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Application of Artificial Intelligence in Soccer Tactical Analysis and Player Performance Evaluation

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Abstract:

Tactical analysis and player performance evaluation in soccer are undergoing a shift from traditional experience-based judgment to a combination of data and theoretical support. This paper systematically reviews and categorizes two mainstream technical pathways and one novel technical pathway in the current field of football analysis: video and computer vision analysis methods, big data analytical methods, and the ecological dynamics method. Exploring the underlying principles, structural mechanisms, and respective weaknesses and strengths of the various technical methods, this paper points out that diverse methods have their own differences in research objectives as well as application contexts and show a high degree of complementation. Moreover, this paper suggests that these ways can be implemented in various areas, such as the assessment of player performance, tactics, and the work with the team in the long-term. Finally, the paper presents the problems of football analytics in terms of data quality, model interpretability, integration of methods, and the development of talent based on interdisciplinary talent. It also describes the future trends of the convergence of various technologies.

Keywords: Artificial intelligence, Soccer tactical analysis, Player performance analysis, Computer vision, Big data analytics.

1. Introduction

Competition in soccer in the last few years has not been limited to the pitch. With the rhythm of the match getting faster, the tactical systems become more complicated, the number of matches and data are growing out of proportion, so in many cases, the difference between the leading clubs lies in their off-field components, such as facilities and technical conditions. A good data analysis team is an absolute necessity in a top club should it desire to win the championships. Total dependency on old manual means of the coaching staff is not efficient and accurate enough. This is why artificial intelligence is

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slowly turning out to become a significant tool in tactics optimization of teams, the evaluation of their players, and the deployment of teams during training, game preparation, and on the field.

The importance of using Artificial Intelligence in soccer is that it enhances the modernization of soccer. Firstly, AI may aid coaching personnel in tactical planning and analysis. As an example, AI can assist the coaching personnel in examining future opponents and offer useful guidance. In addition, AI can detect the shifts in the opposing team formations, offensive or defensive shortcomings during matches automatically. This will allow coaches to make greater and more timely tactical changes that will eventually lead to a win for the team. Secondly, AI can deliver coaching personnel with data-driven, objective, and extremely precise analysis of each player. AI does not only have fundamental data of a player (i.e. next run, passing route, etc.), which is automatically tracked or predicted, but logs all actions during training and games, including shots, passes, and positions. This data will be given to the coaching staff, and they will be able to place more reasonable positions and tactics for each player to make the personal benefits of the players more productive. Lastly, AI can be used to assist coaching personnel in determining which players are most suitable to the current tactical needs of the team, which the clubs will be able to make better decisions when recruiting players.

Over the last few years, more works devoted to the implementation of AI in soccer are being published. As an example, Aliyararov et al. offers a review of the use of artificial intelligence in analyzing soccer matches and player performance, referring to the modern level of development of such technologies as computer vision technologies, big data analysis, wearable devices, and machine learning in the sphere of football [1]. Based on big data and neural network technology, Fang et al. developed a new algorithm that would be used in tactical decision-making in soccer. Moreover, it is suggested to use the long short-term memory networks to improve the existing algorithms to provide new information on how soccer can be applied in combination with computer technology [2]. In this paper, Ferreira et al. apply big data to sports, and the present applications of AI and machine learning to soccer, particularly in terms of performance analysis, are discussed [3]. In addition, they provide the opportunity to see how the ecological dynamics theoretical approach can be employed as an instruction when researching performance and introduce a new spatial-temporal indicator named the density zone.

According to these research papers, the paper will examine the application of various AI technologies and models to soccer, aiming to optimize the tactics (team) and analyze the performance of players. In addition to that, case studies in actual soccer clubs will be addressed in the paper to present more accurate and tangible analysis. Lastly, the paper will conclude with providing the present state of AI technology development in soccer, contrasting the pros and cons of different technologies and models, and suggest future research and development objectives with AI in soccer.

2. Principals Technologies and Models.

2.1 Video and Computer Vision Analysis Technology

One of the most basic approaches in modern-day soccer match analysis is the video and computer vision analysis technology. This technique involves match footage as a source of data with the help of high-resolution cameras and image processing software, so that the computer understands visuals of matches automatically. It converts the video images that were previously seen through the human eye into the form of data that can be calculated, analyzed statistically, and interpreted [4, 5].

The main processes of this technology include automatic identification of soccer players by the computer, which is thereafter tracking the identified soccer players continuously and tracking the soccer. The results of the analysis are represented in the form of visual representations. YOLOv5 is an algorithm of real-time object identification that enables fast speed and quality performance. This approach was based on a huge pool of pictures, such as pictures of participants, balls, and coaches in various behaviors [6-8]. Convolutional Neural Networks (CNNs) are the most renowned and reliable networks when it comes to object tracking [1]. It can follow the identity of players since it identifies their jersey numbers.

There are numerous benefits of this technology. To begin with, video information can vividly record dynamic changes in the process of matches and present real-time statistics. To illustrate, it will be able to capture and document the body positions of players, movement patterns when the player is not in possession of the ball, and general team dynamics. Other technologies can hardly capture this. The decision-making process and strategies in a sport that requires quick results cannot be conducted by using a post-match analysis only [6]. Live-time information analysis and presentation mean real-time insights, which are essential in making decisions during the match [6]. Secondly, this technology is less indirect and more convenient. Like a normal game, coaches can observe the behavior of players entirely, and the results of the analytical work can be overlaid or even mapped onto the original

game footage. Lastly, the technology is a non-invasive technique of data collection. Sportsmen do not have to attach extra gears to their bodies. Therefore, it does not affect the comfort or free movement of players during the competition, which facilitates collecting more realistic game data.

The demerit of this technology is that the systems being developed need expensive equipment, high-resolution cameras, high-bandwidth traffic, and hardware [1]. Reduced video resolution, frame rates, and camera angles can result in broken automatic recognition and tracking. Moreover, real-time and recorded data are impossible to process without the involvement of several operators to track the data of each player and his position [1]. Lastly, the system requires immensely high standards for the environment. This, coupled with unfavorable weather, crowds of people accumulating, or blocking the view of the match, may very easily result in loss of targets or identification of the middle. The primary source of complexity is the regular and rapid movement of players, often in complex routes and interferences with each other [6]. An example is that it is snowing, there is heavy fog, or two or three players are allowed to scramble after the ball.

2.2 Big Data Analytical Technology

The process is recording past games with the goal of players, including the number of passes and shot attempts. After that, a combination of these thousands of data points will be made to analyze and discover some special patterns and trends that cannot be discovered by the human eye.

Data collection is the main process in this technology. It necessitates the data that must be considered in more than one dimension. The data diversity involved in soccer consists of position, video, fitness, training, and skill performance [9, 10]. To discuss the team tactics, it is necessary to have a large amount of data, including various sources, which may be technical competence, physiological level, and team formations, to present the multifaceted processes leading to the tactical behavior [9]. Then, cleaning and sorting the collected data in a way that would be understood by computers. Lastly, apply machine learning algorithms to strategic choices. Indicatively, deep neural networks utilize additional layers of neural networks, hence can give more details on the input and can better depict reality [2]. In the research article, Fang et al. designed a neural network model using long- and short-term memory and proved through the experiment that the algorithm can predict the pass success rate and defensive tackle position [2].

The benefits of this technology are as follows: Firstly, the analysis results are stable and reliable. It is because the data analyzed is considered over the course of a season or even several seasons, and it therefore does not have the chance of making wrong judgments based on the chance results of a given game. Secondly, through this technology, coaches can perform a comparison of performance and trends of their team during various challenges, and to create a macro-level strategy and future strategies.

The demerits of this technology are first place; the data is abstract. The direct reflection of game situations can sometimes be hard. This is because soccer matches are unpredictable due to own goals. And many players, strategies, and maneuvers are involved, making many of the tactics presently available incapable of directly attending to the nature of the game [2]. To ensure the filling of the industry loops, the researchers must develop neural network algorithms that are specific to football sports and consider their peculiarities [2]. Secondly, it has a high dependence on data collection systems and past databases. The results, too, will be unreliable in case the data itself is not accurate and complete, or the historical database is not large enough. The existing systems only depend on information instead of looking at the whole, which may result in the misinterpretation of the game [2]. It is on this account that many coaches still find themselves making more use of their eyes than of data [2]. Lastly, the third concern is the privacy of players. Being caught in some behavioral characteristics may occur, which may not be liked by some players. Moreover, in case of some of the data being leaked to other clubs, the impact it has on their club may be profound.

2.3 Ecological Dynamics Technology

In addition to the conventional approaches that use video or massive competition data, another form of ecological dynamics is based on the same premises. The approach also relates every person or group to the very performance habitat that they are currently operating in, with ecological interactions and not on the non-contextual factors [3]. As an example, a defender will not make rational decisions to make a tackle based on the speed of the ball or the accurate distance to it when making a decision. Rather, it is informed by a general impression as to the prevailing situation in the game. Like, their physical abilities at that time, the ability of the opponent to control the ball, and the spatial environment of the setting.

Ferreira et al. in the research paper, apply ecological dynamics using artificial intelligence and machine learning procedures and present a concept of the so-called density zone. DZ constitute the areas or zones which are marked by clusters of people because of the level of closeness

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who are allocated to a zone [3]. Simply explained, it determines a local spatial territory on which a player or ball position is centered. Then add all the players in this zone, teammates, and opponents. The zone of density is dynamic. It varies depending on the motion of the ball, the formation of the teams, the possession changes, and the changes in the movement pattern of players. There will also be a change in the number, dimensions, location, and internal disposition of density zones.

The benefit of this approach is that it has the potential to examine the behavior, which is more akin to the reasoning of real matches, and describe the decision of players, as opposed to inferring it. Through the position and movement trends of players in various density areas, the coaching staff will be able to gain an even deeper and more intuitive insight into how they make their decision-making and hence find out which of their strengths and weaknesses they possess using the area of high density and the area of low density. The correspondence of ecological processes with AI and ML can help to comprehend the geographically intricate environment, such as football, more effectively and enhance the worth of the analysis to the stakeholders, including athletes, coaches, and managers [3].

The drawback of this approach is that this technology possesses a good theory description, yet tough and challenging to emulate in practice. Considering the case of this method, the highly complex algorithms to dynamically analyze, and it is generally based on high-resolution player location tracking data is generally required. This concept places a lot of requirements on the quality of data, computer algorithms, and the knowledge of the researchers on the match circumstances. Most clubs are also finding it hard to put all these aspects in place. So, a question to research in the future is how to address the practicality of the methodology and preserve the theoretical integrity.

3. Discussion

3.1 Challenge

Even though all methods presented, video analysis approaches, big data analytics, and approaches that rely on the ecological dynamic's theory have their unique benefits in terms of football performance analysis. Nonetheless, in the generalized application, such technologies have demonstrated certain general challenges of practical application.

Firstly, the quality of the data and its collection conditions are very critical to the analytical results. The accuracy and consistency of analysis results, whether it is tolerance of clarity and shooting angles in the analysis of video or the need for high-accuracy track data in the analysis of big data and ecological dynamics analysis is undermined when the conditions of data are not sufficient. This causes the high differences in effectiveness of advanced methods of analysis within the various competition environments and clubs.

Secondly, a certain difference between the results of data analysis and the situation in the real games still exists. Numerous methods of analysis are good at determining macro-level trends but are incapable of analyzing the decision-making processes and on-the-fly modifications that can take place during matches. Such abstraction makes it difficult to apply the results of the analysis directly to the tactical decisions, making both the simplicity in their application and their dependability less definite and certain.

Third, analytical processes are so elaborate that it becomes a hindrance to realistic use. Although theory-based methods like ecological dynamics are potentially beneficial in characterizing the processes of behavior, their execution usually presupposes complex model formulation and choice of advanced data processing involved, which is not always possible in actual football contexts.

Lastly, the lack of talent of a multidisciplinary nature also limits the development of football analytics. A delicate deployment of these methodologies is not only the solid data analysis and technical expertise but also the awareness of the context of the football match and its logic of tactics, which is not yet abundant in researchers or analysts.

3.2 Expectation

These challenges can be mitigated by employing a number of directions in future studies of football performance analysis. To begin with, as the data collection technology and computing capabilities are improved, the match video quality and accuracy of the player tracking will also proceed to improve. This will give them a more solid support of data to be used in the different modes of analysis and reduce the technical input of applying them in practice.

Secondly, analytical results should put more emphasis on interpretability and their practical usefulness in future studies so that data analysis may inform coaching practice and player development in a more direct way than just performance metrics based on models or statistical findings.

Moreover, the intersection of various methods of analysis will become one of the trends. By combining the video analysis, big data analytics, and ecological dynamics approaches, a more comprehensive and systemic framework of football analysis may be built.

Lastly, the enhancement of interdisciplinary collaboration and multidisciplinary talent should allow overcoming the

disconnection between technological study and football practice and continuing the development of artificial intelligence in tactical analysis and the evaluation of players' performance.

4. Conclusion

In this paper, the mainstream research approaches in the analysis of football matches today are systematically reviewed and discussed with reference to the works built on the video analysis, big data analysis, and ecological dynamics theory. By classifying and contrasting the literature available, the paper notices that various technical methods have quite peculiar features of data sources, the objective of the analytic method, and focus on research, contributing to the development of modern football.

To begin with, approaches to video analysis can reconstruct match sequences in a visual manner, and their primary usage is for match review, training, and technical skills. Second, big data analytics assists in determining long-term tactical tendencies, primarily applied to the evaluation tactics that are sustained, prior to match preparation, and decision assistance. Finally, the ecological dynamics approach is theoretically justified to explain the mechanism of player behavior and team tactical group formation, which has been largely used to explain the dynamics of player choice to play and collaborative dynamics within a team.

All in all, these three technical approaches are not exclusive to each other but are instead characterized by a certain degree of complementary and interrelatedness. The football clubs can adequately implement all three approaches to improve the overall competitiveness at various levels, such as management of the team, decisions of the coaches, and development of players. These technologies have greatly advanced modern football to more scientific levels and the systematization of its development. Analytical research in football in the future should not be limited to the enhancement of one technology, but focus on combining the approaches to analysis as much as possible. At the same time, it is necessary to develop high-level, multi-disciplinary talents who can not only know and enjoy football per se but also have skills in data analysis and application. It is at that point that researchers can lead the permanent advancement and growth in such fields as tactical analysis and evaluation of players' performance using artificial intelligence in football.

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