1N-06

チェスボード撮影動画からの駒認識

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1. Introduction

Chess is a very popular sport that is played by more than 8.6% of human population and more than 2 million chess athletes all over the world in 2015.

Human has shown a deep interest in making chess robot, the history of chess robot started with “Mechanical Turk” in 1770. “Deep Blue”, a chess computer which the development started in 1985, won against world champion, Gary Kasparov in 1996. It could evaluate 200 million positions per seconds and it said to be the breakthrough of chess robot algorithm.

“Gambit”[1] and “Marine Blue”[3] are examples of chess robot that uses technology of chess vision to detect chess pieces movement.

In chess game, chess notation is used as a way to record chess matches. However, it often requires players to write chess notation manually, which is a tedious task. There is lack of studies that apply computer vision in a chess game. Consequently, limited studies identify chess pieces’ type and location in noise environment. Additionally, studies that identify chess pieces’ type from a video taken from an arbitrary position are not well understood.

Due to the research gaps, this paper aims to apply image processing based methods to reduce noises of image to increase the accuracy of edge detection. Further, this paper introduces an algorithm to recognize the type and color of chess pieces on the board from an arbitrary chess position. It also aims to generate chess notation from the output of the previous processes.

2. Methodology

This section explains a series of steps required to determine the existence of the pieces on a chessboard and recognition of chess pieces types and colors.

Step 1: Images Extraction from Video
Step 2: Piece Existence Determination
Step 3: Difference Extraction
Step 4: Pieces’ Type and Color Determination

In this research, we assume that the camera angle of input chessboard images is perpendicular to the chessboard.

2.1. Images Extraction from Video

The goal of this step is to extract the frame where there is no hand movement and distinct frame from the previous extracted frame.

Every 0.3 second, a frame from the video will be taken, the difference between the frame and the previous frame extracted is calculated, and if it reached a certain threshold, it represents movement and the frame will be ignored. Once the movement stops, the frame will be extracted and will be passed into Step 2.

2.2. Piece Existence Determination

This step recognizes the four corners of the chessboard and identifies the inside as ROI (region of interest). There are two methods to do so, the first one requires user to specify the corners manually, or to capture the video before chess pieces are put to recognize the corner using chessboard corner detection method. Then the four corners are remapped using the “Homography” method into a square. For simplicity, white pieces will be remapped and located to the bottom side.

To reduce noises, Gaussian filter is applied to the input image. After Canny edge detection applied, lines that are dividing the chessboard must be trimmed. Failing to do so, the lines will become an unwanted noise and directly affect the Canny value (ratio of white pixels with respect to black pixels of an image that has been processed by Canny edge detection). It will influence the judgment of the pieces existence.

ROI then divided into 64 squares, where each square represents each square of a chessboard.

Threshold value is used to determine if a certain Canny value indicates existence of chess piece. However Canny value will vary depends on the amount of noise or piece’s complexity after the Canny edge detection process, therefore, it is important to generate a dynamic threshold value that is robust against noises.

Dynamic threshold value can be generated by sort ascending the canny value, take the largest gap from the sorted canny value, divide by two, then add it to the low point where the largest gap resided.

Each Canny value of each square then compared with the threshold, if the value is bigger, it can be concluded that the square is occupied. The result will be stored as an 8×8 matrix (piece existence matrix), where 0 represents no piece, and 1 represents square occupancy.

If the first frame captured from Step 1 shows that the game is played from the beginning, the pieces’ color and type can be immediately recognized, and Step 4 can be skipped.

2.3. Difference Extraction

If the array of piece existence matrix added from Step 2 contains only 1 frame, then this step can be skipped.

$$D(n) = M(n) - M(n-1)$$

The M(n) is the matrix output from Step 2 on the n frame which is a 8×8 matrix, while M(n-1) is the matrix of the previous frame. Next, $D(n)$ which represents the difference between two frame is calculated, where element with -1 value in matrix $D(n)$ represents the square where the piece resided and

Chess Piece Recognition from a Captured Video of a Chess Board
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element with 1 value of matrix $D(n)$ represents the destination of the piece.

When one captures the opponent's piece, the difference matrix will consist of only one element with -1 value and other elements' value will be 0. In order to detect where the piece goes, each square brightness is compared with the same square on the previous frame, and the one with the most brightness difference will be treated as the destination square.

2.4. Pieces' Type and Color Determination

If the result of Step 2 states that the game if played from the initial position, this step can be entirely skipped.

By analyzing the difference matrix continuously, the type of each piece in the chessboard can be recognized even when the video of the chessboard started to be taken at an arbitrary chess position. Because each type of chess pieces has different moves and maximum amount, the chess pieces' color and type can be guessed over time.

Also, the piece color can be determined by looking at the change of the brightness on the destination's square after capturing opponent's piece.

Special moves like *En passant* and *Castling* produce special matrix that can be used to recognized the type and color of pieces involved by comparing the matrix with the matrix defined beforehand.

3. Result

Experiments were conducted by using a real video of a chess match.

3.1. Determination of Piece Existence

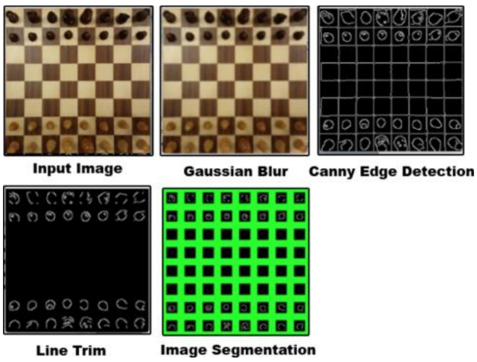

Figure 1 Process of piece existence determination

Figure 1 shows the process of Step 2 by using the output of Step 1 as the input image. Experiments were conducted to test the accuracy of piece existence determination from when the video starts until the end. Experiment 1 (Table 1) was tested using wooden textured chessboard and experiment 2 (Table 2) was tested using solid color chessboard.

Table 1 Experiment's result – wooden textured chessboard

	Tested	Correct	Percentage
Number of Moves	73	61	84.7%
Number of Squares	4672	4611	98.7%

Table 2 Experiment's result – solid color chessboard

	Tested	Correct	Percentage
Number of Moves	73	73	100%
Number of Squares	4672	4672	100%

Based on the result of the experiments, piece existence determination by using a solid color chessboard shows 100 % of accuracy, while wooden textured chessboard shows 84.7 % of accuracy.

3.2. Piece Type and Color Determination

An experiment was conducted to identify chess pieces' types and colors from the beginning of the game. And it successfully recorded all movements such as knight moves, *En passant*, *Castling*, and piece capturing movements. However *Promotion*, are not yet identified.

Experiment was conducted from an arbitrary chess game position, it could detect chess pieces' color and types if knight moves and special moves such as *En passant* or *Castling* occurs.

4. Conclusion

This paper proposed concepts of deducing owner of objects by identifying movement that later can be utilized to estimate future movements. The concept of this study potentially contributes to wide range of applications. Not only in a chess game, it can also be applied to identify movement and belongingness of objects during certain situations where there are different parties involved, such as sport competition, etc.

The result of determination of piece existence on wooden chessboard was not reliable, because of the texture of the chessboard. It can be improved by enhancing low-pass filter to minimize the noise of the texture.

The determination of pieces' type and color can be improved by cross-referencing with chess movement database, and by knowing the Elo-rating of the players.

After the pawn reaches the end of the chessboard, which is called "Promotion", the type of the piece will change and therefore it has to be determined one more time by using other method.

More detailed research that covers how many moves needed in order to recognize chess pieces' type and color, recognition accuracy, etc. will be conducted in the near future.

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