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Mobile Robot Navigation Based on Interactive SLAM with an Intelligent Space

Fumitaka HASHIKAWA, Kazuyuki MORIOKA
[1] Department of Electrical Engineering, Meiji University, Kanagawa, 214-8571, Japan
(Tel : +81-44-934-7304; E-mail: ce01073@meiji.ac.jp, morioka@isc.meiji.ac.jp)

Abstract –Several methods of SLAM have been proposed. One of them is called Fast-SLAM based on Particle Filter. Especially, on the map construction based on a grid map is one of methods to improve accuracy of SLAM. However, those methods use only sensing data from the mobile robot to achieve SLAM. In this study, a new method of SLAM, which uses laser range sensors fixed in an intelligent space, is introduced. This method shares information with SLAM of mobile robot. Laser scan results by the mobile robot are compared with map built by the distributed laser scanners in the intelligent space in addition to normal FastSLAM. As a result, more accurate map can be built by cooperative SLAM with the intelligent space.

Keywords – Mobile robot, SLAM, LRF, Intelligent Space, sensor fusion

1. Introduction

Generally, recognizing the structures around the robots is one of the most necessary information for autonomous mobile robots. Mobile robots have to make maps of unknown environments for navigation. Positions of mobile robots and range data around the robots are often exploited for mapping. Maps are obtained by matching range data according to position estimation of mobile robots. Making a planar map of the environment and estimating positions of a mobile robot simultaneously is called SLAM (Simultaneous Localization and Mapping). It is also necessary to consider how to represent the environment that any moving objects exist around the mobile robots. Especially, grid-based maps are often used for SLAM. Grid-based maps, that each grid expresses probability of object existence, are not affected from moving objects, compared with landmark-based maps.
However, there remain matching errors in estimating position and map by grid-based FastSLAM. Then, this study considers extending SLAM by robot itself to cooperative SLAM with an intelligent space. The intelligent space generally includes networked laser range scanners, cameras and the other sensing device in the environment[1][2]. The cooperative SLAM uses such networked sensors for accurate map estimations. As a result, mobile robots can make more accurate estimation of positions and map of the environment. Achievement of the cooperative SLAM with the intelligent space is the final goal of this study.

2. Grid-Based FastSLAM

SLAM is a method to make a map of the environment, and estimate position of mobile robots simultaneously based on interaction between position of mobile robots and a map of the environment.
It is said that one of the most practice methods is FastSLAM based on particle filter [3], because it can achieve SLAM with high speed and high accuracy.
Especially, grid-based Fast SLAM is more promising [4]. This method includes building a probabilistic grid map based on environment information obtained by a laser

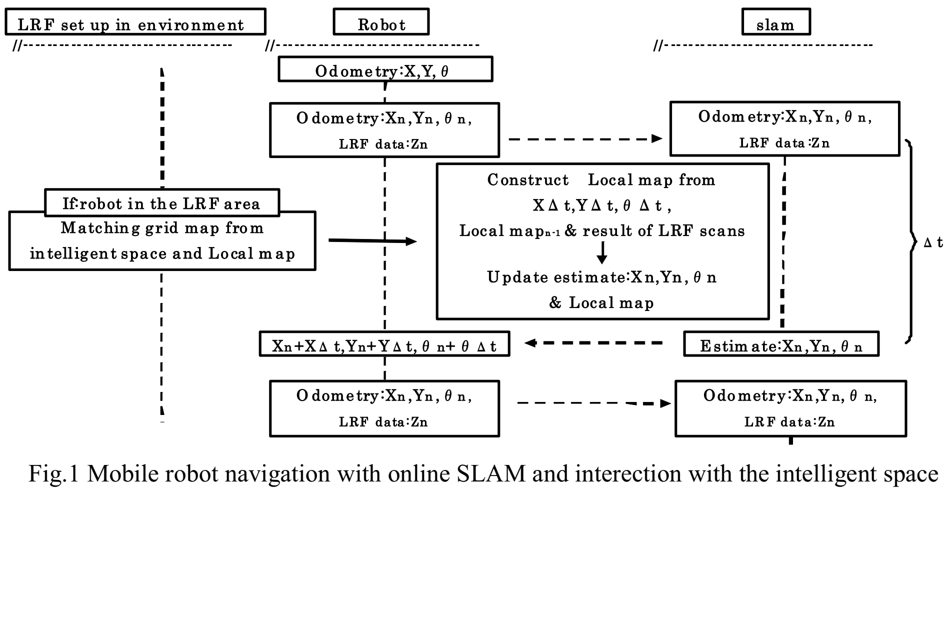

Fig.1 Mobile robot navigation with online SLAM and interection with the intelligent space

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range scanner on the mobile robot. Then, the grid map and new scan results are compared every sampling time, and the grid map is updated.
In this study, networked laser range scanners fixed in the intelligent space are also used for supporting SLAM. Each laser range scanners in the intelligent space build a grid map. Grid maps by laser range scanners in the intelligent space can be transmitted to the mobile robot and shared when mobile robot is in the correspondent laser range scanner's area. Accuracy of SLAM can be improved by interaction between the robot and the laser range scanners in the intelligent space. A software structure implemented in the mobile robot is shown in Fig.1. This contains robot control module and SLAM module that includes data sharing and matching with the map generated from the laser range scanner in the intelligent space. When the mobile robot is in the networked laser range scanner's area, grid maps built by the networked range scanners are shared with the mobile robot. In that case, grid map by networked range scanner and laser scan results of the mobile robot are compared for matching in each particle in addition to matching local maps in SLAM by robot itself with laser scan results. Particles that match both maps will be preserved in the FastSLAM.

3. Experiments

In this study, Pioneer3-DX was used as a mobile robot. UTM30-LX was installed in the robot and URG04-LXs are placed in the intelligent space. SLAM experiments were performed in the building of our university.

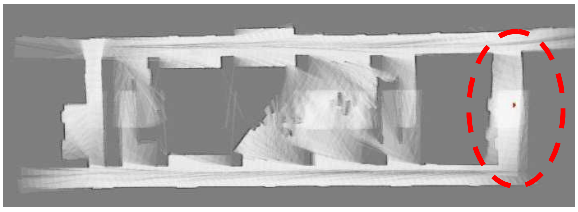

Fig.2 Map building by the normal SLAM

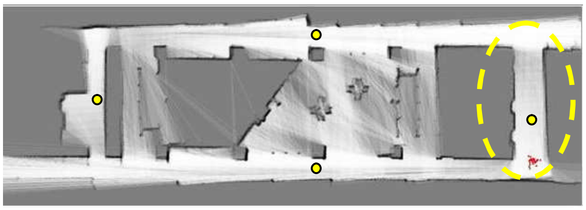

Fig.3 Map building with LRFs in an intelligent space

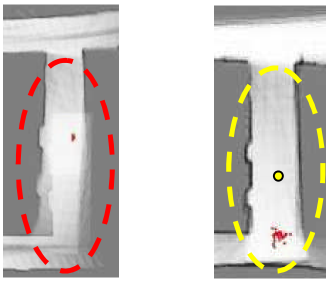

Fig.4 Comparison of loop closing in map building

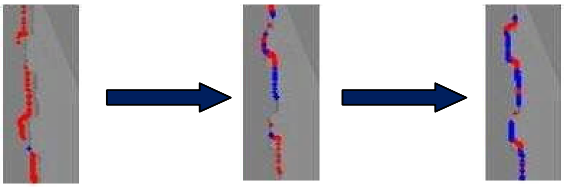

Fig.5 Change of collation state based on LRFs

Fig.2 shows results of SLAM with normal grid-based FastSLAM. Fig.3 shows results of proposed cooperative SLAM by integrating the laser range scanners in the intelligent space. In this experiments, 4 laser range scanners are placed in yellow points as shown in Fig.3. The map in Fig.3 shows shapes of structures and objects in the floor more clearly than the map of Fig.2. Especially, the map by proposed SLAM achieved loop closing accurately. Fig.4 shows extended map in dashed ellipse of Fig.2 and 3. Left map shows the normal SLAM result. Right map is the result of integration between the mobile robot and the intelligent space. Fig.5 shows a process that the accuracy of SLAM was improved by the interaction with the intelligent space. The blue points in Fig.5 represent matched points between scan data in the mobile robot and grid map built by laser range scanners in the intelligent space and red points represent scan data in the mobile robot without matching with grid map of laser range scanners in the intelligent space. Matching in the normal SLAM raises matching errors with maps from networked laser range scanners. In the proposed SLAM, likelihood of each particle is calculated according to matching errors between scan data and maps from networked laser range scanners in addition to matching rate between scan data and local map in normal SLAM. Then, particles matching both maps are regenerated in particle filter and scan data and maps from the intelligent space are matched gradually. As a result, mobile robot's position and heading are also updated.

4. Conclusion

In this study, navigation of the mobile robot with online grid-based SLAM and networked laser range scanners in the intelligent space was more effective than only grid-based SLAM. Experiments of robot navigation were performed and navigation in the indoor environment was achieved.

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