Application of Simultaneous Location and Map Construction Algorithms Based on Lidar in the Intelligent Robot Food Runner

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Abstract: With the rapid development of artificial intelligence, there are more and more "shadows" of artificial intelligence in restaurants. In the market, the intelligent robot food runner is relatively expensive and not widely used. In this paper, an intelligent robot food runner with lower price but better performance is proposed, which is suitable for restaurants. Among them, this paper mainly analyzes how to use laser radar SLAM to build restaurant map, locate and navigate, and how to build obstacle avoidance and path planning. Through ROS platform, the whole process of intelligent robot food runner is simulated and verified, which can meet the needs of restaurants.

1. Introduction

In recent years, more and more restaurants have used intelligent robots, which also shows that the demand for intelligent robots in the service industry is growing. For robot positioning, when outdoors, satellite GPS/GPRS is mainly used for positioning, such as unmanned aerial vehicles. However, in the face of some complex indoor scenes, relevant sensors are needed to collect environmental data. This paper proposes an intelligent robot food runner based on laser radar SLAM technology, which can realize real-time status and map construction in the restaurant. Its applicability and stability in restaurant environment are relatively excellent.

The problem of simultaneous location and map construction was first proposed by Cheeseman, Smith, and Self in 1988.0 In the problem of autonomous navigation of mobile robot, it has very important application and theoretical value. Since the emergence of the first mobile robot in the late 1960s,0 SLAM technology has always been the hot and key research in the field of intelligent robots, which is the key technology to realize autonomous navigation and positioning of intelligent robots. 0

Path planning and obstacle avoidance are also very important parts in the navigation system of the intelligent robot food runner, and there is a higher and more urgent demand for the environmental adaptability and planning efficiency of the navigation system of intelligent robot food runner. Therefore, this paper proposes an intelligent robot food runner based on laser radar SLAM technology, and combines ultrasonic radar, Dijkstra algorithm and motion control system. On this basis, the intelligent robot food runner can complete more effective obstacle avoidance and path planning capabilities.

In the experimental simulation, this paper studies the map construction and real-time positioning of the intelligent robot food runner based on lidar SLAM algorithm in the simulated restaurant environment built by ROS platform, and makes the vegetable delivery robot realize the functions of path planning,
obstacle avoidance and autonomous navigation in the simulated restaurant environment.

2. Laser SLAM builds a map

2.1. Gmapping algorithm
In the research field of mobile robots, Lidar is a common and important optical sensor, and the method of constructing SLAM system using lidar is called laser SLAM. In the application of laser SLAM technology, some excellent indoor laser SLAM algorithms have been proposed. In this paper, Gmapping algorithm based on filtering is used, which is more suitable for small scenes like restaurants, with higher accuracy and less computation.

In 2007, Grisetti et al. proposed the Gmapping algorithm based on the Fast-SLAM scheme. Gmapping algorithm is a 2D laser SLAM algorithm based on particle filter, which is suitable for two-dimensional map construction and location of indoor environment. The core of particle filter is random sampling, which is mainly divided into the following stages: (1) initializing the pose of intelligent robot food runner; Get feedback information after randomly distributing particles; The approximate integral is obtained by a series of random samples, Then calculate the weight of particles; Redistribute particles according to their weights; Repeat the above process, and finally estimate the map. Compared with particle filter algorithm, Gmapping algorithm adopts an adaptive method to reduce the number of particles in RBPF, considers the odometer readings and lidar observations of the robot at the same time, thus reducing the inaccuracy of robot pose estimation. It is considered that it can be used well in restaurant environment, and can also improve the overall performance of intelligent robot food runner.

2.2. Occupy raster map
When people use 2D lidar to build maps, they often consider using occupied grid maps with features. Elfes and others put forward the concept of occupying raster map in 1980. It can be used to express the spatial characteristics of robots in the working environment and is widely used. In this paper, the occupied grid map can help solve the problems of autonomous navigation and positioning, path planning, obstacle avoidance, etc.

2.2.1. Construction algorithm of occupied raster map
A multidimensional space is subdivided into small cells, each of which stores the probability estimation of the corresponding cell, and such they are called grids. For the occupied grid, each small cell has only two states, one is occupied and the other is idle. Therefore, every occupied grid can express its own state with a binary random variable.

Assuming that a two-dimensional restaurant map can be subdivided into a limited number of grid units, the grid map can be expressed as:

\[ m = \{ m_i \} \]  

In the formula, \( m \)-----grid map composed of all grid units; \( m_i \)-----the \( i \)th grid unit.

The construction algorithm of occupied raster map is to estimate the posterior probability of the whole restaurant map according to the observation data of lidar. The posterior probability of a map can be expressed as:

\[ p(m | z_{1:T}, x_{1:T}) \]  

Where, \( z_{1:T} \)-----all measured values of the sensor up time; \( x_{1:T} \)-----the path defined by the pose of the robot.

Assuming that each occupied grid unit is updated independently, the posterior probability of the entire occupied grid map can be approximately expressed by the product of marginal probability expressed by the following formula, thus transforming the problem into the updating problem of each grid unit.
\[
p(m | z_{t_1}, x_{t_1}) = \prod p(m | z_{t_2}, x_{t_2})
\]

Where, \( p(m | z_{t_1}, x_{t_1}) \) —— posterior probability of the whole map;

\( p(m | z_{t_2}, x_{t_2}) \) —— occupation probability of a single grid unit.

Under the observation of lidar sensor, the updating formula of each cell occupying grid can be deduced according to Bayesian filtering principle.

### 2.2.2. Experiment of constructing raster map

In this project, the process is divided into several steps: the robot adds its initial pose to the map at the initial position, and then the lidar in the system extracts artificial features by scanning the environment and adds them to the map. In the process of transferring vegetables, the robot constantly scans the environment of the restaurant. The features are extracted from lidar and matched with the existing features in the map. If matching features are found, constraint relations are established between the corresponding features. If no matching feature is found, the feature is added to the map as a new feature.

When the intelligent robot food runner stops working, the optimization module is used to globally optimize various constraints established between features, thus reducing errors and obtaining more accurate maps.

### 3. Obstacle avoidance system and path planning of intelligent robot food runner

#### 3.1. Construction system of intelligent robot food runner

In this project, Raspberry PI 4B is used as the main control board, STM32F103 is used as the driving control chip, Mecanum wheel chassis is used as the mobile platform.

#### 3.2. Obstacle avoidance and path planning of intelligent robot food runner

Obstacle detection is an important part of the intelligent robot food runner’s perception of environment. In the whole process of dish passing, the intelligent robot food runner needs to avoid obstacles such as crowds and dining tables to ensure the accuracy and integrity of the delivery process. In this paper, two external sensors, ultrasonic and lidar, are considered to improve the obstacle avoidance ability of the intelligent robot food runner.

Lidar has the advantages of high resolution, high precision and strong anti-interference ability 0, but the laser will penetrate the glass. It is inevitable that the surrounding glass can not be detected and...
mistakes will occur. However, the auxiliary use of ultrasonic sensors can change this situation and they can strengthen the ability to avoid people who suddenly pass by or sudden obstacles in time. In this paper, the obstacle avoidance system based on laser radar and supplemented by ultrasonic wave can effectively complete the obstacle avoidance task of the intelligent robot food runner, and has strong robustness.

In the path planning section, Dijkstra algorithm is considered to plan the shortest path in this project. In this way, the intelligent robot food runner can complete the whole process of vegetable delivery efficiently.

4. Experimental verification

Through the above research on the intelligent robot food runner based on laser radar SLAM, the restaurant environment is simulated and built on Gazebo simulation software platform.

![Figure 3 Restaurant environment simulation diagram](image)

According to the simulated restaurant environment generated in the above figure, the lidar carried in the intelligent robot food runner scans the restaurant environment and builds a 2D raster map as shown in the following figure.

![Figure 4 A 2D raster map](image)

When lidar and ultrasonic help to avoid obstacles at the same time, the vegetable delivery process of the robot is relatively stable and reliable; Through Dijkstra algorithm and motion control system equipped with mcnam wheel, the robot completes the process of transferring dishes.
Figure 5 the path planning and navigation of the vegetable delivery robot

Compared with this project, the intelligent robot food runner in the market are more expensive. However, the intelligent robot food runner studied in this project has achieved good performance at a lower price and has a good market prospect.

5. Conclusions
In this paper, the restaurant environment is simulated on Gazebo simulation software of ROS system, and based on this, the 2D raster map of restaurant is constructed by laser SLAM algorithm and Gammpping algorithm. The simple lidar sensor is assisted by ultrasonic sensor, which makes the intelligent robot food runner have stronger obstacle avoidance ability. Finally, the path planning is completed by Dijkstra algorithm and motion control system, so that the intelligent robot food runner can complete the stable and reliable process of serving the dishes in the restaurant. In this paper, a cost-effective and reliable food delivery robot is realized, which has market development potential. The robot constructed in this project is of great significance to the restaurants and further promotes the application of artificial intelligence in daily life. The future, the direction of this project is to use 3D laser to build clearer and more simulated maps, and further improve the accuracy of navigation and positioning, so as to improve the system performance of the robot.

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