Mobile robot navigation in an unknown environment

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Background

In recent years, autonomous navigation has become a hot issue in the field of robotics. According to their understanding of the environment, autonomous navigation can be divided into two types: global navigation with completely known environmental information and local navigation with completely or partially unknown environmental information. One of the research objectives of autonomous mobile robots is to be able to navigate and avoid obstacles autonomously in unstructured or unknown environments without human intervention, so as to realize the exploration of the environment. In the completely unknown environment, the establishment of an environment model by robot is an important research direction developed in the field of robot research, and has attracted the attention of academic circles at home and abroad.

Objectives

Place the robot in an environment where there are different obstacles. The robot needs to obtain map information and locate itself based on the information from the sensor. At the same time, the robot needs to move from the start point to the end point according to the instructions to generate a navigation trajectory, and needs to constantly adjust the position on the way so that the robot does not collide with obstacles.

Preliminary Literature Review

In practical applications, the working environment of robots is mostly in two extreme cases, that is, part of the environmental information is unknown, the overall layout of the environment is known, and there are unpredictable obstacles in the environment. For navigation problems in partially unknown environments, some researchers have adopted different navigation methods based on landmarks. For example, Maeyama[1] proposed a method of outdoor robot navigation, in which the user selects specific objects as road signs (such as trees and shrubs), but the robot cannot recognize other objects except the designated road signs, and only the information of road signs is recorded in the map, so the robot can only follow the path guided by the road signs. Taylor[2] proposed a boundary location map method based on visual road signs, but this method has higher restrictions on setting road signs. In order to enable the robot to obtain some prior knowledge about the environment, Kidono[3] proposed a human-guided robot navigation method. However, the accuracy of the generated map cannot be guaranteed by only using visual information. Once the map is generated, it will not change. The robot cannot avoid new obstacles. Matsumoto[4] proposed to use image sequences obtained in the guidance process to navigate, but the robot must follow the guided path, and this method is easily affected by lighting conditions.

Methodology

First, create a robot model with laser range finder sensors or RGB-D camera. Then use the velocity motion model to analyze the dynamics of the robot, control the linear velocity, angular velocity, and acceleration of the robot. One thing should be noted that the maximum movement speed of the robot should be limited to avoid the inability to respond to the algorithm's obstacle avoidance command in time when the speed is too fast.

In order to obtain map information and obstacle information, fast SLAM based on particle filtering is used to allow the robot to dynamically obtain map information and locate the location of the robot.

Then, use the Dijkstra algorithm to carry out the global planning of the robot, and find the starting point and ending point of a global path with the least cost. Use the navigation stack method to re-plan a new trajectory when encountering obstacles, so as to avoid any obstacles encountered on the new path. After obtaining the global planning path, use the DWA (Dynamic Window Approach) algorithm for local planning, so that the robot can better avoid obstacles and pass through some more difficult paths (for example, through a door)

Citations

[1] Maeyama, Shoichi, Akihisa Ohya, and Shin'ichi Yuta. "Non-stop outdoor navigation of a mobile robot-Retroactive positioning data fusion with a time consuming sensor system." *Proceedings 1995 IEEE/RSJ International Conference on Intelligent Robots and Systems. Human Robot Interaction and Cooperative Robots*. Vol. 1. IEEE, 1995.

[2] Taylor, Camillo J., and David J. Kriegman. "Vision-based motion planning and exploration algorithms for mobile robots." *IEEE Transactions on robotics and Automation* 14.3 (1998): 417-426.
[3] Kidono, Kiyosumi, Jun Miura, and Yoshiaki Shirai. "Autonomous visual navigation of a mobile robot using a human-guided experience." *Robotics and Autonomous Systems* 40.2-3 (2002): 121-130.
[4] Matsumoto, Yoshio, Masayuki Inaba, and Hirochika Inoue. "Visual navigation using view-sequenced route representation." *Proceedings of IEEE International conference on Robotics and Automation*. Vol. 1. IEEE, 1996.