

# Ran Tao

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## EDUCATION

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### University of Illinois Urbana-Champaign

*Ph.D. candidate, M.Sc., B.Sc. in Mechanical Engineering*

*Expected May 2026*

### University of Illinois Urbana-Champaign

*M.Sc., B.Sc. in Mechanical Engineering*

*Aug 2017 - May 2021, Aug 2021 - Dec 2022*

- Highest Honor: University Honor

## TECHNICAL SKILLS

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**Research Expertise:** Adaptive Control, MPC, Optimization, State Estimation, Dynamics Modeling and Simulation, Reinforcement Learning, Machine Learning

**Programming Languages:** C++, Python, MATLAB, Linux Shell

**Technologies/Frameworks:** git, PyTorch, LaTeX, MATLAB Simulink, OpenAI Gym for RL, CAD

## RESEARCH EXPERIENCE

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### Advanced Controls Research Lab (PI: Naira Hovakimyan)

Fall 2021 – Present

*Graduate Student Researcher*

*Urbana, IL*

- **Safe Planning for Autonomous Vehicles under Mission Uncertainty**
  - \* Developed an innovative path planning algorithm to enhance safety for autonomous vehicles during complex operations with long-horizon emergency response and mission uncertainties.
  - \* Formulated a multi-objective MPC to maximize the feasibility of all missions, 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.
- **Model Predictive Control against Dynamic Uncertainty**
  - \* Developed a robust adaptive MPC controller to handle uncertainties and disturbances in system dynamics.
  - \* Integrated L1 Adaptive Control for uncertainty estimation and compensation, and ensured robust constraints enforcement through constraints tightening.
  - \* Achieved superior tracking performance over existing robust and tube MPC methods, demonstrated through simulations involving longitudinal aircraft motion control and a soft landing of a spacecraft on an asteroid.
- **Closed-loop Learning for Model Predictive Control**
  - \* Developed an innovative closed-loop learning method to auto-tune MPC parameters using auto-differentiation.
  - \* Extended differentiable programming to implicitly differentiable MPC controllers, enabling gradient-based tuning for nonlinear systems in real-time.
  - \* Improved quadrotor tracking performance by 20% compared with hand-tuned parameters through simulations in RotorPy and reduced tuning iterations for convergence compared with state-of-the-art methods.
- **Intelligent Crop Management System**
  - \* Developed an intelligent crop management system integrating reinforcement learning, imitation learning, language models, and crop simulations using DSSAT.
  - \* 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.

## SELECTED PUBLICATIONS

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- **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, 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.
- **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.