I-Teen Extended Abstract for Humanoid Teen-size League of RoboCup 2026

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Abstract. This paper presents our team's strategy for RoboCup 2026. Building on over a decade of experience, we have established structured team management to ensure sustainable development. Our technical efforts are directed at three core areas: a robust Particle Filter-based localization system, an enhanced vision pipeline for line and object detection, and a PPO reinforcement learning framework for agile locomotion. These components are currently being integrated and tested to improve our robots' stability, accuracy, and cooperative play. Our work aims to contribute to the league's technical progress and to advance robotics education at our institution.

Keywords: RoboCup, Humanoid Robotics, Localization, Reinforcement Learning, Team management

1 Lessons Learned and Team Development Strategy

Since our debut in 2010, continuous participation in the RoboCup Humanoid Kid-Size League has taught us that systematic team development is as crucial as technical innovation. Success in domestic and international tournaments and steady team growth have necessitated moving beyond ad-hoc preparation. We have therefore institutionalized structured pre-competition training. This framework centers on simulated match practice, which serves a dual purpose: it is vital for debugging hardware-software integration while simultaneously training newcomers and preserving team expertise. This focus on foundational processes ensures a reliable platform for deploying sophisticated robotic systems.

2 Technical Roadmap: Challenges, Solutions, and Current Status

Our strategy for 2026 targets key performance barriers through integrated technical upgrades, all currently in active development.

2.1 Localization

This year, we have explored multiple localization strategies using various field markings, including single markers, T-marking pairs, and combinations of goalposts with L- or T-markings. The core of our localization system is based on a Particle Filter algorithm [1], which is designed to achieve high-accuracy positioning by fusing multi-source observations. Following extensive real-world validation and upcoming tests, we plan to select the most effective strategy. Enhanced simulation and training programs have been implemented to ensure reliable localization, rapid environmental adaptation, and efficient in-competition maintenance.

2.2 Vision

Our visual perception system has been upgraded with two key developments: a Line Segment Detector [2] for robust recognition of field line features, and an object detection module for identifying the ball, goalposts, and other robots. These components provide the essential perceptual input for both localization and decision-making. The integration and performance optimization of this vision pipeline are scheduled for comprehensive testing and refinement in the upcoming spring semester.

2.3 Dynamic Locomotion via Reinforcement Learning

To achieve more natural and stable running and kicking, we are employing a Proximal Policy Optimization (PPO) framework [3]. This trains motor skills in simulation, with a dedicated focus on ensuring successful simulation-to-real transfer through dynamics randomization. Ensuring subsystem cohesion and team operational readiness is critical. Our enhanced training protocols, including rigorous simulation sessions, are actively used to test integration, debug systems, and train the team in maintenance.

3 Impact and Research Contributions

We are developing publishable methodologies in key areas: a novel Particle Filter application for multi-cue humanoid soccer localization, an integrated vision pipeline for robust perception, and a practical PPO framework for locomotion tailored to the teen-size platform. We commit to sharing insights and, where feasible, tools or datasets from this research to support league-wide advancement. The project acts as a premier applied research and education platform, immersing students in cutting-edge robotics challenges across perception, control, AI, and systems engineering. It elevates the university's profile in international robotics and inspires local STEM engagement, demonstrating the exciting real-world applications of theoretical knowledge.

References

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