Moving Robot Path Search including Obstacles by GA using Quadrant Idea

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Abstract

This paper describes the problem to search the robot path. We solve this problem by using GA system. To operate GA system for searching the path, Quadrant Usage to Improve Zone (QUIZ), to reduce the search space by using a quadrant idea is proposed. QUIZ also includes new method, Split Coordinates and Avoid Method (SCAM), to avoid obstacles in the maze by splitting zones surrounding the obstacles and to find the path. The Quiz including SCAM is applied to some path search examples. As a result, it is ascertained that QUIZ is useful.

Key words: Path search, GA, Obstacles, Initial individuals

1. Introduction

This research describes the problem to search the robot path. The search is done in the space including obstacles and the robot visits some places in the space. The path search research has been done [1]. Our research finds the path by using Genetic Algorithm (GA). We have developed the path search by using GA [2][3]. This paper proposes the new idea to use the quadrant of an x-y axis to decrease the search space in creating initial individuals of GA. By using the idea, we develop the system to search the path and apply it to some examples.

2. Environments

The problem of the paper is to search the moving robot path in the space including obstacles. As shown in Fig.1, the environments of the research have the maze including many square obstacles. We will search the path that a moving robot moves via some points and solve it by using GA system.

The research for the path problem solved by using GA system has been done. The conventional research environments are simple and it did not include complicated obstacles.

3. QUIZ and SCAM

To operate GA system for searching the path, the paper proposes the new method, Quadrant Usage to Improve Zone (QUIZ), to reduce the search space by using a quadrant idea. QUIZ also includes new method, Split Coordinates and Avoid Method (SCAM), to avoid obstacles in the maze by splitting zones surrounding the obstacles and to find the path. The path search including QUIZ considers a moving path as finding the path by arranging the x-y coordinates in the moving space where a moving robot moves and indicating the coordinate points.

Fig. 2 shows the outline of GA system including QUIZ. Though the conventional GA system carry out to generate initial individuals, calculate fitness for each individual generated and to give crossover and mutation, our GA system starts QUIZ before generating initial individuals. The fitness used in our GA system is adopted as the distance between the robot current point and the next point. The smaller the distance is, the better the fitness is.

The characteristics of QUIZ are to reduce the search space in order to create the excellent individuals beforehand and to create initial individuals corresponding to the ones that will not collide with obstacles or will not become lethal individuals by SCAM system.

3-1. QUIZ

Quiz is the method to limit the search space by excluding useless points beforehand in order that a moving robot does not visit these points. The strategy of QUIZ is to consider the 4 quadrants (1st quadrant, 2nd quadrant, 3rd quadrant and 4th quadrant) that divides the robot moving space with the orthogonal axis (x-y axis) whose origin of the coordinates is the robot current point and consider the search space as one of the 4 quadrants. Because of the strategy, the search space can be reduced to a quarter.

The algorithm of QUIZ is as follows.

Step1: Consider the start point and the end point as $A_i(x_i,y_i)$ and $A_z(x_z,y_z)$ for each.
Step2: Calculate the value k of the equation (1) and, by using the value, C_1 of the equation (2) and C_2 of the equation (3) are acquired. The next rules are carried out and the quadrant that A_x exists is found.

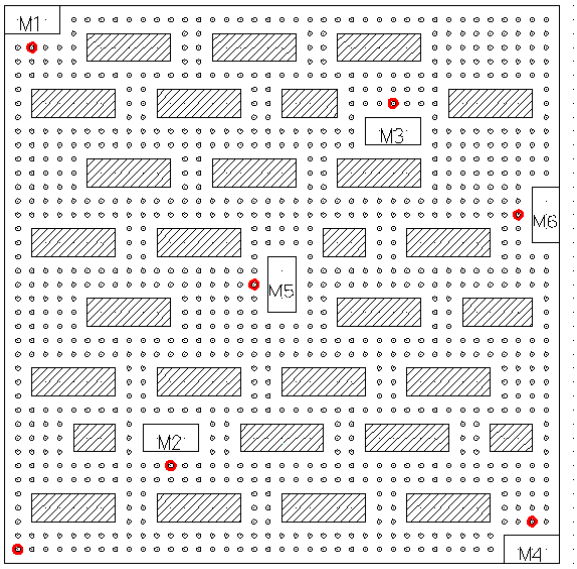

Fig. 1 Search space including obstacles

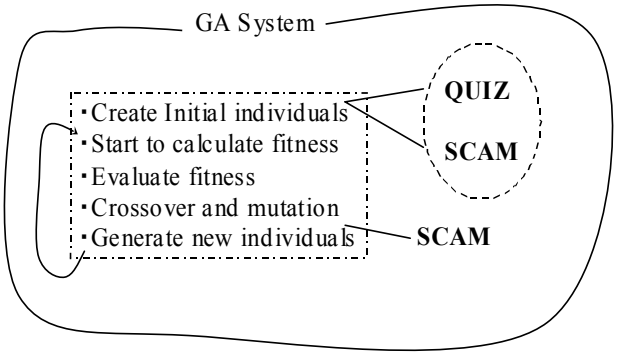

Fig. 2 Outline of GA system

$$k = \sqrt{(x_z - x_i)^2 - (y_z - y_i)^2} \cdot \cdot \cdot \quad (1)$$

$$c_1 = \frac{y_z - y_i}{k} \cdot \cdot \cdot (2)$$

$$c_2 = \frac{x_z - x_i}{k} \cdot \cdot \cdot (3)$$

if: $c_1 \geq 0, c_2 \geq 0$, then: A_z exits in the 1st quadrant

if: $c_1 \geq 0, c_2 < 0$, then: A_z exits in the 2nd quadrant

if: $c_1 < 0, c_2 < 0$, then: A_z exits in the 3rd quadrant

if: $c_1 < 0, c_2 \geq 0$, then: A_z exits in the 4th quadrant

Step 3: Express all points set in the quadrant where A_z exists as Set(A_q), from among the set, select one element and express it as A_n.
Step 4: Carry out SCAM system (judgments to avoid obstacles) between the point A_i and the point A_n. If there is an obstacle, return to Step 3 and if not, consider A_n as the next A_i and go to Step 5.
Step 5: Search a new A_n from among the Set(A_q) and if $A_n = A_z$, go to Step 6, if not, return to Step 4.
Step 6: Consider Ai and the A_n value sequence acquired in Step 3~5 as an initial individual and finish the algorithm. □

In this way, in the process of Step 2, QUIZ searches the quadrant where the current point and the end point exist. In other words, QUIZ calculates the values of $\sin\alpha$ and $\cos\alpha$ in Fig. 3 and searches the quadrant depending on the positive and negative numbers of the values. Because of this, whenever each gene of an initial individual is decided, QUIZ searches the quadrant corresponding to the search space and can reduce the search space as shown in Fig. 4.

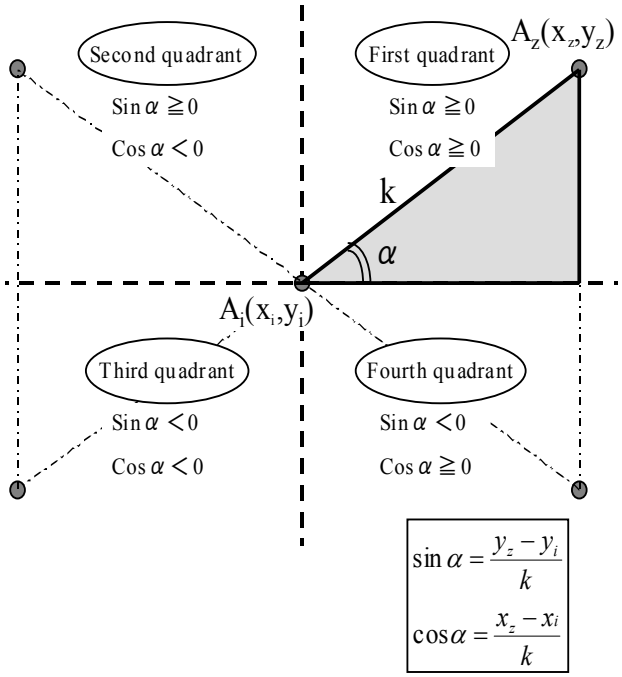

Fig. 3 Quadrant of QUIZ

3-2. SCAM

SCAM is the system to judge whether there is an obstacle between two points a moving robot visits or not. The obstacles of the paper are square. When the straight line that links the current point and the corners of an obstacle is found as shown in Fig. 5, SCAM judges the existence of an obstacle whether the next point is included in the shaded portion or not. In other words, if the next point exists in the shaded portion, it is judged that there is an obstacle between the two

points.

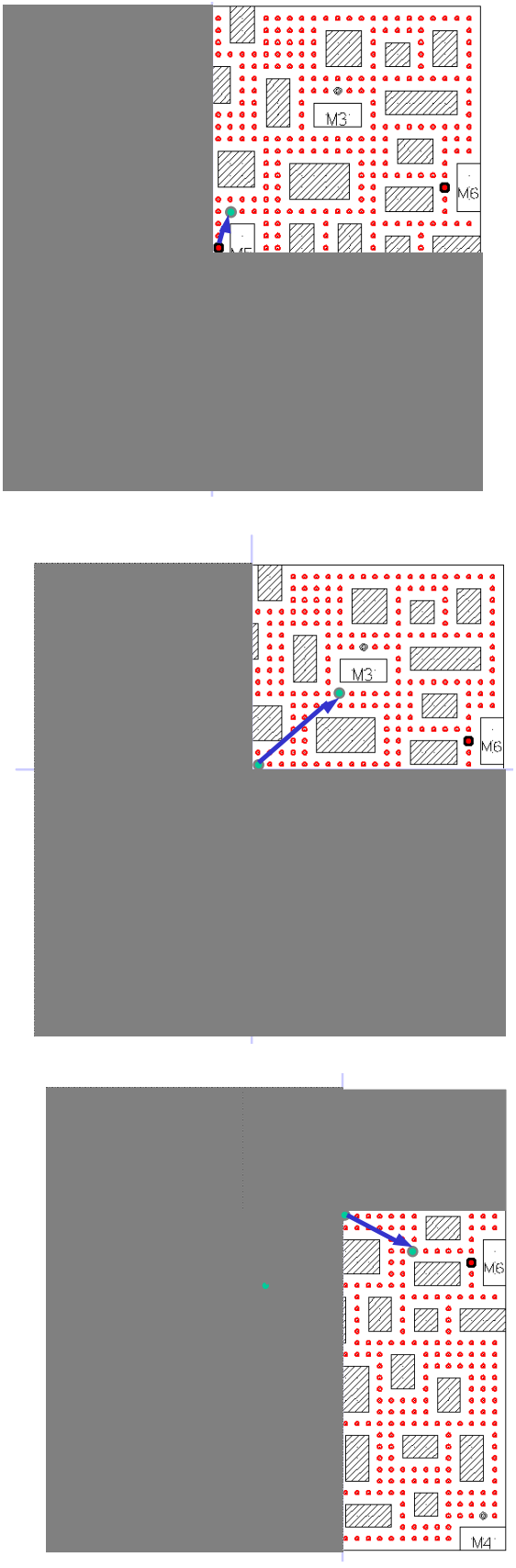

Fig. 4 Example to deduce search space

4. Application Examples

The developed QUIZ including SCAM was applied to some examples. The examples are that moving robots visit some machine (M1~M6) and finally get the end point in the space including obstacles. Fig. 6 and Fig. 7 are the search results.

The examples' moving robots start M1, visit M2, M3, M4, M5 and M6 in turn and finally return M1. In the figures, red marks indicate the bays of each machine and moving robots visit there. Fig. 8 shows the change curves for the maximum fitness of the result used QUIZ and the one not used QUIZ. The curve of Quiz converged earlier and it acquired higher fitness. Judging from the results, it is ascertained that the research to use QUIZ and SCAM is useful.

5. CONCLUSIONS

The research described the path search problem that a moving robot gets the final destination via some points in the space including obstacles by using GA system. Specifically, the idea of the quadrant in the x-y coordinate space was adopted in order to find better individuals in generating initial individuals in GA system. The idea can limit the solution space and converge early to find the solution. The idea is called as QUIZ and in the process of QUIZ, SCAM system not to generate lethal genes corresponding to the path that collides with an obstacle was adopted.

After applying the developed system to some path search examples, it is ascertained that the developed system can get better paths and earlier converge.

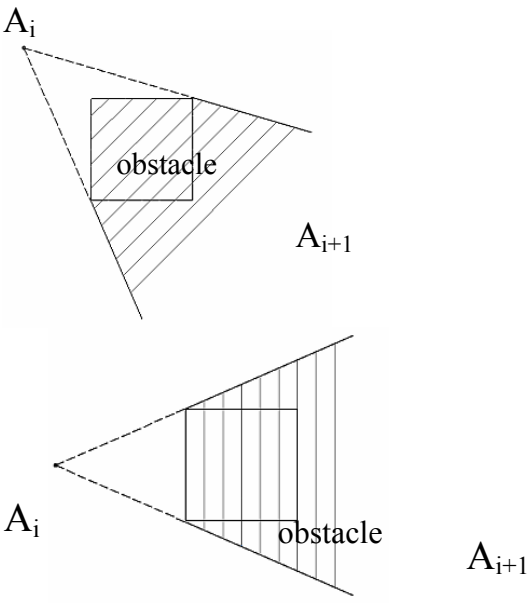

Fig. 5 Obstacles and moving points

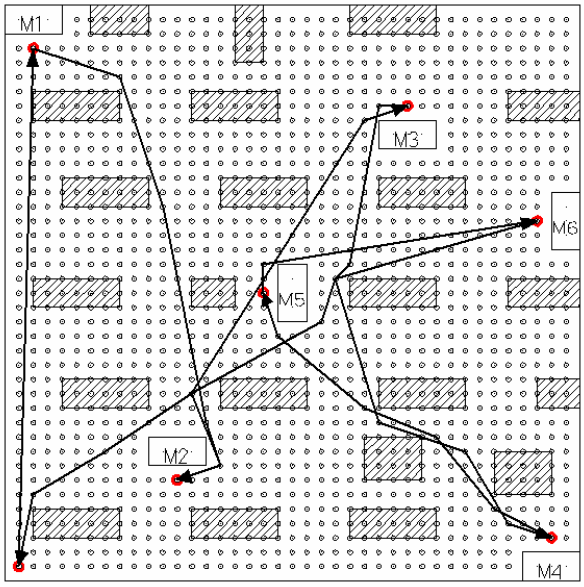

Fig. 6 Acquired path result 1

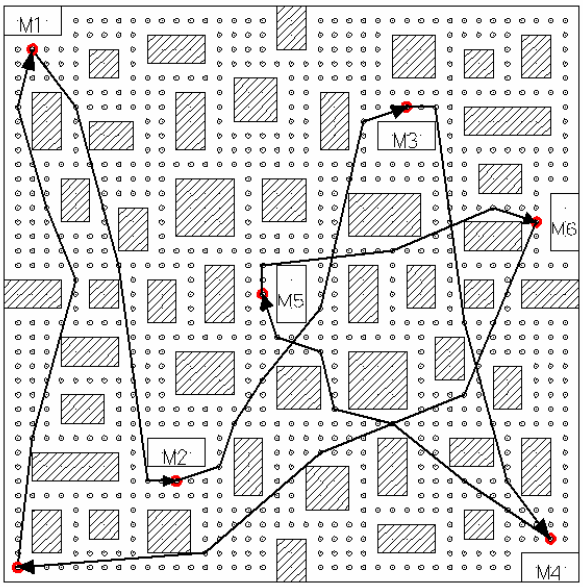

Fig. 7 Acquired path result 2

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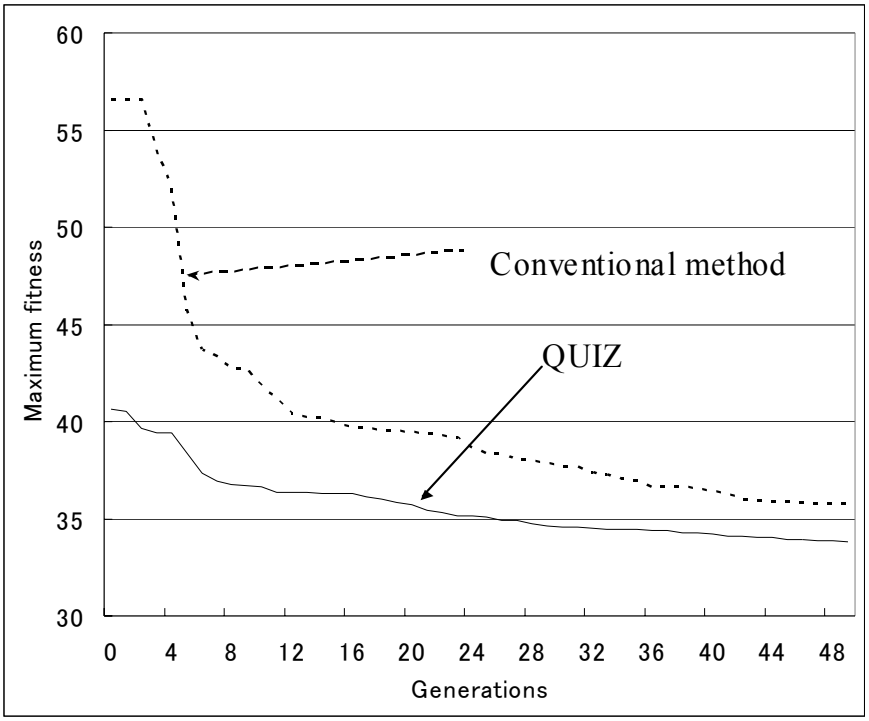

Fig. 8 Maximum fitness curves