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Using Image Processing Techniques to Automate Chess Game Recording

G.D.Illeperuma
Department of Physics, University of Colombo

ABSTRACT

Chess is a popular board game. Recording a chess game is important. It allows players to replay the game and to improve their strategies by rehearsals. It also allows details of the game to be shared among others in a compact unambiguous manner. Different standards are used to record a chess game. Most widely accepted notation is the 'Algebraic Notation'. In this research, feasibility of using a web camera to automate the recording procedure and to produce algebraic notation is studied. Using real time video and image processing techniques, it was shown that it is feasible to automate the game recording procedure with high level of accuracy. Texture of the board and lighting conditions were found to be the most effecting factors for accuracy. Under controlled environment, accuracy of identifying a correct movement was over 95%. Further research in image recognition and noise filtering algorithms may produce a much robust system which can be used as practical, low cost chess recording mechanism.

1. INTRODUCTION

Discovered in India, in 6th century, Chess is considered to be the most intellectually challenging board game ever to be discovered. This game has attracted not only players but also computer scientists, who look at chess as a bench-marking tool for artificial intelligence. However some fields of this game, such as game recording, were largely neglected by the scientific community. Even today most of the time game recording and timing is carried out as it was in the 18thcentury, using a pencil, a paper and a chess clock. In this research, an automated system was developed, that could record chess games in real time. Cost of the implemented system was kept to a minimum by using commonly found components such as web cameras.

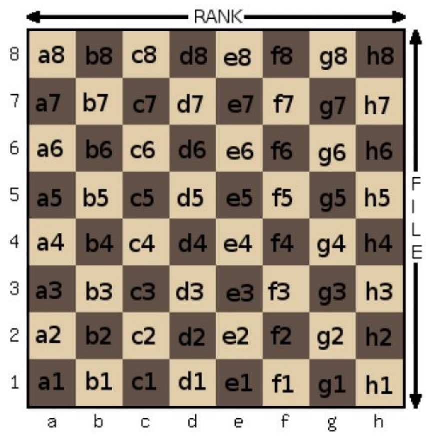
2. DIFFERENT CHESS NOTATION SCHEMES

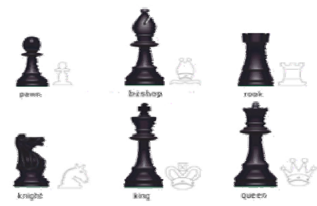
Recording a chess game is vital. It allows one to replay and analyze various situations of the game multiple times. Using game recording, it is possible to pause a game, and to resume it at a later time. At the era before the internet, chess notations were vital for 'play by post' tournaments. Chess books and magazines extensively use chess notations to inform readers about board and piece positions. Learning chess notations is highly recommended for all chess players.

There are multiple standards to record a chess game. Algebraic, Figurine Algebraic, Long Algebraic, Reversible Algebraic, Concise Reversible, Smith, Descriptive, Coordinate, ICCF are few of such notations. ICCF is a method used by computers to record the moves [1].UCI (Universal Chess Interface) is the standard chess protocol for computers. For humans Algebraic notation is the most popular and compact method used today and is approved by World Chess Federation (FIDE).

2.1 Algebraic Notation

Squares in chess board is labeled using letters from A to H and numbers from 1 to 8. 'A1' is the leftmost square of the white player. Chess pieces are abbreviated either to a single letter or to a simplified shape. A move is recorded using "from to" format (Figure1).





King : K
Queen: Q
Rook : R
Bishop : B
Knight : N

Examples

Pawn e2 to e4	e2e4
Knight f3 to f6	Nf3Nf6
Bishop cut pawn at C6	BxC6
Bishop to b4 and check	Bb4+
Castling king side	o-o

Figure 1: Example of Algebraic notation

3. METHODOLOGY

A web camera was positioned over the center of the chess board and was directed downward (Figure 2). Distance between camera and the board was 1.15 m and did not block the view for the two players. Camera resolution was set to 800×600px with 1fps frame rate. Simulink was used to capture the video, process images, identify pieces and to produce final result.

3.1. Factors Effecting the Performance

Several board types, sizes and environments were tested to determine the accuracy and robustness of the system.

Following factors were identified as having major effect on the performance.

- Texture / Pattern on the chess board.
- Color of the squares/ Pieces.
- Lighting condition.

Figure 2: Setup

3.2. Texture and Pattern of the Board

Early chess games were played on a board which had 64 black and white squares. But at present there exist many boards with different patterns on them. This made the identification of chess pieces more complex. Board that was tested in early experiments had a texture of wood. Black squares were dark brown with strokes of darker circles. White squares were light brown with stronger broken lines. Although this may appeal to a human player, it lowered the accuracy of identifying white pieces on white squares. Accuracy of identifying other combinations were unaffected by the texture. Most accurate and suitable board was a board with two complementary color squares without any texture or pattern.

3.3. Color of the Squares

Accuracy was highly affected by the color of squares on the chess board. Notably shining black squares reduced the accuracy of detecting black pieces on them. Among the boards selected from the market, dark brown - light green color boards had the highest degree of accuracy (Figure 3).

Since camera was mounted directly over the board, most pieces produced almost identical circular patches on the image, making it impossible to identify the type of the piece.

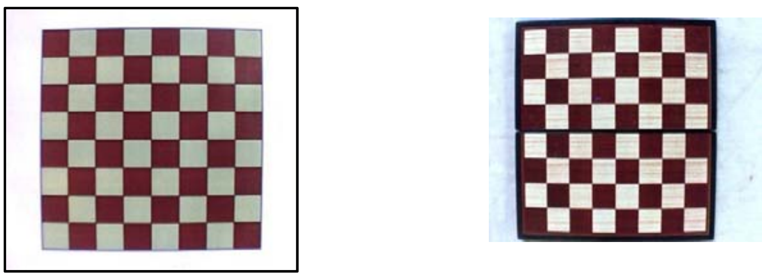


Figure i: Some of the boards used in the experiment

3.4. Lighting Condition

Lighting of the board was a vital factor. Most suitable light source was found to be a diffused white light source directly above the board. In most of the standard games this conditioned is met. Worst case was a pointed light source from a side of the board. Shadow and glare created by such a light sources were sometimes misinterpreted as chess pieces.

4. PROCESSING

Processing consisted of four separate stages

- Identify the board, light condition and other initial parameters.
- Identify positions of pieces.
- Detect and identify moves.
- Convert moves into algebraic notation.

4.1. Steps in Identifying Board

- Load the video.
- Confirm image quality.
- Convert image to gray scale.
- Calculate horizontal and vertical sums (Figure 4).
- Detect boarders of the board and crop the image (Figure 6).
- Save the background image and boundaries to detect changes in later stages.

4.2. Identifying the Board

Once the physical setup was in place, first step was to identify the board position. This step was automated. One unexpected issue was the web cameras tendency to auto adjusts brightness of pictures. Camera initialized at a lower brightness level and brightness of the images slowly increased until a certain threshold was reached. This was a built in functionality of the camera and could not be disabled externally. Although it is considered to be a nice feature for web conferencing it was having an ill effect on the program since brightness at the beginning was replaced with a new unknown value. Solution at this point was to pause image capturing until camera finished its self-adjusting. Once the camera was ready, a real-time video of the board was presented to the user. If the user was satisfied about video quality, position of the board and lighting conditions, he confirmed to continue the processing and the program automatically captured the image. This image allowed program to identify and familiarize itself with the size, colors and the patterns on the board. It was also used to identify board position relative to the photo.

Differences in intensities were used to determine the position and size of the board relative to the photo (Figure 4). These data were used to crop and resize the board to a predefined size (Figure 5 and Figure 6).

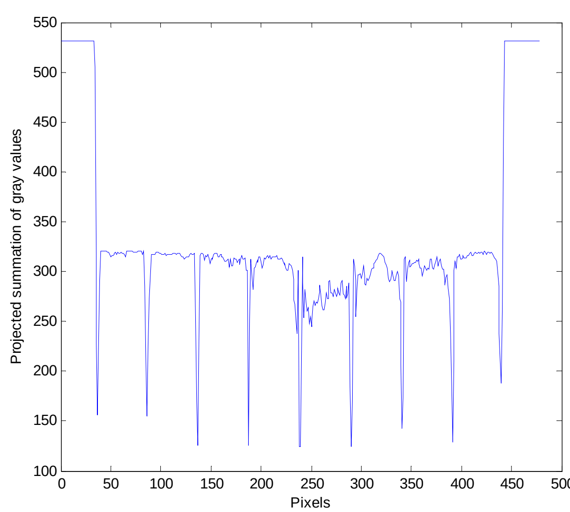


Figure 4:Vertical projection of intensities

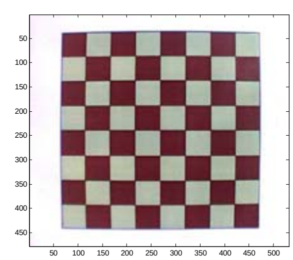


Figure 5: Empty Image

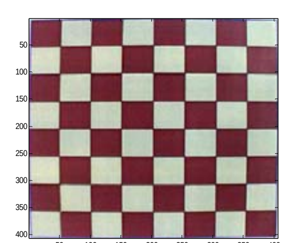


Figure 6: Cropped image

Once the empty board was initialized, the game was started. Using the stream video feature, images were captured in real time. Basic image enhancing was done. To avoid processing an image while a move is not completed, boundary conditioned was checked (Figure 7).Image of a hand of a player should not be forwarded to piece identification algorithm. Further, it was noted that rings, silver wrist watches and dark nail polish can be misinterpreted for chess pieces. In order to minimize such errors a separate sub procedure was used to identify the presence of a human hand. A strip around the board was cropped from present image and was compared to initial empty image. If a hand was present, it should be different than the background image (Figure 8). Using this logic, the presence of a hand was detected.

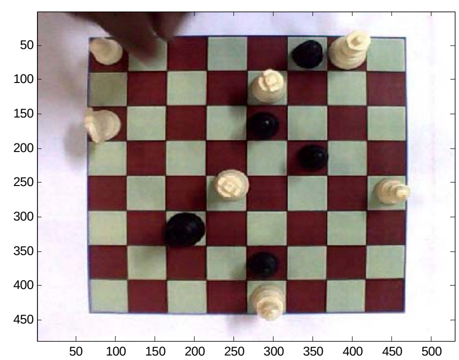


Figure ii: Image captured in a middle of a move

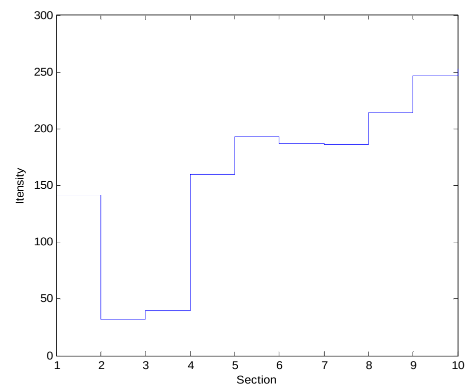


Figure iii: sudden drop of intensity in top boarder due to hand

4.3. Detecting Pieces

Board was detected and cropped from the background (Figure 9). New board image was subtracted from empty board image. Results consisted of a three dimensional matrix, with three separate layers for Red, Green and Blue. Blue layer was found to be the most effective color for identifying white pieces (Figure10).

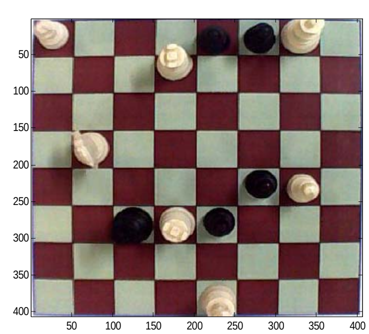


Figure 9: Cropped image

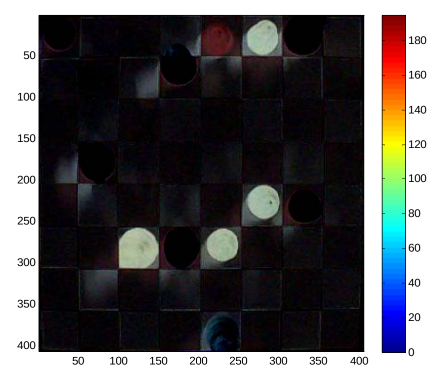


Figure 10: Difference in boards

4.4. Identifying Black Pieces

It may worth to note that the black pieces on white squares have high intensity drop than black pieces on black squares. White piece on any square would increase its intensity and was neglected. Pixels with an intensity drop higher than a preset threshold value were selected. These pixels were set to a value of 1 while other pixels were set as 0. Black pieces appeared as large patches while smaller patches were due to the noise. One major issue was the effect of shadows. A careful threshold function was needed to remove the effect of shadows.

By applying a 4× 4 median filter, noise was reduced [2] while keeping the major patches relatively unchanged (Figure 11 and 12). Image was then resized to a 16×16 grid to reduce noise, and to facilitate the calculation of position of detected pieces. Although 8 × 8 would be ideal and would directly represent the board, it was found that some pieces cast such small changes they would simply vanish when resized to 8 × 8 (Figure 13 and Figure 14).

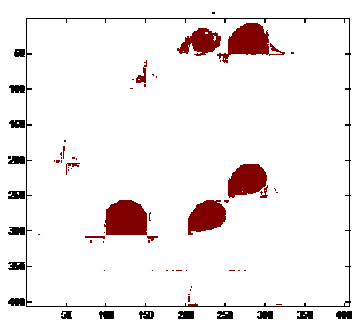


Figure 11: Difference of images

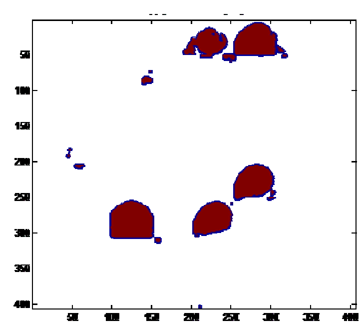


Figure 12: Filtered by median filter

In order to map to the final board, 4 consecutive squares were grouped together in the 16×16 grid creating an 8×8 grid. If any of these small squares contained a positive value, large square was considered as containing a piece. By this method, the board was resized to 8 × 8 while preserving the presence of smaller shadows (Figure13 and Figure 14).

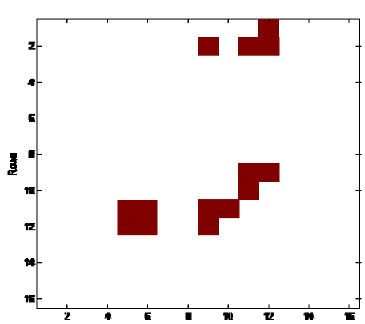


Figure 13: 16×16 grid

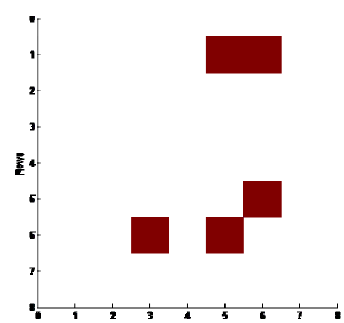


Figure 14: Converted to 8×8 board

4.5. Identifying White Pieces

Detecting white pieces was identical. Only exceptions were, new board was subtracted from the empty board and threshold value was different. This is due to the fact that the white pieces increased intensity of squares while black pieces decreased it (Figure 15 and 16).

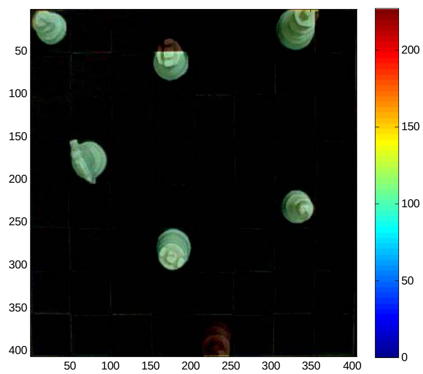


Figure 15: Difference in boards

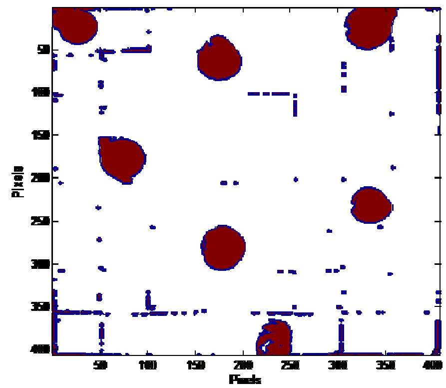


Figure 16 Finding difference n pixels

Note at the very bottom, there is a white piece on a white square and is almost invincible. Careful calibration of threshold function was needed to resolve such situations. After filtering and resizing, all the white pieces were identified (Figure 17 and 18).

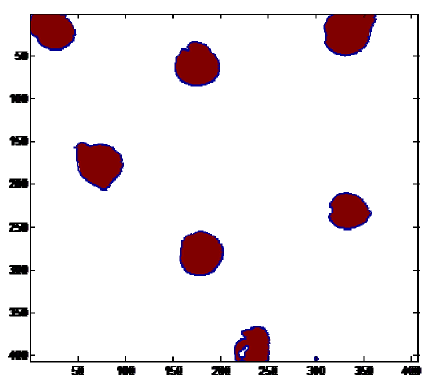


Figure 17: After filtering

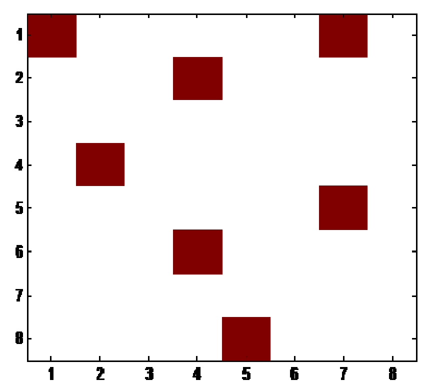


Figure 18: Identified pieces

In the final phase, board with black pieces was merged with the board with white pieces (Figure 19).

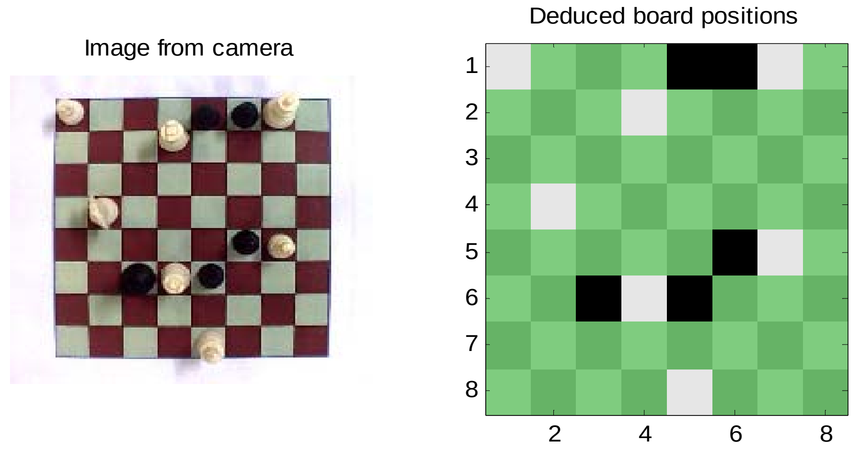


Figure 19: Final result

4.6. Converting To Movement List

Positions of chess pieces were recorded in a cell matrix. By comparing previous position and new positions, it was possible to detect weather a piece was moved or not and if moved, from which square to which square. Since the initial setup of the board was known, it was possible to identify the pieces at each square if the game was recorded from the beginning. A simple parse program was written in MATLAB to produce algebraic notation as the output.

5. CONCLUSION AND FURTHER DEVELOPMENTS

When board size, colors and lighting conditions were met, system was able to record the movements with more than 95%of accuracy. When deviated from the specified values, minor errors were introduced in identifying chess pieces. But more sophisticated image processing techniques could make system more robust and resistant to noise.

Most of the games have one or more time constraints. It might be the total time given for a player or time between two moves or both. This timing process can be automated by attaching a small microphone to the board and sensing the sound of contact. Once enhanced and was sent in to an Artificial Neural Network [3], it is expected to identify this contact sound from the separate background noise. This time of contact together with the position detected by the camera should provide all the information to record a game in details.

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[3]. works, Math. http://www.mathworks.com/products/image/. *http://www. Mathworks.com.* [Online] Mathworks.

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