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 *Sep 2020 – Dec 2025 (expected)*

- Advisor: Prof. Xiangru Xu
- GPA: 4.00/4.00
- Thesis (tentative): Formal Analysis and Verification of Neural Network Control Systems

University of Michigan-Ann Arbor Ann Arbor, MI
Master of Science in Engineering in Mechanical Engineering *Sep 2017-May 2019*

- Advisor: Prof. Necmiye Ozay and Prof. Jean-Baptiste Jeannin
- GPA: 4.00/4.00
- Project: Vision-based Autonomous Taxiing and Landing of Aircraft

Peking University Beijing, China
Bachelor of Engineering in Energy and Power Engineering *Sep 2013-Jun 2017*
Bachelor of Economics *Sep 2014-Jun 2017*

- Advisor: Prof. Jianchun Mi
- GPA: 3.46/4.00
- Thesis: Experimental and Simulation Research on MILD Combustion Properties in Methanol Boilers

Experience

University of Wisconsin-Madison Madison, WI
Research Assistant at Autonomous & Resilient Controls Lab *Sep 2020-Present*

· 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.
- Applied parallelization (CUDA, OpenMP) to accelerate Monte Carlo reachability and real-time state estimation for high-dimensional nonlinear systems.

· 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.

University of Michigan-Ann Arbor Ann Arbor, MI
Research Associate *Sep 2018-Jun 2020*

· 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.

University of Michigan-Ann Arbor Ann Arbor, MI
Course Project *Sep 2018-Dec 2018*

· Robot kinematics and dynamics.

- Implemented PID control for robotic manipulators in joint-space and Cartesian-space, and designed a whole-body controller based on quadratic programming to satisfy physical and task constraints.
- Generated optimal manipulator trajectories in cluttered environments using advanced planning and optimization methods, including PRM, RRT, A*, and potential field.
- Applied state estimation algorithms (KF, EKF, UKF, MHE) to achieve high-accuracy estimation of the manipulator position.

Peking University Beijing, China
Undergraduate Research Assistant *Feb 2016-Jun 2017*

· 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.

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)

Leadership and Community Service

Engineering EXPO — Madison, WI
Student Exhibitor — *Apr 2023*

- Demonstrated quadrotor experiments to middle school students, earning the Honorable Mention Award.

Practice Department in College of Engineering — Beijing, China
Vice President — *Sep 2014-Jun 2015*

- Organized summer internship programs and coordinated local company visits for undergraduates.

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

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, JoshuaWilhelm, 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

Courses

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