Ran Tao

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Education

University of Illinois at Urbana-Champaign
Ph.D. Student in Mechanical Engineering — *Expected May 2026*

University of Illinois at Urbana-Champaign
M.Sc. in Mechanical Engineering — *Fall 2021 - December 2022*

University of Illinois at Urbana-Champaign
B.Sc. in Mechanical Engineering — *Fall 2017 - May 2021*

- Highest Honor: University Honor

Research Experience

Advanced Controls Research Lab (PI: Naira Hovakimyan) — Fall 2021 – Present
Graduate Student Researcher

- AI for Agriculture Management
  - Developed an intelligent crop management system utilizing reinforcement learning (RL), imitation learning (IL), and crop simulations to optimize policies that are deployable in the real world, leading to increased crop yields, reduced resource consumption, and minimal environmental impact.
  - Extended the Gym interface between the existing crop simulator and the RL agent to include additional significant environmental variables and enable multi-year simulation for policy training.
- Backup Plan Safety
  - Developed and evaluated a new safety concept called "backup plan safety" for autonomous vehicle path planning based on multi-objective model predictive control (MPC) with multi-horizon control inputs.
  - Focused on enhancing mission feasibility, ensuring feasible alternative strategies, like emergency landings, amidst primary mission failure due to unforeseen circumstances.
  - Developed an algorithm ensuring the closed-loop system's asymptotic stability and enhanced computational efficiency through Model Predictive Path Integral (MPPI) implementation.
- Robust Adaptive MPC
  - Developed an uncertainty compensation-based robust adaptive model predictive control (MPC) framework for linear systems with both matched and unmatched nonlinear uncertainties subject to constraints
  - Leveraged L1 adaptive controller to compensate for the matched uncertainty and ensure guaranteed transient performance.
  - Leveraged the calculated performance bounds from L1 adaptive control to ensure robust constraint satisfaction of the closed-loop system.
- DiffTune-MPC: Closed-Loop Learning for Model Predictive Control
  - Innovated DiffTune-MPC, a novel learning approach for automatically tuning MPC cost functions in a closed-loop manner, overcoming traditional manual tuning's complexity and limitations.
  - Differentiated the MPC formulation implicitly using KKT conditions
  - Validated the method through comprehensive simulations in MATLAB, demonstrating improved performance and adaptability, and highlighting the impact of constraints on learning efficacy.

Technical Skills

Research Expertise: Adaptive Control, Robust Control, MPC, Optimization, Reinforcement Learning, Simulation and Control of autonomous vehicles;
Programming Languages: Python, MATLAB; **3-D CAD Modeling**: SolidWorks, Creo;

Published Papers

- Wu, Jing, Ran Tao, Pan Zhao, Nicolas F. Martin, and Naira Hovakimyan. "Optimizing Nitrogen Management with Deep Reinforcement Learning and Crop Simulations." In Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition Workshops, pp. 1712-1720. 2022.
- Tao, Ran, 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." Proceedings of the Thirty-Second International Joint Conference on Artificial Intelligence, IJCAI-23 AI for Good. Pages 6228-6236.
- Tao, Ran, Hunmin Kim, Hyung-Jin Yoon, Wenbin Wan, Naira Hovakimyan, Lui Sha, and Petros Voulgaris. "Three-dimensional printable nanoporous polymer matrix composites for daytime radiative cooling."AIAA Journal of Guidance, Control, and Dynamics, 2023/10, doi: 10.2514/1.G007627.
- Zhou, Kai, Wei Li, Bijal Bankim Patel, Ran Tao, Yilong Chang, Shanhui Fan, Ying Diao, and Lili Cai. "Three-dimensional printable nanoporous polymer matrix composites for daytime radiative cooling." Nano letters 21, no. 3 (2021): 1493-1499.