SABANA Herons

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Abstract. This team description paper presents the technical development and competitive strategy of the Sabana Herons, the robotics team of Universidad de La Sabana, for the RoboCup Humanoid Soccer League (HSL). Our software architecture is built upon the B-Human 2023 Code Release, providing a robust foundation for perception, localization, and motion control. Building on this framework, we address the critical challenge of rigid decision-making under strict embedded computational constraints. Our primary contribution is a significant advancement in perception efficiency: we redesigned the whistle detection system to analyze raw audio data using frequency-focused signal analysis, reducing latency and CPU usage without hardware modifications. Crucially, the recovered computational budget will enable the deployment of adaptive multi-agent positioning strategies. Using Reinforcement Learning, our humanoid robots are going to dynamically adjust their actions in response to teammates and opponents while adhering to HSL rules. We outline our current implementation status for RoboCup 2026 and our plan for open-source dissemination, aligning our work with RoboCup's collaborative mission and driving engineering education in the region.

Keywords: Reinforcement Learning · Whistle detection · Embedded perception.

1 Team introduction

1.1 History and lessons

Sabana Herons is the representative robotics team of Universidad de La Sabana in Colombia. Since our foundation in 2018, the team has built a strong legacy in the Standard Platform League (SPL), competing globally in Australia (2019), Thailand (2022), and the Netherlands (2024). These experiences have allowed the team to grow technically and organizationally while engaging with the global robotics community. In 2019, the team achieved second place in the Challenge Shield category, marking a significant milestone in its competitive history.

Beyond technical achievements, the most valuable result of this journey has been the formation of a resilient learning community that understands failure as an essential step toward innovation. Autonomous robotics constantly exposes to uncertainty, which has taught the team to transform errors into structured opportunities for growth while strengthening collaboration, leadership, and critical thinking. For Sabana Herons, RoboCup is not only a competition but a formative environment where students learn that engineering excellence must be guided by human values, creativity, and a genuine commitment to society.

Over the years, Sabana Herons has also developed strong soft skills that are fundamental to long-term success. Teamwork, leadership, problem-solving, adaptability, flexibility, and effective time management have emerged naturally through continuous collaboration under real-world constraints. The group has experienced significant member rotation since its foundation, and this constant renewal has strengthened our culture of knowledge sharing. Mistakes are not judged; instead, challenges are treated as an opportunity to learn and teach one another.

Lastly, the team has made important research advancements in image recognition on the NAO platform. Researchers from our group have explored methods for sign language recognition embedded in humanoid platforms, developing real-time systems and specialized datasets such as the LSC-54 [4, 3, 2]. Furthermore, this work extends to core robotics challenges, including the development and comparison of neural networks for obtaining inverse kinematics [1]. These researches emphasize the ideals of the group, which are not limited to industrial applications but seek a significant social and cultural impact.

2 Significant Advancement

2.1 Core problem

Traditional positioning methods fall in robotic soccer rely in rigid solutions, with pre-established strategies designed to certain enviromental conditions. Limitations of these approaches have an impact in the dynamics on team response to the positioning of the rival: With none intelligent or adaptive response to the conditions of the soccer game, robotic games fail to play with variable strategies and positioning as human soccer matches are. This fundamental constraint represents a critical barrier for the Humanoid Soccer League (HSL) in achieving human-level performance, particularly in terms of intelligent reasoning and real-time adaptation to game conditions.

Implementing adaptive algorithms to overcome these limitations requires significant computational efficiency. Contemporary advances in artificial reasoning demand a substantial computational budget for a embedded application, as is in this humanoid soccer matches case, to not only work on low latency but also give better performances that constrained ones.

2.2   Proposed solution

The team proposed for the optimization of Central Processing Unit (CPU) and Random Access Memory (RAM) resources a rebuilt of the whistle detection system from the scratch. The algorithm prioritize a signal analysis inside an effective frequency window, taking into account energy ratios for a proper discrimination between nominal noise, such as background, and whistles executed by the judge. By processing raw audio data directly, this approach eliminates computationally expensive pre-processing steps, reducing both CPU usage and response latency. This optimization frees critical computational resources for higher-level reasoning tasks.

With these freed resources, the team can now implement end-to-end Reinforcement Learning (RL) for dynamic robot positioning. The RL algorithm considers teammate and opponent positions to calculate optimal positioning and actions for each robot, following HSL rules. This approach replicates human-like reasoning in soccer positioning, bringing HSL closer to human-level behavior and strategic gameplay.

2.3   Solution status

Current status of the whistle recognizer system rebuild is functional and compatible with our system core workflow which is Bhuman 2023. To this moment the algorithm reports gains in both CPU usage and RAM consumption, each respect deep learning approaches and Fast Fourier Transform (FFT) analisys. Great part of the resources optimization is done by the capabilitie of the proposed algorithm to cut off the necessity of calculate the correlation between the signal and the signes in real-time, because the proper algorithm does not requiere the use of signs for detection and nomenclature. This enables the possibility of implementing the Reinforcement Learning inside the robotic team.

To validate the robustness and viability of the algorithm in real-time conditions, as a proper calibration of the hyperparameters, a dataset near to 2,000 raw audio samples was created with this purpose. The dataset enables a proper benchmark between different approaches thanks to its reality, in which background noise is intended to be the most realistic as a real soccer match, with the consideration of cross-field whistle interference to interpretate the algorithm beahviour from false positives. The dataset is expected to be release as open source to future teams which could want to benchmark their approaches on this specific case.

In the other hand, the creation and implementation of the Reinforcement Learning is on a beta phase. The team is currently working on the creation of the enviroment and simulator, alongside stablishing the bases for futures training in order to validate and start to implement on NAOs robotics.

3   Participation impact

3.1   To HSL

The participation of Sabana Herons in the Humanoid Soccer League aims to contribute solutions that are both technically relevant and practically accessible to the broader community. Rather than focusing only on performance improvements for the own team, we seek to generate tools, data, and methodologies that can support collective progress within the league.

A key aspect of this contribution is the commitment to openness and reproducibility. In addition to the redesigned whistle detection module, the dataset collected and curated for whistle and background noise analysis will be shared with the community. This dataset can serve as a common reference for evaluating robustness and reliability of auditory perception systems under realistic competition conditions.

Furthermore, team's participation brings the perspective of a student-led undergraduate research group operating with limited resources. This constraint naturally drives us toward solutions that are efficient, modular, and relatively easy to implement on existing platforms such as NAO. The team believes this approach complements the work of more resource-intensive teams by offering alternative paths that emphasize practicality, scalability, and real-world feasibility. These contributions demonstrate that meaningful advances in adaptive behavior and intelligent reasoning can be achieved without relying on extensive hardware upgrades or excessive computational budgets.

3.2   To Universidad de La Sabana

Sabana Heron's participation in HSL serves as proof of a laboratory which connects academic reasoning with socially meaningful innovation. Through the competition, the solutions proposed by the team transform theoretical knowledge into concrete technological solutions, all done by undergraduate students. This process follows a pathway: Real problems are identified in the field, prototypes are designed under resource constraints, results are validated on physical robots, and the generated knowledge is returned to the community through open dissemination.

This cycle has become the methodological recipe that guides the research group and represents the university in international scenarios. Students learn that engineering is not only a technical execution, but also an ethical commitment to improve human life. By addressing real challenges with creativity and rigor, the team promotes a vision of robotics centered on service and education, preparing future professionals capable of leading technological projects with both scientific excellence and social responsibility.

4   Acknowledgements

We would like to express our deepest gratitude to the B-Human team for their invaluable contribution to the robotics community. Our work is fundamentally

built upon the B-Human 2023 Code Release, whose robust and well-documented architecture has been the cornerstone of our development. Their commitment to open-source excellence allows teams like Sabana Herons to focus on high-level innovation and contributes significantly to the technological growth of the Humanoid Soccer League.

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