Journal of Information Systems Engineering and Management
2025, 10(3)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Educational Practice of AI Technology in Sports Training and Competition Data Visualization

Wei Chit Chun

Guangzhou Foreign Language School, Dave17771799901@163.com

ARTICLE INFO

Received: 08 Nov 2024
Revised: 28 Dec 2024
Accepted: 25 Jan 2025

ABSTRACT

Evolutionally changes have been realized in the sports sector following the integration of technology. This includes the of AI which has been effective in performance management and training interventions. Data visualization and analytics are the main components of this development helping in optimization of human limitations. The use of VAR in football has brough about reduce errors in officiating of the games. Also, AR and VR technologies have been a common trend among coaches as they implement structured training sessions. This study will use case studies to achieve three main objectives. First, to analyze the application of AI in sports training and competition. Secondly, the study will evaluate the educational strategies. The third objective is to recommend evidence-based recommendations that enhances a balance sport science environment.

Keywords: AI, training, sports, competitiveness, education strategies, sports pedagogy

INTRODUCTION

Breakthrough in sports has been realized through integration technology. The use of the artificial intelligence (AI) has been instrumental in support of data visualization to improve performance and training incentives [26]. For instance, the use of VAR in football has brough about reduce errors in officiating of the games [1]. Also, through data visualizations coaches are able to offer simulated training session on various practices that would enhance their professionalism. This therefore creates a breakthrough in the way sporting activities are carried out to improve efficiency and competitiveness. The convergence of AI has led to the integration of complex algorithms and computing systems that optimizes the application of data insights to enhance training sessions [13]. This is an important factor that enhances the understanding and implementation of the sport's knowledge and skills through representations of the tactics preferred by the coach. Also, the benefits of AI have been achieved through the analysis of past matches to ensure that the players, coaches and other team members get to learn about concepts that would improve their performance.

This study will pursue three main objectives with the first being to analyze the application of AI in sports training and competition through concepts such as data visualization. The second objective is to evaluate the educational strategies that enhance sports training through integration of technology. The third objective is to propose evidence-based recommendations that enhances a balance sport science environment that observes human limitations and abilities to reinforce the authentic competition despite the use of technology. This study will use case studies to achieve three main objectives

LITERATURE REVIEW

The transition from basic statistical concepts to complex roles of data visualization has exposed the contribution of AI in sports. The development revolves around improving competition and training interventions. This is an important evolution that supports sports pedagogy given the expansion of the instructional strategies that enhance athletic performance. Coaches have been using AI to facilitate structured training on patterns and tactics that enhances high performance [14,25]. Also, AI has been instrumental in monitoring biophysical ability of the athletes to assess their fitness. For instance, a smartwatch is commonly used to track different athletic performance metrics critical in identification of areas of improvements.

Figure 1: Smartwatch

Also, AI has been a key factor in psychological measures to identify the athletic indicators and responses [1,27]. The goal is to examine the ability of the athletes to perform by learning needed skills. Performance optimization is a key component that continue to call for increased integration of AI to enhance an interplay in the context of strategic choices by the coaches to influence the competitiveness of individual performance [12,24]. Visualization displays are critical in terms of helping the athletes to learn about the patterns that results in high performance. Thus, the use of simulation concepts such as virtual reality (VR) and augmented reality (AR) are critical game changers [31].

Educational Implementation Strategies

The application of AI in sports science and in particular training and competition has been enhanced by four models of education implementation. This includes awareness, guided application, integrated practice and creative extension [21]. Awareness is explored by the commitment of the coach to provide basic training on concepts relevant in each sporting activity. This is followed by guided application where the coach aims at facilitating the learning of structured experience [2,23]. This is realized through the exposure to visual presentations of competitive patterns and tactics. Integrated practice as an educational framework supports the commitment by the coach to facilitate modelling of the concepts learned and putting them into practice. Finally, the sports pedagogy in relation to the application of AI demands for the creative extension which is the exploration of the athlete's performance and measuring their output. An interplay of the four education frameworks supports the use of AI visualization as an opportunity for learning through progressive feedback on dynamic sports outcomes [15].

Data Visualization Methods for Sports Analytics

One key AI tools used to enhance sports training and competition is the motion and biochemical visualization [13]. These resources help in the assessment of kinetic and kinematic assessment of the players. Such is representations helps in mapping the expected performance and output of an individual based on their fitness and preparation. Also, visualizations tools on strategic and tactical patterns have become common helping the coaches the implemented their structured style of play expected by the athletes [3,22]. This would include visual representations of heat maps, defensive coverage, passing networks and individual movements. Analysis of these metrics provides a tactical advantage on what an athlete should improve to become better. This also enhance the emphasis on pattern-based performance which often helps in predicting the likelihood of achieving certain outcomes [11]. The use of real time dashboard is also another visual representation enhance at training and competition levels. This creates a data environment which supports better understanding of the improvements that could be made in each stage of competition.

AI Technologies in Sports Training

A variety of AI technologies such as computing vision have played a critical role in the interplay of technology on enhanced sports activities [11]. The technology uses neural networks to help with the identification and assessment of athletic movements and other attributes of performance. The goal is to realize the movements that would help an athlete improve their performance by providing real time feedback which allows provision of immediate feedback to support improvement [14]. The algorithmic programming of certain movements serves as a point of reference during training.

Machine learning technology is significant in analyzing different visual representation. This a crucial development that enhances improvement of performance by providing insights. the use of the technology in trainings helps the athletes to be aware of the what is expected in ideal competition [3]. The use of the natural language processing (NLP) is also important given its role in conversion of qualitative data into quantifiable insights [1,23]. The insights are essential to help the athletes in decision making during competition.

THEORETICAL FRAMEWORK

Education strategies of AI in sports training and competition follows the principles of constructivism theory. The theory advocates for progressive learning realized through development of knowledge from experience and training [14]. This explains why coaches are intentional to understand individual performance through frequent assessment to identify areas of improvement [8]. Data visualization component is critical in training to help the athletes learn the importance of different movements and position. The aim is to reduce errors that would lower their performance and competitiveness.

Data literacy is another component that has shifted the application of AI in sports. This entails the need for analyzing different visual representation to enhance better understanding of different athletic tactics and patterns [13]. Thus, accuracy in interpretation of the visual representations is desired to enhance improvement in training and competition. The application of the insights gained helps the athletes to improve their technical ability [17]. Also, through data analysis athletes reflects on their performance as a foundation of improving their weaknesses.

Ethical consideration in the use of AI in sports helps in creating a fair and responsible structure of competition [14,21]. This includes concepts such as privacy to ensure personal information is protected. Another ethical consideration is the likelihood of biased insights limited by use of limited data in the design of respective algorithms [16]. This is supported by the rationale that the use of AI is primarily enhanced by algorithmic design which depends on learning about patterns that leads to development of automated feedback [4,18]. This mechanism while successful may call for the review of the need for a balanced system that observes the ethical implication to create an enabling and sustainable sport ecosystem [21]. This means that despite the use of AI in training and analysis of different competitions it is important for the coaches the understand the impact of continuous assessment on the athletes. Such is critical in consideration of issues such as fatigue, emotional stress and trauma associated with failure to meet expected performance in multiple cases [9]. Thus, the need to evaluate the application of AI to create a balance ecosystem that recognizes the interplay of AI in training and management of sports activities while maintaining an authentic view of athletic capacity and limitations.

Case study 1: use of VAR in football competition

Football is described as a competitive sport which is fast spaced and very dynamic. This description provides a rational why most details are often missed due to the limitation of human error during the match. In this case, referees are limited to capture details such as tight off-sides, bad tackles, and other abuses designated in the officiating process of the game. These gaps make significant differences in terms of the team that wins or lose [17]. In particular context the use of VAR has led to evolutionary outcome with the re-evaluation of different plays to determine the execution of red cards, yellow cards, penalties as well as wrong awarding of cards. With these developments accuracy in football has been enhanced. However, despite this success there are certain limitation especially with lose of authentic play by individual players which are limited by excess scrutiny of the sporting activity [5]. Despite the challenges the use of the VAR has led to the realization of the potential success of AI algorithms in enhance efficiency of the sports competition by improving the dynamics of analysis violations of rules that may lead to wrong awarding.

Figure 2: (a) Video assistant referee (VAR) team. (b) Main referee with VAR

Case study 2: Application of AI In Basketball Training

A study by Hu (2023) examines the application of AI in basket ball training. The relevance of the application is based on the complexity of human motions in the basketball which limits aspects of precision in recognizing competitive patterns. In the study the author contextualized the use of the ARBIGNet a system that utilizes a Whale Optimized Artificial Neural Network (WOANN) that optimizes large pool of data from basketball games [11]. The use of this system in the study helped the author to identify the opportunities of AI in sports training. The outcome of different video application used in training as show in figure 2 shows higher efficiency in the use of AI. The results indicated CapsNet approach has obtained an accuracy of 98.8% and mAP of 95.5% which provides the rationale for continued use of AI in sports training [11]. This creates a diverse application beyond the coaches' anecdotes and experience into a more nuanced technical skills that improves technical ability of the athletes. The use of the algorithmic system utilized in this study shows the important of AI and especially visual representation in enhancing accuracy in learning [11].

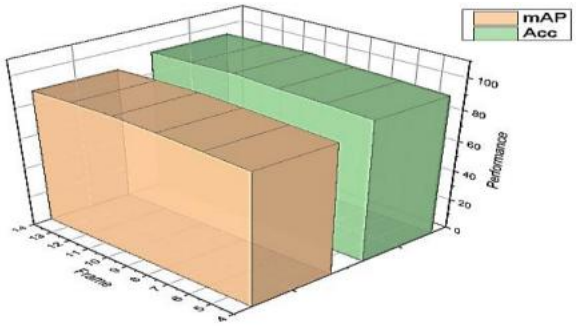

Figure 3: Outcome of different video frame Hu (2023).

Case study 3: Automatic application of scoring rules based on action recognition in Wushu Sanda competition

The use of AI provides a promising intervention in enhancing efficiency in scoring reporting and analysis. This is in specific context of Wushu Sanda competition where accuracy and fairness may be limited by the complexity of the game. In this case, the movements of the athletes change often and are complicated thus making results and scores be subjective. Relying on human capacity would result in errors that are bypassed by the use of AI [8]. The study by Fu & Wu, (2024) reviews a scoring system founded on the application of algorithm to identify patterns in the play to enhance the determination of the score. The implication of the system enhances identification of real time feedback in terms of activities such as the kick, swing fist and straight fist among others to determine the individual score. The use of this system provides a competitive edge over human subjective decisions that may be constrained by bias of the officiators. Also, the accuracy in identifying the movements is another issue [18]. Thus, the application of AI is described as an effective model that enhances accuracy in sports operations with the successful identification of movements by the athletes that are crucial in awarding scores. The systems accuracy level was at 90% in whips and straight punches [8]. However, the accuracy was low in movements that were uncommon. This creates the need for further intervention to address the limitation of increased evolution on human behavior that cannot be fully captured through algorithmic models.

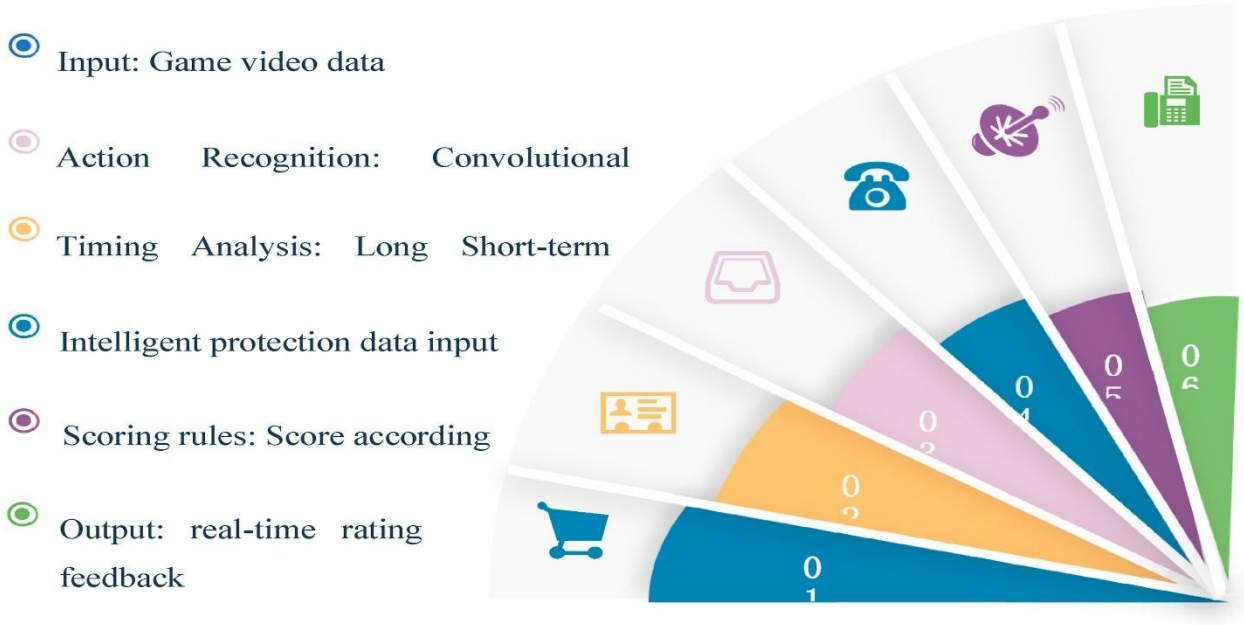

Figure 4. Automated flow chart of action recognition and scoring in Wushu Sanda competition (Fu & Wu, 2024)

CHALLENGES AND LIMITATIONS

The success of AI has been constrained by several factors such as accessibility and technical barriers [20]. These factors form critical foundation upon which the 100% transition into the use of AI and other technologies in sprots pedagogy and competition has been enhanced [10]. The limitation on access is distributed across different sports and geographical regions based on the availability of the right infrastructure [6]. Resource constraint is a key barrier given that the implementation of AI system is expensive. For instance, the use of VAR in football is not accessible to different competitions and this may result in inconsistency and failed roll-out of the systems. Also, access to training tools may also result in discriminatory incentives in terms of competition with teams that lack the facilities being disadvantaged.

The implementation of AI in sports has been challenged by ethical issues. This is based on the limitations associated with a short-time since implementation which constraints the number of assessments made to determine the gaps and opportunities. One notable ethical concern is privacy which is enhanced by lack of proper measures on the consent of the athletes for their data to be used [19]. Also, another challenge relates to the psychological distress that comes as result of continuous quantitative assessment of individual and team performance. This may lead to struggles with the reality of immediate feedback with minimal time to make improvements [7]. Such occasions are overwhelming to the players. Also, lack of transparency in the algorithms used in AI tools used for training and sports competition creates a major gap that may lead to bias. This is based on the likelihood of inconsistent update of data based on the evolving policies.

CONCLUSION AND RECOMMENDATION

The use of AI in sports creates a promising edge in enhancing competition and efficiency. This is supported by the technical abilities of technology in enhance visualization of different data insights to facilitate knowledge and skills acquisition. The use of AI in different sports settings has created a complex interplay that requires more research to understanding the opportunities and challenges as well as the associated implications. The goal is to enhance continuous learning through a multidimensional approach which considers the input of different interdisciplinary fields. Such opportunities optimize expansion of sports science knowledge through capacity building in training and reflection of individual and team performance. Through these initiatives construction of relevant knowledge and experience is enhanced through continuous learning.

The use of AI creates an expansive view into sports pedagogy particularly with the focus on how instructions are passed from the coaches to the athletes. This creates an opportunity for enhanced learning experience that enhances capacity building in the context of maximizing efficiency in technical development. Thus, future directions in this fields demands the integration of evidence-based insights to inform the best practices that enhance the successful application of AI in sports pedagogy. This means that the limitation identified such the psychological constraints due to continuous assessment are addressed to maximize the welfare of the athletes. As a result, the athletes will be cushioned against trauma that results from failure to meet the desired expectations. Also, while considering this limitation it is important to note the significance of AI in enhancing skill development through continuous learning and reflection. Thus, a balanced perspective is desired to enhance constructive application and development of AI in sports pedagogy and management of related activities. The need for collaborative efforts that integrates different interdisciplinary fields will provide a safer ecosystem where sports management and developments will be more realistic and focused into the implementation of modern-day technologies. With these sports activities will optimize the evolution of technology that is creating a promising avenue for learning and improving competitiveness.

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