

## Artificial Intelligence & Sports

Murat Meriçelli<sup>1</sup>

Mürsel Ozan İncetas<sup>2</sup>

### Abstract

Artificial Intelligence has gained tremendous momentum with factors such as increased computational capacity, big data analysis, and the development of deep learning algorithms. Artificial intelligence is redefining the rules of the game and the performance of athletes, entering the world of sports, which originates in human history. The use of artificial intelligence in sports can be summarized under the following eight key areas: Training Programs, Score Predictions and Betting, Health Applications, Tactical Strategy and Transfers Determination, Referee Decision Support Systems, Artificial Intelligence Playing Sports and Esports-Sports Journalism, Wearable Technology and Sensor Data. This close collaboration is reshaping the future of sport by fundamentally altering the experience of both athletes and fans. Combined with technological innovations, sports have the potential to provide a more efficient, effective, and entertaining experience. Sports and artificial intelligence can combine to deliver unforgettable moments for both athletes and spectators, but an approach that balances this evolution is required. Therefore, this close cooperation between sports and artificial intelligence should be managed with a perspective that attaches importance to ethical values and human factors.

### INTRODUCTION

It is possible to talk about the concept of digitalization and the impact of computers on human beings' lives on many different issues in daily life. Individuals' interaction with information technologies started with the emergence of personal computers, and large masses have been digitalized

1 Dr. Öğr. Üyesi, Kastamonu Üniversitesi/Mühendislik ve Mimarlık Fakültesi/Kastamonu  
Email: muratmericelli@gmail.com, ORCID 0000-0003-0168-3221

2 Doç. Dr., Alanya Alaaddin Keykubat Üniversitesi/ Alanya Ticaret Ve Sanayi Odası Meslek  
Yüksekokulu/Antalya, Email: ozanincetas@yahoo.com, ORCID 0000-0002-1016-1655

with several developments, such as the development of the Internet-based Web and the emergence of mobile applications. Artificial intelligence (AI), which was the subject of science fiction movies until the recent past, has become an essential field of study in computer science, and today it is seen that departments named “Artificial Intelligence Engineering” have been established in informatics faculties (YÖK, 2023). So what is the AI? Although people generally think of intelligent robots taking over the world, is it so?

AI refers to machines and computational methods endowed with the ability to perceive, store information, and make decisions aligned with predefined objectives (Chris et al., 2022). AI has surged forward, driven by factors like augmented computational capacity, big data analysis capabilities, and the continuous development of deep learning algorithms. AI aims to create systems with human-like abilities to solve complex problems and make decisions. Recently, AI applications have significantly succeeded in many areas, such as image recognition, natural language processing, game strategy development, and autonomous driving.

New technologies and research applications in the AI field have created a significant revolution in the world of sports in recent years. Sport has always attracted great attention as an activity based on maximizing people’s physical abilities and performing in a competitive environment. However, the introduction of AI into the world of sports is redefining the rules of the game and the performance of athletes (Chmait & Westerbeek, 2021).

The convergence of AI and sports science confers substantial advantages in optimizing athlete performance, mitigating injury risks, and refining game strategies. For instance, AI can conduct biomechanical analyses by closely monitoring athletes’ movements, offering valuable insights to help athletes enhance their techniques (Ding, 2019). Furthermore, big data analysis supports tactical development processes while making training programs more personalized. Rapid technological advances in computer science and the evolution of sports science have led to a unique coming together of these two distinct fields. By combining these two disciplines, AI has significantly impacted several areas, such as sports analysis, performance optimization, and sports broadcasting. This chapter embarks on the development of AI in computer science and sports sciences and discusses what innovations these two fields bring forward.

## METHOD

This study has been prepared as a literature review.

## SPORTS ACTIVITIES

The origins of sports go back to human history. People survived by using their physical abilities during the hunting and gathering periods. Over time, these activities have evolved into events carried out for ritual, entertainment, and competition purposes. Crucial insights into the origins of sports can be gleaned from the historical records of civilizations such as Sumer, Egypt, Ancient China, and Ancient Greece. Events like the Olympic Games in Ancient Greece stand as a testament to the transformation of sports into endeavors that acquired a social and cultural significance (Akıncı, 2022) (Tekin & Tekin, 2014). The foundations of modern sports were laid in the 19th century. Industrialization, urbanization, and the development of communication technologies have enabled sports to gain a more organized and institutional structure. Modern sports have become an area where rules are determined, and national/international organizations are organized (Atasoy & Kuter, 2005)(Ekmeççi et al., 2013). The development stages of sports can be summarized as follows (Akıncı, 2022)(Tekin & Tekin, 2014) (Ekmeççi et al., 2013)(Atasoy & Kuter, 2005):

- **Practicality and Survival:** Early humans relied on skills like hunting, running, and jumping for survival.
- **Rituals and Worship:** Sports were part of ritual and religious activities. In ancient times, games dedicated to the gods were organized in civilizations such as Greece and Rome.
- **Competition and Entertainment:** Sports evolved into events organized for competition and entertainment, with the Ancient Olympic Games serving as the oldest example of this transition.
- **Institutionalization:** The foundations of modern sports were laid in the 19th century. Rules and organizations were established. Sports such as football, tennis, and cricket have become popular.
- **Moving to the International Arena:** Thanks to the development of communication technologies, sports events began to spread internationally. International tournaments and events were organized.

Sports play many essential roles in human life and contribute to various aspects. The importance of sports in human life can be summarized as follows:

- **Health and Physical Well-Being:** Sports are an integral part of physical activity and form the basis of a healthy lifestyle. It promotes cardiovascular health, muscle strength, and weight management (İmamoğlu, 1992).
- **Mental Health:** Exercise can alleviate stress, mitigate depression, and bolster mental well-being by increasing endorphin production.
- **Entertainment and Stress Reduction:** Engaging in and watching sports allows people to have fun and reduce stress (Çoruh, 2019).
- **Social Bonds and Social Integration:** Team sports or group activities strengthen social bonds, enhance teamwork, and contribute to social integration (Duman, 2020).
- **Discipline and Self-Control:** Sports require regular training and participation, encouraging discipline and self-control.
- **Character Development:** Participation in sports fosters character traits such as leadership, teamwork, and competitiveness.
- **Cultural and National Identity:** Some sporting events express national or cultural identity. For example, the Olympic Games create a unifying effect at the international level (Şahin et al., 2010).

As sports development continues in parallel with social changes, its importance in human life has become more diverse and deepened. Its role in health, social bonding, mental well-being, character development, and cultural context indicates that sport is indispensable to human life. Professional and amateur sports or participation-based physical activities have an important place in the daily lives of human beings. At this point, it is impossible for sports, which represents a vast industry, not to be affected by AI applications. This interaction is seen in different research and practical applications.

## **SPORTS AND ARTIFICIAL INTELLIGENCE RELATIONSHIP**

The sports ecosystem has four essential components: Athlete, judge, coach, and fans. These components help make the complex sports ecosystem easy to handle. The use of AI technologies in sports can be discussed through four main components as follows (Laukyte, 2020):

1. Enhancing athletes
2. Advising the Coaches

3. Supporting judges
4. Involving the fans

With AI, training programs can be created to improve athletes, and injury prevention and health monitoring can be carried out. Steps to determine tactics, strategies, and transfers to support coaches are possible with player monitoring based on sensor data. Many sports teams use artificial intelligence to analyze and improve player performance. For example, “SportVU” cameras in basketball track players’ movements and collect data. Then, the data are analyzed to understand better player movements and team performance (Westney, 2015). Video referee systems support referee decisions using artificial intelligence in sports like football. These systems help make more accurate decisions in disputed positions by analyzing match footage. Some sporting events use AI-based applications to provide more personalized experiences for spectators. For example, mobile applications can offer spectators the best seat recommendations (Microsoft, 2017) or facilitate food and beverage orders. Wearable technologies and AI monitor athletes’ training data and physical health. These data help athletes perform better. In general, the use of AI in sports can be grouped into the following eight items:

1. Training Programs
2. Predictions and Betting
3. Health Applications
4. Deciding Tactical Strategy and Transfers
5. Referee Decision Support Systems
6. AI Playing Sports and Esports
7. Sports Journalism and Fans
8. Wearable Technology and Sensor Data

### **Training Programs**

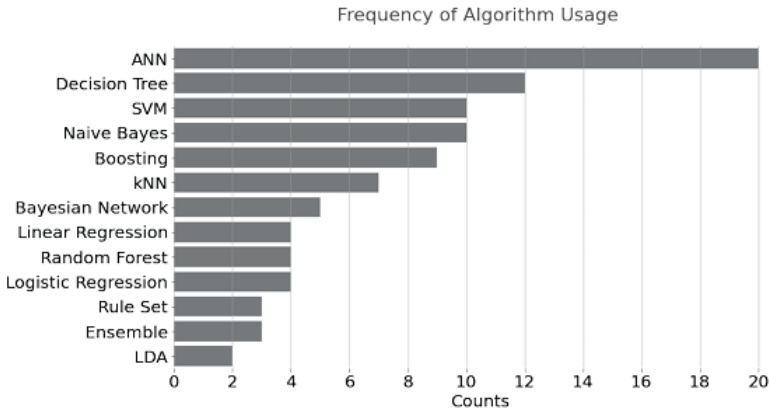
Using AI technology in sports training can potentially improve traditional training methods. AI can perform precise data analysis, provide personalized recommendations, and simulate realistic training scenarios. In this way, it can help athletes train more effectively and increase their athletic performance. Additionally, integrating AI into sports training can offer new and innovative training methods for athletes (Wei et al., 2021). AI is used to examine the performance of athletes on the field, create training programs, and increase

training efficiency. This technology has provided data collection, analysis, and prediction capabilities to evaluate athletes' performance and optimize training programs (Özsoy et al., 2023). Current training tracking is possible with drones (Sever Hilmi, 2019), and detailed analysis of past competition data and performance tracking of athletes is possible with sports analytics companies such as OPTA3 and Stats4 (Beal et al., 2019). In addition, applications such as Athletica, FitnessAI, Freeletics, Cure.fit, Fitbod, and Vi Trainer can serve as fitness coaches or personal coaches and create training programs for individual athletes.

### **Predictions and Betting**

Predicting the behavior of large and complex systems has been the focus of research in many branches of science. Different examples can be given, such as the forecast of stock markets and exchange rates in the near future or the weather forecast for the next month. Predicting the consequences of unrealized events based on historical data is of great importance for many people and organizations (Karaoğlu, 2015). As the sports betting industry and technology have experienced significant growth, it is now even more critical to predict the outcome of a sporting event using a technology-driven approach. People are subject to certain limitations when processing large amounts of information. However, artificial intelligence techniques can overcome this problem.

Additionally, sports have a large data pool to consider (Fialho et al., 2019). There are different applications regarding this in the literature. For example, in estimating the number of Athletes (Wrestlers), the number of athletes for the next two years was estimated using Artificial Neural Networks with the data of the past ten years (Dalkılıç et al., 2017). Bayesian Networks were used to predict football match results with artificial intelligence (Min et al., 2008) in the study conducted for 16 football leagues; the most successful predictions were obtained with the Decision Table technique (Karaoğlu, 2015). Data such as Points, Opposing Team Points, General Performance, Home Performance, Away Performance, Performance in the Previous Match, Performance in the Previous  $n$  Matches, Team Ranking, Points in the Previous Match, Points in the Previous  $n$  Matches, Position, Player Status were used in score prediction with the help of the MLP technique (McCabe & Trevathan, 2008). The examples here can be multiplied; However, summary data such as Table 1 and Figure 1 will be helpful to perceive the distribution tendencies of the algorithms in this scope. The frequencies of the algorithms used in score predictions were found as follows for 31 different studies (Bunker & Susnjak, 2022).



*Figure 1 Histogram of AI algorithms used in sports studies. Source: (Bunker & Susnjak, 2022)*

Table 1 presents a summary of the findings regarding the use of machine learning (ML) algorithms from AI techniques and their prediction success rates in competitions in different types of sports.

*Table 1 Machine Learning Algorithms Used in Match Prediction. Kaynak: (Beal et al., 2019)*

ML Method	Accuracy of Result	Sport
Neural Networks	68.8% (Hucaljuk & Rakipovic, 2011)	Football
	72.2% (Shi et al., 2013)	Basketball
	67.5% (McCabe & Tevathan, 2008)	Rugby
Decision Trees	41.72% (Joseph et al., 2006)	Football
	69.16% (Shi et al. 2013)	Basketball
	58% (McCabe & Tevathan, 2008)	American Football
Clustering Methods	50.58% (Joseph et al., 2006)	Football
SVM(Support Vector Machines)	75% (Jayantha et al.,2018)	Cricket
	54.5% (Baboota & Kaur,2018)	Football
Random Forest	56.5% (Baboota & Kaur,2018)	Football
	62.2% (Shi et al., 2013)	Basketball
Gradient Boosting	56.7% (Baboota & Kaur,2018)	Football
	68.8% (Hucaljuk & Rakipovic, 2011)	Football

It will be useful to consider the following principles in studies on match score prediction (Bunker & Susnjak, 2022):

- Low-scoring sports may have higher unpredictability.
- Lower competitiveness means higher predictability.
- Sports with more probable outcomes are less predictable.
- Better features and richer data sets tend to increase predictability.
- Different scoring systems have effects on predictability.
- Predictability is ultimately multifactorial.

### **Health Applications**

Sports medicine has emerged as an essential medical branch that undertakes the tasks of protecting, repairing, developing, and rebuilding the human motor system. Sports medicine has a broad perspective and aims not only to heal after trauma but also to improve the performance of athletes and prevent injuries (Cheng et al., 2023). Injuries to professional players can have a significant impact on their careers. These injuries not only affect the player's career but can also negatively affect the team's performance. A player unable to play due to injury may reduce the team's chances of winning, which may result in the team's drop in the rankings. Additionally, when a player is injured, the team may face additional financial burdens, such as hiring a temporary player to replace him or paying the salary of a benched player. Therefore, athlete injuries have a significant impact on both individual careers and the performance of teams (Beal et al., 2019). For these reasons, the provision of AI in sports health practices is precious. In this context, GPT-4 AI applications within the scope of sports medicine can be considered as follows (Cheng et al., 2023):

- Diagnostic Imaging
- Exercise Program and Medical Observation
- Sports Nutrition
- Medical Supervision
- Medical science research

### **Deciding Tactical/Strategy Transfers**

Sports teams use AI to analyze opposing teams' playing strategies and player behavior. Specific criteria may be needed when using AI in team sports. For instance, questions such as what is the role of the tactic or what



affects the decision need to be answered. Games such as tennis and volleyball involve less contact and players, while sports such as football and American football entail more contact. This complexity results in variations in tactical formations and strategies for each team sport and necessitates differences in the AI systems guiding them (Mozgovoy et al., 2021). Data such as past competition, training, health, and sensor data are analyzed for this. These analyses are used to make better decisions during the game. In team sports, AI can analyze the team's performance and make tactical recommendations (Pavitt et al., 2021). For example, AI can analyze football teams' matches and offer suggestions to optimize offensive strategies, defensive formations, or player positions. Clubs send scouts to evaluate various athletes, collecting extensive data encompassing variables like playing style, strengths, weaknesses, and work ethic. AI aids clubs in making transfer decisions by effectively processing this vast amount of data (Rathi et al., 2020).

### **Referee decision support systems**

The use of AI in referee decision support systems emerged, intending to improve the accuracy of decisions in sports. The applications of these support systems in various sports have increased in recent years. The Instant Replay application is utilized in various sports, including baseball, basketball, cricket, fencing, football, American football, ice hockey, hockey, motorsports, rodeo, and rugby.

In football, the Video Assistant Referee (VAR) application is employed in situations such as goal/no-goal, penalty/no-penalty, direct red card decisions, and the correct player identification when issuing red or yellow cards. Following its introduction in the 2018 World Cup, VAR has been adopted in numerous competitions across different leagues worldwide (FIFA, 2022). The percentage of correct decisions, 93% before VAR, increased to 98.80% after VAR. There is also ongoing discussion about the more extensive use of applications during the trial phase, including semi-automatic/automatic offside determination and the automatic determination of whether the ball has crossed the goal line (Rathi et al., 2020). In sports like tennis, cricket, and volleyball, where ball tracking is crucial, the Hawk's Eye system is employed. This technology, developed in 2000, led to rule changes, such as introducing the right to challenge decisions in tennis and volleyball. Two alternative technologies, Cyclops and FoxTenn, are also essential in these sports.

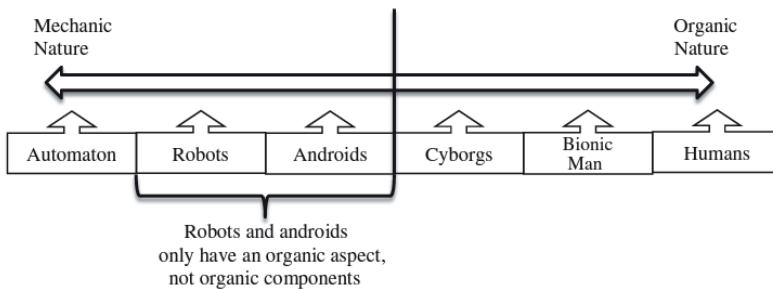
Additionally, cricket uses the Snickometer for audio and video tracks; tennis employs the Electronic Line Judge for line tracking, and time-based

athletics sports rely on the Fully Automatic Timing (FAT) system (Kapil, 2018). Debates continue about the potential for AI to completely replace the human factor in officiating, with some suggesting a complete transition. In contrast, others believe humans will always have a role at the assistant level (Rathi et al., 2020).

### AI Playing Sports and E-Sports

It is indeed fascinating that AI has a direct involvement in sports. On May 11, 1997, IBM's Deep Blue computer achieved a momentous victory over the world chess champion after a six-game battle, marking a pivotal turning point (IBM, 2011). One of the central questions in Human-Computer interaction is whether machines can exhibit behavior akin to that of humans. The “Frías-Triviño” test, akin to an adaptation of the renowned Turing Test for sports, comprises four inquiries or stages (Frias & Triviño, 2017):

1. Can robots understand the rules and traditions of the game?
2. Can robots develop physical abilities?
3. Can robots embody the emotional attitude of striving for physical perfection?
4. Can sports with robotic participants have institutional stability?



*Figure 2 From automatons to humans. Different types of beings depend on the combination of organic and mechanical nature. Source.:(Frias & Triviño, 2017)*

The transition from humans to automatons is depicted in Figure 2. Can human-like robots really play sports? In popular culture, robots are playing football like humans in the cartoon GGO Football (GGOFootball, 2010). The concept of creating robots with human-like behavior has perpetually intrigued humans.

The International E-Sports Federation defines *e-sports* as “a competitive sport in which players use their physical and mental abilities to compete in various games in a virtual, electronic environment” (IESF, 2021). Nowadays, E-sports is an industry, and professional YouTubers are in this field. In e-sports, game types and applications such as MOBA, FPS, RTS, Battle Royale, Sports, MMORG, and Fighter can be mentioned (Çağlayan & Uygur, 2022). The example given here is AI’s success in a game involving complex thinking skills. The success rates of the new AIs in the 2012 HD Edition and the 2017 versions of the Age of Empires II game, which was introduced by Microsoft Games in 1999, are attractive in winning this game that requires complex strategy and planning (Fandom, 2017).

### **Sports Journalism and Funs**

AI technology has ushered in an era where robots assume control of sports media broadcasts. This technological advancement streamlines the interpretation of games and the precise dissemination of sports content through the media, obviating the necessity to dispatch camera crews to various media outlets. Consequently, sports content is directed with greater accuracy and efficiency, thanks to the control of automated media broadcasts (Nadikattu, 2020). The availability of data streams, the burgeoning demand for news on mobile devices, and the continuous advancement of algorithms contribute to the increasing prevalence of automated journalism. Against the specific background of sports journalism’s content, means of production, and consumption, the question the article answers is that the imminent rollout of auto-generated content may only herald another evolutionary stage in sports journalism (Galily, 2018). Spectators hold a pivotal role within the sports industry, serving as a vital source of revenue. This scenario underscores the application of AI solutions to serve the audience directly. These solutions may encompass elements designed to enhance interactive enjoyment, such as real-time sharing of scores and statistical data with fans, automated rewind and replay features, and predictions regarding ticket sales, match outcomes, and tournament victors.

### **Wearable Technology and Sensor Data**

Wearable technologies are portable devices that can be worn as accessories or integrated into clothing, including mobile devices. These devices have the capability to capture various sensor data. Through wearable technology, data such as blood pressure, heart rate, body temperature, electrocardiogram (ECG), electroencephalogram (EEG), sweat analysis, and measurements related to displacement, speed, and acceleration can be collected and

processed using AI. This data can be utilized effectively in the following areas (Chidambaram et al., 2022):

- **Injury Prevention:** Wearable technologies play a crucial role in helping athletes and individuals engaged in physical activities reduce the risk of injury. The data collected can be used to identify abnormalities in the body or early signs of potential injuries.
- **Performance Optimization:** Athletes can use wearable devices to optimize their training and performance. The data gathered can be used to tailor training programs, leading to improved results.
- **Game Day Optimization:** Wearable technologies assist athletes in optimizing their performance on game days. The data enables players to manage their energy levels and make strategic adjustments.
- **Post-Injury Diagnostics:** Wearable devices aid athletes in tracking their recovery progress after injury and provide healthcare professionals with valuable information.
- **Rehabilitation:** Wearable technologies can monitor the rehabilitation process and provide data to physical therapists, enhancing the effectiveness of rehabilitation programs.

The use of wearable technologies in these areas is an indispensable tool for enhancing the health and performance of athletes, preventing injuries, and achieving superior results.

## **THE COMMON FUTURE OF SPORTS AND AI**

The close collaboration between sports and AI is fundamentally transforming the experiences of athletes and fans, reshaping the future of sports. The widespread application of AI in sports is expected to continue growing. Nevertheless, as technology permeates all aspects of sports, there is a concern that the industry may lose some of its inherent charm while ensuring fairness in decision outcomes. It is worth noting that certain ‘imperfections’ in sports competitions contribute significantly to their allure. Therefore, there is a need for extensive and thorough research to ensure the scientific and judicious application of AI in sports (Ding, 2019). In particular, concerns are raised regarding excluding the human element, cost implications, and potential errors.

Critics argue that replaying games can disrupt ongoing competitions, potentially hindering certain offensive strategies. While implementing these intricate AI systems can minimize human error, they can also pose

significant financial burdens on less affluent sports federations. Suggestions for the judicious application of AI in sports include (Ding, 2019):

- Clearly defining the roles and responsibilities of governments and sports departments, along with bolstering policy and financial support.
- Elevating the standards for smart product applications in sports and promoting fairness.
- Establishing rigorous standards for data representation and information in AI sports.
- Enhancing the training of sports personnel and their proficiency in AI applications.
- Actively promoting high-quality AI capabilities and optimizing the seamless integration of production, education, and research.

The convergence of sports and AI plays a pivotal role in shaping the future of sports. The combination of sports and technological innovations promises to deliver a more efficient, effective, and enjoyable experience. However, amidst this transformation, it is crucial not to overlook ethical values and the human factor. While the integration of AI promises to provide unforgettable moments for athletes and fans, this evolution must be managed with a balanced approach.

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