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Research article

Modern technology, artificial intelligence, machine learning and internet of things based revolution in sports by employing graph theory matrix approach

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Abstract: The sports industry is gaining popularity with time and all the countries are investing a lot of money for fame and entertainment around the world. To ensure the high quality of sports, modern techniques such as machine learning (ML), artificial intelligence (AI) and the Internet of Things (IoT) are playing a very optimistic role. Various IoT-grounded smart sensors are implemented with integration in AI and ML for the safety and high performance of the players. Based on the numerous applications of modern technologies, it is very convenient to capture different body movements of the players and avoid any severe injuries and long-term health issues. AI and IoT-driven smart devices are revolutionizing the analysis of athletes' training and performance, offering precise insights for their improvement. This article delved into the remarkable strides made in scientific sports, highlighting how computer-based elements are reshaping the sports landscape for athletes and spectators alike. These innovations enable real-time health monitoring, prevent accidents, capture diverse postures and analyze sporting outcomes. By extensively reviewing existing literature, key features have been identified and prioritized. Using the graph theory matrix approach (GTMA), this piece compared and ranks available alternatives based on these selected features. Moreover, the parameter matrix and normalized matrix were reported in tabulated form and the ranks for ten paradigms are illustrated graphically for better visualization.

Keywords: technology; artificial intelligence; scientific sports; postures; fall events
Mathematics Subject Classification: 03E72, 90B50, 90C31

1. Introduction

Along with refreshment, sports events are very important for peace of mind, healthy life, and enjoyment. Various skills polished through competitive sports can be employed in practical life for achieving one's goals. In today's modern technological world, artificial intelligence and machine learning (ML) based techniques are implemented in almost every step of modern life. They are very helpful in increasing productivity while reducing humans' efforts and time. These modern paradigms can be used in sports for the betterment and enhancement of various activities in sporting events. For accurate training and high performance of athletes, different IoT grounded smart sensors can be used. The causes of severe injuries in sports can result in both physical and financial harm. Van Eetvelde et al. [1] has surveyed various ML grounded techniques for predicting and preventing injuries in sports. Based on the ML methodologies, various effective procedures have been applied in sports for the efficient prevention of injuries along with the identification of players at greater risk of harm. The data for the study was obtained from the various articles in the PubMed database. The results revealed that ML-grounded methods are very helpful in the detection of various injuries but there is still the need for improvement in the efficient utilization of modern technologies for the betterment of sports and players. Goud et al. [2] has conducted a study on the employment of ML paradigms for the enhancements in the skills and performance of teams and players in sports. All the countries are focusing on the development of the sports industry for fame around the globe. For good quality sports, the performance of the players is a key factor. With the assistance of ML and IoT-based smart devices, the performance of the players can be measured and improved very effectively and human efforts and time can be saved. Smart and intelligent devices may replace different players' performance analysis-related personnel.

The fatigue recognition of a sportsman is an important factor in the development and advancement of skills and performance of a player. A study developed an efficient fatigue recognition methodology with the help of ML and the integration of a back propagation (BP) neural network and physiological parameters. With the employment of controlled trials, fatigue is recognized. The experimental data shows that the developed architecture can monitor fatigue very precisely and can be implemented practically. With the fatigue recognition system, the abilities of the athletes can be improved very efficiently [3]. Velichkov et al. [4] conducted a study for the prediction of the result of a sporting event before it took place. The proposed architecture applied ML and natural language processing (NLP) based techniques on the interviews of players for the prediction of results before the sporting event. For effective results analysis, deep learning contextual methods were utilized on the unstructured textual documents. The results identified that there is valuable information in the interviews of players that can be efficiently used for the prediction of the outcome of a sports event. The outcomes of the study are in the favor of the proposed result prediction model. Takano and Li [5] have performed a study on the development of an AI-based smart system for instruction in a tennis game. With the applications of computer-grounded intelligent instruction systems, the time, space and cost consumed by the traditional methods are now minimized to a great extent. For the efficient working of the proposed architecture, the system collects motion data, cleans it, and then processes it. The experimental data shows that the paradigm effectively records the data related to motion capture and identification. AI-based learning and instruction architectures are of great importance in both education and sports. AI is revolutionizing the sports industry both in the training and performance evaluation of the players. Bartlett [6] has surveyed the usage of AI-based

models to diagnose wrong moves in sports and the example of knowledge regulation for such intelligent paradigms. For the effective technique analysis, artificial neural networks were applied while focusing on the Kohonen self-organizing maps. Various models based on multi-layer networks are also employed in biomechanics in general. The study also presented an example of the employment of evolutionary computation for the effective movement in soccer during a throw-in.

From the detailed study of the existing literature, it was identified that AI, ML and IoT, are very good candidates for revolutionizing the atmosphere of sports. The employment of these technologies is very beneficial for athletes and coaches, as well as other sports-related people. They can assess the players' performance, monitor the real-time health of the athletes, and alert them about any unwanted situations during training and games. The main contributions of the study are:

- The positive role of different technologies in sports was highlighted very briefly.
- Various valuable features are derived from the existing literature and important ones are selected from them.
- Based on the selected features, various computer-based smart systems for sports are ranked with the usage of the graph theory matrix approach.

2. Related work

One of the valuable and important factors in the planning of sports and training is the analysis and prediction of a player's performance. The difficult and time-consuming task of performance analysis of a player can be performed very quickly and conveniently by the employment of ML methodologies. The study conducted a survey of various ML-based paradigms employed for the performance prediction of female handball players along with the valuable features that are affecting the analysis of the performance prediction. A sum of 23 properties and estimations of qualities and 118 occurrences of training patterns were recorded for each AI model. The outcomes showed that the radial-basis function neural network beat different models and was equipped for foreseeing the athletic performance with R2 scores somewhere in the range of 0.86 and 0.97 [7]. Novatchkov and Baca [8] have proposed a study on the efficient role of AI grounded methodologies in sports with weight training as an example. The main aim of the article was to study the employment of pattern recognition methods on the training machines. The data was gathered with the help of various smart sensors attached to the weight machines, and the displacement and force determinants are computed while training. By the utilization of the calculated data, different valuable features such as movement velocities are measured. The results of the study are in favor of AI-based systems utilization for the assessment of the performance of a player along with showing valuable suggestions to them. Farrokhi et al. [9] performed a study on the integration of AI and the IoT to provide the users with a smart and efficient fitness system. The data gathered with the help of IoT-grounded smart sensors can be utilized for productive training with the assistance of AI-based smart methodologies. With the effective employment of sensor-to-sensor association by social-IoT, the training and workout experience of various users can be shared very conveniently without any constraints of space and time. A detailed overview of numerous fitness trackers and applications was provided while focusing on efficient training and well-being. The research was conducted for enriching the experience of nonprofessionals during live game events with the help of intelligent architecture. The developed system is based on intelligent target tracking technology for the precise capturing of an athlete's movement. During the ball games, the architecture can predict the position of a ball or the drop point

of the player. The experimental data revealed that the accuracy of the system is high when the player is facing the capturing camera. The accuracy was significantly affected by the absence of data on the playing field and it changes greatly. Hence, before the implementation of the system to the fall point prediction, a sufficient amount of data will be needed [10].

The employment of an AI-based system for the efficient joint movement estimation of football players is a very challenging process. Zhang et al. [11] conducted a study on the development of the smart architecture for the recognition of the joint movement estimation method in a football game. The proposed architecture utilizes the recognition algorithm in light of the multilayer tree recognizer to distinguish the joint movement; the investigation shows that the technique utilized in this paper precisely recognized joint movement for football players in sports training. Based on the various sensors, the data was gathered from the players' acceleration and angular velocity. Tan and Xie [12] proposed a study for the precise movement recognition for table tennis. Accordingly, this paper involves an acceleration sensor as a movement recording gadget for a table tennis plate and investigates the three-pivot acceleration information of four normal swing movements. The field of human movement acknowledgment has profited from the ascent and improvement of sensor innovation. For the precise classification of swing motion, various ML-grounded algorithms such as decision tree and random forest tree are employed. The resultant data shows that the developed system is far better than the traditional ones and by its effective employment; the accuracy was increased to 91%. Taking into account the unfortunate impact of current sports dance movement identification, this paper advances a sports dance movement recognition strategy in light of posture acknowledgment by utilizing the rule of posture acknowledgment to get the trademark data of sports dance movement, build the activity trademark assessment framework, enhance the action recognition process joined with pose recognition innovation, and understand the arranged recognition of sports dance developments. The proposed architecture is more effective than the existing approaches and its performance is not affected by the characters in an image [13].

Su et al. [14] conducted a study for measuring players' efficiency with the help of data collected from the wireless networks. The proposed model has employed a recursive Bayesian estimation algorithm for the efficient analysis of training and testing of players' performance with the help of physical training. By the implementation of the developed architecture, the success of a player can be analyzed very precisely at a higher level. The results show that the presented algorithm achieved an accuracy of 99%, which is 9% and 18% more than the neural network and fuzzy set model, respectively. Modern technology should be implemented for the effective training of athletes. Liu [15] based on the data gathered from the smart sensors, the neural network allows deep learning of data, and a very effective technology-grounded training strategy can be formulated. In the performed study, a user-friendly and efficient training technique was developed for the enhancement of players' performance and human-computer interaction with the deep fusion of data. The results revealed that the proposed training strategy guide the players in a very productive manner and their efficiency was enhanced by 20%. The proposed study analyzed the sports intelligence paradigms grounded on AI and the IoT by considering swimming as an example. With the precise integration of AI and IoT, a posture analysis procedure was presented for the productive training of the swimmers. For the effective evaluation of the developed architecture, a professional coach was invited. The four most commonly used postures butterfly, backstroke, breaststroke, and freestyle are experimentally analyzed by the system in the presence of the humanized coach. It was found that the architecture can be applied for the training of the swimmers and achieved an accuracy of 92.12%.

Based on time-varying parameter autoregressive models and artificial neural networks, Zhou and Fu [16] constructed the analyzing security of authenticated routing protocol (ARAN) algorithm and compared it with the autoregressive moving average (ARMA) algorithm and convolutional neural network (CNN) algorithm. They used the established ARAN algorithm to evaluate the surface electromyographic signal characteristics of low back pain in 106 golf players. Research has found that the accuracy, sensitivity and specificity of the ARAN algorithm are superior to the CNN and ARMA algorithms. Research has also found that the time-varying parameters of surface electromyography signals can effectively evaluate the low back pain and treatment and rehabilitation effects of golf players. Ikram et al. [17] conducted a study for the development of an effective IoT-grounded paradigm for the football game named IoT Football. The proposed system is the integration of built-in sensors, telecommunication devices, and cloud computing for the analysis of foot players health and to minimize the chances of occurrences of extreme injuries. The various IoT-based components are embedded in the ground during the football game. The main aim of the study is the designing of smart and intelligent wearable helmets for sports, where the usage of the helmet is necessary. During the training and game, various information related to players' health was collected by the employment of IoT-based sensors. The gathered data was analyzed and the player was informed about the injuries and health conditions. The proposed model is very efficient in improving the performance of the players by monitoring and analyzing the external atmosphere during the training sessions [18].

Helbing et al. [19] reported that traditional approaches like deterrence strategies, often prove insufficient in managing crowd disasters, crime, terrorism, war and disease spreading. Models and data analysis reveal that these conventional methods fall short due to their inability to account for feedback loops, instabilities, and cascade effects within the systems. They often fail to capture the actual behavior of these complex systems, leading to ineffective containment strategies. Perc et al. [20] examined social dilemmas involving conflicting individual and collective interests, scenarios posing challenges for AI to make accurate decisions. This is notably seen in the well known case of autonomous vehicles. They also delve into legal challenges, focusing on torts seemingly linked to AI that result in harm or loss for the claimant. Determining legal responsibility and its scope poses a significant challenge. Their conclusion includes a forward-looking perspective and a succinct set of guidelines aimed at effectively addressing these identified challenges. Kofahi et al. [21] developed a real-time health monitoring paradigm for athletes during mixed martial arts (MMA). The proposed architecture is the fusion of IoT and in-sport health facilities for the effective monitoring of body temperature, strike force, and the number of strikes received by a fighter during MMA. The evaluation of the system shows that it is very productive in safeguarding the chest against powerful and heavy strikes. In contrast to the existing approaches, the presented architecture is very efficient in both accuracy and response time. The second leading event that causes death is falling which can occur to any group of people, like babies and the young. With advancements in modern technology, the IoT can be employed very productively for the diagnosis of fall events. The proposed article focuses on the three phases of the fall event, which are prediction, prevention and detection. By the fusion of edge, cloud, fog computing and IoT, a very efficient and smart fall diagnosis system can be developed. The study focused on taking the fall-related IoT-based systems implementation very seriously [22].

3. Methodology

As the use of technology is increasing with time, smart and intelligent devices are replacing

humans in every aspect of life and the same is true for sports events. Various intelligent paradigms are employed for ensuring high-quality and healthy sports activities. The athletes are now feeling more comfortable and energized both during training and games. They can learn new and advanced skills with the valuable assistance of computer-grounded techniques. These techniques can monitor their health records in real time and alert them about any unwanted condition.

Meena Kabilan et al. [23] performed a study for analyzing the variation of foot pressure of athletes during running and walking in various sports. In the proposed paradigm, the piezoelectric sensor gathered the data of pressure and transfered it to the cloud. For the classification of the collected data, a supervised learning algorithm was employed. For the effective transmission of data, the ESP8266 module was implemented. Clinicians for analyzing the movement of the players monitored the data in the cloud. With the employment of the proposed device, the risk of injuries in sports will be minimized very greatly and efficiently. To further develop the computation productivity of sports injury assessment results and save the expense of assessment and investigation, Li and Zhu [24] proposed a sports injury risk analysis system based on neural networks, which uses blockchain and the IoT. This system propose a sports injury rehabilitation monitoring system that can quickly identify the location of injuries and achieve accurate tracking and analysis.

One of the main hurdles during sports training is sports injury. In the proposed article, the neural network was employed for the analysis of big data associated with a sports injury. This paper examines the source of sports risk and the fundamental injury factors, plans the sports injury assessment model grounded on the enormous information examination, lays out a unique evaluation model in view of the radial basis function (RBF) neural network, and fabricates the big data network climate expected for the model computation by working on the topological construction, joining big data and the deep neural network [25].

3.1. Extracted features

The study focuses on the technological-based advancement in sports and studies the existing approaches in this scenario. Some of the valuable features obtained from the literature are shown in Table 1.

Table 1. Extracted features.

Citations	Features	Citations	Features
[1]	Injury prediction, injury prevention, quality, risk	[13]	Posture recognition, dance movement, effectiveness, feasibility
[2]	Player's performance, performance analysis, smart coaches	[14]	Training analysis, athlete's performance, physical training, accuracy
[3]	Fatigue detection, efficiency, physiological parameters	[15]	Sports training, scientific training, user-friendly, training efficiency

Continued on next page

Citations	Features	Citations	Features
[4]	Interviews analysis, prediction, result extraction	[16]	Swimmer's training, swimmer's posture, monitoring, accuracy
[7]	Player's performance, efficiency, accuracy	[17]	Damage detection, sports injury, treatments, injury prevention
[5]	Smart instructional system, motion analysis, accuracy, motion identification	[18]	Footballer's health, controlling emergencies, training session, smart sensors
[6]	Movement optimization, smart coaching, expert systems	[19]	Intelligent helmet, player's health, injury prevention, alerts
[8]	Training optimization, athlete's assistance, automatic suggestion, performance assessment	[22]	Health monitoring, measuring number of strikes, assessing power of strike, chest safety
[9]	Fitness trackers, fitness applications, training optimization, performance	[23]	Fall detection, fall prevention, fall prediction, diagnosis system
[10]	Target tracking, athlete's movement, ball's location, drop point	[24]	Foot pressure monitoring, running patterns, athlete's movement
[11]	Joint movement, sports training, accuracy, player's actions	[25]	Injury estimation, injury prevention, accuracy, efficiency
[12]	Swing motion, motion recording, acceleration sensor, accuracy	[26]	Sports risks, injury estimation, injury factors, risks monitoring

3.2. Elected features

Those features, which are most commonly used in the existing literature are identified from the extracted ones and shown in Figure 1.

Figure 1. Cycle of selected features.

3.3. Graph theory matrix approach

One of the uses of graph theory is to give a bound together formalism to the vast majority of different looking issues. Graph theory is a consistent and systematic approach. Graph diagram portrayal has ended up being valuable for demonstrating and breaking down different sorts of frameworks and issues in various areas of science and innovation. The matrix method helps examine the graph models quickly to infer the framework capacity and record to meet the goals. The GTMA comprises of performance attribute selection, digraph making, matrix representation, permanent function computation and ranking of the available alternatives [26]. The various steps involved in the process of the GTMA are given in Figure 2.

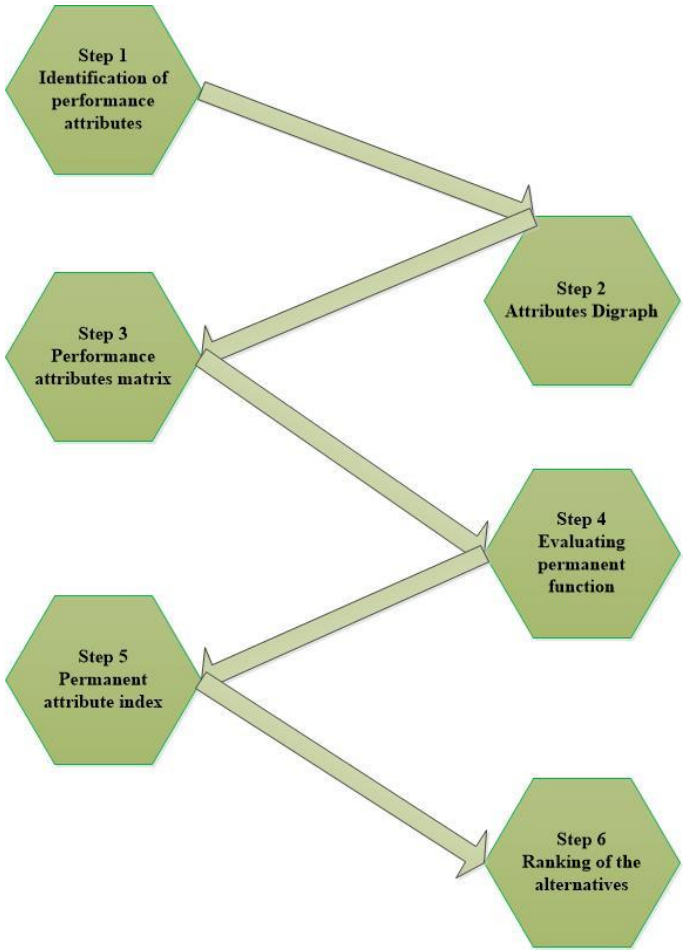

Figure 2. Flow chart of procedure GTMA.

- **Performance attributes**

The first and foremost step in the GTMA method is the identification of the alternatives and criteria. In the present article, the various alternatives along with the performance attributes are shown in Table 2.

Table 2. Alternatives and their performance attributes.

	Injury detection	Alerts	Quality	Fitness	Target tracking	Joint movement	Scientific training	Athlete's health
Paradigm 1	4	8	6	5	2	3	8	1
Paradigm 2	3	8	2	3	5	7	4	2
Paradigm 3	9	6	3	2	1	8	6	1
Paradigm 4	3	9	8	7	6	5	4	2
Paradigm 5	9	8	7	6	5	4	2	7
Paradigm 6	1	2	3	4	5	6	7	8
Paradigm 7	3	4	5	6	7	8	3	2
Paradigm 8	2	3	4	5	6	7	8	7
Paradigm 9	5	4	3	7	8	9	9	8
Paradigm 10	6	8	9	2	4	5	6	6

- **Performance attribute digraph**

A directed graph seems to be a connected collection of objects (called vertices or nodes) with all edges directed from one node to the next. A directed graph is also known as a directed network or a digraph. Undirected graphs, on the other hand, are those with bidirectional edges. The edges of a directed graph are usually depicted as arrows to indicate the direction. In terms of nodes and edges, the performance attributes digraph illustrates the performance attributes and their relationships. A collection of nodes N=i, i= 1, 2, 3, ..., M and a set of edges E={e_{ij}} make up the digraph. For the current scenario, the performance attribute digraph can be drawn as shown in Figure 3.

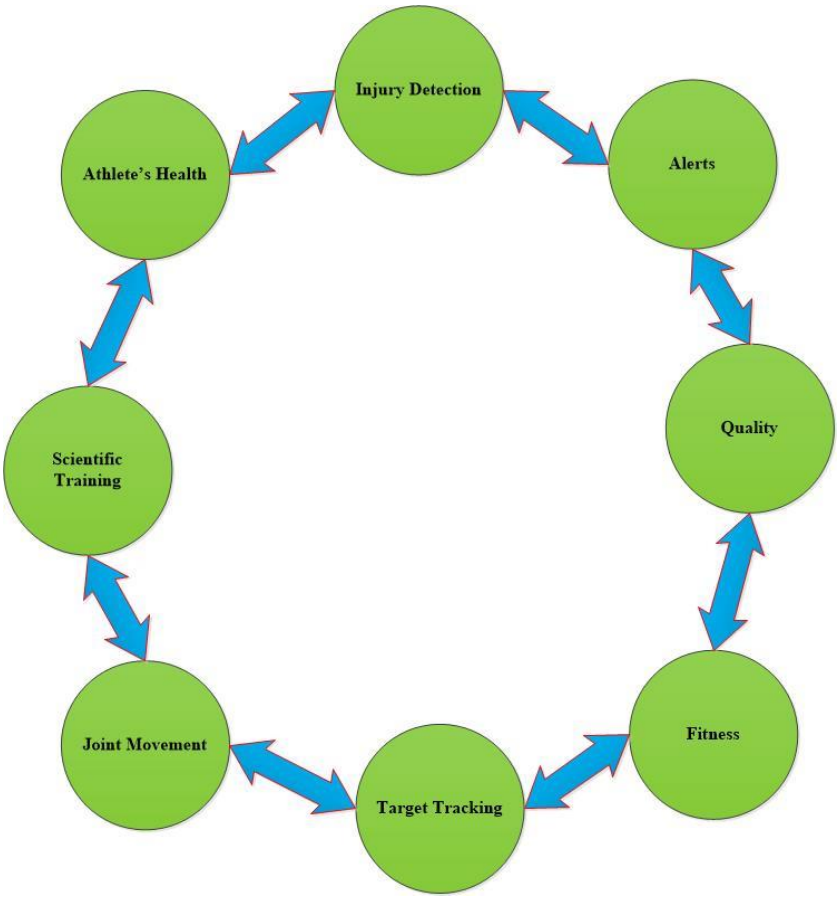

Figure 3. Flow chart of attribute digraph.

- **Relative importance values**

For the computation of the permanent matrix for the attribute digraph, the relative importance of one attribute over the other must be calculated. Table 3 shows the value of relative significance between two characteristics (a_{ij}), which is likewise assigned on a scale of zero to one. If a_{ij} represents the relative importance of the i^{th} attribute over the j^{th} attribute, then (1) can be utilized for the calculation of the importance of the j^{th} attribute over the i^{th}:

$$a_{ji} = 1 - a_{ij}. \tag{1}$$

Table 3. Relative importance values.

Class description	Aij	aji = 1- aij
Two attributes are equally important	0.5	0.5
One attribute is slightly more important than the other	0.6	0.4
One attribute is strongly more important than the other	0.7	0.3
One attribute is very strongly more important than the other	0.8	0.2
One attribute is extremely important over the other	0.9	0.1
One attribute is exceptionally more important over the other	1.0	0.0

- **Performance attribute matrix**

Matrices are a straightforward and elegant way to express digraphs since they allow one-to-one representation. The performance attributes matrix (PAM) is described as a matrix that contains all attributes (Ri) and their degree of importance (aij). This is a $N \times N$ matrix, which is illustrated in Eq (2). In graph theory, the PAM is comparable to the adjacency matrix.

$$\text{PAM} = \text{A} = \begin{bmatrix} R_i & a_{ij} & a_{ik} \\ a_{ji} & R_j & a_{jk} \\ a_{ki} & a_{kj} & R_k \end{bmatrix} = \begin{bmatrix} R_1 & a_{12} & a_{13} \\ a_{21} & R_2 & a_{23} \\ a_{31} & a_{32} & R_3 \end{bmatrix}, \tag{2}$$

where aij is the comparative significance of the ith characteristic over the jth attribute indicated by the edge eij, and Ri is the magnitude of the ith attribute represented by node v_i. The present scenario can be represented in the performance attribute matrix, as shown in Table 4.

Table 4. Performance attribute matrix.

	Injury detection	Alerts	Quality	Fitness	Target tracking	Joint movement	Scientific training	Athlete's health
Injury detection	R_1	0.7	0.4	0.8	0.3	0.5	0.8	0.6
Alerts	0.3	R_2	0.9	0.3	0.8	0.5	0.9	0.7
Quality	0.6	0.1	R_3	0.2	0.1	0.5	0.4	0.2
Fitness	0.2	0.7	0.8	R_4	0.3	0.5	0.8	0.4
Target tracking	0.7	0.2	0.9	0.7	R_5	0.9	0.5	0.4
Joint movement	0.5	0.5	0.5	0.5	0.1	R_6	0.2	0.7
Scientific training	0.2	0.1	0.6	0.2	0.5	0.8	R_7	0.3
Athlete's health	0.4	0.3	0.8	0.6	0.6	0.3	0.7	R_8

- **Normalized matrix**

For the values of $R_1, R_2, \ldots$ and R_8, the normalized matrix is computed by utilizing (3) and (4) as shown in Table 5.

$$\bar{x}_{ij} = \frac{x_{ij}}{x_j^{max}} \text{ (For beneficial Criteria)} \tag{3}$$

$$\bar{x}_{ij} = \frac{x_j^{min}}{x_{ij}} \quad \text{(For non-beneficial Criteria)} \tag{4}$$

Table 5. Normalized matrix.

	Injury detection	Alerts	Quality	Fitness	Target tracking	Joint movement	Scientific training	Athlete's health
Paradigm 1	0.444444	0.888889	0.666667	0.714286	0.25	0.333333	0.888889	0.125
Paradigm 2	0.333333	0.888889	0.222222	0.428571	0.625	0.777778	0.444444	0.25
Paradigm 3	1	0.666667	0.333333	0.285714	0.125	0.888889	0.666667	0.125
Paradigm 4	0.333333	1	0.888889	1	0.75	0.555556	0.444444	0.25
Paradigm 5	1	0.888889	0.777778	0.857143	0.625	0.444444	0.222222	0.875
Paradigm 6	0.111111	0.222222	0.333333	0.571429	0.625	0.666667	0.777778	1
Paradigm 7	0.333333	0.444444	0.555556	0.857143	0.875	0.888889	0.333333	0.25
Paradigm 8	0.222222	0.333333	0.444444	0.714286	0.75	0.777778	0.888889	0.875
Paradigm 9	0.555556	0.444444	0.333333	1	1	1	1	1
Paradigm 10	0.666667	0.888889	1	0.285714	0.5	0.555556	0.666667	0.75

- **Permanent matrix**

Based on the normalized decision matrix and permanent attribute matrix, the permanent matrix for each alternative can be calculated. For Paradigm 1, the permanent matrix is shown in Table 6.

Table 6. Permanent matrix for paradigm 1.

	Injury detection	Alerts	Quality	Fitness	Target tracking	Joint movement	Scientific training	Athlete's health
Injury detection	0.4	0.7	0.4	0.8	0.3	0.5	0.8	0.6
Alerts	0.3	0.8	0.9	0.3	0.8	0.5	0.9	0.7
Quality	0.6	0.1	0.6	0.2	0.1	0.5	0.4	0.2
Fitness	0.2	0.7	0.8	0.71	0.3	0.5	0.8	0.4
Target tracking	0.7	0.2	0.9	0.7	0.25	0.9	0.5	0.4
Joint movement	0.5	0.5	0.5	0.5	0.1	0.3	0.2	0.7
Scientific training	0.2	0.1	0.6	0.2	0.5	0.8	0.8	0.3
Athlete's health	0.4	0.3	0.8	0.6	0.6	0.3	0.7	0.12

Similarly, we can calculate the permanent matrix for every single alternative. The permanent function and its value for each available alternative can be computed based on (5) and it is shown in Figure 4.

$$\text{Per (A)} = R_1*R_2*R_3+a_{12}*a_{23}*a_{31}+a_{13}*a_{21}*a_{32}+a_{13}*R_2*a_{31}+a_{12}*a_{21}*R_3+R_1*a_{23}*a_{32} \text{ (For 3X3 matrix)} \tag{5}$$

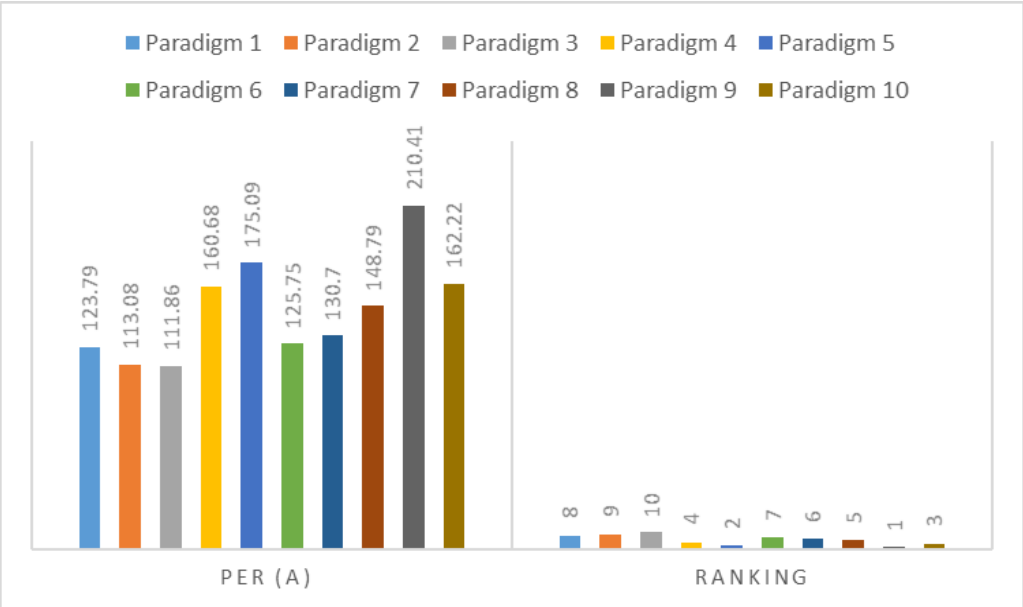

Figure 4. Permanent function values and ranking of alternatives for paradigm 10.

4. Results and discussion

A very comprehensive and brief overview of the role of modern techniques like AI, ML and the IoT in the sports revolution was given in the proposed article. The sports of today's world are of more fun and high quality. The players can show their high-level skills and performance while feeling safe from severe injuries and long-term health issues. The coaches and other professionals can now brief and train the athletes very effectively and productively by utilizing smart and intelligent IoT-grounded devices. With the employment of AI and ML methodologies, the performance and fatigue level of the players can be assessed very precisely and conveniently. The proposed study selected important features from the identified ones and by the implementation of the GTMA, different technology-based sports paradigms were ranked, as shown in Figure 4. The paradigm with the highest permanent function value (Paradigm 9, 210.41) is ranked at the top while the one with the lowest value (Paradigm 3, 111.86) is placed last.

5. Conclusions

A sport is an activity in which an individual or group competes with others for fun. It can be played for a variety of objectives, including fame, fun, and rewards. The use of AI, ML, and smart sensors has significantly revolutionized and improved the sports sector of today. Today, all sports may be played in a setting that is both safe and healthy. Modern technology is incredibly beneficial in the development of top-notch, talented sportsmen. The study conducted a thorough investigation of the technical strategies now used to promote sporting activities. Numerous aspects from the literature have been extracted on the basis of this study, and the most significant ones have been chosen. We employed of the GTMA approach, strategically evaluating diverse options according to specific features. This methodology serves as a valuable aid for experts in selecting reliable and effective processes adaptable to various sporting activities. The graph theory matrix method

simplifies decision-making by offering flexibility, ease, clarity and efficiency with minimal processing. Its versatile application extends beyond sports, showcasing a remarkable decision-making capacity across diverse scientific and technological domains. Hence, this method emerges as a superior choice, excelling in its feature-rich performance when compared to other available alternatives. Moreover, AI, ML and IoT integration in sports encounters crucial hurdles, ensuring accurate and ethical athlete data, costly infrastructure demands and complexity in implementation and maintenance. Ethical challenges like fairness, bias and transparency in algorithms, coupled with regulatory compliance, pose additional barriers. In addition, these technologies might not uniformly benefit all sports and scenarios. In the future, prioritizing data security and privacy will be crucial, as well as necessitating robust measures and ethical protocols to safeguard athlete data. Continuous improvement of AI and ML algorithms is vital to minimize biases, increase transparency, and adapt systems to diverse sporting environments. The future of technology in sports holds immense promise, but it requires a concerted effort to address limitations and navigate ethical, regulatory, and technical challenges for sustainable and inclusive advancement.

Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

Conflict of interest

All authors declare no conflicts of interest in this paper.

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