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Design and Implementation of a Smart Electronic Chess System using Raspberry Pi

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ABSTRACT

As we can see, different people are addicted to mobile and computer games nowadays and rejected the famous ancient games like chess. This paper depicts design and construction of smart electronic chess system using electronic circuits which change the playing ability of human chess game to a non-idealized behavior, it's up to difficult mode. Chess Board environment and its searching methodology are given by to use of openly sourced chess game engine the "STOCK FISH ". It will be restructured by using python ide. When user play its move, the spawn's original location and its current location are fed into a chess engine through by using sensors, these moves are detected and then again fed into the chess engine. By using alpha-beta pruning technique the chess engine then replies with its move, giving the spawn's current location and the desired destination. The chessboard comprises of reed switches for sensing the piece location and Integrated Circuits which are fixed on a PCB (Printed Circuit Board). Multiplexers and Demultiplexers are also be placed on the PCB which can give a way for one-way and two-way serial in and parallel out and parallel in serial out communications between the sensors and chess engine. Min Max algorithms which support the Alpha Beta searching method is used to deploy the game. Different commands display on the Raspberry pi screen and can also be integrated to different other parts. When the Stock fish game chess engine runs, software is being able to perform different decisions on chess game and manipulating them the spawn's onto the chessboard. The reed switches and raspberry pi is one of the best solutions to reducing the cost of expensive sensors and motors which is to be used on the old electronic chess system which is based on digital robots. Newly design system works efficiently and is to be tested on a real time environment and gave satisfactory results.

Keywords*:* Chess Board, Raspberry Pi3, Reed Switches, LED, Magnets, 72HC595 ICs, PCB, Stock fish Chess Engine, Shift Register, Multiplexers, Demultiplexers, Artificial Intelligence, Minimax algorithm, and Alpha-beta pruning.

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1. Introduction

Computer chess game are played anciently from many years and now on this developed era many programmers can recently uses their old methodology, which have same as those methods which is describe on Shannon in (1950). On 11 May, 1997, famous IBM's computers manufacturing company can use Deep Blue chess playing computer system that can defeats the most of chess players which is the best human chess players Garry Kasparov [1]. Therefore, then we can say in reality, that when the chess playing system has ability to calculates the spawn's movements in the chess board also then human player can simultaneously assists them to executes spawn's moves onto the chess board.

Physical boards' game can still a big problem factor to humans being and the machine interaction researches. When you can play the chess game it can involves many thinking techniques that human can reasoning on chess game positions and spawn's positions, and it can also interact to the real spawn's while interacting them to another chess player opponents [19]. Further different many chess board games playing system gives the right path to all the simple humans to machine cooperative playing systems [2]. Thinking about chess playing system, different behaviors are shown on the humans thinking about the playing game against the chess playing system, and manipulates the behavior of spawn's movements when playing them with the human chess opponent was involve. Designing and implementation on smart electronic chess playing system can opens different other ways to other general humans to machine interacting systems that will be consider less expensive and best responsive structure.

The aim to build this project smart electronic chess playing system is that which play the chess game against the human on the simple handmade normal size chess board instead of robot or any other person by neglecting the physical motors which are previously used and reduce cost and increase the game efficiency. Chess is also be works as military strategy which can also be consider the intelligent game into which it is only be play by two players at same time, it can be played by using black and white spawns which can also be known as "chessman". Chess game is playing on a square board which contains 64 squares blocks prints by order of 8*8 grids. Initially every square block in the board can be empty or occupying by some spawns [20]. The initial chess board position consists of 32 spawns in which 16 white spawns and 16 black spawns. White spawns are always play its first move. In typically, first user can select a white piece and place it to another location which is the desired destination. The place of square is either be empty or it contains the opponent spawns. Our main focus in game is to defeats the opponent

king. Traditionally, chess board game is playing by two users that can be seated opposite to each other over the chess board [3, 4]. It's one of the most ancient and famous game, which can be playing by thousands of people in worldwide. Normally the game of chess is played between two human players involving an intensive exercise of mind on both sides. Our project works is to replace them one of the human players to shape like a robot vs. human challenge.

This paper introduces smart electronic chess playing system that is designed to autonomously play chess board game against human (or robotic) opponents which not only reduce motor cost but it plays game without any technical error. A large number of chess playing automata have been constructed in the last three decades suggested that the robotic chess games should be an interesting as an entertainment application. Hence, the robotic chess games can be view accordingly as a test board problem of adjustable difficulty that have new modern researches in thinking and moderates a noise, low constrains in real-world environment [5]. It also describes the implementation of a computer chessboard programs that watches master-level human games and uses clustering techniques to learn and recognize situations in the game which is appropriate to play a move. It can be difficult, to find someone who plays on the same level as you do. To solve this type of dilemma, and to increase playing skills, the smart electronic chess playing system comes in handy.

The task of one move by smart electronic chess playing system can be classified into three parts i.e. first it can identify the current chess board status, then it checks the any incorrect placement of spawn's, calculating the best possible move for the robot and then play its move. The electronic circuitry comprising of LED's, IC's and Reed switches to identify the current chess board status. Then the decision is taken for the best possible move which is based upon artificial intelligence and is implemented by the help of min-max algorithm supported by alpha-beta pruning technique.

Smart electronic chess playing system is a perceptional system that can tracking the chess board positions and the user opponents in the real time situation. The board is fixed and is continuously calibrated during the game play. This allows the game to play with explicitly and to indicate the move for completion. The electronic chess playing system which consists of several parts i.e. Integrated circuits, internal sensors, transistors, resisters, external power source, and computer screen and control computer [6]. Furthermore, the programmed software should be accumulated as an integral section of the aggregate system, since the

method in which all the system is controlled and programming has to be a big impact to its performance.

As we can compared to previous work on robot chess playing systems with specifically instrumented chess playing boards and/or chess spawns was used, Furthermore, some people used expensive motors or robotic arm to move the spawns. This chess playing system represents an ongoing forward way in generally, and its natural work behavior suggested further more upcoming moves in the way of decreasing structure and increasing performance. Smart electronic chess playing system can play with an arbitral strategy on a different chess board, which requires no instrumentations or models of spawns [6]. The chess engine continuously capturing the opponent behavior as well as the player positions that what type of moves it may perform. Moreover, smart electronic chess playing system is directly communicating with the user by the help of a natural language interface on computer screen.

2. Related Works

The Mechanical Turk [7] is the first developed in 1770, it is the first automated chess playing automation system. It is automated but not of all system is works automatically, as it is the newly develop system on that time so that it integrates with human chess game master for thinking, games modularity, and to working with Turk's system. It's hardware parts, which consists of an automated arm which working like human hand, as well as a "sound box" that would be used to saying a single alphabet i.e. ("Echec"). The Turk autonomous chess playing system works with magnetic power which is placed under the chess board. The spawns that can enables the motor to sensing all the current game positions on chess board by using the movements of connecting magnets in the users. Hence the mechanical Turk was basically an autonomous chess tele operating system, nor an automated system.

Another smart chess playing system which is electronic based system uses different electronic components i.e. reed switches, magnets and IC's is design by Mahmood N.H et al. [8] and it implements them latterly. The main objective of this chess playing system is to works automatically and then processing all the chess system, then it displays it on the computer system screen during the chess game is played. The main circuit unit of this automated electronic chess board game is comprised of different piece of IC's set which can receives different information's into the reeds switches to get collect all the data of the game position of the chess spawns. The information which is about chess board positions is

collected by the main control machine and then it converts it to the useful processed information form which is according to IC'srs-232 standard format. The upcoming data is passed to network cables to the computer system screen which can display all the detail processing of the chess game playing system. The prize of the hardware and other many small components are less expensive, so it is applicable to the chessboard game tournaments. The design of chess board is implemented in that way that it can recognized the present's positions of the spawns in the chess board and to show the chess game on the computer display but problem arises here that it will not capturing the positions of spawns repeatedly.

Matuszek [9] can designed another automated chessboard playing system which is also based on robotics and well known famous i.e. "Gambit". It is designed to playing the chess game with automatically against another user. The components which it can be used to developed this system is Prime Sense depth camera which can be placed it on the robotic hand and another straight camera is placed it on the front sight of the hand which provides details and RGB colors information. The depth camera and RGB color information's is record in detail which can perform different operations i.e. detection and recognition the spawns on chess board.

Nasrul [10] is designed smart chess playing system that uses also reeds switches to recognize the spawns on chess board that is playing it on the simple chessboard. The developer uses the simple and direct method that can reads all the 64 box positions by the help of the multiplexers that can reduces the input wires into 64 to 8 inputs to 6 inputs only. The scanning algorithm is simple and work straight easier. This method can add an unusual circuit therefore the cost to the hardware and complexity of the system is also high. And the electronic chess board on this system cannot give us desired results to them.

Gurjit [11] developed an artificial intelligence based a microcontroller system in which chess playing system can defeat against the opponent and also calculates its board positions i.e. spawns positions. The spawns in the chess game were detects by the help of image processing technique. The robotic system is comprised of two sections i.e. vertical section and horizontal section.

Santhosh [12] can developed another chess game robot system which introduced for those people who are blind and darkness will be there in its lifetime. The visual lenses are used for players which needs to 'seeing' through 'touching' the handmade chessboard game and eligible the movements by using the special designed

keyboard. Voice detection techniques is also implemented to get the last spawn move.

Piskorec [13] can program a smart chess vision system is designed in that way that can detects the spawns and recognized the actual chess board pieces location. The smart chess vision system is program using C++ language with the help of using Open Source Computer Vision (Open CV) libraries and its other functions that works with oriented two cameras i.e. front-view and position-view camera. Our aim is to using these cameras of the front-view camera is to get the positions of spawns in the chess board' while it can also be interacting with the help of different cameras is used to recognizing the type of spawns in game.

3. Methodology

Traditionally smart electronic chess playing system can be programed usually by using a tree-base searching technique in that way that can find best moves to play the chess game. However, the searching techniques is also complex and large, many other techniques also be used such as alpha-beta pruning technique which we used to searching the piece positions in the game board. In addition, some people used transposition tables to cuts the number of nodes down in forward way that needs to be searching (Marsland, 1992) [14]. Different chess board games engines can now use the leap forward searching techniques and is to be implemented into many hundreds or thousands and millions of movements is to be performs to get the inner most depth is taken in a very short time, scores each one can heuristically performs its best move deciding on information which it can gets and algorithm techniques which it can be implemented [18]. However, by using alpha-beta pruning technique the chess engine then replies with its move against the opponent.

3.1 Hardware Design

The smart electronic chess playing system uses Reed Switches for the detection of each square position in the chess board. Previously expensive motors and robotic arms was used to sense the position of spawns and to move piece from one place to another which is some time stuck or drop the spawns. These Reed Switches is use to continuously sensing the positions of different spawns in to the chess board during game play. It works when the spawns are placed into the Reed switch the sensor is sensing the spawns due to of magnetic field of magnets which is attached under each spawn's, these sensors than changes its state to open-close circuit. Each 8 rows in the chess board can contains eight different square blocks that will connects with data to selected multiplexer 8 to 1.

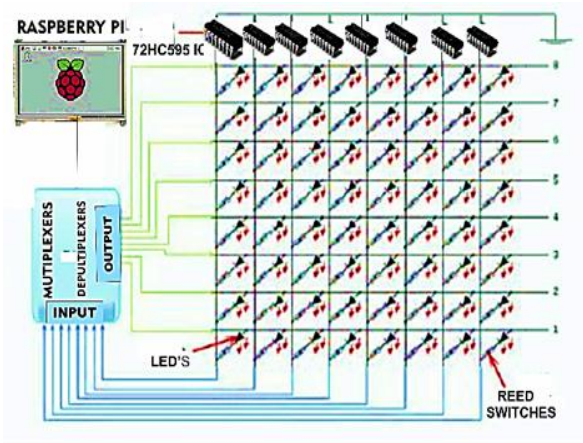

Figure 1. Hardware Design

The IC's (74HC595) is implementing the multiplexing method. The output which comes from the multiplexer data is the input to the raspberry pi. In this way the implementation of reeds switches is simply be placed under the chess board. Figure 1 demonstrates how the reed switch works on the chessboard. It can also simply show the setting of the sensors design for the electronic chess set. Figure 2(a) showing the reed switches state when it is in 'OPEN' circuit. The spawns are then attached with the magnets placed into the chess board of each square. Therefore, then these reed switches work when the magnet is placed on them. In this way, the working of the reed switches is attached beneath the chess board. Then the magnet is far from the reed switches, this placement of Reeds switches is opened in that way it gets its movement and location. In figure 2(b) it shows the sensors when it is in 'closed' state. In that way when spawns are attached with magnets the sensor closes its state from "Open state - Close state". As using this type of circuits, the result we get will have 0V value.

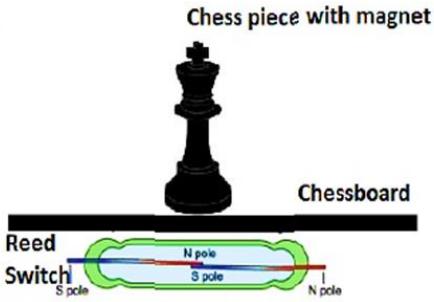

Figure 2(a) Attach reed switch to chess board "Close State"

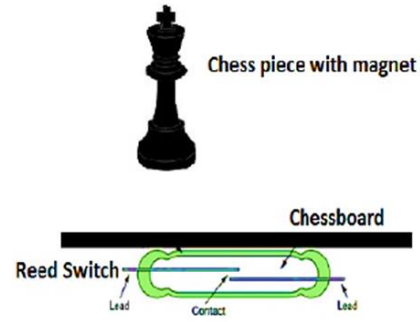

Figure 2(a) Attach reed switch to chess board

which we say (logic ‘0’) and the sensors is in open state. It will give the value of 5V value which we say (logic ‘1’) when the sensors are in close state. The smart electronic chess playing system requires the 64 of the reed switches as sensors because whole chess board game will have 64 blocks and each square of the chessboard are needed a sensor which is placed under each block, therefore we required the 64 inputs and all inputs is connected to raspberry pi. So hence there are too bulks inputs required to connected to raspberry pi. There we can use multiplexer 8 to 1(74HC595) is placed into our chessboard game. So that will reduce inputs in the raspberry pi i.e. 64 inputs into eight inputs only. All inputs can represent the columns of the chess board. The IC (74HC595) multiplexer is consists of three inputs selector. These three inputs can select it to each of multiplexer will interconnected and become one common input.

3.2 Software Design

Our smart electronic chess playing system the chess board represents to 8x8 matrixes into the stock fish chess game as present in Fig 3(a).

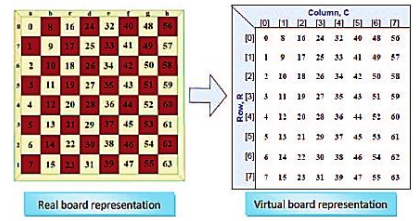

Fig. 2. Real and virtual board representation

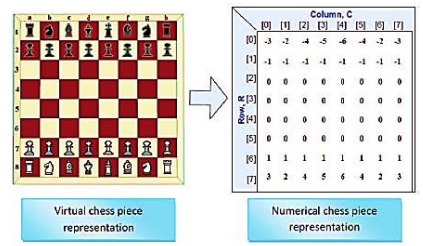

Figure 3 Software Design

The numbers and the matrix into the chess board game can be represents by the decimal value codes for each of Separate Square in the chess game. The 8x8 matrixes can uses the python programming codes to analyzing and validating the destinations of the current spawn’s locations as shown in Fig. 3(b) shows the virtually and numerically representations for spawns’ these all processing is done

in the stock fish engine. Negative signs on the chess board is showing black spawns, also positive signs are showing the white spawn's positions. The non-fill squares in the chess game is showing by zero sign in the game engine software. The virtually spawns are showing is presents into the computer system screen, while another information is also showing in computer display relates to the programming codes.

3.3 System Flow

When the chess game starts a single spawn is put it on the chess board. When as movements identify its code. The Raspberry pi gets the 64- to- 6-line cascading multiplexer is to take the codes from sensors which can be based it on the fixed sides to identify its code [15]. All the processes are to be repeats itself until all the spawns are puts it on chess board system. This whole process is representing in Figure 4.

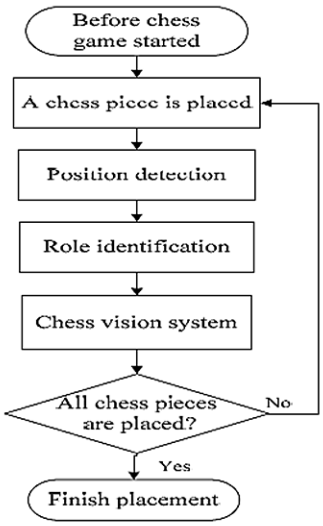

Figure 4 System Flow

When the user can pick the spawn into the chess board, then 64-to-1 way forward multiplexer can detect that which spawn is to be raised it on the chess board. Hence, then the proper placement position of the current spawn is to be analyzing by stock fish system and then it will be sending the data to the 64-bits serially-in to parallel-out shifting registers to opens the sensor switch and OPEN the LEDs of the picked spawn [21]. Therefore, while placing back the spawns to its right place into the chess board, the sensors can detect the placement of the spawn and then sending this spawn information to the chess system. This whole process is then repeating itself until and unless the whole chess game is not ended. When spawn is placed it on the chess board the reed switches closed the circuit due to

magnet which is placed lower side of the spawn's and light switch "ON". It will send signal to the 74HC595 IC which controls the piece position and in turn send command in raspberry pi that the move is placed. The 64-to-8-line cascade encoder detecting that in which movements the spawns is placed and it will create a decimal code as movement identification code [24]. The Raspberry pi setting the 64- to- 6 lining cascading the multiplexers to get these binary codes of the reed switches which depends to the fixed positions of identifying that codes.

3.4 Circuit Design

As we can explained in above portion, the prototyping can utilize the Raspberry pi as the main supporting part that can takes the different inputs into the chess board by the help of reed switches, and then transmitting these collected data into the output devices in to the computer screen. Hence an advantage by using Raspberry pi have enough numbers of inputs and outputs pins for the proposed system. The prototyping which we can used can required.

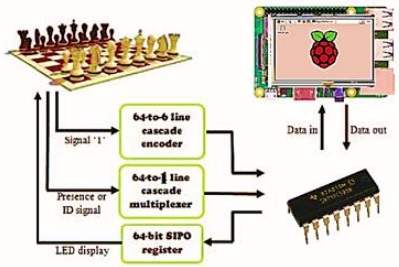

Figure 5 System flow of smart electronic chess

sixty-four reed switches and sixty-four LEDs. Therefore, we can design a smart electronic chess board game system to overcome the electricity and to run on power bank. Initially, as display in Figure 5. The 64-to-6-line cascading encoder is to be prepared by using 8-input NAND gates as shown in Figure 6.

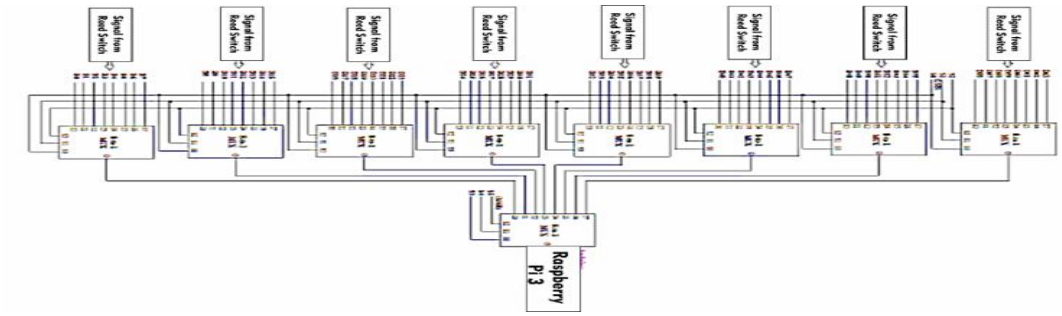

Figure 6 Block diagram for the 64-to-1-line multiplexer

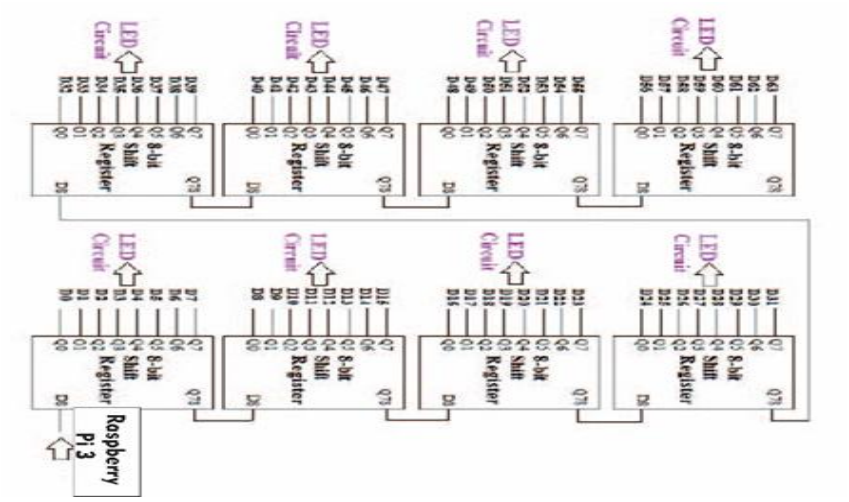

Figure 7 Block diagram of the 64-bit serials-into parallel-out shift registers

to converting the actively low states into binary points to inputting the active-high binary output code as shown in Figure 7. For example, if a spawn is placed into the chess board 'b8' which represents the decimal code '7', the LED's in the reed switches at the 'b8' location will detects the spawn, and then produces the signal to the cascade encoder. The cascading encoder encodes the decimal codes '7' into binary results '11100' as a movement's code to be transmitted to the Raspberry pi. Hence, the used of multiplexer in which 64 - to – 6 Line cascading encoding function will perform its task as a movement of the spawns in the chess board. Then, the next digital circuit is a 64-to-1-electronics line multiplexers that can works circuits cascading by taking the positions. [25].

4. Scanning Algorithm

When our system starts the game, each spawn is placed to its own position in the chess board, then first it can get the spawns in the chess board by the help of reed switches and then compared it to the output of the final known chessboard positions and then saying to robotic

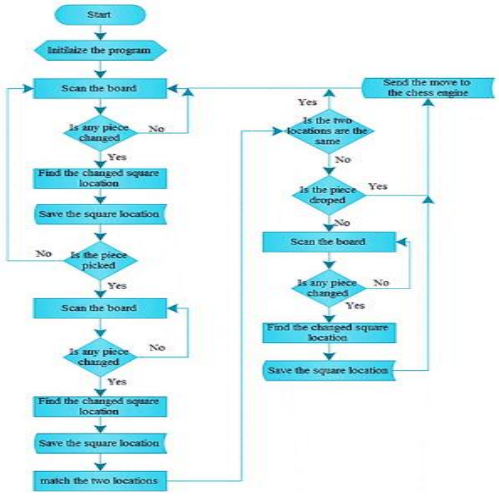

Figure 8 Smart chessboard algorithm

5. Smart Electronic Chessboard

The implementation of smart electronic chessboard system is display in Fig 8. The body to the plain board of the chess game are 54 cm * 55.8 cm and the weight is 7.5 cm. The smart chess board have left to right pads where captured pieces are inserted. Raspberry pi is placed inside the board. The computer screen is placed in top of the board where the Python programming codes is taking to converts the inputs from all the positions of the spawns onto the electronic chessboard in the text format. Furthermore, it can also display the positions history of spawns and game timing in written form on the computer screen.

Figure 9 Smart electronic chess playing system

6. Testing

The primary aim of this testing was to ensure that all move positions and validations performance as it should do, and to identify possible bottlenecks in the program that could be optimized to improve the overall performance of the program. Testing was also expected to be performed on the program's artificial intelligence, series of tests conducted to determine whether all the sensors, LED's and IC's are working correctly or not also check the system performance. For invalid move or incorrect pick, it recovers or not. The software program in Raspberry pi is required to analyze the valid destinations of the current spawn during a chess game. There we have some general moves for the movements of pawn, knight, rook, bishop, queen and king in chess game.

7. Results and Analysis

The aims of this project smart electronic chess playing system were to build an efficient chess game that enforced all the rules of chess and allowed play between one player, and a functional chess engine, capable of making on-the-fly decisions based on the ever-changing state of play, such that it is capable of providing a challenging game experience to a player of average skill. Our main objective is to design this game which are successfully achieved is to replace expensive motors and physical robotic arm that sometimes create technical issues during the game and at the same time it stops the engine as they are unable to recover it, as there are so many complexities available in this game i.e., by pick up the marked spawn and place it into their desired position is some time negligible in old systems. The electronic chess system the robot for this situation can have the task to show its behavior to the opponent, in this way it can increase the general performance by marking the spawn very precisely and continuously analyzing the whole board positions and the chance to get stuck is completely resolved. In this way people can enjoy their game without any interruption. This system can be used as a general robotic system because it has more functions to get the human-to-human interaction. That way we can learn that it is a right selection to interact to our general chess playing system.

8. Conclusion

The main contribution of this work was to design and implement the model of smart electronic chess board system. This implementation was achieved by the used of reed switch and raspberry pi which we can implement it accordingly to our aim, by replace the motors and expensive physical arm that was previously

used and also replace the old algorithm with Min-Max algorithm due to not completely be able to configure it properly and stuck problem in the middle of the game, and sometimes it also violates the game rules, moreover, our system has the ability to get store all the positions of the spawns in advance when game starts that where it is placed on the chessboard and continuously scanning all the board in every time. It also has the ability to show the movements of the spawn's history and game timing on the chess program. To conclude, we have achieved the objective of developing a chess physical board by using cheap electronic circuits. Inspired by computer chess game, this model is worked with socially and physically with the general chessboard games, with the virtually interface of only one user in automated chess game. We named our model "Smart Electronic Chess System". The results we have two experiments to made this automated chess game suggests that player first understands all the game state and rules when they are getting play as the agent's behavior in real life situation, also participants had more fun with chessboard game that can using an automated robot player than of those player that can playing the chess game against a same with a reality virtual opponent in a GUI (graphical user interface). Moreover, another tests can evaluate shows that the opponents get suggested our smart electronic chess game over their ordinary chess game software's. There results show us that automated chess games can be considered best which is based upon our model and is completely played by a wide range of people around the world. By working and learning different fields of computers games we can see different paths that we can bring back computerized chess back into the real-world environment. Therefore, the other versions of computer's game can also be inspired to us that we can make such other innovating games in future.

Declarations

Competing Interests

The authors declare that they have no competing interests.

Authors' Contribution

All the authors have contributed in the paper.

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