# Exploring Humanoid Behaviours and Dynamics

# in a 3v3 Soccer Challenge

Maharaj Faawwaz A Yusran[1], Hoong Dao Jing[1], Muhammad Tareq Adam bin Ellias[1], Chia Jing Hui[1], Zati Hakim Azizul Hasan[1]

[1] Department of Artificial Intelligence, Faculty of Computer Science and Information Technology, University Malaya, 50603 Kuala Lumpur, Malaysia

**Abstract.** We are a team from the Robotedge AI Robotics Lab at Universiti Malaya, specializing in the development of fully autonomous agents for high-stakes, dynamic environments. While our foundation lies in service robotics and ROS-based integration, our current research focuses on the social&services, search&rescue, healthcare and perception including computer vision and machine learning. Having secured the championship in the RoboCup Malaysia @Home category and successfully competed across the 2025 RCAP circuit— including Beijing, Chongqing, and Abu Dhabi—we have transitioned our expertise to the Booster T1 humanoid platform. Our technical approach integrates YOLOv8-based object detection with optimized Inverse Kinematics to achieve stable, agile movement on the pitch. By participating in the RoboCup 2026 Humanoid Soccer League, we aim to refine our decentralized team logic and contribute to the advancement of robust, human-like athletic behaviors. This paper details our progress in bridging the gap between static service tasks and the complex, dynamic requirements of humanoid soccer.

**Keywords:** Humanoid Soccer, Multi-Robot Strategic Coordination, Booster T1 Platform

## 1    Introduction

Robotedge is an interdisciplinary research collective based at Universiti Malaya, integrating expertise from Artificial Intelligence, Computer Science and Mechanical Engineering to push the boundaries of autonomous robotics. While our laboratory's foundation was built on success in service robotics—notably as champions in the RoboCup Malaysia 2024 and 2025 @Home category—we have since pivoted our research toward the significantly more complex domain of humanoid soccer. This transition represents a major technical leap from stable, wheeled platforms to bipedal systems that demand sophisticated dynamic balance, high-frequency gait control, and decentralized multi-agent coordination.

Our team spent the 2025 season aggressively testing and iterating on the Booster T1 humanoid platform across the RoboCup Asia-Pacific (RCAP) circuit, establishing a clear evolutionary path of development. Our campaign began at the RCAP Beijing World Robot Games, where we established the fundamental software-to-hardware interface and focused on baseline walking stability. This was followed by the Chongqing and Qingdao Invitationals, where we refined our hardware configurations and sensor integration to maintain stability during rapid pivot turns. The season culminated at RCAP Abu Dhabi, where we shifted our focus toward advanced player logic, implementing autonomous role-switching and

coordinated positioning. This paper details the technical milestones achieved during this campaign and outlines our ongoing development as we prepare for the global stage at RoboCup 2026 in Incheon.

## 2    Background and Motivation

Team RoboTedge is primarily composed of researchers from the RoboTedge AI Robotics Lab within the Department of Artificial Intelligence at Universiti Malaya. Founded by Dr. Zati Hakim Azizul Hasan, the lab's name reflects its core "EDGE" values: Ethics, Diversity, Green technology, and Engagement. While our early years focused on developing service robot modules—achieving success in the RoboCup@Home Edu 2022 in Thailand and securing back-to-back championships at RoboCup Malaysia 2024 and 2025—these achievements served as a catalyst for a more ambitious technical challenge. Recognising that the future of embodied AI lies in more dynamic and complex environments, we expanded our team to include students from Mechanical Engineering to transition from wheeled service platforms to the high-performance domain of humanoid robotics. This interdisciplinary synergy allowed us to move beyond navigation and pick-and-place tasks toward the demanding physics of bipedal soccer.



**Fig. 1**. Team Robotedge at RoboCup@Home Edu, Bangkok 2022



**Fig. 2**.Team Robotedge at RoboCup Malaysia 2024

**Fig. 3.** Team Robotedge at RoboCup Malaysia 2025

Our transition into the humanoid domain was defined by a rigorous international campaign throughout 2025, where we utilized the Booster T1 platform to test our algorithms under diverse competitive conditions. Our journey began at the RCAP Beijing World Humanoid Robot Games , where we focused on establishing a stable software-to-hardware bridge and mastering the robot's initial gait dynamics. We continued to iterate through the Chongqing and Qingdao Invitationals, where we modified our hardware setup and sensor integration to ensure stability during high-speed maneuvers on the field. This evolutionary process reached a significant milestone at RCAP Abu Dhabi, where we leveraged our background in YOLO-based vision and ROS-based logic to implement sophisticated autonomous player behaviors and real-time strategic coordination. These experiences have shifted our motivation from simple task execution to the mastery of fluid, human-like athletic dynamics. By joining RoboCup 2026 in Incheon, we aim to build upon this 2025 foundation, transitioning from regional contenders to global participants in the pursuit of advanced humanoid autonomy.



**Fig. 4.** Team Robotedge at RCAP Beijing World Humanoid Robot Games



**Fig. 5.** Team Robotedge at RCAP Abu Dhabi

## 3        Robotic Platform: Booster T1

| Category | Feature | Specification |
|---|---|---|
| Physical | Height | 118 cm |
| | Weight | 30 kg |
| | Degrees of Freedom (DoF) | 23 (Legs: 12, Arms: 8, Head: 2, Waist: 1) |
| Actuators | Primary Motors | High-torque Brushless DC Motors |
| | Peak Torque | 130 N·m (Knee/Hip joints) |
| | Feedback System | Dual-encoder (Absolute + Incremental) |
| Computing | Main Processor (Logic/AI) | NVIDIA Jetson AGX Orin (200 TOPS) |
| | Sub-processor (Motion) | Intel Core i7 |
| | Communication | WiFi 6 / Ethernet / CAN Bus |
| Sensing | Vision System | Intel RealSense Depth Camera |
| | Motion Sensing | 9-Axis IMU (Accelerometer, Gyro, Magnetometer) |
| | Joint Feedback | Integrated Position, Current, and Temp Sensors |
| Power | Battery Type | Lithium-ion (24V - 48V) |
| | Operating Time | ~45 to 60 minutes (Competition workload) |
| Performance | Walking Type | Omnidirectional Bipedal Gait |
| | Recovery | Autonomous Self-Righting (Prone/Supine) |

Table 1: Booster T1 Hardware Specifications

### 3.1        Hardware Specifications

The Booster T1 is equipped with **23 Degrees of Freedom (DoF)**, allowing for fluid, human-like movement on the pitch. The joint configuration includes 6 DoF per leg, 4 DoF per arm, 2 DoF for the head (yaw/pitch), and 1 DoF for the waist, enabling the complex weight shifts required for kicking and fall recovery. Each joint is powered by high-torque motors (up to 130 N·m at the knee) with dual-encoder feedback for high-precision posture control.

### 3.2        Perception and Computing

To handle the "fully autonomous" requirements of the HSL, our T1 units utilize a dual-processing architecture:

- On-board Computing: An **NVIDIA Jetson AGX Orin** (delivering up to 200 TOPS of AI performance) serves as the primary vision and logic hub, paired with an Intel i7 processor for real-time motion control and gait planning.
- Sensors: Environmental perception is driven by an **Intel RealSense depth camera** for 3D spatial awareness and ball tracking. This is supplemented by a **9-axis IMU** for real-time balance correction and fall detection.

### 3.3        Movement Capabilities

The T1's motion control system supports **omnidirectional walking** and rapid directional changes, which we have optimized for soccer-specific drills. Its durability allows it to withstand the physical rigors of a 3v3 match, including high-impact falls, with a built-in "self-

righting" routine that enables the robot to autonomously return to a standing position from either a prone or supine state.

## 4     Community Contribution and Refereeing

Team RoboTedge is committed to the sustainable growth of the RoboCup community and recognizes the critical importance of high-quality refereeing in the unified Humanoid Soccer League (HSL). Drawing from our extensive match experience across the 2025 RCAP circuit, our members are well-versed in the official laws of the game and the technical requirements of humanoid competition. We are fully prepared to support the league by providing qualified personnel for the following roles:

- **Court Main Referee:** Experienced members capable of managing match flow, enforcing rules, and ensuring fair play during 3v3 matches.

- **Sideline and Technical Referee:** Team members available to assist with technical inspections, clock management, and sideline officiating to ensure all robots adhere to safety and autonomy standards.

## 5     Conclusion and Future Direction

This paper outlines the technical evolution of Team RoboTedge as we transition from a background in autonomous service robotics to the high-performance domain of humanoid soccer. Through our extensive campaign across the 2025 RCAP circuit—spanning Beijing, Chongqing, Qingdao, and Abu Dhabi—we have successfully adapted our expertise in ROS, YOLOv8, and real-time sensor fusion to the Booster T1 platform. Our participation has demonstrated that the integration of deep learning for visual perception and optimized inverse kinematics is key to maintaining competitive performance in the unpredictable, dynamic environment of a 3v3 soccer match.

Beyond the pitch, RoboTedge remains deeply committed to fostering a culture of robotics innovation in Malaysia through STEM outreach and interdisciplinary collaboration. By sharing our progress in humanoid dynamics with the wider community, we aim to inspire the next generation of engineers to tackle the complexities of embodied AI. Looking ahead to RoboCup 2026 in Incheon, we seek to further enhance our team's strategic synergy and stabilize our locomotion algorithms on the new unified Humanoid Soccer League (HSL) turf. We view this competition not only as a platform to showcase Malaysian robotics on the world stage but as a critical opportunity to collaborate with international peers and contribute to the global advancement of robust, human-like autonomous systems.

### Acknowledgements

### References

1. Quigley, M., Conley, K., Gerkey, B., Faust, J., Foote, T., Leibs, J., Wheeler, R., & Ng, A. Y. (2009). ROS: An open-source robot operating system. In ICRA Workshop on Open-Source Software (Vol. 3, No. 3.2).

2. Robotics, B. (n.d.). Booster T1 | Made for developers. Booster Robotics. https://www.booster.tech/booster-t1/