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Research on RoboCup Simulation 2D Shooting Strategy Based on Digital Twin Framework

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Abstract. RoboCup, as one of the main platforms for studying artificial intelligence theory, is an international academic competition. The shooting strategy is one of the most important skills in the RoboCup simulation 2D competition, which is one of the important branches of RoboCup. In the digital twin framework, this paper focuses on extracted game data from specific teams and establishes portraits of the players' shooting strategies by factor analysis method. The main factor that determines the impact of the shooting strategy from the portraits is the shooting distance feature. Then, by optimizing the shooting strategy of YuShan2019 based on the feedback on the difference of the shooting strategy portrait of each team, excellent performance can be achieved in the actual competition, which indicates its effectiveness.

Introduction

RoboCup simulation 2D competition is a research platform that integrates multi-agent collaboration and confrontation. It provides a fully distributed control, real-time asynchronous multi-agent environment [1]. In the simulation 2D, by capturing a scene which is very similar to human football, the potential correlation between them can be further discovered. For example, through the playback of each player's running position according to the historical position information, their position information displayed in real time is available; through the statistical analysis of the player's physical fitness data, the player's physical state can be monitored in real time to optimize the lineup; through some diversified data indicators statistically analyzed in the game, such as shooting, kicking, tackling, running position actions, passing of the ball, offensive and defensive postures of two sides in the games, the level of competition between both sides can be compared; through many aspects such as the formation changes, stamina management, offensive and defensive conditions as well as the strategies of passing and controlling of the ball, the game can be further analyzed. In this way, the team can generalize a reasonable and effective strategy. Therefore, the combination of human football and simulation 2D research has high commercial value.

In the RoboCup simulation 2D competition, there are various such tactical strategies as shooting strategy, motion evaluation, defensive system, dynamic characters and dynamic movement [2, 3, 4] of players. Among them, shooting strategy is one of the most critical technologies. In order to optimize the shooting strategy, this paper guides the optimization of the team's shooting strategy by the difference between the feedback portraits, which is based on the digital twin framework and combines with factor analysis, then uses the Binary management of the physical layer, the data extraction of the information layer and the portraits establishment of the digital twin layer. Finally, it is proved by experiments that the key factor affecting the shooting strategy is the distance of the shooting points, which indicates the effectiveness of the shooting strategy research by the digital twin framework.

Methods

Shooting Strategy Portraits Based on Digital Twin Framework

In the simulation 2D, each participating team regards the client program written by themselves as Binary. After uploading it, all teams can participate in the competition. Binaries of different teams will show different combat styles according to their specific tactical strategies. The digital twin framework on the simulation 2D platform is defined as: constructing player portraits for the team's Binary by extracting players' basic data from the log files, using the data analysis and mining technology; through the analysis of the differences between the portraits of players, the analytic results are finally used to guide the developers to complete the optimization of YuShan2019 [5].

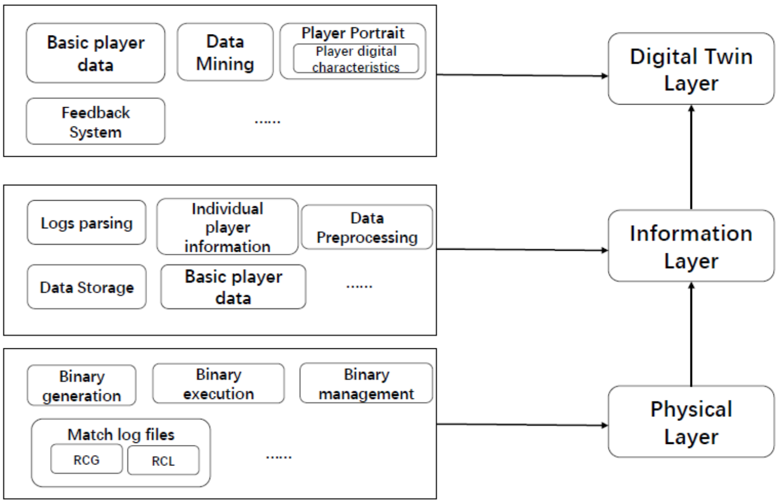

Figure 1. A three-layer architecture of YuShan2019 digital twin framework.

This paper integrates and improves the digital twin framework on the simulated 2D platform (Fig.1), which is the three-layer architecture of the team's digital twin model. The model framework can be divided into three layers from the bottom up, namely the physical layer, the information layer and the digital twin layer.

The physical layer is a collection of activities such as Binary management, execution, optimization, and storage of log files. As the basis of the entire framework, the layer contains three aspects and steps. The first step is Binary management and execution and the generation of the corresponding RCG and RCL files. Among them, the RCG file mainly records the information about the court environment during the whole game, such as the position of the ball, the position of the player and the stamina of the player and the like. The RCL file mainly stores the communication information, including the call information between the players, inter-communication between the players and the coach as well as other related information. The second step is to extract RCG and RCL information and provide it to the information layer for portraits creation of team and players. The third step is to receive feedback from the players' portraits on the digital twin layer, which can be used to optimize Binary, achieve new Binary optimization, and continuous iterative optimization can finally form a closed loop.

The information layer implements data extraction by compiling a parsing program to complete the classification of player behavior information. The information layer extracts the basic information of players by parsing, classifying and storing the log files. In this process, feature selection, data conversion, data regularization, data formatting, data cleaning, etc. are realized, and the preprocessed information is transmitted into the digital twin layer for processing.

The core of the digital twin layer is the establishment and feedback of the players' portraits. The digital characteristics of the team and players include the characteristics of the players' on-the-spot status and behavior. They can be divided into two types. The first type is the single behavioral characteristics of the players, such as the shooting action, the kicking action, the intercepting action, tackling action, turning action and dashing action and so on. The second type is players' cooperative behavior characteristics, such as player formation, offensive-line, positioning, communication and passing of the ball. The digital twin layer receives information from the information layer and creates player portraits by using the data mining algorithm. Then, the differences between the player portraits can be discovered, which should be fed back to the physical layer for guiding the optimization of Binary.

Factor Analysis

Factor analysis is an analytical method for finding the common factor model. By studying the internal dependencies between many variables, the basic structure in the observed data is explored, and its basic data structure should be represented by a few potential variables [6].

In this paper, the KMO test, the Bartlett test and the variable communality test are used to perform factor analysis on the shooting data.

The KMO (Kaiser-Meyer-Olkin) test [7] is an index for comparing the correlation coefficient and the partial correlation coefficient between variables. The KMO statistic should be between 0 and 1. When the sum of the squares of the correlation coefficients between all variables is much larger than that of the partial ones, the KMO value, which is closer to 1, means that the correlation between the variables is stronger. In other words, the data is more suitable for factor analysis.

The Bartlett test [7] is used to test whether the correlation matrix is a unit matrix. When the significance probability is less than 0.05, the questionnaire has a structural validity, indicating that the data is suitable for factor analysis.

The commonality of variables [7], which is the sum of the squares of the loads of all factors on a given original variable, reflects the degree to which all common factors explain the variance of the original variables. If the commonality of most variables is higher than 0.7, the result from the factor analysis should be better.

Experiments

Factor Analysis

This section creates portraits of each team's shooting strategy within the digital twin framework by using the factor analysis method. The Binaries from Helios, Gliders, Cyrus, Oxsy, MT, HfutEngine, and Alice are selected, and play against YuShan2019 for 100 games separately. At the same time, the RCG and RCL data obtained in the log files should be pre-processed, and then process the log files with uniform treatment. In other words, the final data set as the object of modeling analysis is formed from the original data. To this end, this paper writes a parsing program to parse, extract and store basic data such as player behavior information.

This paper extracts 12 characteristics of shooting data from RCG and RCL log files, namely ShootCycle, GoalCycle, Cycle, GoalTeam, X coordinate of shooting point (ShootX), Y coordinate of shooting piont (ShootY), X coordinate of goal point (GoalX), Y coordinate of goal point (GoalY) (i.e. DropPoint), StartSpeed, shooting distance (Distance) (i.e. the distance from the shooting point to the goal point), the power of shooting (Power) and the angle of shooting (Angle). Among these characteristics, the shooting features analyzed in this paper mainly focuses on Distance, StartSpeed, Cycle, Angle and DropPoint, which are represented by X1, X2, X3, X4 and X5 respectively.

The extracted shooting data is used for the factor analysis, and the results of the commonality analysis of each feature are illustrated in Tab.1.

Table 1. Factor analysis of shooting data of different teams.

	CYRUS	CYRUS 2018	Glider s2016	Helio s2017	Helios 2018	MT 2018	HfutEngine 2017
X1	***0.988***	***0.965***	***0.952***	***0.943***	***0.952***	0.868	***0.951***
X2	0.986	0.956	0.946	0.888	0.824	***0.916***	0.864
X3	0.491	0.745	0.829	0.337	0.541	0.515	0.673
X4	0.622	0.829	0.802	0.693	0.648	0.643	0.547
X5	0.004	0.175	0.865	0.817	0.600	0.446	0.800

From Tab.1, it can be found that the variables of the shooting distance from all teams except MT2018 have the highest commonality, indicating that the shooting distance is the primary factor.

Furthermore, according to the difference of the shooting distance, the position of the shooting point can be divided into seven areas, which are Area1—Area7, as shown in Fig.2, and the corresponding areas are represented as shown in Tab.2.

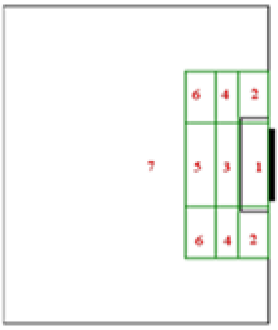

Figure 2. Area division of shooting position.

Table 2. The representation of shooting range.

	X value range	Y value range
Area1	(46.5, 52.5)	(-9, 9)
Area2	(46.5, 52.5)	(-20, -9)∪(9, 20)
Area3	(42, 46.5)	(-9, 9)
Area4	(42, 46.5)	(-20, -9)∪(9, 20)
Area5	(36, 42)	(-9, 9)
Area6	(36, 42)	(-20, 9)∪(9, 20)

According to the divided areas, this paper further analyzes the distribution of the shooting distance of each team. The distribution of the shooting areas of each team is shown in Fig.4. The distribution map of the shooting points of YuShan2019 is presented in Fig.3.

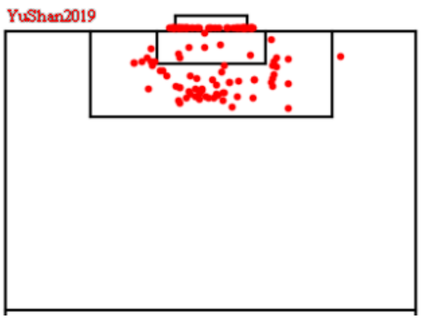

Figure 3. Shooting points distribution for YuShan 2019.

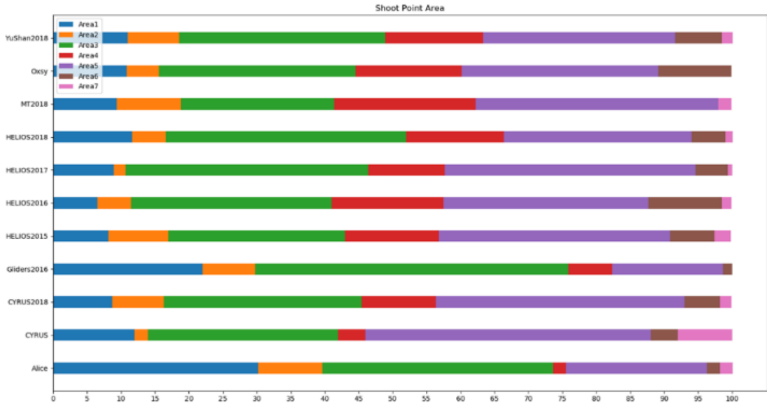

Figure 4. The distribution of the shooting area of each team.

As shown in Fig.4:

(1) The frequencies of shooting points of Gliders and Alice's in Area 1 and Area 3 are much higher than other teams', suggesting that the two teams concentrate in the penalty area for shooting, indicating there is a great similarity in the shooting strategy near the penalty area.

(2) Helios (Helios 2017, Helios 2018) and Cyrus (Cyrus 2017, Cyrus 2018) have more distribution points in the Area 3 and Area 5 than other teams, indicating that the two teams have the similar shooting strategies in the middle. Under normal conditions, Helios' shooting strategy is to find the opponent's defensive gap in the middle and outside the restricted area in order to do breakthrough shooting. Cyrus's strategy is to do shooting by using the bottom-to-middle pass tactics.

(3) YuShan has relatively fewer long-range shootings (such as in Area 6 and Area 7), and more close shots (such as in Area 3 and Area 5). Comparing with the shooting distribution between strong teams, we can discover that their shooting strategy can be found with general similarity.

Therefore, within the digital twin framework, the factor analysis method is used to establish the shooting portraits, which can represent each team's shooting strategy, that is, approaching the bottom line of the restricted area and adopting the effective shooting strategy at close range. By adding the above conclusions to the code, good results can be achieved in actual competition.

Conclusion and Outlook

Based on the research of RoboCup simulation 2D shooting strategy of digital twin framework, this paper establishes portraits for players through the digital characteristics of shooting data. Factor analysis and frequency analysis methods are explored and implemented for the shooting data. After applying the shooting strategy to the optimization of YuShan's Binary, YuShan2019 achieved better performance. For example, our team won the runner-up in the 2019RoboCup China Competition, the championship in the Anhui Robotics Competition and the 4th place in the RoboCup2019 Australia World Cup.

We hope to establish similarity portraits for YuShan's cooperative strategy and explore the essence of more sophisticated and deeper problem as our next goal.

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