

HERoEHS, Team Extended Abstract

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Abstract. Team HERoEHS and AeiROBOT present the latest iteration of ALICE4, building on previous achievements in walking algorithms, mechanical design, vision recognition, and localization. Key advancements include a DCM-based stepping controller with InEKF odometry, kinematic optimization with a dedicated robotic hand, YOLOv11-based vision, and a robust three-stage localization pipeline. For RoboCup 2026, we plan to integrate the stepping controller with MPC-based Whole-Body Control for torque-level regulation, enabling enhanced disturbance rejection in dynamic match scenarios. Through these refinements, we aim to validate ALICE4’s adaptability to real-world environments, advancing our shared vision of “A robot for ALL.”

Keywords: ALICE4 · RoboCup · Large Size League · Humanoid Robot

1 Introduction

Team HERoEHS has participated in the RoboCup Humanoid Large Size League since 2018, continuously advancing ALICE4 through improvements in control, mechanical design, and perception. In collaboration with AeiROBOT, the latest iteration features DCM-based stepping control, optimized kinematics with a dedicated manipulator, YOLOv11-based vision recognition, and a multi-stage localization system. The electrical architecture has also been upgraded with custom motor drivers and a 48V hot-swappable power system.

For RoboCup 2026, our primary goal is to integrate MPC-based Whole-Body Control with the existing stepping controller, achieving torque-level regulation for improved balance recovery and robustness. In pursuit of our shared vision, “A robot for ALL,” we aim to demonstrate a versatile platform capable of adapting to diverse real-world tasks and environments.

2 Technical Issues

2.1 Walking Algorithm

Conventional ZMP-based walking showed limited disturbance rejection in dynamic match environments. To address this, we introduced omnidirectional walking in 2023, followed by QP-based balance optimization and Parallel Walking in 2024. In 2025, we developed a DCM-based stepping controller that maintains stability under external forces, coupled with InEKF-based odometry for robust state estimation.

However, the current position-controlled system lacks adaptability for dynamic contacts. In 2026, we plan to integrate the DCM stepping controller with MPC-based Whole-Body Control (WBC) to enable torque-level regulation, improving balance recovery and disturbance rejection.

2.2 Mechanical Design

Building on ALICE4’s linear actuator-based parallel mechanism, we optimized the kinematic configuration for target tasks. The pelvis pitch was pre-tilted toward the nominal operating posture, maximizing the usable joint range during locomotion and manipulation. A dedicated robotic hand was integrated for reliable ball handling.

The low gear ratio design enables back-drivable joints and current-based torque estimation, allowing compliant and precise force control.

2.3 Vision Recognition

We employ YOLOv11 trained on approximately 90,000 images for detection, segmentation, and classification. Models are optimized via TensorRT and process real-time stereo imagery (ZED2i) to identify the ball, goalposts, and field landmarks—achieving significant improvements over our 2024 system.

2.4 Localization

To address localization drift observed in previous competitions, we implemented a three-stage pipeline: (1) semantic landmark extraction via vision models, (2) pose estimation using probabilistic filtering, geometric constraints, and feature matching, and (3) adaptive sensor fusion with outlier rejection and context-aware weighting. Validation is ongoing in simulation.

2.5 Electrical Design

ALICE4’s electrical system was upgraded with custom motor drivers featuring high-bandwidth current control and high-speed communication, replacing the previous Dynamixel actuators. In-house sensor modules were developed to support the walking algorithm. For improved availability, a 48V hot-swappable power system enables continuous operation during charging. Safety was enhanced through wireless emergency stop and additional protective circuits.

3 Future Work & Conclusion

Team HERoEHS and AeiROBOT have established a solid foundation through DCM-based stepping control with InEKF odometry, optimized kinematics with a dedicated robotic hand, YOLOv11-based vision, and a robust three-stage localization pipeline. The electrical system has also been upgraded with custom motor drivers and a 48V hot-swappable power system for improved performance and availability.

Looking ahead to RoboCup 2026, the primary focus is integrating the DCM stepping controller with MPC-based Whole-Body Control to achieve torque-level regulation. This will significantly enhance balance recovery and disturbance rejection in dynamic match scenarios. Additionally, the localization pipeline, currently validated in simulation, will be deployed and refined on the physical platform.

These efforts will be demonstrated on ALICE4, a platform designed for real-world everyday and workplace environments. By validating our technologies in the demanding RoboCup setting, we aim to build a versatile robotic system capable of performing diverse tasks advancing our vision of “A robot for ALL.”