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Review Article

Exploration of Intelligent Coaching Systems: The Application of Artificial Intelligence in Basketball Training

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Abstract

Basketball was invented in 1891 by James Naismith, a professor of physical education in Springfield, Massachusetts. It has a history of 130 years and is one of the most popular sports in the world. In the United States, the number of people who have played basketball at least once in a year in 2021-2021 will exceed 27 million people per year. The International Federation of Basketball Associations estimates that at least 450 million people around the world participate in this sport. In my country, the general basketball population in China is 125 million, accounting for about 1/4 of the total global basketball population, and the core basketball population is 76.1 million. It can be seen that basketball Sports are very popular in our country. The National Basketball Association (NBA) game is recognized as the highest level of professional basketball in the world. From 2001 to 2022, the total revenue of the NBA league will reach 10.02 billion US dollars. In recent years, many new technologies have been applied to basketball training and competitions. The "14th Five-Year Plan for Sports Development" issued by the State Sports General Administration in October 2021 clearly stated that information technology is widely used in the field of sports. The 14th Yao Ming, deputy to the 1st National People's Congress and chairman of the Chinese Basketball Association, said that Chinese basketball should take the "digital road". The digitalization of artificial intelligence is of great importance to improving the technical level of athletes, reducing sports injuries, enhancing game enjoyment, attracting fans, and promoting the development of basketball-related industries. significance. Artificial Intelligence (AI) is a branch of computer science that enables computers to perform tasks that normally require human intelligence. Machine learning is a subset of artificial intelligence that automatically improves the performance of computing programs by learning patterns in data and has been successfully applied in various fields. The advantage of artificial intelligence is that it can quickly analyze and process massive data, and data analysis methods are continuously improved, enabling users to obtain important information that is difficult to obtain by manual methods. It is without a doubt one of the most promising technologies for the future of humanity, and its benefits are extending to the world of sports. This article provides a comprehensive overview of the application of artificial intelligence in the field of basketball.

Keywords: Sports intelligence; artificial intelligence; sports training.

1. Application of AI technology in competitive sports

AI technology is changing the way sports refereeing is done, especially in ball games that require high speed and precise judgment. Because AI technology can accurately track the position of the ball, even down to the millimeter level, it can provide very accurate coordinates of the center of the ball. When the ball goes out of bounds, the AI technology can compare with the preset limit data, and then use digital and sound warnings to prompt the referee and display the specific position of the out-of-bounds. First of all, in ball games, AI is used as a boundary digital monitoring system to assist referees. It can be more accurately judged whether the ball is out of bounds, mainly through the computer real-time vision system to continuously capture the spatial position information of the ball in real time and calculate the coordinates of the center of the ball. The captured trajectory is generated by an algorithm into a three-dimensional image to be presented on a large screen.

In addition, in sports such as gymnastics, due to the complexity of its rules and the subjectivity of scoring, the development and application of artificial intelligence referee systems have also received extensive attention. For example, the gymnastics referee system developed by Japan's Fujitsu is changing the way of judging the vaulting event. This system uses

infrared technology to project 2 million infrared points to the athlete and its surroundings, track the movement of the athlete in real time, and convert it into a three-dimensional image. The core of the system is "skeleton recognition technology", which can analyze the rotation, twisting and other movements of athletes, and accurately measure the angles of joints such as elbows, shoulders and knees. Then, the system will judge the technical completion based on the stored game data and scoring standards. The goal of this system is to eliminate referee bias due to the inability of the human eye to accurately measure joint angles by precisely tracking the player's movements and joint angles. The error of this system is reported to be less than ±1 cm. It's an example of the perfect combination of technology and sport that is expected to revolutionize the fairness and accuracy of gymnastics competitions. Similarly, at the Beijing Winter Olympics in 2022, China also demonstrated the combination of AI technology and sports referees. The Beijing Winter Olympics used the "Figure Skating AI Assisted Scoring System 1.0" independently developed by China, which realized the stability and visualization of competition judgments and provided important auxiliary functions for the scoring of the technical group. Artificial intelligence technology is being widely used in all aspects of sports. For example, through cameras and wearable sensors, computers can accurately obtain sports data and physiological data of athletes during training or competition. China first established the first "digital physical training laboratory" in Beijing in June 2016 at the Beijing Institute of Sports Science, applying the world's advanced sports science and physical training theory, through the self-developed physical training management platform. Functions such as status assessment, real-time monitoring of training quality, key data collection, and training information sharing in physical training (use AI technology to analyze these data). Daily training data also requires high-quality coaches to analyze these data to make targeted suggestions. This traditional training will not only consume a lot of human and financial resources, but may also cause athletes to overtrain due to incorrect data collection, resulting in sports problems. Injury, which seriously limits the possibility of athletes hitting higher competitive arenas. In response to this situation, a batch of AI technologies are introduced and developed to collect and supervise athletes' daily training, which can not only help coaches develop personalized training plans for athletes, but also help coaches formulate the best game strategy.

For athletes, maintaining a healthy body is crucial. Artificial intelligence technology has become a core part of the sports team's medical toolbox. It can not only arrange regular physical examinations and analyze health indicators for athletes, but also track physical conditions through the combination with wearable devices to prevent health problems and sports caused by overtraining. harm. Through artificial intelligence technology and big data analysis, it is possible to objectively evaluate athletes' performance records, physical conditions and sports parameters, etc., to help teams recruit the most suitable athletes. In recent years, Chinese athletes represented by Liu Xiang and Su Bingtian have continuously made breakthroughs in sprint competition. While introducing advanced training concepts from developed countries, they have also systematically introduced Freelap timing system, Keiser strength training, BSXinsigh, muscle oxygen monitoring, Polar heart rate monitoring, Cosmed gas metabolism monitoring and other advanced wearable training analysis and evaluation instruments. Real-time detection and feedback of human body activities through internal sensors, evaluation of training effects such as muscle strength, speed, body coordination, etc., while breathing , heart rate, muscle oxygen, blood lactic acid and other sign information for quantitative real-time monitoring and analysis, so as to monitor athlete fatigue, prevent training injuries and formulate scientific physical recovery and training plans. Sports event broadcasting is an important part of the sports industry. Artificial intelligence-based software and hardware devices can automatically extract and generate game highlights, and combine virtual reality, augmented reality and mixed reality technologies to enhance the audience's experience.

2. AI technology in basketball games

The individual physical abilities of basketball players can be easily tested in laboratory conditions, but team performance must be observed in actual games. It is difficult to use artificial methods to evaluate the overall performance of a basketball team. In 2007, Perse *et al*., proposed an artificial intelligence method using Bayesian networks to automatically evaluate the performance of teams and players in games. Through the analysis of 63 real trajectories, they found that when the player's real activity type is consistent with the basketball suggested activity type When matching as an expert, the score will be tripled. In-depth analysis of the graph structure of Bayesian networks can also help coaches find and eliminate the causes of poor performance in specific activities. In another study, Wu used a neural network-based fuzzy comprehensive evaluation method to comprehensively evaluate the offensive and defensive capabilities of the 12 women's basketball teams in the 30th Olympic Games. The comprehensive evaluation results are consistent with the actual competition rankings. K.P *et al*., analyzed player position data recorded by the Ubisense tracking system during a basketball game using a method that fuses a self-organizing map (MSOM) and a general dynamic control network. The results show that both methods are effective in identifying players' tactical patterns. In order to identify the key factors that affect the outcome of basketball games, Cene conducted an analysis of the 2016-2017 Euroleague season. Using cluster analysis, games were divided into three groups based on final score differences, and then Bayesian model averaging

was used to identify key candidate variables. Finally, a conditional interference classification tree is built for all matches. The classification tree results show that true shooting percentage, steals, and fouls are the main factors that determine the outcome of a close game. In addition, 2-point shooting percentage, 3-point shooting percentage and defensive rebounding are also key factors. Leichter *et al*., The relationship between the game performance and 12 team performance indicators in the men's and women's basketball competitions of the 2004-2016 Olympic Games was studied, and the interference classification tree was used in the binary logistic regression and conditional analysis. The results showed that "shooting percentage", "defensive rebound The combination of ", "mistakes" and "steals" can effectively explain the results of the game, and the conditional interference classification tree method is more practical. Essential guidance for designing training and competition strategies. Heaven and others. Developed a machine learning model to automatically identify and classify offensive and defensive strategies by analyzing tracking data from entire teams in a basketball game. Li *et al*., used a dataset of player and ball trajectories from nearly 630 NBA basketball games in 2012/13 and showed that Support Vector Machines (SVM) was the best machine learning solution with a classification accuracy of 68.9%. The technology helps coaches guide player training, formulate game strategies and team tactics. Automatic analysis of sports video data, such as technical statistics data collection and tactical analysis, is very important for teams to formulate appropriate game strategies. In 2010, Xing Jiang *et al*., A solution is proposed for tracking multiple highly dynamic and highly interactive players in football, basketball and other sports videos. The algorithm is based on progressively built-up observations and adopts a unified dual-mode bidirectional Bayesian inference method to express the multi-object tracking problem. The method has achieved satisfactory tracking results in many typical real-world sports videos, and the authors believe that the method can also be used for automatic analysis on the spot. Hojo *et al*., used a 3D optical motion capture system with six cameras to record temporal and spatial data of the player and the ball. Based on the analysis of video data, they proposed an automatic identification system for strategic coordination. In this study, a set of video data was collected from 10 male players of Japan's top college basketball teams. The players are divided into two teams and take turns to play a five-on-five half-court basketball game. The real game data came from an international competition held in 2015, and they analyzed the data with support vector machines (SVM). The results show that the method can classify cooperative play in various situations on stage. Preliminary analysis suggests that this technology plays an important role in the field. Yin *et al*., introduced a system that can automatically identify and track the trajectories of players and basketballs in basketball games. The system can perform real-time analysis on the basketball game video captured by the dynamic change of the camera angle, such as the public live broadcast video of the NBA game. The AI algorithm used in the system is a convolutional neural network. The system can also recover any lost trajectory information from motion history extracted from previous video frames. The author believes that although the accuracy of the system needs to be further improved, the system can effectively reveal the key determinants of team performance and help coaches design better game strategies. In a recently published review paper, Vangelis *et al*., summarize the statistical metrics used by the NBA and European leagues to evaluate basketball team and player performance. These basketball indicators can be used for the improvement of athletes' careers, team composition, assessment of the strength of the team and opponents, tactical optimization, and prediction of game results. In addition, the authors speculate that in the future analysis of basketball sports, the use of machine learning and data mining techniques, combined with data obtained from wearable sensors and cameras, will significantly improve the level of sports analysis.

3. AI 分析篮球运动员的表现

At present, the evaluation methods of basketball players mainly rely on the experience of the coaches, and lack of objective evaluation methods. In 2013, Lu established a radial basis function neural network comprehensive evaluation model based on physical fitness (100-meter running, 5.8-meter x 6 shuttle running, standing long jump, running vertical jump, etc.) Skills, comprehensive passing and layup, comprehensive dribbling, etc.). The model can help coaches monitor and adjust the training of young basketball players. In another study, Huo described a system that uses wireless three-axis accelerometers and machine learning to evaluate a basketball player's performance on the court. The improved Bayesian algorithm and fuzzy comprehensive evaluation method are used to establish the athlete value evaluation model. The author used this method to evaluate the dribbling ability and shooting percentage of 492 young male and female basketball players aged 18-20. The results show that the model has better evaluation results and fairer value distribution compared to the trainer's results. Fans are closely watching the prospects of the NBA's annual draft and predictions for the future performance of these prospective players. Cannan *et al*., The 2009-2014 NBA draft data and the performance of these players in 174 NBA games were analyzed with random forest classification. The results show that college league performance is a success factor for players in the NBA draft. In 2010, For Prediction of NBA Game Results Miljković *et al*., A data mining technique is proposed to solve this problem. They converted the problem of predicting the outcome of the game into a classification problem, compared several classification methods, and found that the naive Bayes classifier provided the best test results. They used the system to predict 778 NBA

league games in the 2009/2010 season and correctly predicted 67% of the games. In another study, Cao built a model to predict the outcome of NBA games using a simple logistics classifier, artificial neural network, support vector machine, and naive Bayesian algorithm. Five regular NBA season datasets are used for model training, and one regular NBA dataset is used for model evaluation. The results show that the simple logistics classifier has the highest accuracy rate of 69.67%. P *et al*., developed a hybrid model combining SVM technique and decision tree approach to analyze NBA game results. The forward reasoning function of the model can be used to predict the result of the game, and the reverse reasoning can provide the necessary factors for the coach to adjust the game strategy. The empirical results show that the model can obtain a relatively satisfactory prediction accuracy (85.25%). Horvath *et al.,* Comparing seven different classification machine learning algorithms to predict NBA games based on 13 fundamental characteristics related to team performance, such as 3-pointers made/attempts, 2-pointers made/attempts, and free throws made/attempts the result of. They validated the predictions with two validation methods (Train and Test and crossvalidation). The results showed that the machine learning algorithms produced similar predictions, but the nearest neighbor algorithm achieved the best results. Cross Validation is a better validation method. Better predictions can be made using the latest data. However, the best prediction results can only reach 60%, which may be due to the limited features used for prediction. Ozkan introduced a hybrid intelligent system called a concurrent neuro-fuzzy system. The authors reported that the system had an accurate prediction rate of 79.2%. During the 2013-2014 season, the NBA installed cameras and tracking software systems throughout. 30 arenas. These systems allow the coordinates of all players and balls to be recorded and processed digitally. Through the analysis of tracking data, every aspect of the game can be quantified, including every pass, every screen, and every defensive rotation. Skinner *et al*., A network model is proposed to analyze the relationship between individual player skills and the team's success in different competitions. This method automatically learns player skills by analyzing player tracking data, and then predicts the performance of an untested 5-man lineup. They used the model to analyze the 2011 playoff series between the Memphis Grizzlies and the Oklahoma City Thunder and showed that the model could successfully predict player interactions in a given lineup based on how the players performed in different lineups. Zimmerman *et al*., using the results of the 2009-2013 NCAAB competition as training and testing datasets, compared the predictive accuracy of several machine learning models, including decision trees, rule learners, artificial neural networks, naive Bayesian Classifier and Random Forest Classifier. It turns out that artificial neural networks with multi-layer perceptrons are the most effective models. The attributes of the team are more important than the model, but there is an upper bound on the quality of the predictions, which is 74%. The authors believe that the reason for limiting the prediction accuracy is that there is no objective standard for some attributes, and new attributes must be added to improve the prediction ability. For the prediction of the outcome of basketball games in other countries, Mr. Li applied the improved backpropagation (BP) neural network to establish a basketball mathematical prediction model. Based on sports performance (including shooting percentage, three-point shooting percentage, assists in the 2004 Olympic Games, the 14th World Basketball Championship, the 2006 Intercontinental Cup basketball game, the 2004 Athens Olympic Games, the data of the Chinese men's basketball team, and the rebounding data, this study MATLAB software was used to predict the sports performance of the 2012 London Olympic Games, and the results showed that the prediction error was very small. Cai *et al*., developed a hybrid ensemble learning framework by combining bagging strategies and random subspace methods to predict the results of basketball games. The The framework includes 12 parameters, which are two points, three points, free throws, offense, defense, assists, fouls, steals, turnovers, blocks, fast breaks and dunks. The data set used for training and testing contains the 2016/2017 Chinese Basketball Association 380 games from 20 teams in the regular season. The authors compared the hybrid ensemble learning framework with other machine learning models such as Naive Bayes, Markov models, Artificial Neural Networks, Apriori, Logistic Regression, and Poisson Regression, The hybrid ensemble learning framework was found to be the best; achieving 84% accuracy.

4. AI Basketball Coaching System

AI technology can also be used to assist basketball teaching. In 2016, Li *et al*., launched an AI-based college basketball intelligent teaching system. The system is a multi-level dynamic interactive multimedia demonstration system, mainly including knowledge base, student model, teacher model and man-machine interface. The system designs a personalized teaching mode according to each student's level, tracks the student's learning records and adjusts the teaching mode, which has good interactivity and adaptability. Teaching experiments show that the effect of the artificial intelligence teaching system is significantly better than that of the control class. According to reports, there are many teachers who are intelligent and can integrate the computer-aided system (ICAI) of teaching methods and experiences to help students carry out individualized independent learning. Zhao and Xieuseda questionnaire method to evaluate the effect of ICAI in basketball training. The survey results show that students and teachers are satisfied with the effect of ICAI, but there are deficiencies in the process of using it and further improvement is needed. In addition, Yang also introduced the AI basketball coaching system based on the Baum-Welch algorithm.

The system can formulate and adjust the training plan according to the player's personal physical condition, athletic ability, and changes in athletic skills measured during the training process.

5. CONCLUSION

Currently, the application of artificial intelligence (AI) in the field of basketball has attracted extensive research interest. These applications cover multiple aspects, including analysis of team and player performance, prediction of game results, analysis and prediction of shots, basketball education, use of smart training equipment and venues, and prevention of sports injuries.

The research results show that AI technology and wearable devices have significant effects in improving the training level of basketball players, assisting coaches in formulating game strategies, and preventing sports injuries. However, it must be emphasized that although some progress has been made in the application of AI in the field of basketball, this field is still in the research and exploration stage, and the quantity and quality of related academic papers still need to be improved.

Basketball is one of the most popular sports in the world, and its related industries have produced huge economic benefits. Therefore, we call on all basketball-related interest groups to actively support the application research of AI in the field of basketball and provide more research funding for universities and research institutions. We firmly believe that AI technology will advance basketball technology and make the game more exciting, while its popularity around the world will continue to grow.

Taken together, this study provides us with a theoretical framework to understand and evaluate the potential and challenges of AI in basketball. We look forward to future research that can further deepen the understanding of this field, especially how to use AI technology more effectively to improve the competitive level of Chinese basketball

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