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Finding Kicking Range of Sepak Takraw Game: A Fuzzy Logic Approach

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Abstract

This paper presents a method to find kicking range of sepak takraw game when player kicks back the ball to the other team. This research works considered how fuzzy logic can be applied for the sepak takraw game - for addressing uncertainty in kicking range of the ball. Six different conditions are described. This research has chosen Tsukamoto's fuzzy reasoning scheme, because the individual rule outputs are crisp numbers, and therefore, the functional relationship between the input vector and the system output can be relatively easily identified. The result reveals that the farthest range of the ball coming to the other team in condition 1 obtained range 10.1% of far, condition 2 obtained range 10.23% of very far, condition 3 obtained range 10.16% of very far, condition 4 obtained range 10.03% of far, condition 5 obtained range 10.28% of far, and condition 6 obtained range 10.42% of far.

Keywords: *sepak takraw; fuzzy logic; Tsukamoto method; kicking range*

1. Introduction

Sepak takraw or kick volleyball is a sport native to Southeast Asia, resembling volleyball, except that it uses a rattan ball and only allows players to use their feet and head to touch the ball. A cross between football and volleyball, it is a popular sport in Thailand, Cambodia, Malaysia, Laos, Philippines and Indonesia. The strategies in Sepak takraw are also very similar to those in volleyball. The receiving team will attempt to play the takraw ball towards the front of the net, making the best use of their 3 hits, to set and spike the ball [1]. Some research related with kicks and sepak takraw have been developed which were the study to identify differences in kicking kinematics between the kuda and sila service techniques [2], data's researcher showed that angular velocity pattern between both techniques were comparable with no significant difference observed for the thigh, shank and foot angular velocities at ball-contact. Samuel et al. [3] introduced an approach to enable humanoid soccer robots to execute kicks quickly and ensure that they move the ball down field, this paper presents a kick engine capable of kicking at a variety of distances and angles and then describes a kick decision method for selecting from among a large set of possible kicks. This method prunes and orders the kicks according to a metric and then chooses the first possible kick that ensures that their field position is improved. Currently, the use of Fuzzy Logic is widespread and also numerous system have been developed for the sports [4], [5], [6], [7], [8], [9]. This research has chosen Tsukamoto's fuzzy reasoning scheme, because the individual rule outputs are crisp numbers, and therefore, the functional relationship between the input vector and the system output can be relatively easily identified.

2. Schematic Representation of Sepak Takraw Game

Sepak takraw is a highly complex net-barrier kicking sport that involves dazzling displays of quick reflexes, acrobatic twists, turns and swerves of the agile human body. The rules of the game allow players to make contact to the ball up to three consecutive times per side [1]. Figure 1 shows a schematic representation of sepak takraw game. A match is played by two regus, each

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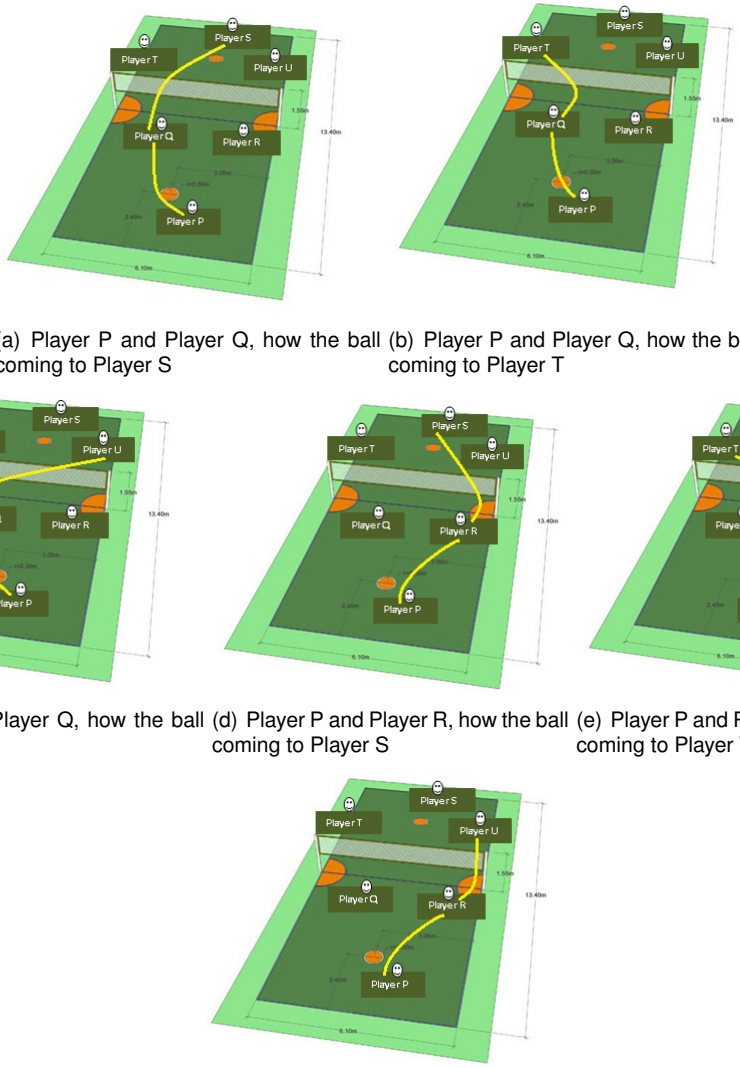
consisting of three players. One of the three players shall be at the back and the player is called a ”Tekong” which include Player P and Player S. The other two players shall be in front, one on the left and the other on the right which include Player Q, Player R, Player T and Player U. The player on the left is called a ”Left Inside” and the player on the right is called a ”Right Inside”. Area of 13.4 m x 6.1 m free from all obstacles up to the height of 8 m measured from the floor surface. The width of the lines bounding the court should not be more than 0.04 m measured and drawn inwards from the edge of the court measurements. All the boundary lines should be drawn at least 3.0 m away from all obstacles. The Centre line of 0.02 m should be drawn equally dividing the right and left court. At the corner of each at the Centre Line, the quarter circle shall be drawn from the sideline to the Centre Line with a radius of 0.9 m measured and drawn outwards from the edge of the 0.9 m radius.



(a) Player P and Player Q, how the ball coming to Player S

(b) Player P and Player Q, how the ball coming to Player T

(c) Player P and Player Q, how the ball coming to Player U

(d) Player P and Player R, how the ball coming to Player S

(e) Player P and Player R, how the ball coming to Player T

(f) Player P and Player R, how the ball coming to Player U

Figure 1. Schematic representation of sepak takraw game

Figure 1(a) shows schematic representation of sepak takraw game from Player P and Player Q with reference to how the ball coming to Player S. Figure 1(b) shows schematic representation of sepak takraw game from Player P and Player Q with reference to how the ball coming

to Player T. Figure 1(c) shows schematic representation of sepak takraw game from Player P and Player Q with reference to how the ball coming to Player U. Figure 1(d) shows schematic representation of sepak takraw game from Player P and Player R with reference to how the ball coming to Player S. Figure 1(e) shows schematic representation of sepak takraw game from Player P and Player R with reference to how the ball coming to Player T. Figure 1(f) shows schematic representation of sepak takraw game from Player P and Player R with reference to how the ball coming to Player U.

3. Using Fuzzy Logic in Sepak Takraw Game

Professor L.A. Zadeh introduced the concept of Fuzzy Logic [10], Tsukamoto Fuzzy reasoning are models based on Fuzzy Logic [11]. These rules are easy to learn and use and can be modified according to the situation. It helps to make decisions and can be used in decision analysis. Tsukamoto Fuzzy reasoning does mapping from given input to an output using Fuzzy Logic. Figure 2 shows Tsukamoto model of Fuzzy inference. Tsukamoto Fuzzy reasoning has a number of rules based on $if - then$ conditions. In this method, the consequence of each Fuzzy rule is represented by a Fuzzy set with a monotonic membership function. The rule base has the form as: R_i: if u is A_i and v is B_i, then w is C_i, i = 1, 2, , n. Where μC_i (w) is a monotonic function. As a result, the inferred output of each rule is defined as a crisp value induced by the rules matching degree (firing strength). The overall output is taken as the weighted average of each rules output. Suppose, that the set C_i has a monotonic membership function μC_i (w) and that α_i is the matching degree of its rule. For the Fuzzy set input (A', B') is given by the equation 1:

$$\alpha_i = min[\max_u(\mu_{A'}(u) \wedge \mu_{A_i}(u), \max_v(\mu_{B'}(v) \wedge \mu_{B_i}(v))] \quad (1)$$

In this case, **IF** Player P is SERVE VERY NEAR **AND** Player Q is KICKING VERY FAR, **THEN** the ball should be [COMING RIGHT ON Player S]

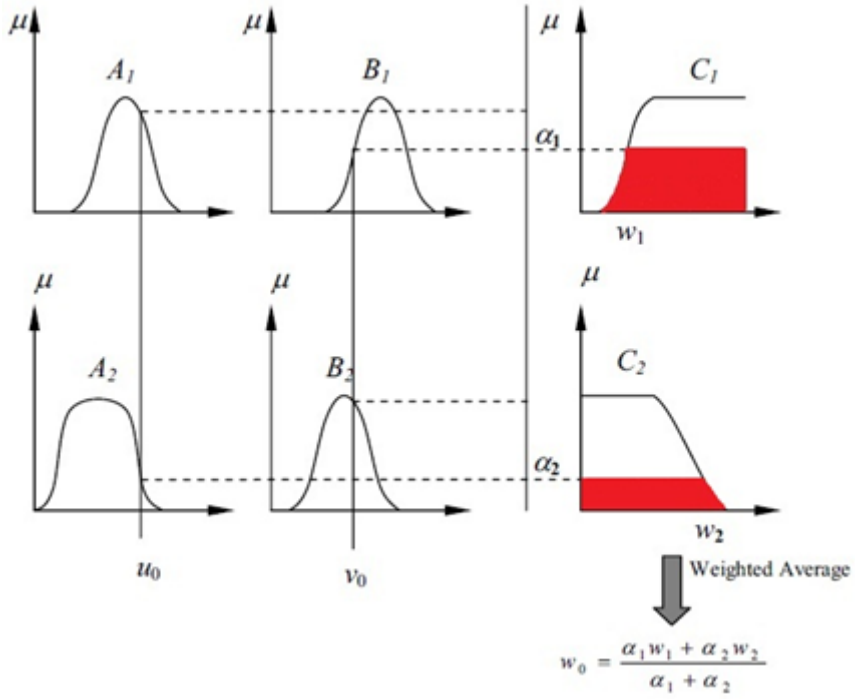


Figure 2. Tsukamoto model of Fuzzy Inference

A linguistic variable is a variable whose values can be expressed by means of natural

language terms [12], [13], [14]. The different terms or linguistic values are represented by Fuzzy sets characterised by membership functions defined on the universe of discourse. Linguistic variables to find kicking range of sepak takraw game are shown in Table 1.

Table 1. Linguistic variables

Player P serve	Very Near (PSVN)	Near (PSN)	Right On (PSRO)	Far (PSF)	Very Far (PSVF)
Player Q Kicking	Very Near (QKVN)	Near (QKN)	Right On (QKRO)	Far (QKF)	Very Far (QKVF)
Player R Kicking	Very Near (RKVN)	Near (RKN)	Right On (RKRO)	Far (RKF)	Very Far (RKVF)
Coming to Player S	Very Near (CVNS)	Near (CNS)	Right On (CROS)	Far (CFS)	Very Far (CVFS)
Coming to Player T	Very Near (CVNT)	Near (CNT)	Right On (CROT)	Far (CFT)	Very Far (CVFT)
Coming to Player U	Very Near (CVNU)	Near (CNU)	Right On (CROU)	Far (CFU)	Very Far (CVFU)

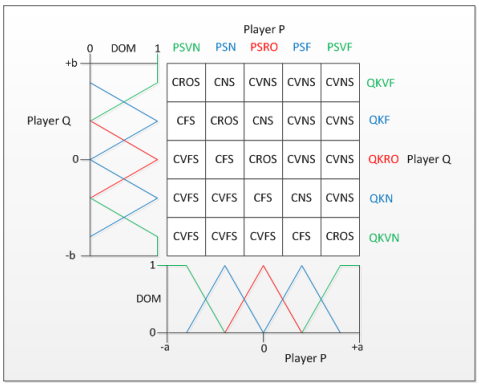
Table 2 shows kicking range for inputs to find kicking range of sepak takraw game. Condition 1 is Player P and Player Q, how the ball coming to Player S; Condition 2 is Player P and Player Q, how the ball coming to Player T; Condition 3 is Player P and Player Q, how the ball coming to Player U; Condition 4 is Player P and Player R, how the ball coming to Player S; Condition 5 is Player P and Player R, how the ball coming to Player T; Condition 6 is Player P and Player R, how the ball coming to Player U;

Table 2. Kicking range for inputs to find kicking range of sepak takraw game

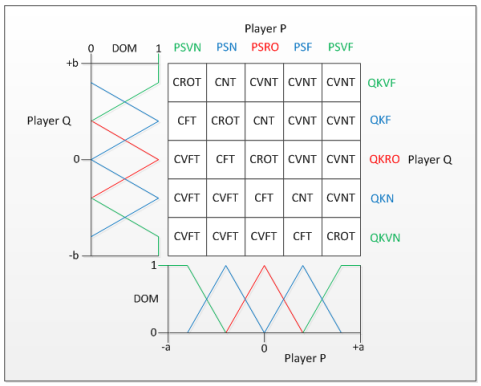
Condition	Action	Range				
		Very Near	*Near*	*Right On*	*Far*	*Very Far*
Condition 1	Player P serve	3.50	4.50	6.00	5.50	7.00
	Player Q kicking	1.50	2.50	4.50	5.00	8.00
Condition 2	Player P serve	3.20	4.10	5.20	6.60	6.70
	Player Q kicking	1.00	1.50	3.50	7.60	7.70
Condition 3	Player P serve	3.40	4.20	5.40	6.80	7.20
	Player Q kicking	1.30	1.75	3.90	7.70	7.90
Condition 4	Player P serve	3.70	4.30	5.60	6.90	7.20
	Player R kicking	1.70	2.20	4.20	3.50	8.30
Condition 5	Player P serve	3.80	4.70	5.80	7.30	7.60
	Player R kicking	1.90	2.70	5.50	4.50	8.50
Condition 6	Player P serve	3.90	4.80	6.30	7.40	7.90
	Player R kicking	2.20	2.90	6.90	5.50	8.70

The matrix on Figure 3 presents a group of 25 Fuzzy rules that associate Player P and Player Q with reference to how Player S should be changed. The matrix on figure 3(a) presents a group of 25 Fuzzy rules that associate Player P and Player Q with reference to how the ball coming to Player S should be changed. For example, the rule would be read as: **IF** Player P is [SERVE VERY NEAR] **AND** Player Q is [KICKING VERY FAR], **THEN** the ball should be [COMING RIGHT ON Player S]. The matrix on figure 3(b) presents a group of 25 Fuzzy rules that associate Player P and Player Q with reference to how the ball coming to Player T should be changed. The matrix on figure 3(c) presents a group of 25 Fuzzy rules that associate Player P and Player Q with reference to how the ball coming to Player U should be changed. The matrix on figure 3(d) presents a group of 25 Fuzzy rules that associate Player P and Player R with reference to how the ball coming

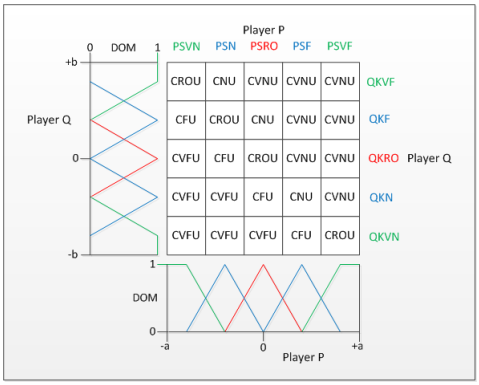
to Player S should be changed. The matrix on figure 3(e) presents a group of 25 Fuzzy rules that associate Player P and Player R with reference to how the ball coming to Player T should be changed. The matrix on figure 3(f) presents a group of 25 Fuzzy rules that associate Player P and Player R with reference to how the ball coming to Player U should be changed.



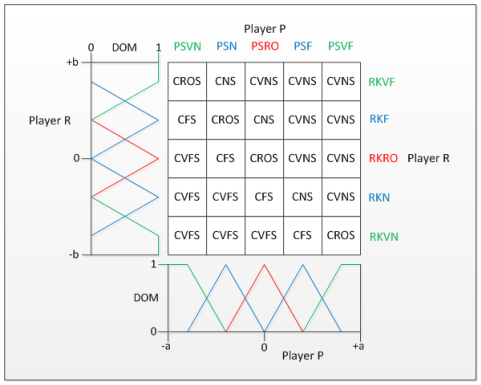
(a) Rule matrix of Fuzzy rules between Player P and Player Q, how the ball coming to Player S



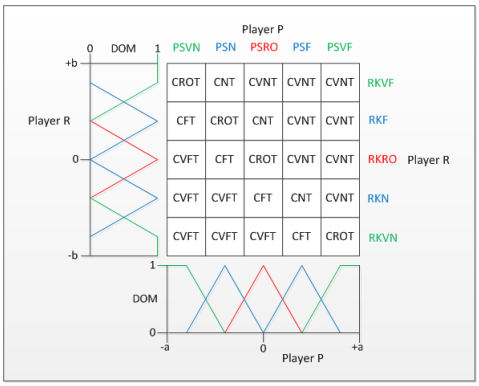
(b) Rule matrix of Fuzzy rules between Player P and Player Q, how the ball coming to Player T



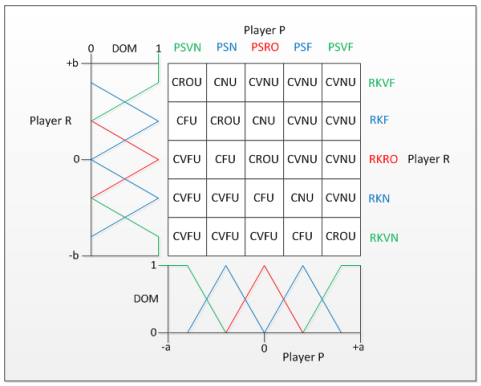
(c) Rule matrix of Fuzzy rules between Player P and Player Q, how the ball coming to Player U



(d) Rule matrix of Fuzzy rules between Player P and Player R, how the ball coming to Player S



(e) Rule matrix of Fuzzy rules between Player P and Player R, how the ball coming to Player T



(f) Rule matrix of Fuzzy rules between Player P and Player R, how the ball coming to Player U

Figure 3. Rule matrix of Fuzzy rules

When a game begins by one serve, a ball can be touched by the attack of one time to three times. The player can use a head, a back, legs, and anywhere except for the arm from the shoulder to the point of the finger. Assume that player position and kicking range in the be-

ginning of sepak takraw game can be defined as follows: Player $P_{\text{very near}}$ = 3; Player P_{near} = 4; Player $P_{\text{right on}}$ = 5; Player P_{far} = 6.5; Player $P_{\text{very far}}$ = 7.5. Player $Q_{\text{very near}}$ = 1; Player Q_{near} = 2; Player $Q_{\text{right on}}$ = 3; Player Q_{far} = 7.5; Player $Q_{\text{very far}}$ = 8.5. Player $S_{\text{very near}}$ = 3.5; Player S_{near} = 4.5; Player $S_{\text{right on}}$ = 5.5; Player S_{far} = 9.5; Player $S_{\text{very far}}$ = 10.5

Player $S_{\text{very near}}$ is used to define the variable very near. The weight is calculated by the following formula:

$$\mu(\text{Player } S_{\text{very near}}[w]) = \begin{cases} 1, & w \leq 3.5 \\ \frac{4.5-w}{4.5-3.5}, & 3.5 \leq w \leq 4.5 \\ 0, & w \geq 4.5 \end{cases} \quad (2)$$

Player S_{near} is used to define the variable near. The weight is calculated by the following formula:

$$\mu(\text{Player } S_{\text{near}}[w]) = \begin{cases} 0, & w \leq 3.5 \text{ or } w \geq 5.5 \\ \frac{w-3.5}{4.5-3.5}, & 3.5 \leq w \leq 4.5 \\ \frac{5.5-w}{5.5-4.5}, & 4.5 \leq w \leq 5.5 \end{cases} \quad (3)$$

Player $S_{\text{right on}}$ is used to define the variable right on. The weight is calculated by the following formula:

$$\mu(\text{Player } S_{\text{right on}}[w]) = \begin{cases} 0, & w \leq 4.5 \text{ or } w \geq 9.5 \\ \frac{w-4.5}{5.5-4.5}, & 4.5 \leq w \leq 5.5 \\ \frac{9.5-w}{9.5-5.5}, & 5.5 \leq w \leq 9.5 \end{cases} \quad (4)$$

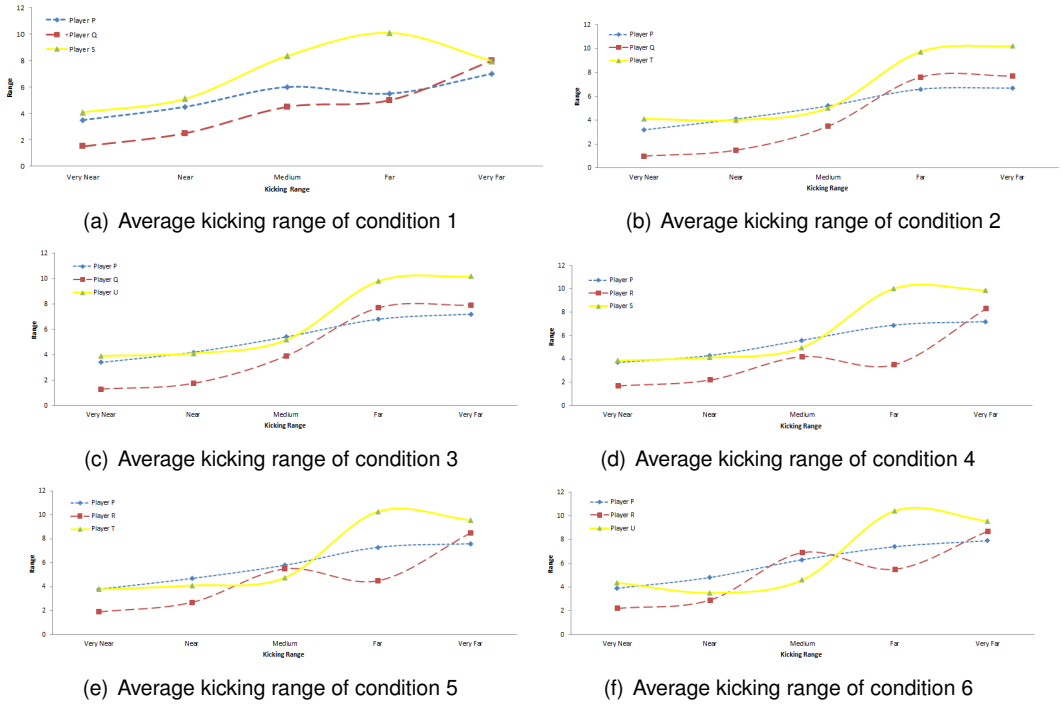
Player S_{far} is used to define the variable far. The weight is calculated by the following formula:

$$\mu(\text{Player } S_{\text{far}}[w]) = \begin{cases} 0, & w \leq 5.5 \text{ or } w \geq 10.5 \\ \frac{w-5.5}{9.5-5.5}, & 5.5 \leq w \leq 9.5 \\ \frac{10.5-w}{10.5-9.5}, & 9.5 \leq w \leq 10.5 \end{cases} \quad (5)$$

Player $S_{\text{very far}}$ is used to define the variable very far. The weight is calculated by the following formula:

$$\mu(\text{Player } S_{\text{very far}}[w]) = \begin{cases} 0, & w \leq 9.5 \\ \frac{w-9.5}{10.5-9.5}, & 9.5 \leq w \leq 10.5 \\ 1, & w \geq 10.5 \end{cases} \quad (6)$$

During the Sepak takraw game, both teams will make different powerful moves to kick and spike the ball to go to the opponent side and fall within the boundary line of the court, players try to play the ball toward the front of the net, making the best use of their three hits to pass, set and spike. Figure 4 shows average kicking range. Figure 5 shows kicking range of the ball coming to the other team. The ball coming to player S in condition 1 obtained range 4.09 of very near, 5.11 of near, 8.36 of medium, 10.1 of high, 7.97 of very high. Condition 2 obtained range 4.13 of very near, 4.02 of near, 5.04 of medium, 9.73 of high, 10.23 of very high. Condition 3 obtained range 3.91 of very near, 4.11 of near, 5.16 of medium, 9.79 of high, 10.16 of very high. Condition 4 obtained range 3.86 of very near, 4.13 of near, 4.98 of medium, 10.03 of high, 9.87 of very high. Condition 5 obtained range 3.78 of very near, 4.11 of near, 4.76 of medium, 10.28 of high, 9.57 of very high. Condition 6 obtained range 4.36 of very near, 3.51 of near, 4.61 of medium, 10.42 of high, 9.55 of very high.



(a) Average kicking range of condition 1

(b) Average kicking range of condition 2

(c) Average kicking range of condition 3

(d) Average kicking range of condition 4

(e) Average kicking range of condition 5

(f) Average kicking range of condition 6

Figure 4. Average kicking range

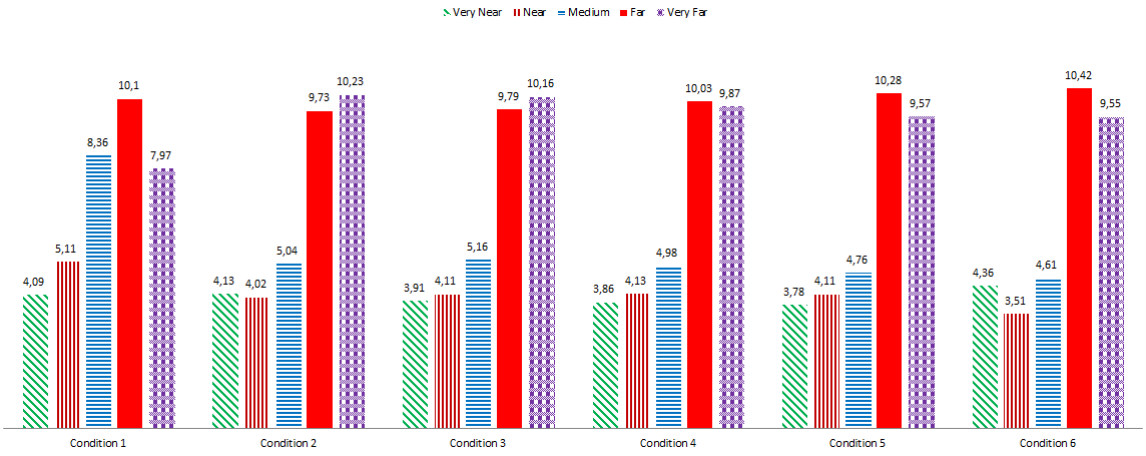


Figure 5. Range of the ball coming to the other team

4. Conclusion

This research has described a method to find kicking range of sepak takraw game using Tsukamoto's Fuzzy reasoning. To serve, one player stands in the right semi-circle on their side of the court. The player throws the ball to the server, who stands in the circle on their side of the court. The player kicks the ball up and over the net then opponent player kicks back the ball. The vagueness present in the definition of terms is consistent with the information contained in the conditional rules. Even though the set of linguistic variables and their meanings is compatible and consistent with the set of conditional rules used, the overall outcome of the qualitative process is translated into objective and quantifiable results. Fuzzy mathematical tools and the calculus

of Fuzzy IF-THEN rules provide a most useful paradigm for the automation and implementation of an extensive body of human knowledge heretofore not embodied in the quantitative modelling process. These mathematical tools provide a means of sharing, communicating, and transferring this human subjective knowledge of systems and processes. The result reveals that the farthest range of the ball coming to the other team in condition 1 obtained range 10.1% of far, condition 2 obtained range 10.23% of very far, condition 3 obtained range 10.16% of very far, condition 4 obtained range 10.03% of far, condition 5 obtained range 10.28% of far, and condition 6 obtained range 10.42% of far. The farthest range in condition 6 (10.42%), followed by Condition 5 (10.28%), condition 2 (10.23%), condition 3 (10.16%) and condition 1 (10.1%).

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