

Yuhao Zhang

PhD Candidate in Mechanical Engineering

University of Wisconsin-Madison

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SUMMARY

Ph.D. candidate with expertise in mathematical optimization, robotic systems, control theory, and large-scale numerical computation. Specializing in the integration of control theory, optimization algorithms, and machine learning to develop safe and reliable control frameworks for autonomous systems, ensuring real-time safety and enhanced performance in complex environments. Published 10+ papers in top control theory and robotics conferences/journals.

EDUCATION

University of Wisconsin-Madison

Madison, WI

Doctor of Philosophy in Mechanical Engineering

Dec 2025

- Advisor: Prof. Xiangru Xu
- GPA: 4.00/4.00

University of Michigan-Ann Arbor

Ann Arbor, MI

Master of Science in Engineering in Mechanical Engineering

May 2019

- Advisor: Prof. Necmiye Ozay and Prof. Jean-Baptiste Jeannin
- GPA: 4.00/4.00

Peking University

Beijing, China

Bachelor of Engineering in Energy and Power Engineering

Jun 2017

- Advisor: Prof. Jianchun Mi
- GPA: 3.46/4.00

EXPERIENCE

Research Assistant

Sep 2020-Present

Autonomous and Resilient Controls Lab - ME Department, UW-Madison

Madison, WI

Safety-critical control with measurement and actuation uncertainties

- Developed a provably safe feedback controller using sampled-data Control Barrier Functions (CBFs) and convex optimization for nonlinear systems with measurement and actuation uncertainties.
- Implemented the controller on Franka Research 3 robot manipulator and Crazyflie quadrotor, achieving real-time obstacle avoidance where conventional controllers failed.

Scalable verification of learning-enabled systems

- Designed an efficient and tunable method for safety verification of perception-based autonomous systems using set-based computation and optimization techniques (LP, MILP, SDP).
- Accelerated robustness and sensitivity analysis of large-scale neural networks by 10x compared to baseline tools, through a novel local NN compression method and MILP cutting-plane techniques.

- Integrated verification results into controller design, achieving provably safe goal-reaching and obstacle avoidance for robotic systems with machine learning components.
- Supervised undergraduate research on optimizing algorithm runtime and scalability; guided one mentee to co-author a publication in a top venue.

Robust stability of neural network control systems

- Derived new robust stability conditions via Linear Matrix Inequalities and quadratic constraints, enlarging the certified stability region by 5x over baseline methods.
- Developed a data-driven, provably stable controller design and verification framework for uncertain and disturbed systems without requiring system identification.

Research Associate

Necmiye Ozay Research Group - EECS Department, UMich

Sep 2018-Jun 2020

Ann Arbor, MI

Hierarchical control for autonomous aircraft taxiing

- Built a hierarchical architecture for autonomous taxiing, including high-level graph-based path planning, mid-level trajectory generation, and low-level tracking control.
- Ensured safety-by-design control of aircraft taxiing by integrating ATC-level constraints (e.g., runway selection) and ground-level requirements (e.g., speed limits, obstacle avoidance) using graph theory and MPC.

Perception-based autonomous aircraft landing

- Developed vision-based landing control using camera sensing, PID control, YOLO detection, SIFT feature extraction, and geometric state estimation via Perspective-n-Point algorithms.
- Validated the proposed algorithms in the X-Plane 11 high-fidelity flight simulator.
- Collaborated with cross-disciplinary teams (CS, EE, Aerospace) to integrate perception, optimization, and control modules into a unified autonomous aircraft platform.

Undergraduate Research Assistant

State Key Laboratory of Turbulence and Complex Systems - Peking University

Feb 2016-Jun 2017

Beijing, China

Computational fluid dynamics of MILD combustion

- Built high-fidelity 3D models of boilers and performed CFD simulations of methanol MILD combustion under varying operating conditions.
- Conducted experimental validation in a mid-scale boiler, demonstrating higher thermal efficiency and lower emissions compared to traditional combustion.

ACADEMIC PROJECTS

Robot kinematics and dynamics

- Implemented PID control for robotic manipulators in joint-space and Cartesian-space.
- Generated optimal manipulator trajectories in cluttered environments using advanced planning and optimization methods, including PRM, RRT, A*, and potential field.
- Applied state estimation algorithms (Kalman Filter, Extended KF, Moving Horizon Estimation) to achieve high-accuracy estimation of the manipulator position.

High-Performance Computation of Monte Carlo Simulation

- Accelerated Monte Carlo simulation and real-time state estimation for high-dimensional nonlinear systems by 65% through parallelization with CUDA and OpenMP.
- Implemented parallelized Monte Carlo methods with conformal prediction techniques to enhance prediction accuracy in a traffic alert system.

SKILLS

Programming: Python, C++, C, MATLAB

Software/Tools: Simulink, PyTorch, TensorFlow, Gurobi, Linux, CUDA, OpenMP, FEM, Git

Hardware: Crazyflie quadrotor, Raspberry Pi, Arduino

Language: English, Chinese (Mandarin)

AWARDS AND ACHIEVEMENTS

Student Research Grants Competition Award

University of Wisconsin-Madison Graduate School

Jun 2025 & Apr 2023

LeRoy Fellowship

Department of Mechanical Engineering, University of Wisconsin-Madison

Sep 2020

XIA Shouyu and HUANG Yuqin Scholarship

College of Engineering, Peking University

May 2016

Community Service Award

College of Engineering, Peking University

Dec 2015

Second prize in National High School Mathematics Competition

Chinese Mathematical Society

Nov 2012

PROFESSIONAL SERVICE

Grader

- ECE 560 - Linear Systems Theory at the University of Michigan-Ann Arbor

Journal Reviewer

- Automatica
- IEEE Transactions on Control Systems Technology (TCST)
- IEEE Control Systems Letters (L-CSS)
- IEEE Robotics and Automation Letters (RA-L)
- Systems & Control Letters
- Control Engineering Practice

Conference Reviewer

- IEEE Conference on Decision and Control (CDC)
- American Control Conference (ACC)
- IEEE International Conference on Robotics and Automation (ICRA)
- Annual Learning for Dynamics and Control Conference (L4DC)

COURSES

Nonlinear Optimization, Dynamic Programming, High Performance Computing, Advanced Computational Dynamics, Linear System Theory, Robot Kinematics and Dynamics, Self-Driving Cars: Perception and Control

PUBLICATIONS

Journal Publications

- J1. **Yuhao Zhang**, Xiangru Xu, “Robust Stability of Neural Network Control Systems with Interval Matrix Uncertainties”, *Automatica*, 177: 112289, 2025. <https://doi.org/10.1016/j.automatica.2025.112289>
- J2. **Yuhao Zhang**, Hang Zhang, Xiangru Xu, “Reachability Analysis of Neural Network Control Systems with Tunable Accuracy and Efficiency”, *IEEE Control Systems Letters*, 8: 1697-1702, 2024. <https://doi.org/10.1109/LCSYS.2024.3415471>
- J3. **Yuhao Zhang**, Hang Zhang, Xiangru Xu, “Backward Reachability Analysis of Neural Feedback Systems Using Hybrid Zonotopes”, *IEEE Control Systems Letters*, 7: 2779-2784, 2023. <https://doi.org/10.1109/LCSYS.2023.3289572>
- J4. Hang Zhang, Abigail Winn, **Yuhao Zhang**, Xiangru Xu, “Goal-Reaching Control Synthesis for Neural Network Control Systems via Backward Reachability”, *IEEE Control Systems Letters*, under review.

Peer-reviewed Conference Publications

- C1. **Yuhao Zhang**, Xiangru Xu, “Efficient Reachability Analysis for Convolutional Neural Networks Using Hybrid Zonotopes”, *American Control Conference*, Denver, CO, USA, page 1321-1326, 2025. <https://doi.org/10.23919/ACC63710.2025.11107585>
- C2. Hang Zhang, **Yuhao Zhang**, Xiangru Xu, “Hybrid Zonotope-Based Backward Reachability Analysis for Neural Feedback Systems With Nonlinear Plant Models”, *American Control Conference*, Toronto, ON, Canada, page 4155–4161, 2024. <https://doi.org/10.23919/ACC60939.2024.10644573>
- C3. **Yuhao Zhang**, Xiangru Xu, “Reachability Analysis and Safety Verification of Neural Feedback Systems via Hybrid Zonotopes”, *American Control Conference*, San Diego, CA, USA, page 1915–1921, 2023. <https://doi.org/10.23919/ACC55779.2023.10156417>
- C4. **Yuhao Zhang**, Xiangru Xu, “Safety Verification of Neural Feedback Systems Based on Constrained Zonotopes”, *IEEE Conference on Decision and Control*, Cancun, Mexico, page 2737-2744, 2022. <https://doi.org/10.1109/CDC51059.2022.9992655>
- C5. **Yuhao Zhang**, Sequoyah Walters, Xiangru Xu, “Control Barrier Function Meets Interval Analysis: Safety-Critical Control with Measurement and Actuation Uncertainties”, *American Control Conference*, Atlanta, GA, USA, page 3814–3819, 2022. <https://doi.org/10.23919/ACC53348.2022.9867681>
- C6. Sara Shoouri, Shayan Jalili, Jiahong Xu, Isabelle Gallagher, **Yuhao Zhang**, Joshua Wilhelm, Jean-Baptiste Jeannin, Necmiye Ozay, “Falsification of a Vision-based Automatic Landing System”, *AIAA SciTech Forum*, 2021. <https://doi.org/10.2514/6.2021-0998>
- C7. **Yuhao Zhang**, Guillaume Poupart-Lafarge, Huaiyuan Teng, Joshua Wilhelm, Jean-Baptiste Jeannin, Necmiye Ozay, Eelco Scholte, “A Software Architecture for Autonomous Taxiing of Aircraft”, *AIAA SciTech Forum*, 2020. <https://doi.org/10.2514/6.2020-0139>

Preprints

- P1. **Yuhao Zhang**, Xiangru Xu, “Finding Matrix Sequences with a High Asymptotic Growth Rate for Linear Constrained Switching Systems”, *arXiv:2009.12948*, 2021. <https://arxiv.org/abs/2009.12948>