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IMPLEMENTATION OF THE CHINESE CHESS GAME WITH THE COMPUTER USING ARTIFICIAL INTELLIGENCE

Kuo-Lan Su[1,*], Shen-Ta Su[2], Kuo-Hsien Hsia[3] and Bo-Yi Li[2]

[1]Graduate School of Electrical Engineering
[2]Graduate School of Engineering Science and Technology
National Yunlin University of Science and Technology
No. 123, University Road, Section 3, Douliou, Yunlin 64002, Taiwan
[*]Corresponding author: sukl@yuntech.edu.tw; g9910810@yuntech.edu.tw

[3]Department of Computer Science and Information Engineering
Far East University
No. 49, Zhonghua Road, Xinshi, Tainan 74448, Taiwan
khhsia@cc.feu.edu.tw

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Abstract. *The article develops the decision rules to win each set of the Chinese chess game using artificial intelligent method, and presents the movement scenarios of the chesses using mobile robots on the chessboard platform. Users play the Chinese chess game with the supervised computer using the mouse according to the evaluation algorithm of the game rules on the user interface. The user interface of the supervised computer controls mobile robots according to the programmed motion paths of the chesses moving on the platform via wireless RF interface. We use the enhanced A* searching algorithm to solve the shortest path problem of the assigned chess. The supervised computer will select which chess moving to the best position to win the set using artificial intelligent method. Then we use simulation method to display the motion paths of the assigned chesses on the user interface. The supervised computer implements the simulation results on the chessboard platform using mobile robots. Finally, we make a famous set to be called "seven stars in one" to implement the proposed method.*
Keywords: Chinese chess game, Artificial intelligent method, Mobile robots, Evaluation algorithm, Wireless RF interface, Enhance A* searching algorithm

1. **Introduction.** Chinese chess game is one of the most popular games in China. A two-player game with a complexity level is similar to the Western chess, and is classified red side and black side. Recently, the Chinese chess game has gradually attracted many researchers' attention, and many evolutionary algorithms are to be proposed. Darwen and Yao proposed the co-evolutionary algorithm to solve problems where an object measure to guide the search process is extremely difficult [1].

There are many algorithms to be proposed in Chinese chess game. Su et al. developed smart mobile robot using voice module, and programmed the motion trajectories for multiple mobile robots based Chinese chess game [2] and developed decision rules of the Chinese chess game using evaluation algorithm and presented the movement scenarios of the chesses using mobile robots [3]. Kong et al. used adaptive harmony search algorithm to solve optimization problems [4]. Fu and Yin used the position evaluation function to play an important role for building an intelligent chess computer game [5]. In some conditions, the mobile robot must program the shortest path and avoid the other chess moving to the next position. A* heuristic function is introduced to improve local searching ability and to estimate the forgotten value [6]. We proposed the enhanced A* searching algorithm to decrease the movement distance to be shown in [12].

Qiu et al. used Hash Table to improve the efficiency of pruning for computer game, and implemented the proposed techniques to be very useful [7], and developed a common platform of two-person player game according to the characteristics of computer game, such as Dots and Boxes, Surakarta, Connect-six and Amazons, too [8]. Mei et al. described the computer game about Military chess's protocol and the war platform's system framework, key technologies and the prospect of application [9]. Lu et al. introduced a brand new competition based on a 2D fighting game written in Java, and focused on a genre called fighting game to be Street Fighter, Tekken and Mortal Kombat, and selected the winner in the fighting game with less damager or the last one standing [10].

2. **Mobile Robot.** The mobile robot has the shape of cylinder, and it is equipped with a microchip (MCS-51) as the controller, two DC servomotors and driver devices, some sensor circuits (contain compass circuit), a voice module, three Li batteries, a wireless RF interface and three reflect IR sensor modules. Meanwhile, the mobile robot has four wheels to provide the capability of autonomous mobility. The structure of the mobile robot is shown in Figure 1.

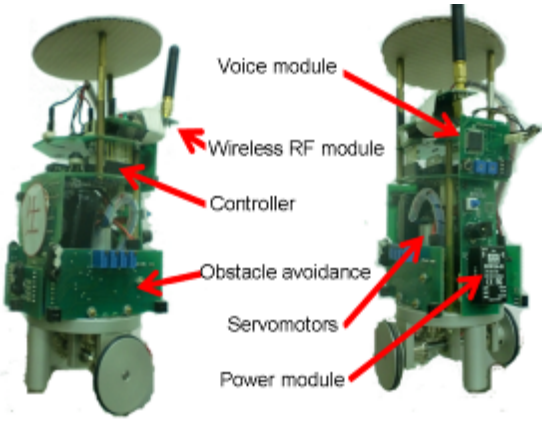


FIGURE 1. The mobile robot

The core of the wireless RF module is microprocessor (AT89C2051), and communicates with the controller of the mobile robots via series interface (RS232). The communication protocol of the system is 10 bytes. There is a start byte (Byte 0), eight data bytes (Byte 1 to Byte 8) and a check byte (Byte 9). The communication protocol is listed in Table 1 from the computer to mobile robots. The communication protocol is listed in Table 2 from the mobile to the computer. The start byte trigs the wireless RF module to transmit or receive the signals from the transmitter of the computer or mobile robots. The data bytes contain ID code (1 byte), robot code (1 byte) position and orientation data bytes. The ID code decides the transmitting direction between the supervised computer and mobile robots. The check byte can decide the format of the transition data to be right or not.

TABLE 1. The communication protocol from the computer

Byte	0	1	2	3	4	5	6	7	8	9
Definition	Start	ID	R_CH	S_X	S_Y	T_X	T_Y	R_D	Go_Flag	Check

TABLE 2. The communication protocol from mobile robots

Byte	0	1	2	3	4	5	6	7	8	9
Definition	Start	ID	R_CH	R_X	R_Y		R_D			Check

We use evaluation algorithm to decide the movement method of chess. The evaluation algorithm calculates and compares the scores of the moveable chesses, and decides a movement method of the assigned chess by the player. The proposed algorithm compares the evaluation scores of the moveable chesses. The evaluation score adds side score, moveable score and relation score. The supervised computer can compare which score to be maximum of both sides, and calculate the evaluation score using the total scores of both sides. The proposed algorithm is described in [11].

3. **Experimental Results.** We make an example to explain how to implement in Chinese chess game, use Artificial Intelligent method and evaluation algorithm to decide the moving chess with the highest evaluation score, and use enhance A* searching algorithm to program the shortest motion paths of the assigned chesses from the start positions to the target positions. There are seven chesses (one king, two rooks, one cannon, three pawns) in red side and seven chesses (one king, one advisor, one rook, and four pawns) in the black side shown in Figure 2. Movement process of the set belongs to two players (one is player and the other is computer) shown in Table 3 until one side to win the set. In the first step, the player moves red cannon from $(8, 8)$ to $(6, 8)$. The movement scenario of the assigned chess is shown in left side of Figure 3(a) on the user interface. The movement status of the mobile robot is instead of the assigned chess shown in right side of Figure 3(a).

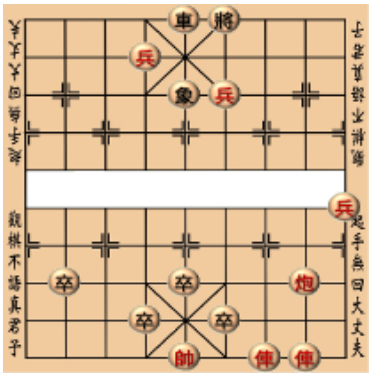
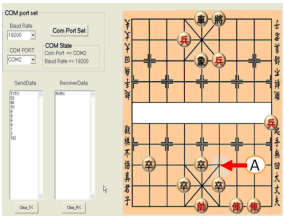
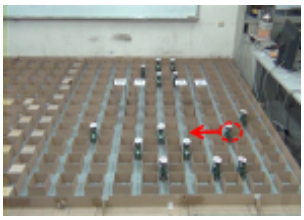


FIGURE 2. Seven starts in one

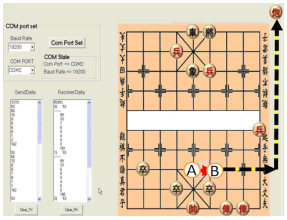
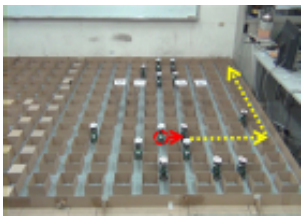
TABLE 3. Movement process of the set "seven starts in one"

	Player (red side)	Computer (black side, using evaluation algorithm)	
		Movement process	Score
First step	Cannon $(8, 8) \rightarrow (6, 8)$	Pawn $(5, 8) \rightarrow (6, 8)$	7
Second step	Pawn $(6, 3) \rightarrow (6, 2)$	King $(6, 1) \rightarrow (6, 2)$	320
Third step	Rook $(7, 10) \rightarrow (7, 2)$	King $(6, 2) \rightarrow (6, 1)$	242
Fourth step	Rook $(8, 10) \rightarrow (8, 1)$	Elephant $(5, 3) \rightarrow (7, 1)$	247
Fifth step	Rook $(8, 1) \rightarrow (7, 1)$	Rook $(5, 1) \rightarrow (5, 0)$	19992
Result		Winner	

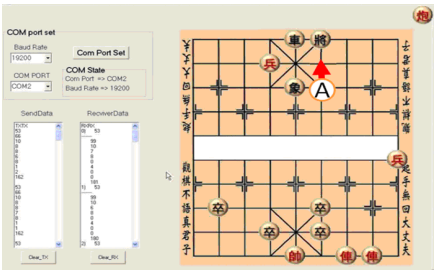
Then the computer moves the black pawn to take the red cannon from $(5, 8)$ to $(6, 8)$. The movement process of two chesses (black pawn and red cannon) are presented on the user interface and the chessboard platform. There are two chesses moving on the chessboard platform simultaneously. The red cannon is taken by the black pawn and moves to the exterior of the black side to be the number $\underline{10}$ from the position $(6, 8)$. The black pawn moves to the position $(6, 8)$ to be the original position of the red cannon. Two chesses have not the collision problem in the step. The movement scenarios of two chesses are shown in Figure 3(b).

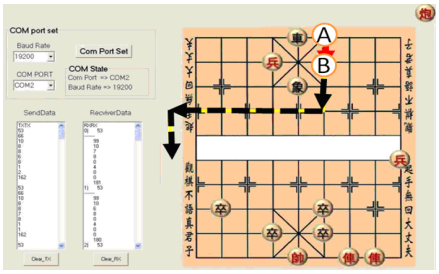
(a) The first step by the player

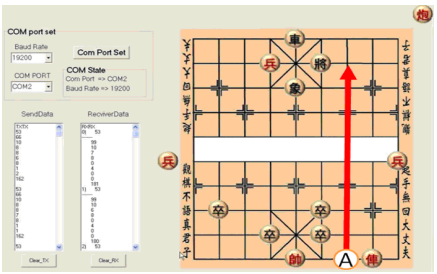
(b) The first step by the computer



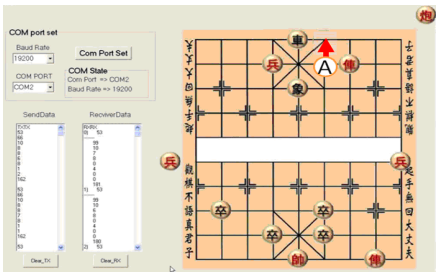
(c) The second step by the player



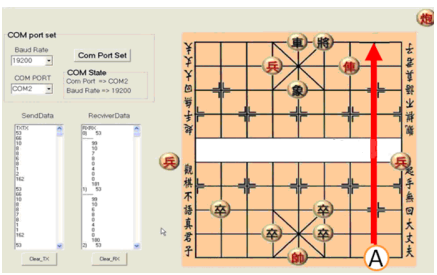
(d) The second step by the computer



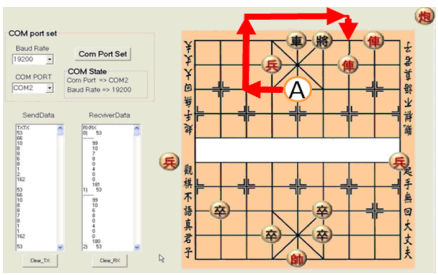
(e) The third step by the player



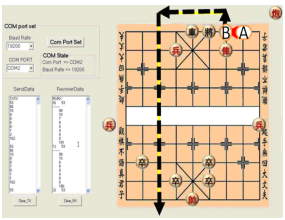
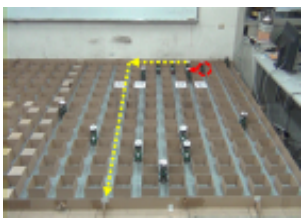
(f) The third step by the computer



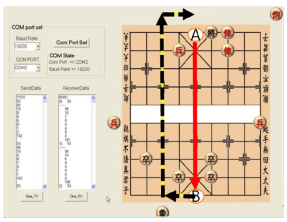
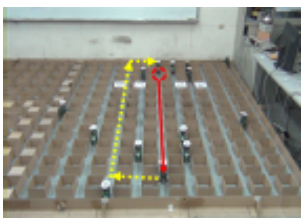
(g) The fourth step by the player



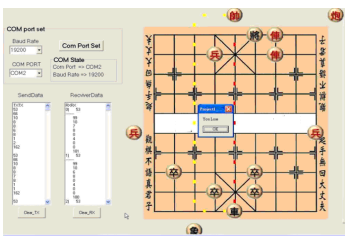
(h) The fourth step by the computer

(i) The fifth step by the player

(j) The fifth step by the computer




(k) (l)

FIGURE 3. Moving process of the set "seven starts in one"

In the second step the player moves red pawn from the position $(6, 3)$ to the position $(6, 2)$, and the computer moves black king from the position $(6, 1)$ to take the red pawn. The red pawn is taken, and moves to the exterior of the assigned position 14. The movement process of the user interface and the grid based platform is shown in Figures 3(c) and 3(d). The score of the second step is calculated using the proposed evaluation algorithm to be 320. In the third step the player moves red rook from $(7, 10)$ to $(7, 2)$, and the computer must move the black king from $(6, 2)$ to $(6, 1)$. Otherwise, the black king will be taken by the red rook, and the game will be ending. The movement scenarios of two chesses (two mobile robots) are shown in Figures 3(e) and 3(f).

The player moves the other red rook from $(8, 10)$ to $(8, 1)$, and the computer moves the black elephant from $(5, 3)$ to $(7, 1)$. The black elephant can protect the black king to be taken by the red rook. The movement status of the mobile robot (black elephant) cannot move to the assigned position from the right side. The mobile robot must program another motion path to avoid the obstacles (red rook and black king) on the platform using enhance A* searching algorithm. The experimental results are shown in Figures 3(g) and 3(h).

Finally the player moves the red rook to take the black elephant from $(8, 1)$ to $(7, 1)$. The black elephant must move to the assigned position (3, 11) to be the number 30. The computer moves the black rook to take the red king from $(5, 1)$ to $(5, 0)$ and wins the set. The movement scenarios of the fifth step are shown in Figures 3(i) and 3(j). In the movement process of the set, the computer uses five steps to win the player of the red side in the set. The arrangement positions of the remainder chesses for the set ending are shown in Figures 3(k) and 3(l). In other case the player uses various movement methods for each step. The computer will use various movement methods to protect the attacker from the red side using evaluation algorithm and searching method.

4. **Conclusion.** We have presented a Chinese chess game system using multiple mobile robots. The system contains a supervised computer with the user interface, some wireless RF modules, a chessboard platform and thirty-two mobile robots. The supervised computer can select moveable method of the assigned chess using evaluation algorithm and Artificial Intelligent method. We program the shortest motion paths of assigned chesses using enhance A* searching algorithm. All chesses must obey the rule of Chinese chess game. In the proposed set "seven stars in one", users can move the chess using the mouse on the user interface, and solve the collision problem for multiple mobile robots moving on the chessboard platform simultaneously. In future, we want to develop the formation arrangement using more and more mobile robots moving on the platform simultaneously, and propose a new motion planning method to avoid the collision problem.

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REFERENCES

[1] P. Darwen and X. Yao, Coevolution in iterated prisoner's dilemma with intermediate levels of cooperation: Application to missile defense, *International Journal of Computational Intelligence Applications*, vol.2, no.1, pp.83-107, 2002.

[2] K.-L. Su, S.-V. Shiau, J.-H. Guo and C.-W. Shiau, Mobile robot based online Chinese chess game, *The 4th International Conference on Innovative Computing, Information and Control*, Kaohsiung, Taiwan, p.63, 2009.

[3] K.-L. Su, C.-Y. Chung, K.-H. Hsia and K.-Y. Jhang, Implementation of the Chinese chess game with computer, *ICIC Express Letters, Part B: Applications*, vol.6, no.2, pp.549-555, 2015.

[4] Z. Kong, L. Gao, L. Wang, Y. Ge and S. Li, On an adaptive harmony search algorithm, *International Journal of Innovative Computing, Information and Control*, vol.5, no.9, pp.2551-2560, 2009.

[5] T. Fu and H. Yin, Designing a hybrid position evaluation function for Chinese-chess computer game, *International Conference on Software Engineering and Service Science*, Beijing, China, pp.75-78, 2012.

[6] Y. Saber and T. Senjyu, Memory-bounded ant colony optimization with dynamic programming and A* local search for generator planning, *IEEE Trans. Power System*, vol.22, no.4, pp.1965-1973, 2007.

[7] H. K. Qiu, F. X. Gao, Y. J. Wang, Y. Ge, Q. Qiu and H. M. Sun, Research on techniques of computer game, *The 25th Chinese Control and Decision Conference*, pp.97-100, 2013.

[8] H. K. Qiu, F. X. Gao, Y. J. Wang, X. X. Song, Q. Qiu and Y. X. Sun, Implementation of common platform for two-person game, *The 25th Chinese Control and Decision Conference*, pp.929-932, 2013.

[9] X. Mei, D. L. Zhang, Q. J. Liao, Y. X. Jiang, H. B. Zhang and N. N. Zhan, Research on platform system of military chess computer game, *The 25th Chinese Control and Decision Conference*, pp.1754-1757, 2013.

[10] F. Lu, K. Yamamoto, L.-H. Nomura, S. Mizuno, Y.-M. Lee and R. Thawonmas, Fighting game artificial intelligent competition platform, *IEEE Global Conference on Consumer Electronics*, pp.320-323, 2013.

[11] K.-L. Su, B.-Y. Li, J.-H. Guo and K.-H. Hsia, Implementation of the chess game artificial intelligent using mobile robot, *International Conference on Soft Computing and Intelligent System*, Kitakyushu, Japan, pp.169-174, 2014.

[12] K.-L. Su, B.-Y. Li and C.-Y. Chung, Enhance A* searching algorithm applying in multiple robot system, *Applied Mechanics and Materials*, vol.479-480, pp.773-777, 2014.