Barelang FC Team Description Paper

Humanoid Soccer League RoboCup 2026 - Icheon

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Abstract. This paper presents the Barelang FC team's development and preparation for RoboCup 2026 in Icheon, South Korea. We discuss lessons learned from previous RoboCup competitions, where we achieved third place, outline our major technical improvements, including accelerated vision processing with Hailo-8 NPU integration and enhanced mechanical durability through soft bumper implementation and structural redesign. The paper also describes our contributions to the Humanoid Soccer League community through open-source software development and educational outreach programs.

Keywords: humanoid robot · bipedal robot · robot soccer · RoboCup humanoid.

1 Introduction

Barelang FC is a research group at Politeknik Negeri Batam, Indonesia, specializing in humanoid robotics and regularly participating in RoboCup competitions since 2017. The team currently consists of 20 members from Mechatronics and Robotics Engineering departments, supported by two faculty advisors. Our participation in RoboCup serves as a platform for evaluating research developments, supporting international collaboration, and advancing humanoid robotics technology.

At RoboCup 2024 in Eindhoven, The Netherlands, Barelang FC achieved third place in the Kid-Size Humanoid League, demonstrating significant improvements in locomotion speed (0.34 m/s) and vision capabilities [1]. However, the competition also revealed critical challenges that require further development. Due to financial constraints, the team was unable to participate in RoboCup 2025, which provided an extended development period to implement substantial improvements for the upcoming 2026 competition.

This paper outlines our lessons learned, the major technical challenges, the solutions implemented, and the contributions to the Humanoid Soccer League and the wider robotics community.

2 Lessons Learned from Previous Competitions

At RoboCup 2023 Bordeaux, our third-place finish revealed critical performance gaps: locomotion speed of only 0.31 m/s (vs. finalists at 0.33-0.35 m/s), goalkeeper field coverage of 61.13% with poor lateral detection, and an absence of obstacle avoidance, leading to frequent collisions.

For RoboCup 2024 Eindhoven, we improved the walking speed to 0.34 m/s (9.67% gain), upgraded to See3CAM 24CUG cameras with wider lenses and integrated MiDaS depth estimation [1][3]. We achieved third place but identified two critical challenges for future development: (1) The computer system struggled with concurrent vision and control tasks, causing inconsistent latency and affecting real-time responsiveness during matches, and (2) hard collisions with opposing robots caused actuator over-current conditions requiring robot removal from the field, highlighting the need for improved mechanical durability and impact protection mechanisms.

3 Major Technical Developments for RoboCup 2026

3.1 Vision Processing Enhancement with Hailo-8 NPU

Our vision system evolved through three phases: (1) 2024: YOLOv8 on Jetson Xavier NX with TensorRT providing detection and segmentation for field boundary identification, (2) 2025: Transition to cost-effective Radxa ROCK 5B+ with RKNN models, (3) 2026: Full integration of dedicated Hailo-8 NPU (26 TOPS) offloading detection entirely from the main CPU, achieving stable 15 FPS without controller interference. This modular architecture enables future algorithm enhancements without compromising system performance.

3.2 Mechanical Structure Improvements

We implemented 3D-printed TPU soft bumpers at the shoulder, elbow, front body, and back body regions to absorb impact forces during falls and collisions, reducing actuator stress. Optimized arm positioning during locomotion reduces the probability of collisions. 1 describe the current mechanical structure of Barelang FC robot for preparing RoboCup 2026 competition. The robot underwent a structural transformation into a pole-based system with four main pillars, delivering improved maintenance accessibility, enhanced load distribution, and a lower center of gravity, improving stability and reducing fall risk.

4 Team Contributions and Impact

4.1 Open-Source Software and Research

Barelang FC contributes to the RoboCup community through open-source releases at https://github.com/BarelangFC, including control frameworks, vision

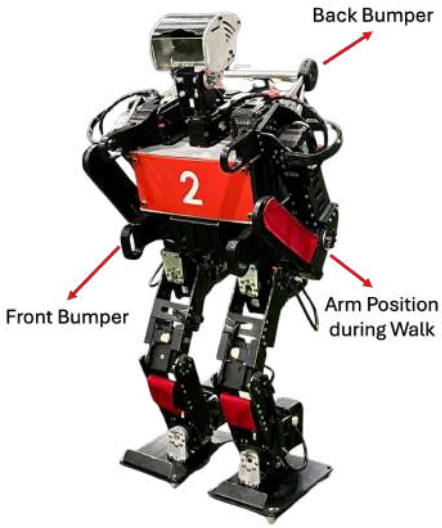

Fig. 1: Barelang FC humanoid robot for RoboCup 2026 Incheon.

modules, and simulation environments. In 2023, we published a proceedings paper on the development of a simulation model for adult-size humanoid robots [2], advancing theoretical foundations and practical implementations. Our primary research contributions for RoboCup 2026 focus on an efficient vision processing architecture with dedicated NPU acceleration and mechanical design optimization to improve durability in competitive environments.

4.2 Community Impact

Our RoboCup participation has significantly impacted the Humanoid Soccer League community through multiple channels: (1) open-source software contributions enable other teams to build upon our implementations, (2) cross-team collaboration through student exchanges at National Taiwan Normal University and Tamkang University facilitate knowledge transfer in control algorithms, vision processing, and mechanical design, (3) active participation in technical discussions and sharing of competition insights help advance collective understanding of humanoid soccer challenges, and (4) documentation and publication of our research methodologies contribute to the broader humanoid robotics research community. We actively seek collaboration opportunities with other teams in vision processing architectures, mechanical design optimization, and competition strategies to foster innovation within the league.

5 Conclusion and Future Work

Barelang FC has made substantial progress in addressing the critical challenges identified through our RoboCup competition experiences. Our vision processing enhancements, enabled by Hailo-8 NPU integration, deliver stable, high-performance object detection without compromising controller responsiveness. The improved mechanical structure, with soft bumper protection and an optimized design, provides greater durability and stability during competitive play. Together, these developments create a more robust and competitive platform for RoboCup 2026.

Our commitment extends beyond competition success to meaningful contributions to the Humanoid Soccer League community through open-source software, research publications, educational programs, and international collaboration. The two-year development cycle since RoboCup 2024 has allowed us to implement substantial improvements while maintaining our focus on advancing humanoid robotics research.

For RoboCup 2026, we aim to build on our third-place finish in 2024, demonstrate the effectiveness of our integrated improvements to competition conditions, and continue fostering collaborative relationships within the global RoboCup community.

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