SICE Annual Conference 2008
August 20-22, 2008, The University Electro-Communications, Japan

Support System for Pocket Billiards

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Abstract: A support system for beginners of pocket billiards has been developed. The system exhibits all the guiding lines, which mean the directions to shoot the cue ball in order to sink any of the balls into a pocket, and helps the player to know the easiest shot to sink a ball. The player is also able to know if he/she has shot the cue ball in the correct direction using the image in which the trajectories of the balls are superimposed on the guiding line. A GUI helps the player to easily use the system.

Keywords: Pocket Billiards, Pool, Support, Image processing

1. INTRODUCTION

Pocket Billiards is a game to sink an object ball to one of six pockets. A player needs to acquire skills to decide the correct direction to shoot a cue ball. It is, however, difficult for beginners to decide the correct direction because it is hard to know if the direction which they decided was wrong or they failed to shoot the cue ball in the aiming direction. Our goal is to realize a support system for such beginners.

There are some related works which assist the players to improve their skills [1]-[4]. All of them exhibit guiding lines which instruct the players at which a cue ball should be shot. However, the errors in the ball positions detected from the image are large, about 6mm in case of [2], when the image is captured using a head-mounted video camera [1] or a camera held by a player [2].

This accuracy can be improved by using a camera set above the billiard table. Larsen developed a system which draws supporting information including a guiding line on the billiard table [3]. The system, however, needs a projector besides the camera, and the situations are limited to very simple situations where only a cue ball and a yellow ball are on the table. In the system developed by Shih [4], players are able to adjust the cue stick according to the guiding line. The system, however, requires the players to specify both the target pocket and the ball to be pocketed, which is not easy for beginners. And, in all the works [1]-[4], no trajectories of the balls are shown, as a result, it is hard for the player to know if he/she has shot a cue ball in the correct direction.

We realized a system to calculate and exhibit all the guiding lines to sink any of the balls except for the cue ball when the first target ball (the ball to be hit by the cue ball first) is specified. The player can know the easiest shot, which means the allowable error in the striking direction is the largest, using exhibited guiding lines. The system can also exhibit both the trajectories of the balls and the guiding line simultaneously, and the player can easily know if he/she has shot the cue ball correctly.

2. METHODS AND RESULTS

2.1 System configuration

The size of billiard table used is about 2/3 of the standard size. The diameter of the balls is 42mm. The image of the table is captured by a CCD camera (640x480 pixels) set above the table. The captured images are sent to a PC and processed.

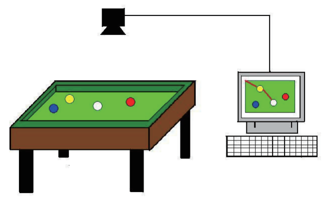


Fig. 1 System configulation.

2.2 Outline of the methods

Fig. 2 shows the outline of the methods.

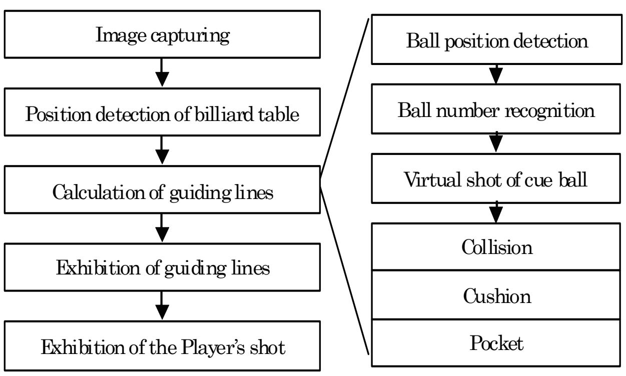


Fig. 2 Outline of the methods.

2.3 Correction of image distortion

The captured image contains lens distortion which degrades the accuracy of the ball position detection. First, the coefficients of lens distortion were estimated. Then, the image distortion is corrected using estimated coefficients. Fig. 3 shows an example of a corrected image.

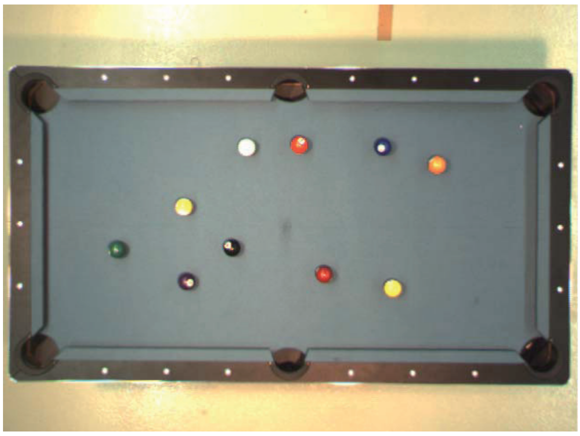


Fig. 3. An example of a distortion-corrected image

2.4 Position detection of billiard table

A circum-rectangle including the billiard table is extracted using the color difference between the background (floor) and the frame of the table. Fig. 4 shows the result of table extraction.

Next, the 18 diamonds (white circles) in the frame are extracted based on the color and shape information (Fig. 5). Using extracted positions of those diamonds, both x axis (red line) and y axis (blue line) are set as shown in Fig. 5, and image and actual coordinates of the billiard table are calibrated.

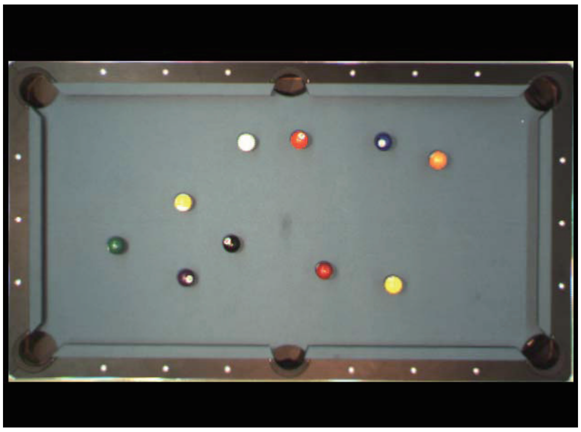


Fig. 4 Result of table extraction.

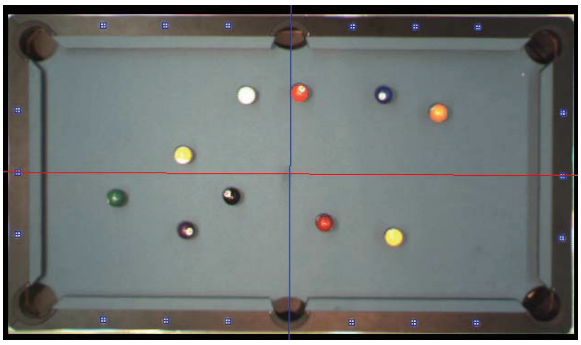


Fig. 5 Result of diamonds extraction and coordinates setting.

2.5 Ball position detection

The area of green cloth (background) is divided into patches, each patch is composed of 10 x 10 pixels. Then, the hue having the highest frequency in each patch is decided to be the hue of the patch. Fig. 6 shows the histogram of hues of all the patches. The hue of green cloth is automatically extracted as a range of hue having high frequency in the histogram. By removing the background (the pixels having the hue in the range) from the image, ball areas are extracted as shown in Fig. 7(b).

The position of each ball area is, then, calculated by a pattern matching using an ideal ball pattern as a template. The calculated ball position, however, has a deviation from the actual position on the table as shown in Fig. 8. This deviation (x') can be easily corrected based on the ball distance L from the center of the table (the camera position) because both the camera height (Z) and the ball diameter (r) are known. The corrected ball position is shown as a cross in Fig. 7(c).

An experiment was carried out to evaluate the accuracy of ball position detection. The average error of the ball positions was about 2.3mm on the table (about 5% of the ball diameter). This error, we think, is an acceptable level for the beginners.

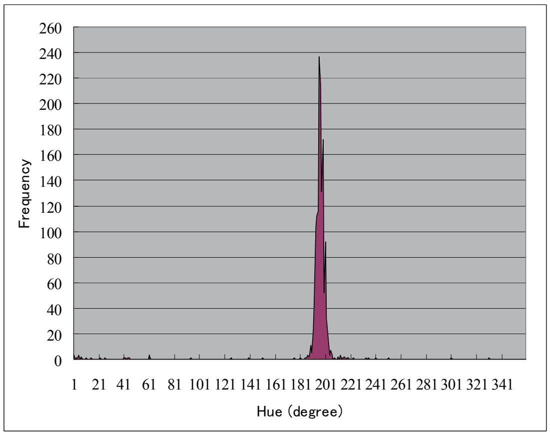
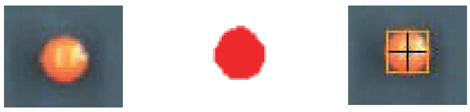


Fig. 6 Histogram of hue.



(a) (b) (c)

Fig. 7 An example of ball position detection.

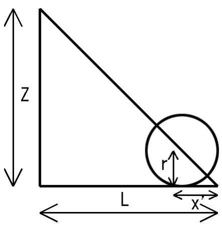


Fig. 8 The ball position in the image has a deviation from the position on the table.

2.6 Ball number recognition

The number (1-15 or cue ball) is recognized using the color information in each ball area.

An experiment to evaluate the accuracy was carried out using 50 images in which the balls are placed apart from each other. Fig. 9 shows an example of the number recognition. The average correct ration was about 99%.

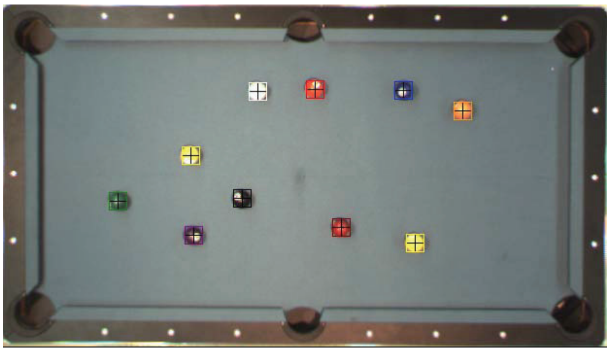


Fig. 9 Result of ball number recognition.

2.7 Cushion model

Fig. 2 shows the experimentally obtained relationship between the velocities of the ball before and after the cushion, where v_x and v_y denote the velocities parallel and perpendicular to the cushion, respectively. The velocity after the cushion (v'_x, v'_y) is assumed to obey the following equations.

$$v_y' = -0.5 \cdot v_y \qquad v_x' = 0.67 \cdot v_x \tag{1}$$

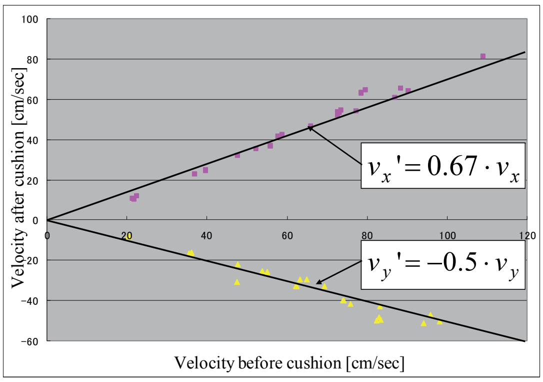


Fig. 10 Velocities before and after the cushion.

2.8 Collision model

The velocity after the collision (s_0', u_0') was also experimentally assumed to obey the following equation, where (s_0, u_0) is the velocity before the collision. s_0 and u_0 are the velocities to the direction parallel and perpendicular to the line between the centers of two balls, respectively. Suffix '0' and '1' denote each of two balls.

$$\begin{aligned} s_0' &= s_0 - 0.88(s_0 - s_1) \\ s_1' &= s_1 + 0.88(s_0 - s_1) \\ u_0' &= u_0, u_1' = u_1 \end{aligned} \tag{2}$$

2.9 Detection of pocket

Red lines in Fig. 11 show pocket detection lines. If the position of the ball is on or outside these lines, the ball is judged to be pocketed.

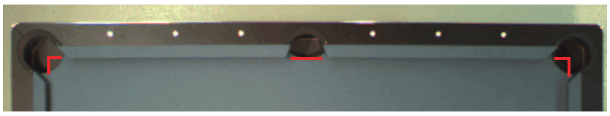


Fig. 11 Pocket detection lines.

2.10 Calculation of guiding lines

A cue ball is virtually shot in one direction with a predetermined velocity. The motions of all the balls are simulated according to the dynamics models such as collision and cushion models. If the cue ball hits the predetermined target ball first and any of the balls except for the cue ball sink into one of the pockets, we call the shot "the pocket shot", and the trajectories of the cue ball is shown as a guiding line.

Fig. 12 shows all the guiding lines where the cue ball is shot in all the directions with the angle resolution of 0.1deg. There are 11 guiding lines which hit the No.6 ball first and sink it into one of the pockets. If a mouse cursor is moved to near one of the guiding lines, a group of the guiding lines in which the ball is sunk into the same pocket is highlighted.

In Fig. 12, three guiding lines in which the ball is sunk into the upper right pocket are drawn as yellow lines. Fig. 13 shows another group of highlighted guiding lines in which the No.6 ball is sunk into the upper central pocket. In this case, the player can know cushion of the cue ball is necessary. Fig. 14 shows the guiding lines for the lower right pocket. In both Figs. 13 and 14, only two guiding lines are highlighted. So, the player can know the allowable deviation in shooting direction is smaller compared to the case of Fig. 12 (three guiding lines). By switching and observing the highlighted guiding lines, the player can easily know and select the easiest or the best shot.

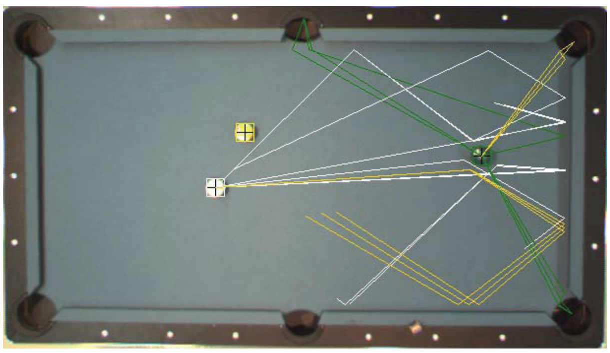


Fig. 12 Calculated guiding lines. The guiding lines for the upper right pocket are highlighted.

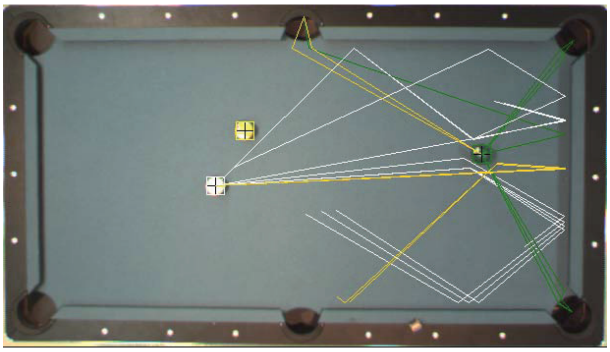


Fig. 13 The guiding lines for the upper center pocket are highlighted.

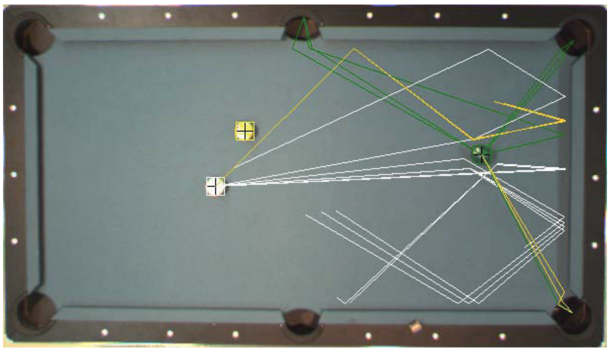


Fig. 14 The guiding lines for the lower right pocket are highlighted.

2.11 Exhibition of player's shot

The system has a function to display both the guiding line and the trajectories of the balls simultaneously as shown in Fig. 15. The player can easily know if the cue ball has been shot in the correct direction.

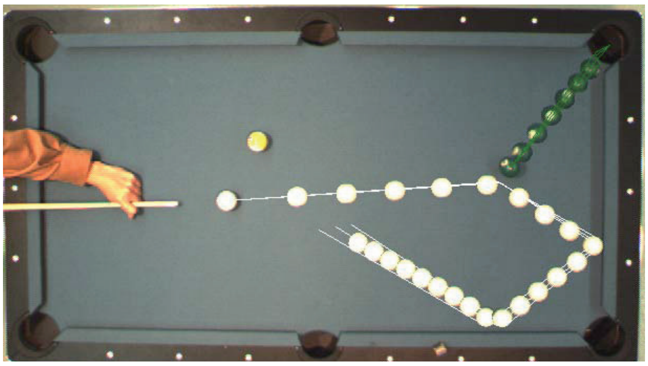


Fig. 15 Player's shot with a guiding line.

3. GRAPHICAL USER INTERFACE

A graphical user interface (GUI) was developed to help the player easily use the system. Fig. 16 shows an example of the GUI window. The player can specify any of the balls as the target ball by selecting one of the radio buttons in the right side of the window.

Fig. 16 An example of GUI window.

4. CONCLUSION

A support system for the beginners of pocket billiards has been developed. The system helps the player to know the easiest shot. Exhibition of the trajectories also helps the player to know if he/she has successfully shot the cue ball. All the functions are easily used using a GUI.

REFERENCES

[1] T. Jebara, C. Eyster, J. Weaver, T. Starner and A. Pentland, "Stochastics: Augmenting the billiards experience with probabilistic vision and wearable computers", *Proceedings of the International Symposium on Wearable Computers*, pp.138-145, 1997.

[2] H. Uchiyama and H. Saito, "AR Display of Visual Aids for Supporting Pool Games by Online Markerless Tracking", *17th International Conference on Artificial Reality and Telexistence*, pp.172-179, 2007.

[3] L. B. Larsen, R. B. Jensen, K. L. Jensen and S. Larsen, "Development of an automatic pool trainer", *Proceedings of the 2005 ACM SIGCHI International Conference on Advances in computer entertainment technology*, pp.83-87, 2005.

[4] C. Shih and W. C. Chu, "A Vision Based Interactive Billiard Ball Entertainment System", *The First IEEE International Workshop on Digital Game and Intelligent Toy Enhanced Learning*, pp.200-202, 2007.