Path planning of ROS autonomous robot based on 2D lidar-based SLAM

Shengmin Zhao
dept. Division of Electronics and Electrical Engineering
Dongguk University
Seoul, South Korea
Shengmin.zhao@dgu.ac.kr

Seung-Hoon Hwang
dept. Division of Electronics and Electrical Engineering
Dongguk University
Seoul, South Korea
shwang@dongguk.eduddress

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***Abstract*—Indoor robots are more and more widely used, and their path planning directly affects traverse efficiency and quality, which has always been a hot research topic. Excessive requirements for sensor accuracy and accuracy may reduce the adaptability of path planning or cause unacceptable costs. Based on the analysis of the path planning requirements of the indoor robot, this paper proposes a ROS path planning method based on 2D Lidar-based SLAM. The algorithm is simple and effective. In the simulation test, the robot has a high coverage of the entire area and strong environmental adaptability.**

***Keywords*—Ros (Robot operating System), 2D Lidar-based, SLAM (Simultaneous Localization and Mapping), Autonomous robot.**

I. Introduction

Originating from the combination of a vacuum cleaner and a mobile robot to achieve an automatic traverse function, someone proposed the concept of a robot. Specifically, a robot needs a good design and combination of sensors, control systems, roadbed planning, and other systems. Among them, the design and control of the robot's autonomous movement path is an important key technology. General path planning of mobile robots refers to planning the shortest path from the starting point to the target point that does not collide with obstacles in the scene according to the environment perceived by the robot and according to certain optimization indicators.

Most of the path planning of mobile robots is divided into two types. The first is point-to-point path planning and full-area coverage path planning. Point-to-point path planning, which requires the robot to find a path from the starting point to the endpoint in the working area [1]. The other is a complete traversal path planning, which requires the robot to find a path in the workspace that can traverse every feasible one in the environment Point path [2-3], so that the robot can traverse any passable point in the working environment when it ends. At the same time, the robot can avoid all obstacles autonomously and reach all areas except obstacles.

The path planning research of mobile robots generally includes two aspects: (1) the modeling method of the environment; (2) the path planning algorithm. The current modeling methods for the environment include the template model method, topology method, visible method, free space method, geometric method, and grid method [4]. Path planning algorithms include genetic algorithm [5], ant colony algorithm [6], heuristic algorithm, A* algorithm [7], and so on. S. X.

Different from the above path planning, the path planning of the robot is to complete the traversal of all traverse areas in the shortest possible time. Therefore, the path planning described here does not refer to planning the path from the starting point to the end point but needs to realize the full coverage path planning of the traverse area by the robot, and at the same time, make the repetitive coverage rate as low as possible under the premise of satisfying full coverage. In terms of full-coverage path planning, the problem of coverage in the barrier-free area has been satisfactorily resolved, and some research has been carried out on the area segmentation of the known environment and the map generation of the unknown environment. Results.

At present, the robots on the market mostly use random path planning algorithms. For example, the iRobot Roomba 3-8 series developed by iRobot in the United States is a typical representative of random collision pathfinding systems. The robot uses sensor information to allow the robot to randomly rotate a certain angle to select the next moving direction when it encounters an obstacle or walks to the boundary of the area. This method can theoretically achieve full coverage when the time is long enough. However, due to the limited power provided by the battery and the practicality of the problem, the stochastic path planning algorithm has limitations that cannot be ignored.

This paper proposes a path planning algorithm for ROS autonomous robot based on laser SLAM mapping. To realize autonomous and intelligent navigation of mobile robots, it is usually necessary to solve the four major problems of mapping, positioning, navigation and motion control to realize the robot's intelligent perception of the environment and autonomous decision-making. Among them, on the positioning system, AMCL (Particle Filter) is selected as the positioning method. The Karto-SLAM algorithm is chosen as the method of constructing the first laser SLAM map. The complete coverage path planning algorithm (Complete Coverage Path Planning) is used in navigation planning as the first planning result, and then the planned path points are sent to the robot navigation system in turn according to the distance, and the robot is controlled to execute. At the same time, the form of Gazebo simulation is used to realize the construction and testing of the robot. Experimental results show that the path full coverage algorithm proposed in this paper can effectively cover the traverse area.

II. Improved algorithm

A. Autonomous robot based on full coverage path planning

This part mainly adopts the idea of CCPP(Complete Coverage Path Planning). First, the original grid map area without obstacles is divided according to the size of the robot, and then all the divided areas can be traversed directly. To traverse directly according to certain rules, the path is not guaranteed to be optimal, it can achieve relatively better and complete basic functions.

Step 1: If the front of the robot has been covered or there is an obstacle, then turn left or right and rotate 180 degrees and then walk to achieve S-shaped walking, as shown in Figure 1.

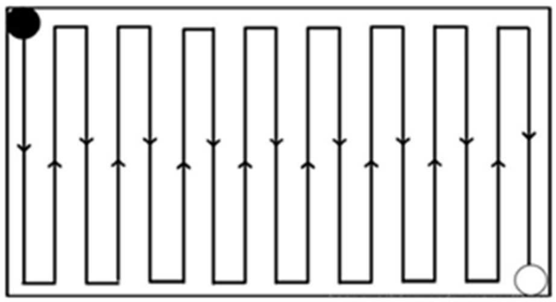

Fig.1. Schematic diagram of full coverage path planning

Step 2: If the surroundings of the robot are covered, take the current robot position as the starting point and the uncleaned area as the target point, and use the A* algorithm to find the path. Repeat Step 1 and 2.

Step 3: If there is no uncleaned area, the algorithm ends.

To find a better solution, this problem can also be regarded as a business travel problem, that is, all the divided areas are regarded as nodes to be visited, and the shortest path through all nodes is obtained. This method plans a better path and can be realized. The shortest path is usually solved by the backtracking method.

B. *ROS robot main node design*

In order to realize the path planning of dynamic obstacle avoidance and mutation points, I use the move_base navigation stack as the module to control the robot to track the full coverage path. The system structure diagram is shown as in Fig. 2.

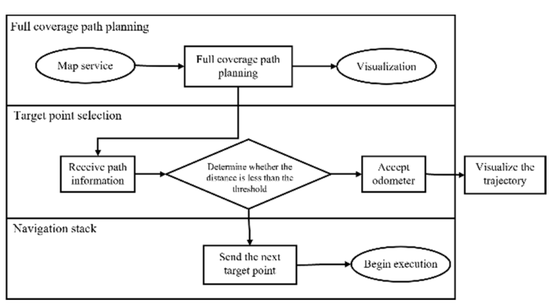

Fig.2. System frame structure diagram

First, the map is divided according to the size of the robot, and then traversed according to fixed rules. However, because the path after the planning is the center point position after the map is divided, every two points are only separated by the size of the robot, and the next path planning point is sent only when they arrive, which makes the robot easy to go and stop, and the traverse efficiency is relatively high. low.

Therefore, an additional target point sending program is added. Realize the dynamic sending of the target point. The realization idea is to calculate the Euclidean distance from the robot to the current target point based on the pose data fed back by the current robot odometer and send the next point when it is less than the set threshold. The program receives two topics, one is the odometer data of the robot, and the other is the path planned by the path planning node. In the path callback function, the accepted path will be judged. When the path length is 0 or the length has not changed, it is the last path, and the path stored in the system is not updated. Otherwise, update the path and track it from the beginning.

At the same time, to display the path in rviz, I added the posture data of each odometer feedback to a path message, and then published it to achieve visualization.

C. *A* algorithm*

In computer science, A* (pronounced as “A star”) is a computer algorithm that is widely used in pathfinding and graph traversal, the process of plotting an efficiently directed path between multiple points, called nodes. It enjoys widespread use due to its performance and accuracy.

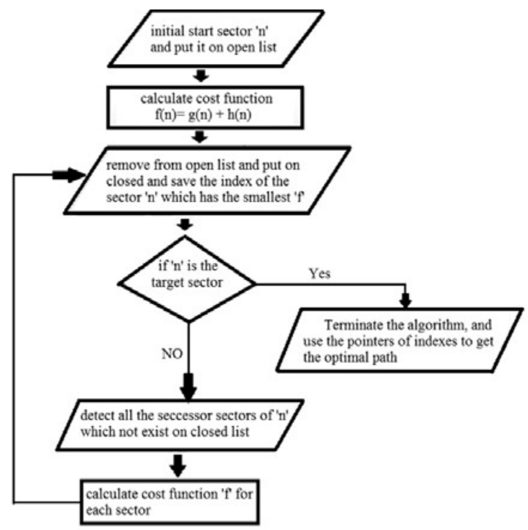

Fig.3. Flow chart of A* algorithm

III. EXPERIMENT

Because the test environment is relatively small, the burger robot in the turtlebot3 series robot is selected as the test robot.

Gazebo is a powerful 3D physics simulation platform, with a powerful physics engine, high-quality graphics rendering, convenient programming and graphics interface. So Use Gazebo simulation form to realize the construction and test of robot. Set up a simulation environment of 10m * 5m in the building edit function of gazebo as required, including wall panels and obstacles, and build the simulation environment as shown in Figure 4 below.

According to the simulation environment in Fig.4(b), the path planning ability of the robot is tested. Before robot path planning, the planning path density can be set. The higher the density, the denser and more detailed the path planned by the robot will be. The result is shown in Fig.5.

The green line in the result figure represents the autonomously planned traversal path of the machine, and the brown is the actual area cleaned after the traverse is completed. The comparison shows that when the path is denser, the area covered by the traverse is larger and the traverse efficiency is higher. At the same time, when the set path density is higher, the path full coverage effect is better.

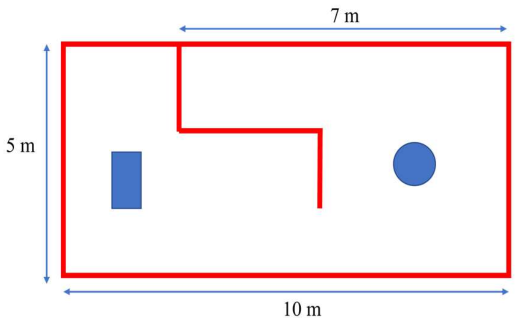

Fig.4 (a) Room structure diagram.

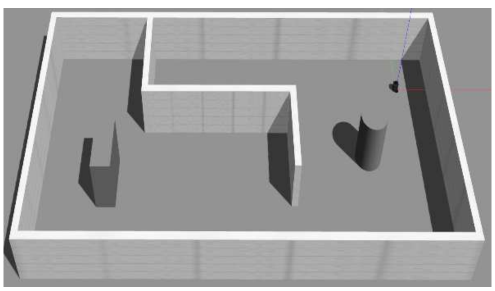

Fig.4 (b) Room structure diagram (Gazebo).

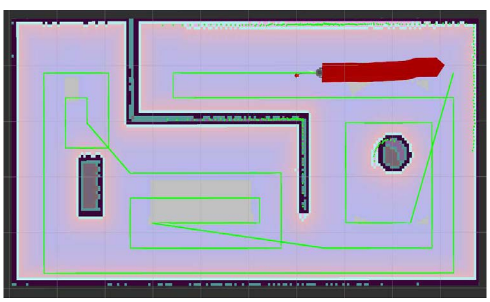

Fig.5 (a) Traverse planning path(density=7).

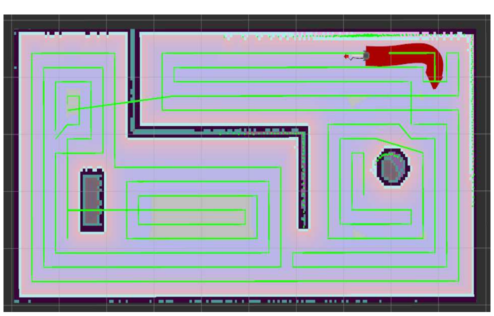

Fig.5 (b) Traverse planning path(density=5) .

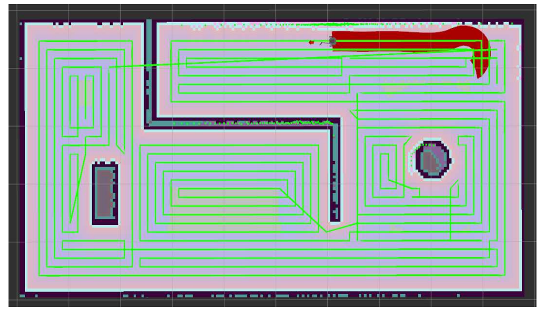

Fig.5 (c) Traverse planning path(density=1)

TABLE I. COMPARISON OF DIFFERENT DENSITY PATHS

Table Column Head		
Planning path density	***Running time***	***Coverage***
7	~ 6 min	52%
5	~ 16 min	83%
1	~ 30 min	97%

IV. CONCLUSION

In this paper, based on the 2D lidar-based SLAM, the precise composition of the unknown environment is adopted, and the full coverage path planning algorithm is used to complete the efficient and autonomous traverse of the robot. And through the design of the main nodes of ROS, the visualization of map services, robot communication and simulation are completed. In the future, further attempts can be made to add functions such as autonomous exploration and mapping by robots.

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