

Artificial Intelligence in Sports Facility Management (Digitization as a Model)

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Abstract

This study aims to address the role of artificial intelligence in sports facility management, focusing on digitization as one of the application models. This is done by clarifying the concept of artificial intelligence and its main characteristics and reviewing its uses in sports, especially in facility management. The most recent technological and artificial intelligence developments are revolutionizing every facet of our existence, facilitating profound changes across numerous fields, such as medicine, education, and finance. The impact also reaches the sports field, where sports complexes are under tremendous pressure to maximize operational efficiency. In this context, artificial intelligence offers innovative solutions to address these challenges. In the Qatar 2022 World Cup, command and control centres used over 15,000 cameras to track crowd movements. In addition, artificial intelligence was used to prevent stadium crowding and predict crowd movements. The rapid development of information and communications technology requires sports facilities to adopt digital strategies that contribute to improving performance, developing mechanisms, and enhancing the sports experience for fans by moving towards digitizing the management of sports facilities, which contributes to improving efficiency and effectiveness. In the present study, the researchers utilized a descriptive approach to analyse the phenomenon in a structured and scientific manner to demonstrate the role of artificial intelligence in sports facility management and showcase the potential through which digitization can enhance efficiency as well as effectiveness in this field.

Key words: artificial intelligence, sports facilities, digitization.

Introduction

Unquestionably, the global environment is undergoing a revolution sparked by artificial intelligence (AI) that is influencing every sphere of life without any exception. With human needs constantly changing, there has been an ongoing quest for new technology applications in different forms. AI has become an inevitable part of modern life, mimicking human thought processes. The explanation of artificial intelligence has been predominantly positive, emphasizing its overall capability and resemblance to human capabilities. But it is depicted as a significant threat, an existential threat that seeks to dominate and enslave society.

The fundamental growth and development of artificial intelligence (AI) have historically been linked to the advancement of information technology world, describing all digital apparatuses and devices designed to assist in the analysis and general processing of knowledge acquired by different means. And it has enabled them to thrive and, in real application, integrate them into actual activities to meet their targets positively. For instance, during the 2022 FIFA World Cup in Qatar, there were many areas in which AI was involved for their improvement. The temperature inside stadiums was controlled according to AI systems. Also, thousands of

cameras were placed to observe the players' and fans' movements within the stadiums, demonstrating how AI expands efficiency, precision, and management of the events.

In addition, since a more specialized and more comprehensive area of AI application is evolving within the sports sector, AI integration primarily pertains to enhancing athlete performance, operating sports facilities, improving professional workflows, and majorly advising referees in their decisions. As its influence is reaching a plethora of areas, it is common belief that utilizing AI in sports is no longer a question of when, but of where. In light of these considerations, the particular premise of the present study is established around the research question:

- How does artificial intelligence enhance the management of sports facilities?
- What is the status quo of digital transformation in the sports industry?

The researchers in this study attempt to conceptualize the notion of artificial intelligence (AI) and provide its main features, with specific references to its use in the field of sports. Here, they aim to analyse artificial intelligence (AI) and provide its main features, with particular references to its use in sports. Here, they also aim to analyse the use of AI in the management of sports centres by applying digitization as a method.

The importance of this study ranges from revealing a more broadened definition of artificial intelligence through different interpretations that have jointly created a shared understanding of AI technology to their roles in contemporary human life growing more pronounced. This study builds further on the strategic orientation of the sports industry professionals who have begun to respond to the increasing demands of two sets of activities: sports facility management and administration. In addition, this study provides the theoretical foundation that could be built upon for future studies and investigations. Methodologically, this involves a descriptive method commonly regarded and a systematic analysis and interpretation method geared toward achieving specific research objectives. This includes setting into view what is, providing vivid descriptions, and reporting on the findings, both quantitative and qualitative. Within this framework, the research is organized as follows:

To address the research questions, the study is structured as follows:

- **First Axis:** Concepts of artificial intelligence (AI)
- **Second Axis:** Using AI applications in the field of sports facilities management
- **Third Axis:** Digitization in the sports field as a model
- **The Fourth Axis:** Artificial Intelligence in Sports Facilities: Child Protection and Ethics of Application

1. The first axis: concepts of artificial intelligence (AI)

1.1 Defining artificial intelligence (AI)

Intelligence entails the capacity to seek goals, exhibit reasoning, and solve problems. Artificial intelligence (AI) is a field of computer science that addresses the development of intelligent systems that mimic human intellectual abilities. Such systems enable decision-making, mimic human action, and perform complex activities such as language processing, reasoning, and problem-solving (Arnous, 2007).

AI can be defined as the science and engineering of creating intelligent machines that have human-like capabilities like understanding, hearing, vision, and reasoning (Al-Sayed, 2004). AI is characterized by Boinnet (1993) as designing computer programs that mimic mental processes to solve issues or make decisions based on established rules.

By combining the later definitions, AI employs science and technology to create independent machines capable of performing complex tasks using analytical processes similar to human minds. This is a field that studies human intellectual processes to create more efficient smart systems.

1.2 The historical development of artificial intelligence in sports facilities management

Artificial intelligence in the sports field has evolved significantly through several phases.

Starting from simple applications to advanced systems capable of analysing complex data and making strategic decisions. This historical development can be summarised as follows:

1.2.1 Phase I: Mathematical modelling and statistical analysis (1970s/1980s)

- At this stage, AI applications in sports focused primarily on using mathematical and statistical models to analyse the performance of players and teams.
- These models were used to predict match outcomes, evaluate players, and improve strategies.

1.2.2 Phase II: Rule-based expert systems (1990s)

- This phase saw the development of rule-based expert systems, which used logical rules derived from sports experts to analyse situations and make decisions.
- These systems were used to advise coaches, develop game plans, and analyse the performance of opponents.

1.2.3 Phase III: Phase 3: Machine learning and data mining (2000s)

- With the development of machine learning and data mining techniques, it has become possible to analyse massive amounts of sports data and extract valuable patterns and information.
- Applications such as automated video analysis have emerged to track player and ball movement, opening up new opportunities for performance analysis and strategy development.

1.2.4 Phase IV: Phase 4: Deep learning and advanced ai (current decade)

- The current decade has seen rapid development in the field of deep learning and advanced artificial intelligence, opening up new horizons for AI applications in sports.
- Deep neural networks are used to analyse complex data, such as player movement data, and provide deep insights into performance and strategies. AI is being used to develop robotic systems to assist in training.

1.3 The future of artificial intelligence in sports

AI is expected to play a greater role in improving athletic performance, developing new strategies, and providing immersive sports experiences for fans. The coming years will see developments in areas such as sports robotics, virtual and augmented reality in sports, and advanced sports data analysis. In short, AI in sports has evolved from simple statistical analysis applications to sophisticated systems based on deep learning and advanced artificial intelligence, and this development is expected to continue to revolutionize the world of sports in the future.

1.4 Artificial intelligence characteristics

We can present the most important characteristics of artificial intelligence in the following points:

1. Using intelligence to solve the problems presented to it in the absence of complete information that it does not have to use in solving such a model of problems, it has the ability to deal with ambiguous situations in the absence of information as well. (Adjal and Sagheer, 2023, p. 53)
2. The ability to think and create is one of its distinctive characteristics in light of what it offers in the forms of creativity.
3. The ability to acquire and apply knowledge, as knowledge is the basis of modern technology that linked information and communication technology to the application of artificial intelligence.
4. The ability to learn and understand from previous experiences and expertise, as it has the ability to store the information it obtains, and thus the ability to refer to it and use it in another way.
5. Rapid response to new situations and circumstances that it encounters, and it forms for us an image of these situations quickly through the ability to deal with difficult and complex cases (Dahiya, Bin Sayeh, 2023, p. 1005)

6. The ability to imagine and innovate in organized matters and perceive them, as it has the ability to provide information to support administrative decisions and thus make correct decisions at the appropriate time without exerting great effort or wasting time (Al-Najjar, 2010, p. 170)

1.5 Objectives of Artificial Intelligence

Artificial intelligence aims to achieve a set of goals that contribute to developing technologies and improving performance in various fields. The most prominent of these goals are:

1.5.1 Simulating human intelligence

This is done by working on developing a set of systems capable of logical thinking and making decisions like a human being, based on simulating human intelligence, the information available to him, and his way of thinking, as is the case with designing software that simulates human learning and problem-solving methods.

1.5.2 Automate processes and improve efficiency

The emphasis here is reducing the effort of humans on time-consuming and tedious tasks that require lots of time and energy. With the help of AI-powered tools, such tasks can be done effectively in less time, thereby improving the quality of work and speeding up the completion of tasks in different industries.

1.5.3 Big data analysis and precision decision-making

Today we live in a world with millions of gigabytes of information that needs to be analysed and exploited. Artificial intelligence aims to develop systems capable of processing huge amounts of data quickly and effectively, and supporting smart decision-making based on data analysis and future predictions.

1.5.4 Promoting Innovation and Technological Advancement

What is noticeable today is the trend towards relying on robots in many fields, and here is the role of artificial intelligence in improving the performance of robots and smart systems in fields such as medicine and industry. And working on developing new technical solutions that contribute to improving the quality of life.

1.5.5 Improving user experience and interaction with technology

Developing intelligent interfaces such as virtual assistants like Siri and Google Assistant. Thus, improving personalized recommendation systems in shopping, entertainment and services.

1.5.6 Enhancing cyber security and protection

In light of the challenges facing the world today, starting with cyber-attacks that require a lot of technology to confront them, artificial intelligence is working to develop advanced systems to combat cybercrime and detect fraud. And improve surveillance and facial recognition systems to ensure public security.

1.5.6 Enhancing cyber security and protection

2. The second axis: Using AI applications in the field of sports facilities management

Artificial intelligence is one of the modern tools that contribute to improving the management of sports facilities in all their forms. This is done by working to enhance operational efficiency, improve the audience experience, and support strategic decision-making in them. The following are its most prominent applications in this field:

2.1 Areas of application of artificial intelligence in sports facilities

2.1.1 Improve operational management

The matter here is based on sensor systems that rely on artificial intelligence in order to monitor the condition of the sports facility and predict malfunctions before they occur, which reduces emergency maintenance costs on the one hand. Moreover, researchers also note in this the use of artificial intelligence technologies to monitor the availability of sports tools and equipment and ensure their constant readiness.

2.1.2 Improving audience experience

The concept of ticket management and smart entry has become one of the ABCs of artificial intelligence, according to which sports facilities are developing systems based on facial recognition and smart cards to speed up the process of entering stadiums and reduce congestion at the time of entry and exit to attend matches and sports competitions. Artificial intelligence has also provided the feature of analysing fan behaviour, as it has the ability to analyse fans' interests and provide customized content, such as promotions or recommendations related to seats or services.

Additionally, it enables enhancing security within sports facilities through surveillance cameras that rely on artificial intelligence that have the ability to detect abnormal behaviour and immediately alert potential incidents (Al-Mullaji, 2023, p. 54). In addition, artificial intelligence has also been used to control and improve fan practices inside and outside stadiums, which contributes to improving the fan experience. For example, the American Golden State Warriors club relies on artificial intelligence to create virtual practices that allow fans to easily obtain match tickets or view match schedules and match programs. The Los Angeles Dodgers club also uses artificial intelligence technologies to facilitate the process of finding seats for fans inside the stadium, which reduces chaos and ensures a more comfortable and smooth experience for the audience.

2.1.3 Enhancing marketing strategies and financial management

The role of artificial intelligence applications is in various processes in the field of marketing and financial management, including revenue and sales analysis, which is based on the use of artificial intelligence to study the purchasing patterns of audiences directly and indirectly, and then try to provide effective marketing strategies to increase revenues. It is also done in the field of advertising and personalized promotion: where artificial intelligence plays a role in developing targeted marketing campaigns based on the interests of fans and their behaviour online.

2.1.4 Enhancing environmental sustainability

Artificial intelligence has been adopted in designing smart stadiums by applying artificial intelligence technologies to create environmentally friendly stadiums, through the use of smart lighting systems and water conservation technologies. Artificial intelligence is an effective tool in developing the management of sports facilities, as it contributes to improving operational efficiency, enhancing security, and increasing interaction with fans, leading to a more advanced and sustainable sports experience. (Adjal and Sagheer, 2023, p. 56)

2.2 Areas of application of artificial intelligence in sports facilities

Over the past few years, the sports industry has undergone a major shift towards digital transformation, which has radically changed the way fans experience games. Smart stadiums, equipped with the latest connectivity and IoT solutions, have emerged as the next frontier in fan engagement. These technologically advanced venues not only elevate the gaming experience, but also create new opportunities for teams and organizations to connect with their fan base.

2.2.1. The development of fan interaction.

The dynamics of fans have significantly evolved with the advent of the digital era. Modern fans desire more than simply occupying a seat in the audience; they yearn for an engaging and comprehensive experience (Berkan ATASOY, 2021). This shift in expectations has led to sports organizations investing in technology that enhances fan engagement. Smart stadiums have emerged as a workable solution to this problem, offering a wide range of features and services that cater to the needs of today's fans.

2.2.2. Connectivity: the backbone of smart stadiums

The success of a smart stadium is founded on its connectivity infrastructure. Quick and reliable Wi-Fi networks, complemented by cellular networks, that provide constant connectivity to the

fans during the event. A good network is essential for the fans who want to upload selfies on social media, view match data in real time, or order refreshments at their seats.

2.2.3. Wi-Fi networks

Smart stadiums are equipped with wireless internet networks that ensure seamless connectivity for multiple spectators simultaneously. This allows the spectators to access various digital services, such as mobile applications, live broadcasting without any disruption.

2.2.5. Mobile Apps

Sport organisations and their respective stadiums have developed dedicated mobile apps aimed at providing a personalized and interactive experience for spectators. These apps feature functions such as mobile ticket buying, ordering food from your seat, live commentary for games, and offering virtual reality experiences.

2.2.6. IoT Solutions to Enhance Fan Experience

Internet of Things (IoT) technology is instrumental in enabling fan engagement in smart stadiums. Through the integration of multiple IoT devices and sensors, such stadiums are able to capture data, automate operations, and create special experiences for fans.

2.2.7. Smart Ticketing

Instead of paper tickets, electronic tickets on the mobile phones of fans enable them to enter the stadium conveniently. This not only reduces queues but also provides a contactless solution amidst the COVID-19 era.

2.2.8. Smart Seating

IoT-powered embedded in seating arrangements can offer real-time information regarding seat availability, thereby assisting spectators in finding empty seats throughout the event. Smart seating can also incorporate haptic feedback technology, which enhances the more sensory experience for guests by generating vibrations at key moments such as goals or touchdowns.

2.2.9. Smart Devices

IoT-powered kiosks and vending machines have the potential to automate food and drink ordering procedures. Consumers can place orders conveniently through mobile apps and receive notifications when their items are available for collection, thus reducing wait time and offering an experience free of inconvenience.

2.2.10. Stadium Security

The Internet of Things (IoT)-enabled security systems, focusing on facial recognition and video analytics, offer heightened safety while ensuring an atmosphere that is conducive to enhancing fan experiences. Supporters are able to enter the stadium quickly and easily without much hassle.

2.2.11. Environmental Monitoring

Nowadays, smart stadiums are also leaning toward environmental consciousness. For instance, IoT sensors can keep track of energy use, waste disposal, and water use and help stadiums cut down on their carbon footprint and involve fans in making sustainability efforts.

2.2.12. Enhancing the fan/crowd experience

The primary goal of smart stadiums is to enhance the fan experience, making it more enjoyable, interactive, and immersive. Some ways in which smart stadiums achieve this include:

- **Interactive Screens:** Smart stadiums feature interactive screens and video walls that provide real-time statistics, replays, and dynamic content. Fans can engage with these screens to gain deeper insights into the game and enjoy a more immersive experience.
- **Gamification:** Interactive screens and video walls presenting all kinds of statistics, replays, and dynamic content form an important part of smart stadiums. Fans can gain insights into the game and enjoy a more immersive experience through interactive engagement with these screens.
- **Fan-Centric Analytics:** IoT solutions are gathering the information on fan behaviour, preferences, and reactions. The data can be analysed by the sports organizations to gain

knowledge on their fan base and consequently improve the marketing strategies intended to connect more with its audience.

2.2.13. Monetizing Fan Engagement

Apart from improving the fan experience, smart stadiums give sports teams fresh income sources and chances for monetising:

- **Sponsorship and Advertising:** Smart stadiums provide appealing sponsorship prospects for companies with digital screens, interactive content, and focused advertising. Personalised content and interactive campaigns let advertisers involve fans.
- **Data Monetization:** Data gathered from Internet of Things devices can be really useful. Sports corporations can profit from this information by offering analytics and insights to sponsors, advertisers, and other businesses trying to know spectator behaviour.
- **Merchandising and Concessions:** IoT technologies improve the whole fan experience by streamlining the shopping for concessions and goods procedure. This extra comfort can inspire more sales and income for the venue.

2.3 The role of artificial intelligence in smart, climate-friendly stadiums

In the framework of global efforts, teams and nations compete hard in numerous sports—particularly football—this competition has gone beyond the field towards sustainability, promoting the creation of ecologically friendly stadiums and facilities. The impetus for sustainability is not exclusively anchored in climate concerns; rather, the economic rewards of investing time and money.

Numerous reports show that some large stadiums worldwide have been planned or redeveloped with a strong emphasis to environmental sustainability. One noteworthy example is the Mercedes-Benz Stadium in Atlanta, United States, home to the Atlanta Falcons and Atlanta United football teams. This stadium was the first professional sports facility in the U.S. to obtain the Leadership in Energy and Environmental Design (LEED) accreditation. It is widely recognised as one of the most sustainable sporting venues internationally, integrating energy-efficient technology, renewable energy sources, and specific water conservation measures. Notably, the stadium incorporates rainwater harvesting tanks with a capacity of 680,000 gallons, which are employed for cooling and irrigation reasons (Elnour, 2023).

In London, Tottenham Hotspur's new stadium is committed to lowering carbon emissions by 2030, with the objective of becoming totally carbon-neutral by 2040. Sustainability efforts at the stadium include a 100% reliance on renewable energy sources, ongoing initiatives to limit plastic waste and promote recycling, and the establishment of biodiversity-friendly areas with wildflower meadows, ponds, and habitats for insects and bats. These activities illustrate a holistic approach to environmental responsibility in sports infrastructure.

Meanwhile, the Rams Park Stadium (previously known as Nef Stadium) in Istanbul, home to the Galatasaray football team, just set a Guinness World Record for the most solar energy output by a sporting venue. The stadium's huge rooftop solar network, encompassing 40,000 square meters, generates 4.2 megawatts of power through over 10,000 solar panels. This renewable energy output is equivalent to the electricity consumption of 2,000 families and reduces annual carbon dioxide emissions by 3,250 tonnes (Elnour, 2023). These examples illustrate the vital role that AI-powered solutions can play in boosting the efficiency and sustainability of sporting facilities.

2.4 Comparing artificial intelligence in developed and developing countries

Aspect	Developed Countries	Developing Countries
Technological Infrastructure	Advanced systems, including high-speed internet and cloud computing, facilitating AI development.	Weak infrastructure hinders AI adoption and implementation.
Investment & Funding	Significant investment from public and private sectors.	Insufficient funding for AI research and development.
Skills & Expertise	Strong AI talent pool in computer science and engineering.	Shortage of skilled professionals in AI fields.
Data Availability	Abundant data resources supporting AI applications.	Limited data collection and analysis capabilities.
Regulatory Framework	Established legal and ethical AI regulations.	Lack of clear AI governance policies.

This comparison demonstrates the discrepancy between industrialised and developing nations in AI use. Bridging this gap requires strategic actions, including improved investment, infrastructural improvements, and capacity-building programs to ensure that AI benefits are equitably spread worldwide.

2.4.1 Opportunities and challenges

2.4.1.1 Opportunities

Artificial intelligence can contribute to reaching sustainable development goals in developing countries by increasing healthcare, education, and agriculture. It can also promote sports practices and infrastructure development through international sports bodies' projects (CIO-FIFA).

2.4.1.2 Challenges

The challenges include the digital gap, a shortage of skilled people, exorbitant expenses, and ethical considerations. Therefore, bridging these gaps requires deliberate policy, international coordination, and investment in human resources to ensure AI-driven improvements benefit all industries equitably.

2.5. How to reduce the costs of using artificial intelligence in sports facilities

2.5.1 Improving energy efficiency

Smart energy management systems can boost energy efficiency in sporting facilities by automatically adjusting lighting, heating, and ventilation based on parameters such as crowd size and weather conditions. Predictive maintenance can assist identify equipment flaws and anticipate potential breakdowns before they occur, and prolonging equipment lifespan.

2.5.2 Enhancing operational management

AI can improve crowd control by guiding spectators within and outside the facility, decreasing congestion and boosting their entire experience. Security and safety in sporting stadiums can be increased with intelligent surveillance systems that detect suspicious behaviours and inform security staff.

2.5.3 Enhancing fan/crowd experience

AI can deliver individualised recommendations to fans, such as food, beverages, and products, enhancing sales and overall pleasure. It can also provide interactive experiences, such as augmented reality applications and interactive games, making events more enjoyable and driving repeat attendance.

2.5.4 Utilizing shared resources and open-source software

Instead of investing in expensive equipment, sporting facilities can rent cloud computing services as needed, saving maintenance and infrastructure costs. Open-source software can be used to develop AI solutions at a reduced cost, minimising dependency on pricey commercial

software.

2.5.5 Building strategic partnerships and sharing experiences

Collaboration with technology companies helps sporting venues to design bespoke AI solutions tailored to their specific demands. By exchanging data and experience, sports organizations may minimise development costs and boost overall efficiency.

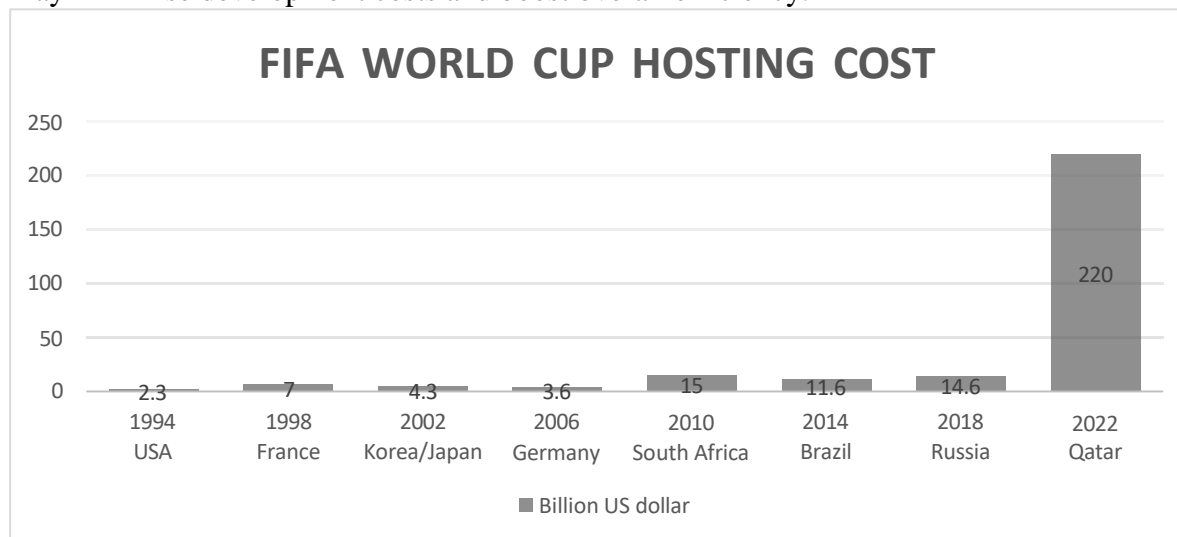


Table 1: Costs of Hosting the FIFA World Cup

From table one it is obvious that the cost of hosting the FIFA World Cup has dramatically escalated throughout the years, with Qatar 2022 marking an unparalleled spending compared to prior events. This underscores the growing necessity for creating strategic alliances and sharing experiences to manage expenses effectively and ensure sustainable event management.

2.6. The risk of AI replacing human judgment in critical decisions

The growing tendency of substituting human judgment with artificial intelligence in crucial decision-making processes provides a complex array of issues and potential threats that must be thoroughly examined. As AI systems continue to evolve and integrate into numerous industries, questions regarding ethical implications, reliability, accountability, and unexpected repercussions become increasingly prominent. Therefore, a careful and complete examination is necessary before full dependence on AI can be contemplated, ensuring that its implementation conforms with ethical standards, safeguards human interests, and mitigates the risks involved with delegating key choices to non-human intelligence.

One big risk is bias and discrimination. AI models are trained on large volumes of data, and if this data reflect existing societal biases, the algorithm will learn and apply them in its conclusions, potentially leading to discrimination against specific groups. For example, an AI system might decline a loan application from a person belonging to a certain ethnic group based on historically biased data (Aldeen, 2023, pp. 50-61).

Over-reliance on AI provides another risk, as complete dependency on AI for important judgements may degrade human decision-making ability. This is particularly harmful in emergencies or unanticipated scenarios where AI may not be ready to respond appropriately. A fundamental ethical and legal concern is accountability. If an AI system makes a poor judgement that causes harm, who is responsible? Should the culpability fall on the firm that designed the system or the individual who utilised it? These concerns demand explicit legal and ethical frameworks (Aldeen, 2023, pp. 50-61).

To mitigate these concerns, AI should be applied cautiously in important decision-making. Ensuring model openness, thorough testing, and regular performance monitoring is critical. Human monitoring should remain a vital aspect of AI-driven decisions, and clear legal and ethical guidelines must be created. Instead of totally replacing human judgment, AI should be

utilised as a supportive tool to boost decision quality and consistency while keeping the human position as the final authority.

3. The Third Axis: Digitization in the sports field as a model

3.1 Defining digitalisation

Digitalization is derived from the verb "to digitize," which refers to the act of transforming physical paper-based writings into electronic documents that operate using a binary system of 1 and 0. One of the key advantages of digitalization resides in its ability to establish a direct relationship between two essential factors that support contemporary computing systems: precision and speed (Wafi & Sahli, 2007/2008, p. 71). Moreover, digitalization comprises a set of methods and actions aimed to turn actual, physical documents into digital representations made of symbols, numbers, and codes that can be stored and retrieved via computer systems (Dekhakhni et al., 2021, p. 302). Therefore, based on the previous definitions, digitalization can be regarded as a process of electronically handling information and data, shifting from paper-based and physical formats to digital platforms. Additionally, the fundamental purpose is to maximise task performance, reduce effort, and boost efficiency.

3.2 Domains of digitalization in sports administration

Digitalization has been a crucial feature in enhancing sports administration. In recent years, sports facilities have increasingly embraced digital technologies, given their various advantages that exceed potential negatives. Some significant domains of digitalization in sports administration include:

3.2.1 Sports information management systems: Digitalization facilitates the automation of administrative operations involving all stakeholders within a sports organization, including management, technicians, coaches, and players. This comprises tasks such as athlete registration, contract management, payroll processing, and social security administration.

3.2.2 Digitalized access control in sports facilities: One of the most significant technology solutions in the sports sector is the adoption of digital access control systems. These systems govern the entry and exit of individuals within sports complexes, ensuring a secure and efficient environment. Players, coaches, employees, and visitors are registered by smart cards, facial recognition, or biometric scanners for precise attendance tracking.

3.2.3 Online ticketing platforms: The switch to digital ticketing platforms has altered how sports event tickets are purchased globally. Platforms like "www.tazkarti.com" offer secure and seamless online ticket reservations, minimising conventional crowds at physical ticket booths. The idea is to enhance the fan experience while expediting the ticket buying procedure.

3.2.4 Artificial intelligence in sports facilities: Traditionally, preparing for big sporting events entails conducting training camps to examine a team's strengths and shortcomings. However, other elements, such as stadium circumstances and referee choices, may impact match outcomes. Given current technical breakthroughs, artificial intelligence (AI) has become a key element in sports administration. Notable AI-driven technologies include Goal Line Technology (GLT) and the Video Assistant Referee (VAR) system. GLT gives precise evaluations of whether the ball has fully crossed the goal line, while VAR allows for a thorough review of contentious referee decisions, improving the accuracy and fairness of officiating (Kamal Eddine, 2020).

3.2.5 Video assistant referee (VAR) technology: FIFA has embraced VAR technology as part of its commitment to advancing sports officiating and defending the rights of athletes and clubs. The VAR system depends on AI and high-resolution video records to examine important choices, including as offside calls, penalty area infractions, and red card offenses. Advanced image processing and deep learning techniques permit the speedy discovery of faults, enabling increased accuracy in match adjudication.

3.2.6 The impact of digital transformation on job roles in sports facilities management

The advent of digital transformation has significantly reshaped functional roles in sports facility

management, leading to substantial shifts in responsibilities and required skill sets. The table below illustrates key changes in various roles before and after digitalisation:

Role	Pre-Digital Transformation	Post-Digital Transformation
Facility Manager	Focused on maintenance, scheduling, and budgeting.	Uses data and technology for efficiency and informed decision-making.
Event Management	Relied on manual processes and in-person interactions.	Leverages digital platforms for ticketing, promotion, and audience engagement.
Maintenance	Followed fixed schedules, leading to inefficiencies.	Uses IoT and predictive analytics for proactive maintenance.
Marketing & Communication	Used traditional methods with limited reach.	Employs digital tools for targeted marketing and customer insights.
Customer Service	Depended on direct or phone-based support.	Integrates AI chatbots and digital platforms for 24/7 service.

This paradigm shift underscores the necessity for sports facility managers and personnel to acquire digital literacy and adaptability. As the sector continues to evolve, embracing technological advancements will be crucial for maintaining operational efficiency and competitive advantage.

(Jokela, 2024)

4. The Fourth Axis: Artificial Intelligence in Sports Facilities: Child Protection and Ethics of Application

4.1. AI and Sports: A Quantum Leap or the Beginning of Ethical Problems?

Artificial intelligence has revolutionized many fields, and sports are no exception. We have previously discussed how AI contributes to improving athletic performance, match analysis, fan experience, and even the management of teams and sporting events more efficiently. However, while we celebrate these amazing benefits, it is essential to critically consider the other side of the coin: the ethical challenges and potential negative impacts that may arise from the increasing reliance on AI in sports.

4.1.1- Ethical Challenges and Impacts of AI in Sports Facilities

It is undeniable that integrating AI into sports opens up new horizons, but at the same time, it raises fundamental ethical questions that must be seriously addressed. These challenges include:

Stadium Surveillance: Smart surveillance systems are used in stadiums to provide security, analyze audience behavior, and even improve the attendee experience. However, these systems, which rely on high-resolution cameras and facial recognition, collect enormous amounts of personal data about audiences often without their knowledge or their consent.

* **Privacy Violation:** This continuous surveillance raises serious concerns about privacy. Who has the right to access this data? How is it stored and used? Could it be used for undeclared purposes or utilized outside the context of sports, such as in-depth personalized marketing or even general surveillance?

Bias in Decision-Making: Error-making Robots

Artificial intelligence, in essence, relies on the data it is trained on. If this data is biased or reflects pre-existing biases in society, AI systems will replicate and amplify these biases in their decisions.

* **Bias in Facial Recognition Algorithms:** Facial recognition systems are a clear example of this problem. They are often less accurate in recognizing faces of women and dark-skinned individuals, due to a lack of diverse data in training datasets.

* **Facial Recognition Errors in Sports:** Problems may arise in the a situation where a facial recognition system is used to identify fans banned from entering the stadium or to provide personalized services. If this system is biased, it could lead to errors in identity recognition,

causing innocent fans to be denied entry or be treated unfairly.

* Bias in Sports Performance Evaluation: If AI is used to evaluate player performance and determine team selections based on biased historical data, talented players may be excluded due to their backgrounds or characteristics that were undervalued in previous data.

4.1.2- The Impact of AI on Employment: The Question of Robots Replacing Humans

The advancement of AI raises legitimate concerns about its impact on the labor market. In sports, as in other fields, there is a significant potential for automating tasks that were previously performed by humans. Among its impacts are:

* Replacement of Human Labor in Facility Management: AI can take over sports facility management tasks such as maintenance, security, cleaning, and can be more efficient and cost-effective in energy management. This may lead to a reduced need for human labor in these areas, resulting in job losses.

* Potential Loss of Coaching and Analysis Jobs: While the role of human coaches and analysts remains important, AI can help analyze data faster and deeper, and may take over some of their traditional tasks in the future. This could reduce the need for human coaches.

* Socio-economic Impact: Job losses resulting from AI automation can have negative socio-economic impacts on individuals and communities that rely on these jobs. Consideration must be given to retraining affected workers and providing them with new job opportunities in other fields.

A call for a Responsible Use of AI in Sports

To address the above ethical challenges, it is essential to adopt a responsible approach to the development and use of AI in sports facilities. This requires:

* Ensuring Special Attention for Ethical Challenges and Impacts: A detailed discussion of ethical challenges should be included in any discussion of the benefits of AI in sports. This section should include a comprehensive assessment of potential risks and propose solutions to mitigate their negative impacts.

* Developing Clear Laws and Regulations: There is a need for laws and regulations governing the use of AI in sports, especially regarding privacy, personal data, and bias. These laws should ensure the protection of individual rights and the avoidance of discrimination.

* Transparency and Accountability: AI systems used in sports must be transparent and accountable. It must be possible to understand how these systems work and how they make decisions. In the event of errors or biases, there must be mechanisms for accountability and correction.

* Developing Ethical and Neutral AI: Focus should be placed on developing AI systems specifically designed to avoid biases and ensure fairness. These systems should be trained on diverse and unbiased data, and periodic tests and evaluations should be conducted to ensure their effectiveness and fairness.

* Prioritizing the Human Element: We must always remember that the ultimate goal is to enhance the human experience in sports – be it an athlete, a fan, or a worker. The use of AI should be a means to achieve this goal, and not come at the expense of fundamental ethical values or human rights.

4.2. Contribution of Artificial Intelligence to Child Protection in Sports Facilities

4.2.1. Smart Surveillance and Enhanced Security

* Smart Surveillance Cameras: AI-equipped surveillance cameras can analyze video in real-time to detect unsafe situations or suspicious behaviors. For example:

* Fall and Injury Detection: AI can recognize patterns of falls or injuries that children may experience during sports activities and alert officials immediately.

* Monitoring Restricted Areas: The system can detect children entering dangerous or restricted areas such as heavy equipment zones, unsafe storage areas, or construction zones.

* Identifying Dangerous Crowds: In areas such as entrances, exits, or viewing areas, AI

can analyze crowd density and predict dangerous overcrowding situations that could expose children to pushing or trampling.

- * Facial Recognition for Authorized Individuals Only: Facial recognition systems can be used to ensure that only authorized children and adults enter specific areas within the facility, such as locker rooms or children's areas. Officials can also be alerted if an unauthorized person or someone on a no-entry list is identified.

- * Sound Analysis for Distress Detection: AI can analyze sound from microphones installed in the facility to identify signs of distress, shouting, or unusual noises that may indicate a child in danger, a child being bullied, or one being assaulted. (Steve Miller, 2024)

4.2.2. Improving Safety Procedures and Reducing Accidents

- * Monitoring the Quality of Sports Equipment: AI can analyze images and videos of sports equipment, such as seats.

- * Analyzing Movement Patterns to Identify Potential Hazards: By analyzing movement data and patterns of children's use of the facility, AI can identify areas or times where the likelihood of accidents or injuries increases. Preventive measures can then be taken, such as increasing supervision, modifying the area design, or placing warning signs.

- * Early Warning Systems for Hazardous Weather Conditions: AI can integrate current and forecast weather data with facility location data to provide early warnings about hazardous weather conditions such as thunderstorms, strong winds, or extreme heat. These warnings can help the authorities make immediate decisions, such as evacuating the facility or suspending outdoor sports activities to protect children.

4.2.3. Enhancing Supervision and Timely Alerting of Officials

- * Automated Supervision Alert Systems: AI can analyze the density of children in different areas of the facility and compare it to recommended supervision ratios. If the system detects that an area is under-supervised (e.g., a large number of children with very few supervisors), it can send automatic alerts to officials to dispatch more supervisors.

- * Assisting Supervisors in Rapid Incident Response: In the event of an accident or injury, AI systems can assist supervisors in providing a faster and more effective response. The system can provide immediate information about the location of the incident, the potential type of injury, and the initial actions to be taken.

- * Improving Communication Between Children and Supervisors: Applications or smart devices (such as smartwatches designed for children) may be developed to allow children to send quick distress alerts to supervisors if they feel they are in danger or in need of assistance.

4.2.4. Combating Bullying and Harassment

- * Analyzing Behaviors to Detect Potential Bullying: AI can analyze videos and audio recordings to detect behavioral patterns that may indicate bullying or harassment, such as aggressive body language, abusive language, or social isolation of a child. The system can alert supervisors when such behaviors are detected for early intervention.

- * Providing Safe Reporting Channels: Electronic platforms or AI-powered applications may be created to allow children to report incidents of bullying or harassment confidentially and safely. AI can analyze these reports, categorize them, and direct them to the appropriate officials for necessary action.

Ethical Considerations and Necessary Safeguards:

With all these potential benefits, it is essential to emphasize the important ethical considerations and safeguards for child protection:

- * Privacy and Data Protection: The collection and use of children's data must be transparent and responsible, with informed consent from parents. Data must be protected from unauthorized access or misuse. Strict adherence to privacy regulations concerning children's data is mandatory.

- * Bias and Discrimination: Assurance must be made that AI systems used do not incorporate

any biases or lead to discrimination against any group of children. These systems must be periodically tested and evaluated to ensure their fairness.

* **Balancing Security and Excessive Surveillance:** A careful balance must be achieved between using AI to enhance security and protect children and avoiding excessive surveillance that may stifle their freedom or make them feel constantly monitored. The goal should be to create a safe and comfortable environment for children.

* **The Centrality of Human Supervision:** AI should not completely replace human supervision. AI should be a tool to support and enhance the work of human supervisors, not a replacement for them. Human interaction and relationships remain fundamental to child protection and care.

* **Training and Awareness:** All personnel in sports facilities (supervisors, coaches, administrators) must be trained on how to use AI systems effectively and ethically, and how to respond to alerts and notifications issued by these systems. Children and parents should also be educated about how these systems work and be made aware of their privacy rights (Steve Miller, 2024)

5. Methods

Based on a descriptive approach, researchers in this study incorporate a wide range of analytical techniques in extracting findings and interpreting data. Primarily aiming on describing phenomena as they exist in reality. Additionally, utilising qualitative analysis to examine the meanings of words and phrases within their contextual framework. Therefore, this method allows for an in-depth exploration of the themes and issues embedded within the study's key axes, offering a comprehensive understanding of (AI) and its role in sports facility management.

6. Literature review

Alsuhaime (2024) attempted to investigate how artificial intelligence applications may improve Saudi Arabia's sports institutions' performance. Researchers sought to find possible advantages of AI in helping staff members of these companies to perform their jobs. The results revealed that AI may be practically applied in several fields, including marketing, audience involvement, team and player performance analysis, and future performance trend prediction.

Particularly in view of fast developments in artificial intelligence technology, Mathkur (2022) looked at how AI applications may be used to improve remote learning. The research examined the extra value artificial intelligence could provide for distant learning and came to the conclusion that in this regard AI is a quite useful instrument. Emphasising the creation of expert systems acting as virtual human advisers in many fields, the study indicated the eventual potential of totally virtual schooling.

Using Saudi Arabia's Vision 2030 as his framework, Al-Qahtani (2022) investigated how artificial intelligence may help to reach sustainable development goals. Using a descriptive-analytical methodology, the phenomenon under examination was examined and explained. The results exposed that artificial intelligence has been effectively applied in several spheres, including education, financial markets, industry, automation, law, scientific research, and technology. The research underlined how artificial intelligence might be a major enabler of sustainable development since it could drive social and economic revolution.

7. Findings

Artificial intelligence offers enormous potential for radically altering the management of sports facilities. It promotes more accurate and efficient decision-making, enhances audience engagement, increases operational efficiency, and unlocks new revenue streams. Nonetheless, the integration of artificial intelligence applications has to be handled carefully since it raises issues with regard to privacy, security, prejudice, and ethics. To realise the full benefits of AI, stakeholders must adopt a deliberate, forward-thinking strategy that blends innovation with responsibility. Successful AI adoption needs thorough planning, judicious technology selection, intensive staff training, and regular evaluation to guarantee alignment with industry

trends. Moreover, establishing a culture of adaptation and ethical AI governance is vital to avoid risks and enhance the long-term effect of AI in the sports sector.

8. Recommendations

To effectively harness the potential of artificial intelligence (AI) in sports facilities, a number of strategic recommendations should be considered:

Enhancing individualised fan experiences: AI may be exploited to create bespoke experiences for spectators, including seat recommendations, customised food and beverage offers, and immersive virtual and augmented reality experiences.

Security and safety optimisation: AI-powered analysis of data from cameras and sensors can boost security measures by detecting suspicious conduct, reducing overcrowding, and guaranteeing a safer environment within sporting facilities.

Efficient resource management: AI applications can optimise the management of energy, water, and other resources, resulting to cost reductions and increased environmental sustainability.

Athlete performance analysis: Advanced AI systems can evaluate athletes' performance indicators, giving data-driven recommendations to optimise training programmes and avoid injury risks.

Robotics integration: AI-powered robots can be engaged for numerous duties, such as stadium cleaning, customer service, and security inspections, thereby enhancing operational efficiency.

AI integration with new technologies: Combining AI with technologies such as the Internet of Things (IoT), blockchain, and virtual and augmented reality can lead to more integrated and effective solutions in sports facility management.

By embracing these ideas, sports institutions can strike a balance between technical innovation and responsible AI deployment, assuring sustainable and ethically sound improvements in the industry.

9. Conclusion

The foregoing discussion demonstrates the enormous impact of artificial intelligence (AI) across numerous facets of the sports industry. The move to digital management in the sports sector has become an inevitable step in keeping pace with technology improvements and reaching higher levels of efficiency and transparency in administration. The rapid development of information and communication technology mandates the use of digital techniques that enhance administrative performance, improve decision-making processes, and elevate the entire sports experience for fans.

For this transition to succeed, several basic components must be ensured, including investment in digital infrastructure, the deployment of current equipment, and the continual development of human capital through training and capacity-building initiatives. The integration of AI in sports management has become a defining aspect of the modern period, particularly through the digitalisation of sports facility operations. AI-driven solutions in sports training enable the study of athletes' performance data, allowing for accurate forecasts regarding their future performance and movement patterns. Additionally, AI-powered facility management boosts operational efficiency and enables seamless contact with a broad audience.

The application of AI-based video technology in sports officiating has drastically transformed the worldwide football environment, delivering radical improvements in match regulation and decision-making. Furthermore, the creation of legal and regulatory frameworks controlling the sector is vital to effectively manage and protect the digital rights and data of athletes and spectators. The increased reliance on technological solutions—such as AI, cloud computing, and the Internet of Things—empowers sports management to assess data, enhance performance, and make educated decisions. Collaboration between the public and commercial sectors plays a critical role in facilitating this transformation by providing the necessary finance and technology resources.

Ultimately, e-governance in sports is no more a mere choice but a strategic imperative for assuring the development, professionalism, and sustainability of the business. Through the appropriate utilisation of technology, sports organisations may take major leaps in boosting administrative performance, fostering transparency, and growing the sector in conformity with global norms.

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