International Journal of Computer Information Systems and Industrial Management Applications
ISSN 2150-7988 Volume 18(17s) 2026 pp. 206-218
https://doi.org/10.70917/ijcisim-2026-4732
Article

SoccerCoach4U: An Intelligent Computing based Soccer Sports Management System

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Abstract: Soccer is one of the most-watched and popular sports on the planet. It facilitates the players to develop tactical awareness, sportsmanship, endurance, coordination, stamina, and strategic thinking. A well-designed soccer management system can significantly reduce manual effort, eliminate bias, reduce subjectivity, and improve the collective performance of players and the team. Therefore, developing a holistic algorithmic framework for effective soccer management is a need of the hour. In this work, a complete framework for soccer sports management system is presented that enables the selection of team line-up by estimating individual player performance in terms of two types of ratings: non-goal impact ratings (NGIR) and goal impact ratings (GIR) integrated with strategic planning method for estimation of soccer sports match outcome and game tactic technique. The proposed research has built a soccer sports management prototype based application named SoccerCoach4U that assists soccer sports management. This developed system is tested on 300 users and validated by the domain experts from soccer sports. This prototype-based application provides a user-friendly interface that allows the user to input in-game event data, player data, or half-time match data and provides effective decision making for players, coaches, managers, and sports enthusiasts to enhance performance.
Keywords: Soccer Sports Management, Game Tactics, Strategic Planning, Selection of Team Line-Up

1. INTRODUCTION

Sports contribute significantly to the physical, mental, and social development of individuals and communities. It is known for promoting discipline, teamwork, skill, and physical fitness. Soccer is the most famous sport in the world. It has been estimated that there are 240 million enrolled players in soccer sports and it generates the largest revenue of US$350 billion [1], which makes it the most watched, most followed, and most widely played sport across the planet. Soccer promotes physical fitness, mutual coordination, agility, and self-confidence. It also endorses socialization by acting as a universal language.

A soccer sports management system aims to enhance team and player performance through a systematic process that comprises strategic planning, data analytics, team selection, training and development, game tactics, and injury management [2]. Nowadays, every soccer organization and club tries to stay ahead in terms of new techniques and technologies to keep themselves frontrunners in this highly competitive world of soccer [3]. It facilitates coaches, managers, and organizers to efficiently handle tasks such as strategic planning, injury management, performance tracking in terms of estimating player and team performance, training schedules, game tactics, data analysis, etc.

Bias is indeed a subjective preference for summarizing and a conclusive task [4]. By mitigating subjective human bias and minimizing manual efforts, the system facilitates more informed decision making and enhances overall team efficiency. Furthermore, the implementation of such a system promotes transparency, improves resource utilization, boosts productivity, and supports the continuous development and performance enhancement of both individual players and the team collectively.

In the proposed work, a complete framework for soccer sports management system is presented that integrates the selection of team line-up, intelligent strategic planning, and efficient game tactics through web application SoccerCoach4U. This web application uses the MVC (Model-View-Controller) architectural paradigm [5].

Based on the provided input data, the proposed application estimates the final team performance and provides efficient support for decision making by generating team formation based automatic suggestions for handling the soccer game tactics and strategic planning. Another functionality of the application is to unbiased selection of team line-up based on players' estimated ratings.

The rest of the paper is organized with literature review elaborated in section 2. Soccer sports management framework: SoccerCoach4U with major functional components is discussed in section 3. Results and analysis is presented in section 4. And finally the paper is concluded with future work in section 5.

2. RELATED WORK

In recent years, extensive research has been undertaken to explore various game tactical aspects aimed at enhancing the performance of super teams. Consequently, several relevant studies are already available in this field. Some of the most notable contributions are summarized below:

In the former studies, Pariath et. al. devised a player performance prediction system using a linear regression model intended to learn from diverse attributes and skill sets of soccer players and predict the players' performance value to present the scope of improvement and potential of the concerned player. The main aim of such a predictive system is to facilitate the coach, manager, and team management to identify the future prospects of their team and players [6]. Similarly, Pappalardo et al. designed a data-driven framework named PlayerRank by deploying a gigantic dataset comprising four seasons of 18 famous soccer leagues. The ratings produced by the PlayerRank framework have been explored further to perform a comparative analysis of top players. The proposed PlayerRank tool has been used to detect the role of a player in a match. The proposed framework was based on soccer logs describing all the ball-touching movements [7]. In their work, Pantzalis et. al. worked on football analytics in terms of team and player performance prediction. The proposed work predicted the league final table for some famous football leagues using advanced statistics. The work also estimated and compared the team performance for the upcoming season with that of the previous season. The main idea behind this approach is to simulate each match of a specific season and to classify the match outcome as home team victory, draw, or defeat. Furthermore, the attributes and diverse in-match actions affecting the central defenders' playing ratings have also been explored using a dataset that comprises more than 50 central defenders who played in English Premier League [8].

In the same way, Lorenzo-Martinez et al. examined the consequence of soccer player substitution on match tactical behavior using positional data. More than 650 substitutions from the German Bundesliga league have been taken as a sample for the proposed work. By considering the players' positional roles, all the considered substitutions have been categorized under three classes, i.e., defensive, offensive, or neutral. The performance of the team before and after each substitution was analyzed using diverse attributes [9]. Malamatinos et al. worked on the prediction of soccer match outcome using a dataset that comprises the Greek Super League and also tested on the English Premier League. After performing data cleaning and feature engineering, the proposed work employed five machine learning models, such as LogitBoost, k-NN, Random Forest, SVM, and CatBoost, to offer more efficiency [10]. Kinalioğlu et al. proposed a hybrid classification model for forecasting the match outcome of upcoming football games using clustering and classification techniques. There were three types of dependent variables, i.e., home, draw, and away. The proposed hybrid model employed K-means clustering and Fuzzy C-means clustering with classification methods such as artificial neural network, Naïve Bayes, SVM, and Random Forest classifier [11]. Rahimian et al. presented an end-to-end deep reinforcement learning framework that takes tracking in-game data of the match and provides optimal ball target location on the ground. By using the proposed approach, coaches and players are able to analyze past actual behavior and acquire the plan and optimal behavior for the upcoming games. The output of the proposed optimized model presents more short passes in ball possession phases and shorts in the attack phase to enhance the chances of goals [12].

3. Soccer Sports Management Framework: SoccerCoach4U

SoccorCoach4U is an intelligent computing framework that integrates three main components, i.e., unbiased selection of team line-up, strategic planning, and game tactics at the backend and provides the user friendly interface through web application as shown in Fig.1.

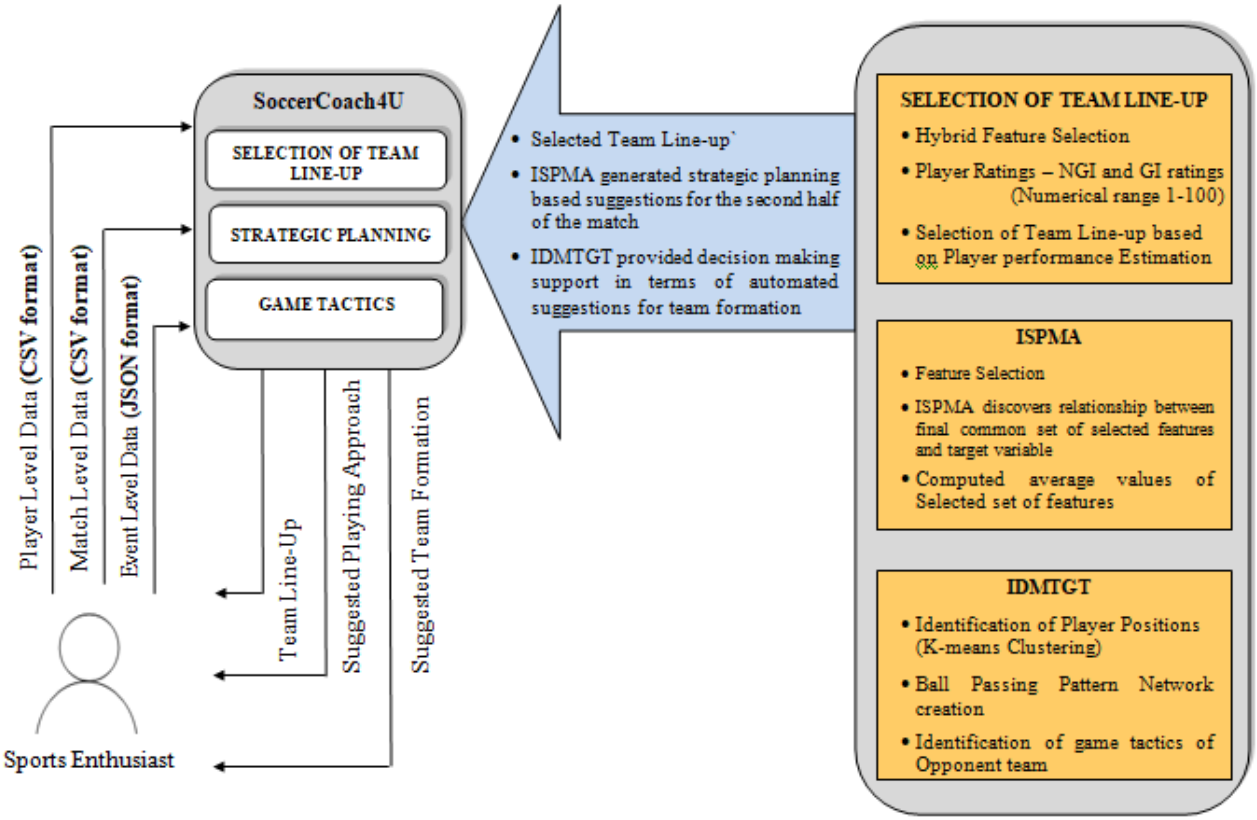

Fig.1. The Detailed Framework for Soccer Sports Management System

A combination of machine learning techniques has been employed to estimate the two types of ratings, non-goal impact ratings (NGIR) and goal impact ratings (GIR), for all the positional player categories, i.e., forwards, midfielders, and defenders. Decisive final ratings have been obtained by the fusion of both NGIR and GIR ratings to estimate the player performance for selection of the team line-up [13]. The second major functional component is an intelligent strategic planning method based algorithm (ISPMA) that uses the first half match statistics of the soccer game and computes average values of every selected feature to predict match outcome in terms of win, lose, or draw, followed by generating the strategic planning for the next half of the soccer game [14]. In the third component, an intelligent decision making technique for soccer game tactics (IDMTGT) offers efficient support for decision making by generating team formation based automatic suggestions by constructing the pattern of ball passing between opponent teams' players for handling game tactics [15]. Finally, an end-user web application is offered for societal use to facilitate the unbiased selection of team line-up, strategic planning, and game tactics for soccer sports with an easy to use interface.

3.1 Component I: Player Performance and unbiased Selection of Team Line-up

This is a machine learning based method for the selection of team line-up by estimating the player performance in soccer sports. The FIFA 22 soccer player dataset of 423 players have been taken from Kaggle. The dataset includes a total of 56 features comprises players' physical features as well as skill based features. In physical, the major features were age, weight, preferred foot, etc, and in skill based, the major features are dribbling, pace, shooting, defending,

skill-long-passing, ball-control, movement_agility, sprint-speed, shot-power, power_stamina, power-long-shots, etc. Before training machine learning models, the feature selection was done in two segments. Initially, feature selection was done by the expert based on their domain knowledge to classify the features into two groups: goal based impact features and non-goal based impact features. In the next segment, machine learning based four feature selection techniques, i.e., Lasso, Mutual Information, Random Forest, and RFECV have been applied to the above two groups of features in each player positional category, i.e., forwards, midfielders, and defenders. The common output features from all four techniques have been fed to three models, i.e., Gradient Boost, Linear Regression, and Random Forest. The best model in terms of accuracy, i.e., Random Forest has been used to estimate the two types of ratings, non-goal impact ratings (NGIR) and goal impact ratings (GIR). The estimated output is in the form of numerical ratings (range 1 to 100). Decisive final ratings have been obtained by the fusion of both NGIR and GIR ratings to estimate the player performance for selection of the team line-up.

3.2 Component II: Strategic Planning Method for Predicting Soccer Team Performance

In this component, the eleven seasons of the famous English Premier League have been used as a dataset comprising more than four thousand matches, where 418 matches have been utilized to test and 3762 matches to train the proposed model [17]. Firstly, the machine learning based feature selection has been carried out. For this, four well-known feature selection methods, i.e., Chi-square, Extra_tree classifier, Pearson correlation, and forward_selection, have been employed, followed by combining the output of all the techniques before supplying it to the seven classifiers, i.e., Decision tree, Naïve Bayes, AdaBoost, SVM, Logistic regression, Random Forest, and K nearest neighbor. After comparing the accuracy scores of all the classifiers, Random Forest was selected to predict the match outcome in terms of win, lose, or draw based on the first half match statistics of the soccer game and computes average values of every selected feature to provide strategic planning in terms of suggested playing approach for the next half of the soccer game.

3.3 Component III: Team Formation based Soccer Game Tactics

After identifying the player positions, graphs have been created based on the ball passing pattern network, where the thickness of the edges represents the frequency of the successful passes. To create a ball passing pattern network, player positions needed to be partitioned into three classes, i.e., attacking, defensive, and midfielders. This partition has been done using K-means clustering. The considered dataset is taken from the UEFA Women's Euro Cup knockout stages and group-level matches [18], with more than 2600 passes and nearly 900 shots made in all the matches. The soccer game tactics techniques offers efficient support for decision making by generating team formation based automatic suggestions by constructing the pattern of ball passing between opponent teams' players for making adjustments and managing soccer game tactics. It eliminates biasness and offers support both at the international as well as beginner's level in adapting and making adjustments correspondingly.

3.4 Soccer Sports Management Web Application SoccerCoach4U

To facilitate Soccer Sports Management for societal use, SoccerCoach4U web app is developed in python programming language using flask framework. This Flask framework-based web application is developed using the MVC architecture and is categorized into three components: Model, View, and Controller, as shown in Fig.2.

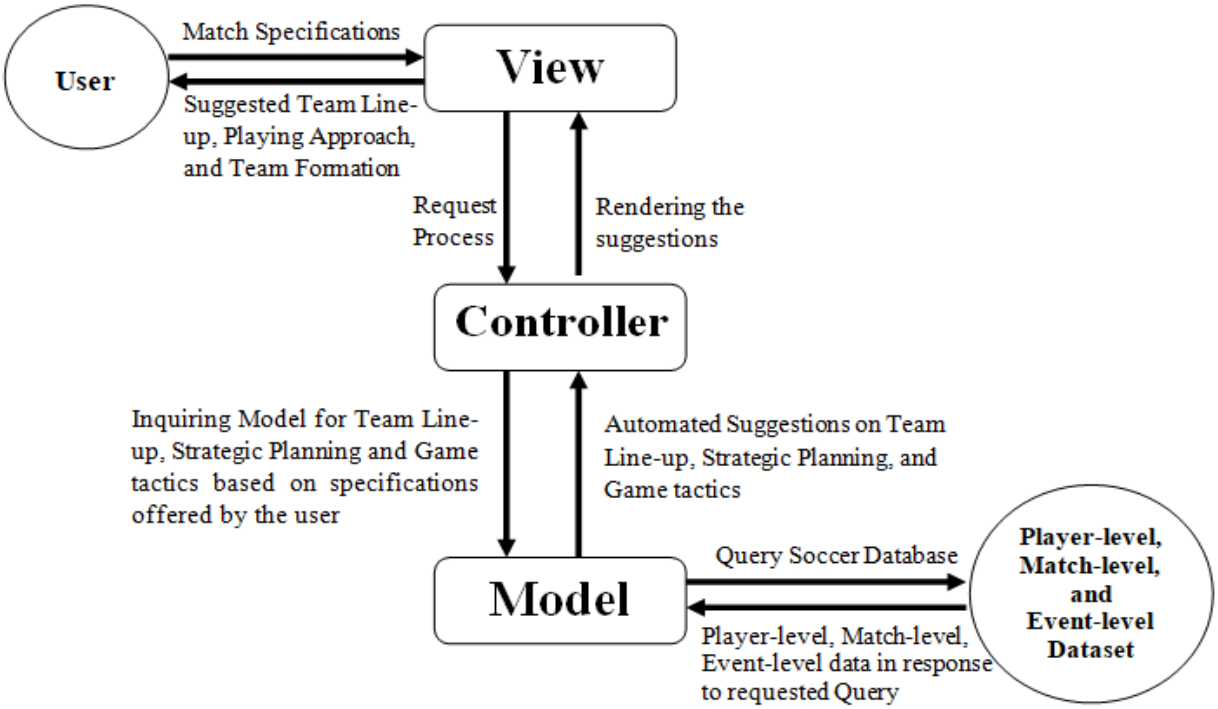

Fig.2. SoccorCoach4U: Design of Soccer Sports Management Web Application

The GUI of **the** Soccer Sports Management Web Application SoccerCoach4U offers services to the end-user and sports enthusiasts in three forms, i.e., Selection of Team Line-up, Strategic Planning, and Game Tactics (Fig. 3 to 6).

Fig.3. Graphical User Interface of Soccer Sports Web Application SoccerCoach4U

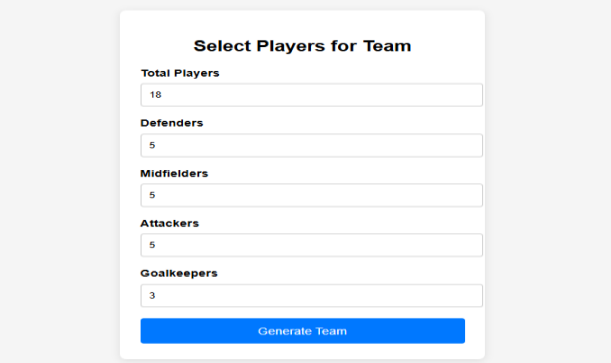

Fig.4. GUI of the SoccerCoach4U showing Team Selection Component

Fig.5. GUI of SoccerCoach4U showing Strategic Planning Component

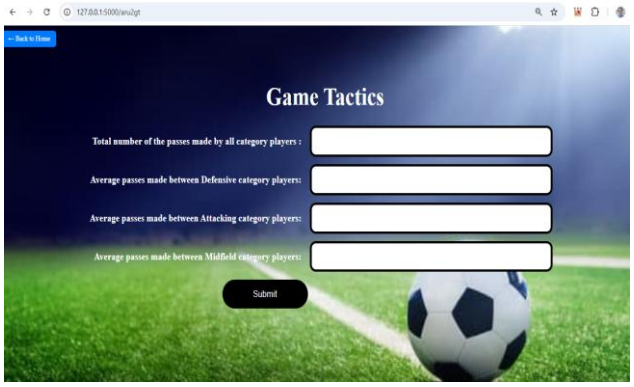

Fig.6. GUI of SoccerCoach4U showing Game Tactics Component

4. RESULTS AND ANALYSIS

The proposed soccer sports management prototype is tested on 300 users. This data has been analyzed by the domain experts from sports academies, university, and school for testing its relevancy. The proposed soccer sports management system is validated using the following test cases:

- Consider the inputs given to Component I of SoccerCoach4U (Table 1)

Table 1. Inputs given to Component I of SoccerCoach4U for selection of team line-up

Input	Input Value
Dataset CSV File	academy_players.csv

Total Players	18
Defenders	5
Midfielders	5
Attackers	5
Goalkeepers	3

According to the given inputs based on the data of 42 players with 56 features provided by a soccer academy based in Ludhiana in the form of specific .csv file containing all the enrolled school soccer players, total number of players to make squad, number of defenders, midfielders, attacking forwards, and goalkeepers needed in the team (Fig. 7), the proposed system presents the team line-up (Fig. 8) based on two types of estimated player rating, i.e., non-goal impact based player performance ratings (NGI ratings) and goal impact based player performance ratings (GI ratings).

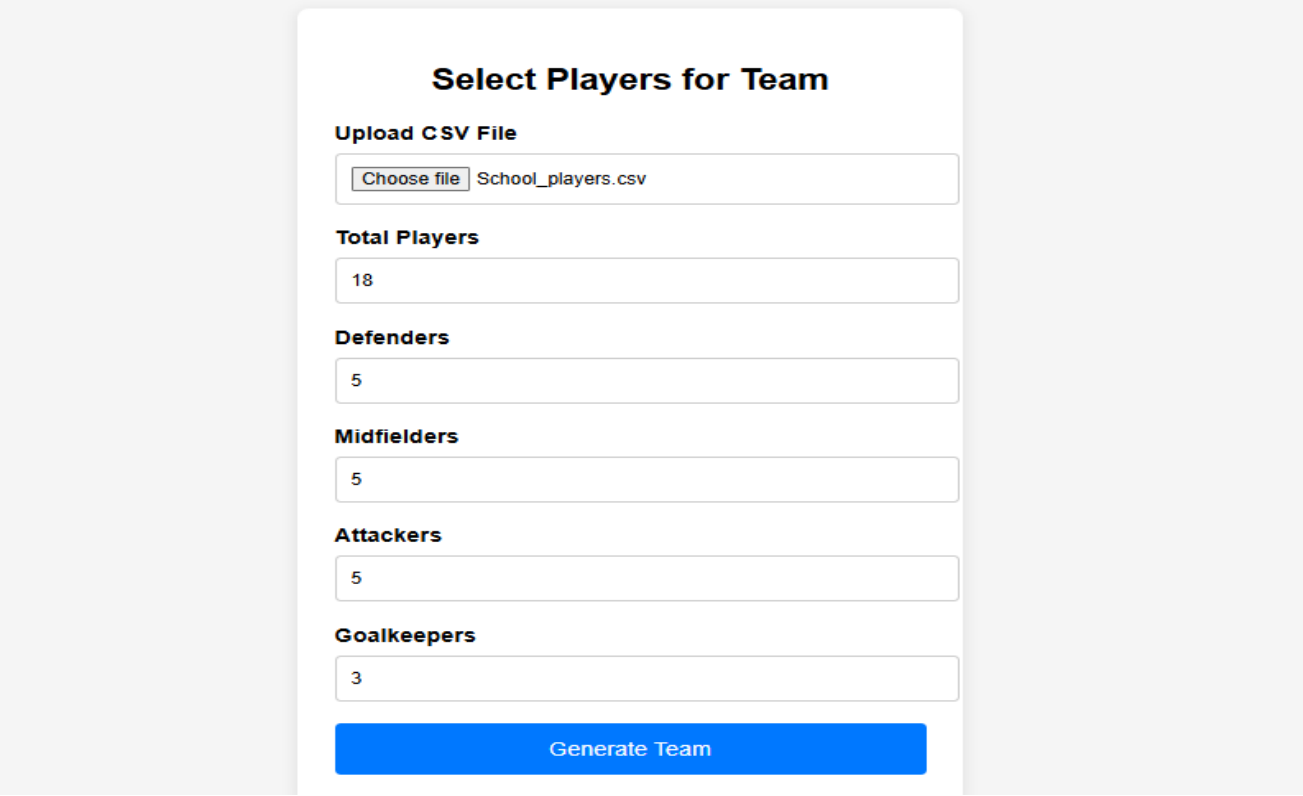

Fig.7. SoccerCoach4U: Sample input values for Selection of Team Line-up

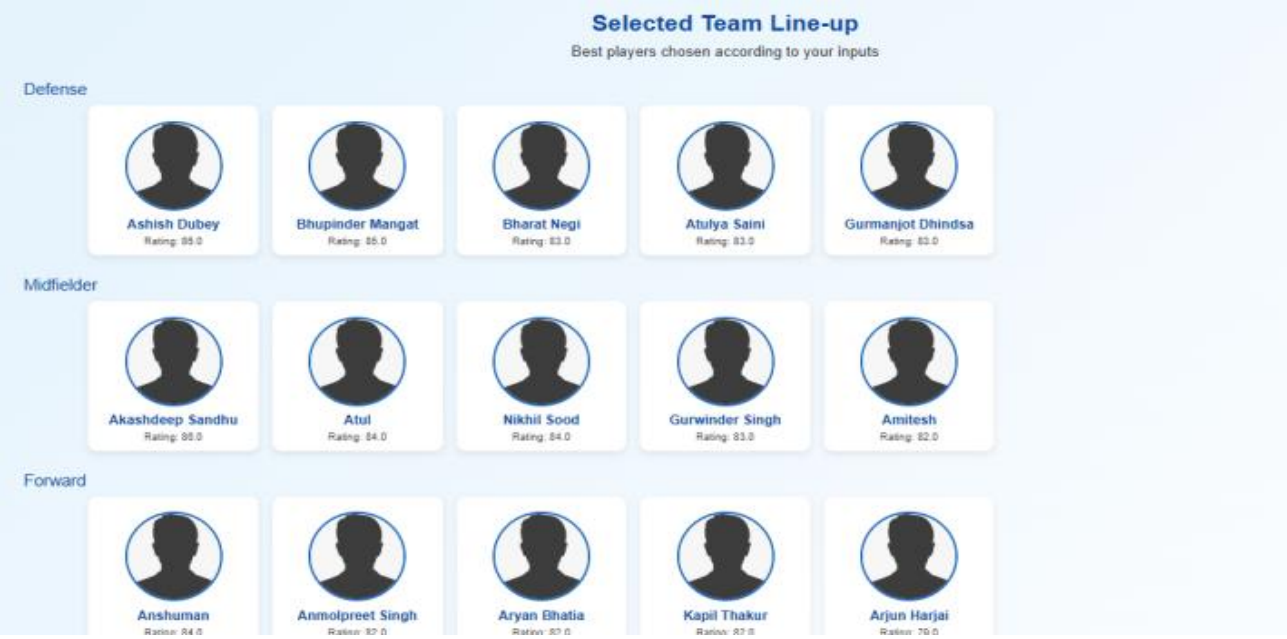

Fig.8. SoccerCoach4U: Suggested Team Line-up

- Consider the sample inputs given to Component II of SoccerCoach4U (Table 2):

Table 2. Component II inputs based on match statistics of first half of the match

Features	Input Values
HTHG (Home Team Goals after Half Time)	2
HTAG (Away Team Goals after Half Time)	0
HST (Home Team Shorts on Target after Half Time)	7
AST (Away Team Shorts on Target after Half Time)	4
HS (Home Team Shorts after Half Time)	17
AS (Home Team Shorts after Half Time)	8

Based on the input 2, 0, 7, 4, 17, and 8 given to the selected features, i.e., HTHG, HTAG, HST, AST, HS, and AS after the first half of the match (Fig. 9), the proposed system finds the relation between the selected features and the target variable by computing the average values of HTHG, HTAG, HST, AST, HS and, AS. Based on the estimated team performance, the proposed system provides strategic planning based suggestion to switch defensive strategy for the second half of the match (Fig. 10).

Fig.9. SoccerCoach4U: Sample input values for Strategic Planning

Fig.10. SoccerCoach4U: Suggested Strategy for the second half of the game

- Consider the sample inputs given to component III of SoccerCoach4U

Table 3. Component III sample inputs in terms of number of passes made by the opponent team

Features	**Input Values**
Total Number of Passes made by All Category Players	210
Average number of Passes made between Defensive Category Players	88

Average number of Passes made between Attacking Category Players	44
Average number of Passes made between Midfield Category Players	78

According to the given inputs in terms of total number of passes made by all category players, average number of passes made between defensive category players, average number of passes made between attacking category players, and average number of passes made between midfield category players (Fig. 11), the proposed system provides suggested game tactics in terms 4-3-3 team formation based on the ball passing pattern network of the opponent team (Fig. 12).

Fig.11. SoccerCoach4U: Sample input values for Game Tactics

Fig.12. SoccerCoach4U: Suggested team formation based game tactics

Soccer Sports enthusiasts with different profiles, such as coaches, experts, ex-soccer players, active soccer players, and soccer fans, used SoccerCoach4U and provided feedback on their experience with SoccerCoach4U using the feedback link. The proposed research has gathered feedback from a sample set of 300 users through a Google form. Offering comprehensive analysis coverage, this validation has shown useful insights into the ease of use, relevancy, and overall soccer sports management system experience of the users with the SoccerCoach4U interface. User ratings of SoccerCoach4U on the key parameters, such as relevancy, ease of use, and overall experience, have been collected and further summarized. The results of the proposed prototype validation by the general users from different backgrounds are provided as follows:

98.7% of users believe that the contribution of the coach, manager, or an expert is very significant to the success of a soccer team and its players (Fig. 13). There is a potential gap due to the absence of a coach or expert for the survival of the soccer team.

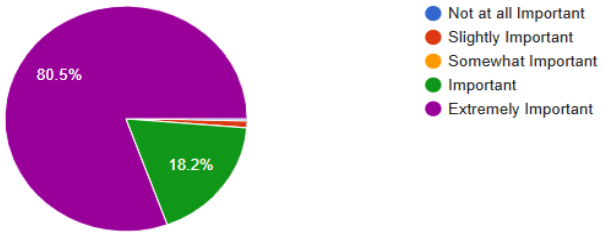

Fig.13. Users' reviews on the significance of the coach, or an expert to the success of a soccer team

Fig. 14 shows that 99.3% of users (297 out of 300 sample user population) rated the ease of use of SoccerCoach4U as 5 or 4 (on a standard scale of 1-5). With 80.8% of the users giving the highest rating of 5, it denotes that almost all the sample users find the SoccerCoach4U process to be highly user-friendly and effortless. This overwhelmingly encouraging response can be taken as a testament to the effectiveness of SoccerCoach4U for soccer sports enthusiasts.

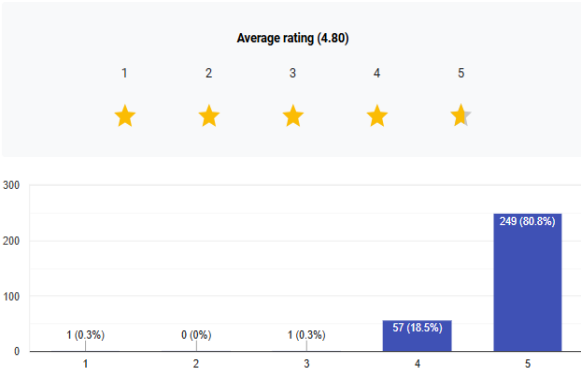

Fig.14. Users' ratings on the ease of use of SoccerCoach4U

Fig. 15 shows the users' reviews on the reliability of SoccerCoach4U. It has been observed that 98.4% of the users have found the interface highly reliable and gave 5 or 4 (on the standard scale of 1-5).

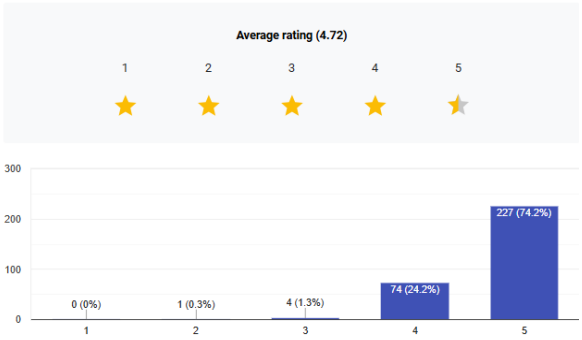

Fig.15. Users' ratings on the reliability of SoccerCoach4U

96.3% users (289 out of 300 users in the sample population) rated their overall experience with SoccerCoach4U as 5 or 4 (on a standard scale of 1-5), as shown in Fig. 16. This overwhelmingly encouraging feedback of 96.3% users, who have given 5 or 4 stars, is a sharp indication that SoccerCoach4U has succeeded in providing an enjoyable, effective, and seamless user experience, leading to extraordinary satisfaction levels among soccer sports enthusiasts.

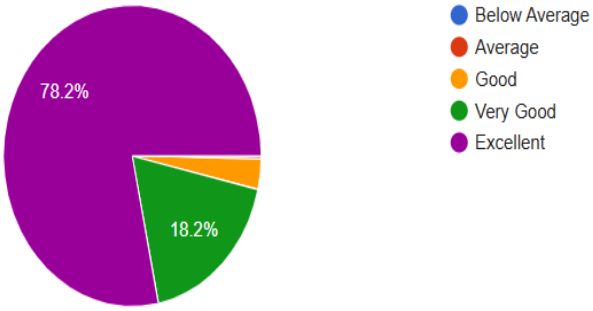

Fig.16. Users' ratings on the overall experience with SoccerCoach4U

The data gathered from Soccer Sports enthusiasts who have experienced SoccerCoach4U has been validated by the Soccer experts and they have found it user-friendly and relevant.

5. CONCLUSION AND FUTURE WORK

The proposed Soccer Sports Management system facilitates the selection of team line-up, provide intelligent strategic planning, and effective decision making technique for handling game tactics in soccer sports in real time. A web application named SoccerCoach4U provides a graphical user interface, where users can enter the match statistics, and the system provides support for efficient decision making in terms of automated strategic planning based playing approach and automated suggestions for team formation to handle game tactics in soccer sports, in addition to the selection of team line-up to enhance team performance. Soccer Sports Management prototype was tested on 300 users including domain experts from educational institutes, academies and sports enthusiasts with different profiles, such as ex-soccer players, active soccer players, and soccer fans, who have provided feedback in the form of a Google Form for its relevancy through soccer sports management web application SoccerCoach4U. Users' reviews suggest that 98.4% of the users find suggestions obtained from SoccerCoach4U as highly reliable, and overall experience of 96.3% of users is highly satisfying. The Soccer sports management system can assist coaches, managers, and the team in carrying out effective decision-making to enhance performance in terms of selection of team line-up, strategic planning, and game tactics in soccer sports to enhance performance. The research work can be extended by including Injury Risk Assessment and Training Analysis, which could be a valuable future extension. Everyone is not privileged to hire a professional soccer coach, manager, or analyst due to many reasons like financial barriers or geographic

factors. The proposed research will be beneficial for the research community and society in general, and soccer sports enthusiasts in particular.

DECLARATIONS

Ethics Approval: Not applicable (as the results of the studies do not involve any human or animal).

Funding: The authors have not received any financial support for the research or publication of this manuscript.

Acknowledgments: The authors appreciate the contribution of Dr. Anuj Vohra, Soccer Coach, Strawberry Fields High School, Chandigarh and Mr. Gurdeep, Soccer Coach, GSS, Katiani Kalan, Ludhiana as soccer experts, who offered value-added suggestions from time to time. The authors also sincerely appreciated the editor and reviewers for their time and valuable comments.

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