A Mapping and Visualization of the Role of Artificial Intelligence in Sport Industry

Received: 2023-06-05
Accepted: 2023-11-21
Vol. 5, No.1. Winter .2024, 44-56

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Abstract

Purpose: The purpose of this study is to analyze how the scientific community has assessed and addressed the application of artificial intelligence in the sports industry and to identify dominant academic themes and neglected topics.

Methods: A total of 2023 articles and 13081 keywords were analyzed for co-occurrence analysis. The analysis aimed to identify the dominant academic themes that scholars tackle and the topics that are neglected.

Results: The analysis identified seven core topics, including real-time sport medicine, wearable technology, swarm intelligence, automatic motion detection and deep image analysis, intelligent athlete training and education, and athlete robots. The study also revealed the necessity for increased scholarly focus on subjects like precision sports medicine and metaverse technology.

Conclusion: The revolutionary technology of artificial intelligence has impacted all industries, including the sports sector. The analysis demonstrates how AI has revolutionized the sports sector and what areas require further attention. Policy makers and the scientific community can utilize this study as a practical guide to better grasp the impact of AI on the sports industry.

Keywords: Artificial intelligence, sport industry, co-occurrence analysis

Introduction

In order to increase production and efficiency, many sectors are turning to artificial intelligence, which is becoming more and more integrated into our daily lives. One of these sectors is the sport industry, where artificial intelligence is utilized to track athlete performance and wisely allocate resources. The value of AI in sport is anticipated to reach 19.2 billion by 2030, increasing at a compound annual growth rate of 30.3% from 2021 to 2030[1]. the main drivers boosting the growth of AI in the sports market are the rise in demand for tracking and monitoring player data as well as the rise in popularity of chatbots and virtual assistants for interacting with fans(Rouhiainen, L, 2018).

AI in four major steps of sport management can be used, which are talent management (Charlwood, 2021) (talent identification and talent selection), pre-game preparation (such as training and coaching in regard to nutrition, physical, biomechanics and mental, injury management, team selection and strategic and tactical game planning)(Araújo et al., 2021a; Bezobrazov et al., 2019; Huang, 2021), in-game activity (such as umpiring and specialist coaching)(Li and Xu, 2021) and post-game analysis (fan relationship management, eSports, injury management, recovery and analysis and feedback)(Mamo et al., 2022) .

The academic community began researching and exploring the roles of artificial intelligence in the sport sector at the same time that the sport industry spearheaded the implementation of AI. The development of scientific knowledge in the area of AI in the sports sector has, however, been limited. This research intends to investigate the themes that academics have mostly studied in the area of AI in sport management. This study, to the best of our knowledge, is the first to examine the role of AI in the sport sector. The scientific research on AI in the sports business is mapped out in this report. Researchers can analyze scientists' and researchers' performance and output using quantitative literature review methodologies, as well as identify new areas of research. (Daim, Oliver, & Kim, 2013). These quantitative methods as the measurement of literature and texts will "capture some of the information inherent in the content and patterning of the literature…[and] to measure and interpret technological [and scientific] advances" (Kahraman, Kerre, & Bozbura, 2012).

This paper aims to answer the following questions:

What are the key topics that have been extensively discussed in the literature on the application of artificial intelligence in the sports industry?

How have the topics related to artificial intelligence in the sport industry evolved?

What are the possible future strands of study?

This report could be used as a reference by researchers, governments, and investors to gain a better understanding of the most contentious issues and uses of AI in sport management. This research will also help to clarify which areas of AI in the sport industry are overlooked or under supported, and which require more scholarly attention and support from management and governments and finally gave the key topics that have been extensively discussed in the literature on the application of artificial intelligence in the sports industry.

Materials and Methods

Data from the Scopus database was gathered. In the abstract, title, and keywords, we looked for the following keywords: artificial intelligence AND sport OR athlete OR AI. Concerning the time of the papers and topics, we did not place any restrictions. English-language papers were also included. 2023 articles were extracted in total. The papers were then screened to

[1] https://www.alliedmarketresearch.com/artificial-intelligence-in-sports-market-A12905

determine which papers did not explicitly address AI in sport. This process was carried out three times by the co-authors. The Kappa value was 0.839, which indicates that the coding was highly reliable. The kappa number, which runs from 1 to 0, indicates how closely the authors who code the papers agree on certain points.

To recognize the topics and display the topic mapping, we used the VOSviewer software. All keywords, including author and index keywords, served as the analysis's unit. We chose the fractional counting approach, which is the software's default, out of the two counting options: complete counting and fractional counting. Out of the 13081 keywords, 1816 met the criterion because we set the minimum number of occurrences for a term at 3. After that, we manually removed the terms that were either redundant or unhelpful by doing the stop word and lemmitization operation. Learning systems (2982), algorithms (1538), forecasting (981), classification of information (965), and computer vision were the top five terms with the highest TLS scores (957). Seven clusters were produced by the co-occurrence analysis of the terms, which the authors manually labelled.

Results

Content analysis of topics have seven key topics emerged from the analysis, which are shown in Figure 1. These topics are related to intelligent athlete training and education, automated motion identification and deep image analysis, wearables, swarm intelligence, ubiquitous computing, real-time sport medicine, and athlete robots.

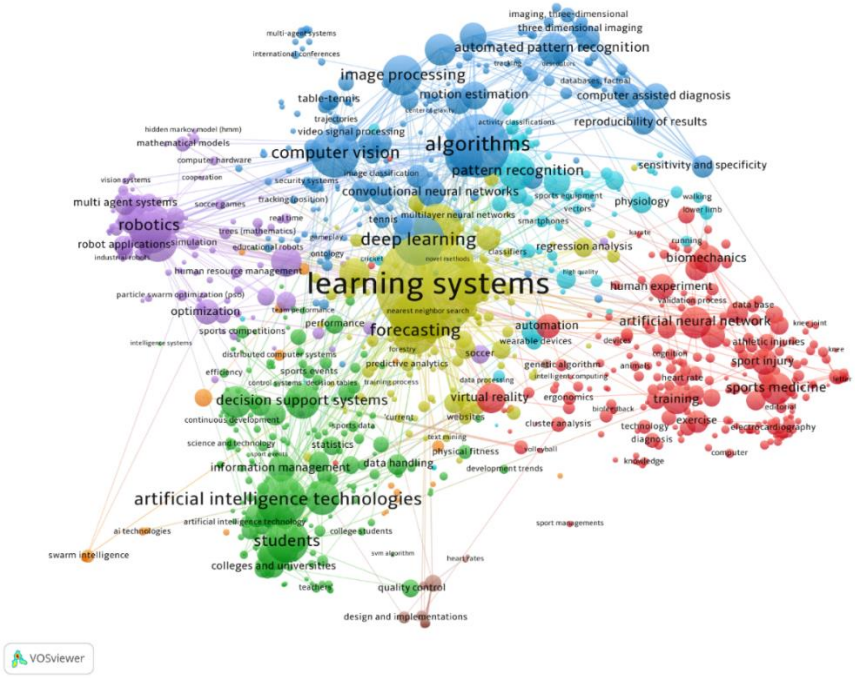

Figure 1. As the visualization network shows, the co-occurrence analysis of keywords yielded to 7 major topics

- Sport Medicine

The first subject is sport medicine, a field of medicine that deals with physical fitness as well as the treatment and avoidance of accidents associated to sports and exercise. By automating repetitive processes, artificial intelligence has significantly changed the practice of athletic medicine and freed up doctors' time to spend more time with patients. AI is viewed as a tool to supplement rather than

replace physicians' expertise (Ramkumar et al., 2022). According to some research, experts in this sector surpass AI in the interpretation of diagnostic investigations like MRI scans, which are more complex than simple radiography, because sports medicine is such a highly specialized field (Paschos, 2021). Additionally, the technology is utilized in team sports to measure injury risk and anticipate performance (Claudino et al., 2019). Bioinformatics and biomechanics are two other concepts in this area. Sports movements and tactics are evaluated using diagnostic tools built on AI-based expert systems (Bartlett, 2006). Additionally, earlier research has highlighted the integration of AI with other "omics" technologies, such as bioinformatics, towards upgrading sport (LIMA et al., 2021).

Other important terms in this area include anthropometry and anxiety (such as using AI to analyze the relationship between these two among athletes), assistive (such as using AI by using the anthropometric data for the efficient design of wheelchair in Paralympic), biofeedback, bioinformatics, biomechanics, biophysics and biomedical engineering (such as AI-based analysis of smart sport equipment and biofeedback applications, the use of deep learning algorithm in biomedical engineering in intelligent automatic processing and analysis of sports images), and blood pressure, body mass, breathing rate (to allow coaches, physicians and trainers to better understand the physical demands of athletes in real-time).

- Intelligent Athlete Training and Education

The use of AI in contemporary training and education is the second heavily debated subject in the realm of AI and sport. Athletes' competitive abilities have substantially increased since intelligence sports training systems based on AI emerged as a supplementary training system (Li and Cui, 2021). By lowering private coaching time to avoid excessive exposure and enabling players to receive feedback to enhance their performance, AI technologies and methodologies have made it possible for athletes to obtain private, precise, and effective coaching (Ma, 2020). AI is more effective at comprehending kinematic and physiological indicators, which will improve athlete performance monitoring (Araújo et al., 2021b). Sport trailing plans are automatically generated using computational intelligence techniques, especially for individual sports disciplines (Fister et al., 2021). Additionally, AI has facilitated the creation of speedy feedback systems for elite sports training, which include sensors and devices into sporting goods or players to record the biomechanical, physiological, cognitive, and behavioral qualities of their workout(Baca and Kornfeind, 2006).

Some of the other major keywords of this cluster are active learning (through AI and other emerging AI techniques), collective intelligence (enabled by computational intelligence to increase adaptability to a changing environment), college physical education (based on artificial intelligence to improve efficiency and construction of digital, information and intelligent training), college sports, data mining technology and algorithms (to develop intelligent computer-aided athlete training), e-learning (the development of virtual learning platforms), educational robots (such as intelligent image recognition technology of football robot using omnidirectional vision of internet of things), engineering education (such as virtual reality for remote controlled robotics), knowledge management (such as knowledge-based approaches to promote human–robot collaborations) , personalization (such as personalization of intelligent virtual agents for motion training), and robot learning.

- Automated Motion Recognition and Deep Image Analysis

The third often discussed subject is athlete motion analysis and tracking using AI, deep

learning, and sophisticated algorithms to find underlying patterns in their movements. The image analysis made possible by deep algorithms is also a part of this field. A variety of data collection methods, including as live observation and post-event video analysis, have contributed to the development of player motion tracking efforts (Barris and Button, 2012) due to the advancement of AI and deep learning algorithms, which has enabled automated pattern recognition of athletes' motions(Li et al., 2022). The application of cutting-edge deep learning methods, such as artificial convolutional neural networks, will enable real-time monitoring, optimization of training plans, and feature extraction of athletes for use in later sports training systems (Liu and Ji, 2021). Other studies have created a machine learning-based SVM model for classification and recognition that can classify and recognize athletes based on their movement (Geng, 2021). Prior research has demonstrated how deep learning-based multi-athlete detection and tracking has transformed motion analysis for athletes (Brumann et al., 2021). Previous research emphasizes that deep learning-based computer vision techniques offer a workable substitute for marker-based motion capture systems (Needham et al., 2021).

Some of the other major keywords in this cluster are action recognition. In order to help coaches train athletes more effectively and give some references for sports movement identification, action recognition can be used to extract the players' training postures from the analysis of sports movements. Another concept is employing automated pattern recognition to examine the physiological and positional data of athletes, which are frequently obtained using wearable technology. Other keywords are: Bayesian inference, biometry (such as using biometry tools for fracture and injury assessment), computer vision (for purposes such as ball tracking, player tracking and pose estimation), gesture recognition (by using algorithms such as 3D Convolutional Networks), human pose estimation, image classification, image enhancement, image processing, image recognition, image segmentation (by using deep learning algorithms), imaging systems, motion recognition, object recognition, real-time performance analysis, posture, recognition algorithms, sports video analysis, and video surveillance. In conclusion, deep learning has allowed us to analyze images intelligently and thoroughly for things like position or gesture estimate and recognition.

- Athlete Robots

The role of robotics and robots in the sport industry was the fourth topic. Robots are either created specifically to compete in sporting events, or they are developed to be used in training or to boost an athlete's performance (Luis Ordonez-Avila et al., 2022). The construction of humanoid athlete robots with anticipatory behavior is the subject of this topic. These athletic robots can predict their opponent's moves by synchronizing their eyes, head, and legs (Molfino et al., 2014). Humanoid athletic robots are autonomous agents with the capacity to forecast (Mirmohammad et al., 2022). In the past, researchers have created intelligent training robots for sports like badminton, soccer, and basketball to assist with injury prevention and prediction (Xie et al., 2021). Additionally, mobile robots are developed for uses such as running exercises (Sun et al., 2021). As the topic demonstrates, the majority of athlete robots are integrated with other cutting-edge technology like the internet of things (Waqar et al., 2021). The topic also includes video games, which are regarded as top-notch labs for studying AI and computational intelligence. Studies, for instance, illustrate how AI World Cup, a set of AI competitors centered on the sport of soccer, was designed (Hong et al., 2021). The connection between humans and robots is extensively investigated in this topic for issues like encouraging individuals to

engage in physical activity (Yang et al., 2022). Some of the major keywords of this topics are autonomous agents, humanoid robots, intelligent agents, intelligent robots, opponent modelling, robocub soccer, robot applications, robot programming, robot soccer competition, robotics, robots, simulators, soccer agents, and soccer robots.

- Wearables & IoT Applications

Wearable medical technology is the fifth topic covered. Wearables can be used for a variety of purposes, including patient monitoring and delivering physiological data. Wearables employ big data to offer real-time monitoring systems by combining with sensors and smartphones (Saheb, 2018) for purposes such as automated activity recognition (Nithya and Nallavan, 2021) and ambulatory monitoring(Oubre et al., 2020). Wearable sensors can be used to perform gait analysis, which is a cheap, convenient, and effective way to provide important information for numerous health-related applications (Tao et al., 2012). Additionally, there are campus sport applications, like football, where wearable technology sensors can be connected with the Global Positioning System (GPS) and FPGA (Field Programmable Gate Array) (Chen and Sun, 2021). In order to collect, process, and analyze athlete biometric information much faster, fog computing and ubiquitous computing have grown in popularity as a result of the use of wearables in the sports business (Baca et al., 2009). Considering that wearables collect biometric data of athletes by using IoT (Saheb et al., 2022a), they also raise concerns regarding the privacy of athletes (Saheb and Saheb, 2021). Some of the other major keywords in this topic are testbeds, sensor data, intelligent sensors, intelligent control, body sensor networks, and ambient intelligence.

- Swarm intelligence & Automated Sport Planning

Swarm intelligence, which researches distributed, self-organized systems that can act swiftly in a synchronized approach, is the sixth topic in this analysis. Swarm intelligence, a core component of AI, is influenced by biological systems and emulates the cooperative behavior of a sociable group of animals in their struggle for survival (Chakraborty and Kar, 2017). Several studies have suggested using Swarm Intelligence algorithms to automatically schedule sports training sessions (Fister et al., 2019). The Internet of Things and other technologies have been utilized to identify emotions on biomedical parameters, anticipate, and interfere in sports assault behavior using swarm intelligence, and the swarm intelligence algorithm has been employed as the basic technological optimization model in these applications (Deng et al., 2022). Injury evaluation has also integrated SI algorithms like IPSGWO (Ding et al., 2021). The classification and optimization of an athlete's training effect heavily incorporates Particle Swarm Optimization (PSO).(Zhu, 2022). PSO is a swarm intelligence-based global optimization evolutionary method.

- Ubiquitous computing & Augmented Sport Applications

The seventh topic of discussion is about ubiquitous computing, which has gained popularity as a result of the growth of IoT and wearables in the sports industry. A combination of sensors, communications, and computing is characterized as ubiquitous (pervasive) computing (Baca et al., 2009). By enhancing interactive and human-centered encounters in sporting and fitness applications, this technology progresses augmented sports (Nojima et al., 2015). Popular games that use ubiquitous computing include shoot ball and smart playing cards (Römer and Domnitcheva, 2002; Sugano et al., 2006). For instance, a game called "smart playing cards" utilizes ubiquitous computing to add information technology capability to a traditional card game

by embedding RFID tags in the cards (Römer and Domnitcheva, 2002). In general, prior research has focused on three key aspects of sports technology: athlete performance, leisure and entertainment, and how technology may alter game rules (Chi et al., 2005).

For Historical Evolution of Keywords, we explain how the major keywords have evolved over time.

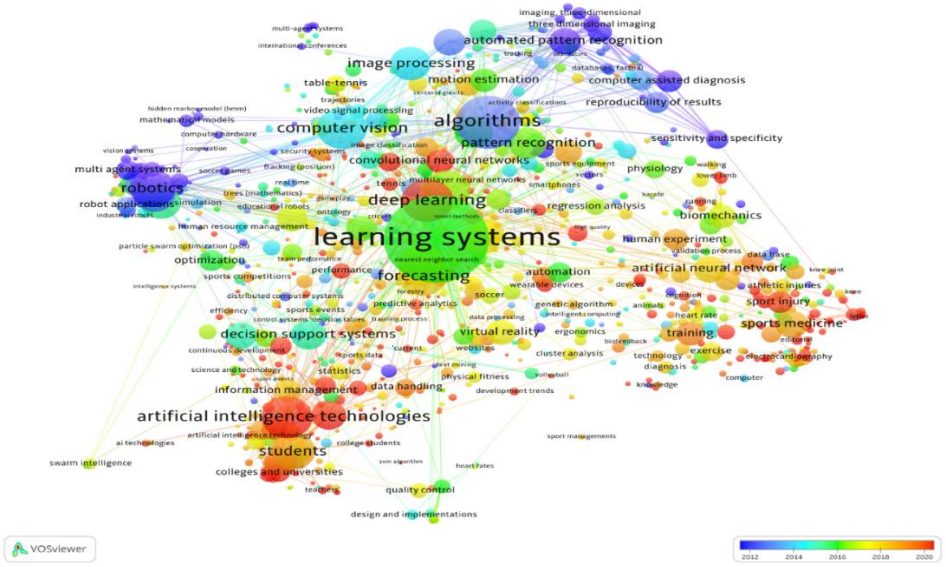

Figure 2. Historical evolution of keywords

The overlay visualization (Figure 2) demonstrates that topics related to robotics, automated pattern recognition, and computer assisted diagnosis are frequently discussed before and shortly after 2012 (dark purple). By 2013, the advancement of algorithms in 3D imaging and video recordings in the sport industry became common. 2014 saw the usage of AI in image processing, DSS, and computer vision. In 2016, forecasting and prediction made extensive use of AI. In 2018, academics focused a lot of attention on the use of AI in sports medicine, as well as in virtual reality-based training programs for students and athletes. Deep learning and other cutting-edge AI tools and technologies become widely used in 2020.

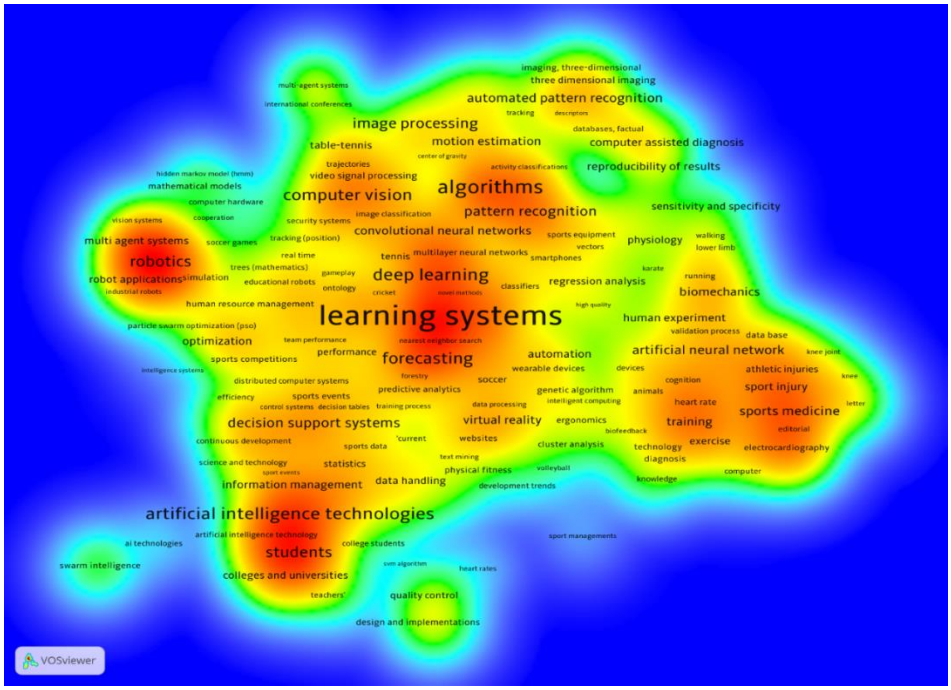

Figure 3. Density visualization of scientific research on the use of AI in sports

As the density visualization (Figure 3) demonstrates, the very dense cluster is associated with predicting, followed by advanced AI technologies for training and teaching. The third dense cluster, which is located at top left, is associated with the usage of robots and multi-agent systems in the sports industry. Computer vision, sport medicine, and pattern recognition algorithms are other dense clusters.

Discussions

In order to determine the impact of artificial intelligence on the sports industry, we undertook a co-occurrence analysis of scholarly papers. This study presented seven topics, which are depicted in Figure 4. These topics included sport medicine, training and education, motion recognition, robots, wearables, swarm intelligence and ubiquitous computing. This analysis demonstrates how AI has paved the way for the sports business to deliver real-time sport medicine and has increased the pace at which athletes receive medical attention. AI has also made it possible to create athletic intelligence-training and instruction programs. Applications for augmented sports and fitness have also been facilitated by ubiquitous computing, which has been implemented on digital technologies including IoT. The monitoring of athletes at all times and locations has been improved through wearable technology and Internet of Things apps. The automatic identification of athletic movements and motions has also been accomplished by deep learning algorithms. Hard AI and robotics have also been employed by the sports sector to create athlete robots.

Conclusion

According to the analysis, real-time analytical medical services, intelligent learning, augmented sport applications, automated sport planning, deep learning image analysis, and integration with wearable technology have been the main applications of AI. However, given how quickly AI is being adopted in the sports industry, this study suggests a number of issues that need further scholarly investigation. The first topic is associated with the advancement of precision sport medicine, which depends on large data obtained from game-changing technical advancements like inexpensive genome sequencing or cutting-edge

biotechnology. Precision medicine is a young field that prioritizes an individualistic plan to disease prevention, diagnosis, and treatment. The advent of precision sport medicine is suggested as a potential area of research by this study. Studying the use of Metaverse technology in sport and athlete training and education is the second area that needs further scholarly attention. Sports are by their very nature social, and the idea behind the metaverse is to provide social experiences that have been updated for the age of technology. The International Cricket Council strongly supports metaverse in sports, therefore future study on the paradigm of AI, metaverse, and training may be one area of focus. The third potential area of research is the ethical considerations raised by the use of AI in the sports sector, particularly with regard to athletes' privacy and surveillance. In addition, more academic research is needed on the idea of responsible AI as well as the accountability and responsibility of sport technology firms and startups.

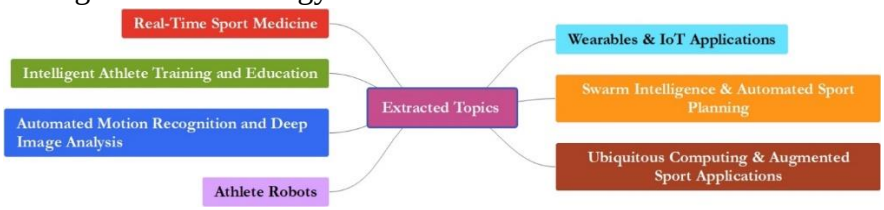

Figure 4. Extracted topics of AI in sports subjects.

The study also explores the more pressing challenges of AI and places a strong emphasis on athletic robots, but it gives only passing mention to drone use and camera movements. Future research can examine the application of drones to athletic competitions and training sessions to enhance athlete performance. Video Assistant Referee, also known as VAR, is another underestimated technological advancement that calls for deeper academic scrutiny. VAR and real-time assistance, such as in a football game, can help officials determine whether the ball has crossed the goal line or not.

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