Web Application for Support in Basketball Game Analysis

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Abstract: The development of ICT technologies and usage in various fields enable faster development and analysis of large amounts of data, but also a way of saving the data. Stored data are easier to search, edit and analyse. Stored data, usually stored in databases, can be analysed and useful information can be drawn. As Internet communication becomes the dominant way in exchange of data and information, many application and expert system were developed. In this paper is shown AssistantCoach expert system, which was developed for supporting basketball coaches in making decisions and analysing games. It describes a new algorithm for game win percentage prediction and allows users to make notes about opponent players and teams, but also notes about their own players, trainings and different types of game analysis. Based on input parameters (IPE in selected time period, predicted parameters) the expert system calculates game win percentage. By increasing or decreasing parameters, coaches are able to find the highest percentage for the win and to use time before game to correct team mistakes. In addition to the algorithm for game win percentage, the expert system offers their user a number of different analysis and statistics. Expert system uses every input game boxscore and other notes as a new material to learn. Described methods and algorithm are verified on a selected sample of basketball games and selected time period.

1 INTRODUCTION

Nowadays, the usage of computer analysis in sports, especially in professional, has become a normal part of the game analysis (Havaš et al., 2014). Statistical analysis, also known as notational analysis, has become interesting not only to coaches and sports workers, but also to sports fans and reporters (Hughes and Franks, 1997; Hughes and Franks, 2004). Mathematical presentation of a player's performance can give a realistic image of player performance and supports coaches to analyse player's performance in a quick and easy way, very often during a game or practice. The goal of the game analysis is not to establish how good or bad team or individual performance is, but to find and correct common mistakes that will lead to increasing of the individual performance and thus the team performance. In every sport, especially team sports like basketball, in which there is an individual or team approach, using information and communication technologies (ICT) enabled user's (coaches, sport workers or sport fans) possibility to analyse game on a different level (Dežman et al., 2001). In a situation where there is an expert system that has the ability to analyse player or team performance and to extract useful information, Internet communication becomes dominant among users and the expert system (Havaš et al., 2013; Havaš et al., 2013).

In this paper is shown one such expert system that supports basketball coaches to analyse individual or team performance in a game by using web based application (Jackson, 1998; Leondes, 2002). The application can analyse team or player performance before, during or after the game in real time and supports coaches in making decisions. Input data into the expert system's database are boxscores of played games, player notes, training information and opponent notes.

The second part of this paper describes the expert system architecture while the third part of the paper shows the development of the expert system through several stages of development. In the fourth part is described and shown verification of results for a selected time period. The final part of the paper gives a conclusion and the list of references.

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2 AssistantCoach EXPERT SYSTEM REPRESENTATION

The prototype of the expert system was developed by using open-source programs (PHP and MySQL). The whole application solution was programmed in first object-oriented version of the language PHP, version 5.4 (PHP, 2015). The database was designed and implemented in MySQL relation database, version 5.1.61 (MySQL, 2015).

2.1 The Architecture of an Expert System

The first display which users of the prototype of AssistantCoach application encounter is shown in the Figure 1.

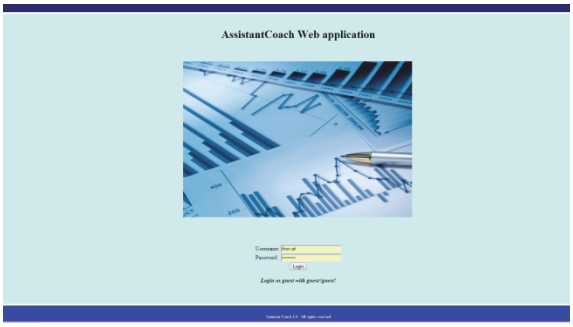

Figure 1: Opening display of AssistantCoach application (log in the page).

Users can log in to the application as an administrator, moderator or guest. The privilege to add new users has only the administrator. The moderator has limited privileges and can add new games, boxscores, notes and can update information about players. The guest can only see a schedule of playing, boxscore of every game and player individual average statistics. When the user has successfully logged in, the user is presented with a home page, in accordance with the authorization level. A specific part of the application, functions or menu items, is shown or hidden from the user. Home page, which is shown after successful log in, gives user the possibility to adjust the time period for setting start and end date of every analysis. AssistantCoach application consists of nine menu items, including Home page, contained in the navigation bar.

Menu item Players allows application users to add, update or delete players, adding notes about players, but also tracking players' technical and physical development.

Menu Games gives the user the possibility to add new games, change the game result and to add individual player performance during the game. Menu Games also gives user the possibility to analyse the game in order to compare with other games in selected time period, but also a comparison of players in selected time period. Very interesting part of Games menu is the game prediction. Expert system, based on user input parameters (predicted game parameters and player's minutes in play) calculates the possibility for the win. Predicted parameters are selected based on coach's prediction, based on opponent quality and current condition of his team. Probability to win is calculated according to the average player and team statistics of the selected time period and the games against the selected opponent. Menu Games also gives user the possibility to make live statistics during the game and possibility to compare current team and player statistics to selected time period statistics. Statistics can be analysed during the game.

Menu Statistics gives user all kinds of statistics including IPE calculation which will be discussed in later chapters. Menu Statistics also gives user the possibility to define and save their own statistics, according to their own view on the particular game parameters.

Menu Opponents gives user the possibility to make notes about opponent teams and players, while Menu Reports gives user the possibility to make a report about player in selected time period (average numbers, notes, individual performance on every game and training arrivals).

Menu Training gives user the possibility to make records about every training and intensity of every aspect of training, but also records about players and their performance.

Menu About gives information about team staff while Menu Fan Area behaves as a forum where fans or reporters can leave their observations about teams.

While AssistantCoach is Web based application and authorization is needed, application AssistantCoach can also behave as club Internet page. Authorization level allows an administrator to define the privileges of each user, thus the amount of displayed information.

2.2 Input Data into Expert System

Input data into the expert system are game boxscores, game result by minutes, notes about own players, opponent players, opponent teams and training information. Boxscore and result change by

minutes can be inserted into the database using form Livestats or manually after the game, while all kind of notes must be inserted manually. Segment of livestats form is shown in the Figure 2.

Figure 2: Livestats form.

Expert system users can also make notes about opponent teams or players, but also notes about trainings and their own players. Notes can support the coach in making decisions and can be used as a reminder for previous played games or opponent players. Flow chart of the expert system is shown in the Figure 3.

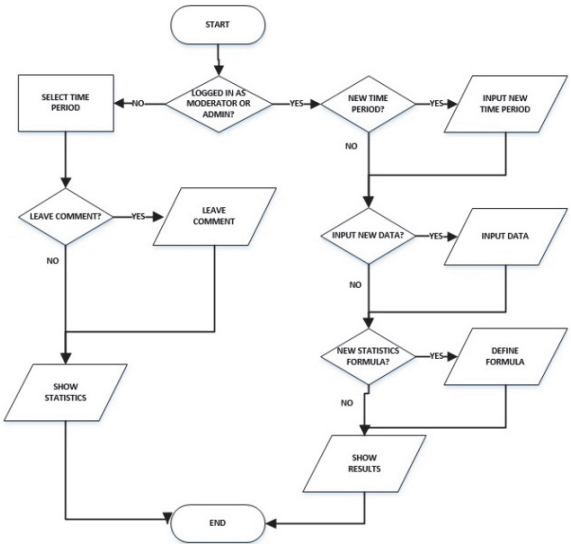

Figure 3: Expert system flow chart.

2.3 The Index of Player Efficiency (IPE)

Player efficiency index is a statistical data which mathematically differently evaluates the basic elements of the basketball game and thus numerically evaluates the usefulness of a player in a particular game or time period (Lidora and Arnon, 2000). Statistical analysis, like IPE, is a kind of notational analysis. Notational analysis is basically the gathering and analysing of data that has been obtained by observing the performance of a team or an individual in a competitive situation (Hoofler and Payne, 1997; Karapidis et al., 2001). The staff makes a list of measurable performance indicators as a list of key elements of a match and then, based on experience, the team or individual performance can be evaluated mathematically using the appropriate algorithm. One such algorithm is Index of Player Efficiency (IPE).

The main advantage of IPE compared to other known player efficiency indexes is the fact that IPE makes players' defensive activities equal to attacking activities. Due to the fact that the average basketball game viewer favours player's attacking activities (dunks, buzzer beater shots, clutch shots…) and basketball staff, especially coaches, analysis of the whole player game, IPE makes balance between offensive and defensive activities, especially valuing above average contributions of an individual in relation to the team. IPE algorithm consists of a number of components where every component represents a segment of the game (points, rebounds, field goal percentage, steals, turnovers, assists, fouls…). Every component of the algorithm is then multiplied by particular factor. Application AssistantCoach allows their users to adjust the factors in the IPE algorithm according to their wishes.

2.4 Game Prediction Algorithm

Various analysis and performance indicators have allowed coaches to make faster and more efficient analysis of a team or individual. Based on statistics of previous games and time period selected by the user, the system can draw useful information and predict the percentage for the win. Coaches can predict game parameters of scheduled game and expert system will, based on statistics of previous games, calculate percentage for the win. By increasing or decreasing some parameters, coaches are able to find the highest percentage for the win and use time before game to correct team or individual mistakes during the game.

Using decision trees application AssistantCoach can predict the percentage for the win based on predicted parameters and statistics of games played in the selected time period. Decision tree learning is a method usually used in data mining with a goal to create a model that predicts the value of a target

variable based on input data. Input data into AssistantCoach application are boxscores of played games.

The Application AssistantCoach uses decision tree for every parameter of the game. The output of one decision tree is input into another decision tree. The initial percentage of victory is set to 50%. Application AssistantCoach gives user the possibility to set parameters according to users' prediction. Parameters of prediction can be divided into three groups:

- predicted team parameters – predicted group statistics of a particular game (team field goal percentage, offensive and defensive rebounds, steals, assists and turnovers)
- individual parameters – predicted time in play for every player
- opponent team parameters – opponent team name, venue, predicted opponent team quality in relation to users' team and number of opponent team offensive rebounds

The application compares team average statistics in the selected time period to users' predicted numbers and based on result increases or decreases the percentage for the win. If some of the parameters remain empty, the comparison for that particular parameter is neglected. Predicted game form is shown in the Figure 4.

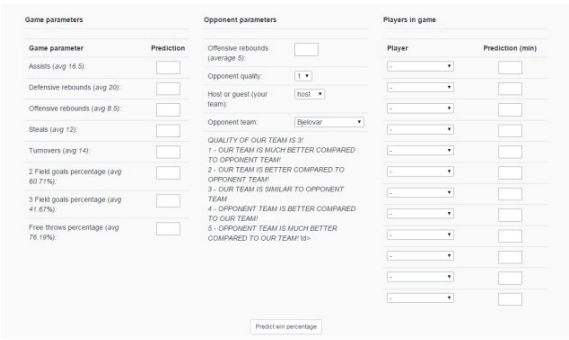

Figure 4: Predict game form.

As it is shown in Figure 4, user predicts game parameters, predicts minutes in play for every player and predicts and defines opponent performance and quality. Some parameters can remain empty or unpredicted, a decision tree for the particular parameter is skipped and the percentage for the win remains unchanged. Basic game parameters (Game parameters in the Figure 4) are calculated based on average team performance in the selected time period. Worse predicted parameters decrease percentage for the win while better predicted parameters increase percentage for the win. Based on the ratio of predicted and average parameters, the expert system defines coefficient, which is multiplied by the current percentage for the win. Current percentage for the win is output from previous decision tree. The expert system also analyses similar game parameters and based on average and predicted performance also defines the coefficient. As noted earlier, empty parameters do not change the percentage and every parameter makes one decision tree. Output of the decision tree is input into another decision tree. Also, as noted earlier, input into first decision tree is coefficient 0.5 or 50%. Prediction of more parameters and selecting a longer time period, the expert system can more accurately calculate the percentage for the win.

The second group of parameters, Players in the game in the Figure 4, predicts minutes in play for every player. The expert system, based on average IPE which is introduced in the Chapter 2.3 the Index of Player Efficiency (IPE), calculates coefficient which is multiplied by the current percentage for the win.

Last group of parameters, Opponents parameters in the Figure 4, defines and predicts the opponent quality and venue. The expert system, based on results in the selected time period against the same and other opponents, predicts opponent offensive rebounds, opponent quality and venue calculate coefficient which is then multiplied by the current percentage for the win. The Figure 5 shows the example of a decision tree where the coefficient for assists is calculated. Based on the ratio between predicted assists number and the average team assists per game, the coefficient of the particular ratio is multiplied with current win percentage (w_perc). The output of assists decision tree is input into steals decision tree. The decision tree is built for every component. If predicted parameter remains empty, the win percentage remains unchanged.

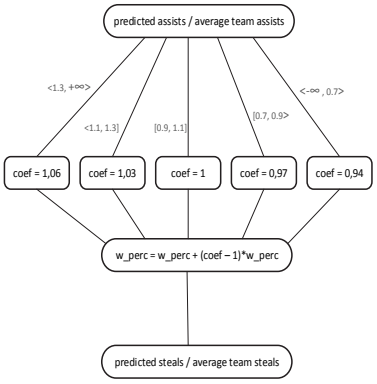

Figure 5: Decision tree for assists.

3 DEVELOPMENT OF THE EXPERT SYSTEM

The development of an information system passes through several stages of development; conceptual design phase, implementation phase and phase of the physical design. Conceptual design, also known as a conceptual model, identifies the highest-level relationships between different entities. Conceptual model of the data is usually represented by ER (Entity - Relationship) model which is a graphical representation of entities and relationships among them, typically used in computer sciences to present the organization of data within databases and information systems (Chen, 1976). ER model of the expert system is given in the Figure 6.

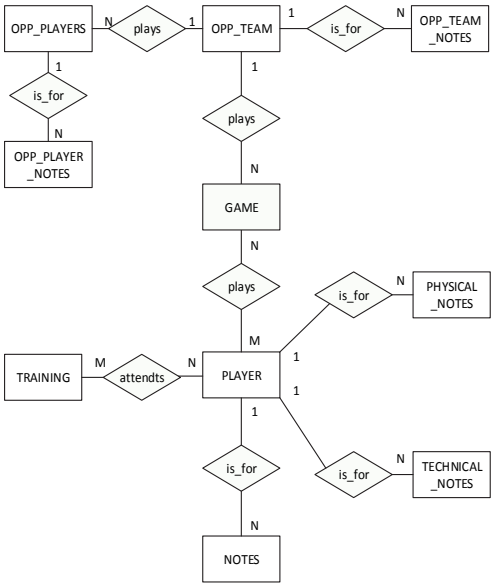

Figure 6: ER model of the expert system.

ER model in the Figure 6 shows the relationships between entities in AssistantCoach application on conceptual design phase. ER model says that the game is played by more players and the player plays more games. Every note, regardless if it is made for a player or an opponent team is for one player or team and player or opponent team can have more notes. ER model in the Figure 6 also says that the player attends more trainings and the training is attended by more players (relationship between entities TRAINING and PLAYER). Relation OPP_PLAYERS – OPP_TEAM says that the player plays for one team and in a team plays more players. Creating an ER model completes the first phase of the development of expert system. The next step in the development of an expert system is the creation of a logical model. The resulting ER model is translated into a relational schema. Steps and conversion rules for converting into relational model are known from earlier. Relational model is then implemented into the database management system. The relational model of an expert system is shown in the Figure 7.

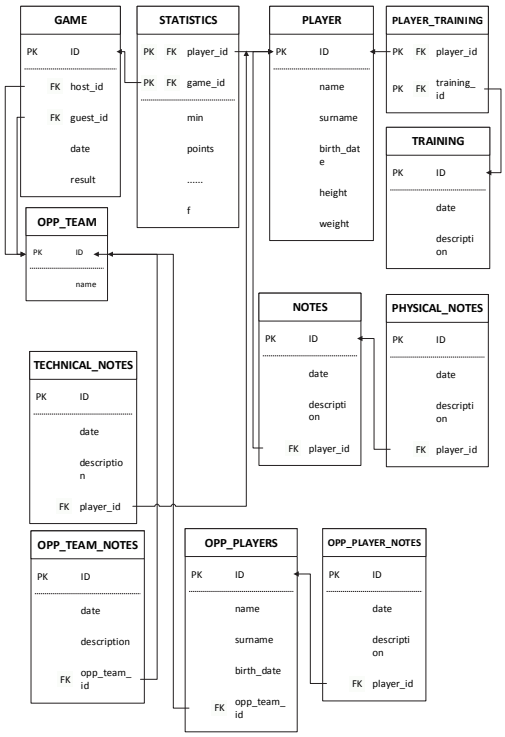

Figure 7: Relational model of the expert system.

Expert system, Web based application AssistantCoach, was developed with the purpose of enabling the exchange of information in real time. The application works on client-server architecture. Client (user) sends a request to the server, which passively waits, receives the request and sends a response back to the client. The client can connect to the Web page using a variety of devices that have access to the Internet. The client sends a HTTP request by writing the Web address into a Web browser and Web server sends the answer back to client. Architecture of Internet communication of AssistantCoach application is shown in the Figure 8.

The developed expert system has been verified in the selected time period. Games of the season 2014/2015 in Croatian 2nd basketball league were analysed. For every game, team and individual statistics were made, inserted into the database and analysed by the developed expert system.

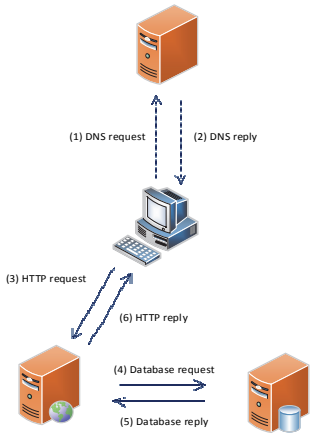

Figure 8: Internet communication architecture.

Predictions were made based on average parameter before the game was played, real parameters and no parameter, just based on the team opponent name and venue. The time period used for predictions was whole 2014/2015, including friendly, Cup and league games. Predictions were calculated for the time period up to a match, while prediction based on real parameters was calculated after the game was played, also for time period up to a match. Table 1 shows game prediction of a league game of season 2014/2015. Columns colored in red show wrong prediction.

4 RESULTS

As was mentioned earlier, Table 1 shows results based on game prediction results during whole 2014/2015 season. Table 1 consists of five columns; first column shows game date, the second column shows the game result where prefix L means lost game and prefix W means won game, the third column shows win percentage based on average parameters up to the game, the fourth column shows game win percentage based on real game parameter up to the game and the fifth column shows game win percentage based only on opponent name and venue. Fifth column gives prediction based only on previous game against the same opponent and ratio of win and lost games based on venue in selected time period, so it is called “no parameter prediction”. As is evident, time period and number of played games significantly affect game prediction algorithm. A greater amount of data in the database reduces the possibility of extreme data which will be included in the analysis.

Extreme data usually appear in the case of a small sample data when the expert system does not have enough data to learn and to extract useful information. In the case of larger amounts of data occurrence of extreme data is significantly decrease, and thus analysis and game prediction percentage more accurately. Based on the results from Table 1 and a sample of 21 matches and 63 predictions, it is

Table 1: Game prediction results.

DATE	RESULT	AVERAGE PARAMETER PREDICTION	REAL PARAMETER PREDICTION	NO PARAMETER PREDICTION
11.10.2014.	L 69:75	47%	42%	54%
18.10.2014.	L 70:69	60%	43%	46%
26.10.2014.	W 97:70	81%	71%	54%
2.11.2014.	W 64:78	83%	79%	60%
8.11.2014.	W 91:68	95%	49%	84%
15.11.2014.	W 82:101	100%	100%	87%
22.11.2014.	W 99:79	67%	78%	67%
29.11.2014.	W 85:120	74%	100%	83%
6.12.2014.	W 100:82	59%	91%	59%
14.12.2014.	W 98:111	94%	85%	83%
19.12.2014.	W 112:65	99%	100%	84%
11.1.2015.	W 80:87	50%	59%	50%
18.1.2015.	L 79:84	63%	53%	70%
31.1.2015.	W 96:75	68%	75%	75%
7.2.2015.	W 64:111	86%	94%	98%
14.2.2015.	W 95:64	69%	67%	79%
21.2.2015.	W 82:90	54%	81%	62%
28.2.2015.	W 117:97	73%	100%	75%
8.3.2015.	L 81:75	60%	45%	62%
13.3.2015.	W 114:109	73%	91%	75%
22.3.2015.	W 67:108	96%	100%	98%

clear that the game prediction algorithm was wrong on 8 predictions. The biggest mistake is recorded for the game played on 18.1.2015. The reason for this is the fact that the match was played without five very important players, players with the highest average IPE.

5 CONCLUSIONS

This paper shows modelling of a Web based expert system for support in basketball training and game decisions. Expert system allows their user to easily analyse basketball games or make good preparation for upcoming games based on previous analysed games or notes made about opponent teams or players, but also previous played games. This paper shows complete development of the expert system.
Game analysis is very complex matter. It takes years of experience and knowledge to analyse game, especially if it is made by hand. Developed expert system supports coaches to analyse game on fast and efficient way.

Second chapter presents expert system architecture and shows expert system flow chart. Input data into the database are boxscore and notes about own players, opponent teams and opponent players. Very interesting information about player performance are player efficiency indexes. The developed expert system uses IPE (Index of Player Efficiency) index, statistical data which mathematically differently evaluate basic elements of basketball game and thus numerically evaluates the usefulness of a player. The main advantage of IPE compared to other known player efficiency indexes is the fact that IPE makes players' defensive activities equal to attacking activities.

Expert system, based on IPE, previously played games and predicted parameters, calculates game win percentage prediction. By changing parameters coaches are able to find the highest percentage for the win and use time before game to correct team mistakes. The initial percentage of victory is set to 50%. The Application AssistantCoach uses decision tree for every parameter of the game, by increasing or decreasing win percentage based on ration between average and predicted parameter. The output of one decision tree is input into another decision tree. Parameters of prediction can be divided into three groups; predicted team parameters, individual player parameters and basic opponent team parameters.

Third chapter presents the development of the expert system through phases of conceptual and logical phase. Conceptual model of the data is represented by ER (Entity - Relationship) model which is a graphical representation of entities and relationships among them. The resulting ER model is translated into a relational schema, which is implemented into MySQL database. The application works on client-server architecture.

Verification of the algorithms and the methods has been conducted on a basketball 2014/2015 season.

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