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Research on Navigation Algorithm of ROS Robot Based on Laser SLAM

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Abstract

The premise for mobile robot to realize autonomous navigation is to perceive its own position and environment. Therefore, it is necessary to establish an environment map to ensure the autonomous and stable operation of the robot. The working environment of mobile robot is mostly corridor. Because the corridor is narrow and the environment is changeable, it is necessary to establish a more accurate corridor map to realize the autonomous navigation of robot. Therefore, it is necessary to study slam technology in order to establish a more accurate environment map.

Keywords

Markowitz portfolio theory; Mean-variance model; Efficient frontier.

1. FIGURE PRINCIPLE OF OPTIMIZING SLAM ALGORITHM

The SLAM algorithm based on graph optimization is different from the SLAM algorithm based on particle filter. It not only optimizes the pose of the mobile robot at the previous time, but also corrects the pose of the mobile robot at the current time. The basic idea of graph optimization SLAM algorithm is to estimate the motion trajectory and map of mobile robot by using all the saved sensor measurement information and its spatial constraints [1]. In this method, nodes are used to represent the pose of mobile robot, and the edges between nodes in the graph represent the spatial constraint relationship between poses. The resulting graph is called pose graph (SOD). After constructing the pose map, the pose sequence is adjusted so that it can best satisfy the constraints expressed by the edges [2]. The optimized result is the constructed map and the trajectory of the mobile robot.

The graph optimization SLAM algorithm is mainly divided into two processes: front-end and back-end. The front end is responsible for Closed-loop Detection and data association. The closed-loop detection is mainly aimed at the global data relationship. The data obtained by the sensor is used to determine the pose matching between the current pose of the robot and the previously visited area, as well as the estimation of the relative pose. The data association is mainly used to deal with the relationship between local data, solve the problem of matching between continuous data frames and related pose estimation. Through the above two processes, the pose graph is created and the front end of graph optimization slam is completed. Because the sensor observation will produce noise, and there will be errors in scanning matching, which leads to the errors in the pose map obtained by the front end, so the back end map optimization is needed to correct the pose map. The back end just optimizes the pose map created by the front end and obtains the maximum likelihood estimation of pose, that is, the optimal pose sequence. The algorithm framework is shown in Figure 1.

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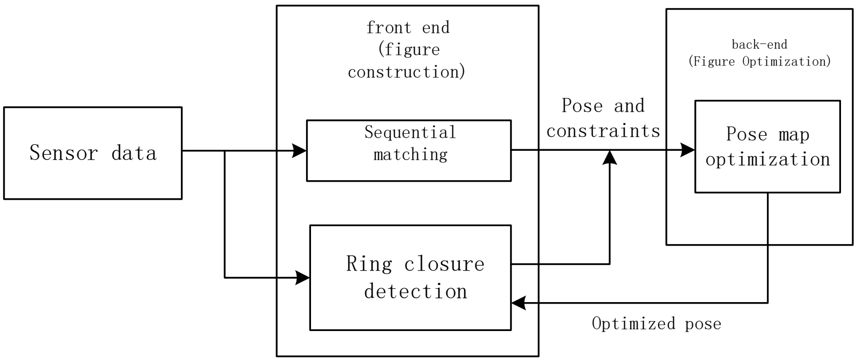

Figure 1. FRAMEWork diagram of optimized SLAM algorithm

The constraint relationship and pose sequence of the robot in the graph optimization slam method are expressed in Figure 2:

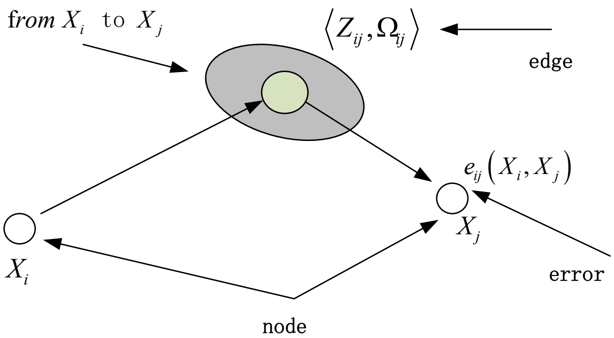

Figure 2. Robot pose transformation diagram

Figure 2 is a vector point set, which represents the pose sequence of the robot, where and respectively represent the pose of the node and the node at the current position; Represents the relative pose between nodes; Representing the information matrix between nodes; Is a vector error function, which represents the error between the predicted value and the measured value; Is the measurement function, which represents the measured value in the ideal case.

Assuming that the error function obeys Gaussian distribution, the expression of the objective function is:

$$F_{ij}(x) \propto \left(f_{ij}(x) - z_{ij} \right)^T \Omega_{ij} \left(f_{ij}(x) - z_{ij} \right)$$
$$F_{ij}(x) \propto e_{ij}(x)^T \Omega_{ij} e_{ij}(x) \quad (1)$$

Where is the measurement function. It can be seen from the above formula that the optimal solution can be obtained as long as the node is found to minimize the objective function, that is:

$$F_{ij}(x) = \sum_{\langle i,j \rangle \in C} e_{ij}(x)^T \Omega_{ij} e_{ij}(x) \quad (2)$$

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$$x^{*} = \arg\min F(x) \tag{3}$$

The above formula makes the graph optimization SLAM problem finally transformed into the problem of finding the optimal solution.

2. CARTOGRAPHER ALGORITHM BASED ON GRAPH OPTIMIZATION

In 2016, Google proposed cartographer SLAM algorithm based on graph optimization, which proposes a new loop detection method based on laser data, which meets the needs of large-scale mapping and optimizes large-scale data in real time [3].

Cartographer is a SLAM algorithm based on lidar sensor, which was released by Google in October 2016. The algorithm can generate grid map in real time through sensors such as lidar, with a resolution of 5cm. Cartographer adopts the slam theoretical framework based on graph optimization method and is divided into two parts: the front end is mainly responsible for scanning the sub graph and loop back detection, matching the processed lidar data with the sub graph, and local loop back detection will be carried out when the new data frame is not inserted into the generated sub graph. After the subgraph is created, if the found result is the best match with the current estimated pose, it will be added to the loop constraint [4]. The back-end is mainly responsible for the optimization of pose estimation, and uses the pre calculated grid and branch and bound to realize the global closed-loop detection. Cartographer algorithm uses Ceres solver to calculate the optimal solution between pose and pose to optimize pose.

3. CARTOGRAPH ALGORITHM FRONTEND AND BACK-END

3.1. Cartograph Algorithm Frontend

In 2D slam, the pose of the mobile robot is determined by the three parameters of translation (x, y)and rotation (ξ_θ) observed by lidar, expressed as $\xi=(\xi_x,\xi_y,\xi_\theta)$. In the cartographer algorithm, the laser observation value in the current attitude is called laser scanning frame, and a certain number of laser scanning frames form a sub map (sub map). Local slam uses scan matching to insert a series of continuous laser scanning frames into the sub map.

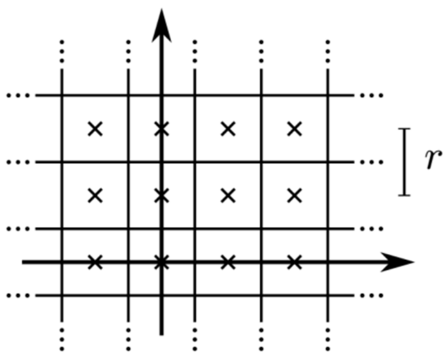

Figure 3. Grid points and related pixels

3.2. Cartograph Algorithm Backend

The laser scanning frame is only matched with the current sub map, and the map is composed of multiple sub maps. As more sub maps are created, the cumulative error in the process of scanning and matching will become larger and larger. Therefore, sparse attitude is adopted to adjust and optimize the pose of all laser scanning frames and sub maps[5]. The relative pose of the laser scanning frame is stored in the memory for closed-loop optimization. When the sub map is no longer changed, the group of laser scanning frames and sub maps will be used for

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closed-loop detection. Once it is detected that the laser scanning frame and sub map match well, the relative pose of the group will be added to the optimization.

4. CONCLUSION

Taking the autonomous navigation technology of mobile robot based on lidar as the research object, the research on simultaneous positioning and mapping (SLAM) technology, robot global path planning technology and robot local path planning technology based on lidar is carried out, and the autonomous navigation system of mobile robot is built, which realizes the function of real-time path planning and obstacle avoidance when mobile robot navigates autonomously in indoor environment.

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