THMOS Extended Abstract for Humanoid Adult-size League of RoboCup 2025

Song Lu

Department of Mechanical Engineering, Tsinghua University, Beijing 100085, China
lus23@mails.tsinghua.edu.cn

Abstract: This paper outlines the lessons learned from our participation in previous RoboCup Humanoid League competitions and presents the enhancements planned for RoboCup 2025. We focus on improving our robot's walking algorithms, vision systems, and decision-making processes. By integrating advanced control strategies and enhancing team training protocols, we aim to achieve greater stability, accuracy, and cooperative capabilities in the upcoming competition.

1. Lessons Learned and Problems

Our team has been participating in RoboCup humanoid league competition for almost ten years and have made outstanding achievements. Last year, we participated in RoboCup Humanoid League (adult-size) for the first time. From last year's experience, we identified that increasing the number of simulated matches before the competition can help detect potential hardware issues such as motor failures and structural instabilities. Additionally, it allows for more effective debugging of the robot's gait. To address these challenges, we have implemented more rigorous simulation sessions and enhanced training programs to ensure seamless robot deployment, swift component replacement, and efficient maintenance during competitions.

2. Plans of the major changes

2.1 Walking

Building on our previous work, this year we are exploring advanced gait algorithms, including Central Pattern Generators (CPG), Model Predictive Control (MPC), and Reinforcement Learning (RL). We plan to integrate these algorithms with our existing LIP-Based MPC and QP-Based WBC framework to enhance walking stability and adaptability. Thanks to the support from Fourier Intelligence, we now have access to improved hardware, which provides better motor performance and structural reliability. This allows us to push the boundaries of our walking algorithms and achieve more robust and dynamic locomotion. Real-world validations are ongoing, and we aim to finalize the most effective algorithm by early 2025.

2.2 Vision and Simulation

We have completed the development of a Line Segment Detector, which is crucial for recognizing various line features on the field. Combining this with our Particle Filtering Algorithm, we aim to achieve high-accuracy positioning. Additionally, we are refining our depth perception capabilities using the ZED 2i Stereo Camera and integrating IMU data to improve the extrinsic matrix calibration. These developments are scheduled for comprehensive testing and refinement in the upcoming spring semester.

2.3 Decision making

This year, we have successfully developed multi-robot communication based on UDP, which allows our football robots to coordinate more effectively on the field. The goalkeeper has been designated as the ROS host due to its simpler decision-making requirements, primarily focusing on defensive actions based on ball position updates from teammates. The other robots act as listeners, actively searching for the ball and making strategic decisions such as chasing, passing, or kicking. These robots continuously communicate with the host to share field information and determine appropriate actions.

We are also incorporating the enemy's position into our decision-making process, utilizing path planning algorithms like A* to enhance the effectiveness of their aggressive actions. This allows our robots to anticipate opponent movements and make more informed decisions during gameplay. Additionally, we are reconstructing the entire decision-making framework to achieve more comprehensible and modular logic, enabling easier debugging and future enhancements. These improvements will enable the implementation of distinct offensive and defensive strategies, enhancing our team's tactical flexibility.