ITAndroids Humanoid Team Description Paper for RoboCup 2026

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Abstract. ITAndroids is a robotics competition group associated with the Autonomous Computational Systems Lab (LAB-SCA) at Aeronautics Institute of Technology (ITA). ITAndroids is a reference team in Latin America, having won 91 awards in robotics competitions in the last 14 years. The team has been evolving the robot's hardware and software while participating in many competitions, especially RoboCup and Brazilian Robotics Competition (CBR). This work describes our recent development efforts for RoboCup 2026.

1 Lessons learned in previous RoboCup competitions

1. Annotating images during competition can significantly improve the robot's computer vision performance.
2. Some changes in active vision, such as requiring looking at the ball while kicking and prioritizing scanning the field in a higher neck tilt angle, are necessary to improve the ball's tracking and robot's localization.
3. The introduction of TPU-based damping elements in critical mechanical structures significantly increased the robot's mechanical robustness, reducing misalignment and impact-related damage and increasing field uptime.
4. Uncertainties related to mechanical assembly, calibration procedures, and servo motor gearbox backlash in the real robot introduce systematic errors that negatively affect the accuracy and consistency of the robot's localization.

2 Major problems that the team is trying to solve for the upcoming competition

1. Vision: the robot commonly misidentifies white objects, such as the NAO's feet and white sneakers, as the ball. Moreover, the localization inaccuracy is exacerbated by the angular offsets of the robot's joints.
2. Mechanics: some structural components of the robot tend to become loose over time, especially in regions such as the pelvis and shoulders. Improving the fixation and mechanical robustness of these parts is necessary to maintain calibration and ensure reliable operation throughout a match.
3. Game Controller: a stability issue occurs when the robot starts to play by the Game Controller, causing the robot to fall at the starting position.

3 Plans for the major changes that the teams anticipate to have implemented by the RoboCup 2026 competition

1. Vision: the team expects to (i) retrain YOLO to recognize the adversary and teammate robots and to avoid false positives in ball recognition; (ii) improve the efficiency of YOLO in the Intel hardware.
2. Perception: development of a more accurate calibration for the inertial measurement unit.
3. Localization: design and implementation of tools for calibration and debugging.
4. New robot: construction and testing of the Chape G2 robot.
5. Simulation: transition from the current Gazebo-based simulator to MuJoCo.
6. Mechanical calibration: development of a better joint offset calibration method.
7. Dynamic kicking: dynamic kick behavior so the robot does not need to stop walking in order to kick
8. Odometry calibration: investigation of automatic odometry calibration procedures to mitigate drift and improve long-term localization consistency.
9. Ball tracking: implementation of a multi-hypothesis filter for ball detection and tracking.

4 The implementation status of the changes planned by the time of applying

1. Vision: image annotation and YOLO optimization are in progress.
2. New robot: the MuJoCo-based simulator is under development and close to completion, and it is already being used in the Chape G2 development. The mechanical structure of the new robot is advanced, while the electronic system is still in the schematic design phase.
3. Dynamic kicking: the dynamic kicking behavior, which allows the robot to kick the ball while walking, has been implemented and is currently undergoing debugging.

5 The impact of the team's participation and research in RoboCup

1. The Humanoid Soccer League: The ITAndroids team has contributed to the RoboCup Humanoid Soccer League through continuous technical development, open knowledge dissemination, and competitive benchmarking. Over the years, the team developed and validated solutions for humanoid walking, kicking, perception, and localization under competition constraints [4, 5, 7]. These efforts resulted in scientific publications, partially open source software, and a fully open source Webots humanoid model made available to the league[1].
   The team also actively supports knowledge sharing by participating in league-wide initiatives such as the Bit-Bot Humanoid League Survey[2] and by offering educational activities, including humanoid walking courses taught at national robotics events (BRAHUR 2019 and CBA 2020), with publicly available material[3]. Through consistent participation in RoboCup and regional competitions, ITAndroids also contributes to strengthening the technical level of the league, particularly in Latin America.
2. The team's university/community: At the Aeronautics Institute of Technology (ITA), RoboCup is a central element of ITAndroids' research and education activities, serving as a real-world platform for integrating control systems, robotics, computer vision, and artificial intelligence into a complex humanoid system [9]. Several research projects, theses, and publications developed within the team are directly motivated by RoboCup challenges.
   Beyond the university, ITAndroids promotes robotics education and outreach through online technical content[4], participation in national and international competitions, and technical presentations and demonstrations across Brazil. These activities help train new researchers and engineers and contribute to strengthening the robotics ecosystem in Brazil and Latin America.

6 Contribution to the RoboCup Humanoid Soccer League or humanoid robotics research in general

The ITAndroids team's contributions to the RoboCup Humanoid Soccer League are grounded in research-oriented developments in humanoid locomotion, motion planning, and perception, many of which resulted in peer-reviewed publications and are directly used or planned to be used in RoboCup 2026.

1. Integrated Walk and Kick using Model Predictive Control: The team proposed an MPC-based framework that integrates walking and kicking into a

[1] Open source code and models: `https://gitlab.com/itandroids/open-projects`
[2] `https://robocup.informatik.uni-hamburg.de/en/2022/07/results-of-humanoid-league-survey-2/`
[3] `https://www.youtube.com/watch?v=v2cxlF8oExE`
[4] `https://www.youtube.com/@ITAndroids`

single continuous motion, allowing the robot to kick without stopping its gait [2]. This approach improves kick speed, accuracy, and stability, and directly supports the walking and kicking engines used by the team in RoboCup matches.
2. Minimum-Time Footstep Planning for Humanoid Robots: An MPC-based footstep planning method was developed to minimize locomotion time while respecting robot constraints and handling obstacles through step-over and bypass strategies [6]. This contribution is relevant for fast and precise navigation in dynamic soccer scenarios.
3. Feasibility-Aware Online Footstep Adaptation: The team contributed an online footstep adaptation method that guarantees feasibility of MPC-based walking by locally adjusting step positions, timings, and orientations [1]. This increases robustness to disturbances and modeling errors during humanoid locomotion.
4. Energy-Efficient Humanoid Walking: Inspired by human gait, an extension of ZMP preview control incorporating center-of-mass height variation and curved feet was proposed to reduce energy consumption in humanoid walking [8]. This work supports the development of more efficient and sustainable humanoid locomotion systems.
5. Imitation Learning of MPC-Based Walking Controllers: The team explored imitation learning to approximate MPC-based walking controllers with neural networks, enabling real-time execution with significantly reduced computational cost while preserving performance [10]. This contribution is particularly relevant for embedded humanoid platforms used in RoboCup.
6. Deep Learning-Based Soccer Field Segmentation: A comprehensive evaluation and optimization of U-Net and SegNet encoder–decoder architectures for soccer field segmentation in RoboCup was conducted [3]. This work informs the design of robust vision systems under realistic competition conditions.

These research contributions are complemented by partially open-source software and fully open-source simulation models released by the team, supporting reproducibility, knowledge transfer, and the advancement of the RoboCup Humanoid Soccer League.

Notice that the works listed above correspond only to research results produced in the last two years, reflecting the team's most recent advancements that are directly relevant to RoboCup 2026. The ITAndroids team has a longer history of contributions to humanoid robotics and RoboCup-related research, including additional publications, software developments, and technical innovations not listed here due to space limitations.

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