

# Ruihan Xu (Multy)

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## EDUCATION

### University of Michigan – Ann Arbor

Bachelor of Science in Computer Science Honor Degree, Mathematics Minor

GPA: 4.0/4.0

#### Course Highlights:

*Graduate level:* Self-Driving Vehicle, Mobile Robotics, Continuous Optimization Methods, Human-Robot Interaction

*Undergraduate level:* Machine Learning, Computer Vision, Autonomous Robot, Large Language Models

Ann Arbor, MI

Dec 2024

## PUBLICATIONS

[1] Joey Wilson\*, **Ruihan Xu\***, Yile Sun, Parker Ewen, Minghan Zhu, Kira Barton, Maani Ghaffari, Latent BKI: Open-Dictionary Continuous Mapping in Visual-Language Latent Spaces with Quantifiable Uncertainty, *IEEE Robotics and Automation Letter (RA-L)*, 2024, In Submission.

[2] Jana Pavlasek, Joshua Jin Zhi Mah, **Ruihan Xu**, Odest Chadwicke Jenkins, Fabio Ramos, Stein Variational Belief Propagation for Multi-Robot Coordination, *IEEE Robotics and Automation Letter (RA-L)*, 2023.

## REFEERED WORKSHOP PAPERS

[1] **Ruihan Xu**, Anthony Opipari, Joshua Jin Zhi Mah, Stanley Lewis, Haoran Zhang, Hanzhe Guo, Odest Chadwicke Jenkins, Single View 3D-Reconstruction via SO(2)-Equivariant Gaussian Sculpting Networks, *Robotics: Science and Systems Workshop on Geometric and Algebraic Structure for Robot Learning (RSS @ GAS)*, 2024.

## RESEARCH EXPERIENCE

### Computational Autonomy and Robotics Laboratory (CURLY) – University of Michigan

Research Assistant

Supervised by Dr. Maani Ghaffari

#### Latent Spatting: Open-Dictionary Gaussian Splat Map with Quantifiable Uncertainty

- Advanced the mapping with ideas from two of my previous work to create better representation
- Integrated Latent BKI with Gaussian Splatting to achieve fast training with a map with open-dictionary query ability and uncertainty

#### Latent BKI: Open-Dictionary Continuous Mapping in Visual-Language Latent Spaces with Quantifiable Uncertainty [[arXiv](#)]

- Designed and implemented the Latent Bayesian Kernel Inference algorithm for latent map update.
- Constructed and tested method to quantify uncertainty in the latent space using sampling, D-optimality, E-optimality.
- Demonstrated real world usage using iPad and constructed real world map of an indoor environment.
- Applied open-dictionary query in real world map to find anything matched with description

### Laboratory for PROGRESS (L4P) – University of Michigan

Research Assistant

Supervised by Dr. Chad Jenkins

#### Single-View 3D Reconstruction via SO(2)-Equivariant Gaussian Sculpting Networks [[arXiv](#)][[video](#)]

- Designed and implemented Gaussian Sculpting Network (GSN) with ResNet backbone and multi-layer perceptron.
- Constructed new Extended Chamfer Distance suitable for loss calculation between Gaussian Splats to ensure equivariance.
- Applied GSN to Robot simulation using PyBullet to test applicability of network in robot manipulation tasks.
- GSN achieve comparable performance in visual quality and faster inference speed compared to the SOTA model.

#### Stein Variational Belief Propagation for Multi-Robot Coordination [[arXiv](#)][[video](#)][[Website](#)]

- Facilitated the creation of a message passing method (MBot Bridge) between robots (MBot) using WebSocket allowing the robot to sequentially update their message/belief for other robots.
- Devised an MPC-style velocity controller for the robot to follow the trajectory published in MBot Bridge to realize Stein Variational Belief Propagation (SVBP) developed in simulation.
- Conducted real-world experiment with 3 MBots in 4 different designed environments with obstacles to test SVBP algorithm and record 30 experiment videos for performance analysis.

#### SURE (Summer Undergraduate Research Experience) – MBot Development [[arXiv](#)]

- Developed a new image recognition function using OpenCV with an improved computer vision algorithm to extract shapes from sticky notes, being used for a project for an undergraduate robotics course.
- Fixed message-passing issue in LCM to let SLAM and autonomous navigation algorithm adapt to the new robot firmware.
- Created testing script in C for new robot firmware to calibrate odometry, lidar reading, and PID control.

### Horizon Lab – University of Rochester

Summer Research Assistant

Supervised by Dr. Yuhao Zhu

#### Multispectral Imaging Processing on Culture Heritage

- Mastered the math of SVD (Singular Value Decomposition), PCA (Principal Component Analysis), and linear regression with a focus and application on training image recognition and reconstruction using MATLAB.
- Designed an algorithm to sample images under light with multiple spectrums and reconstruct the material reflectance spectrum to reveal the hidden detail that cannot be seen by the human eye by applying SVD, and PCA.

Rochester, NY

May 2022 – Aug 2022

## HONORS AND AWARDS

James B. Angell Scholar, <i>Academic Merit</i>	Mar 2024
University Honors, <i>Academic Merit</i>	Dec 2022, Apr 2023, Dec 2023
Phi Kappa Phi, <i>National Honor Society</i>	Nov 2023
Phi Beta Kappa O'Brien Book Award (Top 15 students in freshman year), <i>Academic Merit</i>	Apr 2022
Dean's list, <i>Academic Merit</i>	Dec 2020, Apr 2021, Dec 2021, Apr 2022
Davis UWC Scholarship, <i>Academic Scholarship</i>	Sep 2020, Feb 2021, Sep 2021, Feb 2022

## TEACHING EXPERIENCE

### University of Michigan - Robotics Department Ann Arbor, MI

Rob 330 Localization, Mapping, and Navigation

*Instructional Aide*

Aug 2024 – Present

- Written comprehensive MBot setup and use instructions for student to easily use NoMachine, VSCdoe with MBots.
- Explained difficult concept by filling the concept that was not in lecture slides, such as particle filter, action noise, to students in office hour.
- Supported students with difficulty in implementing algorithm by breaking down algorithm with easy-to-understand pseudocode during lecture and lab section.
- Provided debugging tips, programing tips, and MBot common issue suggestions on Piazza to help student identify potential problem in their code implementation.

Rob 102 Introduction to AI & Programming

*Instructional Aide*

Aug 2023 – Dec 2023

- Created modified course projects, particularly the MBot project for autonomous navigation with computer vision algorithms.
- Facilitated Lab session each week by teaching project specific programming skills and providing help to students with difficulties

## PROJECT EXPERIENCE

### University of Michigan Ann Arbor, MI

UMDrive: Towards Robust and Safe SLAM on Real-World Scenarios – ROB 530 Mobile Robotics

Mar 2024 – May 2024

- Created real-world outdoor video dataset with various weather condition, camera poses reconstructed by SFM (structure from motion) using Colmap
- Evaluate several state-of-the-art visual SLAM models for in-door 3D reconstruction on outdoor dataset augmented with noise.

Monocular Camera 3D Object Detection for Autonomous Vehicle – ROB 535 Self-Driving Vehicle

Oct 2023 – Dec 2023

- Finetuned the 3D detection model based on MonoCon and adopted data augmentation for images presented in foggy environment.
- Produced 4 pages of CVPR paper format report with detail comparison and analysis with other similar detection model.

Human-Object Interaction (HOI) Detection – EECS 442 Computer Vision

Oct 2023 – Dec 2023

- Led team of 4 to create a neural network that detect possible interaction between human and object in an image.
- Devised the PyTorch dataloader for the VCOCO data set for training.
- Implemented and fine-tuned the neural network pipeline using YOLOv8 with additional convolutional layers, and Multi-layer Perceptron (MLP).

A Review for Human-Robot Handover – ROB 599 Human-Robot Interaction

Aug 2023 – Dec 2023

- Produced 8 pages IEEE conference paper format review paper by reviewing more than 40 papers on Human-Robot Handover problem.
- Devised a toy example using neural network to detect human handover action.
- Idea been adopted as a formal research project by the professor.

## LEADERSHIP

### Blue Record Student Band Group

*E-board Member*

May 2023– Present

- Led team of 20 to form bands to perform at major university shows, and organized practice sessions, workshop, recording sessions.
- Organized large event “Blue Record Music Festival” with 250 attendances and over 50 performers.

### First Robotics Competition (FRC) - Team 7280 MITO-Octopus

*Software Team Leader*

Dec 2017 – Aug 2021

- As Co-founder, vice president, programming lead (Team 6394 & 7280), train new members.
- Programmed computer vision for object detection for robot automation in grabbing, ball shooting, motion planning using raspberry Pi, Java, Python and OpenCV.

## TECHNICAL SKILLS

<i>Programming Skills:</i>	Experienced with: Python (Pytorch, Numpy, Pandas, OpenCV), C++/C (Eigen), MATLAB, CUDA, Java, Conda, Docker.
<i>Machine Learning:</i>	PyTorch, OpenCV, experienced with Vision Language Models, Convolutions, MLPs, Tranformers
<i>Robotics Skills:</i>	ROS, Gazebo, Pybullet, Meta AI Habitat, MPC, vehicle dynamics, trajectory optimization with CasADI in Python
<i>Web development:</i>	PHP, MYSQL, Script, Python, HTML, CSS