A Practical Interactive Chess Board with Automatic Movement Control

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***Abstract*—The interactive chess board game is unlike games in its ordinary way. This board game together with tangible movements of all pieces is considered to be users attraction. Therefore, the new chessboard with an automatic moving mechanism for every piece is chosen. Initially, we have designed and developed an aluminum core structure for positioning X and Y-axis. Furthermore, a controllable magnet is deliberated for holding and moving an individual chess piece according to player manipulations. Purpose of this interactive chess board is applying technology to board game for excitement, interest, amazement, and attraction. Arduino microcontroller is used for controlling every step of piece movement. The microcontroller receives control information through the user interface and then moves the chess piece to the destination on the board. The position calculation is brought to identify the chess piece and drive accurately the stepper motors in X and Y-axis.**

Keywords—Interactive Chess game, X-Y Cartesian Axis

I. INTRODUCTION

Playing game is an activity which belonged to people for long. Nowadays, we live in the digital age. Many games have been created for many players to enjoy. Companies invest to produce games that combine with technology for a newer age. In this work, we create the game to has more fun, realistic, and interactive with the player. This game makes an action on physical objects, not on a monitor. They are tangible and movable. This work is the chess game on the interactive board. For more imaginary, the work mimics from the Harry Potter movie that all ages could enjoy.

Variety of chess developed through history encourage that the automatic chess could be very interesting in term of entertainment. Recently robotic and automation trends are widely propagated. In 2015, [1] have proposed the robot arm to play chess. Their robot recognizes the position of chess pieces by using camera which mounted on top. It moves pieces by using clamp and arm mechanism. The robot arm exposes the mechanical parts to players. The feeling of the player could be more interesting if the movement of the chess piece was produced with the hidden mechanic.

Another approach [2] to create an automatic chessboard system is to place the photo reflectors under the chess board to identify the position of the chess pieces. With the button to control, the players could notify their end turns to the system. The system then detects the changes between the previous and the current positions to recognize the game state. However, all positions of chess piece could be recognized and memorized if they are under control by a software.

Recognition technique to know the game states is required in the automatic chess board. Nowadays, the image processing is widely applied to game state recognition. Many algorithms [3-8] are precise and accurate. Even image processing algorithms could recognize the game states but they require the camera and such computing power.

This work is an interactive chess board, the new experience of playing chess. It consists of two systems. The first system is a game interface for getting input from players. The second is a mechanical movement of chess pieces for moving pieces automatically. Players are allowed to make their moves on a simple graphic interface which shows the game board state. A computer with touchscreen displays all the changes in position of the chess pieces. When a player commands to move a chess piece, the computer communicates to the chess board, then the selected chess piece will be moved.

II. BACKGROUND

A. Rules of Chess

There are many rules and setups in chess [9-10]. Some of them depend on the class of the game. Tournament chess has a timer, but local chess may not. Because of gaming variances, the chess rules are detailed. However, the important rules we interested in are the types of a chess piece and their moving steps. There are six types of chess piece including King, Queen, Knight, Bishop, Rook, and Pawn. Each type of piece has their own movements. In one turn, four types of action are selectable: moving, killing, castling and En passant.

B. Microcontroller

Microcontroller is a small computer on a single integrated circuit. It contains one or more CPUs (processor cores) along with memory and programmable input/output peripherals. Microcontrollers are used in automatically controlled products and devices, such as automobile engine control systems, remote controls, office machines, appliances, power tools, toys, and other embedded systems.

Fig. 1. *Illustration of the user interface (a) on start state (b) when mouse hover (c) after clicking the possible move*

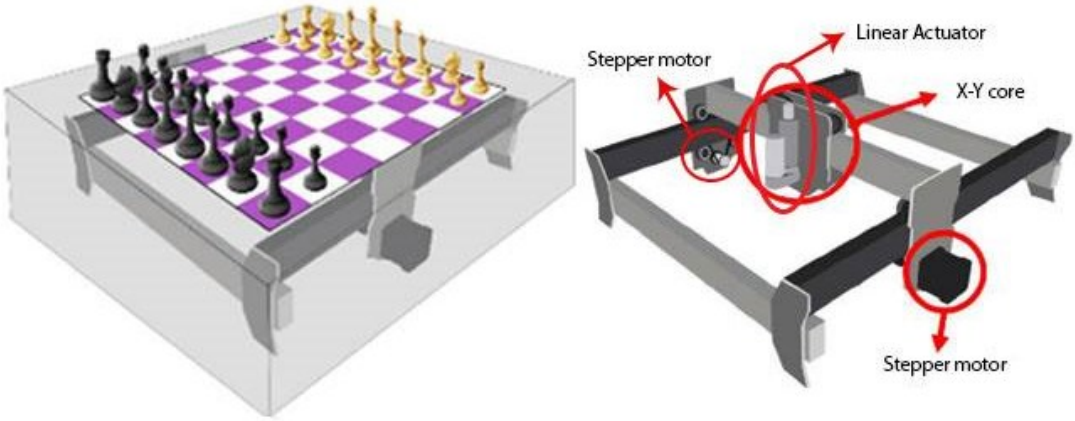

Fig. 2. *Simulation of the model structure*

In this work, Arduino controller which is an open source computer hardware and software platform is chosen. An on-board Arduino microchip are varying to the hardware design. Most of Arduino boards consist of an Atmel microcontroller with different amounts of memory sizes, pins, and features.

C. X-Y Cartesian coordinate system

A Cartesian coordinate system is a coordinate system that specifies each point uniquely in a plane by a pair of numerical coordinates. X and Y are the signed distances to the point from two fixed perpendicular directed lines, measured in the same unit of length. Each reference line is called a coordinate axis of the system, and the point where they cross are its origin, at the ordered pair (0, 0). The coordinates can also be defined as the positions of the perpendicular projections of the point onto the two axes, expressed as signed distances from the origin.

D. Serial communication

Serial communication is the process of sending data one bit at a time, sequentially, over a communication channel or computer bus. Nowadays, it is ordinarily used for transmitting data between device.

III. METHODOLOGY

A. System Overview

Chess game interface is provided for presenting the current status of the board. The screen will show the current game state to the player and wait for a player-selected chess piece. After the player wisely selects a piece, the software will generate all allowed X-Y locations to move the piece and then update the screen. Player can choose only one location. For illustration, the user interface is shown in Fig. 1. Two allowed locations are highlighted. The state of chess game will be changed after player clicks at the location.

In each turn, the program processes the physical movement sequence of the implicated chess pieces and then sends the command to the chess board. In the interactive chess board, the Arduino board will control the movement of all implicated chess pieces by using stepping motors and a linear actuator. If there is a killed chess piece, it will be moved out from the board to the killed area located at left and right side of the chess board. The turn procedure is repeated among players until the winner occurs.

B. Model structure

The interactive chessboard structure consists of 3 layers: (1) top layer of the board, an area for playing chess. (2) X-Y Cartesian layer, an area that includes a stepper motor for X-axis, two stepper motors for Y-axis, and linear actuator with an attached magnet on the X-Y core and (3) storage layer, the layer conceals equipment of interactive chess board such as Arduino controller, wires, power supply, and other components. The model is shown in Fig. 2.

Command type { M, K, C, E }	Source position in Y-Axis [1-8]	Source position in X-Axis [A-H]	Destination position in Y-Axis [1-8]	Destination position in X-Axis [A-H]

Fig. 3. *Protocol of communication between computer and microcontroller (microcontroller input arrays)*

C. Hardware setup

a) Core in X-Y Coordinate: Two stepper motor drivers are set up for controlling stepper motors in two directions. For Y-axis, HYDIV268N stepper driver controls two steppers by the same signal. For X-axis, M415 micro-step driver controls one stepper motor. Stepper driver can control the distance, rotation angle, speed, and torque. However, two limit switches are installed on the nearly corner of the chess board for identifying the origin position of core X-Y. They are directly connected to arduino and set as 'Active low' at the normally closed (NC) terminal since the Arduino supports the internal pull-up pins. Both X and Y stepper motors are moved until pushing the limit switches for initializing the position of X-Y core to the origin.

b) Piece holding: Linear actuator is used in chess move by attaching a magnet on it and placing under the chess board on the X-Y Cartesian layer. When the actuator lifts up close to the chessboard, the magnet will grab a chess piece by magnetization. When the actuator lifts down, the magnet will release a chess piece.

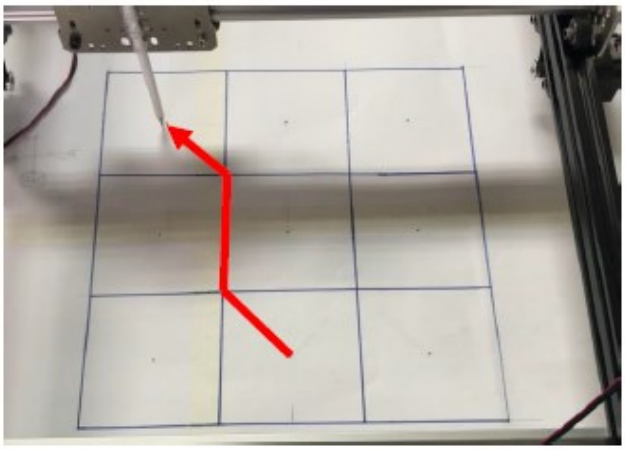

Fig. 4. *Example of special movement (Up2Left1)*

D. Software

a) Chess Game: Chess game is a graphical program created using Python language. The game starts from the initialize states. The game interface displays state of the game, shows the allowed locations of piece move and waits for the user selected action by mouse clicking. After mouse clicking, the game determines the next game state, calculates the piece movement steps, and sends the command to the Arduino.

b) Protocol of Communication: The protocol is created by the array of 5 characters for inputting the data from computer to Arduino as shown in Fig. 3. The first character is the command type. M stands for Moving, K stands for Killing, C stands for Castling, and E stands for En passant. The next two characters are the source positions in Y and X axes. The last two characters are the destination positions in Y and X axes.

c) Chess Piece Movements: Chess board with the size of 8 x 8 blocks (each block is 3.5*3.5 cm) is created. the distance of each block is determined by the number of stepper motor pulses. From the experiment, 1 centimeter equals to 401 pulses. Thus, the movement in one block is 1403.5 pulses.

The basic movement sets are created for each role of the chess piece. The straight movement consists of four directions: Up, Down, Left, and Right. Besides, the oblique movement consists of four directions: UpLeft, UpRight, DownLeft and DownRight. Since the oblique movement are the combination of movements in X and Y axes, X-Y stepper motors could be simultaneously driven with the same speed. In addition, knight has eight special movements which are Up2Right1, Up2Left1, Right2Up1, Right2Down1, Left2Up1, Left2Down1, Down2Left1, and Down2Right1. For these special movements, the straight movement is inserted into the middle of two half-block oblique movements as shown in Fig. 4.

d) Types of command: The first character of the protocol defines the movement type which consists of 4 cases: M, K, C, and E. Movement process of all cases are described by the flowcharts in Fig. 5-8.

To process the command M, first, move the X-Y core from the current position to the source position in both Y and X axes. Next, grab the piece and move to the destination. The direction of the movement could be considered by the source and destination. Then, the steps of the movement are performed. Finally, release the grapped chess piece.

To process the command K, first, move the X-Y core to the destination position in order to grab the killed piece. Move the killed piece a half block. Then, release the piece. Move the X-Y core back to the source direction. Then, grab the killing piece and move to the destination. Release the piece. Finally, move the X-Y core back to the killed piece, move it to killed area, and finally release the chess piece.

To process the command C, first, move the X-Y core to the source position which is King. Next, grab the piece and move into the castle zone depending on King position. Next, release the piece. Then, move the X-Y core to destination which is Rook. Rook supposes to jump over the King. However, the chess piece is controlled by the magnet. Thus, Rook has to be moved outside the board, pass the King's position, and come back into the board to stay nearby King. Finally, release the Rook.

To process the command E, first, move the X-Y core to the source position which is Pawn piece. Grab the piece and move to the destination. Release the piece. Then, move the X-Y core to the killed chess piece which is under or obove the destination in Y-axis. Then, grab the killed piece and move to the killed area. Finally, release the piece.

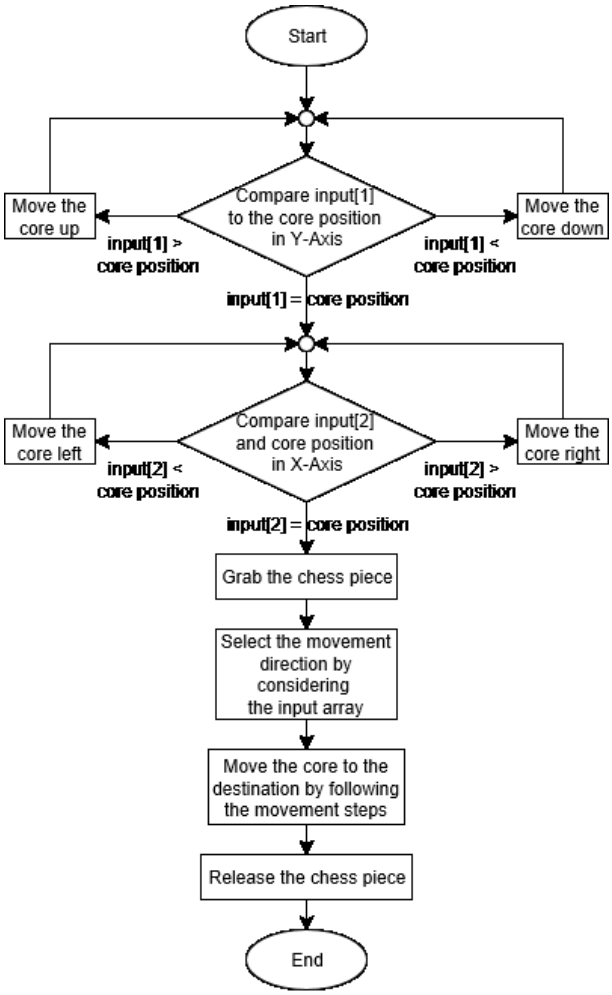

Fig. 5. *The process of command 'M'*

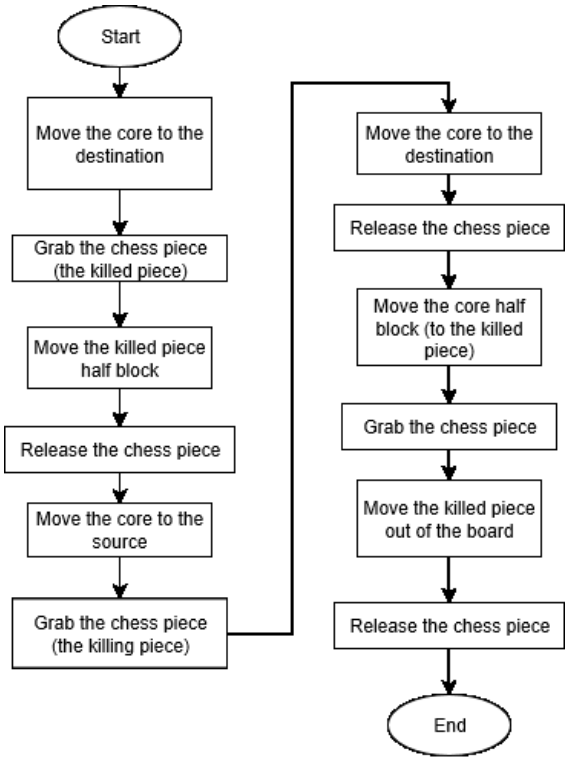

Fig. 6. *The process of command 'K'*

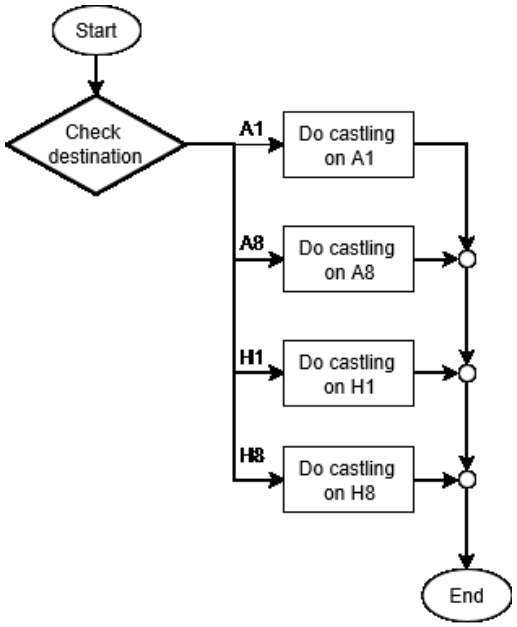

Fig. 7. *The process of command 'C'*

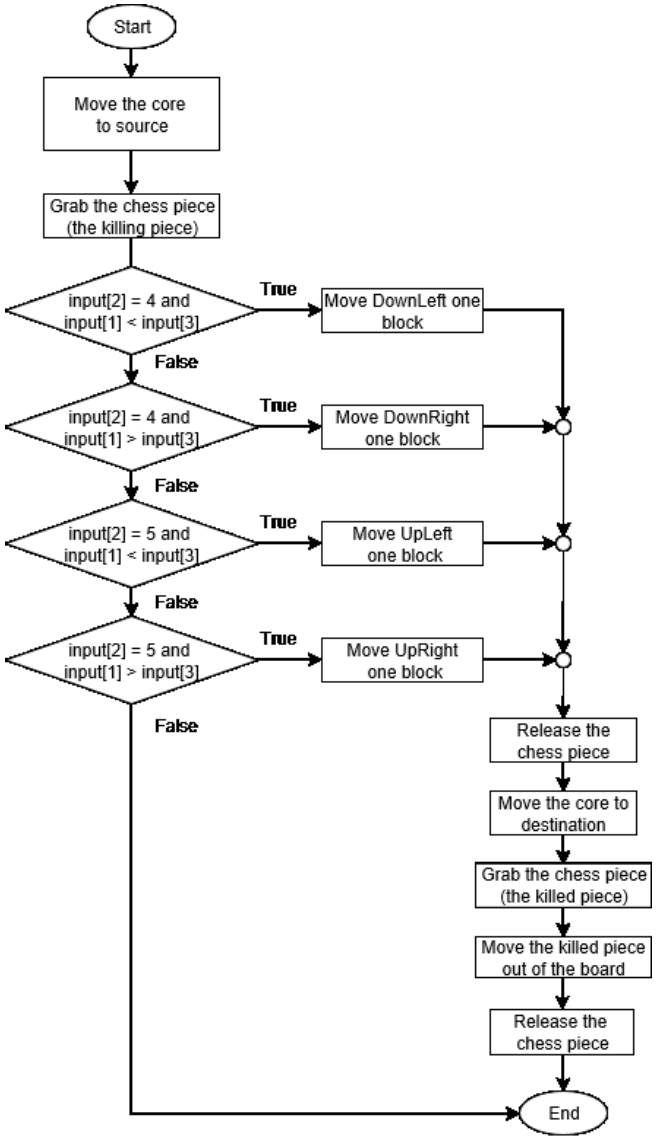

Fig. 8. *The process of command 'E'*

IV. RESULTS AND CONCLUSION

The Interactive Chess Board provides players a new experience, impression and exciting with automatic moving chess. This work consists of two main parts, which are chess game application and automatic movement. When players play chess with real pieces, they will get a feel, pressure, and seriousness from a competitor. In addition, their self-move influences imagination, players will get more realistic of the battle in the game. These are the difference between playing on this board and playing on the smartphone application. Moreover, this work is the beginning of many ideas such as chess piece recognition with specific scale, Artificial Intelligence for chess.

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