Mobile Robot Dynamic Path Planning Based on Genetic Algorithm

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Abstract: In dynamic environment, the path planning of mobile robot is a problem difficult to solve. A path planning method for mobile robot based on genetic algorithm is put forward. This method makes use of real number coding and adaptive function with definite physical meaning in the dynamic environment so as to accelerate real-time calculation and improve calculation precision. The simulation result confirms that the genetic algorithm is feasible and efficient for mobile robot path-planning.

Key words: path-planning; mobile robot; genetic algorithm

1 Introduction

Practical application of robots in a dynamic environment for most of the time-varying environment, obviously a regular off-line planning algorithm, even the best planning results also can not adapt to real-time robot in the process of planning requirements. The main reason is: it needs a priori information on the environment, in most cases it is difficult to achieve. From another perspective, the practical application of the robot path planning problems are often a larger scale, while the existing method of a static environment, most of the pursuit of the global optimal solution, so that a large quantity of calculation, each time re-planning will need to re-large-scale optimization, while the results obtained may not have practical significance. For in a dynamic environment for mobile robot path planning problem, the traditional optimization methodology is complex and time-consuming, it is difficult for mobile robot real-time control. Previous studies showed that genetic algorithm has great potential in this area [1-9]. In this paper, genetic algorithm path planning under dynamic environment to meet the real-time needs.

2 Problem Description

The establishment of a dynamic environment in the initial state shown in Figure 1: a black square the movement of robots; marked with the numbers 1,2, 3,4 elliptical obstacles for the movement; the top and left side of the ruler also said coordinates; robot's starting point in the upper left corner of the window the target point of Rg. In a dynamic environment through different numbers to identify the obstacles and the robot, the robot reach the target point of safety.

3 The parameter settings of Path Planning Algorithm for Dynamic Environment

Genetic algorithms is used in path planning for Dynamic environment, while the parameters set of genetic algorithm and the parameters of static environment is generally the same. Initialized using a wide range of initialization; path for encoding one-dimensional real-coded; genetic operator choices and static environment is the same. The main differences are: the choice of intermediate target points and the choice of fitness function.

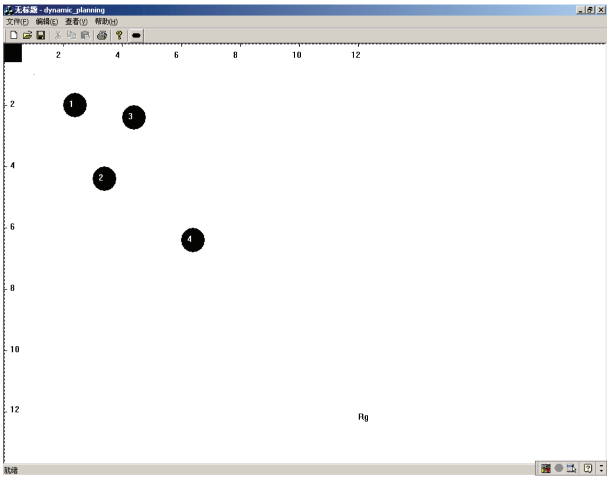

Figure 1. A dynamic environment interface

3.1 Intermediate target point of the strike

Dynamic environment is an environment where the robot is a real-time change, it is not based solely on the state of beginning to plan the whole time during walking path. Robot at every moment according to environmental information where to get it next travel direction and speed. Because when the robot in determining the next action depends on the starting point and destination points, so in real-time travel process, we need to choose some intermediate target points. In this algorithm, the robot's current point as a starting point, the intermediate target point within this time as a planned target point. And the environment obstacles according to their information to complete this cycle of planning. Access to intermediate target point of the formula is:

$$\begin{aligned} \min\_goal\_x &= d*(point\_goal\_x - point\_x)/D + point\_x \\ \min\_goal\_y &= d*(point\_goal\_y - point\_y)/D + point\_y \end{aligned} \quad (1)$$

Where: *min_goal_x*, *min_goal_y* is the x, y coordinates to require the intermediate target point; *point_goal_x*, *point_goal_y* is the ultimate goal location of the point coordinates; *point_x*, *point_y* is starting point for the current coordinates; d is a safe distance of the robot; D for the the current starting point to the target point Rg distance.

3.2 Path coding

In a dynamic environment, in order to better representation of environmental information and the location of robots, but also uses real-coded way. As the real-time robot control, so consider planning algorithm to plan. To shorten the computing time, to reduce the encoding length, so the the method to simplify the encoding length is adopted, that is the path of the two-dimensional codes simplified one-dimensional codes.

3.3 The choice of fitness function

Because it is relatively complex in dynamic environment, so in the formulation of the fitness function, we should give full consideration to all circumstances. Therefore, in this paper to determine the fitness function, fitness function as far as possible the number of small items, but must place the conditions for path planning for integration of the genetic optimization process. Several conditions for the realization of the following:

(1)Dynamic obstacle avoidance is a more critical a constraint, assuming that the number of obstacles, obstructions of the position and velocity can be determined robot vision and laser radar. In the dynamic path planning process, assuming the current rate of mobile robot to walk, the barrier also measured the speed of the current make uniform linear motion, because the control cycle is generally relatively small. Therefore, the dynamic path planning process, we can not consider the speed of walking robot and obstacles change.

R_0-based robots from the current starting point to the *Ri (xi, yi)* the time required for the *ti*. From the R_{i-1} (X_{i-1}, Y_{i-1}) to Ri (X_i, Y_i) the time required for the T_{i-1}, then $t_i = t_{i-1} + T_{i-1}$, which:

$$T_{i-1} = \sqrt{(x_i - x_{i-1})^2 + (y_i - y_{i-1})^2} \Big/ v \quad (2)$$

Where v is the mobile robot's current speed.In time ti, the first k-obstacle location O_{bk} $(x_{bk}(t_i), y_{bk}(t_i))$, then:

$$\begin{aligned} x_{bk}(t_i) &= x_{bk}(t_0) + V_{kx} t_i \\ y_{bk}(t_i) &= y_{bk}(t_0) + V_{ky} t_i \end{aligned} \quad (3)$$

Where $(x_{bk}(t_0), y_{bk}(t_0))$ is the first k-coordinates of the beginning of obstacles, V_{kx},V_{ky} is the first obstacle of the current k-speed V_k coordinate system in the *xoy* weight. Because each one taken within the planning cycle, the path is very short, so you can assume that the speed of robot and all obstacles in the planning of the initial direction and speed of the direction of the moment are the same. With the above assumptions can be described in the following fitness function:

$$fit1 = \begin{cases} \sum_{l=1}^{n} \sum_{k=1}^{m} \dfrac{\sqrt{(x_{bk}(t_i) - x_l)^2 + (y_{bk}(t_i) - y_l)^2}}{v*\cos\theta_{lk} + v_k*\cos\theta'_{lk}} & \sqrt{(x_{bk}(t_i) - x_l)^2 + (y_{bk}(t_i) - y_l)^2} < v*\cos\theta_{lk} + v_k*\cos\theta'_{lk} \\ \sum_{l=1}^{n} \sum_{k=1}^{m} 1 & \sqrt{(x_{bk}(t_i) - x_l)^2 + (y_{bk}(t_i) - y_l)^2} \geq v*\cos\theta_{lk} + v_k*\cos\theta'_{lk} \end{cases} \quad (4)$$

Where v is the moving speed of the robot in the path , v_k is the moving speed of obstacles in the path, θ_{lk} path points in the first l months the direction of robot motion and robot with the first connection between k-barrier angle, θ'_{lk} path points in the first l months obstructions movement direction and the robot with the first connection between k-barrier angle, n is the number of path points, m is the total number of obstacle planning area, d as a safe distance. The fitness function is described in the path of each one the size of the possibility of collision.

(2) The robot path planning also requires robots along the shortest path to reach the target point, and in the process of walking robot should also consider the performance impact, when the robot turns a certain angle can be achieved, namely: are should be the same as in a static environment, consider the robot motion smoothness issues. Therefore, these two factors into a comprehensive fitness function as follows:

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$$fit2 = \sum_{i=1}^{n} \frac{L_i}{l_i} \qquad (5)$$

L_i is to connect the node to the middle of the target point min_goal the distance ,l_i is to connect the path points to the middle of the target point mid_goal distance. By (1), (2) integrated environment to be dynamic fitness function as follows:

$$fitness = \alpha * fit1 + \beta * fit2 \qquad (6)$$

4 Path Planning Method based on Genetic Algorithm

By the method described above to be a dynamic environment path planning using genetic algorithm steps as follows:

1. Initialize the parameters of genetic algorithm, set the population size M, each path the number of path points n.

2. The robot current location as a starting point, select the intermediate target point. Hereditary algebra counter initialized: gen = 0;

3. Mapped out by using genetic algorithms specified in Step 2 from the starting point and objectives of the optimal path between points. Genetic algorithm steps are:

①to initialize the initial population P (gen);

② evaluation of P (gen) in the various paths of adaptation values:,, ...,.

③genetic operator for genetic operations: selection, crossover and mutation.

④to determine whether the maximum-hereditary algebra, and if they can not go back to step; otherwise, the end of the genetic algorithm, output of the optimal path, go to step 4.

4. Smooth path to the above optimal.

5. According to the output of the optimal path down a path of moving point

6. Points to reach the ultimate goal to determine whether Rg, if not reached, go to step 2; otherwise the end of the planning, stop exercising.

Application of genetic algorithms in this article under the path planning in dynamic environment, you can quickly map out the path the robot walk to ensure the robot walking in real time.

5 Simulation results

Robot starting from a starting point, according to optimal path planning out a step by step closer to the end of the target point. Each step must be to re-present the current location as a starting point, and re-select the middle of the target point. From the current starting point to the middle between the target point motion planning using genetic algorithm programming, genetic algorithms operating and static environment, genetic algorithms are the same, only the fitness function into a dynamic environment fitness function. One of the planning period of 600ms, which during this time to plan out from the current starting point to the current intermediate target point of the optimal path, and then robot along this path forward. Then enter the next round of planning, so robots a step by step closer to the target point.

Figure 2-4 are the process of a group of animation map for the robot in a dynamic environment, moving from a starting point to the target point. One obstacle to a uniform vertical movement around the obstacles to make two points for a random movement, obstacles for the three horizontal uniform motion, barrier 4 is static. In this case, we conducted a simulation. Take population size M = 30, n = 16, namely: each path has 16 points, each control cycle hereditary algebra to 1000. Control parameters α = 0.8, β = 0.2.

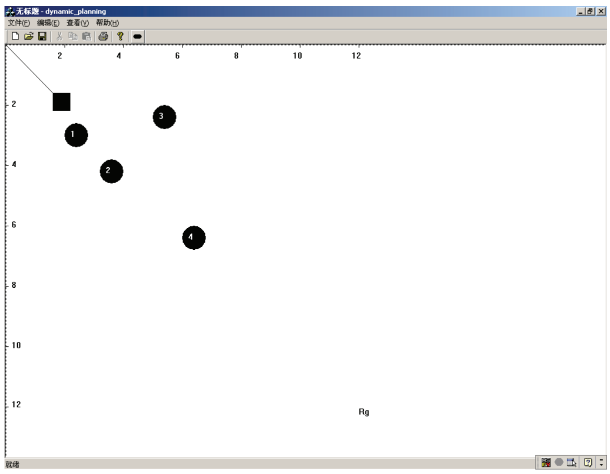

Figure 2. Initial state 1

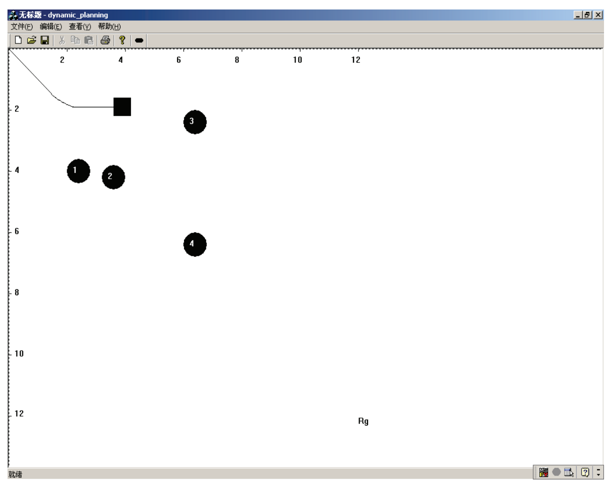

Figure 3. Motion state2

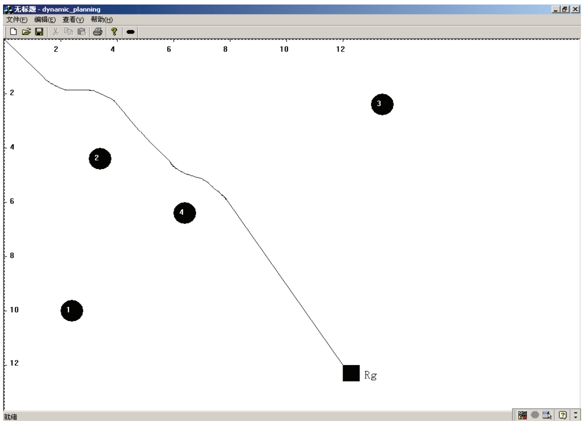

Figure 4. motion state 4

6 Conclusion

A path planning method for mobile robot based on genetic algorithm has been designed, using real-coded and a fitness function of clear physical meaning to accelerate the convergence of the algorithm and improve the computing precision. The simulation results show that its approach is proven effective, and provides a train of thought for the future intelligent, fully autonomous robot.

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