Innovation and Transformation of Sports Event Management Driven by Artificial Intelligence

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Abstract: *Artificial Intelligence (AI) is reshaping the entire lifecycle of sports event management, from event preparation to spectator experience, and from competitive decision-making to commercial operations, marking a paradigm shift. This paper systematically analyzes the application mechanisms of AI in four core scenarios: athlete performance optimization, referee decision support, event security management, and fan interaction innovation, revealing the management model transformation achieved through data-driven approaches, real-time responses, and personalized services. It also discusses challenges such as technology ethics, data sovereignty, and algorithm transparency, and proposes a "technology-institution-humanity" collaborative governance framework, providing theoretical support and practical pathways for the intelligent transformation of the sports industry.*

Keywords: Data sovereignty; Referee decision support; Sports event management.

1. INTRODUCTION

The global sports events market, a domain brimming with vitality and potential, has consistently demonstrated its enormous economic value and robust growth momentum in recent years. According to the latest statistical data from Statista in 2023, the scale of the global sports events market has reached an astonishing $600 billion. This figure not only highlights the extensive influence and deep mass base of sports events worldwide but also reflects the status of the sports industry as a significant component of the global economy. With sports fans' increasing demand for high-quality event experiences and the maturing commercial operation models of sports events, this market is expected to continue its steady growth trajectory. Meanwhile, the digitization process of the global sports events market is accelerating. According to the Statista report, the annual digitization growth rate of this market has exceeded 15%. This means that, riding the wave of digital transformation, the sports events industry is continuously enhancing event operational efficiency, spectator experiences, and commercial value by leveraging advanced information technology and innovative management models. The application of digital technologies has not only brought new growth points to the sports events industry but also injected strong momentum into the sustainable development of the entire sector [1].

Driven by the rapid development of computer science and artificial intelligence technologies, global sports event management is ushering in a profound intelligent transformation. Breakthroughs in a series of cutting-edge technologies, including computer vision, natural language processing, and reinforcement learning, are bringing unprecedented intelligent enhancements to sports event management. The application of computer vision technology makes it possible to capture athlete movements, analyze game scenarios, and assist referees in decision-making during sports events. Through high-precision image recognition and analysis, event managers can more accurately assess athlete performance, promptly identify and correct violations during games, thereby enhancing the fairness and enjoyability of the events. The introduction of natural language processing technology has significantly improved the efficiency and accuracy of processing sports event information. Whether it's the automatic generation of event news reports or real-time monitoring of fan sentiments on social media, natural language processing technology can provide valuable information support to event managers, helping them better grasp market dynamics and fan demands [2]. The application of reinforcement learning technology offers new ideas for sports event strategy optimization and intelligent decision-making. By simulating and analyzing game outcomes under different strategies, reinforcement learning algorithms can provide coaching teams with scientific training plans and tactical guidance, thereby enhancing athletes' competitive levels and the overall strength of the team.

2. AI TECHNOLOGY LANDSCAPE IN SPORTS EVENT MANAGEMENT

Sports event management, as the core component of the sports industry, is undergoing an unprecedented intelligent transformation. In this transition process, Artificial Intelligence (AI) technology plays a pivotal role. With its powerful data processing capabilities, intelligent decision support, and personalized service features, AI technology is comprehensively reshaping every aspect of sports event management. Computer vision technology is one of the most widely applied AI technologies in sports event management. Through high-precision processing of on-site videos or images, it achieves accurate capture and analysis of athletes' movements. For example, the Hawk-Eye tennis refereeing system, an outstanding representative of computer vision technology, boasts a movement capture accuracy of 99.7%, enabling precise judgment of tennis ball landings and trajectories, thus providing strong support for fair adjudication in tennis matches. The application of this technology not only enhances the fairness of events but also greatly improves the spectator experience [3].

Predictive analytics is another highlight of AI technology in sports event management. By utilizing machine learning algorithms, AI can analyze and mine vast amounts of historical data, predicting key information such as athletes' injury risks and match outcomes. For instance, in a 2021 study, Ludwig et al. used a machine learning model to predict NBA players' injury risks, achieving an excellent Area Under the Curve (AUC) of 0.89. The application of this technology provides coaching teams and event managers with scientific decision-making bases, aiding decision-makers in better formulating training and competition strategies. The application of natural language processing technology in sports event management is also noteworthy. It can analyze text information related to events in real time, such as news reports and social media comments, thereby generating multilingual event commentary, fan sentiment analysis reports, and more. For example, AWS (Amazon Web Services) launched the Wimbledon AI commentator in 2022, which utilizes natural language processing technology to provide real-time commentary on tennis matches, offering viewers a more convenient and personalized watching experience. The application of this technology not only enriches the event's dissemination channels but also enhances viewers' engagement and satisfaction with the event.

3. INNOVATIVE PRACTICES IN AI-DRIVEN MANAGEMENT MODELS

3.1 Performance Optimization

In the intelligent transformation of sports event management, AI technology not only provides new solutions for performance optimization but also brings revolutionary changes to critical areas such as injury prevention. Taking football players as an example, the Catapult system adopted by Manchester City Club is an outstanding application of AI technology in performance optimization. The system collects running data from athletes during matches and training, generating detailed running heatmaps. Bunker (2021) pointed out that coaching teams can use these heatmaps to intuitively understand the range and intensity of athletes' activities on the field, thereby adjusting their tactical positions to maximize effectiveness. This personalized training program not only improves athletes' performance levels but also enhances the tactical flexibility of coaching teams [4]. The application of AI technology in injury prevention offers new possibilities for athlete health management. Taking NFL (National Football League) teams as an example, teams use Zebra sensors to collect muscle activity data during training. AI algorithms analyze this data to predict athletes' muscle fatigue levels and potential injury risks. Based on these predictions, coaching teams can promptly adjust training plans, reducing athletes' training loads and thereby lowering the incidence of injuries. According to ESPN, by adopting this AI-driven injury prevention strategy, NFL teams have successfully reduced training injuries by 30%. This achievement not only highlights the enormous potential of AI technology in injury prevention but also provides useful references for injury management in other sports.

3.2 Referee Decision Support

Significant progress has been made in the field of referee decision support in football matches in recent years, particularly with the enhancement of the Video Assistant Referee (VAR) system and the introduction of behavior recognition algorithms, bringing unprecedented improvements to the fairness, safety, and efficiency of matches. This technology utilizes advanced image recognition and data processing capabilities to precisely analyze players' positions within a very short time, accurately judging offside situations. According to a 2023 report by the International Football Association Board (IFAB), the introduction of AI offside judgment in the English Premier League has significantly shortened VAR decision-making time to just 0.5 seconds. This breakthrough not only greatly improves the fluency of the game but also further enhances fans' confidence in the fairness of match decisions. In addition to innovations in VAR technology, behavior recognition algorithms are also playing an increasingly important role in football matches. Especially in the security systems of large international events

such as the 2024 UEFA European Football Championship (UEFA Euro 2024), behavior recognition algorithms developed by technology companies like Huawei have been widely applied. The algorithm analyzes player and spectator behavior patterns in real time through surveillance video, accurately identifying violent behaviors on the field, including pushing, fighting, and other inappropriate actions [5].

3.3 Event Operation Upgrade

In sports event operations, dynamic pricing systems are becoming a key strategy for enhancing revenue and spectator experience. By utilizing machine learning (ML) models, event organizers can accurately predict attendance rates for different matches and seating areas, thereby adjusting ticket prices in real time to maximize revenue. Taking Major League Baseball (MLB) as an example, according to a 2022 report by Forbes, MLB successfully achieved significant revenue growth of 12% by implementing a dynamic pricing strategy. Behind this achievement lies the deep learning and analysis of vast historical data by ML models, including multidimensional data such as team performance, opponent strength, weather conditions, holiday factors, and spectator ticket-purchasing behavior. This intelligent pricing mechanism not only makes event tickets more aligned with market demand but also effectively promotes the full utilization of spectator seats, bringing more considerable economic benefits to event organizers. In terms of safety and security for large-scale sports events, the application of intelligent security technologies is playing an increasingly important role. Especially during the 2022 FIFA World Cup in Qatar, FIFA deployed up to 15,000 AI cameras integrated with facial recognition and behavior analysis technologies, providing unprecedented safety and security for the event. Facial recognition technology can quickly identify and record information on individuals entering the venues, effectively preventing illegal intrusions and impersonations. At the same time, behavior analysis technology monitors and analyzes spectator behavior in real time, enabling the timely detection and warning of potential conflicts and violent tendencies, allowing for necessary preventive measures to be taken. This intelligent security system not only significantly improves the safety level of the event but also creates a more harmonious and secure spectating environment for fans. In the future, with the continuous advancement of technology, intelligent security will be widely applied in more sports events, providing more solid technical support for the safe conduct of sports events [6].

3.4 Reconstruction of Spectator Experience

In the digital era, sports fans' pursuit of spectating experiences is continuously escalating, and the integrated application of augmented reality (AR) and virtual reality (VR) technologies is gradually opening a new chapter in sports event broadcasting. NBA League Pass, the official online streaming service provided by the NBA, has always been committed to enhancing fans' immersion in spectating. According to the latest updates from Microsoft Mesh in 2023, NBA League Pass has now introduced a revolutionary technology – a 180-degree free-viewing angle spectating experience. This innovative feature utilizes advanced AR/VR technologies, allowing viewers to freely choose their spectating angles, as if they were in the stadium. Whether following intense player confrontations, focusing on tactical arrangements on the coaching staff, or even capturing passionate moments from fans on the sidelines, viewers can enjoy unprecedented immersive spectating pleasure at will. The introduction of this technology has undoubtedly pushed the live broadcasting experience of sports events to a new height, enabling every fan to find the most suitable spectating angle and experience every exciting moment on the NBA court [7].

4. CHALLENGES AND CONTROVERSIES IN THE INNOVATION PROCESS

4.1 Dilemma of Technological Reliability

In the intelligent progress of sports refereeing systems, algorithm bias has become a problem that cannot be ignored. According to a 2021 study by Buolamwini and Gebru, an AI refereeing system had a misjudgment rate for dark-skinned athletes that was 2.3 times higher than that for light-skinned athletes. This finding reveals potential biases in the design and training process of algorithms, which not only affect the fairness of competitions but also exacerbate social inequality. Therefore, how to eliminate algorithm bias and ensure the fairness and accuracy of AI refereeing systems has become an urgent issue to be addressed [8]. With the widespread use of wearable devices in sports training and competitions, athletes' biometric data is extensively collected and analyzed. However, if this data is leaked or hacked, it will pose serious privacy risks. For example, in the 2023 Strava military base data breach incident, a large amount of users' exercise tracking data was made public, including information on movement in sensitive areas. This incident reminds us once again that while enjoying the convenience of technology, we must attach great importance to data privacy protection and establish a sound data security

mechanism.

4.2 Conflicts in Sports Ethics

The rise of AI coaches has improved training efficiency and match performance to some extent but has also triggered issues of emotional alienation among athletes. According to Loland's 2022 study, the widespread use of AI coaches has gradually diluted the close relationship between traditional coaches and athletes, leaving athletes lacking sufficient psychological support and emotional sustenance when facing training and competition pressure. The emergence of this humanization crisis not only affects athletes' physical and mental health but also violates the humanistic care in the spirit of sports. In the field of sports competition, the widespread application of AI technology has exacerbated the technological gap between wealthy and poor teams. According to the 2023 report by the FIFA Fair Play Committee, teams with substantial financial resources can invest more in researching and applying advanced AI technologies, thereby gaining an advantageous position in competitions. This technological inequality not only disrupts the fairness of competitions but also hinders the healthy development of sports. Therefore, how to ensure the fair application of AI technology in sports competition and prevent competition inequality caused by the technological gap has become an important issue that needs to be addressed urgently.

4.3 Lagging Institutional Adaptation

The rapid development of AI technology in the sports field poses severe challenges to existing sports regulations. However, rule revisions often lag behind technological developments. Taking the arbitration case 2022/A/9392 handled by the Court of Arbitration for Sport (CAS) in 2022 as an example, the case involved the legal effect of AI decisions, but existing sports regulations did not provide clear provisions on this matter. This led to arbitration institutions having to make rulings based on traditional legal principles during dispute resolution, which may not be fully applicable to the new situations brought about by AI technology. Therefore, how to timely revise sports regulations and clarify the legal effect of AI decisions has become an urgent issue to be addressed. Globally, there are significant differences in the access standards for AI technology among different leagues and event organizations. According to the technical white paper released by the International Olympic Committee (IOC) in 2023, the differences in AI technology access standards among different leagues are as high as 47%. These differences not only lead to confusion in technology application and unfair competition but also increase compliance costs for athletes and event organizers. Therefore, formulating globally unified AI technology access standards to ensure fair, safe, and effective technology application has become a common challenge faced by the international sports community [9].

5. GOVERNANCE FRAMEWORK AND OPTIMIZATION PATH

To address the potential risks associated with the application of AI technology in the sports sector, the EU developed the "Sports AI Ethics Guidelines" in 2023. These guidelines cover key elements such as bias detection and interpretability clauses, aiming to ensure the fairness, transparency, and reliability of AI systems. Through trustworthy AI certification, AI technologies that meet ethical standards can be selected, providing a strong guarantee for fair adjudication in sports competitions.

When handling large amounts of sensitive data, privacy protection becomes a top priority. The Olympic AI Alliance established a cross-national data-sharing framework in 2024, aiming to balance the relationship between data utilization and privacy protection. By signing data sovereignty agreements, countries can share and exchange data while ensuring data security, promoting cooperation and exchange in sports technology [10]. In the face of an increasingly complex digital technology environment, enhancing athletes' digital literacy is particularly important. The International Olympic Committee launched a mandatory AI technology training course in 2022, aiming to help athletes understand the basic principles and application scenarios of AI technology and cultivate their digital thinking and innovation capabilities. This initiative not only helps athletes better adapt to digital competition environments but also promotes the inheritance and development of the Olympic spirit.

6. CONCLUSION

The global sports event market is demonstrating strong growth momentum under the wave of digital transformation, with the widespread application of artificial intelligence (AI) technology serving as a key driving force for this change. AI technology plays a crucial role throughout the lifecycle of sports event management, from event preparation to spectator experience, and from competitive decision-making to commercial operations,

bringing about a paradigm shift. In terms of competitive performance optimization, AI technology collects and analyzes large amounts of athlete data to provide them with personalized training programs and predict injury risks, thereby enhancing athletes' performance levels and health management. In the field of refereeing decision support, the application of AI technology improves the accuracy and efficiency of adjudications, such as the Video Assistant Referee (VAR) system and behavior recognition algorithms in football matches, providing a strong guarantee for the fairness and safety of competitions. In event operations, AI technology promotes the application of dynamic pricing systems and intelligent security technologies, not only improving event revenues and spectator experiences but also effectively maintaining event safety and order. Meanwhile, the integrated application of augmented reality (AR) and virtual reality (VR) technologies, as well as upgrades to personalized content push systems, bring richer and more diverse viewing experiences to sports fans.

However, the application of AI technology in the sports sector also faces numerous challenges and controversies. Issues such as algorithm bias and data privacy risks affect the fairness of competitions and the privacy and safety of athletes. Furthermore, the rise of AI coaches has triggered concerns about emotional alienation among athletes, while the technology gap exacerbates unfair competition between wealthy and less affluent teams. The lag in institutional adaptation is also an urgent issue to be addressed, as differences in existing sports regulations and technical access standards lead to confusion and unfair competition in technology application. In summary, AI technology is reshaping various aspects of sports event management and providing theoretical support and practical pathways for the intelligent transformation of the sports industry. To fully unleash the potential of AI technology, it is necessary to overcome a series of challenges and establish a comprehensive governance framework and optimization path.

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