

Zhihao Ruan

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EDUCATION

University of Pennsylvania

Philadelphia, PA

- *Master of Science in Engineering in Robotics, GPA: 4.0/4.0*

May 2022

General Robotics, Automation, Sensing & Perception (GRASP) Laboratory

- **Selected Coursework:** Modern Convex Optimization, Reinforcement Learning, Advanced Topics in Machine Perception, Interactive Computer Graphics

University of Michigan

Ann Arbor, MI

- *Bachelor of Science in Computer Science Engineering, GPA: 3.9/4.0*

Sept 2018 – May 2020

College of Engineering

- **Selected Coursework:** Embedded Systems Design (grader), Machine Learning (grader), Computer Vision, Autonomous Robotics, GPU Programming & Architecture, Operating Systems

Shanghai Jiao Tong University

Shanghai, China

- *Bachelor of Science in Electrical and Computer Engineering, GPA: 3.6/4.0*

Sept 2016 – Aug 2020

University of Michigan-Shanghai Jiao Tong University Joint Institute (UM-SJTU Joint Institute)

- **Selected Coursework:** Electromagnetics, Signals and Systems, Analog Circuits, Semiconductor Devices

SCHOLARSHIP AND HONORS

James B. Angell Scholar

Mar 2020

University of Michigan Honors

Dec 2018, May 2019, Dec 2019

University of Michigan "Dean's List"

Dec 2018, Apr 2019, Dec 2019

SJTU Undergraduate Excellent Scholarship

June 2017, June 2018

UM-SJTU Joint Institute "Dean's List"

June 2017, Dec 2017, June 2018

"Honorable Mention" of 2017 Interdisciplinary Contest in Modeling

Apr 2017

WORK EXPERIENCE

TuSimple, Inc.

Philadelphia, PA (Remote)

Planning & Prediction Research Engineer Internship

May 2021 – Present

- Developed motion planning software & algorithms for autonomous trucks.

RESEARCH EXPERIENCE

F1/10 Autonomous Racing Group, Real-Time & Embedded Systems Lab (mLab)

Philadelphia, PA

CAD2CAV: Computer Aided Design for Cooperative Autonomous Vehicles

Feb 2021 – Present

- Built a 3D building model rendering pipeline in **Unreal Engine 4** for 2D AutoCAD floor plans.
- Wrote graph-based multi-agent path planner in ROS (Robotics Operating System) & C++ with **Ant Colony Optimization solver for Capacitated Vehicle Routing Problem, Spectral Clustering, and k -Way Graph Partitioning**.
- Implemented **FMT*** for real-time obstacle avoidance and **Pure Pursuit** as the controller for F1/10 autonomous racing vehicles.
- Applied **Cartographer SLAM** and **on-board Tiny-YOLO v4 object detection** on F1/10 autonomous racing vehicles.

Interactive Sensing and Computing (ISC) Lab

Ann Arbor, MI

Research Assistant of Prof. Alanson Sample, Synthetic Health Sensor

Jan 2019 – Dec 2019

- Built an embedded system in **C & MATLAB** with **STM32** microprocessor and Panasonic's GridEye[®] 8 × 8 IR sensor through **I²C & UART** that can collect, detect and visualize heat distribution in the room.
- Constructed **a complete C API** for Panasonic's GridEye[®] 8 × 8 IR sensor for **STM32** microprocessor from scratch.
- Implemented **Direct Digital Synthesis (DDS) in C** of a frequency-sweep ultrasonic sine wave from 39kHz to 41kHz with STM32 microprocessor and ultrasonic transducers.
- Designed two different ultrasound distance measurement algorithms in **Python** including **FMCW (Frequency-Modulated Continuous Wave) algorithm** and **phase-based ranging algorithm** with STM32 microprocessor.

SOCIAL WORK EXPERIENCE

- **Student's Union, UM-SJTU Joint Institute of Shanghai Jiao Tong University** Shanghai, China
Aug 2017 – Jul 2018
Deputy Director of Media Department & Lead of Photography Team
 - Took pictures & report all student's events at institute's official social media platforms.
 - Arranged team building events for Media Department.
- **Center for Learning & Teaching, UM-SJTU Joint Institute of Shanghai Jiao Tong University** Shanghai, China
Mar 2018 – May 2018
Teaching Assistant for VY 200: Academic Writing II
 - Assisted professor on homework & quizzes grading, in-class activities organization.
 - Held office hours & provided instructions for writing academic essays.

PROJECT EXPERIENCE

- **Minimum-Snap Trajectory Generation and Control for Quadrotors** Philadelphia, PA
April 2021 – May 2021
ESE 650: Learning in Robotics, Univ. of Pennsylvania
 - Planned quadrotor trajectory in densely cluttered environments with **A*/Dijkstra's Algorithm**.
 - Formulated minimum-snap trajectory smoothing algorithm into a **Quadratic Programming (QP) problem** with CVXPY.
 - Designed **Constrained Gradient Descent solver** to optimize time duration for each min-snap trajectory segment.
 - Analyzed quadrotor dynamics and developed **Non-linear Geometric Controller** for quadrotors.
- **Mini Minecraft in C++** Philadelphia, PA
Nov 2020 – Dec 2020
CIS 560: Interactive Computer Graphics, Univ. of Pennsylvania
 - Achieved mesh rendering with **interleaved Vertex Buffer Object (VBO)** data in Qt and OpenGL and applied **CPU parallel optimization**.
 - Created **procedural weather** effect in GLSL shader program, **L-system** river generation, **procedural terrain** generation with **Perlin Noise** and terrain smoothing with **Fractal Brownian Motion (FBM)**.
 - Implemented mesh collision checking with **ray tracing** and **3D grid marching**.
 - Created and implemented **animated texturing** for “grass,” “dirt,” “stone,” “ice,” “water,” “lava,” etc.
 - Developed **redstone texturing & redstone circuit logic**; supports “redstone wire,” “power lever,” “redstone torch”.
- **Deep Neural Network Implementation for Machine Perception** Philadelphia, PA
Sept 2020 – Dec 2020
CIS 680: Advanced Topics in Machine Perception, Univ. of Pennsylvania
 - Implemented **YOLO v1** for object detection in **PyTorch**, featuring anchor-based detection & **Non-Max Suppression (NMS)**.
 - Implemented **SOLO** for instance segmentation, using **ResNet50 FPN** as backbone and **MatrixNMS**.
 - Implemented **Regional Proposal Network (RPN)** and **FasterRCNN** object detection head using ResNet50 FPN as backbone, featuring **ROI Pooling**, reaching an **mAP of 0.581**.
 - Implemented multiple GAN architectures including **Variational Auto-Encoders (VAE)**, **DC-GAN**, **CycleGAN**, **BicycleGAN**. Achieved **Fréchet Inception Distance (FID)** score of 70.87 on CycleGAN and 76.82 on BicycleGAN.
- **Computer Graphics Development with OpenGL** Philadelphia, PA
Sept 2020 – Nov 2020
CIS 560: Interactive Computer Graphics, Univ. of Pennsylvania
 - Implemented **3D mesh rasterization** with provided mesh file in **Qt 5.15** and **OpenGL**, integrated with **scene graphs**, with polar spherical camera model, perspective-correct **barycentric interpolation**, texture mapping, Lambertian reflection, and custom-scale **anti-aliasing**.
 - Designed various shaders in **GLSL** including **Blinn-Phong reflection** shader, **Worley noise** shader, Gaussian blur shader, and **Matcap** shader.
 - Built an deformable/editable mesh with **Half-edge mesh structure**, featuring a Maya-like application interface with Qt and **Catmull-Clark surface subdivision**.
- **Real-Time On-Device Flow Statistics Detection and Prediction** Shanghai, China
June 2020 – Aug 2020
Undergraduate Major Design Experience, UM-SJTU Joint Institute
 - Built a system in **Python** which detects human traffic flow, automatically analyzes & detects entrances on **Raspberry Pi 4B**, stores data on a server, visualizes analyzed data on a self-designed front-end website **in real time** (~ 15 FPS with Google Coral Edge TPU USB accelerator).
 - Achieved **20 FPS and 90% accuracy** object tracking & people counting with **self-designed Kalman filter tracker**, automatic entrance detection with density-based clustering algorithm — **DBSCAN** in Python.

- **Linux Infrastructure Implementation on x86 PCs** Ann Arbor, MI
EECS 482: Introduction to Operating Systems, Univ. of Michigan Jan 2020 – Apr 2020

 - Implemented mutex, conditional variables & thread class using context switching API in **Linux kernel library** with multiprocessor support provided using **interrupt handling** and **CPU guard** in C++.
 - Built Unix pager with swap-backed & file-backed pages with **page fault handling** and **process switching & forking** support in C++.
 - Emulated Unix-style file system using inode and directory entry structures with client request handling using **Berkeley sockets** and safe concurrency using **C++ Boost library**.

- **MXNet Optimization with GPU** Ann Arbor, MI
EECS 498: GPU Programming & Architecture, Univ. of Michigan Nov 2019 – Dec 2019

 - Implemented GPU parallelization of forward kernel of MXNet incubator 1.3.x with **tiled matrix multiplication** and **GPU shared memory**; boosted inference speed **from 30s to < 3s** on fashion-mnist dataset and Nvidia TITAN Xp graphics card.

- **DOAPP: Dynamic Object Avoidance and Path Planning** Ann Arbor, MI
Undergraduate Major Design Experience, Univ. of Michigan Oct 2019 – Dec 2019

 - Implemented a **GPU-accelerated motion planning algorithm** originally proposed by Chonhyon Park, et al. in **ROS C++ & CUDA** with Nvidia GPU parallel programming & optimization that could perform **real-time obstacle avoidance**.
 - Built a controller and trajectory follower in **ROS C++** for Dynamixel motors on robot arm from scratch and achieved **30 Hz signal transmission**.

- **Robotics Algorithm Development in LCM** Ann Arbor, MI
EECS 467: Autonomous Robotics, Univ. of Michigan Sept 2019 – Oct 2019

 - Implemented a SLAM algorithm in C++ with **occupancy grid mapping, particle filter localization, A* path planning**. Entire system run on a mobile robot with Raspberry Pi 3 and LiDAR.
 - Implemented robot manipulation algorithms in Python including **Forward Kinematics, Inverse Kinematics (based on Geometry)**. Entire system run on a mobile robot with robot arm that could localize & pick up a block using AprilTag automatically.

- **Cost-Function Prediction Market Simulation with Bayesian Traders** Ann Arbor, MI
ML Research Paper Reading Group of Prof. Sindhu Kutty, University of Michigan May 2019 – Aug 2019

 - Simulated **cost-function based prediction market** mechanism in **Python**, with its performance evaluated and compared with traditional machine learning algorithms.
 - Reconstructed exponential-family prediction markets in different probability distributions **mathematically**.

- **Interactive Game: Step on White Tiles** Ann Arbor, MI
EECS 373: Introduction to Embedded Systems Design, Univ. of Michigan Mar 2019 – Apr 2019

 - Visualized black & white tiles flow by driving a projector with **FPGA** by programming **VGA protocols in Verilog**.
 - Decoded signals from Nintendo controller in Verilog.
 - Built **a complete menu selection user interface in C** on an LCD display with SmartFusion[®] microprocessor and Nintendo controller.
 - Achieved stepping detection on projected tiles through **SPI protocol in C** with Pixy[®] camera.
 - Enabled sound effects using SmartFusion[®] microprocessor, Adafruit[®] Audio Sound Board and Dell[®] stereos in Verilog.

SKILLS

Programming Languages: C/C++, Python, MATLAB, Verilog.

Development Tools: CVXPY, STM32CubeMX, OpenCV, PyTorch, Scikit-Learn, LCM (Lightweight Communications and Marshalling), ROS (Robotics Operating System), CUDA