Research on the Path Planning in Desulfurization Plant

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Abstract. With the gradual improvement of urban construction, hydrogen sulfide detection in desulfurization plant becomes increasingly intelligent. To solve the problem of the detecting robot automatic charging path planning in desulfurization plant, this paper presents an improved global path planning algorithm based on visibility graph algorithm, but overcomes the low efficiency and poor flexibility of the traditional visibility graph algorithms. In the process of modeling, this paper regards a variety of obstacles in the desulfurization plant environment as an approximate rectangle combination, draws a real-time obstacle map, and then simulates in the real-time obstacle map to verify the effectiveness and feasibility of the improved global path algorithm.

Introduction

The appearance of the detection robot instead of human work improves the security of job, which plays an invaluable role in the intelligent community. How the detection robot finds an optimal charging path in desulfurization plants is the most fundamental problem to be solved. The detection robot automatic charging path planning in the desulfurization plant is divided into two categories: The first one is global path planning with the known global arrangement, the second one is local path planning with the unknown global arrangement. Global path planning algorithm method comprises of visibility graph algorithm, free space algorithm and grid algorithm. Local path planning algorithm comprises of the ant colony algorithm, genetic algorithms, artificial potential field algorithm and neural network algorithm.

In this paper, detection robot is for the indoor environment, and the indoor obstacle arrangement is known, so researchers use the global path planning method. The free space algorithm’s obstacle map can be adjusted by the changes in real-time, but the computation complexity is proportional to the obstacle. It requires a large memory capacity, and has a low computing speed. Grid algorithm’s modeling is simple, but it has low spatial resolution and low real-time adjustment. Therefore, researchers propose an improved algorithm based on the traditional visibility graph algorithm. The various obstacles in desulfurization plant can be replaced by the approximate rectangular assembly, link visibility point, and then the shortest path might be chosen. This improved algorithm can simplify the complex obstacle arrangement to rectangle assembly, improve the efficiency, and enhance the real-time performance.

Environmental Obstacle Map Model

The detection robot in the indoor environment can be seen as a mobile node, and the path is the connection between visibility points. During the modeling process of the obstacle map, considering the security of mobile robot, the obstacle modeling is expanded.

The definition of visibility wire is the wire between the expanded obstacles, which are not intersected with the obstacle. Fig. 1 shows the visibility wire between the two simple obstacle models.

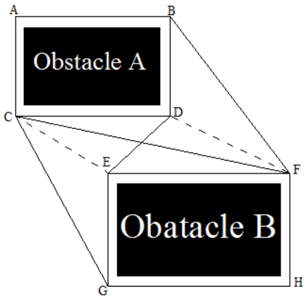

Fig. 1 Visibility Segment between Simple Obstacles

In Fig. 1, there are three visibility wires between point C and another obstruction, and they have to exclude one invalid visibility wire. The method to judge invalid visibility wire is that the product of the angle of this wire and the other two are less than or equal to 0, so researchers can know that the dashed line CE is invalid, and empathy the dashed line DF is also invalid visibility wire. In Fig. 1, there are four effective visibility wires, respectively of segments CG, CF, DE, BF.

For the complex obstacles, researchers treat it as a rectangular assembly, as shown in Fig. 2.

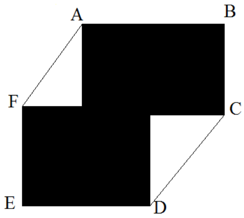

Fig. 2 Visibility Segment in Complex Obstacles

In Fig. 2, there are two visibility wires, respectively of segments AF, CD. This complex obstacle can be seen as a combination of two separate rectangles, and each rectangle can be seen as one endpoint reduction.

Robot automatic charging device will go through many obstacles, researchers will project the obstacles in desulfurization plant onto a plane, see them as a combination of various rectangular, and the environment of desulfurization plant will be made up to an environment map, as shown in Fig. 3. Afterwards, do the expansion treatment to all the obstacles.

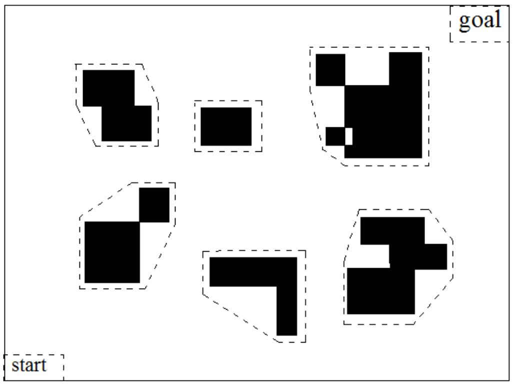

Fig. 3 Obstacle Map Model of the Environment

Correlation Algorithm

Analyzing whether the relevant line intersects with the obstacle. Just as shown in Fig. 4, this paper analyzes the segment SG with start point S and the target point G, and judges whether they intersect with the obstacle or not, in order to compute the distance d between endpoint of obstacle and segment SG. In the coordinate, the obstacle, the starting point, and the target point are all located in the following planes:

$$AX+BY+C=0. \quad (1)$$

The distance d between the endpoint of obstacle and the segment SG is:

$$d = AX + BY + C / \sqrt{A^2 + B^2} \quad (2)$$

As shown in Fig. 4, the researchers specified the point above the segment, d is less than zero; the point below the segment and d is greater than zero. The distance d between point A, B are obtained, and the segment SG are dA, dB, if dA*dB<0, the segments AB and SG are intersected; if dA*dB=0, the endpoint of obstacle is on the segment SG, as the obstacle model have done the expansion treatment, so that the obstacle does not affect the path planning; if dA*dB>0, the segments AB and SG are not intersected. Similarly, determine whether the obstacle boundary line intersected with the segment SG or not, is to determine whether there is any violation between segment SG and obstacle.

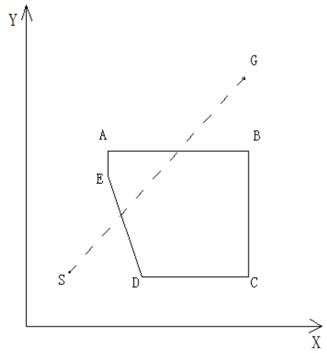

Fig. 4 Visibility Segment in Coordinate

Path Planning Algorithm. Firstly build an environment map model, then determine the start point S and target point G by the RF module, take start point S to join the open list, and take the Eq. 3 as the evaluation function to start heuristic.

$$f=g+h. \quad (3)$$

g is the traveled distance along the path from the start to the current point; h is straight line distance from the current point to the target point. The value of h is shown in Eq. 4:

$$h = \sqrt{(x_m - x_d)^2 + (y_m - y_d)^2} \quad (4)$$

(x_d, y_d) is the current point coordinate, and (xm, ym) is the target point coordinate. Switch the current point to the closed list and delete the point from the open list, figure the feature point of obstacle in the closed list or not; if in, skip this point; if not in, it is determined whether the feature point is in the open list or not; if in, calculate the value of g, h, f, and add to the open list; vice versa, take the value of g as a reference to check whether the new route is better (the smaller the better), if the parent point is better, replace the current point, recalculate the value of g, h, f, and then determine whether the open list is empty; if the path does not exist, end the algorithm. Take the minimum value of f in open list as the current point to determine whether the current point is the target point, may viewpoint, if it is, take the current point as the target point's parent point, calculat the value of point g, h, f, and take the target point to join the open list, the path is found, end the algorithm, finally save the path.

According to the improved algorithm, take the simulation debugging of the desulfurization plant environment in MATLAB. It can be seen this algorithm is superior to traditional visibility graph algorithm, Fig. 5 is improved path planning, Fig. 6 is traditional path planning, and researchers can see the path planning of this paper is better than traditional path planning.

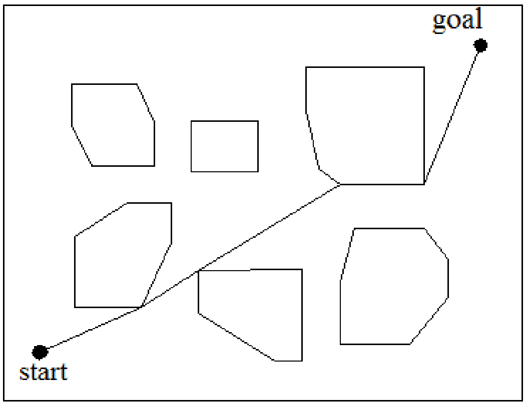

Fig. 5 Path Planning Simulation by This Algorithm

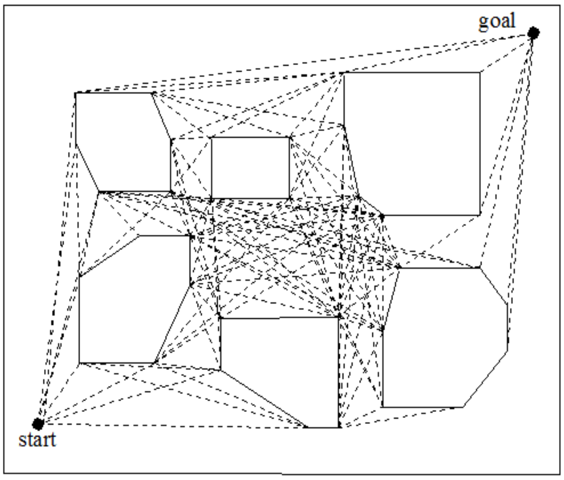

Fig. 6 Path Planning Simulation by Visibility Algorithm

To verify the feasibility of the proposed algorithm, the researchers use the above method and make a path planning simulation, the system can plan out the detection robot walking path immediately, the path is the optimal path, and confirm the feasibility and effectiveness of the algorithm. It is shown in Fig. 7.

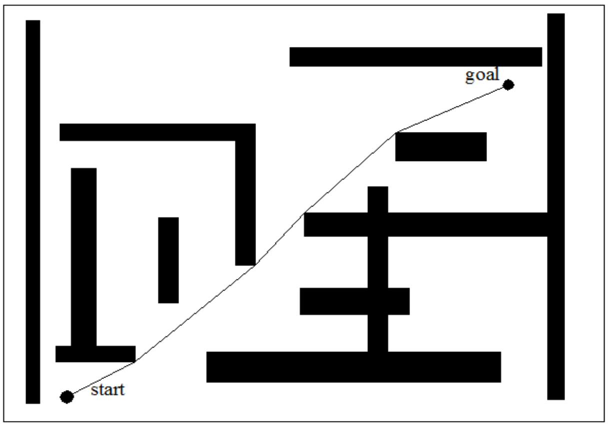

Fig. 7 Path Planning Simulation in Another Modeling

Summary

This paper presents an improved global path planning algorithm based on visibility graph algorithms, but overcome the traditional low visibility, efficiency and flexibility. In the modeling process, an obstacle real-time map is drawn, and the operation in real-time map has verified the effectiveness and feasibility of the path algorithm.

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