Team GeoHBots Team Description Paper for RoboCup 2026 Humanoid League

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Abstract. This paper introduces Team GeoHBots and summarizes our software and system developments for the RoboCup 2026 Humanoid League. Based at China University of Geosciences (Beijing), we focus on robust perception, stable locomotion, and reliable behavior under strict onboard computing constraints. Over the past year, we have improved walking stability, strengthened perception under varying illumination and occlusion, and streamlined decision-making for faster reactions in game situations. Our current system follows a modular ROS 2 architecture with Behavior Trees for high-level control, a vision pipeline combining deep learning with geometric post-processing, and a localization module that integrates visual landmarks with inertial/odometry cues. We also provide rich runtime logging and visualization to support rapid debugging and analysis. These efforts aim to improve real-time performance and robustness in dynamic soccer environments and to contribute reusable modules to the humanoid soccer community.

Keywords: Humanoid robot soccer, Biped locomotion, Robot vision, Localization, Autonomous decision-making

1 Experience and Key Challenges

Team GeoHBots has gained hands-on experience integrating perception, locomotion, and behavior control on a resource-limited humanoid platform. Continuous tests in dynamic, cluttered environments exposed bottlenecks in reaction speed, action timing, and perception continuity, which motivated the following upgrades.

Under defensive pressure, the robot previously tended to spend too long on fine positioning before acting. When the ball entered our half, this additional adjustment time increased the risk of conceding, especially in fast turnovers.

At the system level, three issues were most evident: (i) a limited motion repertoire that reduces adaptability when approaching or striking the ball from different angles; (ii) fragile multi-robot coordination, where delays and simple role assignment can cause poor spacing or duplicate chasing; and (iii) perception dropouts due to occlusion and limited field of view, which can lower localization confidence and lead to hesitation.

These observations define our RoboCup 2026 focus: faster defensive response, adaptive action timing, richer motion primitives, more reliable team coordination, and more robust perception/localization in partially observable scenes.

Key Challenges for RoboCup 2026.
We summarize the most critical challenges toward RoboCup 2026 as: richer approach and kicking motions to handle diverse ball poses and opponent pressure; more stable multi-robot coordination to avoid role conflicts and improve support positioning; and more robust perception/localization to withstand occlusions, lighting changes, and temporary loss of landmarks.

For coordination, we aim to improve role assignment and spacing logic so that only one robot commits to ball pursuit while others provide passing options and defensive coverage, even under communication delays.

For perception and localization, we focus on confidence-aware tracking and short-horizon state estimation so the robot can continue moving safely when detections are intermittent, instead of stopping or oscillating.

Addressing these challenges is essential to raise overall match stability and to support more tactical play in RoboCup 2026.

2 Technical Improvements Toward RoboCup 2026

2.1 Defensive Behavior Strategy

To improve defensive reliability, we redesigned the defender's behavior with an emphasis on rapid response and risk reduction. Earlier versions sometimes prioritized precise alignment over immediacy when the ball entered the defensive half.

In the updated system, we use a zone-triggered clearance strategy: once the ball is detected inside a predefined defensive region, the robot suppresses non-essential behaviors and executes a fast clearance kick toward the sideline or the opponent's half. This simplification reduces reaction latency and improves robustness during dynamic, high-pressure moments.

2.2 Adaptive Kick Timing Optimization

We also improved offensive efficiency by optimizing the timing between ball alignment and kick execution. Previously, fixed delays between the adjustment phase and the kick often caused unnecessary waiting or unstable contact when the scene changed quickly.

The new method introduces an adaptive trigger based on real-time readiness: the system monitors ball position stability, robot posture state, and alignment quality, and fires the kick only when the conditions satisfy a compact set of criteria. This shortens the shooting cycle while maintaining stability, improving both speed and reliability.

3 Motion Diversity, Coordination, and Perception Improvements

3.1 Motion Diversity and Team Coordination

To address the limited motion repertoire, we are extending the attacker's set of approach patterns and kick variants, allowing the robot to adapt to different ball positions, approach angles, and defensive pressure. These additional motion primitives increase flexibility in complex offensive situations.

We are also refining cooperative play by improving role assignment and positioning. The updated framework reduces conflicts such as multiple robots converging on the ball and encourages supportive spacing for passing lanes and defensive fallback.

3.2 Perception Robustness

To mitigate blind spots and localization drops caused by occlusions and limited field of view, we enhance perception continuity through confidence-aware tracking and short-term state estimation. When visual information becomes unreliable, inertial/odometry cues help bridge the gap, reducing hesitation and unnecessary stops.

4 Current Implementation Status

The defensive clearance strategy has been implemented and tested in controlled experiments, showing faster response when the ball enters the defensive half.

The offensive decision logic has been updated with the adaptive kick trigger, and additional approach motions are under integration and continuous refinement through repeated scrimmage tests.

5 Research Contribution and Impact

5.1 Research Contribution

Our work emphasizes behavior-level simplification for urgent defense and adaptive action timing for attack. The clearance strategy and adaptive kick trigger are validated through systematic testing and log-based analysis, offering practical methods to improve responsiveness and action efficiency in dynamic game environments.

5.2 Impact

RoboCup provides a challenging benchmark that accelerates hands-on research and engineering training within our university. The project helps students build skills in perception, control, and system integration through iterative experiments on a full humanoid soccer stack.

The team also promotes collaboration and mentoring: members share tools, datasets, and debugging practices, and we actively onboard junior students to cultivate a sustainable research and engineering group for future seasons.

Suggested in-text citations: rules [1], ROS 2 architecture [2], behavior trees [3], localization/estimation background [4].

References

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