Titãs Da Robótica Team Description Paper 2026

Bernardo Schmiedel Raymundo, Giovany Frossard Teixeira, Gustavo Caldonho, Henrique Frisso Oliveira, Iago Meneses Canuto, João Ricardo Mattedi Cetto

Federal Institute of Espírito Santo, Colatina, Brazil
{bernardo.raymundo, gustavo.caldonho, henrique.frisso, iago.canuto, joao.cetto}@estudante.ifes.edu.br and giovany@ifes.edu.br

Abstract. This document describes the core of the Soccer Simulation 2D team code of *Titãs da Robótica*, a robotics team from the Federal Institute of Espírito Santo – Colatina Campus (Brazil). Over the past year, the team underwent a restructuring process focused on architectural consolidation, along with the introduction of new techniques and tactical behaviors. The main goal of this paper is to present the team's development process by detailing the methods and technologies applied, as well as to analyze the results obtained in recent competitions, highlighting the combined impact of architectural refinements and incremental tactical improvements on overall team performance.

Keywords: RoboCup, Soccer Simulation 2D, Dynamic Marking, kick-in strategy.

1 Introduction

The Robotics Team of the Federal Institute of Espírito Santo - Colatina Campus was created in 2015 under the name Asimov, competing in the Standard Educational Kit (SEK) category at the Latin American Robotics Championship (LARC). In 2016 the group started to compete in the Soccer 2D, Practical and Theoretical categories in Brazilian Robotics Olympics (OBR). In 2018 the project was renamed Titãs Da Robótica.

Also in 2016, motivated by students from the Information Systems course, the team started a focused effort in the Soccer 2D category with the primary goal of applying classroom knowledge to robot development. Programming techniques, match observation, code study, and the application of conventional soccer tactics were employed to improve kicking accuracy, passing, close marking, decision-making, and other key team characteristics.

The team competed for the first time in LARC in October 2016 and won first place; the squad sustained high performance in subsequent editions, achieving top results in 2017, 2018, and 2020, becoming four-time champions in the competition. A restructuring in 2023 prevented participation in that year's championships, but activities resumed in 2024, when the team earned second place at the Brazilian Robotics Competition (CBR) 2024. Building on the developments implemented after that restart, the team later secured the championship title at the CBR 2025.

Historically, the team's code evolution relied on the Gliders2D [2], with many ideas also inspired by the work of teams such as MarliK [3]. Following the 2023 restructuring, several of the team's features and improvements were integrated into Cyrus2D base team [4] aiming to restore and enhance competitive capabilities while preserving the team's original tactical identity. In parallel, efforts were made to introduce new tactical behaviors. As a result of these changes, the team achieved second place at the CBR 2024. Building upon this renewed foundation, in 2025, the team consolidated its developments presented in the team's 2025 TDP [5] and refined its codebase using architectural references from the publicly available and well-established Soccer Simulation 2D codebase, Cyrus Soccer Simulation Team [6], providing a stable platform for further tactical extensions

Furthermore, in an effort to implement new behaviors for the team, recent development cycles focused on incremental tactical and structural improvements. These include refinements in formation design, enhancements in dynamic marking, pressure-oriented behaviors for rapid ball recovery after setplays, coordinated kick-in movements against dynamic marking teams and adaptive defensive wall positioning. The impact of these additions is evaluated through a comparative analysis between the Titans2025 and Titans2026 versions.

2 Codebase Refinement

During the 2025–2026 development cycle, the team revisited its codebase with the objective of strengthening its architectural foundations and facilitating the incorporation of new tactical behaviors. In this context, the public availability of the Cyrus Soccer Simulation Team [6] served as an important technical reference, offering mature architectural solutions and well-established behaviors relevant to the Soccer Simulation 2D league.

Guided by this reference, selected features, structural components, and behavioral patterns were carefully analyzed and selectively integrated into the Titãs da Robótica codebase. At the architectural level, the refinement process was strongly supported by the systematic adoption of established software design patterns, following widely accepted best practices in software engineering, as described in *Design Patterns: Elements of Reusable Object-Oriented Software* [7]. These patterns were employed to improve modularity, separation of concerns, and extensibility, enabling clearer abstraction boundaries between tactical logic, decision-making mechanisms, and low-level utility modules.

As a result, the team achieved a more robust and extensible development environment, supporting faster experimentation, iterative refinement, and reliable validation of new behaviors introduced in the 2026 version. Consequently, this architectural consolidation should be regarded as a supporting factor that facilitated subsequent tactical developments, rather than as an isolated source of performance improvement. The competitive gains observed in recent evaluations arise from the combined effect of this structural evolution and the tactical enhancements presented in the following sections.

3 Enhanced Dynamic Marking

Dynamic marking was initially introduced in the team following observations made during IRONCup 2024, where opposing teams exhibited superior defensive organization in set-piece situations by actively blocking passing lanes through opponent-oriented marking, instead of relying solely on static, formation-based positioning. Although the fundamental mechanism—inspired by methodologies adopted by the RoboCIn team [8]—was successfully incorporated into the 2025 version of the team, its behavior still required further refinement to enhance robustness and adaptability across different match contexts.

In the 2026 version, the dynamic marking system was significantly improved through more precise contextual activation and increased assignment stability. The opponent–player matching process, which remains based on the Hungarian algorithm [9], was refined to mitigate frequent reassignment oscillations, resulting in smoother defensive transitions and more consistent coverage. Consequently, players are now able to maintain their marking responsibilities more reliably, particularly during short-term positional adjustments by opposing players.

4 High-Pressure Formation for Post-Setplay Ball Recovery

Setplay situations often create moments of temporary positional imbalance, during which teams are particularly vulnerable to quick transitions. To address this issue, a pressure-oriented tactical formation was introduced with the objective of rapidly recovering ball possession immediately after opponents setplay executions.

Once a setplay sequence concludes, the team temporarily transitions into a high-intensity pressure formation. In this mode, players are located near the ball area, blocking passing lanes, and interception attempts, while the defensive line advances to compact the playing area and reduce the opponent's available space. This pressure state is maintained for a predefined number of simulation cycles or until possession is successfully recovered.

This behavior is designed to increase the probability of regaining possession in the seconds following a setplay, while minimizing exposure to counterattacks. By exploiting the typically out of formation positioning of the opposing team during these moments, the pressure mode contributes to improved defensive stability and enables faster transitions into offensive phases.

5 Coordinated Kick-In Strategy Against Dynamic Marking

Against teams that employ dynamic marking, kick-in situations often become constrained due to tight defensive pressure near the sideline. To exploit this behavior, a coordinated kick-in strategy was designed to deliberately manipulate opponent marking assignments and create passing opportunities in advanced areas of the field.

Prior to the execution of the kick-in, a nearby teammate performs a decoy movement that attracts the opponent assigned to mark players close to the kick-in location. Due to the activation of dynamic marking, this defender follows the decoy player, vacating the zone near the sideline. As a result, an allied player positioned further upfield—outside the effective range of the dynamic marking —becomes available to receive the ball through a longer, forward-directed kick-in.

This behavior leverages the opponent's marking mechanism itself to reduce local defensive density and open vertical passing lanes. Consequently, kick-ins are transformed into opportunities for progressive play, allowing the team to bypass immediate pressure and initiate attacks in more advanced field positions.

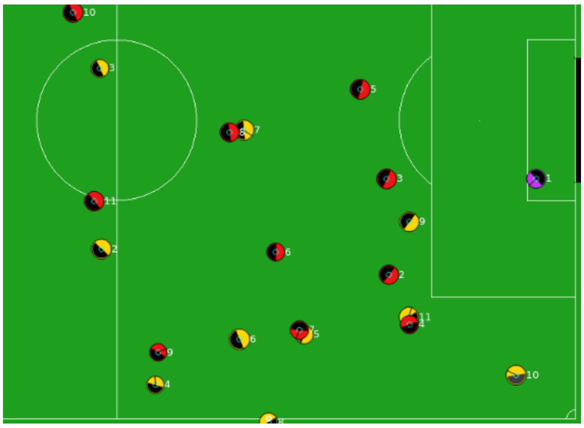

Fig. 1. Coordinated Kick-In Strategy against Dynamic Marking

6 Defensive Wall Enhancement

The defensive wall is a coordinated system in which players are positioned in a line formation and dynamically track the opponent in possession of the ball during specific situations of the match.

A recurring issue observed in the previous implementation of the defensive wall was that, when some players left their assigned positions due to tactical triggers, the remaining structure became fragmented. These departures often created open gaps in the defensive line.

To solve this problem, an improvement was introduced. Whenever one or more players exit the wall, the players that remain dynamically reposition themselves to occupy the vacated spaces. This adaptive reorganization preserves the continuity of the wall and prevents the emergence of exploitable gaps during transitional moments.

By directly addressing the structural weaknesses of the previous wall behavior, this correction significantly improves defensive consistency.

Results

To evaluate the effectiveness of the proposed modifications, an experimental campaign comprising approximately 3,000 simulated matches was conducted. The 2025 and 2026 versions of the Titãs da Robótica team were evaluated against a diverse set of opponents that participated in the RoboCup 2025 competition, including Yushan, Hélios, RoboCIn, ITA, and FRA-United.

Match outcomes were systematically recorded, and the corresponding percentages of wins, losses, and draws were computed. Table 1 summarizes the aggregated results obtained by both versions of the team across this set of opponents.

Table 1. Overall results against the evaluated RoboCup teams

	Titas2025	Titas2026
Victories	15.32%	45.73%
Defeat	64.58%	29.6%
Draw	20.1%	24.67%

This evaluation provides statistically meaningful evidence of the team's performance under a wide range of competitive scenarios, reducing the influence of isolated events or stochastic effects inherent to the simulation environment. By aggregating results across multiple opponents, the experimental setup enables a more robust and unbiased comparison between different versions of the team.

7 Conclusions

This paper presented the main developments carried out during the 2025–2026 cycle and analyzed their impact on the performance of the Titãs da Robótica Soccer Simulation 2D team. The results indicate that the combination of architectural consolidation, selective incorporation of well-established external solutions, and the refinement of internally developed tactical behaviors led to clear competitive improvements when compared to previous team versions.

Rather than a full change of base code, the team adopted a conservative integration strategy, using the publicly available Cyrus Soccer Simulation Team [6] as a technical reference to strengthen architectural robustness and code maintainability, while preserving its own tactical identity and previously validated behaviors.

The experimental evaluation demonstrated a substantial increase in victories and a significant reduction in defeats, providing statistically meaningful evidence that both architectural refinements and tactical improvements positively influenced overall team performance. These results confirm that the adopted development strategy—focused on stability and incremental improvement—was effective.

8 Future Works

Future development efforts will focus on extending the team's tactical repertoire across both defensive and offensive phases, with particular emphasis on coordinated collective behaviors and data-driven decision processes. On the defensive side, one of the planned additions is the introduction of an offside trap mechanism inspired by defensive strategies commonly employed by professional teams in European soccer championships. This behavior will involve the coordinated advancement of the defensive line under specific contextual conditions, aiming to reduce defensive depth, constrain through-ball opportunities, and induce offside situations. Its adaptation to the Soccer Simulation 2D environment is expected to enhance spatial control and improve collective defensive coordination.

From an offensive perspective, the team plans to investigate dynamic unmarking behaviors during attacking phases. In this approach, players without ball possession will adapt their movement patterns in response to opponent marking strategies, actively seeking free spaces and creating additional passing options. By dynamically reacting to defensive pressure, this mechanism is expected to improve ball circulation, disrupt defensive structures, and increase the effectiveness of offensive transitions.

Complementing these tactical extensions, future work will further explore the player selection problem by framing it as a data-driven optimization task grounded in empirical performance evaluation. The proposed methodology involves executing multiple simulated matches against representative opponent teams using different player configurations, allowing the systematic collection of performance data. Aggregated metrics—such as win rate, goal difference, ball possession stability, and defensive efficiency—will be combined into an objective function that quantitatively evaluates the effectiveness of a given lineup for a specific tactical context.

To explore this complex, stochastic, and high-dimensional search space, metaheuristic techniques such as Genetic Algorithms (GA) [10] and Simulated Annealing (SA) [11] will be investigated. Genetic Algorithms are well suited for combinatorial selection problems, enabling the recombination of promising partial solutions through crossover and mutation operators [12]. Simulated Annealing, on the other hand, provides a robust mechanism for escaping local optima by probabilistically accepting inferior solutions according to a cooling schedule, a property that is particularly advantageous in noisy and stochastic evaluation environments [11].

In the proposed formulation, player attributes and role assignments will be encoded as candidate solutions, and the optimization process will iteratively refine these configurations by maximizing the objective function derived from aggregated match outcomes. Neighborhood operators for Simulated Annealing and genetic operators for Genetic Algorithms will be designed to reflect realistic player substitutions and attribute trade-offs, ensuring feasibility within the constraints of the Soccer Simulation 2D environment.

The objective function itself will be progressively refined using statistical techniques, such as regression analysis, to correlate player attributes with observed match performance indicators [13]. This data-driven approach aims to align player selection more closely with the team's evolving tactical style, allowing the optimization process to adapt as strategies and collective behaviors change over time.

Some of these extensions are currently under development and have not yet been fully integrated into the team's competitive framework. Once fully implemented, this approach is expected to improve decision consistency, reduce reliance on manual parameter tuning, and enhance the team's adaptability across diverse opponents and match scenarios, while preserving a coherent tactical structure and enabling more sophisticated collective behaviors in both defensive and offensive phases.

References

1. Hidehisa Akiyama and Tomoharu Nakashima. Helios base: An open source package for the robocup soccer 2d simulation. In Sven Behnke, Manuela Veloso, Arnoud Visser, and Rong Xiong, editors, RoboCup 2013: Robot World Cup XVII, pages 528–535, Berlin, Heidelberg, 2014. Springer Berlin Heidelberg.
2. Prokopenko, M., Wang, P.: Gliders2d: Source Code Base for RoboCup 2D Soccer Simulation League. In: Chalup, S., Niemueller, T., Suthakorn, J., Williams, MA. (eds) RoboCup 2019: Robot World Cup XXIII. RoboCup 2019. Lecture Notes in Computer Science, vol 11531. Springer, Cham, (2019), https://doi.org/10.1007/978-3-030-35699-6_33.
3. Tavafi, A., Nozari, N., Vatani, R., Yousefi, M.R., Rahmatinia, S., Pirdir, P.: MarliK 2012 soccer 2D simulation team description paper. In: RoboCup 2012 Symposium and Competitions: Team Description Papers, Mexico City, Mexico, June 2012 (2012).
4. Zare, N., Amini, O., Sayareh, A., Sarvmaili, M., Firouzkouhi, A., Rad, S.R., Matwin, S., Soares, A.: Cyrus2d base: Source code base for robocup 2d soccer simulation league. arXiv preprint arXiv:2211.08585 (2022).
5. Tissianel, G.G., Campi, G.B., Teixeira, G.F., Oliveira, H.F., Cetto, J.R.M., Souza, V.M.: Titãs da Robótica Team Description Paper 2025. In: RoboCup 2025 Symposium and Competitions: Team Description Papers, Soccer Simulation 2D League, Salvador, Brazil (2025).
6. Zare, N., Amini, O., Sayareh, A., Sarvmaili, M., Firouzkouhi, A., Rad, S.R., Matwin, S., Soares, A.: CYRUS Soccer Simulation 2D Team: Open-Source Code Repository. Available at: https://github.com/Cyrus2D/cyrus-soccer-simulation-team (accessed 2026).
7. Gamma, E., Helm, R., Johnson, R., Vlissides, J.: *Design Patterns: Elements of Reusable Object-Oriented Software*. Addison-Wesley, Boston (1994).
8. Oliveira, C. S., Machado, M. G., Rodrigues, W. M., Araújo, T. S., Cunha, P. V., Labio, R. R., et al.: RobôCIn Team Description Paper 2023 (2023), http://archive.robocup.info/Soccer/Simulation/2D/TDPs/RoboCup/2023/RoboCIn_SS2D_RC2023_TDP.pdf.
9. Munkres, J.: Algorithms for the assignment and transportation problems. *J. Soc. Ind. Appl. Math.* **5**(1), 32–38 (1957).
10. Holland, J.H.: *Adaptation in Natural and Artificial Systems*. University of Michigan Press, Ann Arbor (1975).
11. Kirkpatrick, S., Gelatt Jr., C. D., Vecchi, M. P.: Simulated annealing. Science 220(4598), 671–680 (1983).
12. Goldberg, D.E.: *Genetic Algorithms in Search, Optimization, and Machine Learning*. Addison-Wesley, Reading (1989).
13. Reis, L. P.: *Coordenação em Sistemas Multi-Agente*. PhD Thesis, Faculdade de Engenharia da Universidade do Porto (FEUP), Porto, Portugal (2003).