RONGXUAN ZHOU

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RESEARCH INTERESTS

I study how physical priors — contact mechanics, safety constraints, and multi-modal sensing — should serve as structural elements in learning-based robot control rather than peripheral inputs. My academic work addresses multi-modal fusion pathologies in learned manipulation policies and formal safety integration in generative action planning. My industry experience grounds this in real-time manipulator control, full-stack autonomous platform development, and production-scale optical inspection. This dual foundation — learning-theoretic rigor and deployment engineering — defines my approach to robot autonomy that is both performant and physically realizable.

EDUCATION

Northeastern University, Boston, MA Sep 2024 — May 2026

M.S. in Robotics, Electrical and Computer Engineering — Advisor: Prof. Gilbert Yang Ye

Northeastern University, Shenyang, China Sep 2020 — Jun 2024

B.E. in Mechanical Engineering and Automation

– Thesis: "Design of Mobile Spraying Robot" — Full kinematic modeling, Jacobian analysis, and workspace validation

– T-DT Innovation Lab: Leader of mechanical design; First Prize, 2021 RoboMaster University Championship

PUBLICATIONS & MANUSCRIPTS

In Submission / Preparation

[1] **R. Zhou** and G. Y. Ye, "Is Your Policy Actually Using Touch? Diagnosing Modality Suppression in Tactile-Conditioned Transformers," in preparation, target: CoRL 2026.

[2] **R. Zhou** and G. Y. Ye, "Train Safe, Infer Fast: Integrating Control Barriers into Diffusion Policy Learning," under review, IEEE Robotics and Automation Letters (RA-L).

Published

[3] L. Sun, **R. Zhou**, G. Li, J. Li, and P. Mitrouchev, "Simulation Research on Residual Stress of Swage Autofrettage-processed High-Pressure Cylinder," J. Phys.: Conf. Ser., vol. 2587, 012088, 2023. (EI Indexed)

Related Contribution (Not Co-Author)

[4] W. Xi, J. Guo, C. Wang, S. Wu, and J. He, "A Robust Distributed Odometry for Mobile Robots with Steerable Wheels," IEEE/RSJ Int. Conf. Intell. Robots Syst. (IROS), Hangzhou, 2025. (Lead designer of the mechanical architecture and simulation environment)

RESEARCH EXPERIENCE

Graduate Research Assistant — Northeastern University Feb 2025 — Present

Boston, MA — Advisor: Prof. Gilbert Yang Ye

– SPINE: Multi-Modal Transformer Attention Suppression Diagnosis & Repair

· Discovered that standard Transformer self-attention systematically suppresses weak auxiliary modalities (physics/tactile tokens) in robot manipulation policies, with attention mass below uniform baseline (3.4–4.7% vs 5.26%) and gradient ratio reaching 17.5× between dominant and auxiliary encoders

· Demonstrated that gradient-level fixes (OGM-GE) fail to resolve attention-level suppression, localizing the root cause to Q/K competition within self-attention

· Proposed and validated explicit bypass architectures (FiLM, CrossAttn) that restore functional modality utilization (IG contact/non-contact ratio 3.0–3.7× vs ≈1× for concatenation)

· Behavioral stress tests show physics-utilizing policies degrade gracefully under vision corruption (97%→70% SR) while suppressed policies fail consistently (33%→20%), with non-overlapping 95% CIs at all noise levels

– LSDP: CBF-Informed Safe Diffusion Policy

· Proposed a three-stage pipeline embedding Control Barrier Function (CBF) information into diffusion policy training via exponential-weighted loss with Tweedie-predicted clean trajectories, enabling standard DDIM inference (no per-step safety correction) with a lightweight CBF-QP filter as execution-time safety net

· Achieved 27× inference speedup over SafeDiffuser while simultaneously improving success rate (80.3%→100%) and reducing violation rate (43.1%→34.0%) on safety-critical insertion tasks

· Gradient decomposition theorem shows LSDP gradient = standard denoising gradient + spatial guidance term pointing away from constraint boundaries

· Developed a 4-level task taxonomy (training-indistinguishable / geometry-forced / safety-critical / unsolved) characterizing when CBF-informed training provides value

Research Assistant — Shanghai Jiao Tong University, IWIN-FINS Lab Jun 2022 — Aug 2024

Shanghai, China — Advisor: Prof. Jianping He

– Fines Full-Stack Robotic Platform Design

· Participated in designing the hardware architecture: Host-Embedded co-control system (Master MCU + Intel NUC + Watchdog MCU) balancing computational throughput with real-time determinism

· Participated in developing FineMote embedded control framework: C++ template-based device abstraction with automatic registration, CAN/RS485/I2C bus management, and 1 ms timer-triggered state propagation

· Participated in building FineVision perception pipeline: camera intrinsic/extrinsic calibration, distortion correction, homography-based bird's-eye-view generation, Hough circle detection for object localization

· Designed FineManip 6-DOF robotic arm: Pieper-condition closed-form IK, full-workspace joint torque statistical verification, MoveIt! motion planning integration

· Integrated multi-modal perception: Point-LIO LiDAR odometry, temporal-spatial sensor calibration, UWB indoor positioning

· Platform directly enabled experimental validation for the IROS 2025 distributed odometry paper

– AGV-Manipulator Coordination System

· Developed real-time multi-threaded architecture achieving 15 ms pose synchronization between UR5e and AGV chassis via ROS2 Cyclone DDS on Intel i7-NUC

· Built perception pipeline integrating YOLOv8-ORT with enhanced ICP registration, achieving 93% obstacle avoidance with ≥8 dynamic obstacles/m² per ISO 13849 PLc

– Air-Ground Cooperative Transport System

· Designed hybrid RRT*+APF planner completing dynamic obstacle trajectory prediction within 5 ms cycles; validated in Gazebo + hardware-in-the-loop simulation

· Built distributed middleware using ZeroMQ + Protobuf achieving ≤35 ms end-to-end latency in 1 km LoRa field tests

· Migrated Gazebo-simulated MPC controller to PX4 HIL system, achieving outdoor hovering RMSE 0.15 m

Research Assistant — Shanghai University Jun 2022 — Apr 2023

Key Lab of Intelligent Manufacturing and Robotics — Advisor: Prof. Guiqin Li

– Constructed FEA simulation models in ANSYS Workbench and ABAQUS implementing Bauschinger effect in swage autofrettage processes, achieving simulation accuracy within 5% of experimental data

– Optimized 12 mandrel configurations via SolidWorks modeling, increasing cylinder inner wall compressive stress by 23% and fatigue life by 40%

– Developed residual stress evaluation methodology using LabVIEW data acquisition and Arduino-controlled testing platforms

INDUSTRY EXPERIENCE

Automation Engineer — Dinnar Automation Technology Co., Ltd. Apr 2025 — Dec 2025

San Jose, CA — Full-time

– CSE Round Lighting Check & FI AOI Inspection System for Texas Instruments

· Independently designed 4-CCD multi-angle visual inspection system (top/side/bottom/inner check) detecting 19 defect categories across functional, cosmetic, and assembly defect types for TI semiconductor CSE (Chip Scale Element) products with 100% detection rate

· Completed full mechanical design of inspection equipment (1800×1600×2000 mm) with 18-step automated process flow: basket feeding → pitch change → multi-station transfer → 4-CCD inspection → orientation compensation → NG sorting

· Achieved production throughput >85K units/day; designed vision system deployment with 4× MV-GE501GC industrial cameras at 0.0115 mm/pixel resolution

R&D Intern, Department of Industrial Intelligence — CloudMinds Technology Dec 2023 — Apr 2024

Shanghai, China

– Industrial Manipulator Real-Time Communication

· Developed EtherCAT master module enabling 1 kHz synchronous sampling for 6-axis F/T sensors, reducing joint control cycle from 20 ms to 12 ms with CiA402 conformance

· Refactored PLC logic using IEC 61131-3 Structured Text on CODESYS V3.5, achieving ±0.03 mm trajectory repeatability per ISO 9283

– Flexible Grasping Control

· Implemented data-driven impedance controller replacing Hogan model at 400 Hz on UR5e with 42% vibration reduction; validated through 72-hour aging test
· Developed OPC UA gateway bridging ROS2 with Siemens S7-1500 PLC, command transmission jitter ≤ ±2 ms
– Standardized Robotic Assembly Workstation Design
· Designed modular workstation solution for OP-8 assembly line (5 stations): C-shaped material racks with handling robot, flexible rotary table (6-8 index plates × 3-4 sub-plates = 18-32 fixture positions), 4-axis process robots
· Integrated Siemens SICAR automation standard: HMI visualization, recipe-based product changeover, standardized PLC programming across production lines

Autonomous Driving ML Intern — NIO Inc. Jul 2023 — Oct 2023
Shanghai, China
– Built GAN-based CAN FD signal synthesizer in PyTorch generating 5× augmented training data with Gaussian noise injection and protocol fault simulation, improving ECU test coverage by 35%
– Implemented gradient reversal layers for CARLA → NIO ET5 sim-to-real feature alignment, reducing lateral error by 37% in production vehicle field tests

SELECTED PROJECTS

MuJoCo MCP Server — AI-Driven Robotics Simulation
– Built 65-tool MCP server exposing MuJoCo physics simulation to Claude Code and AI assistants via natural language; supports multi-slot simulation management, contact mechanics analysis, and visualization export (MP4/GIF)
– Implemented trajectory optimization (iLQR, MPPI), inverse kinematics, workspace mapping, domain randomization, and Gymnasium-compatible RL environment integration for 50+ robots from MuJoCo Menagerie

LiDAR-Inertial SLAM Benchmarking (FAST-LIO vs. LIO-SAM)
– Collected real-world driving datasets with Northeastern's NUance platform; benchmarked FAST-LIO vs. LIO-SAM for loop closure and 3D mapping accuracy; integrated FAST-LIO-LC for drift correction

Hybrid Retrieval System for Social Media Short Text
– BM25 + fine-tuned SBERT with FAISS HNSW indexing; MRR@10 = 0.7264 on MS MARCO benchmark

TECHNICAL SKILLS

Programming: Python, C/C++, MATLAB, JavaScript, Git, CI/CD, Docker, Linux
Robotics & Control: ROS2, MuJoCo, Isaac Sim, MPC, Control Barrier Functions, Drake, CasADi, Franka, UR, ABB robots
ML / DL: PyTorch, Transformers, Diffusion Models, CUDA, Reinforcement Learning, Imitation Learning
Hardware & CAD: SolidWorks, ANSYS, ABAQUS, COMSOL, LabVIEW, STM32, Jetson, EtherCAT, OPC UA
Vision & Perception: Multi-camera calibration, AOI system design, LiDAR odometry, Point-LIO, YOLOv8

HONORS & AWARDS

– First Prize, 2021 RoboMaster University Championship — T-DT Innovation Lab, Leader of Mechanical Design
– Excellent Results, Shanghai College Students Engineering Practice and Innovation Ability Competition — Led AGV-manipulator platform design at SJTU IWIN-FINS Lab