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A* Searching Algorithm Applying in Chinese Chess Game

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Abstract: The article presented A* searching algorithm based to be applied in path planning of Chinese chess game, and used multiple mobile robots to present the scenario. The mobile robot has the shape of cylinder and its diameter, height and weight is 8cm, 15cm and 1.5kg. The controller of the mobile robot is MCS-51 chip. We play the Chinese chess game using multiple mobile robots according to the evaluation algorithm of Chinese chess game, and calculate the displacement by the encoder. The A^* searching algorithm can solve shortest path problem of mobile robots from the start point to the target point on the chess board. The simulated results can found the shortest motion path for mobile robots (chesses) moving to target points from start points in a collision-free environment. Finally, we implement the simulated results on the Chinese chess broad using mobile robots. Users can play the Chinese chess game using the supervised computer via wireless RF interface. The scenario of the Chinese chess game feedback to the user interface using image system.

Keywords: A* searching algorithm**,** Chinese chess game, mobile robot, wireless RF interface

I. INTRODUCTION

Chinese chess [1] game is one of the most popular games. A two-player game with a complexity level is similar to Western chess. In the recent years, the Chinese chess game has gradually attracted many researches' attention. The most researchers of the fields is belong to computer science, expert knowledge and artificial intelligent. Chinese chess game is not only the most old-line chess game in the world, but also more complex than other chess game. There are many evolutionary algorithms 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 to device [2]. Yong proposed multiagent systems to share the rewards and penalties of successes and failures [3].

The application of co-evolutionary models to learn Chinese chess strategies, and uses alpha-beta search algorithm, quiescence search and move ordering [4]. Wang use adaptive genetic algorithm (AGA) to solve the problem of computer Chinese chess [5]. Lee and Liu take such an approach to develop a software framework for rapidly online chess games [6]. Zhou and Zhang present the iterative sort search techniques based on percentage evaluation and integrate percentage evaluation and iterative sort into problem of Chinese chess computer game [7]. Su and Shiau develop smart mobile robot using microchip, and program the trajectories for multiple mobile robot system [8]. The article used the evolutionary method to build up the rules of the Chinese chess game. In some condition, the mobiles robot (chess) must avoided the other chess moving to the next position. We used A* searching algorithm to program the short motion path on the Chinese chess game. A^* heuristic function are introduced to improve local searching ability and to estimate the forgotten value [9]. We use A^* searching algorithm to program motion paths for multiple mobile robots in the article.

The paper is organized as follows: Section II describes the system structure of the multiple robot based Chinese chess game system, and describes the structure of the mobile robot. Section III explains the evaluation method of the Chinese chess game using multiple mobile robots, and described A^* searching algorithm for path planning of mobile robots from the start point moving to the target point. The experimental results are implemented in section IV. Section V presents brief concluding comments.

II. SYSTEM ARCHITECTURE

The system architecture of the multiple robot based Chinese chess game system is shown in Fig 1. The system contains a supervised computer, an image system, a wireless RF interface, a remote supervised computer, a color CCD and thirty-two mobile robots. There are two algorithms (evaluation algorithm and A* searching algorithm) to be implemented in the supervised computer. The Chinese chesses (Mobile robots) are classified red side and black side. There are sixteen chesses in each side. The supervised computer can control mobile robots to present the motion trajectory of the mobile robots, and receives the status of the mobile robot via wireless RF interface. The signals contain the ID code, orientation and displacement of mobile robots. The supervised computer can transmit the ID code and command to the mobile robot. The mobile robot moves the next point according to the command, and transmits the ending code to the supervised computer via wireless RF interface. The Chinese chess system can transmit the real-time image to the supervised computer via image system. Users can play the Chinese chess game with others on the supervised computer using mouse, or play the game on the remote supervised computer via wireless Internet.

The mobile robot has the shape of cylinder, and it's equipped with a microchip (MCS-51) as the main controller, two DC servomotors and driver devices, some sensor circuits, a voice module, three Li batteries, a wireless RF interface and some reflect IR sensors. Meanwhile, the mobile robot has four wheels to provide the capability of autonomous mobility. The structure of the mobile robot is shown in Fig. 2.

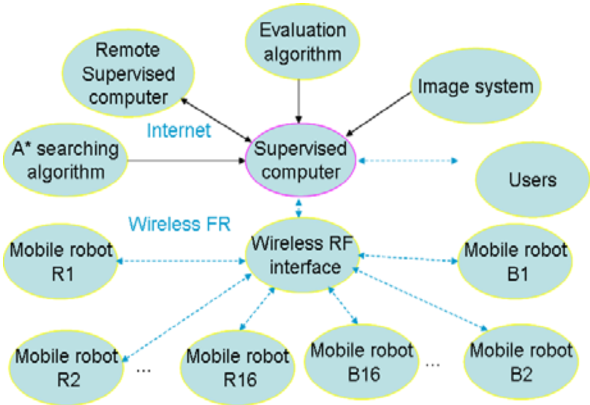


Fig. 1 The architecture of the Chinese chess system

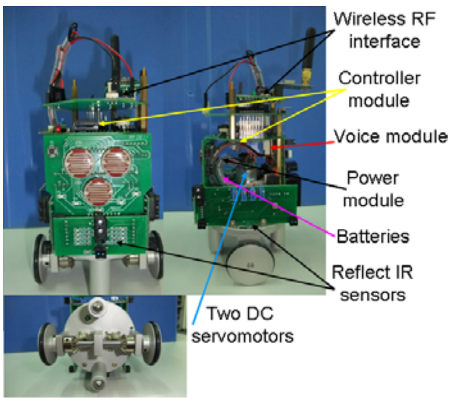


Fig 2. The structure of the mobile robot

The controller of the mobile robot can acquires the detection signal from sensors through I/O pins, and receives the command via wireless RF interface, and transmits the detection results to the supervised computer via wireless RF interface. The switch input can turn on the power of the mobile robot, and selects power input to be Li batteries or adapter. The encoder of the servomotor can calculates the moving distance. We can set the pulse number for per revolution to be P, and the mobile robot move pulse number from the encoder to be B. We can calculate the displacement D of the mobile robot using the equation.

$$D = 4.25 \times \pi \frac{B}{P} \qquad (1)$$

The diameter of the wheel is 4.25 cm. The chess board is grid platform to be shown in Fig. 3. The arrangement of the chess board is 11 grids on the horizontal direction (X axis), and is 12 grids on the vertical direction (Y axis). The distance is 30cm between the center of corridor on the X axis and Y axis of the chess board, and the width of the corridor is 12cm. The mobile robot uses IR sensors to detect obstacles, and decides the cross points of the chess board.

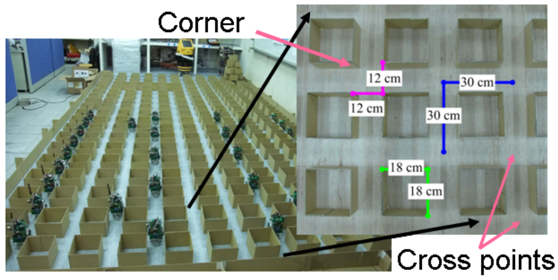


Fig. 3 The chess board of the Chinese chess game

III. ALAGORITHM ANALYZE

The evaluation algorithm of the Chinese chess game is defined by the attribution of the chesses. The definition of the board is shown in Fig. 4. Then we define the initial position all chess pieces. Such as the position of "red king" is (5,1), and "black king" is (5,10)…etc. We plot the possible motion trajectory using black line for the chesses on the board. Then we define the evaluation algorithm, and move the chess piece to the target point. Such as the chess piece "black horse" can move to the position (1,8), (3,8) or (4,9). But the chess piece can't move to the position (4,9) according the rules of the Chinese chess game. The chess "black horse" has an obstacle (black elephant) on the right side.

We define the start positions of the chesses to be (x, y), and define the movement rules of the chesses as following. n is movement displacement on the x axis, and m is movement displacement on the y axis. n and m must be plus integrate. The rules of the Chinese chesses are listed in the reference [10].

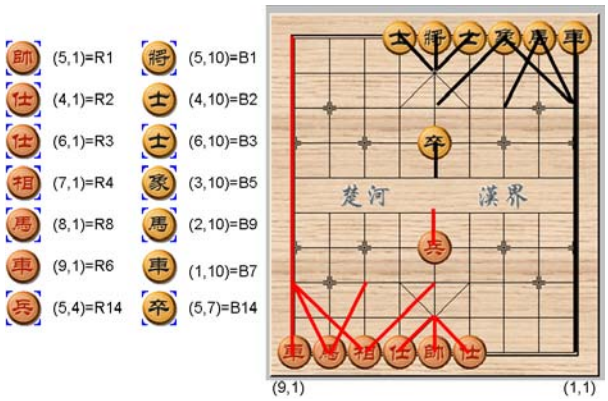


Fig. 4 The definition of the Chinese chesses

A* searching algorithm is proposed by Hart in 1968, and solve the shortest path problem of multiple nodes travel system. The formula of A* searching algorithm is following

$$f(n) = g(n) + h(n) \qquad (2)$$

The core part of an intelligent searching algorithm is the definition of a proper heuristic function $f(n)$. $g(n)$ is the exact cost at sample time n from start point to the target point. $h(n)$ is an estimate of the minimum cost from the start point to the target point. In this study, n is reschedules as n' to generate an approximate minimum cost schedule for the next point. The equation (2) can be rewritten as follows:

$$f(n) = g(n) + h(n') \tag{3}$$

We make an example to explain algorithm. Such as a mobile robot move to the target point "T" from the start point "S". The position of the start point is (2,6), and the target position is (2,9). We set some obstacle on the platform. The white rectangle is unknown obstacle. The black rectangle (obstacle) is detected by the mobile robot using A* searching algorithm. We construct two labels (Open list and Close list) in the right side of Fig. 5. The neighbour points of the start point fill in the "Open list". The "Close list" fills the start point and evaluation points. We construct label on the first searching result to be shown in Fig. 5. We calculate the values of $f(n)$, $g(n)$ and $h(n)$ function, and use the proposed method to compare the values of the function. We select the minimum value of the function $f(n)$ to be stored in "Close list". We can find the target point on the final searching result to be shown in Fig. 5, and we can decide a shortest path to control the mobile robot moving to the target point.

Open	Closed	Point	F_{12}	G_{12}	H_{12}	D
(3,6)	S	(3,6)	1380	732	648	→
(1,6)	(2,7)	(1,6)	1380	732	648	↑
(1,7)	(3,7)	(1,7)	1056	570	486	↑
(6,8)	(3,8)	(6,8)	1704	864	810	↑
(6,9)	(4,8)	(6,9)	1338	690	648	↑
(6,10)	(5,8)	(6,10)	1662	852	810	↑
(4,11)	(5,9)	(4,11)	1338	690	648	↑
(3,11)	(5,10)	(3,11)	1014	528	486	↑
(2,11)	(4,10)	(2,11)	648	162	324	↑
	(3,10)					
	(2,10)					
	T					

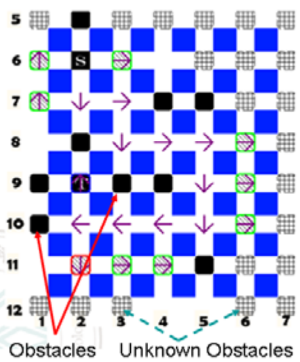


Fig.5 The final searching result

The total distance of the shortest path C_{st} can be calculated as

$$C_{st} = \sum_{n=1}^{m} G_n (m = t - 1) = 2043 \tag{4}$$

Open	Closed	Point	F_{1i}	G_{1i}	H_{1i}	D
	S					
	(2,7)					
	(3,7)					
	(3,8)					
	(4,8)					
	(5,8)					
	(5,9)					
	(5,10)					
	(6,10)					
	(6,9)					
	(6,8)					
	(3,6)					
	(4,6)					
	(1,6)					
	(1,7)					
	(1,8)					

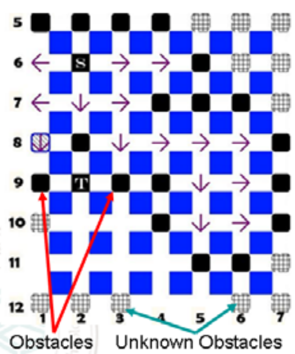


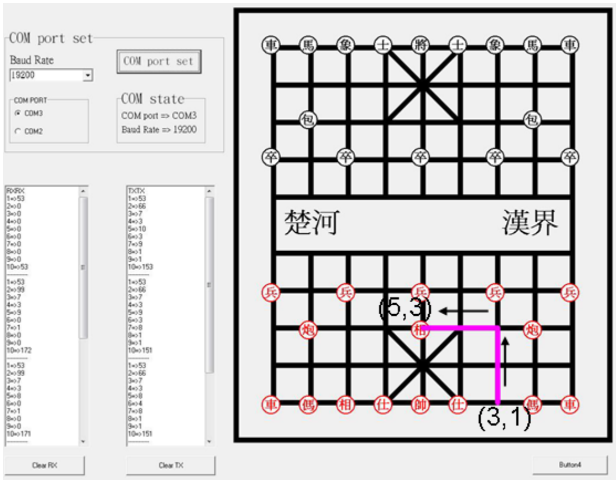
Fig. 6 The final searching result

In the other condition, we rebuild the positions of the obstacles on the platform to be shown in Fig. 6. The mobile robot can't find the path C_{st} moving to the target position using the proposed method. The total distance C_{st} as

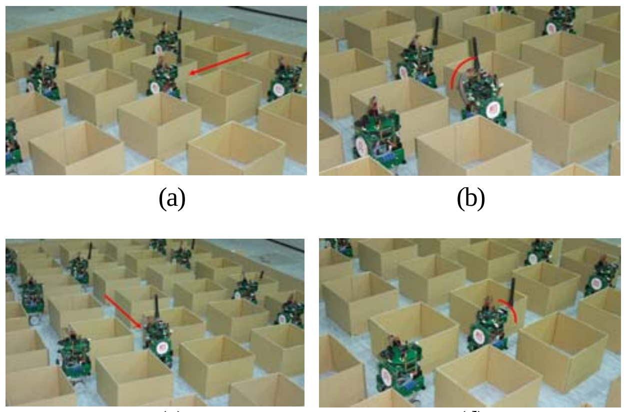
$$C_{st} = \infty \tag{5}$$

IV. EXPERIMENTAL RESULTS

We implement some experimental results on the multiple mobile robots based Chinese chess game system. The first experimental scenario is "red elephant". The user moves the chess "red elephant" using the mouse to be shown in Fig. 7 (a). The start position of the "red elephant" chess is (3,1). The supervised computer orders the command to the mobile robot "red elephant". The chess piece moves forward two grids, and turn left angle to be $\pi/4$. Then the mobile robot moves two grids to the next position (5,3), and turn right angle $\pi/4$ to face the black side and stop. The user interface of the Chinese chess game system uses multiple mobile robots to be shown in Fig. 7(a). The mobile robot can calculate the displacement via encoder, and speak the movement status of the mobile robot using voice module, too. The experimental scenarios use the mobile robot to execute the motion path of the chess "red elephant" to be shown in Fig. 7 (b)-(e). There is not obstacle on the motion path of the chess. We don't the shortest path using A* searching algorithm.



(a)



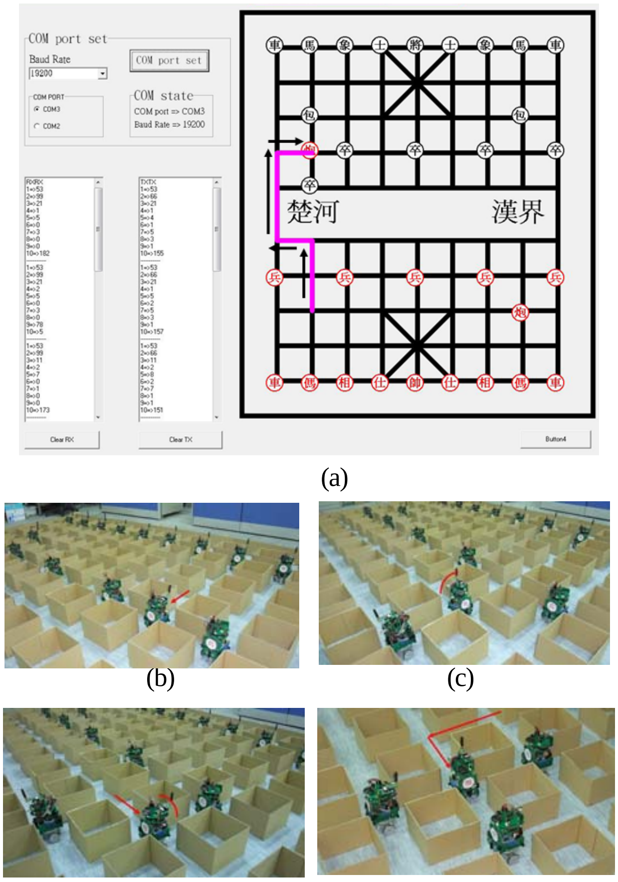
(a) (b)

(c) (d)

Fig. 7 The experimental result for "red elephant"

The second experimental scenario is "red cannon". The user moves the chess piece "red cannon" using the mouse to be shown in Fig. 8 (a). The start position of the "red cannon" chess is (8,3), and the target point is (8,7). The motion path of the mobile robot (red cannon) has obstacle (chess). The supervised computer reconstructs all possible paths using A* searching algorithm for red cannon step by step. Finally, we can find out the shortest path to avoid the obstacle (chess). The path can displays on the interface using red line. The supervised computer controls the mobile robot moving to the target point from the start point using the shortest path to avoid the obstacle. The experiment result is shown in Fig. 8 (a). The supervised computer calculates the cost $f(n)$ to be listed on the left side of the Fig. 8 (a).

The supervised computer orders the command to the mobile robot "red cannon". The chess piece moves forward two grids, and turn left angle to be $\pi/4$. Then the mobile robot moves one grid to, and turn right angle $\pi/4$. Then the mobile robot moves two grids, and turn right angle $\pi/4$. Finally the mobile robot moves one grid to the next position (8,7), and turn left angle $\pi/4$ to face the black side and stop. Finally, the experiment scenarios are shown in Fig. 8(b)-(e).



(a)

(b) (c)

(d) (e)

Fig. 8 The experimental result with obstacle

V. CONCLUSION

We have presented a Chinese chess game system using multiple mobile robots. The system contains a supervised computer, a wireless RF interface, a remote supervised computer, an image system and thirty-two mobile robots (chesses). The mobile robot has the shape of cylinder and its diameter, height and weight is 8cm, 15cm and 1.5kg, and executes the chess attribute using two interfaces. One is wireless RF interface, and the other is voice interface. We develop the user interface on the supervised computer for the Chinese chess game system. The supervised computer can control mobile robots using evaluation algorithm according to the rule of Chinese chess game, and receive the status of mobile robots via wireless RF interface. The chess (mobile robot) has obstacle on the motion path, and uses A* searching algorithm to program the shortest path moving to the target point. In future, we want to develop the artificial intelligent rule to decide which side (red or black) to be a winner.

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