Offense/Defense Decision-Making Controller for a Billiard Robot

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***Abstract* - The objective of this research is to develop a defense/offense decision-making controller for a billiard robot by using Fuzzy and Extension theory. The main purpose is to make the billiard robot possess the imitation ability of how human beings do the defense/offense decision-making in a block ball game. The offense cushion shot means to pocket the object ball. After hitting the table rail, the defense strategy is developed by four conditions which are the distance between the cue ball and the object ball, distance between the object ball and the corresponding pocket, the angles between the cue ball, the object ball and the corresponding pocket, and the information of the block ball. In addition to the four parameters, it must be considered whether the cue ball or the object ball contacts the rail of the table after the cue ball strikes the object ball. Finally, the billiard robot will execute the hitting command to let the cue ball strike the object ball and make an offense or defense shot in the experiments.**

***Keywords* - decision-making controller, Fuzzy theory, Extension theory, billiard robot**

I. INTRODUCTION

Billiard is one of the popular sports on the world. In literature about the relevant of billiard robots, Mr. Hiroki Tokashiki investigated the strike mechanism of the billiard robot [1]. It was similar to a xyz platform. Michael Greenspan proposed a study of billiard robot automatic strike system in the billiard table[2]. He used a computer to simulate the offense and defense of billiard robot. Jr-Syu Yang built up a strike ball mechanism of billiard robot, and combines image processing which can search the position of the ball. His research team completed an analysis for the angle, shooting strength, by cue ball and four object balls, and judges the influence of the block ball[3~5].

II. CUSHION SKILL

The cushion shot means that the cue ball strikes the object ball after rebounding the table rail. The cushion skill is based on the mirror principle[5~7]. In figure 1, position C is the cue ball and position Z is the object ball. And positions Z_1, Z_2, Z_3 and Z_4 are the four mirror positions of Z with respect to the four rails. For example, if we want to make a cushion shot of object ball Z, then it is a possible choice for us to aim the point H first to make cue ball to contact H and rebound to strike the object ball Z.

III. EXPERIMENT

The experimental setup includes a machine vision subsystem, a decision-making controller(PC), a xyz platform and a pneumatic hitting mechanism(Fig. 2). If there is not a block ball on the route, the billiard robot will make a cushion defense shot decision by using the Extension theory[3].

(1) The offense/defense strategies(Fig. 3):

In the offense/defense controller, the billiard robot will use the CCD camera to take the pictures and calculate the center positions of the balls. Then the billiard robot uses the block ball detection to judge whether there is a block ball on the moving route of the cue ball. If there is not a block ball on the route, the billiard robot will make a straight line shot decision directly. If there is a block ball on the moving route of the cue ball, the billiard robot will make the cushion offense/defense decision. If it is able to pocket the object ball in the cushion-shot condition, the robot will make the cushion offense shot decision. And the offense/defense controller is designed based on the hitting angle(θ) and the travel length($L = \overline{CH} + \overline{OH}$) of the cue ball by using the Fuzzy theory (Fig. 4). The output of this controller is the executing command of offense or defense(Fig. 5).

(2) The defense strategies:

Four geometric factors of the billiard games are applied to develop the defense decision-making controller by using the Extension theory (Fig. 6). They are

(i) The distance between the object ball and the corresponding pocket(d_1).
(ii) The angles between the cue ball and the object ball(θ).
(iii) Distance between the cue ball and the object

ball(d_2).

(iv) The distance between the center of block ball and the moving route of the cue ball(d_b).

IV. RESULTS

In figure 7, the billiard robot makes a defense cushion shot in six different hitting strengths. The predicted travel routes are plotted together to make a comparison. The strength parameter of the best striking pattern of those six cases is chosen to be the candidate to make an experiment(Fig. 8). In this case, the cue ball is stroke to contact the upside rail(point A) and rebounded to hit the object ball(position B). Finally, point C* and O* are the predicted stop positions of the cue ball and the object ball respectively after this cushion shot (Fig. 8). It will become a difficult pool condition for the next shot. That means a safety play in the billiard game. The experimental result of this defense cushion shot is shown in figure 9. The white lines are the predicted travel routes of the cue ball and the object ball. The results indicate that the billiard robot is capable to implement a defense cushion shot.

V. CONCLUSION

There are three kinds of pool shooting patterns for the billiard robot in this paper. They are (1) direct straight-line offense shot, (2) offense cushion shot(or bank shot), and (3) defense cushion shot(safety play). Both simulated and experimental results are presented and compared in the discussion. The future research is to make this billiard robot possess more and more varied shooting ability, and be more similar to a human being to play pool games.

VI. REFERENCE:

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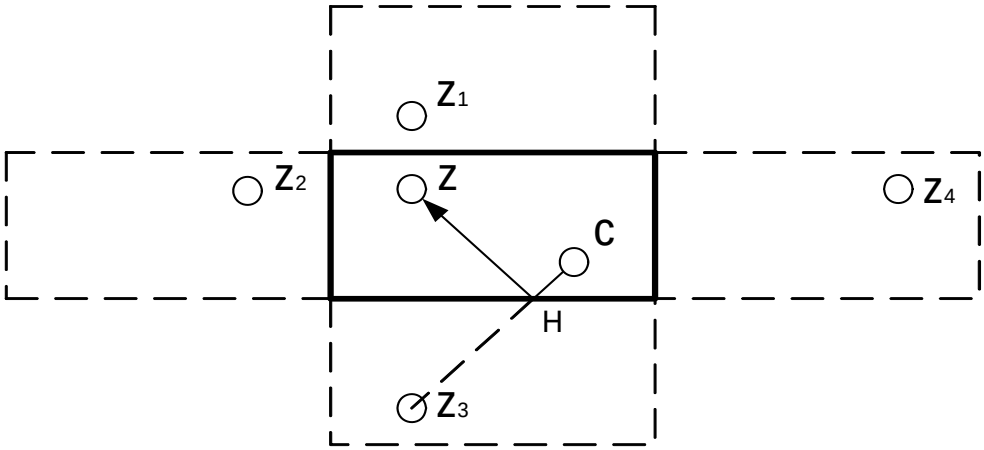

Fig.1 Mirror principle of the cushion shot

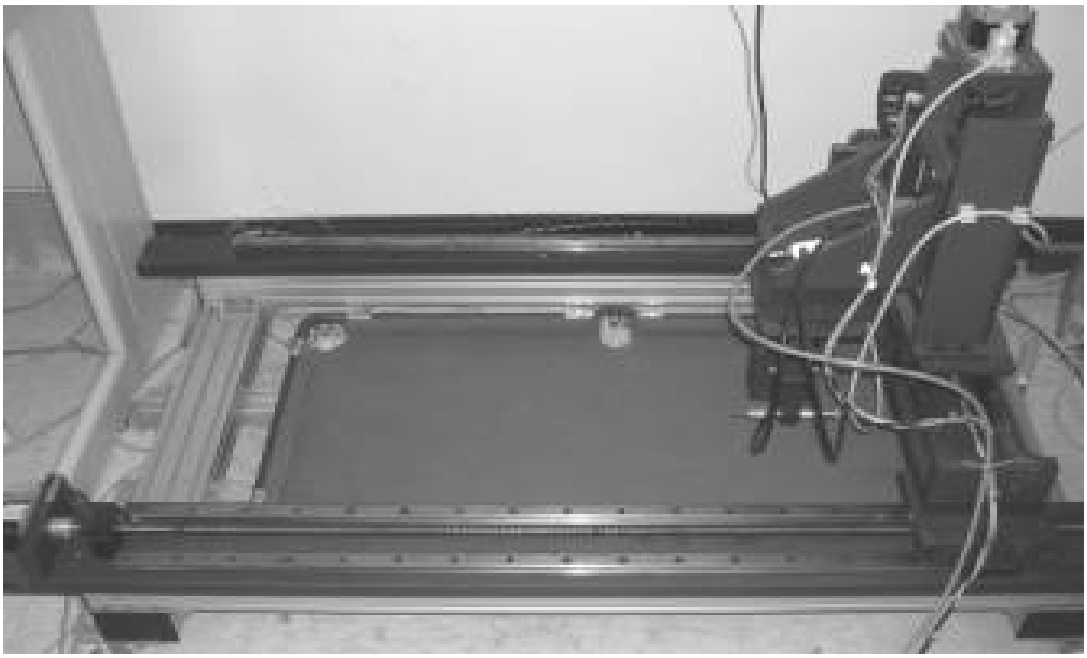

Fig.2. Billiard Robot

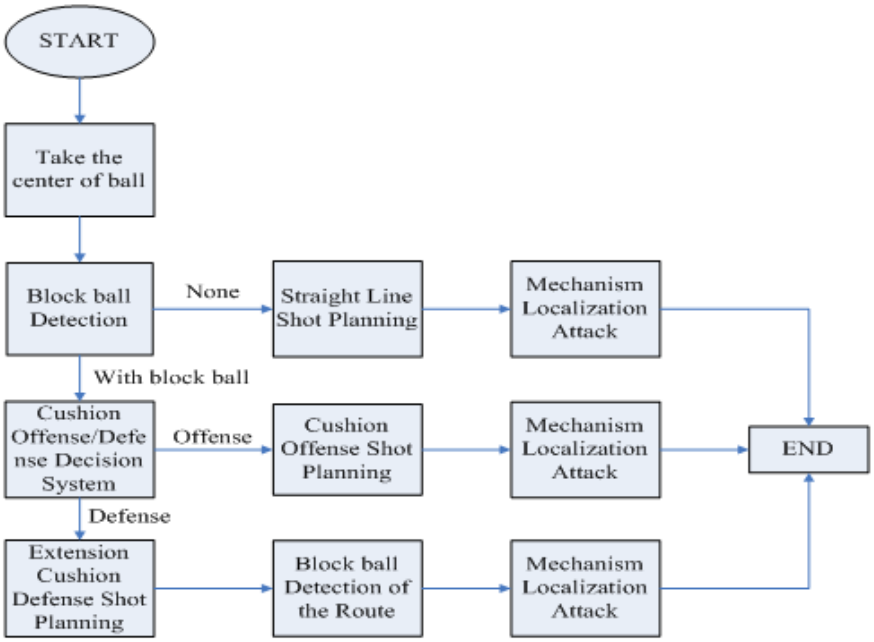

Fig.3. Flowchart of the offense/defense controller

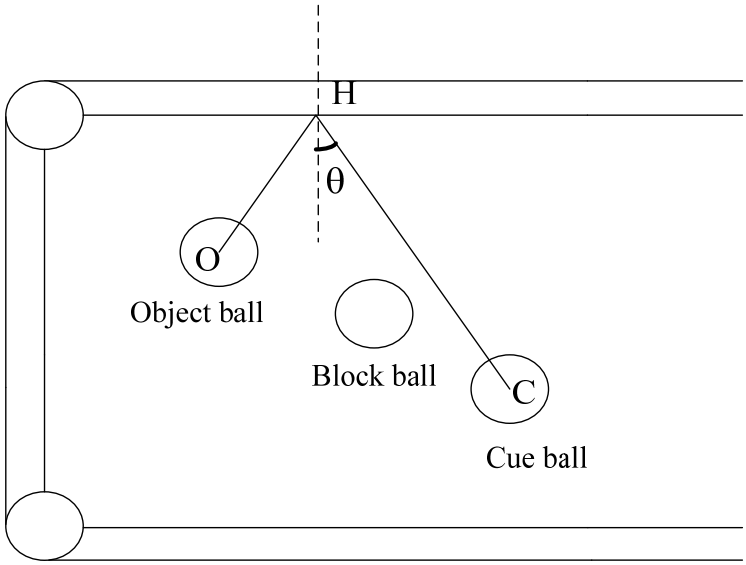

Fig.4. Cushion shot

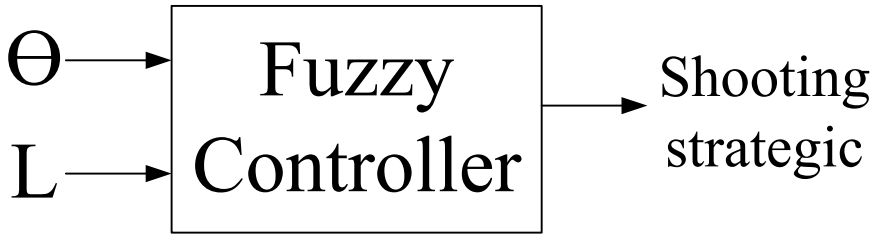

Fig.5. The input/output variable diagram of fuzzy controller

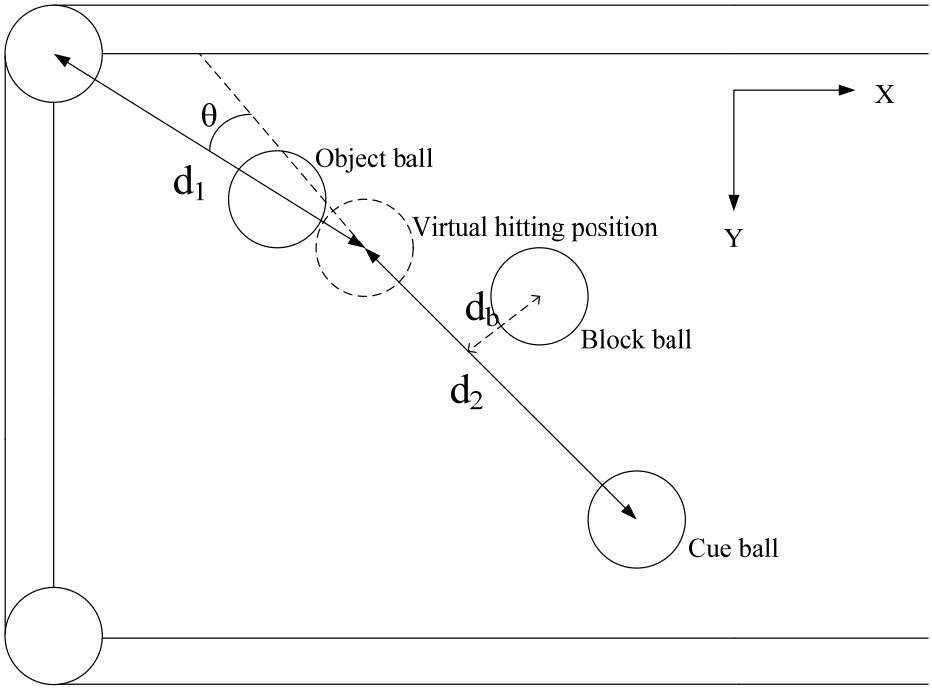

Fig.6 Geometric information of the pool balls