Ran Tao

217-904-5083 | rant3@illinois.edu | Website |

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*

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

RESEARCH EXPERIENCE

Advanced Controls Research Lab (PI: Naira Hovakimyan)   Fall 2021 – Present

Graduate Student Researcher   *Urbana, IL*

- AI for Agriculture Management
  * 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.

- Backup Plan Safety
  * 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 linear and non-linear systems.
- ∗ Showcased significant improvements in computational efficiency and loss reduction through simulations on various control systems.

Cai Research Group (PI: Lili Cai) March 2019 – Spring 2021

Undergraduate Student Research Assistant *Urbana, IL*

- Radiation Cooling Film Project
  - ∗ 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 Project
  - ∗ 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

Sun Harmonics Co., Ltd July 2019 – August 2019

Mechanical Engineer Intern *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

Research Expertise: Adaptive control, MPC, Optimization, Reinforcement Learning, Supervised Learning, State Estimation, Dynamics Modeling, Simulation and Control of Autonomous Vehicles
Programming Languages: Python, MATLAB
Technologies/Frameworks: Pytorch, LaTeX
3-D CAD Modeling: SolidWorks, Creo

Published Papers

- **Ran Tao**, Pan Zhao, Ilya Kolmanovsky, and Naira Hovakimyan. "Robust Adaptive MPC Using Uncertainty Compensation." Accepted at 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.