Jinsun Liu

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EDUCATION

University of Michigan | PhD in Robotics | GPA 3.83/4.00
Sep 2017 - Jan 2023 • Ann Arbor, MI

- *PhD Thesis:* Deterministic and Chance-Constrained Real-Time Motion Planning using Reachability Analysis
- *Thesis committee:* Dr. Ram Vasudevan (advisor), Dr. Jessy Grizzle, Dr. Necmiye Ozay, Dr. Katie Skinner

University of Michigan | M.S. in Electrical and Computer Engineering | GPA 3.95/4.00
Sep 2015 - May 2017 • Ann Arbor, MI

University of Minnesota | B.E. in Electrical and Computer Engineering | GPA 3.91/4.00
Sep 2013 - May 2015 • Minneapolis, MN

Beijing Jiaotong University | B.E. in Electrical Engineering | GPA 89/100
Sep 2011 - Jun 2013 • Beijing, China

PROFESSIONAL EXPERIENCE

University of Michigan | Postdoctoral Research Fellow
Mar 2023 - Present • Ann Arbor, MI

- Utilize parallel computing and dynamical chance constraints to achieve a tighter over-approximation of collision risk during risk-averse motion planning.
- Speed up online motion planning by evaluating Signed Distance Functions using an exact neural network.

Beijing Yiqitong Info. Tech. Co., Ltd. | Software Engineer Intern
Jul 2011 – Aug 2011, Jul 2012 – Aug 2012 • Beijing, China

- Developed a Windows App that improved users' keyboard typing efficiency by considering users' letter usage frequency and ergonomics.
- Designed and developed the company's homepage.

RESEARCH EXPERIENCE

Risk-Averse, Real-Time Motion Planning in Uncertain Scenarios | University of Michigan
Jan 2022 - Jan 2023 • Ann Arbor, MI

- Designed a motion planning algorithm for autonomous driving in uncertain dynamic environments.
- Proposed a parallelizable method to over-approximate the risk of collision in closed form without restricting the probability distribution for obstacle uncertainty modeling.
- Limited collision risk using chance constraints during online planning to improve the planning performance.
- Validated the framework in various scenarios in simulation using a full-size vehicle model and on hardware using an F1/10th racecar robot.

Reachability-Based Trajectory Design using Robust Feedback Linearization and Zonotopes | University of Michigan
Jan 2021 - Nov 2022 • Ann Arbor, MI

- Proposed a parametrized robust controller that partially linearizes the vehicle dynamics with modeling error.
- Performed zonotope-based reachability analysis on the closed-loop, full-order vehicle dynamics to over-approximate Forward Reachable Sets in a parametrized way.
- Generalized the framework to All-Wheel, Front-Wheel, and Real-Wheel-Drive vehicle models.
- Achieved real-time trajectory planning in a receding horizon fashion with safety guarantee both in simulation and on hardware.

Safe Online Gait Design for Bipedal Robots | University of Michigan
Jan 2019 - Mar 2021 • Ann Arbor, MI

- Developed a collision-free and falling-prevented planning algorithm on bipedal robots Cassie and Digit.
- Leveraged the anchor and template framework to simplify the full-order robot model.
- Computed Forward Reachable Sets offline using the simplified model with its modeling error against the full-order model being conservatively considered.
- Encoded robot safety conditions during online planning using Forward Reachable Sets.

Planar Pose Graph and Landmark SLAM Problems | University of Michigan
Jun 2017 - Dec 2018 • Ann Arbor, MI

- Formulated the two SLAM problems as polynomial optimization programs, which can be solved using the sparse bounded degree sum-of-squares (Sparse-BSOS) hierarchy.
- Transferred the Sparse-BSOS hierarchy identically into the complex domain via Laurent polynomial, and solved via sparse semidefinite programming.

Optimal Luenberger-Type Observer for Nonlinear Systems | University of Michigan
Sep 2016 - Mar 2017 • Ann Arbor, MI

- Developed a framework to design Luenberger-type observers for nonlinear systems that guarantee the largest possible domain of attraction for the state estimation error regardless of the initialization of the system.
- Represented the error dynamics abstractly as a linear equation on the space of Radon measures, and solved for the observer gain by an infinite-dimensional linear program on measures.

Unambiguous Optimal Control for Signaling | University of Minnesota
Jan 2014 - May 2015 • Minneapolis, MN

- Studied a two-player problem where the first player balances control costs with the strength of signaling, which is observed with noise by the second player to decipher the intention of the first player.
- Solved the problem by iterative LQR and produced qualitative phenomena observer in human experiments.

PUBLICATIONS

- [**RSS'23**] **Jinsun Liu,** Challen Enninful Adu, Lucas Lymburner, Vishrut Kaushik, Lena Trang, and Ram Vasudevan. "RADIUS: Risk-Aware, Real-Time, Reachability-Based Motion Planning." *Robotics: Science and Systems (2023)* .
- [**T-RO'22**] **Jinsun Liu,** Yifei Shao, Lucas Lymburner, Hansen Qin, Vishrut Kaushik, Lena Trang, Ruiyang Wang, Vladimir Ivanovic, H. Eric Tseng, Ram Vasudevan. "REFINE: Reachability-based Trajectory Design using Robust Feedback Linearization and Zonotopes." *2nd round review at IEEE Transactions on Robotics* (2022).
- [**ICRA'20**] **Jinsun Liu,** Pengcheng Zhao, Zhenyu Gan, Matthew Johnson-Roberson, and Ram Vasudevan. "Leveraging the Template and Anchor Framework for Safe, Online Robotic Gait Design." *IEEE International Conference on Robotics and Automation* (2020).
- [**ICRA'19**] Joshua Mangelson, **Jinsun Liu,** Ryan Eustice, and Ram Vasudevan. "Guaranteed Globally Optimal Planar Pose Graph and Landmark SLAM via Sparse-Bounded Sums-of-Squares Programming." *IEEE International Conference on Robotics and Automation* (2019).
- [**ICRA'18**] Hyungju Park, **Jinsun Liu,** Matthew Johnson-Roberson, and Ram Vasudevan."Robust Environmental Mapping by Mobile Sensor Networks." *IEEE International Conference on Robotics and Automation* (2018).
- **Jinsun Liu,** Hyongju Park, Matthew Johnson-Roberson, and Ram Vasudevan. "A Matrix Representation of the Multiple Vehicle Routing Problem for Pickup and Delivery." *arXiv preprint arXiv:1805.04965* (2018).
- [**CDC'17**] Shankar Mohan, **Jinsun Liu** and Ram Vasudevan. "Synthesizing the Optimal Luenberger-type Observer for Nonlinear Systems." *IEEE Conference on Decision and Control* (2017).
- [**ACC'16**] Andrew Lamperski, Bolei Di, Tyler Lekang, **Jinsun Liu,** and Ran Tian. "(Un)ambiguous Optimal Control." *American Control Conference* (2016).

TECHNICAL SKILLS

Programming Languages and Software: C/C++ • CUDA • Matlab • Simulink • PyTorch • Git • Docker • Solidworks
Hands-on Robot Platforms: Digit • Cassie • F1/10th racecar robot • MAEBot • manipulators • quadrotors

TEACHING

University of Michigan | Graduate Student Instructor

- ROB 535: Self-Driving Cars: Perception and Control
- ME 461: Automatic Control
- ME 561: Design of Digital Control Systems

AWARDS AND HONORS

- **Richard F. & Eleanor A. Towner Prize for Distinguished Academic Achievement** | Ann Arbor, MI•2022
- **Nominee for the Outstanding Graduate Student Instructor Awards** | Ann Arbor, MI•2022
- **Dean's List** | Minneapolis, MN•2014, 2015
- **Learning Scholarship** | Beijing, China•2012, 2013