“Future Becoming” Extended Abstract for Humanoid Large Robot Division League of RoboCup 2026

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Abstract-This paper presents the technical solution of a robot soccer team with experience as champions in the China Open Atomic Competition. Addressing the four core issues revealed by previous competitions-visual tracking, multi-agent collaboration, motion robustness, and decision-making efficiency-the team has proposed a comprehensive, systematic solution. On the hardware side, the system uses 1 Unitree G1 (goalkeeper) and 2 Unitree R1 (forwards), with Intel RealSense D435i cameras for a multi-perspective vision system; On the software side, based on the self-developed "GeWu" simulation platform, the team has developed omnidirectional gait algorithms with dynamic adaptation and self-recovery capabilities for falls. By integrating multiple sensors, the system achieves accurate football and goal recognition. Additionally, a layered collaborative decision-making framework has been built, with the goalkeeper serving as the decision center, incorporating both rules and machine learning. This framework supports complex offensive and defensive strategies, as well as specialized actions. The solution aims to enhance the stability, perception, and collaborative intelligence of the robots during competitions through hardware upgrades and algorithm optimization.

Keywords: Robot Soccer,GeWu Simulation Platform,Multi-agent Collaboration

1.Experience and Solutions

Based on our team’s championship success in the China Open Atomic Competition, particularly in the autonomous robot soccer tournament, we have identified and addressed four key challenges that emerged from previous competitions: the limited field of view in the vision system, communication delays in multi-robot collaboration, insufficient motion robustness, and the need for optimization in decision-making efficiency. To tackle these challenges, we propose a comprehensive and systematic solution, which includes: the deployment of Intel RealSense D435i cameras to construct a multi-perspective vision system; the adoption of the DDS protocol for real-time inter-robot collaboration and a dual-protocol

communication architecture incorporating the UDP protocol for the transmission of competition data; the development of an autonomous ball-seeking, kicking, and fall-recovery network, built upon our team's self-developed and open-sourced "GeWu" simulation platform (**https://github.com/loongOpen/Unity-RL-Playground**); and the optimization of the decision tree structure and hierarchical state machine design to enhance the overall performance of the system.

2.Hardware Configuration

The hardware system adopts a strategic configuration of "1 Unitree G1 goalkeeper and 2 Unitree R1 forwards." Each R1 forward is equipped with a Jetson Orin NX main controller, paired with the native head camera and an additional Intel RealSense D435i to form a multi-perspective vision system that supports DDS/UDP dual-protocol communication. The G1 goalkeeper has also been upgraded with the RealSense D435i camera and is specifically outfitted with professional large-sized gloves, full-body protective gear, and structural reinforcements optimized for goalkeeping movements, enhancing both save performance and the durability of the robot during high-intensity competition. The hardware system employs a differentiated model lineup of "1 G1 goalkeeper and 2 R1 forwards" to balance high dynamic flexibility with structural impact resistance. The forwards are based on the Unitree R1 platform, which weighs only 29 kg and offers an excellent power-to-weight ratio, enabling high-frequency direction changes and explosive running required for the forward role. Each R1 is equipped with an NVIDIA Jetson Orin NX main controller, providing up to 100 TOPS of edge computing power, serving as the computational foundation for real-time whole-body control (WBC) and reinforcement learning inference. The vision system is composed of the native binocular camera on the head and the additional Intel RealSense D435i depth camera, eliminating perception blind spots through overlapping fields of view, thereby achieving sub-centimeter-level positioning of the football and field markers.

The goalkeeper is based on the Unitree G1 Education Edition, which features a peak knee joint torque of 120 N·m, enabling it to bear the immense loads generated during rapid lateral dives. To withstand the high-energy impact environment of the AdultSize category, the G1 has been upgraded with a high-frame-rate RealSense perception module and outfitted with specialized goalkeeping gloves that comply with Law 4 (convex hull area ≤ 920 cm^2). The core joints of the robot are protected by EVA polymer soft materials, significantly enhancing the robot's durability during falls

while complying with the “non-rigid protection” rule. The communication link is based on the high-reliability DDS mechanism of ROS 2, supporting real-time synchronization of the "world model" between the forwards and the goalkeeper.

3.Software System

Our software architecture comprises three core modules. The omnidirectional gait control algorithm, trained through reinforcement learning on the “GeWu” platform, is capable of dynamic terrain adaptation and autonomous fall recovery. The vision system integrates multi-camera fusion and depth information processing techniques, and extensive simulation pre-training ensures robustness in real-world scenarios. A hierarchical collaborative decision-making framework, with the goalkeeper as the decision center, integrates rule-based logic and machine learning, enabling the efficient execution of complex offensive and defensive tactics, including penalty kicks and precise shots on goal.

4.Conclusion

In summary, leveraging our successful competition experience and the self-developed "GeWu" simulation platform, we have built a comprehensive robot soccer solution encompassing both hardware configuration and software algorithms. Through targeted hardware upgrades and precise algorithm optimization, this system aims to achieve exceptional motion stability, accurate environmental perception, and intelligent team collaboration capabilities. We look forward to demonstrating this integrated solution in competitions and contributing to the advancement of robot soccer technology.