2021 – Present
Graduate Student Researcher *Urbana, IL*

- **Safe Control for Autonomous Vehicles under Mission Uncertainty**
  - Developed an innovative model predictive control framework to enhance safety for autonomous vehicles under mission uncertainty by ensuring feasibility of both primary and alternative missions.
  - Formulated a multi-objective MPC with multi-horizon inputs, backed by rigorous stability guarantees and efficient real-time implementation using sampling based method MPPI.
  - Demonstrated the algorithm's effectiveness through UAV emergency landing scenario, showing a 20% decrease in the energy consumption and 10% increase in safety margins compared to baseline methods.
- **Robust Adaptive Model Predictive Control**
  - Developed a robust adaptive MPC controller to handle dynamic uncertainties and disturbances.
  - Integrated L1 Adaptive Control for uncertainty estimation and compensation, and ensured robust constraints enforcement through constraints tightening.
  - Improved tracking performance compared with exiting robust and tube MPC approaches through a flight control simulation.
- **Closed-loop Learning for Model Predictive Control**
  - Developed an innovative closed-loop learning method to auto-tune MPC parameters.
  - Extended differentiable programming to MPC, enabling gradient-based tuning for nonlinear systems.
  - Improved tracking performance by 20% compared with hand-tuned parameters and reduced tuning iteration compared with existing tuning methods in high-fidelity quadrotor simulations using the RotorPy platform.
- **Intelligent Crop Management System**
  - Developed an intelligent crop management system integrating reinforcement learning (RL), imitation learning (IL), and language models (LM).
  - Achieved optimization of nitrogen fertilization and irrigation simultaneously, enhancing economic profit by over 45% while reducing environmental impact in crop simulation.
  - Addressed the challenge of deploying trained policies in real-world settings, considering factors like sim-to-real gap and measurement noise impacts.

Technical Skills

Research Expertise: Adaptive Control, MPC, Optimization, Machine Learning
Programming Languages: Python, MATLAB, Linux Shell
Technologies/Frameworks: git, PyTorch, LaTeX, MATLAB Simulink, OpenAI Gym for RL

Selected Publications

- **Ran Tao**, Sheng Cheng, Xiaofeng Wang, Shenlong Wang, and Naira Hovakimyan. "DiffTune-MPC: Closed-loop learning for model predictive control." IEEE Robotics and Automation Letters (2024).
- **Ran Tao**, Pan Zhao, Ilya Kolmanovsky, and Naira Hovakimyan. "Robust Adaptive MPC Using Uncertainty Compensation." In 2024 American Control Conference (ACC), pp. 1873-1878. IEEE, 2024.
- **Ran Tao**, Hunmin Kim, Hyung-Jin Yoon, Wenbin Wan, Naira Hovakimyan, Lui Sha, and Petros Voulgaris. "Backup Plan Constrained Model Predictive Control with Guaranteed Stability." AIAA Journal of Guidance, Control, and Dynamics, 47(2), 233-246.
- **Ran Tao**, Pan Zhao, Jing Wu, Nicolas F. Martin, Matthew T. Harrison, Carla Ferreira, Zahra Kalantari, and Naira Hovakimyan. "Optimizing Crop Management with Reinforcement Learning and Imitation Learning." In Proceedings of the Thirty-Second International Joint Conference on Artificial Intelligence, IJCAI-23, AI for Good. Pages 6228-6236.