ACADEMIC PORTFOLIO · 2026

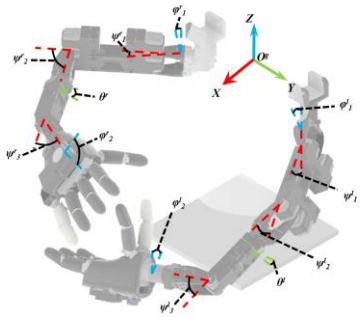
MINGYU LI · 李明宇

Tongji University · School of Mechanical Engineering

Personal Web: mingyuli.com

Bridging the Sim-to-Real Gap in Embodied AI

Hardware-Software Co-Design
for Dexterous Robotic Manipulation
at the Edge



Embodied Intelligence · Embedded Systems · Computer Vision

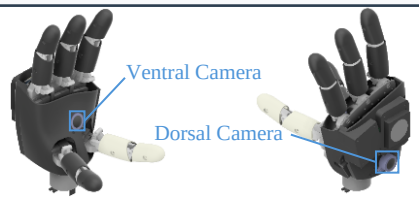
PROJECT I – PART A

Dual-Vision Infinite-Roll Hand

Hardware Architecture: Solving Two Physical Bottlenecks at Once

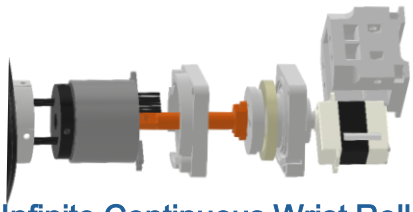
CORE INNOVATION

Conventional robotic grippers face two critical physical bottlenecks in semi-structured environments: rearward perception blind spots and kinematic deadlocks caused by bounded wrist rotation. I addressed both simultaneously through minimalist electromechanical co-design.



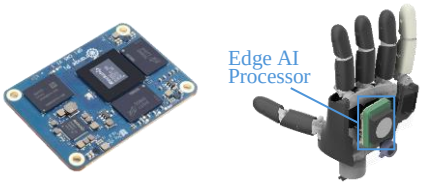
Dual-Camera Relay Perception

Dual SC233HGS sensors form a front-rear relay, eliminating blind spots purely via ego-vision.



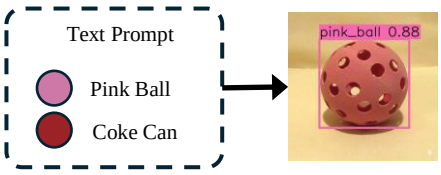
Infinite Continuous Wrist Roll

A conductive slip-ring decouples power and data, enabling unbounded rotation to prevent kinematic deadlocks.



Edge-Native Platform

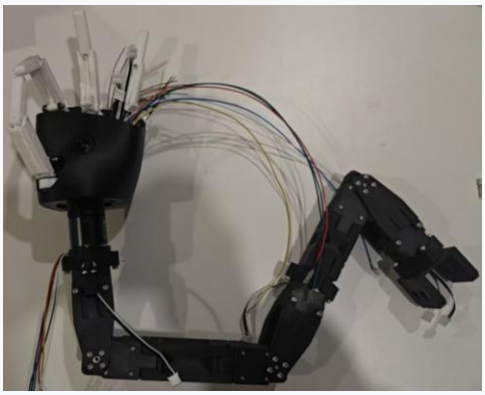
The entire pipeline runs locally on a sub-10W RK3588 NPU for high-frequency closed-loop control.



Language-Guided Grasping

A re-parameterized Vision-Language model maps natural commands to targets, achieving zero-shot open-vocabulary dexterity.

HARDWARE SYSTEM LAYOUT



Bridging the sim-to-real gap requires physical validation. By building this fully integrated prototype from scratch, it proves that solving kinematic bottlenecks at the physical layer is the ultimate prerequisite for deploying robust Embodied AI on edge devices.

Related systematic design and physical evaluation have been accepted by IEEE/ASME ICARM 2026 (First & Corresponding Author).

PROJECT I – PART B

Edge-Native Perception Pipeline

From Zero-shot Detection to Real-Time Grasp Execution

INFERENCE PIPELINE

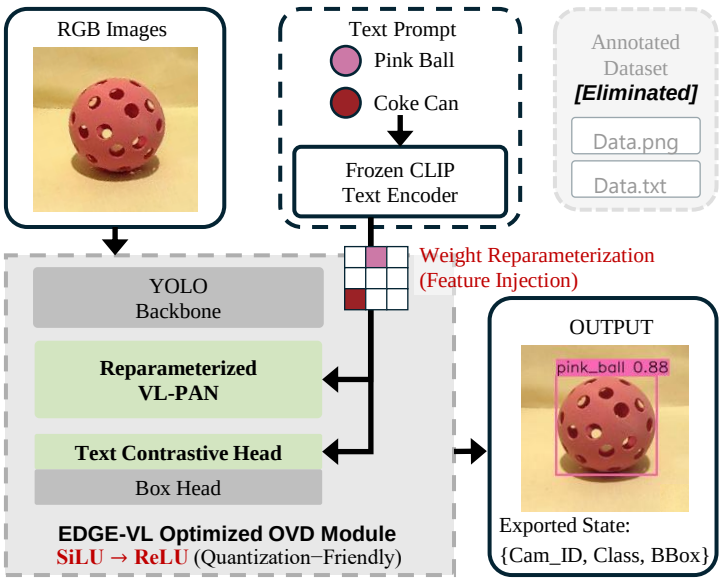
To achieve real-time closed-loop grasping, the entire Vision-Language pipeline is structurally optimized and deployed strictly locally on a resource-constrained NPU, achieving zero cloud dependency.

Dual Camera
SC233HGS Sensors
→ **Visual Encoder**
CNN Feature Extractor
→ **Offline Text Reparameterization**
Pre-Computed
→ **Zero-Shot Detection Head**
YOLO-World
(int8 Quantization)
→ **Grasp Planning**
Task-Prior Driven
→ **Execute Grasp**
Sub-10W RK3588

▲ All stages run entirely on the edge processor – no cloud offloading, no task-specific fine-tuning

KEY TECHNICAL DECISIONS

- **Offline Reparameterization:** Pre-computing text embeddings removes the heavy text encoder from the online inference graph, fundamentally eliminating the compute bottleneck on edge devices.
- **INT8 Quantization & NPU Deployment:** The entire Vision-Language model is quantized to INT8 and compiled directly onto the RK3588 NPU, achieving a stable **16.3 FPS** end-to-end inference speed.
- **Dual-Stream Real-Time Fusion:** Seamlessly synchronizes and processes high-frequency video streams from both dorsal and ventral sensors, enabling smooth target hand-offs between forward and rearward workspaces.



16.3FPS
Dual-Stream End-to-End Inference Speed

INT8
Zero-Shot Model Quantization

<10W
Total Edge NPU Power Consumption

PROJECT II

Precision Robotic Arm Grasping

Intelligent Vehicle Lab · 2024 ~ 2026

SYSTEM INTEGRATION

Developed a complete robotic arm grasping system under 2D-camera and embedding-system constraints. The project emphasized practical deployment: limited sensing, limited computation, yet reliable real-world performance.

HARDWARE-SOFTWARE SYNERGY

Hybrid Perception (2D + IR): Overcame the lack of spatial depth by fusing 2D camera data with an IR sensor for precise 5–10 mm hovering, driving sub-millimeter X/Y visual servoing.

Anti-Drift & Non-Destructive Actuation: Upgraded to a multi-layer corrugated vacuum suction cup to eliminate material deformation. Integrated magnetic encoders on the Z/Y axes to establish an absolute zero-reference, successfully solving open-loop cumulative drift.

Jetson Edge Deployment: Executed full 3D kinematic modeling, physical assembly, and ported the optimized vision-servo pipeline onto a Jetson embedded board for millisecond-level response.

2nd	2D	1x
NATIONAL INTELLIGENT VEHICLE COMPETITION PRIZE	CAMERA-ONLY PERCEPTION (NO DEPTH SENSOR)	EMBEDDED BOARD (NO EXTERNAL GPU)

PROJECT III

Cross-Domain Edge-AI Snake Robot

Vision4Robotics Lab · 2025 ~ Present · Exhibited at CIIF Shanghai

PROJECT OVERVIEW

Designed to address practical deployment challenges of high-DoF snake robots, including structural reliability and edge computing limits. By integrating a modular composite skeleton with a RISC-V edge processor, the platform achieves robust multi-terrain adaptability across land, water, and vertical environments.

MORPHOLOGY & SYSTEM DESIGN

Modular Composite Architecture: Led the 3D modeling and structural design of the head-joint-tail modules using a composite-metal skeleton, balancing high rigidity with rapid on-site field reconfiguration.

High-Density Hardware Layout: Engineered the internal joint topology to tightly integrate serial bus servos, inter-module communication channels, and a 40×40mm RISC-V edge SoC.

Physical Foundation for Edge-AI: The optimized joint geometry resolved kinematic deadlocks, enabling the onboard NPU to execute complex Snake-RL gaits and 6D pose estimation within strict physical constraints.

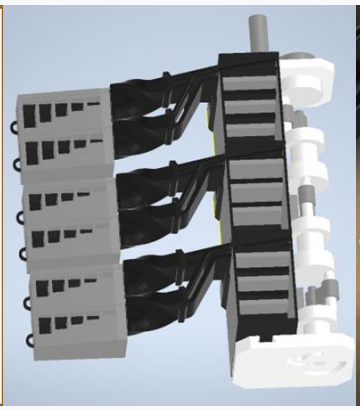
PROJECT IV

Advanced Mechanical Design

National First Prize · Product Information Modeling & Additive Manufacturing

COMPETITION EXCELLENCE

Won **National First Prize** in the "Higher Education Cup" -- China's premier competition for advanced engineering graphics and product information modeling (Additive Manufacturing Track, July 2025).




CORE MECHANICAL COMPETENCIES & DESIGN FOR ADDITIVE MANUFACTURING

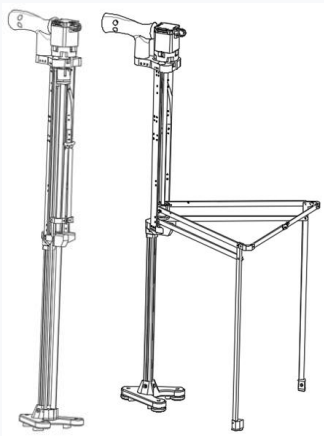
Parametric Modeling & Complex Assemblies: Utilized Autodesk Inventor to architect the complete mechanical system from scratch, ensuring strict geometric constraints and dynamic interference clearance.
Design for Additive Manufacturing: Optimized the structural topology specifically for 3D printing, minimizing support materials while maintaining structural integrity for the moving components.
Sim-to-Real Precision: Successfully translated the digital CAD model into a functional physical prototype, mastering tight tolerances for the internal transmission mechanisms.

PROJECT V

Folding Cane Chair: A Rehabilitation Assistive Device

Utility Model Patent · CNIPA Accepted

INDEPENDENT PRODUCT R&D




Kinematic Linkage Design: Engineered a low-effort, single-action folding mechanism enabling seamless transitions between a mobility cane and a stable tripod seat.
Ergonomic Optimization: Optimized the center of gravity and load-bearing distribution for elderly users, directly leading to an accepted CNIPA utility model patent.
Smart Voice Control: Integrated a local electronic control module for voice-activated deployment, offering a barrier-free and elderly-friendly interaction.

LOOKING AHEAD

From Edge Grasping to Embodied Dexterity

The trajectory I want to pursue in graduate research

Edge-Native Perception
Zero-shot detection on embedded HW

Hardware-Software Co-Design
Mechatronic systems for dexterous hands

Embodied Intelligence
Foundation models for manipulation

Real-World Autonomy
Robust manipulation and cross-domain locomotion

GRADUATE RESEARCH INTEREST

I am seeking **Master's / Direct Ph.D. positions** where I can continue working at the intersection of **hardware-software co-design**, **dexterous manipulation**, and **edge-native perception**. I am drawn to labs that build complete systems — from mechanism design to on-device intelligence — and that value practical, deployable results alongside algorithmic novelty.

My long-term ambition is to make **dexterous robotic manipulation affordable and reliable** for real-world environments — factories, homes, and healthcare settings — by advancing both the hardware and the intelligence stack simultaneously.

INFORMATION

MINGYU LI

Prospective Ph.D. Researcher | Mechanical Engineering & Computer Vision

ACADEMIC EXCELLENCE

- GPA: 4.28 / 5.0
- Publications: First-Author, IEEE ICARM (2026)
- Awards: First-Class Scholarship & Outstanding Student Award (2025)
- English Proficiency: CET-6 (510) | IELTS: 7.0 (Expected, Jul 2026)

CORE TECH STACK

- Robotics & Deployment: Jetson, Rockchip, Kendryte, STM32, ESP32
- Mechanical Design: Autodesk Inventor, Fusion 360, DFAM
- Languages & Tools: Python (Proficient), C++, LaTeX, R, Cursor

CONTACT

Personal Website: https://mingyuli.com

Email Address: 2352659@tongji.edu.cn

Telephone & WeChat: +86 15817679050

GitHub: https://github.com/MingyuLi018

Location: Caoan Road 4800, Shanghai, China