RoboIME: Skills and Tactics of a Debuting Brazilian Team

Fabricio Asfora Romero Assunção[1], Johannes Elias Joseph Salomão[1], Francisco Nazário Pereira Júnior[1], Vitor Amadeu Sousa[1], Emiliano Carlos Serpa Castor[1], Venicius Rocha Jr[1], Dálet Miranda[1], Renato da Paixão Alves[1], Raquel Belchior[1], Joseph Vieira[1], Daniel Bretherick[1], Rafael Cangussú[1], Fabio Suim Chagas[1], Hebert Azevedo de Sá[1], and Paulo F. F. Rosa[1]

Instituto Militar de Engenharia
Rio de Janeiro Brasil
rpaulo@ime.eb.br
http://roboime.com.br/

Abstract. This article describes the overall information for our participation in RoboCup 2025. At this point, as a newcomer, our efforts are focused on advancing the programming and algorithms of our team for tasks such as skills, tactics, behaviors, control, and deep machine learning. The overall concepts are in agreement with the rules of SPL 2025.

Keywords: YOLOv8 · Quantization-Aware Training · EKF (Extended Kalmann Filter) · SLAM algorithm · Knowledge Distillation · B-Human code

1 Introduction

The RoboIME-NAO team, affiliated with the Laboratory of Artificial Intelligence, Robotics, and Cybernetics (LIARC), embarks on an exciting journey in the field of humanoid robot soccer within the Standard Platform League (SPL) at RoboCup. LIARC has recently acquired 12 (twelve) NAO humanoid robots to establish a foundation for advanced research in Artificial Intelligence and engineering. Figure 1 shows the preliminary tests with the recently acquired NAO V6 platform. Additionally, the team aspires to participate competitively on the international stage of RoboCup SPL. Figure 1 illustrates the first steps with the recently acquired NAO V6 platform during the preliminary tests. This platform serves as the cornerstone for the team's endeavors. RoboIME-NAO is an extension of the RoboIME team [2], bringing prior experience from RoboCup competitions. The team has earned notable achievements in the Small Size League (SSL), claiming the title of vice-world champion in 2018, 2019, and 2022. Furthermore, they secured the championship at the Latin American Robotics Competition (LARC) in 2017 and achieved runner-up positions in 2017, 2018, 2019, and 2022, solidifying their status as regional leaders in the SSL category.

Fig. 1. First steps with the real platform

LIARC's track record in competitions involving humanoid robots has also encompassed participation in the entry-level category of LARC since 2019, specifically in the Humanoid Robot Race (HRR). In this category, RoboIME-NAO achieved back-to-back third-place finishes in 2021 and 2022. Finally, in 2024, we claimed the championship title, securing first place. It is worth noting that the team developed its platform from scratch for the HRR category, serving as an exemplary showcase of innovation and ingenuity in crafting customized solutions. With this history of success and knowledge acquisition over the years, RoboIME-NAO eagerly anticipates tackling the challenges of SPL in the RoboCup. The team envisions making significant contributions to the advancement of robotics research and enhancing the prestige of our AI group.

1.1 Code Usage

RoboIME, as a newcomer, built upon the 2023 B-Human code as a foundation [3]. However, we enhanced ball detection for the Mixed League at the Brazilian Robotics Competition(CBR) by training a machine learning model with a new dataset, leveraging Roboflow. This improvement enabled the robot to accurately recognize both the official Standard Platform League (SPL) ball and the Humanoid League ball, ensuring greater adaptability during matches.

Furthermore, for this edition, we plan to optimize detection under different lighting conditions, thereby increasing system robustness. We will explore advanced computer vision techniques to make recognition even more efficient. Finally, we'll modify the whistle detection system, with the goal of reducing the number of false positives triggered by it. For future editions we will modify the neural network compiler for further reducing latency, allowing bigger and more efficient models to be deployed on NAO, as well as the skills and tactics system for quick dynamic adaptation of the robots to their environments.

1.2 Structure of the TDP

This article describes the overall information for our participation in RoboCup 2025. The article is organized as follows: Previous experiences in robotic competitions in Section 2, the league's literature review in Section 3. Contribution of our team, in Section 4. Conclusions are presented in Section 5.

2 Previous experiences of RoboIME at robotics competitions

RoboIME has earned notable achievements in the Small Size League (SSL), claiming the title of vice-world champion in 2018, 2019, and 2022. In the Latin American Robotics Competition, RoboIME consistently secured two consecutive third places in 2021 and 2022 and one first place in 2024, participating in the Humanoid Robot Race (HRR) league. Although all team members are undergraduate and graduate students of our Robotics Laboratory, both SSL and SPL teams are composed of different students, that dedicate their time to achieve good results in the competition and to accomplish sound academic marks, as well.

2.1 Brazilian Robotics Competition - Entry Humanoid League

The Entry Humanoid League challenges teams to develop humanoid robots capable of autonomous locomotion, environment perception, and interaction with objects, such as the game ball. For this competition, the team designed and built a humanoid robot from scratch. As a result, it was necessary to develop computer vision algorithms for recognizing the field lines, as well as locomotion and control systems to optimize walking and kicking motion. Due to the successful development and integration of hardware and software modules, the team managed to overcome all proposed challenges and consequently secured first place in the competition.

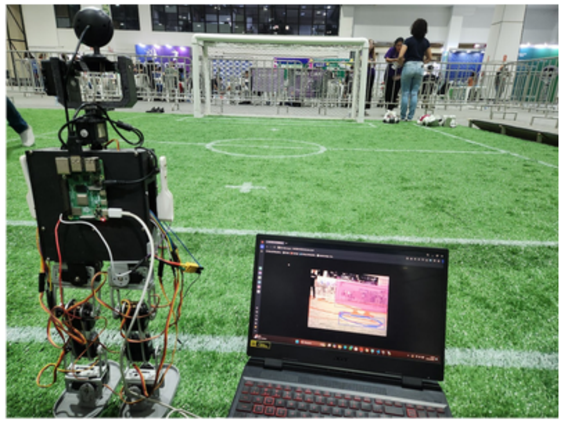

Fig. 2. Entry Humanoid League

2.2 Brazilian Robotics Competition - NAO League

In addition to participating in the Entry Humanoid League, the team also competed for the first time in a category using the NAO robot, a platform widely adopted in international competitions. For software implementation, the team used the B-Human codebase, which was adapted to meet their specific needs. During the competition, we observed that there are very few teams in Brazil dedicated to development with the NAO. Nevertheless, RoboIME secured 1st place. This not only highlights the uniqueness of this category in the national landscape, but also presents an opportunity for growth and innovation in this field.

Fig. 3. Standard Platform League

2.3 Brazilian Robotics Competition - Mixed League

In the Mixed League, the NAO competed against other humanoid robots, facing specific challenges. One of the main difficulties was adapting to the different types of balls used in the competition. The game alternated between the official ball of the Standard Platform League (SPL) and the ball of the Humanoid League. As the use of the Humanoid League ball was not anticipated, the NAO struggled to recognize the ball correctly, which affected its performance. Despite this issue, RoboIME managed to make the necessary adjustments and secured first place in the league as well.

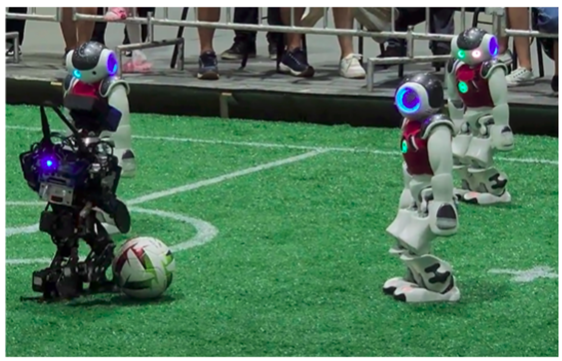

Fig. 4. Mixed League

3 SPL: state-of-the-art at a glance

To catch up with the achievements of the active teams in the league, we have done a comprehensive literature review on selected TDPs and synthesized what we found to be the notorious characteristics of each team (see Table 1).

1. Simulation: SimRobot and Webots are the most popular simulators, widely used by several teams.
2. Behavioral Architecture: The CABSL architecture is common across several teams, providing a framework for behavior control. Some teams also develop their specific architectures, such as the Zweikampf State.
3. Computer Vision: The use of convolutional neural networks (CNNs) is predominant for object detection, especially the YOLO (You Only Look Once) architecture. Traditional algorithms are also used in conjunction with ML techniques, such as random forests and Multilayer Perceptron.
4. Machine Learning: Both traditional algorithms and ML techniques, such as deep learning and neural networks, are employed for different tasks, such as object classification and decision-making.
5. Motion Algorithms: A variety of approaches are used, ranging from phase-based motion generators to trajectory optimization using genetic algorithms. Open-sourcing of code and collaboration between teams are common in this area.

Table 1. Comparative of the related works and methods.

Teams	Simulator	Behaviour Architecture	Computer Vision			Motion Algorithm	Code Usage	Contribution to the League
			Ball detection	Player detection	Field detection			
B-human	SimRobot	CABSL	EKF	Zweikampf	Potential Field	SLAM	rUNSWift (new)	Robocup Symphosium
HTWK Robots	NA	NA	ML	YOLO v3	ML	Nao Motion	NAO Devils(new)	CNN-based whistle detection
rUNSWift	PyBullet	ROS2	MLP	ML	ML	Hengst	NAO Devils(new)	new code
HULKs	Webots	DiTEF	DiTEF/CNN	Yocto	EKF	Rust	B-Human(new)	DiTEF
Nao Devils	SimRobot	Event-based	CNN	YOLO	NA	Dynamic Calibration	B-Human(new)	new code
NomadZ	RaiSim	ROS2	CNN	new algorithm	CNN	rUNSWift	B-Human, rUNSWift (new)	new code
SPQR Team	SimRobot	MCSDA/, CABSL	ML	YOLO	NA	SLAM	B-human (new)	image dataset
Bembelbots	Webots	CABSL	ML	YOLO v3	NA	CABSL	HTWK (new)	robot detection
Berlin United	SimSpark	CNN	NA	NA	NA	New algorithm	own code	other contributions

4 Advancements for RoboIME team

Our team has been developing algorithms to make it possible to achieve sound solutions. The B-Human code release is used as a reference. For the ball detection, a custom quantized tiny-CNN neural network we developed, based on the architecture of MobileNet, is used to detect the ball, as well as the robots and other features of the field, during the match.

4.1 NAO Setup

To streamline the setup of the development and testing environment for our code on the NAO, we propose creating a pre-configured virtual machine image—based, for example, on Windows—that comes with all the essential tools installed and with the build, deploy, and configuration scripts ready for use. This way, simply starting the VM provides a complete system without the need to manually execute each installation or configuration step.

With this pre-configured environment, the entire team will use the same software version and configurations, reducing inconsistencies between developers' environments and eliminating issues arising from configuration differences. Thus, the process becomes faster and less error-prone, allowing the focus to be directed toward the development and testing of our code. This standardized approach also eases future updates, as any necessary changes can be implemented into the image and then re-distributed to all team members.

5 Own Contribution

The RoboIME team aims to debut in the year 2025. Given our previous experience at the Brazilian Robotics Competition, our focus is on finding the best-fitting solutions to known problems encountered by us during our games. We will also address issues reported by BHuman, as we are basing our code on their released code.

Robot Vision We propose a keypoint-based variant of CenterNet, inspired by Objects as Points by Zhou et al. [4]. Unlike its default counterpart, which detects object centers, our variant predicts keypoints such as the head, shoulders, and feet of a robot. This modification enables robust detection under partial occlusion—even if a robot's center is blocked, its presence can still be inferred from visible keypoints. Additionally, this approach enhances orientation estimation by providing explicit directional information without requiring an extra processing step. To ensure real-time execution on NAO's CPU, we apply Knowledge Distillation (KD) to train a lightweight model that maintains the accuracy of a larger one, and Quantization-Aware Training (QAT) to optimize inference speed while preserving detection robustness. This strategy enables efficient, occlusion-aware robot detection with low-latency execution.

Ball Detection Our goal is to minimize false positives in ball detection under challenging lighting conditions while maintaining low-latency inference. In that direction, we will redesign the neural network using Quantization-Aware Training (QAT) for INT8 inference while applying Knowledge Distillation (KD) from a larger YOLOv8 model, allowing the lightweight network to retain high accuracy. Motivated by the recent efficient single-object detection approach from Moos [1], we extend this work with reduced model size and the inclusion of QAT and KD for improved real-time performance. Furthermore, we use the latest methods of data augmentation, including lighting changes and geometric transformations, to further enhance the performance in dynamic field and lighting conditions. The model ensures computational efficiency while the robustness in object detection has increased considerably for RoboCup humanoid soccer.

Whistle Detection One of the primary challenges in whistle detection is the occurrence of false positives, particularly in noisy environments. These false positives significantly impact the accuracy of detection systems, often leading to misidentifications of non-genuine signals. To effectively address this issue, we plan to leverage advanced adaptive filters and machine learning techniques that enable a more precise differentiation between actual whistle signals and various ambient noises.

6 Final Comments

This TDP describes the main initial preparations to enable RoboIME's participation in SPL this year. Most of the programming algorithms are in progress and the team is eager to make a big debut.

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