Portfolio

for HKUST (GZ) RedBird Challenge Camp Application

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Showcasing key projects and expertise in Automation, Robotics, and Embedded Systems. Eager to contribute innovative problem-solving skills and a collaborative spirit to the dynamic environment of the RedBird Challenge Camp at the Hong Kong University of Science and Technology (Guangzhou).

RoboMaster Project (I): Leading Sentry's Evolution & Strategic Development

Project Significance & My Role

> *"In the RoboMaster University Championship, the Sentry robot stands as the **only fully autonomous ground combat unit**, tasked with automated patrolling, target recognition, and striking. Its pivotal role demands advanced technical solutions and tactical precision, reflecting the competition's complex challenges."*

Across the pivotal 2024 season (culminating in national competition) and the ongoing 2025 development cycle, I have consistently held leadership responsibilities:

As Sentry Vehicle Team Lead（2024 & 2025）：
My primary focus in this capacity was on overall project management and team coordination:

- Leading a 10-member multidisciplinary team (mechanical, electrical control, vision algorithms), ensuring 100% completion of project milestones.
- Conducting tactical needs analysis based on competition rules and team strategy, defining technical directions, and assigning tasks to subgroups.
- Facilitating cross-functional communication, resolving conflicts, and maintaining project momentum.
- Strategically allocating resources, including hardware components and testing tools, to ensure timely integration of subsystems.

The Iterative Journey: From Gen 1 (2024) to Gen 3 (2024) & Foundation for 2025

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Our Sentry robot evolved through three key 2024 iterations to meet increasing competition demands:

- Gen 1 (League Matches): Validated core autonomous functions and iterative design principles.
- Gen 2 (Regional Competitions): Enhanced robustness and performance, building on Gen 1 learnings.
- Gen 3 (National Championship): The pinnacle of 2024 efforts; featured a carbon fiber chassis, optimized internal structure, and a revamped embedded system for peak national-level performance.

Learnings from the 2024 Gen 3 directly inform the ongoing 2025 Sentry development. Under my continued leadership, key 2025 R&D initiatives include overall miniaturization for narrow terrains and a novel dual-layer yaw architecture, pushing the boundaries of mechanical and control system integration. The foundational Gen 3 (2024) technical architecture, which underpins these advancements, is detailed in Part II (Page 3).

Fig 1: Leading our dedicated Sentry team with the Gen 3 national competition model（2024）.

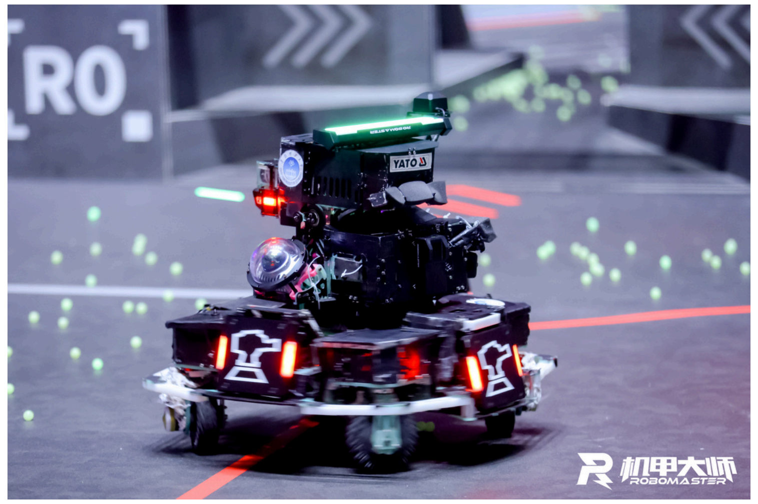

Fig 2a: Gen 1 Sentry - Initial league match prototype (2024).

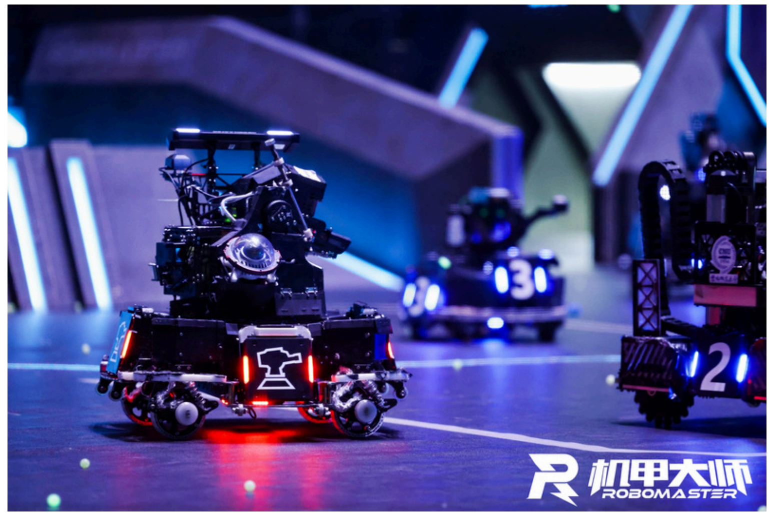

Fig 2b: Gen 3 Sentry - Advanced model for the Nationals (2024).

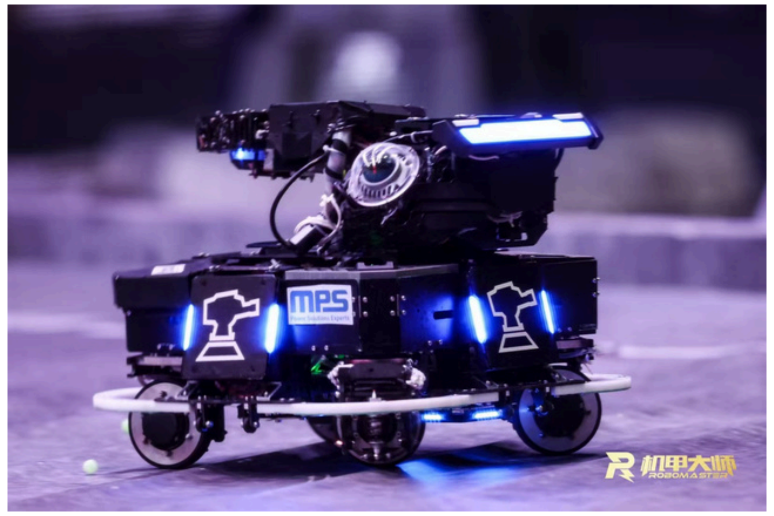

Fig 3: The miniaturized Gen 2 Sentry (2025) featuring a dual-layer yaw architecture, optimized for narrow terrains.

RoboMaster Project (II): System Architecture & Software Framework

This section details the Gen 3 (2024) Sentry's foundational system architecture, module interconnections, and layered software framework.

Gen 3 Sentry (2024): System Module Interconnections

As Electrical Control Lead, I defined the Gen 3 Sentry's module layout and communication topology for robust operation (Fig 1). Key elements:

- **Distributed Control:** Dedicated Main Controllers for Chassis and Gimbal systems enabled **real-time multi-tasking** and specialized maneuver/targeting management.
- **Sensor Suite:** Integrated a **BMI088 IMU** (attitude/motion), IR **TOF** Sensors (x2) (for gun barrel ranging), and an **FS-I6X Receiver** (remote override).
- **Processing & Actuation:** A **miniPC** for high-level computations (vision algorithm interface), precise drive of various motors (Hub, Servo, Gimbal, Launching System), and a **Digital Power Supply** ensuring stable power and calculating chassis power.
- **Communication Network:** **CAN** bus as the primary real-time data backbone; **UART** for logging, Referee System, and miniPC communication; **IO/PWM** for direct actuator/indicator control (e.g., Indicator Light Board).

This strategic interconnection formed the Sentry's robust and responsive core capabilities.

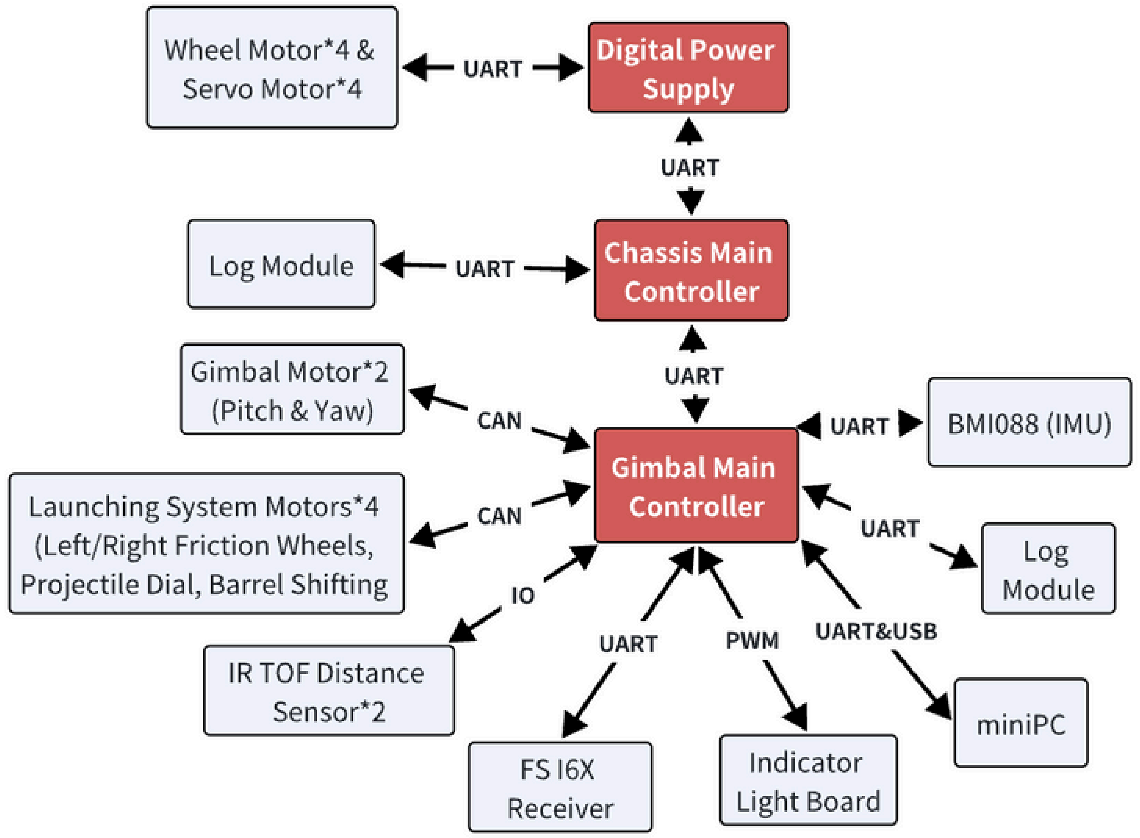

Fig 1: Gen 3 Sentry - System Module Interconnections

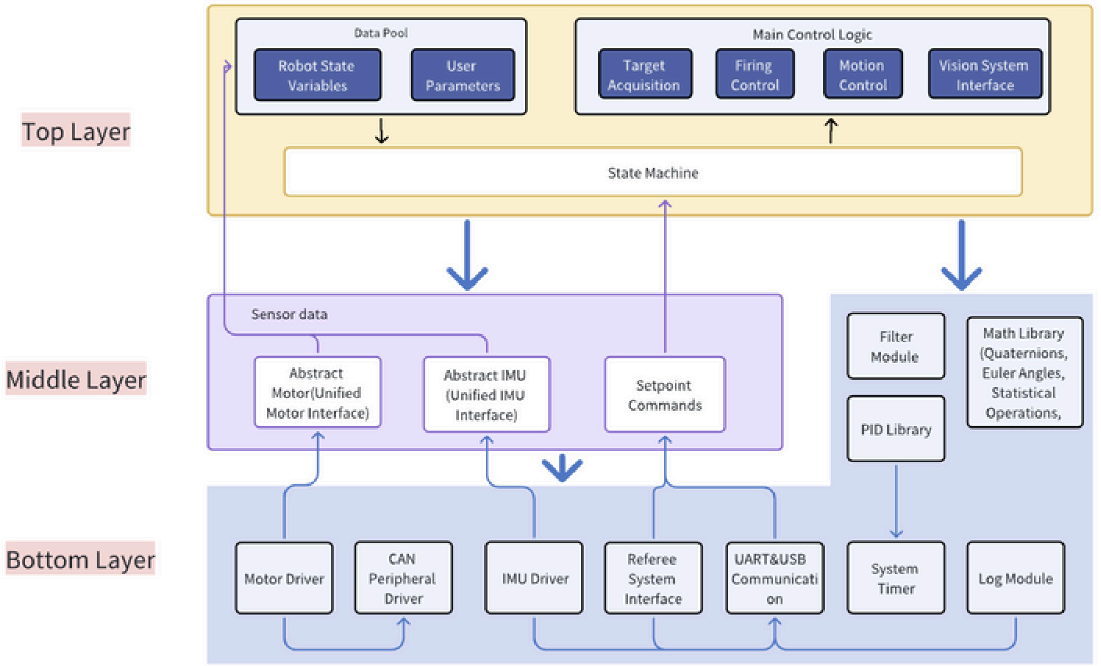

Fig 2: Gen 3 Sentry - Overall Embedded System Architecture

Gen 3 Sentry (2024): Layered Software Framework

The Gen 3 Sentry's software was built upon a classic three-tier layered architecture (Fig 2) for modularity, maintainability, and real-time performance:

- **Bottom Layer:** Directly managed hardware, providing raw data via drivers for motors, CAN bus, IMU, Referee System, UART/USB, System Timer, and Logging.
- **Middle Layer:** Abstracted hardware and processed data. Key modules included unified interfaces for Motors and IMU (with sensor fusion for attitude), setpoint command handling, data filtering, and libraries for PID control and math operations. The STM32F405 MCU with FreeRTOS was central here for real-time multi-tasking.
- **Top Layer (Application):** The robot's "brain," implementing autonomous decision-making. This included a Data Pool (Robot State Variables, User Parameters), a State Machine for complex behaviors (patrol, target recognition, exception handling), and Main Control Logic for target acquisition, firing, motion control, and vision system integration.

This robust software framework, coupled with capable hardware, was foundational to the Sentry's advanced autonomy and our 2024 National First Prize (Runner-up) achievement.

"Everest Program": Coursework & Projects

Selected into the ***"Everest Program" for Super Robotics*** *(30 students per cohort) at the end of my sophomore year, I have actively engaged in its rigorous curriculum for nearly a year. This elite program cultivates innovation leaders in robotics by emphasizing interdisciplinary learning, the fusion of theoretical teaching with engineering R&D, and project-based learning.*

The following are selected course projects：

Specialized Coursework in the Everest Program

- Classical Control Theory
- Introduction to Robotics
- Engineering Mechanics
- Robot Mechanism Design
- Project Management
- Reinforcement Learning and Optimal Control
- Robot Sensors and Perception
- Robot Actuation and Motion Control
- Neural Networks and Deep Learning
- Artificial Intelligence and Machine Learning
- Digital Signal Processing

RL-Based Quadruped Locomotion for Challenging Terrains (legged_gym)

Key Technologies: Reinforcement Learning (RL); legged_gym; PPO; Python; Quadruped Control; Terrain Traversal

Outcome/Highlights: Successfully trained agent for robust navigation on multiple rugged terrains, demonstrating adaptive locomotion.

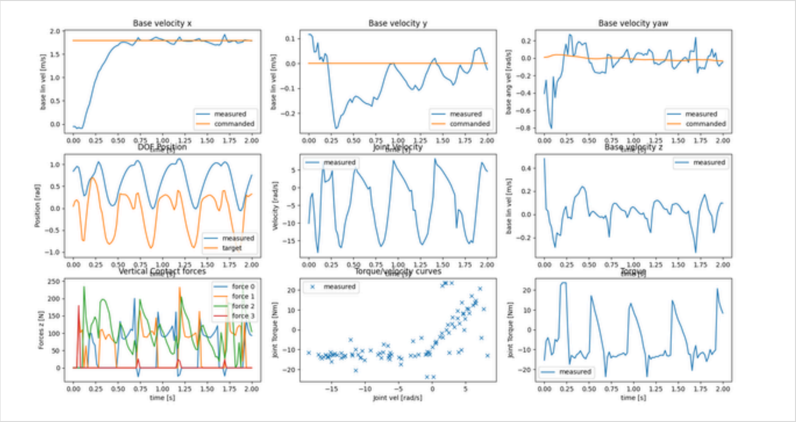

Fig 1a: Reward/Performance Curve

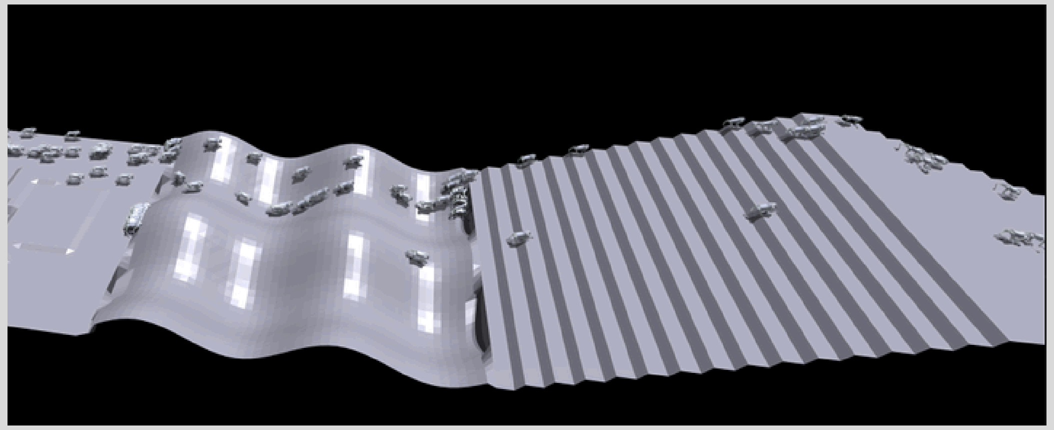
Fig 1b: RL Policy - Navigating Rugged Terrain (Isaac Gym)

MPC-Based Quadruped Locomotion

Brief Overview: Adapted and simplified a MIT open-source controller, utilizing a Kalman Filter for state estimation, to implement Model Predictive Control (MPC) for stable planar locomotion and precise pose adjustment of a quadruped robot in the Webots simulation environment.

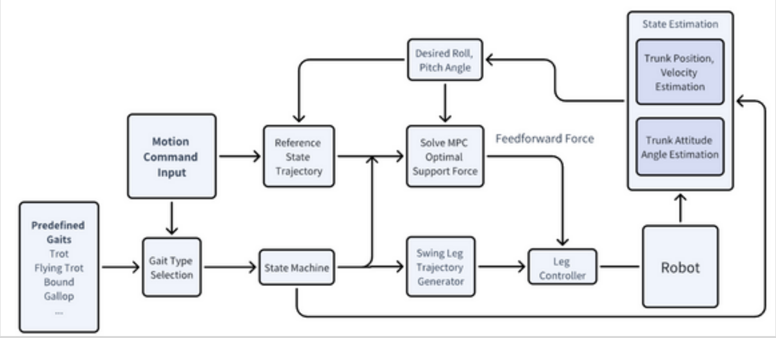

Fig 2a: MPC Control Framework

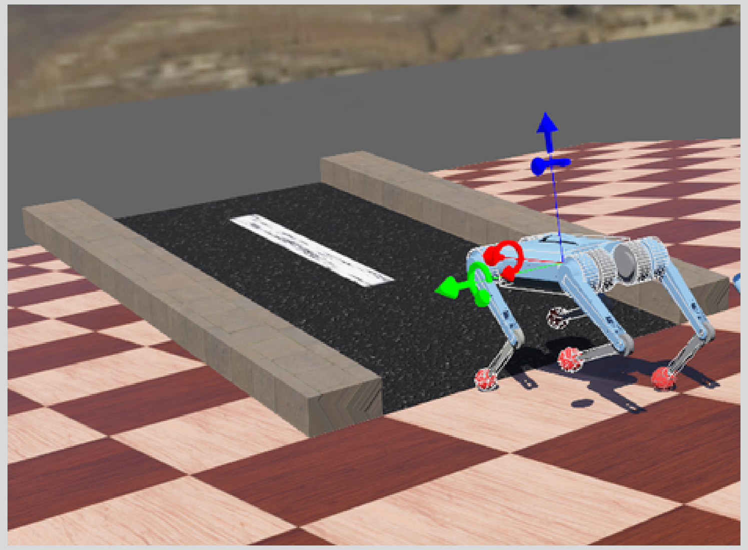
Fig 2b: Quadruped Locomotion in Webots Simulation

Biomimetic Amphibious Robot with Multi-Modal Locomotion

Brief Overview: Developed an amphibious robot with wheeled land movement and vectored aquatic propulsion, featuring rapid mode switching.

My Role: Led the control system and embedded software development, implementing multi-modal locomotion logic and vectored thrust control.

Key Technologies: STM32; C/C++; Multi-Modal Control; Vectored Thrust; Sensor Fusion

Outcome: Successfully achieved amphibious capabilities, meeting all design specifications (speed, transition time, weight, size).

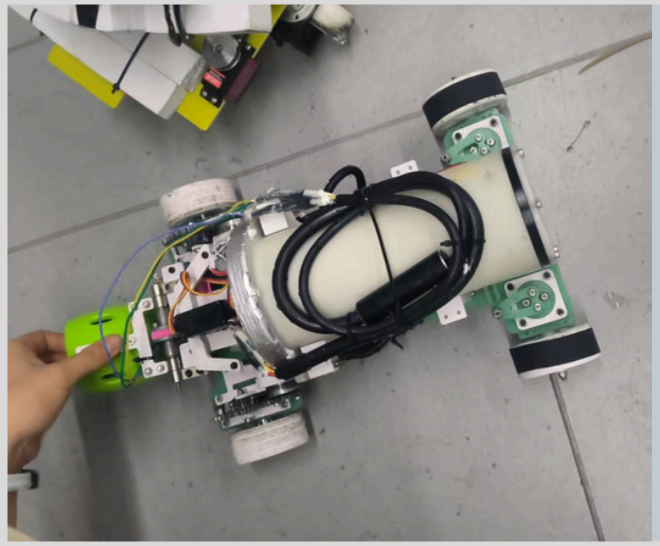
Fig 3a: Actual Robot

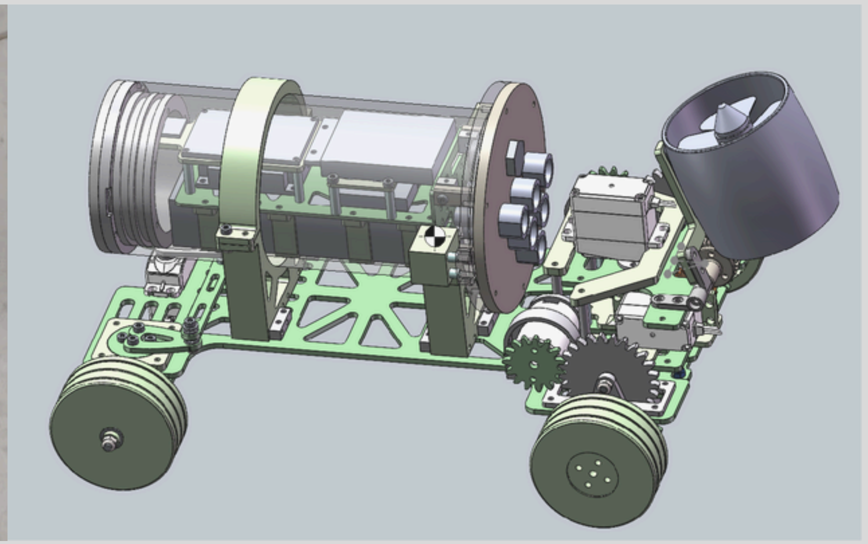
Fig 3b: SW Design Modelt

Analytical Problem-Solving & Industry Experience

Mathematical Contest in Modeling（2025）

Project: Olympic Medal Forecasting - A Hybrid Multi-Modal Feature Fusion Framework

Our team developed a comprehensive framework to predict Olympic medal counts, integrating historical data, athlete characteristics, and national strength metrics. My key technical contributions focused on feature engineering and predictive modeling:

- Designed and implemented the overall data processing pipeline, from raw data ingestion to feature extraction for model input (as illustrated in Fig 1).
- Engineered critical predictive features:
  - Quantified national Olympic strength using **Ridge Regression**.
  - Classified athlete performance levels via **K-Means clustering**.
  - Predicted athlete retirement probabilities using **Random Forest** models.
- Developed and validated the final **XGBoost** prediction model, which integrated these diverse features to forecast medal distributions.
- Conducted feature importance analysis (Fig 2), identifying 'National Comprehensive Strength Score' (country_score) as the most influential predictor (86.46%) for the XGBoost model.

Outcome: Our team (Team #2510970) achieved **Honorable Mention** in this highly competitive international contest.

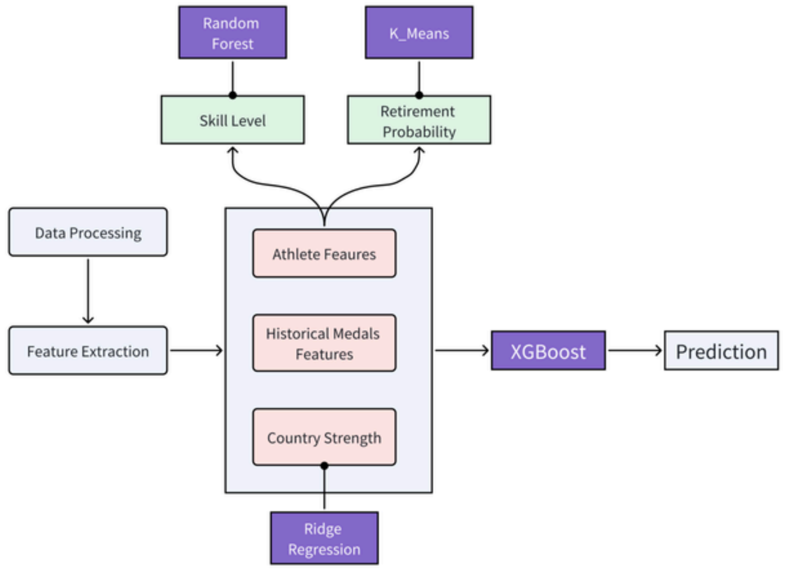

Fig 1: Overall Prediction Model Framework

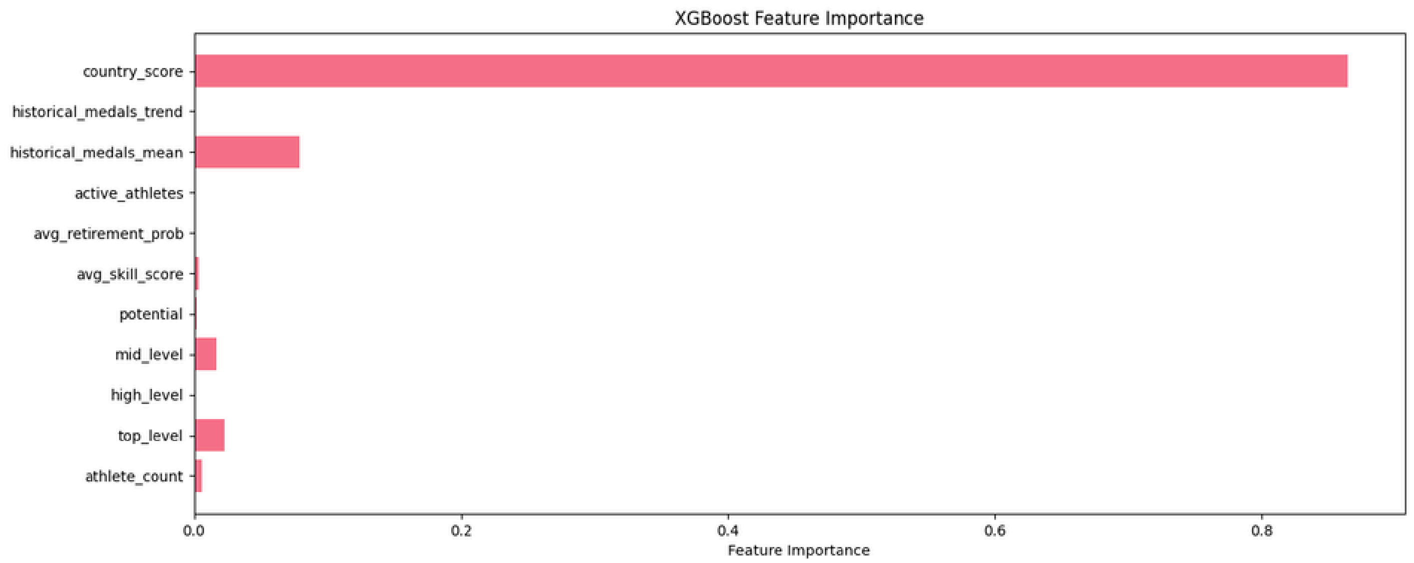

Fig 2: XGBoost Feature Importance Analysis

Embedded Software Intern @ Insta360

Camera Engineering Department, Wi-Fi/Bluetooth Team

Fig3: Example of an Insta360 camera product. My internship focused on the software testing and integration of its internal Wi-Fi/Bluetooth communication modules.

During my internship, I immersed myself in the development lifecycle of cutting-edge camera products, focusing on ensuring the reliability and performance of their core wireless communication functionalities.

My Contributions & Learnings:

- Devised and executed systematic test plans for Wi-Fi and Bluetooth modules on embedded Linux platforms, crafting C programs and Shell scripts to simulate diverse usage scenarios and stress conditions.
- Deepened my debugging expertise by analyzing test logs, C code (Makefile-based builds), and network packet captures (using tools like Wireshark and Ellisys) to effectively reproduce issues and pinpoint root causes of bugs in hardware drivers and Wi-Fi/Bluetooth protocol stacks.
- Proficiently utilized Git for collaborative version control, managing test branches, integrating external patches, and rigorously ensuring compatibility with the main development branch.
- Streamlined testing and issue resolution by implementing systematic debugging approaches and delivering clear, detailed bug reports, thereby reducing turnaround time for software-hardware interaction problems.

Robotics Journey: Experiences & Highlights

Fig 1: RMUC Southern Regional Award Ceremony, 2025.

Fig 2: RMUC National Final Ceremony, Shenzhen Bay Sports Center, 2024.

Fig 3: Performing final pre-match checks on the Sentry's auto-aiming system.

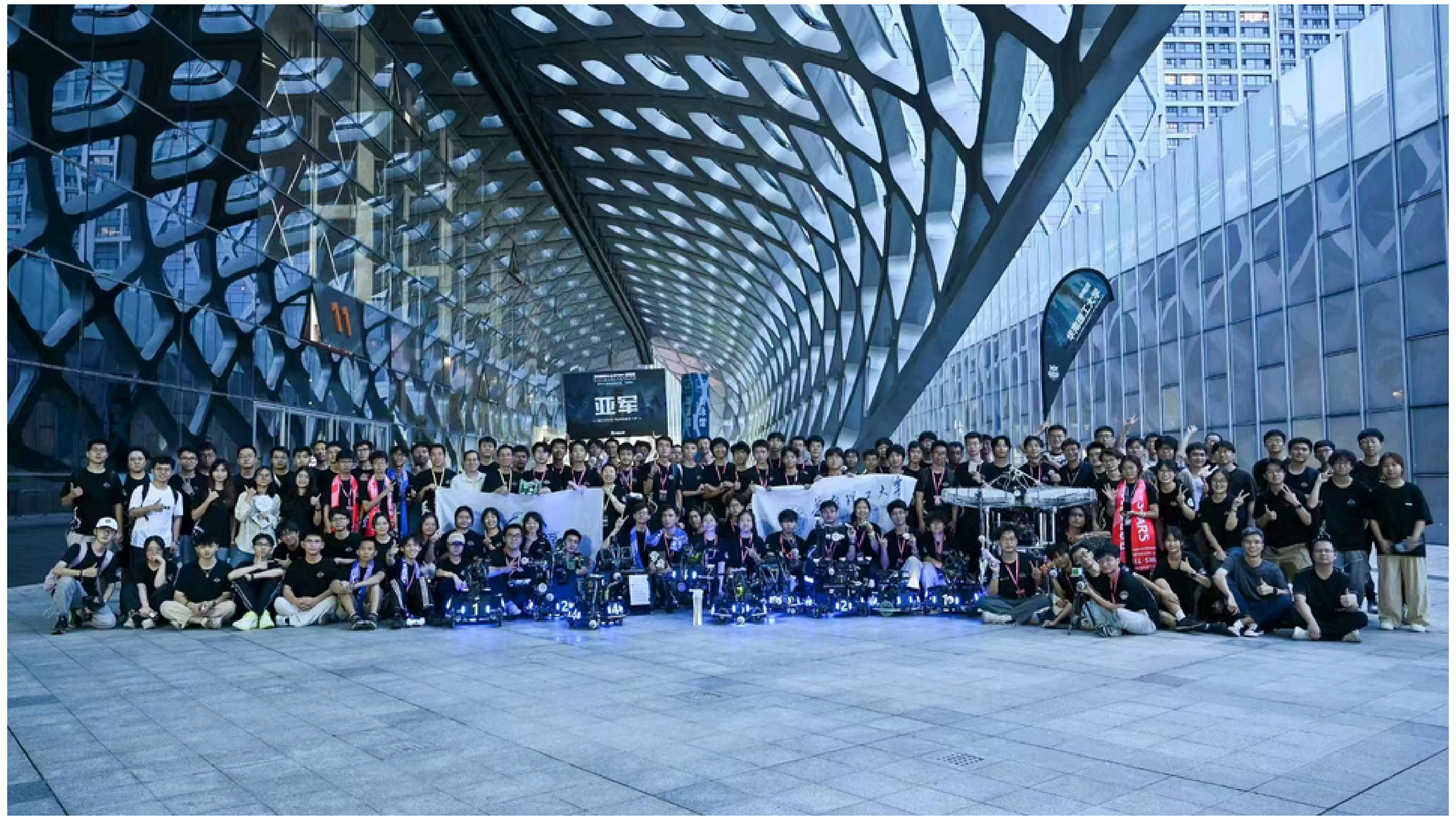

Fig 4: Our Lab at the RMUC 2024

Fig 5: With the Gen 3 Sentry (2024).

Fig 6: Final Defense for 'Robot Mechanism Design' (Everest Program).