AN INTELLIGENT FRAMEWORK FOR AUTOMATIC EVENT DETECTION IN ROBOTIC SOCCER GAMES

An Auxiliar Tool to Help Coaches Improve their Teams' Performance

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Abstract: In soccer, the level of performance is determined by a number of a complex variables interrelated: technique, tactics, psychological factors and finally, fitness. Because of this, analyzing this information in a real-time, even for soccer experts like professional coaches has become an impossible task. Automatic event detection tools occupy an important role in this reality, although nowadays there isn't any tool capable of producing information capable of helping a professional coach choosing his team strategy for a specific game. In this research project an automatic event detection tool is purposed and, a set of game statistics defined by a group of sports researchers. All the teams present in the 2009 RoboCup tournament have a pass success rate superior to 65%. These statistics provide an interesting viewpoint on how to evaluate a team performance, such as the importance of dominating the opposing team field without losing the control of our own (this can be seen on the top 3 zone dominance statistics). In the future this project will serve as a base for building a Framework capable of simulating a match between two heterogeneous soccer teams and produce reliable information for optimizing the team performance.

1 INTRODUCTION

Soccer is a Collective Sport Game (CSG) where two teams compete to achieve a common goal: to score at least one more goal than the opponent.

During a soccer match an observer/coach is unable to view and process the entire action taking place in all of the playing area. Consequently, when a human observer examines a soccer game, he usually adopts the ball tracking as his selection criteria (Hughes et al., 2001). As a consequence of that, performance analysis tools constitute a key role for improving teams' performance. Such tools are already used to produce individual and collective analysis data (Khatoonabadi and Rahmati, 2009) (Chen et al., 2003). In spite of that, the majority of the extracted information has no direct relation to the team performance. An example of this situation is the calculus of team/player running distance during a match. Although this information is present in many soccer analysis tools, other statistics such as the number of missed passes by a player in a certain region of the field among others, would be a greater contribution when assessing a team performance by its coach. In this research work, an automatic tool capable of calculating statistical information is proposed. This tool would be the base for, in a near future, building a framework capable of simulating matches between two distinct teams. The statistics calculated were defined by a group of academic researchers in the soccer analysis area and the produced tool was used to generate statistics for the 2009 RoboCup soccer simulation 2D league games. The results are quite satisfactory which opens a good perspective in terms of future work. The remainder of this paper is organized has follows: section 2 describes the related work in the soccer game analysis, section 3 presents all the concepts behind the statistics calculus, section 4 exposes the achieved results and in the last section the conclusions are presented and future work trends are discussed.

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2 RELATED WORK

A soccer team is constituted of eleven players (agents) with different individual goals but with a common collective goal (previously mentioned).

Being soccer one of the most popular sports in the world (Dunning, 1999) many researchers have developed tools to study it. In this section these tools were split into three groups: **Professional** performance tools used by real soccer coaches; **Playful** solutions incorporate all kind of video games related to Soccer Management; **Research** software, in particular the ones used in the context of the *RoboCup* simulation league.

2.1 Professional Performance Tools

Today, the competitiveness in professional soccer is higher than ever so, even the slightest detail can influence the match result. In order to achieve that goal professional soccer coaches use automatic tools capable of generating tactical and technical information.In this section four distinct softwares were analyzed (table 1). Three of the four analyzed softwares capture the match images through video cameras.

2.2 Playful Software

The first video games appeared in 1948 (Goldsmith and Ray, 1948), and this industry has been growing ever since. Due to market demands, game developers everywhere have been trying to make their simulations more realistic diminishing the differences between simulation and reality. In this section four soccer manager games were analyzed (table 2). In this reality the online softwares (Hattrick and Planetarium manager) have a huge gaming community and periodically simulate some matches of the European leagues. Although they have a huge number of players, they do not generate a large amount of statistics and the simulation has many random factors. On the other hand we have the offline games which have a good player and team model (football manager). However these models are constructed manually by scouts. Simulation wise, this software has one of the most advanced simulation modes but this model is still based in a pseudo random factors and teams formation which, is not the best way to simulate a match.

2.3 Research Software

For this research work the focus will be specially on the soccer simulation environments (table 3). One of the best known simulation applications is the RoboCup Soccer Simulator 2D. Other softwares like SSIL statistics or team assistant have emerged which have the capability to calculate a huge amount of individual and collective statistics complementing the RoboCup Soccer Simulator 2D.

3 APPROACH

In this section the process of event detection and the events themselves are described. The definition and selection of these events was made according to sport expert panel constituted by academical sport professors.

3.1 Initial Considerations

The statistics are extracted from the 2D competition 2009 logs and, for that purpose the SoccerScope2[1] software was chosen as the base for development. This software reads the logs and creates a list of `Scenes` each corresponding to an instant of the game. This structure allows a sequential analysis of the match which, facilitates the adoption of this software for both offline and online analysis.

3.2 Detected Events

The events listed here were considered the most relevant in the study. Although the events detected in this work are of common use, a brief description of them and, when necessary, the algorithms that allow their detection is included.

Ball Kick. A ball kick occurs when a player sends the *kick* or *tackle* command and the ball is within range $[0, kickable\_margin]$.

Ball Possession. Ball possession is determined by the ball kicks. If the team of the current player is the same as the previous player kicking then the ball possession did not change, on the other hand when this does not hold (they are not from the same team) the ball possession between those two kicks is considered to be $NEUTRAL$. This ball possession data is extended by contextualizing every instant of possession to the region where it occurred, the zones considered are the interception of the *Wings* and *Quarters* field partition. **Wings** is an horizontal partition that divides the field in three equal parts. **Quarters** is

[1]More information online at `http://ne.cs.uec.ac.jp/koji/SoccerScope2/index.htm`

Table 1: Professional performance tools comparison.

Name	Strengths	Weaknesses
Amisco	Statistical treatment of the game (individual and collective level)	The need of a manual treatment of the images after acquisition
		Non-existence of player and team modeling
Prozone	Statistical treatment of the game (individual and collective level)	Non-existence of player and team modeling
		Inability to show the real video feed together with the 2D analysis
Ascensio Match Expert	3D game viewer where the user can see the soccer match (from previously collected	Poor statistical treatment when compared to the prvious software analyzed
Match Vision Studio	Automatic image treatment after acquisition	No model construction of the players and teams despite the statistic data permit

Table 2: Playful software comparison.

Name	Strengths	Weaknesses
Elifoot	First manager software that appeared on the market	Player modeling almost non-existent
		No simulation mode
	Very user-friendly interface	Several limitations on player transactions
Football Manager	Very complete player and teams modelling	Player modelling is done manually
	Existence of a pseudo-simulation mode	Limitied training simulation mode
	Current market leader	Non-existence of a realistic game simulation
Championship Manager	Powerful new talents observation mode	Non-existence of a realistic game simulation
	Very complete players database	
Hattrick	Innovative player transaction system	The game report presented at the end of each game is just a random report generated randomly by the application
	Available online with a big community which makes it more competitive	Very limited players characterization with their parameters filled randomly
		No real game simulation mode
Planetarium Manager	Supports various types of competition not only at a senior level but also at a junior level	Non-existence of team modeling
	Supports several different languages and a large number of leagues	Non-existence of a realistic game simulation

Table 3: Research software comparison.

Name	Strengths	Weaknesses
The Robocup Soccer Simulation	Client/Server Architecture	No game statistics generated
	The players can be developed in any programming language that supports sockets	
	Realistic soccer simulation including some human characteristics	Default 2D viewer is very basic
	Possible to connect both online and offline coaches	
SSIL statistics	Capable of calculate many different game statistics	No simulation mode
	XML statistics output includes a XSLT for convenient HTML visualization online	The set of generated statistics are still incomplete and did not present a good spectrum of team performance
Team Assistant	Both individual and collective statistics	Camera sync not yet perfected
	Realistic 3D viewer	No real game simulation mode
Logalyzer	Capable of calculate many different game statistics	No real game simulation mode
Tao of Soccer	Both team management and game simulation	No game statistics generated

a vertical field partition that divides the field into four equal quarters.

Pass. A pass is when two players of the same team, exchange the ball with each other. One of the players kicks the ball so that his teammate can catch it, if the receiver catches the ball without any of the opponents intercepting the pass was successful on the other hand if the pass is intercepted it is considered a **pass miss**. The pass is considered **offensive** when it ends in the opposing teams *MIDFIELD*. It is a **break pass** when the receiving player of the pass is inside the opposing

team *DANGER_AREA* and has a goal-scoring opportunity. The **goal-scoring opportunity** is defined by creating a virtual triangle having the player and the opposing team goal poles as vertexes (figure 1) and checking if the number of the opposing team players inside are less than two. A break pass is always an offensive pass.

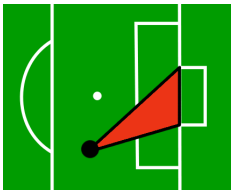

Figure 1: Triangle area in red (the black dot represents the player).

Attack. An attack from a team perspective is when the ball advances in the direction of the opposing team field starting by a kick of one of its players. The attack must last at least 30 cycles to be valid attack. In the attack process if the ball goes back but stays in the last quarter of the opposing team field and in the attacking team possession, the attack remains valid. When the ball reaches the *DANGER_AREA* the attack is classified according to a attacking speed of 0.9ups (units per cycle) or better for a fast attack, $[0.4-0.9]$ups for a medium attack otherwise will be a slow attack. If the ball does not reach the *DANGER_AREA* the attack will be classified as a broken.

Pass Chain. A pass chain is a sequence of passes made by the same team without losing ball possession.

Goal Opportunity. This occurs when three conditions are met. The player is in kicking conditions (the ball is within range - $[0, kickable\_margin]$). The ball is close to the opponent goal. The last condition is that the previously mentioned *goal-scoring opportunity*.

Wing change. This event occurs when a pass starts and ends in different Wings. A wing change from/to the *MIDDLE* wing is considered a *partial* wing change. Two sequential *partial* wing changes represent a *full* wing change.

4 RESULTS

In this section the detected events detected in the RoboCup 2D simulation 2009 league logs will be presented. Due to size limit constraints, the authors adopt to present only a subset of the calculated statistics that where considered to be the most significant ones.

4.1 Zone Dominance

The zone dominance calculates the average ball possession in each field region per team. In the figure 2, the zone dominance of the top three teams in the RoboCup Soccer Simulation 2D 2009 are shown (*Wright Eagle* in red, *Helios20090* in yellow and *Oxsy* in blue respectively). This zone is displayed as if they were attacking from the bottom to the top of the field. As expected all of the 3 top teams have great control over the opponent team field, of these three teams *WrightEagle* is the one that also retains more control in its own field, in particular the middle field. This dominance is closely followed by *Helios2009* and at last we have *Oxsy*. This order is the same as the competition results.

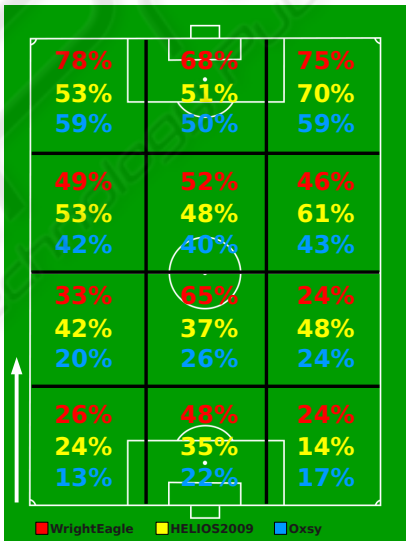

Figure 2: Zone Dominance for the top three tournament finalists.

4.2 Passes

The ratio between the successful and missed passes is calculated and shown in figure 3. Regarding that figure, it is easy to note that even the robotic team that presents the lowest ratio (successful versus missed pass) have a percentage of successful pass greater than 67% of the total executed passes. Comparing this data with the final classification of each team in the latest RoboCup competition, it is interesting to see that the team that presents the best ratio is the champion team (Wright Eagle). However the Bahia 2D team, which occupied the last position in the tournament presents only the sixth worst registry. Also it is

important to note that *Oxsy*, which occupied the third position in the tournament, didn't have a good ratio between successful and missed passed (sixth worst mark), similar to *LsuAmoyNQ* which occupied the fifth position in the tournament and presents the second worst mark. This fact could indicate that this statistics *per se* did not influence directly the final match result.

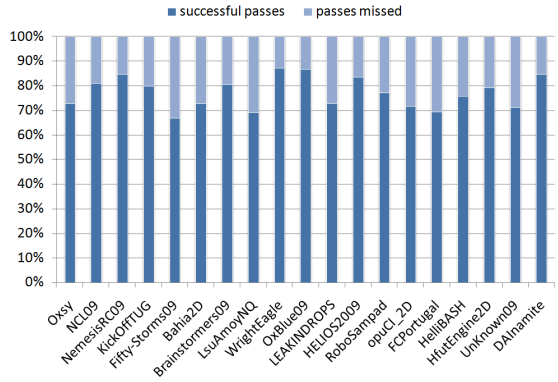

Figure 3: Successful to missed passes relation.

4.3 Temporal Sequence

A temporal sequence is detected when a team has possession of the ball and without losing it, advances in the field with the direction of the opponent goal until it achieves a specific zone called "the last third of the field". This sequence is essentially an attack. Its classification is done according as previously described. The figure 4 shows the calculus of temporal analysis for the top four teams of the tournament. It is clear to note that the main difference between the top three teams is to the number of break sequences over the competition. This indicator can represent that the first team in the tournament (Wright Eagles) has a huge percentage of success in terms of attack in comparison to other teams. Also it is interesting to note that the team in the fourth place team *Brainstormers* presents the lowest value of *Medium Sequence* which is a peculiar characterization of its game.

4.4 Goal Opportunities

The winner of a soccer match is determined according to the final goal difference (scored - conceded). The team that presents the higher goal difference will be acclaimed as the winner of the match. In order to achieve that primary goal, the creation of goal opportunities constitutes a good indicator for a coach to measure his team performance. Observing the figure 5) one can check that three of the four teams that have a large number of goal opportunities, were the three

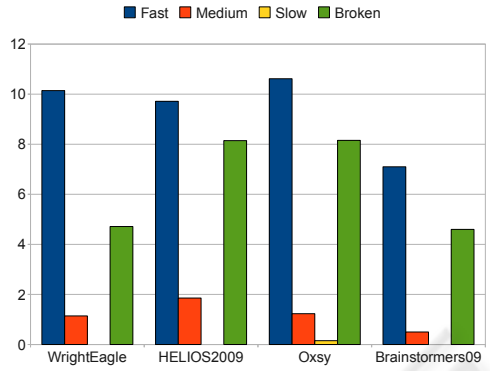

Figure 4: Temporal sequence of the top four teams.

finalist of the tournament and two of them present the higher $(NGoals)/(NOpportunities)$ ratio (up to 40%) in figure 6. Analysing the same figure it is curious to note that the team that presents the best goal success ratio was ranked with the ninth place in tournament (*FiftyStorm team*) which means that in spite of having a higher success rate, the number of goal opportunities is still small when compared to other teams.

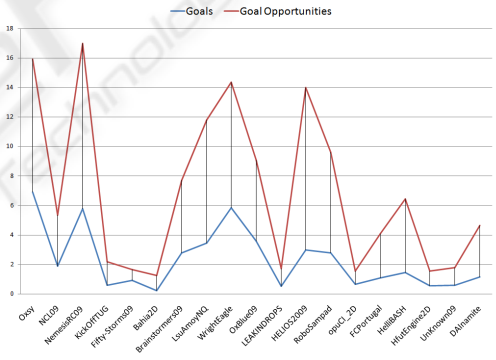

Figure 5: Goals and goal opportunities, per game (average).

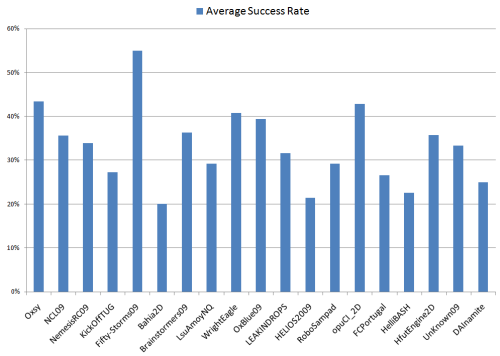

Figure 6: Goal to opportunity ratio.

5 CONCLUSIONS AND FUTURE WORK

In this section the project's main conclusions are drawn based on the results presented in the previous section. In this research an automatic statistical soccer tool is proposed. This tool is capable of identifying soccer events to help soccer coaches improving their teams performance. The set of statistics are defined by a group of sports researchers and the test data used is the RoboCup 2009 tournament – soccer simulation 2D in particular – logs. Similar to other research studies (Castellano-Paulis et al., 2007) in order to detect all of the events, a sequential analysis method was used and proved itself as a good approach for this particular environment.

Regarding the results obtained in the previous section it is important to note that even some of the most simple statistics seem to yield important clues to a way a team plays or some of the characteristics it could improve. One of such statistics is the goal opportunities versus goal scored, in this score the top teams present excellent results. Some other teams such as *Fifty Storm* and *OPUCI_2D* in spite of having a good ratio, still need to improve their creation of goal opportunities over the game. The field zone dominance statistics of the three leading teams suggests that dominating the opposing team field is a must, but what seem to set them apart from each other is the ability to also control their own field. Finally, from the sequence analysis point of view the observed results suggest that the fast attacks are the most important of the bunch. The low number of broken attacks of the *WrightEagle* team also point out that successfully reaching the opponents field can be a distinction factor. It was also curious to note that some important statistics like successful passes to pass misses relation do not seem to demonstrate, by itself, any relation to the final results of the competition. Possible interpretations for this fact could be that the success of the passes is already so high for every team that it loses its' importance or that the statistics should be complemented with further contextual information. Taking into account the project's features then, as referred in previous sections, the next steps of development should focus on three fundamental aspects. The first aspect is the identification of which is/are the statistics (already calculated) that most influence the final result. Off course in this set, for obvious reasons, the scored goals cannot not be considered. The second aspect is the offline match simulation between two distinct teams. The main goal of this is to understand which strategy is better to improve the final game result based on the analysis of specific statistics (previously selected). The authors believe that if a team can use this information before playing a game against an opponent, the changes of victory will greatly increase. The final step of this process is the analysis and identification of strategic opportunities by a team in a competition scenario (real-time/online analysis). This step is preceded by the offline analysis.

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