

# Ran Tao

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## EDUCATION

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### 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*

- GPA: 3.99
- Highest Honor: University Honor
- MechSE Bei Tse & May Chao Award (Spring 2021)

## RESEARCH EXPERIENCE

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

Fall 2021 – Present

*Graduate Student Researcher*

*Urbana, IL*

- Intelligent Crop Management System
  - \* Developed an intelligent crop management system integrating Reinforcement Learning (RL), Imitation Learning (IL), and crop simulations (using DSSAT).
  - \* Achieved optimization of nitrogen fertilization and irrigation simultaneously, enhancing economic profit by over 45% while reducing environmental impact.
  - \* Utilized deep RL, specifically deep Q-networks, for policy training under full observation using numerous state variables from simulators.
  - \* Employed IL for training management policies under partial observation with limited state variables that are easily obtainable, mimicking real-world scenarios.
  - \* Conducted simulation experiments on maize crops in Florida, USA, and Zaragoza, Spain, demonstrating significant improvements over baseline methods.
  - \* Addressed the challenge of deploying trained policies in real-world settings, considering factors like sim-to-real gap and measurement noise impacts.
- Safe Path Planning for Autonomous Vehicles under Mission Uncertainty
  - \* Proposed and evaluated a novel safety concept "Backup Plan Safety" for path planning in autonomous vehicles using Model Predictive Control (MPC) under mission uncertainty.
  - \* Developed a feasibility maximization problem formulation using multi-objective model predictive control (MPC) with multi-horizon control inputs.
  - \* Introduced a backup plan constrained MPC algorithm that ensures asymptotic stability of the closed-loop system and maintains operational safety.
  - \* Validated the algorithm's performance through UAV path planning simulations, demonstrating its efficiency and reliability in complex autonomous systems operations.
- Robust Adaptive Model Predictive Control
  - \* Introduced a robust adaptive Model Predictive Control (MPC) framework utilizing uncertainty compensation for linear systems with both matched and unmatched uncertainties.
  - \* Integrated L1 Adaptive Control for matched uncertainty estimation and compensation, ensuring uniform performance bounds.
  - \* Proposed Uncertainty Compensation-based MPC (UC-MPC) for enhanced tracking performance and robust constraint satisfaction, effectively handling both matched and unmatched disturbances.
  - \* Demonstrated the UC-MPC's effectiveness through a flight control simulation, showcasing its superiority in managing uncertainties and tracking performance compared with traditional robust and tube MPC approaches.
- Diff-TuneMPC: Closed-loop Learning for Model Predictive Control
  - \* Introduced DiffTune-MPC, an innovative approach for auto-tuning Model Predictive Control (MPC) parameters, enhancing controller performance.
  - \* Leveraged KKT conditions to find the implicit differentiation of the MPC problem and used gradient-based optimization for fine-tuning MPC cost function parameters.

- \* Demonstrated DiffTune-MPC's effectiveness in optimizing quadratic cost parameters for multiple linear and nonlinear systems including a differential drive system, and a quadrotor system.

## **Cai Research Group (PI: Lili Cai)**

*Undergraduate Student Research Assistant*

March 2019 – Spring 2021

*Urbana, IL*

- Radiation Cooling Film
  - \* Synthesized micro-structure film for radiative cooling with high emissivity and low absorptivity.
  - \* Conducted thermal measurement on outdoor experiments and optimized the film composition ratio.
  - \* Built a simulation model of the radiation cooling film and its environment to predict the radiative cooling performance.
- 3D Printing of Radiative Cooling Film
  - \* Explored the feasibility of utilizing 3D printing technology to fabricate radiation cooling film.
  - \* Investigated the effect of printing temperature, pressure, speed and print bed temperature on the product's radiation cooling effect.

## **INTERN EXPERIENCE**

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### **Sun Harmonics Co., Ltd**

*Mechanical Engineer Intern*

July 2019 – August 2019

*Hangzhou, China*

- Utilized SolidWorks to create detailed 3-D models of the solar panel holder meeting clients' requirements and specifications.
- Developed a manufacturing process for the solar panel holder, ensuring efficient production and assembly.
- Conducted material selection for the solar panel holder based on functionality and cost considerations.

## **TECHNICAL SKILLS**

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**Research Expertise:** Adaptive Control, MPC, Optimization, Reinforcement Learning, Supervised Learning, State Estimation, Dynamics Modeling, Simulation and Control of Autonomous Vehicles

**Programming Languages:** Python, MATLAB

**3-D CAD Modeling:** SolidWorks, Creo

## **PUBLISHED PAPERS**

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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, Ilya Kolmanovsky, and Naira Hovakimyan. "Robust Adaptive MPC Using Uncertainty Compensation." *2024 American Control Conference (ACC)*.
- **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**, 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* (2023), accessed October 18, 2023. doi: 10.2514/1.G007627
- Jing Wu, **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 (CVPR) Workshops*, pp. 1712-1720. 2022.
- Kai Zhou, 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.