

Khalifa University Robotics Athletes (KURA): Team Description Paper for RoboCup 2026 Humanoid Adult Size League

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Abstract. Khalifa University Robotics Athletes (KURA) is a student robotics team from Khalifa University, Abu Dhabi, UAE, competing in the RoboCup Humanoid Soccer leagues and regional competitions. The team focuses on advanced humanoid control, perception, and autonomous decision-making in highly dynamic soccer environments. KURA has achieved strong results in both Kid Size and Adult Size competitions, including second place in RCAP 2025 (Adult Size 3v3 and Kid Size 4v4), fourth place at WHROG 2025 (Beijing), and second place in RoboCup 2024 (Kid Size League).

This paper summarizes lessons learned from previous RoboCup participations and describes our current Adult Size system based on a ROS 2 software.

Keywords: Humanoid robotics · RoboCup · Behavior trees · Multi-robot coordination

1 Introduction

Khalifa University Robotics Athletes (KURA) is a student robotics team representing Khalifa University, Abu Dhabi, UAE. The team conducts applied research in humanoid robotics and fieldable autonomous systems and uses RoboCup Humanoid Soccer as a benchmark for real-time decision-making, and perception.

1.1 Recent Competition Results

KURA has achieved the following results in recent years:

- 2nd Place – RCAP 2025 Abu Dhabi, Adult Size (3v3).
- 2nd Place – RCAP 2025 Abu Dhabi, Kid Size (4v4).
- 4th Place – WHROG 2025 (Beijing).
- 2nd Place – RoboCup 2024, Kid Size League.

These results demonstrate a steady progression from Kid Size to Adult Size competitions and validate the underlying software and control architecture.

2 Lessons Learned from Previous RoboCup Competitions

KURA has participated in RoboCup and related competitions since the Kid Size league in 2024. Transitioning these experiences to the Adult Size league has revealed several key lessons.

2.1 Multi-Agent Coordination and Communication

Another key lesson is that team coordination is often the decisive factor in 3v3 matches. Without robust communication and shared state, players may chase the same ball, block each other, or leave the goal unprotected. Our experience led us to introduce dynamic role assignment for attacker, support, and goalkeeper.

3 Adult Size System Overview

Our current Adult Size system follows a modular hardware and software architecture built around ROS 2 and a behavior-tree-based decision layer.

3.1 Hardware Platform

The Adult Size KURA robots comply with the Humanoid League Adult Size by using booster T1.

3.2 Software Architecture

The software stack is organized into multiple layers: perception, state estimation, motion control, and team behavior.

Perception Perception is based on color and geometry-based detection combined with learning-based modules. The robots use a camera model calibrated to field dimensions. The system also includes automatic visual calibration routines for camera pitch, yaw, and height, which are parameterized and updated on-field through the shared blackboard.

State Estimation and Localization The robot pose is estimated by fusing IMU data, odometry, and visual features. Line and goal-post detections update a localization module that runs continuously during matches. Ball position and velocity are tracked in both robot and field coordinates, enabling consistent coordination between robots.

4 Major Challenges and Planned Changes for RoboCup 2026

4.1 Major Challenges

Based on our experiences in RoboCup 2024, WHROG 2025, and RCAP 2026, we identify the following main challenges for RoboCup 2026:

- **Attack path planning under congestion:** The Adult Size field and 3v3 format lead to frequent congestion around the ball. We must plan collision-free, efficient paths for attackers and supporters that account for opponents and teammates.
- **Dynamic role assignment in 3v3:** Roles must adapt quickly to ball position, player availability, and GameController states without oscillations or conflicts.
- **Teammate and opponent differentiation:** Robustly distinguishing teammates from opponents using vision and communication is necessary for passing, marking, and tactical positioning.

4.2 Planned Major Changes

To address these challenges, we plan several major developments for RoboCup 2026.

Path Planning for Attack We will extend the use of `MoveToPoseOnField` and related nodes with a dedicated attack path planner. This planner will generate paths that:

- minimize exposure to opponent defenders while preserving a clear shooting lane;
- incorporate predicted ball motion and GameController phases

Dynamic Role Assignment in 3v3 A refined dynamic role assignment mechanism will score each robot for roles such as striker, supporter, defender, and goalkeeper using:

- distance and orientation to the ball;
- current GameController state and penalties;
- reliability of localization and communication for each robot.

The scores will be shared through the blackboard and network messages, and the behavior tree will update `player_role`, `attacker_id`, and `shadow_id` accordingly.

Teammate and Opponent Differentiation We will integrate camera-based jersey detection with communication signals (player IDs and roles) to reliably differentiate teammates and opponents. This will enable:

- safe and purposeful passing to identified teammates;
- marking and blocking strategies specifically targeting opponents;

4.3 Implementation Status at Submission Time

Table 1 summarizes the implementation status of the planned changes at the time of submission.

Table 1. Implementation status of major planned changes.

Area	Planned change	Status
Attack planning	Dedicated attack path planner	Design and simulation in progress
Defense	Parallel goalkeeping behaviors	Basic blocking behavior implemented
Roles	Dynamic 3v3 role assignment	Prototype based on blackboard entries
Perception	Team/opponent differentiation	Color- and ID-based prototype on-robot
Infrastructure	Extended behavior tree (BrainTree)	Used in RCAP 2026, being refined

5 Impact on League and University/Community

5.1 Impact on the Humanoid Soccer League

KURA contributes to the Humanoid League in several ways:

- **Advanced multi-agent strategies:** Our work on dynamic role assignment, attack path planning, and parallel goalkeeping provides concrete examples of scalable multi-robot coordination.
- **Regional development:** Competing in RCAP 2026 Abu Dhabi with Adult Size and Kid Size teams supports the growth of the RoboCup community in the MENA region.

5.2 Impact on Khalifa University and the Community

Within Khalifa University, KURA serves as a platform for:

- **Student training:** Undergraduate and graduate students participate in perception, control, software engineering, and embedded systems development through project and thesis work.
- **Curriculum integration:** Course projects in robotics and AI use KURA software components and data for hands-on assignments.
- **Outreach:** Demonstrations at university events and local schools use humanoid soccer robots to promote interest in STEM disciplines across the UAE.