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Research on Autonomous Robot Navigation Algorithm in Indoor Environment

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Abstract. With the development of the times, in order to make robots more autonomous, this has led to research on autonomous navigation and other aspects. In the research of autonomous navigation, it is generally divided into two aspects. Firstly, the construction of the map requires the combination of sensors and algorithms to construct the map. During the construction process, many factors need to be considered to apply different algorithms in different scenarios and robot hardware facilities. When not applicable, it is easy to experience map misalignment and other phenomena. After building the map, the robot needs to plan its path based on the current environment to reach the desired location. For path planning, Ant colony optimization algorithms with high robustness is used to better adapt to the environment. Compared with other algorithms, Ant colony optimization algorithms has better effect in indoor small environment. On the basis of the traditional algorithm, Ant colony optimization algorithms is improved by adjusting the volatilization coefficient of Pheromone, which makes the path planning of Ant colony optimization algorithms more reasonable.

Keywords. Path planning, Map construction, Autonomous navigation

1. Introduction

Traditional map construction is generally divided into three types: scale maps, topological maps, and semantic maps. The map used in this paper is a scale map. Scale maps are often used for small-scale map construction. Among them, slam technology (instant location and map construction technology) has reached a great development from the earliest technology prototype to now. SLAM technology enables robots to construct maps through sensing methods such as radar, and to calculate its location based on the information in the map. Slam technology needs to rely on sensors to achieve, and in general slam technology sensors are generally divided into lidar and camera, while laser slam and vision slam technologies have gradually matured [1-3]. Wenyou Chen et al [4] proposed a strategy of fusing laser local maps with camera local maps to construct a global map. Heng Zhang et al [5] proposed a strategy to first fuse camera data with LiDAR data by Kalman filtering, and then fuse the laser data with the 2D local maps generated from the camera data by Bayesian estimation. Yan Xiaobin et al [6] used a monocular camera as an aid for laser SLAM, and their method focuses on correcting the

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point cloud distortion during the lidar motion by motion estimation of the monocular camera. Bai Chongyue et al [7] fused three sensors, and used the Kalman filtering algorithm. Shen Dong et al [8] improve a algorithm about sparse positional optimization. Jun-Xin Lu et al [9] proposed a new RGB-D visual odometry, which well combines the respective advantages of point and line features. Gmapping is an algorithm based on slam framework, it is a particle filtering algorithm, generally applied in two-dimensional plane building map, in small maps, gmapping algorithm is less computation, and the accuracy of the map is higher compared with other algorithms, and the hardware that meets the requirements is also broader, more practical value.

For path planning algorithms, compared with traditional algorithms, intelligent algorithms have appeared more and more in recent years, among which, ant colony algorithms are more advantageous due to their own computational power and higher operational efficiency. Moreover, with the continuous development and update of the algorithm, the algorithm has been improved in many ways, thus reproducing. Lei Wang et al [10], on the other hand, influenced the algorithm by changing the heuristic values in the algorithm. The ant colony algorithm can be improved in different ways by different aspects and possesses a strong improvement.

2. Key Technology

2.1. Build a Map

The main research content of this paper is the autonomous navigation algorithm in the indoor environment. Because it is in the indoor environment, it is necessary to select the relevant algorithm suitable for the indoor environment. For the selection of slam algorithm, the size and accuracy of the map representation, the way and dimensionality of the map, the type of the sensors need to be considered. In this paper, we need to compose the indoor environment and construct indoor 2D maps. gmapping requires less frequency for LIDAR and is more robust than other single-line LIDAR algorithms, such as hector algorithm. gmapping is mainly through two aspects of proposal distribution and selective resampling. improvement, which increases the efficiency of the algorithm.

The Gmapping is a rbpf particle filtering algorithm. It is characterized by separating the localization process and the map building.

$$P(X_{1:t}, m \mid Z_{1:t}, U_{1:t-1}) \tag{1}$$

From the equation, it can be concluded that the map of the robot's own pose and surroundings can be inferred from the sensor observations and the data generated by the robot motion. Gmapping is an algorithm based on raster maps, which are often used in the construction of two-dimensional planar maps.

The Gmapping algorithm calculates the values of Xt and m from two inputs Zt and Ut. Then it calculates its current pose and the surrounding environment. After getting the map of the surroundings and the location of itself, the path planning can be started. As shown in Figure 1, the rendering effect of gmapping is shown.

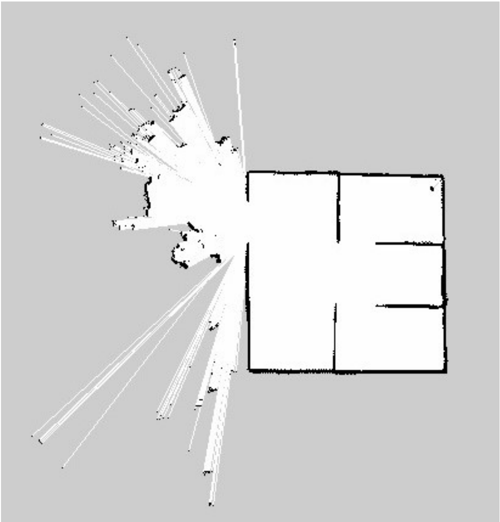

Figure 1. Schematic diagram of construction

2.2. Path Planning

With the research on the related aspects of path planning, many algorithms have been generated for its related aspects. Different algorithms have different advantages for different applications in different environments. For example, the dijkstra algorithm has the advantage over other algorithms in that it is 100% sure to find the shortest path; the free-space algorithm has much more freedom than several other algorithms, allowing the starting point or task point and the final goal point to change during the path planning process. The ant colony is more conducive to the planning of small maps. Therefore, this paper uses the ant colony algorithm for path planning in indoor environment. It influences the probability of selecting the next path choice by the pheromone concentration and the distance. As shown in equation (1). Pheromone concentration and distance are important factors affecting the selection probability of algorithm.

$$P_{ij}^{k}(t)=\begin{cases}\dfrac{\tau_{\mathrm{i}}^{\alpha}(t)\eta_{\mathrm{ij}}^{\beta}(t)}{\sum_{x\in a\|_{i=m}d_k}\tau_{a}^{\alpha}(t)\eta_{ix}^{\beta}(t)} & s\in \mathrm{allowed_k}\\ 0 & s\notin \mathrm{allowed_k}\end{cases} \tag{2}$$

After a path is selected, the pheromone concentration on that path will also change, and the pheromone concentration left by the colony will decrease between time. This also facilitates the selection of better paths. As shown in Equation (3), Pheromone updating is controlled by volatilization coefficient.

$$\tau_{ij}(t+1)=(1-\rho)\cdot\tau_{ij}(t)+\Delta\tau_{ij}(t,t+1) \tag{3}$$

For the traditional ant colony algorithm, some improvements are needed. Among them, the pheromone concentration is an variable of the algorithm. Therefore. The pheromone volatility coefficient can be changed according to the The pheromone concentration can be changed according to the value of the pheromone volatility coefficient. The choice of pheromone volatility coefficient will affect the efficiency of the algorithm and the optimal solution.

To better fit the actual situation, the pheromone volatilization coefficient associated with the number of iterations t, as shown in Equation (4).

$$\rho=\frac{1}{t}+0.2 \tag{4}$$

As the number of iterations increases, at first the pheromone concentration volatility factor is set higher in order to better select the optimal path, and lowering the pheromone concentration coefficient at a later time is beneficial to better find the optimal path and improve the efficiency of the algorithm. The relationship between the pheromone concentration volatility factor and the number of iterations is shown in Figure 2.

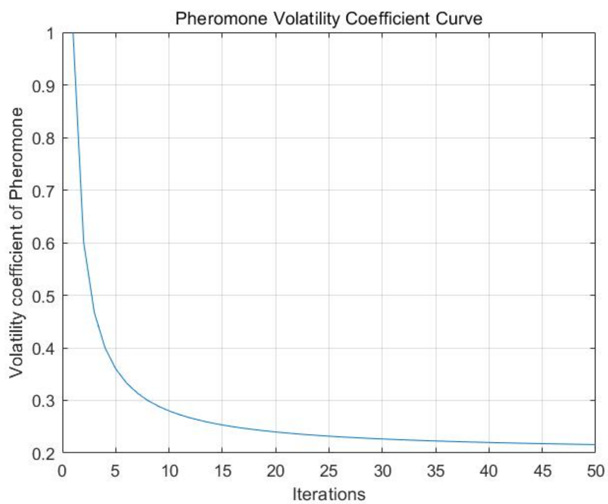

Figure 2. Schematic diagram of Pheromone concentration volatility coefficient

By using the flexibility of the pheromone concentration volatility factor, the efficiency of the algorithm for the path planning process can be improved.

3. Experiment

In this paper, the MATLAB software is used to conduct experiments on the algorithm. After the construction of the map is completed, 10 random task locations are set and the improved algorithm is used to plan the path. The path planning diagram of the improved algorithm is shown in Figure 3.

The specific experimental task point data is shown in Table 1. The data in the table is randomly generated to test the algorithm.

Table 1. Task point coordinates

Serial Number	1	2	3	4	5	6	7	8	9	10
Abscissa	0	3	5	20	32	-30	40	40	-12	-8
Ordinate	0	10	-30	22	30	10	-5	12	20	10

Table 1. (continued)

Serial Number	11	12	13	14	15	16	17	18	19	20
Abscissa	6	15	-10	-3	20	15	-6	-9	-9	1
Ordinate	4	23	-2	26	3	3	6	8	3	13

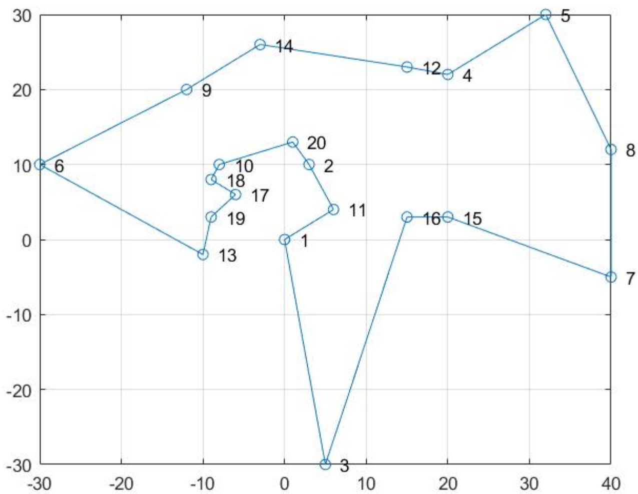

Figure 3. The path planned by the improved algorithm

The experimental results show that the path planned by Ant colony optimization algorithms is more reasonable than before, and the Rate of convergence is faster than before.

4. Conclusion

The improved ant colony algorithm obviously improves the efficiency of the algorithm and greatly enhances the robot's ability to navigate autonomously. In this paper, the map is firstly constructed by the gmapping algorithm, and after the map is constructed, the path planning can be carried out by the improved ant colony algorithm. This allows the robot to navigate autonomously in unfamiliar environments. We improve the efficiency of the algorithm by improving the information transfer mechanism to make the influence of pheromone more effective. By improving the pheromone concentration volatility coefficient, a better optimization effect is achieved and the algorithm is made more efficient while avoiding falling into the optimal solution.

After the matlab simulation experiment, the algorithm is more reasonable than the previous one. All aspects of the algorithm have been improved, and it is more suitable for indoor environment. The improved Ant colony optimization algorithms will also be more suitable for large-scale problems and can effectively meet the search requirements of large-scale problems. In future improvements, other algorithms can also be integrated to fully leverage their own advantages.In future research, the algorithm can also be optimized to particle Pheromone, and then resample particles to improve the efficiency of the algorithm.

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