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FUZZY COGNITIVE MAPS BASED CRICKET PLAYER PERFORMANCE EVALUATOR

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Abstract

Sports persons' performance evaluation is a critical issue. The parameters used for this purpose are vague and imprecise. We propose a fuzzy cognitive map based cricket player performance evaluator tool that uses fuzzy logic to perform computation keeping in view the relations among various input parameters. A very simple and effective graphical user interface is build to use the proposed model.

Keyword: Cricket Players, Fuzzy Cognitive Maps, Fuzzy Logic, Ranking.

1. Introduction

Cricket is one of the most popular sports among every class of people. Cricket is bat and ball game played between two teams having eleven players each. Due to its tremendous popularity, media gives more preferences to this game. It is a sport in which statistics feature heavily [1] and these statistics give clear picture of each and every facet and players of cricket. The International Cricket Council (ICC) is the international governing body that organizes world cricket. It is responsible for the organization of international cricket tournaments.

In cricket, the comparison of cricketers' batting and bowling abilities is usually done with very basic performance measures [2]. System of ranking is followed based on the performance of

cricketers. The Reliance ICC Player Rankings is the official guide which evaluates the player performance. In this game, the rules that evaluate a player's performance are very crisp rules. Due to these crisp rules, the actual performance of a player is not visible. There is a lot of disparity in evaluating the performance of a player. It affects on his ICC rankings. Performance is evaluated on the basis of centuries/half centuries made, rank of the team against which the player is playing, rank of its own team, location of the match i.e. home or away, strike rate and average. The objective of this proposed research work is to develop a model for calculating the player's performance using fuzzy set theory.

In case of sports person's performance evaluation, the parameters considered do not have crisp values. There is a significant amount of vagueness involved which motivates the use of Fuzzy Logic. Fuzzy logic was first presented by Lotfi Zadeh in 1965 [3]. Fuzzy logic is a superset of Boolean logic that is used to handle the concept of partial truth values that ranges in degree between 0 and 1. It is a problem solving methodology which can be applied in developing both linear and non-linear systems for embedded control. Fuzzy logic helps to draw conclusions from vague or ambiguous information. Fuzzy systems typically employ rules to translate vague terms, such as skill or comfort, into system outputs [4]. Fuzzy logic has been applied in various fields such as system control, artificial Intelligence etc. Fuzzy Inference System (FIS) computes the output on the basis of a number of fuzzy input parameters. The disadvantage with FIS is that it does not take into account the interdependence of various input parameters, if any. To incorporate such interdependence, Fuzzy Cognitive Map (FCM) provides a robust and useful mechanism.

FCM is a graphical representation of the knowledge about the system. Political scientist Robert Axelrod introduced the cognitive map in 1976 for using it to represent knowledge. FCM is a very simple and convenient tool that is used in a wider range of applications like business, medical economics, project planning, robotics, expert systems etc. FCM is a graph consisting of nodes and arcs (edges). Nodes are also called concepts that describe the behaviour of the system and can be represented as variables. Concepts can be states, actions, goals, inputs etc. On the other hand, edges or arcs are the relationships among the concepts either positive or negative. Each arc is assigned a weight. Weights characterize the strength of the relations through fuzzy values. Arc lines labelled with weights show the strength of the casual conditions between the concepts. So, a FCM is a directed graph with concepts like policies, events etc. as nodes and causalities as edges. It represents causal relationship between concepts [5, 6].

In this paper, the objective is to define and construct Fuzzy Cognitive Maps for the evaluation of cricket player's ranking. In this game, the rules that evaluate a player's performance are very crisp. Due to these crisp rules, the actual performance of a player is not visible. Hence, the Fuzzy Cognitive Map tool is used to analyze the exact performance and ranking of the player. The objective of the paper is to develop a FCM which represents the factors affecting the performance of a cricket player. In this research work, the proposed fuzzy cognitive map helps the decision makers to know the exact ranking of a player.

2. Related Work

L. A. Zadeh suggests a fuzzy set theoretic approach to provide a framework for representing the meaning of propositions and dispositions [7]. Fuzzy quantifier is employed to denote the collection of quantifiers in natural languages and the concept of cardinality of a fuzzy set is used [8]. Michio Sugeno and Takahiro Yasukawa have proposed the use of fuzzy clustering method for the structure identification of a fuzzy model [9]. L. A. Zadeh describes the role of fuzzy logic in computing with words [10]. Gordon Hayward and Valerie Davidson discuss various applications of Fuzzy logic [11]. Adnan Shaout, Brady King and Luke Reisner presented a complete design and implementation of real time fuzzy based system for a game named Pac-Man [4]. Marco Barajas and Bruno Agard analyze role of fuzzy logic in the improvement of product family development process. For analyzing, they took fourteen fuzzy logic tools and thirteen topics into the product family development process [12].

Fuzzy Cognitive Map is very simple and convenient tool used to extract and analyze different kinds of knowledge about complex systems. Fuzzy Cognitive Maps were originally proposed by Robert Axelrod in 1976. Then Bart Kosko [13] significantly enhanced the power of cognitive maps considering fuzzy values for the concepts and casual relationship between concepts. FCM model was used in different areas of applications for planning and decision making such as engineering, physical science, military sciences etc. João Paulo Carvalho and José A. B Tome introduce Rule Based Fuzzy Cognitive Maps and present a method to implement Fuzzy Causal relations [14]. Fuzzy cognitive maps are used for the renewal of water mains as a decision support tool [15], in medical decision support for the process of predicting infectious diseases [16] and used for analyzing the major reason for suicides using neutrosophic tool [17].

K. M. Curtis [18] analysis batting strokes using fuzzy set theory. Alan C. Kimber and Alan R. Hansford proposed a non-parametric approach based on runs scored for assessing batting performance [19]. David Beaudoin proposes a new measure for assessing the performance of batsmen and bowlers in one-day cricket [20]. Paul Allsopp proposes a method to estimate a projected score for the team batting second in ODI cricket [21]. Uday Damodaran demonstrates the use of stochastic dominance rules to analyze the One Day International (ODI) batting performance of Indian cricketers [22]. Matthews Ovens and Bruce Bukiet develop Markov Chain approach to study the progress of runs for a batting order of non-identical cricket players [23]. Vani K. Borooah and John Mangan [24] suggest new ways of computing batting averages which complement the existing method and present a more complete picture of batsmen's performance. Hermanus H. Lemmer [25] conducted study on how batting and bowling performance measures for one-day internationals can be adapted for use in Twenty20 matches. Paul J. van Staden [26] considers a novel graphical display for comparing the performances of bowlers.

3. Proposed Work

We prepare a FCM based model to predict/compute the impact of recent performance of a cricketer on the current ranking. We use various performance parameters such as Runs Scored, Strike Rate, Balls Faced, Out, Fours, Sixes, Team Strength, Team Against Strength and Ranking to act as nodes of FCM with systematically computed edge weights as described further along with positive and negative impacts.

3.1 Description of Concepts

In the FCM, we have taken the following eight concepts {C_1, C_2, C_3, C_4, C_5, C_6, C_7 and C_8}. The following concepts are taken as the main nodes for our problem. Table 1 shows the name of the concepts, their description and their number of values.

Concept Symbol	Concepts	Description of Concepts	Linguistic Variable
C_1	Runs Scored	Runs made by a batsman.	Low, Med, High

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C_2	Strike Rate	Average number of runs scored per 100 balls.	Low, Med, High
C_3	Balls Faced	Number of balls faced by a player.	Low, Med, High
C_4	Out	Fielding side taking a wicket of the player.	Yes, No
C_5	Fours	Number of boundaries made by a batsman.	Low, Med, High
C_6	Sixes	Numbers of sixes hit by a batsman.	Low, Med, High
C_7	Team Strength	The ranking of the player's team as compared to the other nation's current ranking.	Low, Med, High
C_8	Team Against Strength	Ranking of the opponent team against which player's performance is being measured.	Low, Med, High
C_9	Ranking	Player's current ICC ranking.	Low, Med, High

Table 1: Description of Concepts

3.2 FCM Impact Computation

The above eight concepts are connected to each other. These concepts affect each other either negatively or positively. This relationship is called events. We develop FIS for each event. So, there are steps which we have to follow.

First, it is decided that which concept connect which other concept, then examine the sign of connection and finally determine the weight of each connection. The connections (relation) between concepts are described in Table 2 in the form of events.

Event. No	Input Concept→ Output Concept	Type of Impact	Level of Impact
Event 1	Runs Scored → Ranking	+ve	0.655
Event 2	Runs Scored → Strike Rate	+ve	0.683
Event 3	Strike Rate → Ranking	+ve	0.66

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Event 4	Balls Faced → Strike Rate	-ve	0.345
Event 5	Balls Faced → Ranking	-ve	0.687
Event 6	Out → Runs Scored	-ve	0.69
Event 7	Out → Strike Rate	-ve	0.756
Event 8	Out → Ranking	-ve	0.762
Event 9	Fours → Runs Scored	+ve	0.735
Event 10	Fours → Strike Rate	+ve	0.683
Event 11	Fours → Ranking	+ve	0.686
Event 12	Sixes → Runs Scored	+ve	0.728
Event 13	Sixes → Strike Rate	+ve	0.685
Event 14	Sixes → Ranking	+ve	0.634
Event 15	Team Strength → Ranking	+ve	0.634
Event 16	Team Against Strength → Ranking	+ve	0.655

Table 2: Relation between Concepts and their Level of Impact

Mamdani algorithm is used to understand the event clearly. Let us take an example of Event 1. In this event, the relationship between runs scored and ranking is positive. We used max aggregation and centroid for defuzzification.

Event 1: Runs Scored → Ranking: Runs scored are divided into three levels: low, medium and high. Three different membership functions are used for all the three levels. The formulae are as follows:

zmf: Z-shaped built-in membership function (zmf) is used to define the variable **low**. The weight is calculated by the following formula:

$$f(x;0,0.5)=\begin{Bmatrix} 1, x\le 0 \\ 1-2\left(\frac{x-0}{0.5-0}\right)^2, 0\le x\le \frac{0+0.5}{2} \\ 2\left(\frac{x-0.5}{0.5-0}\right)^2, \frac{0+0.5}{2}\le x\le 0.5 \\ 0, x\ge 0.5 \end{Bmatrix}$$

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gaussmf: Gaussian curve built-in membership function is used to define the variable med. The weight is calculated by the following formula:

$$f\left(x;0.2123,0.5\right)=e^{\frac{-(x-0.5)^2}{2(0.2123)^2}}$$

smf: S-shaped built-in membership function is defined by using variable high. The weight is calculated by the following formula:

$$f(x;a,b)=\begin{Bmatrix}0, x\le 0.5\\ 2\left(\frac{x-0.5}{1-0.5}\right)^2, 0.5\le x\le\frac{0.5+1}{2}\\ 1-2\left(\frac{x-1}{1-0.5}\right)^2, \frac{0.5+1}{2}\le x\le 1\\ 1, x\ge 1\end{Bmatrix}$$

In Event 1, the **Runs Scored** has a direct impact on **Ranking**. Ranking is an output variable which has five levels: very low, low, neutral, high and very high. All these five levels are defined by the membership function trimf.

trimf: Triangular-shaped built-in membership function is defined by using variable ranking. The weight is calculated by the following formula:

$$f(x;a,b,c)=\begin{Bmatrix}0, & x\le a\\ \frac{x-a}{b-a}, & a\le x\le b\\ \frac{c-x}{c-b}, & b\le x\le c\\ 0, & c\le x\end{Bmatrix}$$

Table 3 shows the values of a, b & c for all five variable.

Paramters	a	b	c

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Very Low	-0.25	0	0.25
Low	0	0.25	0.5
Neutral	0.25	0.5	0.75
High	0.5	0.75	1
Very High	0.75	1	1.25

Table 3: Values of a, b & c

3.3 Fuzzy Cognitive Map (FCM) Chart

The proposed FCM model consists of concepts and the various casual relationships that exist between concepts. In our model, we have taken 8 concepts that describe the behavioural characteristics of the system and these are the factors that affect the performance of a player. The signed weighted arcs represent the relationship between concepts. Fig. 1 given below graphically shows that which relationship they are related and to what degree.

There are three types of relationships between the concepts that express the type of influence from one concept to the other. The concepts are represented by C_1, C_2, C_3, C_4, C_5, C_6, C_7 and C_8.

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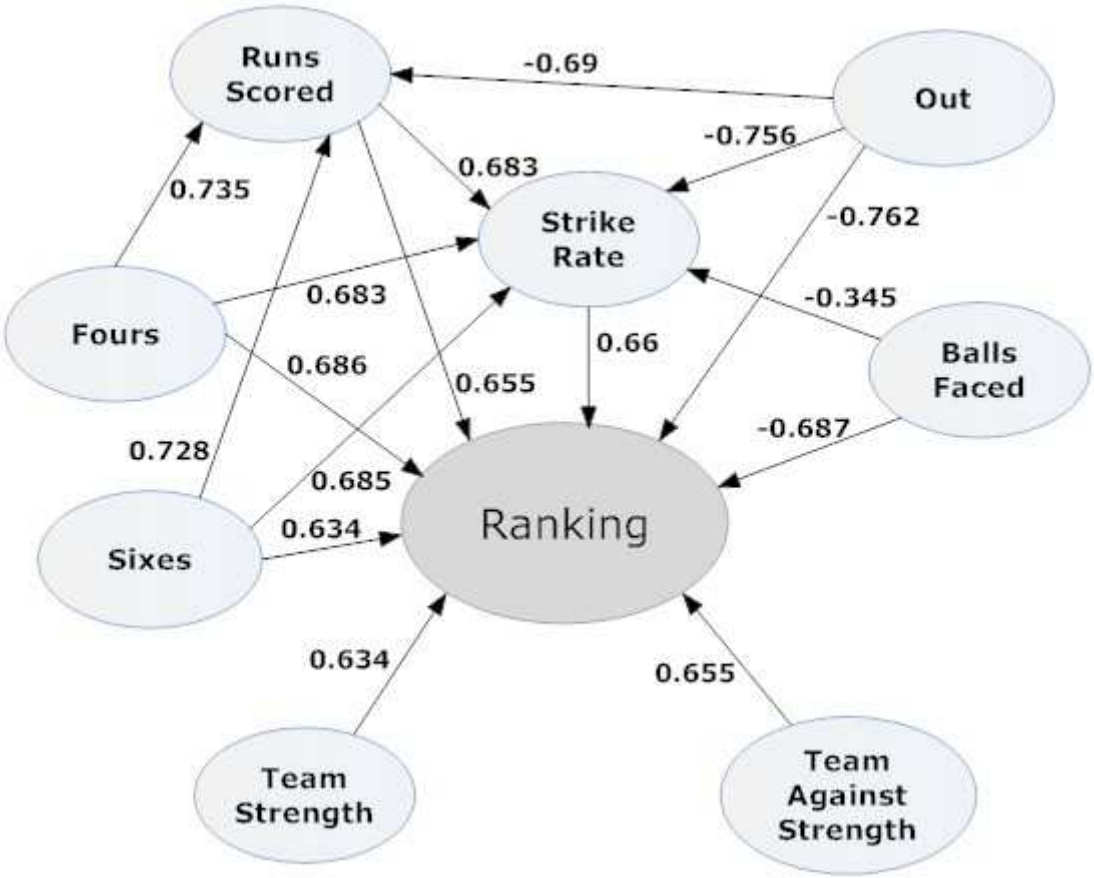

Fig. 1: FCM of Player Performance Evaluator

1. The weight of an arc between concept C_i and concept C_j is **positive** (value 1) if increase (or decrease) in one concept leads to increase (or decrease) in another, (means that an increase in the value of concept C_i leads to the increase of the value of concept C_j, and a decrease in the value of concept C_i leads to the decrease of the value of concept C_j). That means, positive edges represent casual increase.

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2. The weight of the arc between concept C_i and concept C_j is **negative** (value -1) if increase (or decrease) in one concept leads to decrease (increase) in another, (means that an increase in the value of concept C_i leads to the decrease of the value of concept C_j, and a decrease in the value of concept C_i leads to the increase of the value of concept C_j). That means, negative edges represent casual decrease.
3. If no relation exists between the two concepts, then value 0 is given.

3.4 Weight Matrix

Table 3 shows the matrix of concepts and weights. Weight matrix gathers the weights of the interconnections between the concepts of the FCM. The matrix has nine rows and nine columns. The values shown in the matrix is the weights calculated for each event. Each event (connection between concepts) has assigned a weight which ranges between [-1, 1]. For example: The numeric value calculated for runs scored towards strike rate is 0.623, The numeric value calculated for runs scored towards ranking is 0.55 and so on.

		C1	C2	C3	C4	C5	C6	C7	C8	C9
Runs Scored	**C1**	0	0.683	0	0	0	0	0	0	0.655
Strike Rate	**C2**	0	0	0	0	0	0	0	0	0.66
Balls Faced	**C3**	0	-0.345	0	0	0	0	0	0	-0.687
Out	**C4**	-0.69	-0.756	0	0	0	0	0	0	-0.762
Fours	**C5**	0.735	0.683	0	0	0	0	0	0	0.686
Sixes	**C6**	0.728	0.685	0	0	0	0	0	0	0.634
Team Strength	**C7**	0	0	0	0	0	0	0	0	0.634
TAS*	**C8**	0	0	0	0	0	0	0	0	0.655
Ranking	**C9**	0	0	0	0	0	0	0	0	0

*TAS = Team Against Strength

Table 3: Weight Matrix

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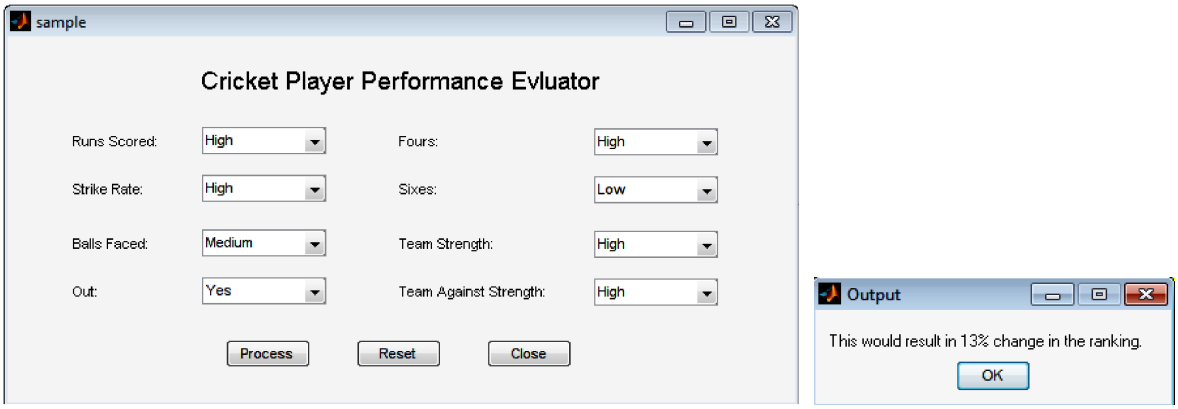
4. Result Analysis

We took three different hypothetical scenarios.

Scenario 1: A player of a high rated team plays against a high rated team too. He scores high amount of runs facing medium balls. Hence, he has a high strike rate. He struck high number of fours and low number of sixes before getting out. All these parameters are entered into the performance evaluator developed in MatLab, shown in Fig. 2 (a).



(a) (b)

Fig. 2: (a): Parameters entered into performance evaluator based on scenario 1. **(b)** Output of scenario 1.

The output of this scenario shows that it affects his ranking by 13%, as shown in Fig. 2 (b).

Scenario 2: The same performance, as in scenario 1, is made by a player of a weak team. The parameters entered are shown in Fig. 3 (a).

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(a) (b)

Fig. 3: (a): Parameters entered into performance evaluator based on scenario 2. **(b)** Output of scenario 2.

The output shows that it must impact his ranking by 19%, as shown in Fig. 3 (b).

Scenario 3: The same player, as in scenario 2, gives same performance but faces low number of balls. The parameters entered are shown in Fig. 4 (a).

(a) (b)

Fig. 4: (a): Parameters entered into performance evaluator based on scenario 3. **(b)** Output of scenario 3.

The output shows that his performance must be counted even better and must affect his ranking by 24%, as shown in Fig. 4 (b).

5. Conclusion

This paper demonstrates the evaluation of cricket player's batting performance and the impact of his performance on his ICC ranking. To perform the evaluation, first a FCM chart is developed which takes into account all the parameters, called concepts, which affect the ranking of a player. Then, a weighted matrix is generated from this FCM chart that shows the amount of impact of one concept on another. Finally, three different scenarios of batting performance are hypothetically assumed, which calculates the change of percentage in his ranking.

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