Semantic Information-based Reliable Autonomous Navigation in Wide Space

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Abstract

Recently, much attention has been paid to intelligent robots. Especially, autonomous navigation of robots is the most important technology and is being developed by many researchers. The autonomous navigation technology is based on the SLAM to find the position from the sensor data that is mounted robots. However, most methods find locations based on high-performance sensors in the predefined environments. This is difficult to apply to complex environments such as wide area due to the difference in locomotion and sensor performance. Therefore, efforts should be made to improve the application of limited navigation technology. In this paper, we propose a method to drive in a wide space for robots with various locomotion and sensor by semantic information based autonomous navigation method. By using semantic information, the robot recognizes the surroundings using available sensor data and performs autonomous travel. For this purpose, a semantic map for a unit space (e.g. a room, a hallway, road etc.) is generated and traveled by receiving information suitable for a robot locomotion and sensor configuration from the local server. The proposed method utilizes the semantic map to drive in the same way as a person in a large space, and can use intelligent robot driving using the property information of the object. Therefore, it is expected that industrialization of robot autonomous navigation will be promoted.

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1 Introduction

Research on the autonomous mobile robot has been done steadily. Recently, robots employ various locomotion and sensors [Khazanov14]. These researches assign robots by task to perform a specific task [Amigoni05], or use semantic information to service in a limited space indoors [Lim10]. In addition, there are studies that use task management, environmental awareness, trajectory planning, decision making and terrain classification using semantic maps and ontology for robot mapping [Liu12], [Li12]. However, these robots mainly carry out autonomous study on predefined areas in a way limited to locomotion and sensor system. In this paper, we

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propose a novel autonomous navigation method that can travel a wide area through a map suitable for semantic DB-based robot motion and sensor systems developed for intelligent robots. The proposed method simulates

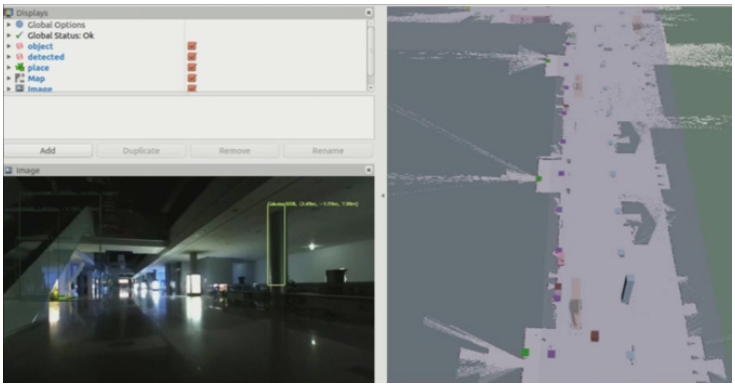

Figure 1: Semantic DB based Reliable Autonomous Navigation

the navigation method used by human beings and drives similarly. Robots travel and recognize objects around them as humans do. To do this, the robot registers and recognizes the objects necessary for navigation, as shown in 1. After that, if the recognized objects are obstacles, they will be avoided or waited after depending on the properties of the motion defined by the semantic information. If the recognized object is an object that affects driving (e.g. a rough road), the driving speed is adjusted according to the drivability defined in the object's properties.

Meanwhile, a wide-area spatial map based on 3D LiDAR sensor and vision sensor is constructed to drive wide-area space suitable for various robot motions and sensors. Robots can use this map to recognize the exact location from the multi-sensor data or even a single sensor. Therefore, the proposed driving method is useful in the wide area where many people walk because they drive according to semantic information. This is expected to bring dramatic developments to the autonomous driving of robots.

2 Navigation Method using Semantic Information

The semantic information used for autonomous driving of robots is based on objects. The robot recognizes the object while driving and uses semantic information of the object to secure driving ability similar to humans. This can be divided into two abilities: First, the motion property is used as semantic information of the object. Using this, an object, such as a person or a chair occupied by a person, is recognized as a movable object and waits for 5 seconds when the robot meets a moving obstacle while driving. After that, it is avoided in the same manner as a fixed obstacle, as shown in 2.

Figure 2: Semantic DB based Reliable Autonomous Navigation

Second, the semantic information used is the drivability property of the object corresponding to the driving road. If you are driving on a road where there is a rough property, change the speed to match the degree of

drive. The degree of roughness is divided into 5 levels and it is possible to secure the driving stability of the robot. 3 shows the difference in running speed on gravel and asphalt roads.

Figure 3: Semantic DB based Reliable Autonomous Navigation

3 Semantic DB based Map Building

The semantic DB is created by modeling object information necessary for driving from the viewpoint of the robot. Based on this, a map that is suitable for the locomotion and sensor system of the robot is build. This is a key factor for driving the robot in a wide space. 4 and 5show the entire flow chart for creating the map and the robot platform used for building the map. The platform was used to build a map based on the point cloud of the 3D LiDAR sensor and the ORB features of the vision sensor [Mur17]. 6 shows wide-area spatial maps for each sensor. It is possible to generate a semantic map including semantic information in a map suitable for the robot sensor.

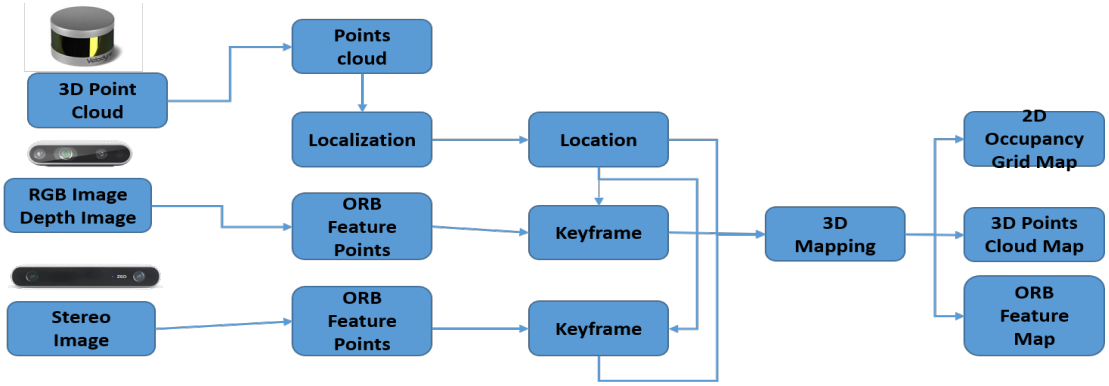

Figure 4: Semantic DB based Reliable Autonomous Navigation

Based on this semantic map, the robot performs autonomous Navigation. The robot sets up the driving strategy according to the properties of the recognized object (e.g. movable, rough etc.). Using this method, the autonomous mobile robot can flexibly move in the wide area.

4 Experimental Results

Using the proposed method, autonomous driving was carried out in a wide area of about 6ooo m2, as shown in 7.

This was tested during the exhibition at the convention center. First, the robot received information about the semantic map and mission (patrol) from the local server and started driving. Next, the robot traveled to pass between the people standing in line for entry and waited a while when it could no longer drive. The robot then continued to drive through the gaps caused by people's movement. As shown in the results, it was possible to drive smoothly in an environment with dense crowds and to travel between crowds using semantic information.

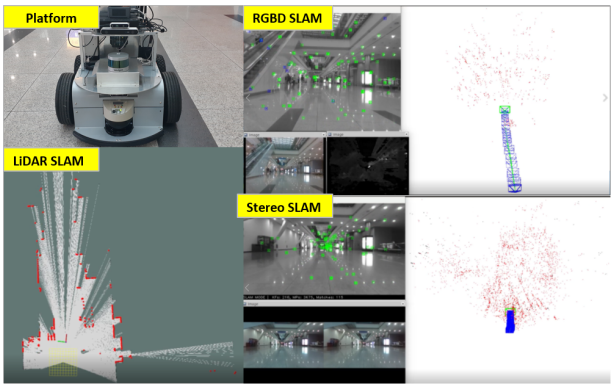

Figure 5: Semantic DB based Reliable Autonomous Navigation

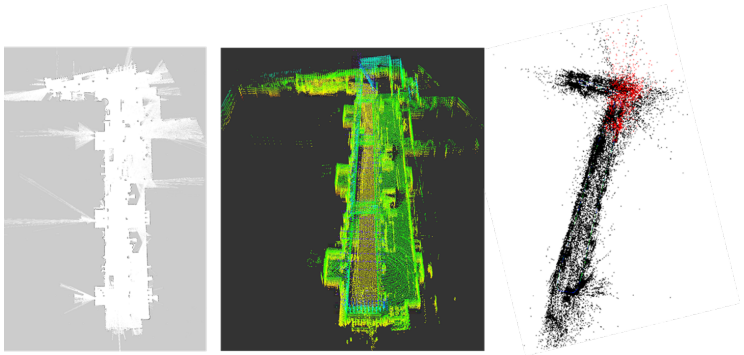

Figure 6: Semantic DB based Reliable Autonomous Navigation

Figure 7: Autonomous Navigation Results in Wide-Area

5 Conclusion and Future Work

In this paper, we propose autonomous navigation method in wide area by generating semantic map suitable for locomotion and sensor system of various robots based on the driving method performed by humans. For this purpose, driving using multi-sensor based semantic navigation map and defined semantic information was performed. In the future, we will apply semantic information-based autonomous driving methods that can be used for more types of locomotion and sensors.

Acknowledgment

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References

[Khazanov14] Khazanov, Mark and Jocque, Julian and Rieffel, John, Evolution of locomotion on a physical tensegrity robot, *Artificial Life Conference Proceedings 14* – pp. 232–239, 2014.

[Amigoni05] Amigoni, Francesco and Neri, Mario Arrigoni, An application of ontology technologies to robotic agentst, *IEEE/WIC/ACM International Conference on Intelligent Agent Technology* – pp. 751–754, 2005.

[Lim10] Lim, Gi Hyun and Suh, Il Hong and Suh, Hyowon, Ontology-based unified robot knowledge for service robots in indoor environments, *IEEE Transactions on Systems, Man, and Cybernetics-Part A: Systems and Humans* – Vol. 41, no. 3,pp. 7492-–509, 2010.

[Liu12] Liu, Ziyuan and Chen, Dong and von Wichert, Georg, Online semantic exploration of indoor maps, *2012 IEEE International Conference on Robotics and Automation* – pp. 4361–4366, 2012.

[Li12] Li, Gang and Zhu, Chun and Du, Jianhao and Cheng, Qi and Sheng, Weihua and Chen, Heping, Robot semantic mapping through wearable sensor-based human activity recognition, *2012 IEEE International Conference on Robotics and Automation* – pp. 5228–5233, 2012.

[Mur17] Mur-Artal, Raul and Tardós, Juan Dg, Orb-slam2: An open-source slam system for monocular, stereo, and rgb-d cameras, *IEEE Transactions on Robotics* – Vol 33 , no 5, pp. 1255–1262, 2017.