An Overview of Multi Agent System for Sports and Healthcare Industry

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Abstract

Playersmore often engage in excessive physical activities during exercise session as well as in the game session because results of the games highly depend over the performance of participants that can be degraded due to various factors current health status, injury history, exercise types and duration, training and game experience. A Multi agent System can analyze all these factors and the overall performance of the participants can be improved using feedback. In this paper, the role of the Artificial Intelligence, Expert System, Machine/Deep Learning/Neural Networks in the sports and healthcare industry will be explored.

Introduction

Multi Agent System can be used to analyze the sports data and its feedback can improve the way of team selection, diagnosis process, and decision making etc. As per Figure 1, data related to different sports can be composed and sorted out for better planning and decision making by management.

A Multi Agent System can be developed for the following sport types

Contact Sports

It requires physical contact between participants i.e. Football, Rugby, Hockey, Wrestling, Boxing etc.
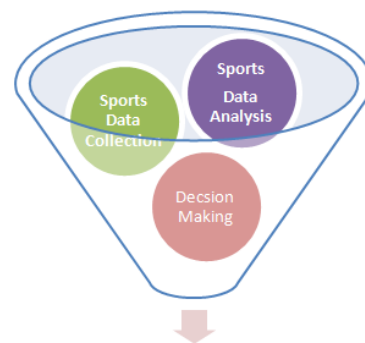
Fig.1: Management Process

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Non-Contact Sports
In this, no physical contact between participants is essential i.e. Racing/Riding/Cycling, Swimming, Snooker etc.

It can contribute to the following areas (as shown in Figure 2)

- Training and performance analysis
- Injury Categorization and Risk Assessment
- Sports Medicines
- Automated diagnosis support
- Artificial decision support system

Automation can be done using Multi Agent System applications and large scale data can be analyzed within a minimum time interval. The analyzed data may be utilized to form the training datasets for future use.

Training and Performance Analysis
Each sport type has unique requirements and the coach selects and prepares the team accordingly but in the absence of an automated feedback system, the performance of the players cannot be refined as desired and it affects the results of the games. Multi Agent System can execute the gap analysis by associating the requirements of the sport with the current performance of the participants.

Injury Categorization and Risk Assessment
As per the sports types following are the injuries may happen to participants:

Contact/Direct Injuries
It is caused by collision with any object.

Non-Contact/In-Direct Injuries
It is caused by the internal forces of the body i.e. overstretching, muscle strain and ligament sprain etc.

Fig.2: Overview of Multi Agent System applications for Sports Domain

Fig.4: Injury Categorization and Risk Assessment

Frequency of above-discussed injuries can be reduced using Multi Agent System by collecting the data about various facts like health status (mental/physical), sports/injury types, history of coaching/exercise/training/total experience in sports etc.

Fig.3: Training and performance analysis

Finally, feedback can be provided to the stack holders through risk assessment w.r.t. sports.


Fig. 5: Sports Medicines

Sports Medicines
Players must use the medicines recommended by the medical team but sometimes players may misuse the drugs so there must be an expert system to keep the track of drug consumption and health recovery over an interval and the doping results. According to the feedback, recommended drugs may be changed.

Automated Diagnosis Support
Figure 6 shows the automated diagnosis supportsystem. It can collaborate the various facts for diagnosis purpose and these are related to patient feedback, current health status as compared to medical history, possible health recovery alternatives and by computing all these parameters, an expert system can recommend the diagnosis plan and estimated time of health recovery.
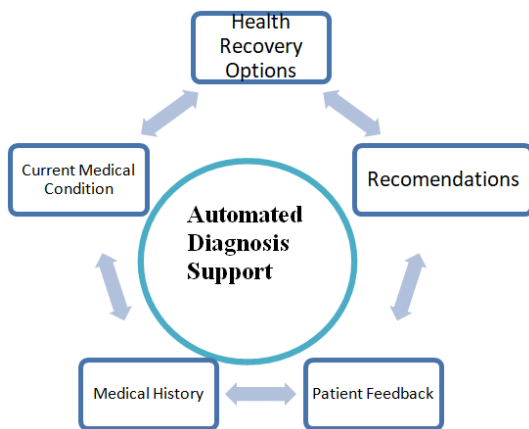
Fig. 6: Automated Diagnosis Support System

Artificial Decision Support System
Figure 7 shows the artificial decision support system that can analyze the large scale data generated by multiple resources and this data can be reused as training datasets to refine the overall performance of the existing system.[1-6]
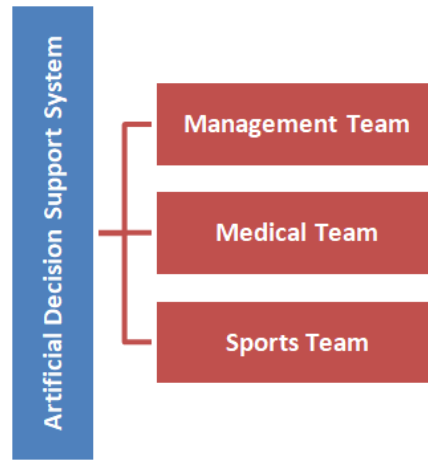
Fig. 7: Artificial Decision Support System

Contribution of Expert System in Sports
The computer-guided system can help the sports industry in different ways and day by day researchers are developing artificial intelligence-based applications. The following section describes the contribution made by them for the same:

N. J. Cronin *et al.*[7] used a deep learning approach to analyze the sports Kinematic. It uses 2D samples collected from multiple sources/locations/sports to build a training set. The outcome of this study can be further utilized for the training/prediction/ development of 3D analysis of sports Kinematic.

G. Kakavas *et al.*[8] studied the role and applications of AI in the domain of sports injuries and found that AI-based prediction models can be used for risk assessment of different injuries related to various sports. The study found the correlation between the type of injury/ sport/performance and health etc. The outcomes of this study can be further utilized to enhance the accuracy of existing prediction schemes.

Elliot B *et al.*[9] did a survey of expert systems for the healthcare domain and categorized them as Rule-based and Machine Learning based systems. The accuracy of these systems depends on the input rules/samples used for training purpose. The study also explores the current issues related to sample data collection, potential challenges for service

providers/end users and it can be further utilized to develop the decision support system for the healthcare industry.

M. Hatamzadeh *et al.*[10] introduced a machine learning method to recover from the knee injury. It subdivides the input samples into different categories i.e. healthy samples and injury samples. The machine learning process the variations in given samples to build a time-frequency strategy for diagnosis purposes. Improvement in health reduces the variations in healthy and injury samples. Analysis indicates its performance in terms of high accuracy of diagnosis/assessment cost as compared to traditional approaches and it can be further used to develop the health recovery models for different sports injuries.

P. Sardar *et al.*[11] investigated that AI can improve the accuracy of existing healthcare applications by analyzing large scale clinical data (including Text and Images). This data can be used for robotic assistance, decision making/training modules etc. The analysis found some barriers for AI-based healthcare systems and these are related to operational cost/complexity of the expert system, the security of clinical/patient data and benchmarking/ validation of training datasets.

H. Ma *et al.*[12] analyzed that issues related to medical data mining in the sports domain and developed an AI-based simulation model to process the large scale data associated with sports medicine/injuries/ diagnosis etc. The analysis shows that the accuracy of data mining can improve the performance of traditional AI methods and it can be used to analyze the (sports) medical image data/time series feature learning.

R. Li *et al.*[13] developed a framework to process large scale sports medical data. It can analyze the effect of health devices being used in sports health and can categorize the different risk levels associated with sports. The analysis shows that the performance and health level of the sports team can be improved using the proposed scheme.

P. Phan *et al.*[14] explored the limitations of existing perdition models used for injury recovery. The study found the deficiencies and lack of validation over the sample data (walking ability). Analysis data can be used to develop highly accurate prediction models using regression.

G. Lebedev *et al.*[15] developed a framework for sports health care services. It can provide the data related to the diet plans, current health issues and remedies etc. As per experiments, collected data can be utilized to guide the diagnosis process, as well as accuracy of existing medical support system,which can be enhanced.

C. E. Pulmano *et al.*[16] developed an intelligent assistant for healthcare. It converts the raw clinical data to binary form and finally, different sets are produced to support the multiple diagnoses. Experiments show its performance in terms of better accuracy/learning/prediction as compared to traditional techniques (Naïve Bayes/Neural Network/ Decision Trees/K-Nearest Neighbor classification). The scope of the developed scheme can be further extended using structure healthcare datasets.

A. Chen *et al.*[17] developed a deep learning-based decision support system to diagnose cancer. It applies segmentation to detect the regions in images and finally, a dataset is produced for decision making. Experimental results indicate its performance in terms of accuracy as compared to another scheme (bilinear interpolation). However, the segmentation of distorted input images is still an open issue.

R. R. Wildeboer *et al.*[18] investigated the deep learning-based schemes that can be used for cancer diagnosis. The study found that various facts can affect the performance of the decision support system i.e. validation of learning methods (supervised/unsupervised), the accuracy of training datasets, size of data samples and experience of the observer etc. Finding of this survey can be utilized to develop an automated diagnosis system.

R. Caldas *et al.*[19] investigated the disorders related to walking patterns and found some constraints for the diagnosis system (i.e. lack of standardized gait data and acquisition methods, kinematics and reaction forces over gait etc.) and there is need to sort out all these factors to increase the accuracy of the prediction system.

A. Kececi *et al.*[20] developed a human gait framework to analyze the different human activities (i.e. Running/Walking/Standing) using a machine learning method. Experimental results show its performance in terms of accuracy as compared to traditional schemes (Random Tree /Bayes Net/ Naïve Bayes etc.).

V. J. M. Alcaraz *et al.*[21] explored the relationship between injury type with w.r.t. inline hockey game. The study found common injuries are ankle sprains/ skating/fractures/overuse/facial injuries etc. Analysis data does not consider the surface type of playing ground, player's training and injury patterns etc.

P. I. D. Díaz *et al.*[22] investigated the integration of machine learning techniques with clinical data. Authors found that AI-based algorithms can reduce the overall processing time of medical images as well as large scale datasets can be prepared for training purpose. Outcomes of this analysis can be used to develop the AI-based decision support system for healthcare industries.

M. Thevis *et al.*[23] did a survey related to doping tests, sports drugs, injuries and misuse of sports drug etc. and focused on the constraints of doping control. The study found that drug detection may take a few months so there must be a provision to detect the effect of the drugs over the body/performance of players at earlier stages.

A. P. Anninou *et al.*[24] explored the limitations of traditional knee injury diagnosis methods and developed a fuzzy logic-based solution to improve the decision support system. It can recognize the different injuries i.e. meniscus, acute and degenerative etc. Experiments show its accuracy in terms of risk assessment, injury detection and recommended diagnosis as compared to existing techniques.

R. O. B. Singh *et al.*[25] studied brain injuries and their impact on human behavior. The study found that it can cause memory loss, mental disorder, impaired brain functionality, and interruption in the neurotransmission process etc. Authors considered all the above constraints to develop AI predicates, training and testing datasets. Using different AI algorithms (Support Vector Machine/Random Forest/ Prediction Analysis for Microarrays/ Generalized

Linear Model/Deep Learning/Linear Discriminant Analysis) experimental data was generated and analysis shows that Deep Learning algorithms are more accurate as compared to others.

N. U. Ahamed *et al.*[26] introduced a fuzzy logic-based scheme to analyze the running patterns. It conducts the speed readings through a single sensor and these values are used as input for fuzzy logic to determine running conditions. Experimental results show its accuracy in terms of the detection of different running levels (High/Medium/Slow).

P. Paliyawan *et al.*[27] developed an intelligent subordinate that forms a health metric by analyzing the movements of body parts during game/ exercise sessions and finally, a fitness function is used for validation and injury risk is reduced by recommending the specific movements to the players. Experimental results show that its prediction accuracy can be amended through the active association of the participants.

S. Noordin[28] explored the various AI-based solutions for sports medicine, knee injuries diagnosis and decision making etc. The study found some factors that can degrade the accuracy of prediction i.e. quality/size of samples for training, sample collection strategy (linear/random) availability of the patients during real-time experiments and knee condition (before and after injury) etc. Facts collected during this survey can be used to develop expert systems for sports medicine and diagnosis.

A. Naglah *et al.*[29] introduced a machine learning-based sports injury model that uses different input parameters (sport type/mental and physical health conditions/exercise routine) for prediction w.r.t. different games and participants. K-means nearest neighbor method was deployed for experiments and results show that the performance of players can be improved using feedback data and its accuracy depends over the input samples and it can be further tested using other algorithms (Random Forest/ Decision Trees).

F. Al-Turjman *et al.*[30] did a survey of the Internet of Things in the medical domain. Various factors i.e. cost of medical data generation/processing/ transmission/sharing/testing/validation etc. were considered for analysis purpose and it is found the

essential components for medical data sharing i.e. data acquisition, communication, and host platforms etc. but there is need to optimize its operational/ infrastructure cost, that is still an open issue.

R. J. Marquardt *et al*.[31] surveyed injuries and their causes in noncontact sports. It covers concussion, stroke types (Ischemic/Hemorrhagic), nerve/muscle disorders and spinal cord injuries etc. It correlates the sport types with injuries and analytical data can be used for sports medicine and health care industries.

A. Karimzadehfini *et al*.[32] investigated the relationship between diagnosis prediction model (based on fuzzy logic), decision making and its impact on the patient's health. The study indicates that the accuracy of the prediction model can optimize the diagnosis time as well as it can also refine the decision-making process. Experimental results show that intelligent frameworks can reduce errors in clinical data processing and it can be integrated with a real-time health care system.

I. Batchkova *et al*.[33] investigated the different agent-based frameworks that can be used for predictions in a real-time environment. These are model-driven multi-agent systems (JADE/agentTool-III/O-MaSE) designed to perform the different activities (subdivided into different abstract layers). All these tools can ensure safety at the application level but scalable/secure communication is still open an issue. M. M. Font[34] investigated the various applications related to sports healthcare services and found that professional players suffer a lot from sports injuries and nanotechnology-based diagnosis systems can recover their health level efficiently. Analytical data of this study can be utilized for the medical assessment of a sports team.

W. Gu *et al*.[35] developed an expert system that can predict the performance of the teams by analyzing the large scale sport's data using machine learning algorithms. It utilizes input parameters like mental/ physical health of the team, confidence level and results of the games etc. to build the decision metrics. Its scope can be extended for team selection and training programs etc.

J. G. Claudino *et al*.[36] investigated the Artificial Intelligence (AI) based diagnosis schemes (based on neural network/Decision Trees/Markov Chain/ Super Vector Machine etc.) for sports injuries that can predict the injury risk by analyzing the input samples of various sports i.e. volleyball/handball/ football/ basketball. The study found the association between types of injuries and sports and it is still an open issue to find out a generic prediction method for all injury types w.r.t. different sports.

Conclusion

In this paper, AI-based techniques for the sports industry and healthcare services were investigated. It highlights the relationship between predictions, risk assessment, diagnosis, decision making, injury/ sports type and its impact on the patient's health.

Researchers considered the limitations of traditional diagnosis methods and introduced different frameworks that can act as an intelligent assistant for end users.

Expert systems can predict the performance of the individual teams by analyzing the large scale sport's data using deep/machine learning algorithms and integration of these techniques with clinical data can reduce the computational overhead. Health metrics and datasets can be formed for perdition models and risk assessment.

Expert systems can also be used for recommendations of sports medicine, doping test and the tracking of misuse of sports drugs.

In the future, a JADE framework based multi-agent diagnosis will be introduced for the diagnosis sports injuries.

Conflict of Interest
All authors the authors declare that there is no conflict of interest.

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