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Robot path planning based on A*algorithm and genetic algorithm

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Abstract: **The traditional algorithm of path planning is slow in time, heavy in calculation and large in storage space. Taking the medical service robot of Raytheon hospital(in Wuhan) as an example, optimizing its path planning, this paper proposes a combination algorithm based on genetic algorithm and A* algorithm, and two-dimensional modeling of the hospital map was carried out by raster method. Through simulation experiments, comparison with traditional algorithm and model tests, the feasibility and effectiveness of the combined algorithm are confirmed. Meanwhile, the efficiency of path planning is improved, the step size is optimized by 23%, the time is increased by 135%, and the calculation amount is reduced, and the calculation time and storage space are reduced.**

Key words: Path planning; Combining algorithm; Mobile robots; Optimization

I. INTRODUCTION

The research field of robotics has always been one of the main parts of the frontier of science and technology. Early as the 2020 outbreak of COVID - 19 in the crowd by infection, isolation measures became the most effective way to resist the outbreak, the medical robots, unmanned delivery vehicles, automatic car driving clean [1] to increase demand, such as more reflects the importance of artificial intelligence and the trends of future technology center of gravity to unmanned. Epidemic situation, the author of this paper to medical robots walk on Raytheon hospital as an example, the method of using rasterize the Raytheon hospital planar map model, using genetic algorithm to distinguish it from other scalability of the algorithm (easily with other fusion algorithms use), and it does not involve the process of the objective function value differential superiority of height, embedded with A * algorithm is responsive to the environment characteristics, according to the traditional genetic algorithm for multiple paths to find out the optimal way of thinking, use coordinates instead of path (i.e. change chromosomes, changing the mode of crossover and mutation [2]), according to the constraint, moderate function make the robot walk walking in single, The coordinate point that is most suitable for the global path is found out from multiple coordinate points locally (the set surrounding area is the range that can be searched in A single step), and then the shortest path to this point is searched through A* algorithm, so as to loop and finally find the optimal path to the destination. Compared with the traditional genetic algorithm (GA) and A* algorithm (A-STAR), this method significantly improves the running speed of the algorithm, effectively reduces the footprint of storage space, and improves the flexibility in path optimization.

II. ALGORITHM DESIGN

A. Environment modeling based on raster method

Raytheon map structure [3] for two-dimensional modeling environment model, the medical robots as a two-dimensional plane moving point on the object, the robot's movement in the two-dimensional plane with a set of coordinates, said to rasterize map, set the black grid represent obstacles, white grid on behalf of the barrier-free passable area. Grid diagram consists of grids M_{ij}:

$$Map = \{M_{ij} | M_{ij} = 0,1\} \tag{1}$$

In the grid diagram, "0" is the white grid (barrier-free accessible area), and "1" is the black grid (area with obstacle impassable area). Establish a 40×40 grid map as shown in Figure 1:

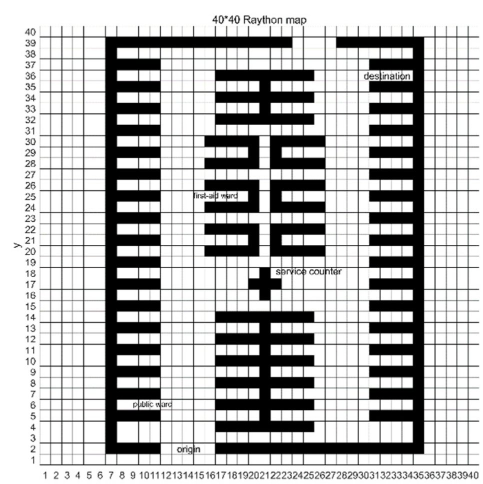

Figure 1. Raytheon Hospital simulation map

B. Algorithm ideas

By referring to the hybrid genetic algorithm embedded in the A* algorithm [4], it divides the path from starting point to ending point into several sections, changes the moderate function and

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increases the optimization logic judgment mode, and proposes the combination algorithm.

The steps of the combination algorithm are as follows:

Step 1: refine map, considering the traditional path planning algorithm in grid method is under the map of the robot as a point object, but the limitation of the area of a grid, this paper will each grid refinement, on the set of nine points (as shown in figure 2, with center coordinates (1, 1) of the lattice, for example), the robot moves can no longer stay in the center of a grid, you can also stay in the grid on the four corners or four edges.

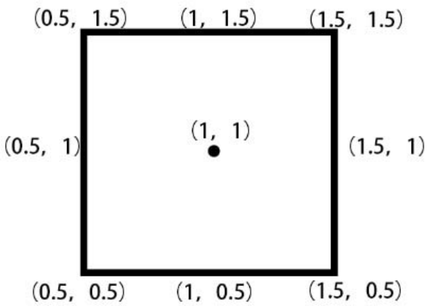

Figure 2. . Schematic diagram of grid coordinates dot

The raster expression is:

$$M（\mathrm{n}）=\begin{cases}(n-0.5,n+0.5),(n,n+0.5),(n+0.5,n+0.5)\\(n-0.5,n),(n,n),(n+0.5,n)\\(n-0.5,n-0.5),(n,n-0.5),(n+0.5,n-0.5)\end{cases}$$

$$0 < n < 40 \text{ , } n \in N^* \tag{2}$$

Step 2: to start around 32 points (as shown in figure 3 black spots on) as the initial population (do this has the advantage of a fixed initial population around as a starting point not far from the coordinates of the points, compared with the traditional genetic algorithm the initial population is about 100 to 200, generally, by reducing the number and reduce the amount of calculation, and take up the storage space.), crossover rate Pc=0.95, mutation rate Pm=0.05

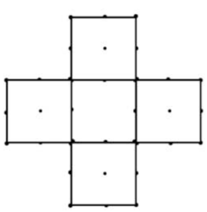

Figure 3. Initial population coordinate diagram

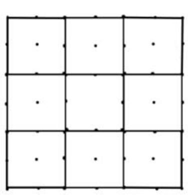

Figure 4. Population coordinate diagram of the second generation

Step 3: Determine the moderation function and divide it into two parts. The first part is used to judge the distance between each individual (coordinate point) and the end point. The formula is as follows:

$$d = \sqrt{(x_{end} - x_n)^2 + (y_{end} - y_n)^2} \tag{3}$$

The second part is the equation of the line connecting the starting point and the end point. (The advantage of doing this is that the equation of the line is the shortest path path from the starting point to the end point without considering obstacles. After obstacles are added to the map, the mobile robot's movement trajectory can be effectively constrained so that it will not deviate too far or even fall into unsolvable situations due to complex terrain.) The formula is as follows:

$$\begin{cases}Y_{start} = aX_{start} + b\\Y_{end} = aX_{end} + b\end{cases} \tag{4}$$

Step 4:Crossover and mutation operators of initial population, the specific operation first 32 points from the initial population to use roulette way randomized crossover operation (each coordinate point of x, y as a chromosome, the two intersect, only for x coordinate cross or y coordinate cross alone), and then to mutation, the x coordinates (or y) replacement for y (or x coordinates), as shown in figure 4 can be obtained a second generation of population (the largest case for 48 points), and then in turn to the second generation of population individual generation into the equation of the straight line (the second part of the moderate function), selecting and linear recent individual (points),Then substitute the moderate function in the first part and select the "optimal individual" with the shortest distance from the end point. Specific coding rules are as follows:

1. Randomly generate 32 Numbers between 0 and 1, Pn.

It corresponds to 32 coordinate points: (x,y), As the roulette whether can participate in the cross - variation operation of the decision basis.

2. Set the judgment value Pc=0.95 for the crossover operation and the judgment value Pm=0.05 for the mutation operation, and check Pn successively. When Pm < Pn < Pc, CROSS will be denoted as the crossover operation object; when Pn < Pm, VAR will be denoted as the variation operation object; otherwise, no CROSS mutation operation will be performed

3. If CROSS is even, then the pair is paired, such as (x1, y1) and (x2, y2). At the same time, a number ranging from 0 to 1, Pxy, is randomly generated to compare with 0.5. If CROSS is odd, then it is substituted into the moderate function in step 3 in turn for testing, and the moderate worst coordinate point is discarded, and then CROSS operation is carried out.

4. VAR is mutated into Pxy, and compared with 0.5. If it is greater than 0.5, for example, (x,y) is mutated into (x+1,y), and vice versa.

Step 5: after "the best individual", which is set to "target", this time using A * algorithm to search around eight nodes (as shown in figure 5), from starting point to make mobile robot "target", during the search to the "target", for every search unit distance (0.5) on the grid map, make A judgment, whether the moment of coordinate more in line with the two moderate function constraint, if meet, is the present coordinate points instead of "the best individual" and stop the search, or search to stop after the "target".(The advantage of doing this is that the direction is corrected at all times, so that the mobile robot is closer to the end point more accurately, and the computation is small each time, so that the search node can be reduced during the execution of A* algorithm, thus reducing the storage space occupied.)

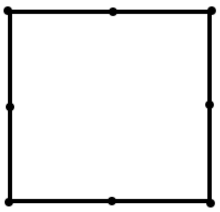

Figure 5. Schematic diagram of search node in grid

Step 6: When the search stops, the local movement begins, and the judgment is made when the absolute value of the x-coordinate (and y-coordinate) of the target point is less than 2 and neither is equal to 0.

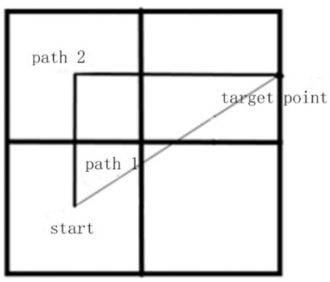

Figure 6. Schematic diagram of path selection and judgment

As shown in Figure 6, it is assumed that path 2 is the path searched by A* algorithm, and path 1 is the line connecting the "optimal individual" selected by genetic algorithm in one iteration to the starting point. Set $\tan = \frac{y_{\mathrm{end}} - y_{start}}{x_{end} - x_{start}}$

There are two types of tan, namely tan >1, 0 < tan < 1, -1 < tan < 0, and tan < -1 is the first type, tan = -1 and tan = 1, these are the second type. Take figure 6 for example, where 0 < tan < 1, Then judge whether the square where (x+1, y) is an obstacle. If yes, choose path 2; if no, choose path 1. Similarly, the first type of case does the same thing for every other case, Then set the "target point" that is the "optimal individual" as the new starting point.

Step 7: Repeat steps 1 through 6 until you reach the destination and get the path expression:

$$\sum_{i=1}^{end}(x_i, y_i) \tag{5}$$

III. SIMULATION EXPERIMENT

In this paper, Intel(R) Core(TM) I7-8750h CPU @2.20ghz 2.21ghz,RAM 8.00GB, 64 operating system, Windows 10 home Chinese version computer and MATLAB 2018B were used for experimental simulation.

A. *The combined algorithm is compared with the algorithm in literature [5]*

The traditional genetic algorithm in literature [5] was taken as the comparison object, where the initial population number was 50, the crossover probability Pc=0.8, and the mutation probability Pm=0.1.The combined algorithm kept the initial population number as 32, Pc=0.95, Pm=0.05.The 20×20 raster map in literature [5] was used as the map of this experiment.

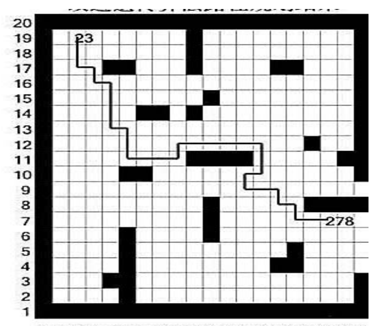

Figure 7. Simulation path of literature [5]

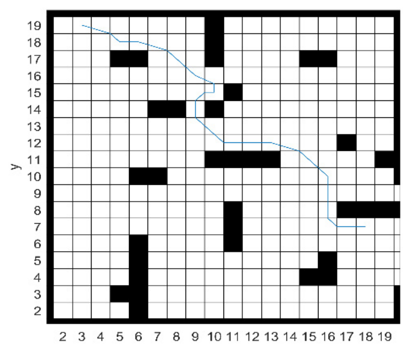

Figure 8. Simulation path of combined algorithm (the first experiment)

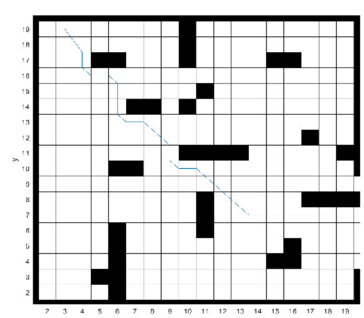

Figure 9. Simulation path of combined algorithm (the second experiment)

TABLE I. DATA COMPARISON BETWEEN GENETIC ALGORITHM AND COMBINATION ALGORITHM IN REFERENCE [5]

	Algorithm of literature [5]	New algorithm		
		first	second	average
Time	20.667m/s	48.218m/s	49.317m/s	48.7675m/s
Step length	31.0000	23.7827	24.1651	23.9739

By comparing the paths in Figure 7, Figure 8 and Figure 9 and combining with Table 1, it can be seen that under the same map, the step size of the algorithm is optimized by 23%, and the timeliness is increased by 135%.

B. Raytheon map test

Through the above comparison experiments, the advantages of the combined algorithm have been proved. The following is to further verify the reliability of the combined algorithm through simulation test in the Raytheon Hospital model. A show in Figure 10 and Figure 11.

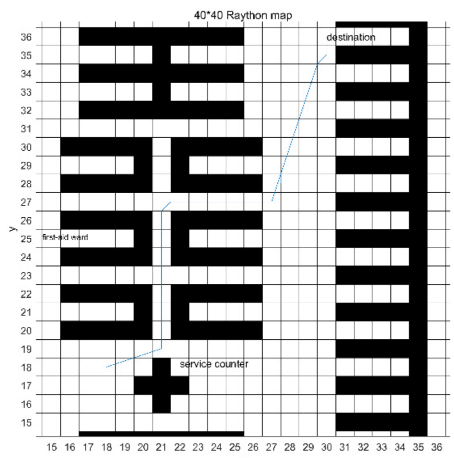

Figure 10. . Simulation path diagram starting from the service desk

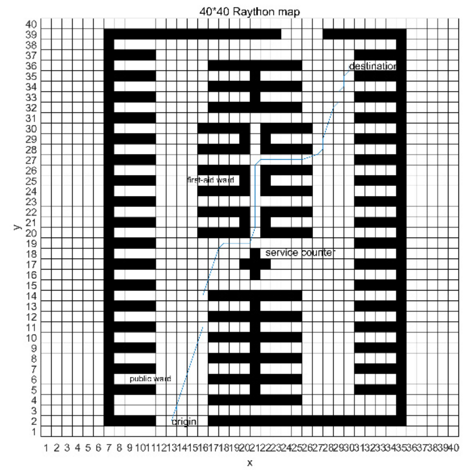

Figure 11. Simulation path diagram starting from the hospital gate

Through the experimental results, we can draw the conclusion: combining algorithm was compared with genetic algorithm (GA) and A * algorithms, don't need A large amount of computing will be able to quickly find the goal, effectively solve the inefficiency and A * algorithm GA take up large storage space, consume more problem, and through comparison with the literature [5] and the model test, once again to prove its reliability.

IV. CONCLUSION

The application requirement of the mobile robot under the outbreak increases with the face of traditional low operation efficiency of the algorithm, large amount of calculation and program takes up too much storage space problem, put forward A kind of based on genetic algorithm (GA) and the combination of the A * algorithm (A - star) algorithm, and simulation experiment, compared with the literature [5] and model test, the step of optimization to nod 23%, aging increased by 135%, confirmed the feasibility and effectiveness of the method. Compared with the traditional genetic algorithm and A* algorithm, it significantly improves the efficiency of path planning, reduces the computation time, reduces the search node, and thus reduces the space occupied by storage. From the path analysis, although the step size is excellent, there is the problem of insufficient path smoothness, so the next step can be considered to continue the research for improvement.

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