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3—4 An Automatic Recording System of the Plays and Moves of SHOGI Games Using Image Processing Technique

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Abstract

This paper describes on a system which records the plays and moves of *SHOGI* games automatically by using image processing technique from the pictures captured with a digital video camera. We have considered the overall structure of the system, and the recognition of movements of a piece, "simple-move" (*ugoku*), "promoting" (*naru*), "dropping-move" (*utsu*), and "capture-move" (*toru*). This paper especially focuses on "promoting". We propose a simple method for recognizing "promoting" and an automatic determination method of thresholds for binarization utilizing characteristics peculiar to *SHOGI* for recognizing "promoting".

1. Introduction

Making records of the plays and moves of *SHOGI* games is performed by human labor. We aim at developing a real-time system which automatically records the plays and moves (*KIFU*) of *SHOGI* games by using image processing technique from the pictures captured with a digital video camera. We have been considering the overall structure of the system, and how to recognize each move of *SHOGI* pieces: "simple-move"*(ugoku)*, "promoting"(*naru*), "dropping-move"*(utsu)* and "capture-move"(*toru*). In order that we aim at a real-time recording system, a simple method is needed so that its computation cost may be small. This paper focuses on the "promoting"(naru), describing a simple method for determining thresholds for binarization that requires for the recognition of "promoting".

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There exist research for automatic recording system of *KIFU*[1]. However, no simple method dedicated for recognizing "promoting" is reported. And, to the best of our knowledge, no practical system for automatic recording system of *KIFU* of *SHOGI* exists yet.

The system appearance is shown in Fig. 1. This system captures the game with digital video camera. It detects the hands moving in and out of the *SYOGI* board to trigger the image processing for recording a move.

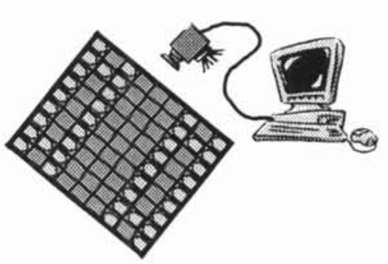


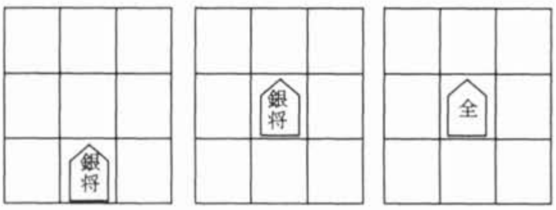
Fig. 1 System appearance

2. Recording the Plays and Moves

By binarizing a picture and checking out the black pixels of characters in each square inside which a *SHOGI* piece is placed, the system knows the existence of a *SHOGI* piece in it. By checking the existence of a piece in each square on the whole *SHOGI* board each time, the system can recognize a pair of squares before and after each move of a piece. And, the system knows the kind of piece, *Hohei* (Pawn), *Kyousya* (Lance), *Keima* (Knight), etc., in each square before each moving, because it has been tracing all the moves from the beginning and the initial layout of the pieces in this game is fixed. Therefore, it can record a *KIFU* (a record of a move) for a "simple-move" with this simple processing. However, the system cannot recognize the motions other than "simple-move" by this method.

3. Promoting ("*NARU*")

In the case of "promoting"(Fig. 2) which is accompanied by the special motion of turning over to its reverse side, it needs other technique for recognizing whether it is promoted or not. (In the *SHOGI* game, promoting or not is optional.)



(a) before move (b) simple-move (c) promoting

Fig. 2 Promoting

The recognition method for promoting or not by recognizing of the characters on a piece using general-purpose character recognition technique might be used. If this method was used, "promoting" might be recognized easily. However, because of low resolution of the obtained image, the characters of a piece spread (Fig. 3). Therefore, the computation cost might be high and, thereby, the creation of *KIFU* on real time would be impossible. We propose a simple technique for recognizing "promoting" by using the difference of the number of black pixels of the character between on the front side and on the reverse side of each piece.

Fig. 3 Characters on pieces

In this method, recognizing "promoting" is recognized with the difference of the number of black pixels of the character between before moving and after moving. If the number of black pixels after moving decreases greatly, it is recognized as the piece having turned to the reverse side, and recognized as "promoting". Otherwise, the piece is recognized that it continues being on front side, and recognized as "non-promoting". By this method, because of recognizing only by counting pixels, its computation cost is low; therefore a real-time operation is possible. Since it is recognized by difference of the number of pixels, it needs to count the black pixels as accurately as possible. It is considered that a threshold is locally determined by applying the method based on the discriminant and least squares criteria[2] for each square. Though, since the thresholds are decided independently for each square, the number of black pixels of the character of the same piece varies from square to square on a *SHOGI* board. Therefore, judgment of "promoting" becomes inaccurate. This paper describes a method that the threshold for binarization at each square is reversely determined from the existing known pieces so that the numbers of black pixels of the same kind of pieces become the same.

4. Automatic Determination Method of Thresholds for Binarization

Due to the intensity of light, the attitude of a shadow and so on; the number of black pixels of the characters on the same piece varies from square to square on a *SHOGI* board. Our new technique utilizes the fact that the kind of the current piece existing in each square is known because all the moves so far have been traced from the beginning.

4.1 Threshold Adjusting Method

4.1.1 At a square with a piece

It creates the gray level histogram for each square where a piece exists. Then, as the threshold value it sets the value that this histogram serves as a peak (the value which can extract characters from input image), which is being used for binarization in the square. It counts the numbers of black pixels of characters on the piece in each square, and computes the average number of the black pixels for the same kind of piece, which will serve as the target number of the black pixels of the kind of the piece. Then, it adjusts each of the threshold values for the squares where a piece of the same kind exists so that the number of black pixels obtained by binarization with the threshold value becomes the target number.

4.1.2 At a square without a piece

For the squares without a piece, the threshold values are determined from the thresholds in its near squares whose thresholds have been determined. In addition, when a piece has moved in for the first time, the method of determining a threshold described in Section 4.1.1 could be applied.

4.2 Difference for Environmental Change

The numbers of black pixels are counted by binarization using the threshold obtained by the above-mentioned method. Suitable thresholds are obtained without the number of black pixels of the character of the same piece varying from square to square.

However, by the intensity of light, the attitude of a shadow and so on; the number of black pixels of the character on the same piece even at the same square varies from time to time. It might be possible to use the above-mentioned method each time. However, the method requires much computation time for adjusting the thresholds little by little in all squares with a piece. It becomes impossible thereby, to create *KIFU* on real-time. We need a method with low computation cost for it. We devised a new technique for determining thresholds that captures the difference for the environmental change in low computation cost. Combining it with the threshold adjusting method, we can determine the thresholds in low computational cost.

For a real-time system, it is necessary to grasp the environmental change by the method with low computation cost. The difference of the feature of the gray scale histogram is regarded as an environmental change. For simple processing, for each square, we use the difference of the values at which the histogram serves as a peak (Fig. 4). The difference is regarded as an environmental change and it is used for threshold determination.

4.3 Entire Method for Threshold Determination

Thresholds for every square are determined using the method described in Section 4.1 and Section 4.2. First, in an initial state, the threshold of each square is determined using the threshold adjusting method described in Section 4.1. It keeps

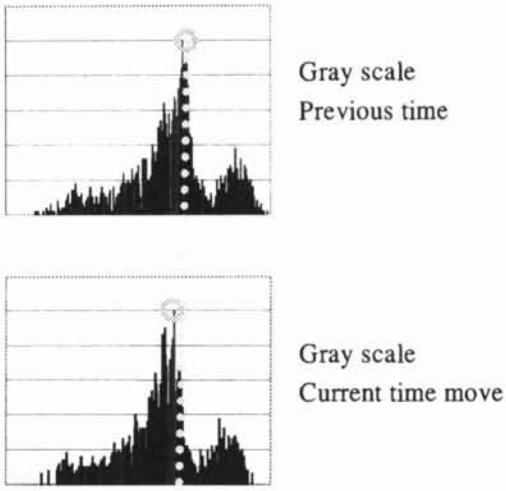


Fig. 4 Difference for environmental change

the threshold values as the base thresholds for each square. When one piece moves and a threshold is needed, an environmental change is grasped by the method of Section 4.2. Then, a new threshold is calculated by adding environmental difference to the base threshold. Binarization is performed using this threshold and the number of black pixels is counted.

5. Experimental Results

The experimental results by three methods are shown in Table 1, which shows the variations, or the standard deviations, of the number of black pixels for every kind of piece. In the first method A, the method of [2] is applied for every square each

Table 1 Variations in the number of black pixels (Standard deviation)

	A	B	C
Hohei	14.5	8.2	8.6
Kyousya	6.5	7.0	6.2
Keima	21.6	9.9	8.8
Ginsyou	11.4	11.9	10.3
Kinsyou	11.7	8.2	8.1
Kakuyuk	11.4	19.0	13.6
Hisya	15.0	15.9	13.9
Ohsyou	27.4	23.5	19.4

time. In the second method B, in an initial state the thresholds are decided only by the threshold adjusting method described in Section 4.1 and use them as a fixed value in subsequent times. The last method C is proposed entire method.

The table shows that the proposed method is suppressing the variation in the number of black pixels the smallest. And thereby, it can be said that the proposal method is effective.

6. Conclusion

For correct recognizing of "promoting" in an automatic recording system of *KIFU* of *SHOGI* games, we have proposed a simple method by utilizing the difference of the number of black pixels of the character between on the front side and on the reverse side of each piece.

We have also proposed a threshold adjusting method and the method of grasping the environmental change by the low calculation cost. The suitable thresholds of each square are determined by combining them. And we have shown the effectiveness of the method by the experimental results.

References

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