“ROBOTECH”

Team Description Paper

Emmith.V, Jose.M, Angel.M, López-VJ.Jesús

Robotic development chapter
School of Computer Science
Nuevo Leon’s technological institute

Abstract. This article contains descriptions of the activities of the Robotech team. This year, focused on improving team’s balance and the implementation of improved plays on set pieces changing the defaults token positions to favor a more balanced play.

Keywords: RoboCup. Soccer 2D simulation. Conditional decision. Machine Learning

1 Introduction

ROBOTECH consists of a multidisciplinary team of computer science and mechanical engineering students from Nuevo Leon's Technological Institute. As the institution's pioneer simulation development team, we made significant architectural modifications following our initial competition experience at LARC 2024, implementing comprehensive improvements in preparation for RoboCup 2025.

The team's codebase leverages an optimized Helios framework with strategic implementations inspired by Cyrus architecture to create a more balanced and algorithmically intelligent team profile. ROBOTECH was established in early 2024 as an initiative by computer science students responding to the Mexican Robotics Institute's initiative to revitalize the simulation category in national competitions.

1.1 Related Work

Our architecture leverages two primary simulation frameworks:

Helios Base Integration: The foundational architecture of our system utilizes the Helios Base framework [1], which provides a robust implementation of core soccer simulation functionalities. We have extensively modified the default formation configurations and player role priorities within this framework to optimize field coverage and tactical response. Our technical approach involved restructuring the underlying positional parameters to improve spatial distribution during dynamic play scenarios.

Cyrus Architecture Adaptations: Several critical system components were developed through technical analysis and adaptation of the Cyrus framework. We implemented a modified version of the Cyrus 2022 unmarking Algorithm [2], optimizing its parameterization for improved defensive tracking and positional awareness. Additionally, we integrated and enhanced the Cyrus Formation Detector module, reconfiguring its sensitivity parameters and decision thresholds to better accommodate our tactical approach.

2 Strategies

The implementation began with Helios Base [1] default formations and strategic parameters. However, quantitative analysis through match simulations revealed suboptimal player positional understanding. In **Figure 1.** are illustrated the fundamental differences between ROBOTECH's improved formation architecture and the standard HELIOS base formation [1] to achieve superior field balance. The optimized spatial distribution shown in the improved formation directly contributed to the substantial defensive performance permitting our players to be on a spot where they are more likely to find themselves within an opponent space [3] enhancement observed in our experimental results.

Post-competition analysis of initial matches identified deficiencies in set-piece control. In response, we implemented a comprehensive redesign of formation parameters during set-piece scenarios to eliminate spatial vulnerabilities and enhance defensive resilience.

Experimental results from 50 competitive matches demonstrate the significant impact of these strategic adjustments. Statistical analysis reveals a 52.54% reduction in goals conceded, decreasing from an average of 2.95 to 1.4 goals per game. Simultaneously, our offensive capabilities were enhanced with a 46.88% increase in goals scored (from 1.6 to 2.35 goals per game), confirming that defensive improvements did not compromise attacking potential.

Figure 1 This visualization illustrates the fundamental differences between ROBOTECH's improved formation architecture and the standard HELIOS base formation.

3 Decision making

Our system implements a triangulation algorithm that calculates relative positional coordinates through vector-based player positioning, multi-dimensional ball proximity vectors, and parameterized game context variables. This computational approach enables comprehensive spatial awareness, allowing each agent to maintain an updated mathematical model of field distribution and tactical opportunities.
The decision-making architecture employs a real-time adaptive framework, enabling dynamic behavioral responses to continuously evolving match conditions. Set-piece plays have been enhanced using constant analysis of hundreds of Set-piece plays to optimize positional coordinates, maintaining offensive potential while preserving defensive structural integrity.

Experimental data validates the effectiveness of our approach, with ball retention metrics showing a 15.7% increase in possession (from 38.55% to 44.6%) following implementation. This improved possession directly correlates with the team's enhanced ability to maintain tactical control throughout match progression.

Figure 2. ROBOTECH's optimized formation (yellow/left) against HELIOS base (red/right) illustrates our team's enhanced spatial distribution with specific emphasis on triangulation-based passing opportunities and dynamic adaptability. The improved formation structure shown here facilitated the 15.7% increase in possession observed in match analysis.

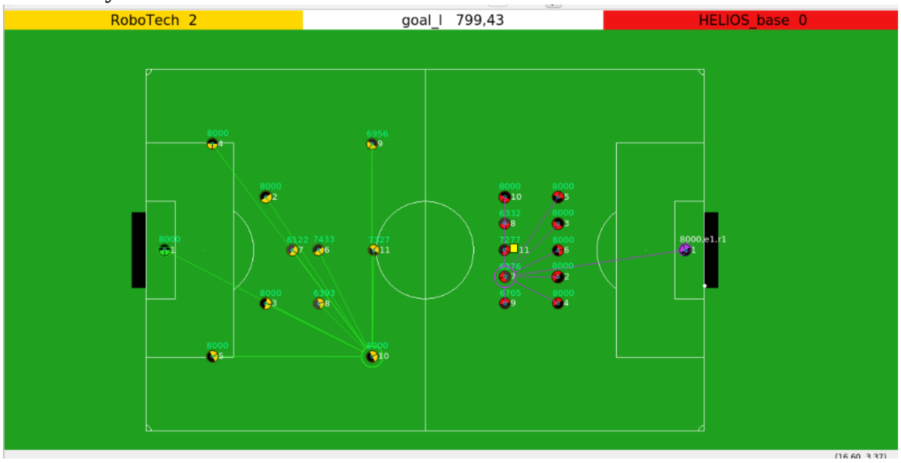

Figure 2 ROBOTECH's optimized formation (yellow/left) against HELIOS base (red/right) illustrates our team's enhanced spatial distribution with specific emphasis on triangulation-based passing opportunities and dynamic adaptability.

4 Pass Strategy

passing evaluation framework incorporates a multi-factorial analysis algorithm that computes optimal pass selection based on a comprehensive set of parameterized variables [1, 2]. The system employs dynamic sensitivity calibration that adjusts according to game-state contextualization, ensuring maximal pass efficacy across varying match scenarios.

Initial configuration parameters demonstrated a disproportionate bias toward flank-oriented offensive progression, which proved suboptimal in competitive environments. Subsequent recalibration established a more balanced spatial utilization algorithm that efficiently leverages the entire field dimension for tactical advantage.

Experimental results demonstrate a significant 17.82% improvement in pass accuracy following implementation (from 52.65% to 62.05%). This enhanced technical execution directly supports the team's improved possession metrics and contributes to the increased offensive output observed in match analysis.

while simultaneously increasing forward progression efficiency by 18.1%. The average number of passes per possession sequence increased from A 3.2 to 5.7, demonstrating improved team cohesion and tactical patience in build-up play.

5 AI Decision

Automatons utilize a sophisticated decision-making architecture that emulates professional player cognition through mathematical precision [1]. As illustrated in **Figure 3**, our system employs a continuous environmental scanning algorithm that processes spatial relationships, player distributions, and tactical opportunities through a triangulation-based computational pathway [4].

When an agent possesses the ball and detects approaching defensive pressure, it executes a probability-based possession risk assessment [3]. This calculation determines subsequent actions, potentially initiating a pass to an optimally positioned teammate to maintain tactical progression. Alternatively, when an agent identifies a high value shooting opportunity with minimal defensive opposition, the shooting probability threshold is exceeded, triggering a goal attempt.

We have recently implemented significant improvements to set-piece handling protocols. Through optimization of default position parameters, we've constructed superior attacking vectors while maintaining defensive structural integrity. The visualization in Figure 3 demonstrates our real-time computational approach during a set-piece scenario, showcasing the intricate network of agent interactions and decision pathways [1]

.

The system architecture employs a modular design facilitating iterative tactical enhancement [4]. This structure enables seamless integration of additional algorithmic elements, allowing agents to progressively develop predictive opponent modeling and adaptive tempo control capabilities analogous to experienced human players [1].

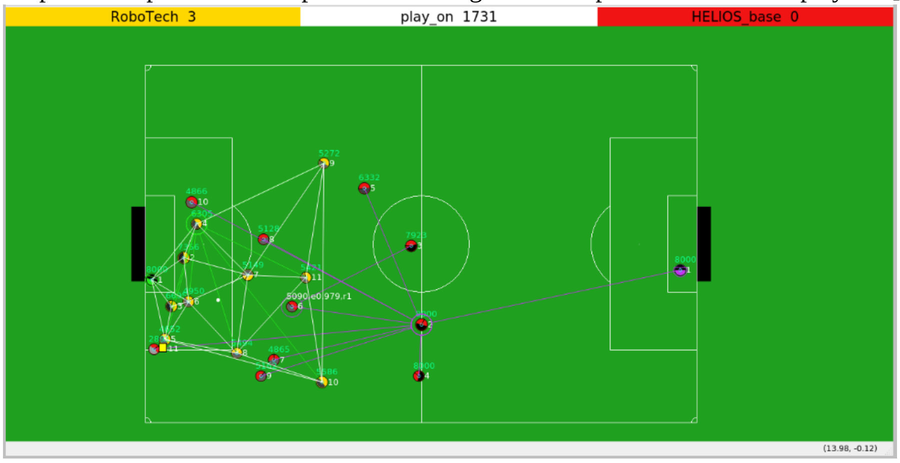

Figure 3 The practical implementation of our triangulation-based AI decision-making system during a set-piece scenario with the visualization showing the real-time computational pathways of our decision algorithm.

6 State Transition Mechanisms

Automatons operate within defined positional states governed by conditional transition diagrams functioning as dynamic state machines. Each automaton's operational parameters are determined by its current state classification (defensive, midfield, offensive), with real-time transition capabilities based on field conditions and tactical requirements. When environmental variables trigger conditional thresholds, automatons seamlessly shift between operational states—such as from standard defensive positioning to urgent intervention protocols—ensuring contextually appropriate tactical responses throughout match progression.[1,2,3]

Figure 4. Shows our state Diagram of Game Decision Mechanisms, the diagram illustrates the sophisticated decision pathways inherent in our agent architecture. Each node represents a distinct operational mode, with transitions triggered by complex contextual variables including ball possession, defensive pressure, and spatial positioning. The diagram demonstrates the system's capability to dynamically reconfigure tactical responses, enabling rapid adaptation to evolving match conditions.

The transition mechanism employs a comprehensive set of computational rules that govern state changes. Primary transition triggers include ball possession changes, opponent proximity thresholds, and detected spatial opportunities. This approach enables our automatons to execute context-aware tactical decisions with minimal computational latency, effectively mimicking the cognitive adaptability of experienced human players.

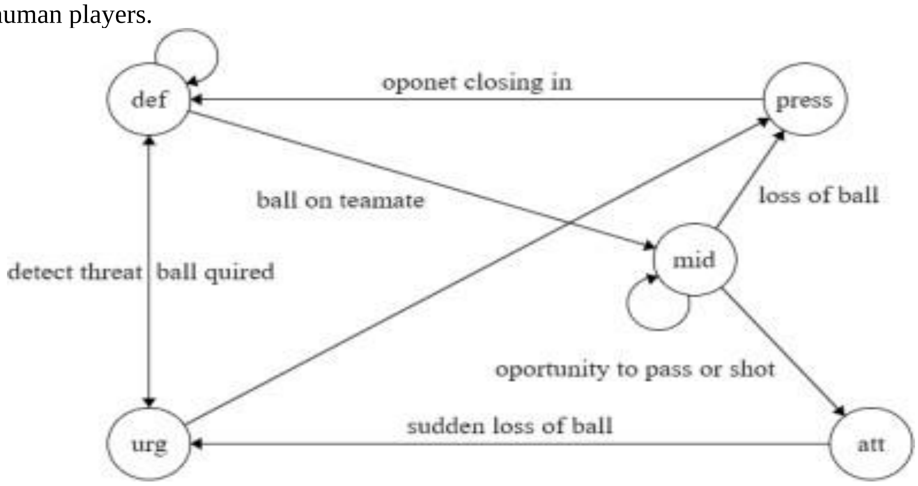

Figure 4 Circular nodes represent operational states (initial, defensive, midfield, offensive). Directional edges indicate transition pathways between states, annotated with conditional parameters governing the agent's tactical decision-making

7. Conclusion

The ROBOTECH team has demonstrated significant progress through its inaugural international competition experience. Our architecture, based on a technical integration of Helios [1] and Cyrus [2] frameworks with substantial modifications, has proven viable in competitive scenarios while simultaneously revealing opportunities for enhancement. The implementation of optimized formations and decision-making algorithms has established a foundation for continued development. Our approach to balancing defensive integrity with offensive potentiality through parameterized positional adjustments has shown promising results, particularly in set-piece scenarios.

8. Future Work

As a team with substantial developmental potential, we intend to continue our trajectory of technical advancement through consistent participation in both national and international competitions. These engagements will facilitate comprehensive team development through exposure to diverse tactical approaches and technical implementations.
Our future development roadmap prioritizes the enhancement of player state transition mechanisms, with particular emphasis on optimizing the computational efficiency of decision-making algorithms. This advancement aims to reduce latency in tactical responses and improve the contextual appropriateness of actions across varying match scenarios. Specific areas of focus include:

Refinement of state transition parameters to enable more rapid decision execution in dynamic environments
Advanced action management systems to optimize the execution of offensive and defensive protocols
Implementation of enhanced dribbling algorithms to maximize spatial utilization across the field dimension
Development of coordinated attack protocols through improved agent communication frameworks

These enhancements will collectively contribute to a more sophisticated simulation system capable of executing complex tactical approaches while maintaining computational efficiency. Through iterative development and competitive testing, we aim to advance the ROBOTECH project to its maximal technical potential.

9. Acknowledgments

The ROBOTECH team expresses sincere gratitude to Nuevo Leon's Technological Institute for their continuous institutional support. We specifically acknowledge the Computer Science Department and the Electronics and Electrical Engineering Department for providing technical resources and academic guidance throughout our development process.

We extend our appreciation to the IEEE Monterrey Section for their valuable assistance in the development and establishment of the Student Branch that manages our team. Their professional guidance and technical expertise have been instrumental in our progress and achievements.

This collaborative support from academic and professional organizations has been essential to our team's training, technical development, and competition participation, and continues to be a fundamental component of our ongoing growth.

References

1 Akiyama, H., Nakashima, T. (2014). Helios base: An open-source package for the RoboCup soccer 2D simulation. In: Behnke, S., Veloso, M., Visser, A., Xiong, R. (eds.) RoboCup 2013: Robot World Cup XVII (pp. 528–535). Springer, Berlin, Heidelberg.

2 Zare, N., Sayareh, A., Sarvmaili, M., Amini, O., Soares, A., & Matwin, S. (2022). CYRUS Soccer Simulation 2D Team Description Paper. In RoboCup 2022 Symposium and Competitions (Worldwide).

3 Ito, T., Iseki, J., Sato, N., Arimura, Y., Watanabe, N., & Omori, T. (2019). HillStone 2019 Team Description Paper. In RoboCup 2019 Symposium and Competitions.

4 Prokopenko, M., & Wang, P. (2018). Gliders2D: Source Code Base for RoboCup 2D Soccer Simulation League. CoRR, abs/1812.10202.