Design of Artificial Neural Networks System for Intelligent Chessboard

Alaa Hamza Omran
Department of Information System Management
University of Information Technology and Communication
Baghdad, 00964, Iraq
Alaa.hamza90@uoitc.edu.iq

Yaser M. Abid
Department of Business Information Technologu
University of Information Technology and Communication
Baghdad, 00964, Iraq
yasseralasady@uoitc.edu.iq

Dr. Huda Kadhim
Department of Information System Management
University of Information Technology and Communication
Baghdad, 00964, Iraq
Dr_hudakj@yahoo.com

***Abstract* - A Chess game is rather difficult for the beginners to understand all its rules and conditions. The intelligent chessboard is used for learning these conditions and positions for all its pieces. In this paper, an intelligent system is proposed that helps the users to know all the correct positions of each piece on the chessboard; furthermore, this system is characterized by the simplicity of the implementation and the low cost of the hardware components. As knowing, in chess game there are six pieces which have different ways to move on the chessboard according to each player, these pieces are pawn, rooks, knights, queen, bishops and king. However, the proposed system trained these pieces individually 64 states for each piece in order to move on the chessboard squares correctly. A back propagation neural networks are used in the training algorithm; and LEDs are used to guide the players to the available correct positions where each piece can moves on.**

Index Terms – Back Propagation Neural Network, Intelligent Chessboard, Artificial algorithms, Chess game, intelligent controller.

I. Introduction

As knowing, chess game is considered as the one of the excellent games which used to test the abilities and intelligence of human brains. It was developed in India and played for many years due to its attributes which can help in many fields such as putting military plans. Nowadays, chess game became as the one of the most important sport's activities in schools. Two players one against the other are needed to play the chess game and in the case of exciting the two players faraway from each other; the games can't be played [1]. Therefore, researchers resorted to connect the modern technologies methods with the standard design of the game; they tried to evaluate it through using computer devices [2][3]. The uses of computers in chess game enable the players who are far away from each other to play the game. Furthermore, it enables the players from playing the game individually; however, sitting for a long time on the computer devices has several disadvantages such as damaging the sight, headache and etc. Artificial neural networks (ANN) used in many area of researches for its efficiency in producing results [4][5][6]. Researches also try to design an intelligent chess game through using cost and complex electrical circuit.

However, there are many researches in this area; [7] presents a system which detects the movement of a chess game through using RGB webcam which capture video frame. MATLAB was used to implement all the steps. However, this system obtained 162 of 164 moves correctly in three games played under different illumination conditions which means incorrect positions may be obtained during the game as well as it needs to a webcam to capture a video then processing this frame to obtain the position which results in complex, high cost and low accuracy system. [8] Presents a robot plays chess game against human opponents; it uses five degree of freedom (DOF) robotic known as Lab-Volt 5150 robotic manipulator. It built a smart chessboard to track the opponent's movement and network control system to the network exchanges the necessary information between the system parts. However, the system designs a smart board to track the opponent's movement rather than built a chessboard which can help the user to play the chess game correctly. [9] Presents a system that can be controlled by a computer device where PC's parallel port and AT89C51 are used to control the chess movements; however, it doesn't take into consideration a specific way which can helps the user to play the chess game correctly. [10] Presents a robot which can play Chinese chess with human and determining the pieces on the chessboard and moves them using its mechanical arm. However, this system as the previous systems that doesn't focuses on the moves of chess's piece on the chessboard. [11] Presents the design and the implementation of chess set using electronic circuits and MATLAB software for educational purposes. The electronic chess designed in order to attract all the interesting of chess game from the children and provides simple basic rules for beginner. The real situation of the chess game is also displayed on the computer screen using graphical user interface (GUI).

II. THE PROPOSED SYSTEM

This paper proposes an intelligent chessboard which deals with chess pieces according to its attributes without needing for computer devices. It uses simple and low cost electrical circuit in designing. The proposed system which obtained the correct position for each piece on the chessboard consists of 64 laser diode, 64 push button, 64 LEDs and for each chess piece LDR sensor is used to detects, and recognizes which chess's piece should be moved this mean using 32 LDR sensor in the proposed system such as shown in figure (1). The proposed intelligent chessboard trained to detect which piece should be moved and what are the available positions where this piece can move on.

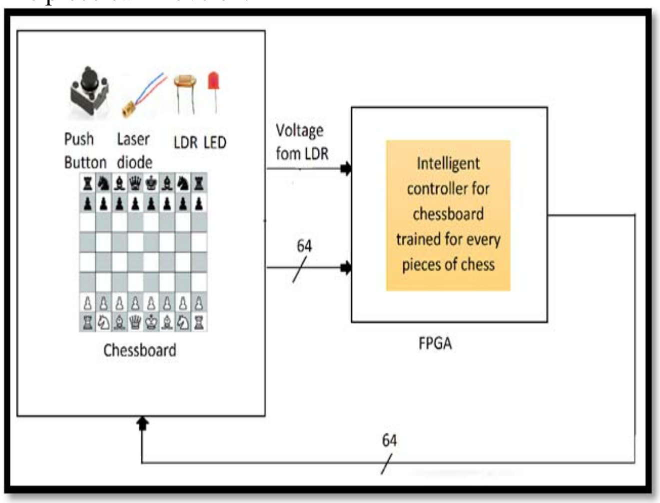

Fig. 1 The block diagram of the proposed system

The detection process occurs through determining a specific range of LDR output voltage for each piece. The LDR sensor connected to different constant resistors to obtain the voltage divider where these resistors are used to control the range of the output voltages when a light falls on the LDR sensor as shown in figure (2).

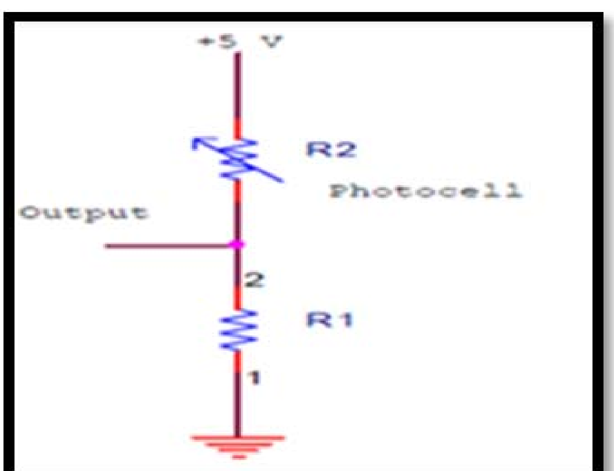

Fig. 2 LDR sensors connected in series with resistors

The voltages which used to specify the pawn are divided into two ranges due to its different direction of movement whether these movements were forward or backward as shown in table 1.

Where the range of voltages 2.6v to 3v are used to recognize the white pieces while the range of voltages 3.1v to 3.5v are used to recognize the black pieces of the pawn.

The chess game has four pieces of rooks, four pieces of knights, four pieces of bishops, two pieces of kings, and two pieces of queens. These pieces are equally divided into two teams black and white. Rooks pieces, black and white rook, have the same direction of movements on the chessboard; therefore, these four pieces have the same range of voltages 0v – 0.5v which provide the ability of moving in forward and backward direction. Also, knights' pieces, black and white knight, have the same range of voltages 0.6v – 1v which provide the ability of moving them in forward and backward direction. Bishop's pieces, black and white bishop, have the same range of voltages 1.1v – 1.5v which provide the ability of moving in forward and backward direction. Furthermore, king pieces, black and white king, have the same range of voltage 1.6v- 2v which provide the ability of moving them in forward and backward direction. Finally, the queen pieces, black and white queen, also have the same range of voltage 2.1v- 2.5v which enable them from moving forward and backward on the chessboard. The range of voltages for each piece of the chess game is shown in table 1. Potentiometers were used instead of using constant resistors and its values were adjusted by experimental results for each piece individually. For example, the king have ranges of voltages (1.6v – 2v), when the light falls on LDR of the king, the voltage which produced from the voltage divider result must be constant in ideal case however, in the theoretical results it changes according to the value of the LDR resistance; therefore, the voltage which produced may increases or decreases according to the change in resistance and give each piece of chess ranges of voltages to overcame the problem that may happen; and when the voltage produced form the voltage divider for example 1.65V the intelligent system trained to detect and recognize the piece was "king" when any voltage in close ranges limited, each Potentiometer value of all pieces adjusted in experimental results and consider as constant resistor.

TABLE I
THE RANGE OF OUTPUT VOLTAGES WHICH SPECIFY ALL PIECES OF CHESS

Name	Range of voltage
Rooks	0v - 0.5v
Knights	0.6v – 1v
Bishops	1.1v – 1.5v
kings	1.6v – 2v
Queens	2.1v- 2.5v
White pawn	2.6v – 3v
black pawn	3.1v – 3.5

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III. SIMULATION RESULTS OF TRAINING

A back propagation neural network is used to train all the pieces of the chess game individually. Trial and error method used to determine the number of layers and the number of neurons for each layer.

A. Rooks

The chessboard is trained on the probability of the rook movement in all squares; figure (3) shows the neural network for the rook training. The simulation results of the neural networks for the rook training are shown in figure (4).

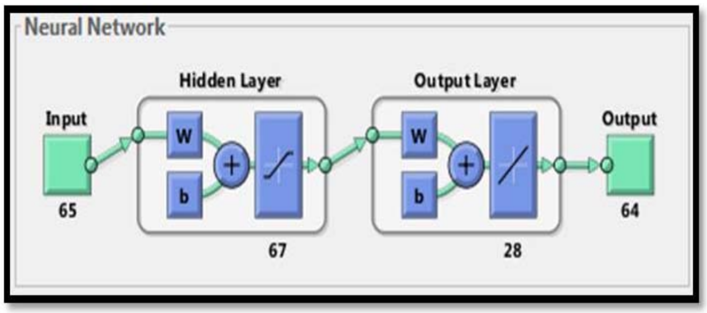

Fig. 3 Neural network used for rook training

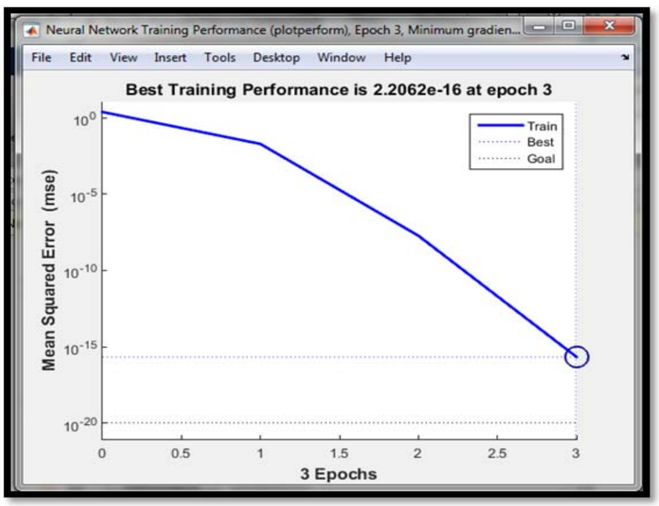

Fig.4 The simulation results of rook movement training

Each square on the chessboard has a specific number; suppose the square which has number "1" is the current position of the rook on the chessboard as shown in figure (5), a simple pressing on the rook piece will results in pressing on a push button that would send a signal to a diode laser which its light will falls on the LDR sensor, then the position of this rook piece will be recognized according to the specific range of voltage. The reorganization process will results in changing the state of the red LEDs to on, then the following squares (2, 3, 4, 5, 6, 7, 8, 9, 17, 25, 33, 41, 49, 57) will be glowed to determine the available position that the rook can moves on.

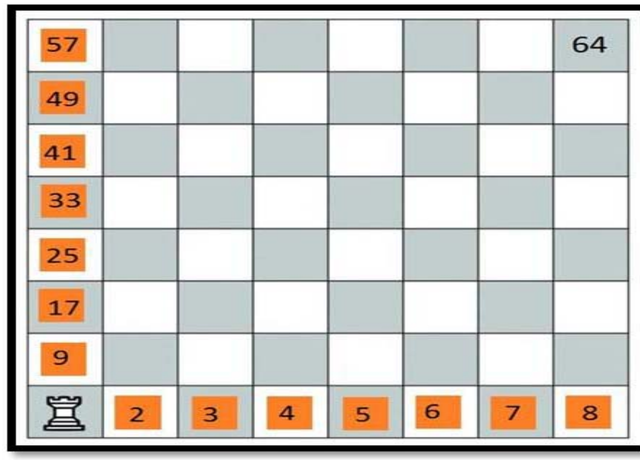

Fig. 5 The position of the rook piece and its movements on the chessboard

All the other possible movements of the rook piece are trained in the same way. The simulation results of the rook piece movements are shown in figure (6).

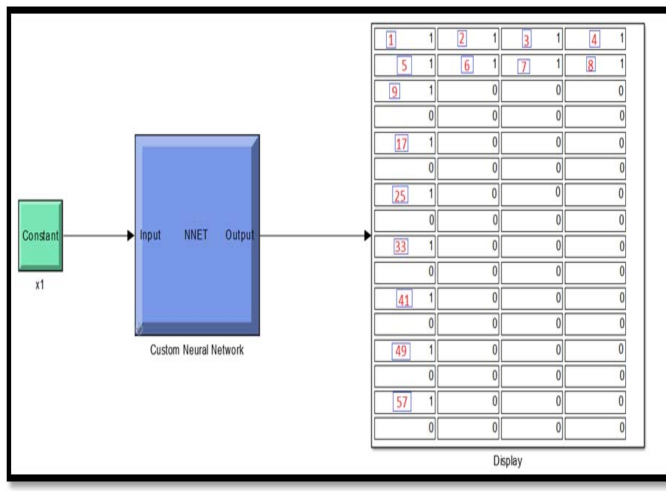

Fig.6 Simulation results of rook piece movements

B. Knights

The chessboard is trained on the probability of the knight movement in all squares; figure (7) shows the neural network for the knight training. The simulation results of the neural networks for the knight training are shown in figure (8).

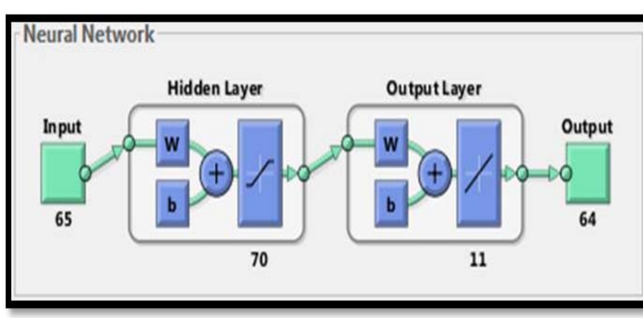

Fig.7 Neural network used for knight training

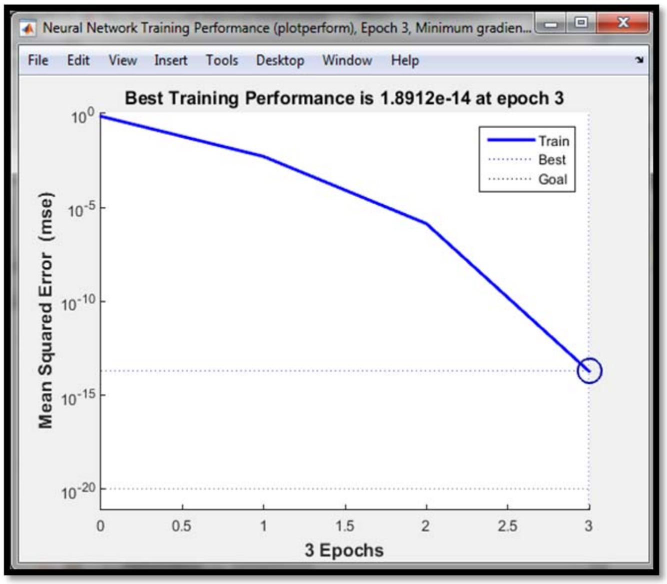

Fig.8 The simulation results of knight movement training

Suppose the number of the square which presents the current position of the knight piece on the chessboard is "37" as shown in figure (9). As discussed previously in the rook scenario, the simple pressing on the knight piece will results in pressing on a push button that would send a signal to a diode laser which its light will falls on the LDR sensor, then the position of this knight piece will be recognized according to the specific range of voltage. The reorganization process will results in changing the state of the red LEDs to on, then the following squares (20, 22, 27, 31, 43, 47, 52, 54) will be glowed to determine the available position that the knight can move on.

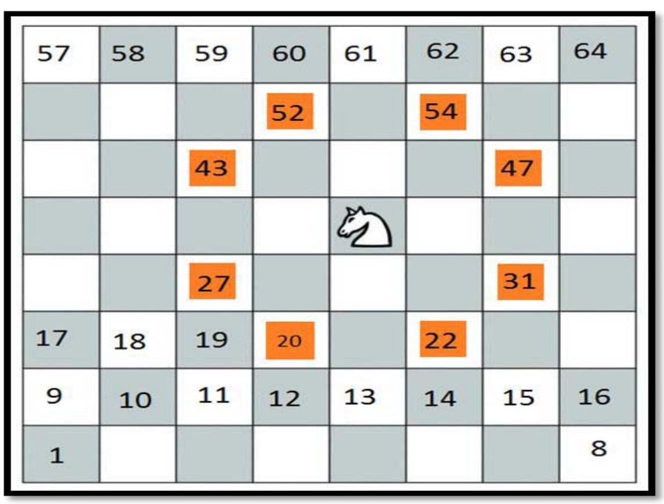

Fig.9 The position of the knight piece and its movements on the chessboard

All the other possible movements of the knight piece are trained in the same way. The simulation results of the knight piece movements are shown in figure (10).

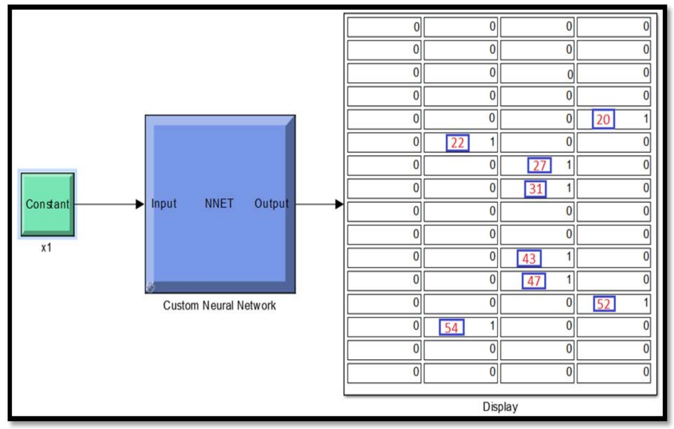

Fig.10 Simulation results of the knight movements

C. *Bishops*

The chessboard is trained on the probability of the bishop movements in all squares; figure (11) shows the neural network for the bishop training. The simulation results of the neural networks for the bishop training are shown in figure (12).

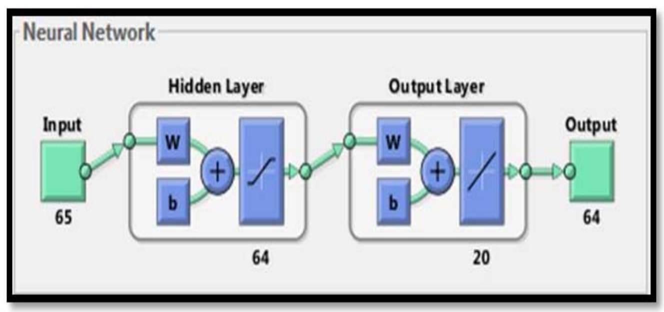

Fig.11 Neural network used for Bishop training

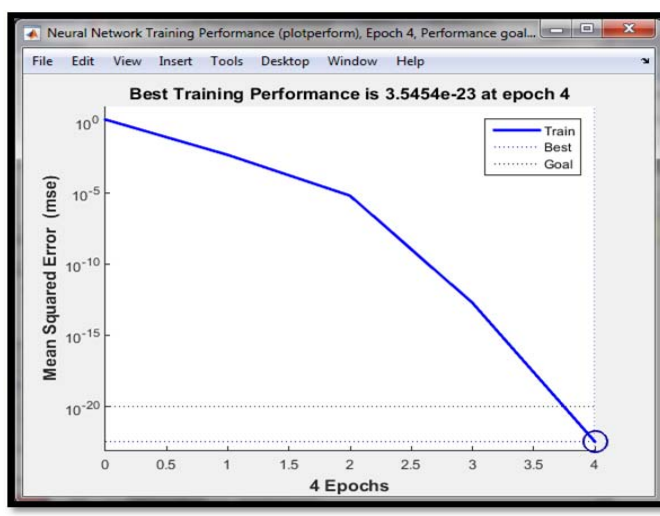

Fig. 12 The simulation results of Bishop Movement training

As the previous scenario of the rook and knight pieces; suppose the square which has number "22" is the current position of the bishop on the chessboard as shown in figure

(13). As discussed previously in the rook scenario, the simple pressing on the bishop piece will results in glowing the following squares (4, 8, 13, 15, 22, 29, 31, 36, 40, 43, 50, 57) to determine the available position that the bishop can moves on.

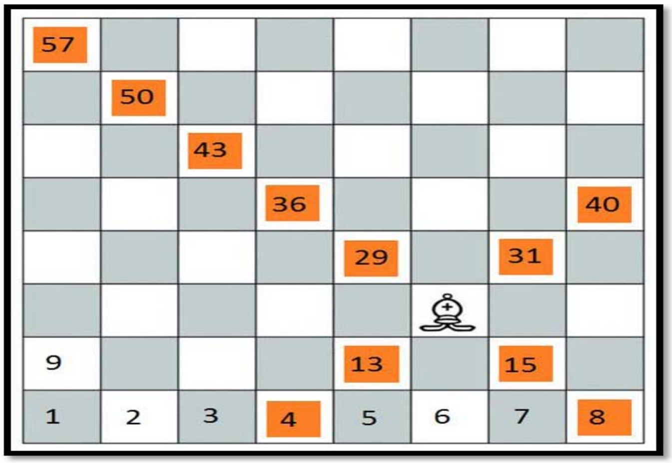

Fig. 13 The position of the bishop piece and its movements on the chessboard

All the other possible movements of the bishop piece are trained in the same way. The simulation results of the bishop piece movements are shown in figure (14).

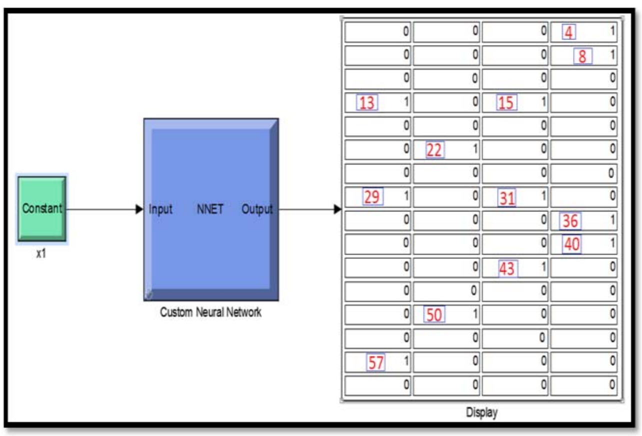

Fig. 14 Simulation results for Bishop when pressed at chessboard square '22

D. kings

Also, the chessboard is trained on the probability of the king movements in all squares; figure (15) shows the neural network for the king training. The simulation results of the neural networks for the king training are shown in figure (16).

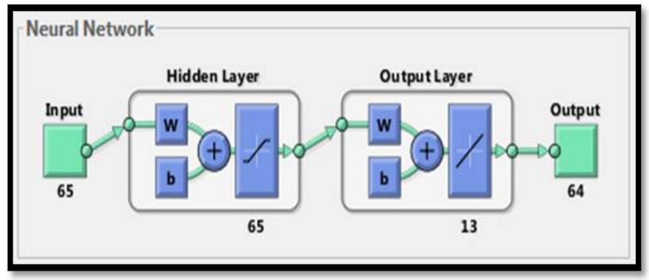

Fig. 15 Neural network used for kings training

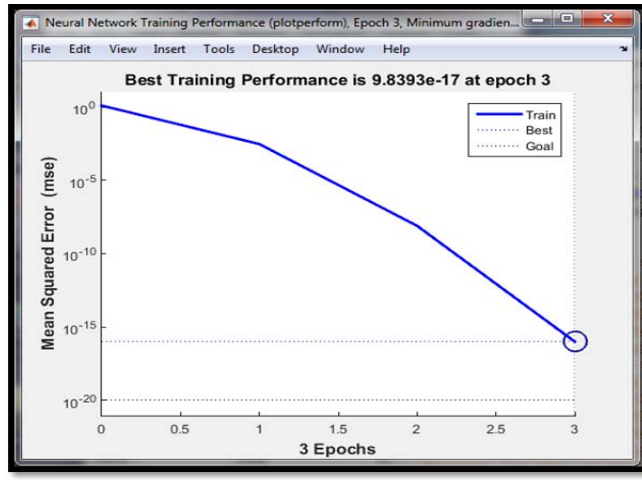

Fig. 16 The simulation results of king movement training

Suppose the square which has number "43" is the current position of the king on the chessboard as shown in figure (17). As discussed previously in the rook scenario, the simple pressing on the king piece will results in glowing the following squares (34, 35, 36, 42, 43, 44, 50, 51 and 52), to determine the available position that the king can move on.

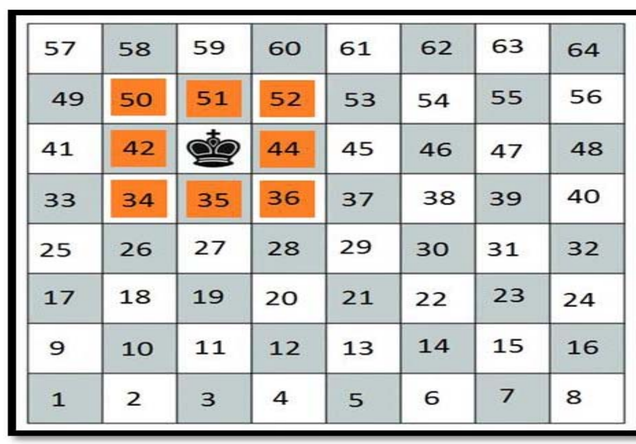

Fig. 17 The position of the king piece and its movements on the chessboard

All the other possible movements of the king piece are trained in the same way. The simulation results of the king piece movements are shown in figure (18).

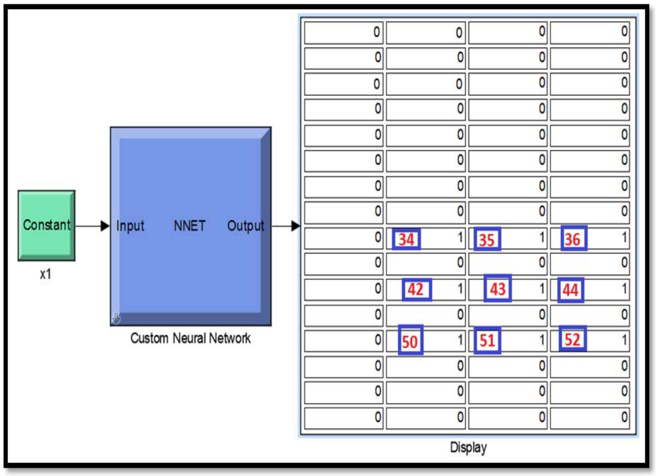

Fig. 18 Simulation results for kings when pressed at chessboard square "43"

E. queens

Also, the chessboard is trained on the probability of the queen movements in all squares; figure (19) shows the neural network for the queen training. The simulation results of the neural networks for the queen training are shown in figure (20).

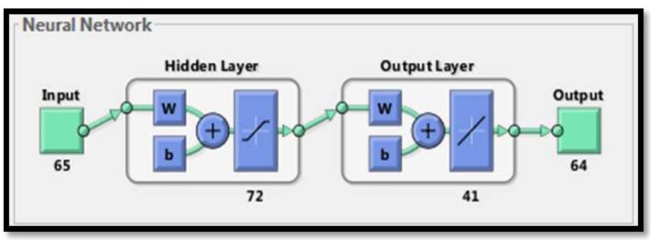

Fig. 19 Neural network used for queen training

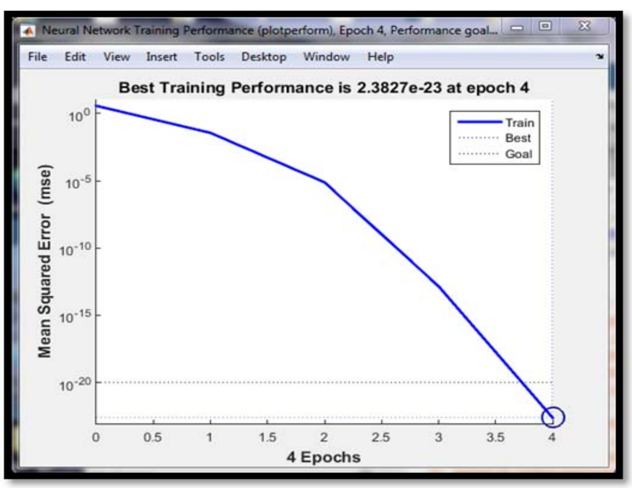

Fig. 20 The simulation results of queen movement training

Finally, the scenario of queen movements like the previous scenarios of the other pieces, suppose the square which has number "31" is the current position of the queen on the chessboard as shown in figure (21). As discussed previously in the rook scenario, the simple pressing on the queen piece will results in glowing the following squares (4, 7, 13, 15, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 38, 39, 40, 45, 47, 52, 55, 59, 63) to determine the available position that the queen can moves on.

Fig. 21 The position of the queen piece and its movements on the chessboard

All the other possible movements of the queen piece are trained in the same way. The simulation results of the queen piece movements are shown in figure (22).

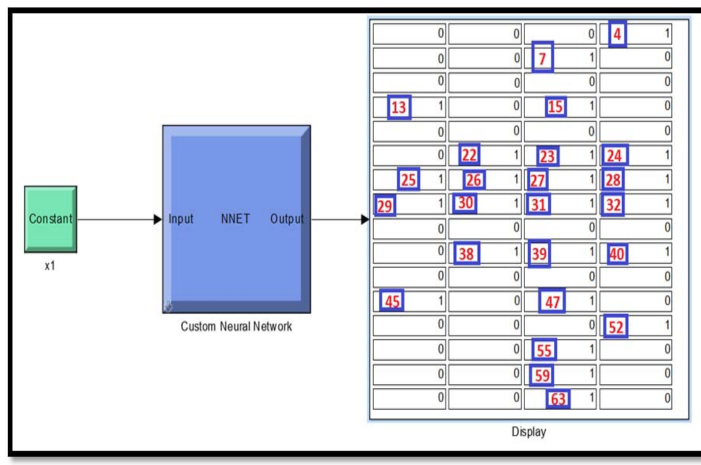

Fig. 22 Simulation results for queen when pressed at chessboard square "31"

Figure (23) shows the full intelligent chessboard where all pieces trained and test for different situations. It can be convert to VHDL code by HDL coder in MATLAB in order to download in of FPGA cart for hardware implementation.

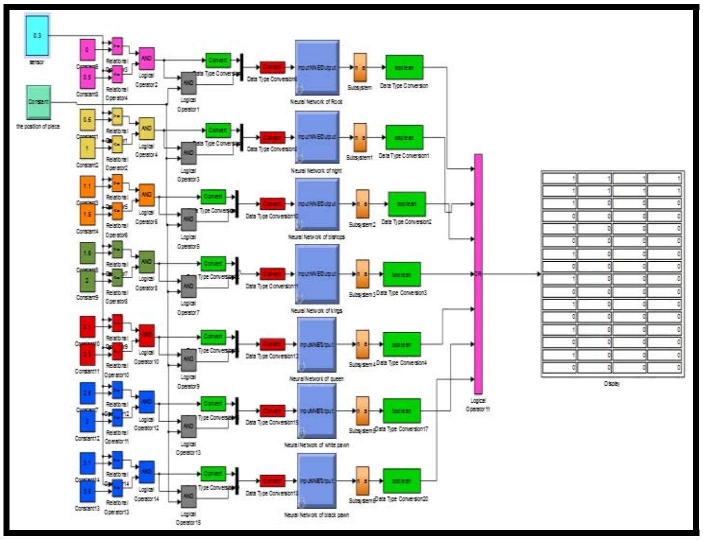

Fig. 23 the proposed intelligent chessboard system

IV. CONCLUSION

In this paper, an intelligent chessboard was proposed; it trained to guide the player to the available correct positions where the chess pieces can moves on. Back propagation neural networks algorithm is trained individually for each piece of the chess (pawn, rooks, knights, bishops, queen and king) and testing all the pieces for the different situation with different positions of the chessboard. The hardware part of the proposed intelligent system can be implemented using FPGA cart due to its simplicity, efficiency and reprogramming ability.

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