Ruiji Liu

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Education

- **Carnegie Mellon University** Aug. 2022 - May 2024
  Master of Science in Mechanical Engineering, Robotic and Control Systems *Pittsburgh, PA*
  - **GPA:** 4.0/4.0 **Advisor:** George A. Kantor
  - **Core Modules:** Robot Learning, AI Safety, Linear Control, SLAM, Computer Vision, Path Planning
- **The Pennsylvania State University** Aug. 2018 - May 2022
  Bachelor of Science in Mechanical Engineering *State College, PA*
  - **GPA:** 3.98/4.0
  - **Core Modules:** Intro Robotics, Modeling Dynamics System, Dynamics

Publications & Technical Reports

[1] **Ruiji Liu**, Francisco Yandun, George Kantor, "Towards Over-Canopy Autonomous Navigation: Crop-Agnostic LiDAR-Based Crop-Row Detection in Arable Fields", in *IEEE International Conference on Robotics and Automation (ICRA)*, 2025. (Under review) [Project page], [Paper], [Code], [Video]

[2] Saira Hussain, Yuqi Zhou, **Ruiji Liu**, Eric Pauli, Randy Haluck, Barry Fell, Jason Moore, "Evaluation of Endoscope Control Assessment System for Measuring", in *Design of Medical Devices Conference*, 2022. [Paper]

[3] **Ruiji Liu**, Francisco Yandun, David Wettergreen, George Kantor, etc., "AIIRA Autonomous Robot Control for Spotted Lanternflies", Technical report (Research). [Project Page], [Paper], [Video], [PPT], [Poster]

[4] **Ruiji Liu**, Xiaoyang Zhan, Yumeng Xiu, Yufeng Ren, Hanjiang Hu, Zixuan Zhang. "3D Reconstruction for Tunnel Inspection Based on RGB-D Data", Technical report (CMU-16833). [Paper], [Code], [PPT]

[5] **Ruiji Liu**, Morgan Mayborne, Vina Wei. "Push-T Experiment with Diffusion Policy and DQN", Technical report (CMU-16831). [Paper], [Code], [Data], [PPT]

[6] **Ruiji Liu**, Letian Leng, Yutong Huang. "Defend Like-a-Lion: Defensive Racing Maneuvers Utilizing Visual Localization", Technical report (CMU-16663). [Paper], [Code], [PPT]

[7] **Ruiji Liu**, Yu Qiu, Runpu Meng, Zongyuan Wu. "Finding Optimal Machine Learning Regression Model for House Prices Prediction", Technical report (CMU-24787). [Paper], [Code]

[8] A. Anand, C. Frantz, .., **Ruiji Liu**, etc., "The Pennsylvania State University Advanced Vehicle Team's Concept Design for the SAE AutoDrive Challenge II Competition's Perception Cart", Technical report, 2022. [Paper]

[9] **Ruiji Liu**, Ryan Maziarz, Alex Nellis. "Autonomous Etch-A-Sketch", Technical report, 2021. [Paper], [Video], [Code]

[10] **Ruiji Liu**, Alan Wagner. "Automatic Path-Planning and Map Drawing by Husky Robot and the Realization of Robot Simulation in Unity", Technical report (MC-REU Scholarship), 2021. [Paper], [Talk], [Video]

Academic Experience

- **Enhancing Robotic Manipulation via Advanced Data Collection Methods** Oct. 2024 – Present
  Research Assistant @ CMU KantorLab, supervised by Dr. George A. Kantor *Pittsburgh, PA*
  - **SAM2 Key Object Extraction:** Leveraged SAM2 to train object detection models for identifying and extracting key objects from video data, integrating outputs to optimize diffusion policy training
  - **Human-hand-based Data Collection:** Exploring human-hand-based data collection for robotic manipulation training, employing HAMER for hand motion tracking and 3D Gaussian Splatting for environment reconstruction to generate multi-angle camera views and enhance policy training
- **AIIRA Crop-Agnostic Autonomous Navigation on Amiga Robot Platform** May 2023 – Present
  Research Assistant @ CMU KantorLab, supervised by Dr. George A. Kantor *Pittsburgh, PA*
  - **High-Precision Robot Localization:** Integrated the ROS robot localization package on the Amiga robot, fusing sensors' outputs from IMU, RTK-GPS, and wheel encoder to enhance robot localization accuracy
  - **Drone Map:** Generated multiple drone maps with position accuracy within 3cm using RGB-D images from the drone across various crop fields
  - **MPC Controller:** Designed and implemented a custom Model Predictive Control (MPC) controller, enabling the robot to follow predefined navigation paths (from the drone maps) autonomously and significantly reducing the need for human intervention (tested in fields)
  - **General Crop Detection Algorithm:** Developed a novel LiDAR-based, crop-agnostic detection algorithm to address crop row detection challenges across various crop types and growth stages, demonstrating the effectiveness in crop row detection through testing in both the Gazebo simulation environments and real fields
  - **Autunomous Navigation without RTK-GPS:** Combined the LiDAR-based crop row detection algorithm with a modified local MPC controller to achieve autonomous navigation in crop fields without RTK-GPS. Tested in corn and soybean fields at different growth stages, both in Gazebo simulations and real field conditions. Presented the project at the AIIRA USDA-NIFA/NSF Annual Review poster session

- **F1 TENTH Autonomous Race Vehicle** Jan. 2024 – May 2024
  CMU 16663 Course Info *Pittsburgh, PA*
  - **Built the F1TENTH Car:** Built the F1 TENTH vehicle from scratch, assembling the chassis, installing the compute module (Jetson Orin Nano & SSD cards), integrating sensors (Hokuyo LiDAR & cameras), and setting up Ubuntu 20.04 with ROS 2 Foxy
  - **Implemented the Autonomy algorithms:** Devised and implemented various autonomy algorithms on a self-built F1 TENTH vehicle for racing. These included perception (computer vision & SLAM), planning (RRT & Gap following), control (PID, Pure Pursuit, & MPC), and machine learning techniques (YOLO, imitation learning, & reinforcement learning)
  - **Racing the vehicles:** Tested our autonomous navigation algorithms rigorously during three race days within the school (reactive racing, racing with map, & head-to-head race). Competed against approximately 10 teams from UPenn and Lehigh university
  - **Autonomous Defensing strategy:** Devised an autonomous defense system for F1TENTH vehicles, including a defensive path-planning algorithm and a YOLOv8 object detection model using the rear-facing camera
- **AIIRA Autonomous Robot Control for Spotted Lanternflies** Feb. 2023 – May 2023
  Research Assistant @ CMU KantorLab, supervised by Dr. George A. Kantor *Pittsburgh, PA*
  - **Spotted Lanternflies Detector:** Applied YoloV5s model to train a Spotted Lanternflies detector based on 3000 images from the iNaturalist website (The dataset was augmented from 700 images through rotation, skewing, and scaling)
  - **Robot in Simulation:** Constructed a URDF model for the Amiga robot to evaluate sensor configurations and autonomous algorithms in the Gazebo simulation environment
  - **Final Results:** Validated the feasibility of the robot control method using artificial fake lanternfly eggs with an 80 % success rate and presented the project at the AIIRA USDA-NIFA/NSF Annual Review poster session
- **Endoscope Control Assessment Using Video and Magnetic Tracking** Sep. 2021 - May 2022
  Research Assistant, supervised by Dr. Jason Moore *State College, PA*
  - **Magnetic Tracking Technology:** Utilized a magnetic tracker to precisely monitor the tip movement of the endoscope within the colon, providing high-precision tip location data, aiding in the accurate measurement and analysis of the endoscope's path and curvature during operation
  - **Video Angle Capture:** Devised CV algorithms to capture the angle changes of the endoscope control knobs, enabling real-time quantification of the operator's input on the controls, enabling the system to thoroughly record and evaluate the operator's control techniques and performance across different stages of the procedure
  - **Integrated Data Analysis:** Compared results of the endoscope tip movement data and the control knob angle data, and provided well-rounded feedback by employing advanced data analysis algorithms
- **Automatic Path-Planning and Map Drawing** Jun. 2021 - Aug. 2021
  Research Assistant @ PSU REAL Lab, supervised by Dr. Alan Wagner *State College, PA (Remote)*
  - **Autonomous Obstacle Avoidance:** Applied ROS and devised bug2 algorithm in Python to enable autonomous obstacle avoidance for the Husky robot
  - **ROS and Unity Integration:** Utilized ROS-TCP-Connector to integrate ROS with Unity, developed odometry and laser data publishers, along with a velocity subscriber, enabling robot simulation within Unity

Academic Service

- **Reviewer of ICRA and IROS** 2024-
- **Teaching Assistant**, CMU ME 24787, Intro to Machine Learning Aug. 2023 - Dec. 2023
- **Grading Assistant**, PSU ME 330, Computational Tools Jan. 2022 - May 2022
- **Teaching Assistant**, PSU CHEM 112, Chemical Principles II Jan. 2020 - May 2020

Other Projects

- **IVSG Auto Work Mapping Van** (ROS, Sensing, Mapping) Jun. 2022 - Aug. 2022
- **AUTODRIVE CHALLENGE II Perception Cart** (ROS, Sensing, ML, Vision) Jan. 2022 - May. 2022
- **Autonomous Construction Robot** (ROS, Sensing, 3D Reconstruct, Planning) Sep. 2021 - Mar. 2022
- **Autonomous Etch-A-Sketch** (MATLAB, Arduino, Electronics) Jan. 2020 - May. 2022
- **RoboMaster Autonomous Combat Robot** (Vision, CAD, Control, Planning) Jan. 2020 - May. 2022

Skills

- **Programming:** Advanced – Python, MATLAB, Intermediate – C/C++, C#, Beginner – R, Julia
- **Tools:** ROS, PyTorch, OpenCV, Linux, Docker, Git
- **Softwares:** SolidWorks, Unity, Gazebo, CATIA V5
- **Languages:** English (fluent), Mandarin (native)

Honors

- **2nd prize,** AUTODRIVE CHALLENGE II Detection competition Jun. 2022
- **Dean's List,** Mechanical Engineering, PSU Aug. 2018 - May. 2022
- **Multi-Campus Research Experience Scholarship for Undergraduates**, PSU Jun. 2021 - Aug. 2021
- **1st prize in 1v1, 3st prize in 3v3 confrontation,** RoboMaster University League 2021 Jun. 2021