Control of Autonomous Mobile Robot through Template Matching with Laser Sensor

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Abstract: A truly autonomous mobile robot will definitely benefit our life in many areas including but not being limited to nursing care services and office guide. However, most of the current robots are still simply following corridors through the pre-defined procedures and moving in a well-defined workspace. The control of an autonomous mobile robot remains challenging. It is necessary for an autonomous robot to perform several tasks including the self-position recognition, route selection and obstacle avoidance. Knowing its current location is the most difficult issue that an autonomous mobile robot has to deal with. Without knowing its current location, it is impossible for the mobile robot to move towards its destination. Let us think how we identify our location when we are put in an unfamiliar place. The most common things that we do will be to collect the geographical features and then match what we have collected with the information on a map. This paper discusses the way to identify the current location of a robot by comparing the distance information acquired with a laser sensor and the environmental map through template matching method..

Keywords: Autonomous Mobile Robot, Environment Recognition, Laser Sensor, Template Matching, A-star algorithm

I. INTRODUCTION

Most of the current robots simply move around a well-defined workspace according to predefined procedures. In addition, an autonomous movement in complex geographical features is very difficult. This indicates that the research and development of autonomous mobile robots still have a long way to go.

Now, though GPS is available to the self-positional recognition in outdoor environment, sensors similar to GPS are not developed for indoor environment yet. Therefore, this paper discusses how a robot recognizes the self-position in indoor environment.

Actually in this research, the template matching is used as a method of comparing the geographical features measured with the laser sensor with the environmental map. At the current stage, our very first goal is to make a robot move autonomously towards the destination in a static environment including unknown static obstacles. The route search to the destination is calculated using the A-star algorithm. With the method proposed in this study, a mobile robot successfully moved autonomously to the specified destination.

II. HARDWEAR CONFIGURATION

A laptop computer is put on the mobile robot to communicate with a motor and a laser sensor. At the beginning, the laptop computer issues a command to acquire data from the laser sensor. Then the distance data are sent from the sensor to the laptop computer. It recognizes the environment around its current location through the analysis of the distance data. Based on the result of environment recognition, it issues a voltage command to the servo pack through the DA board. The servo packing applies a constant voltage to the motor, and the motor controls the wheel.

Fig.1. Communication configuration

III. CONTROL PROGRAM

The environmental map is given to the program in advance. Both an initial position and posture of the robot are also given to the program. Next, the destination is specified on the map. It searches for the route from an initial position to the destination by using the A-star algorithm. Next, a laptop computer obtains the distance data sent from the laser sensor. The robot compares the distance image made from the distance data with the environmental map image. The present position of the robot is calculated from the result. If the present position of the robot is a destination, the robot is stopped. Oppositely, if the present position of the robot is not a destination, the robot is controlled along the searched route. Figure 2 shows the flow chart of the program.

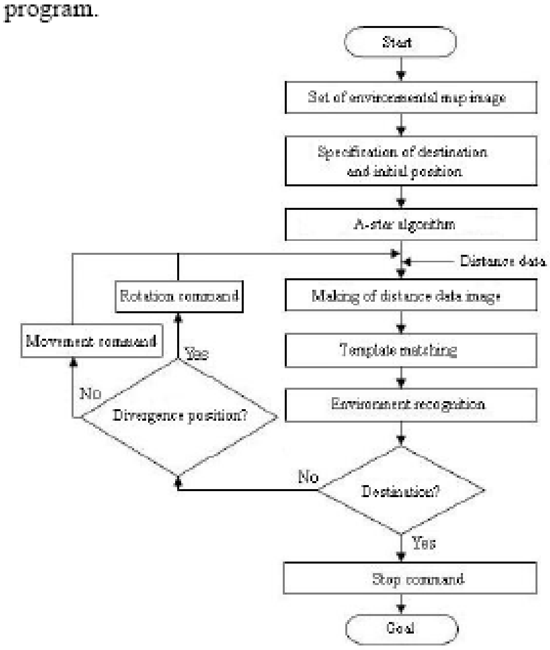

Fig.2. Flow chart of the program

1. Environment recognition by template matching

In the beginning, the robot acquires the distance data from the laser sensor in a certain position. And, the distance image is made based on the distance data. When the entire environmental map image is referred in the template matching process, great amount of processing time is spent. Then, a local environmental map image around the previous position of the robot is cut out for shortening the processing time spent in the template matching. Next, the distance image and local environmental map image are matched in the template matching. Whether they are matched or not is examined with a template-matching algorithm provided with the picture processing software system Halcon. The present position and posture of the robot are calculated based on the result. Figure 3 shows the flow of this template matching.

A robot does not always keep the constant posture even if it intends to go straight along a corridor. Therefore, the distance image and the local environmental map image is matched to the local map by rotating it within the range between -8 and +8 degrees. This is because the robot is supposed to finish localization and generating the next moving command for less than 130ms.

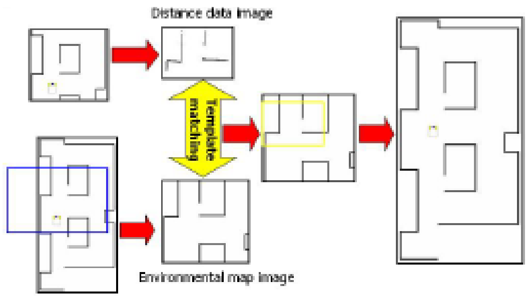

Fig.3. Template matching

2. Route search by A-star algorithm

The A-star algorithm is used to search for the route from an initial position to the destination. As shown in Figure 4, the environmental map is divided into each area at the divergence position and the distance between each area is shown beside the link between nodes. The operator is allowed to add initial position and destination into the environment map. The shortest route from an initial position to the destination is calculated by using the A-star algorithm.

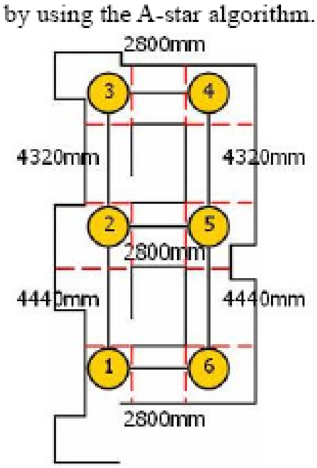

Fig.4. A-star algorithm

3. Autonomous movement

When the robot moves, the control program compares the distance data sampled at 35 degrees on the right side with that at 145 degrees on the left one. In order to minimize the danger of collision, the robot must keep moving along the centerline of the road. When the both distance data are almost equal, both wheels are derived to move forward. When they are different, one wheel must be driven to move forward and another must be reversed. This adjustment is continued until the robot returns to the centerline as shown in the Figure 5.

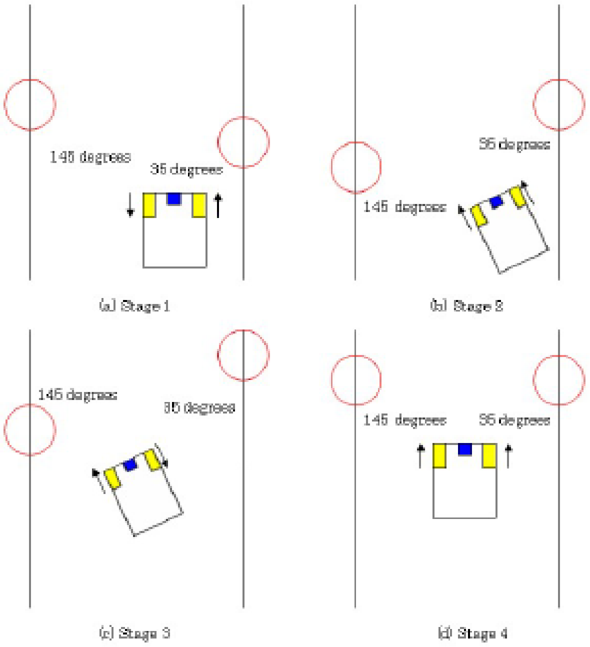

Fig.5. Move to the center

4. Obstacle avoidance

When a robot finds an obstacle at the center of the road that is not registered in the environmental map, there is the danger that the robot may collide with it. How to avoid collision against an obstacle is shown here.

At first, the difference image between a distance image and a matched environmental map image is taken. If a pixel in a distance image is black and the corresponding pixel in the environmental map image is white, then the pixel in the difference image is set black. The labeling of the difference image is done, and center of gravity and the area of the object are calculated. Finally, the obstacle is detected compared with the result of a past labeling. The robot avoids the obstacle based on the position of the obstacle.

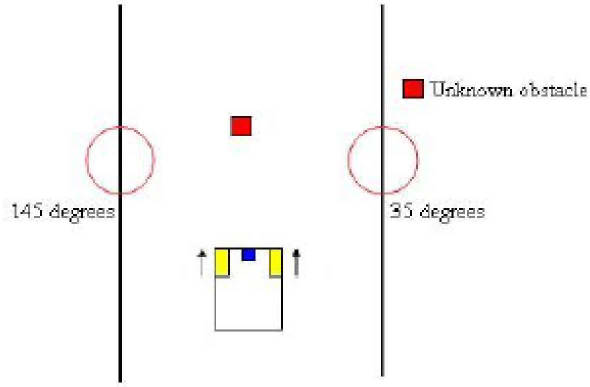

Fig.6. Avoiding obstacle

IV. EXPERIMENT

1. Experiment method

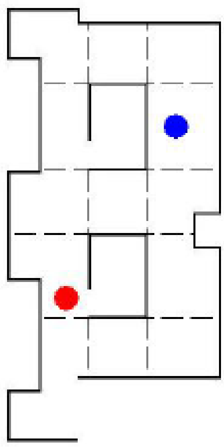

Fig.7. Initial position and destination

The autonomous mobile robot has been experimented in a narrow indoor environment. First of all an initial position and destination of the robot are specified. In Figure 7, the red circle shows an initial position and the blue one shows a destination. And the robot is controlled along the route calculated by the A-star algorithm. At this time, the robot is moving only referring to the distance data obtained from the laser sensor. Then, the robot performs temperate matching based on this distance image, and always tries to identify its own present position. In this process, the robot keeps detecting its orientation. Finally, when the robot arrives at the destination, the robot is stopped. The moving speed of the robot is set to be 0.908km/h in the experiment.

2. Experiment result

The total execution time was 49570msec. The average time taken in template matching is about 128msec and it is performed 387 times. Figure 8 shows the result of control program when the robot arrives at the destination. Left part in figure 8 is a distance image and right one is an environmental map image. And the red circle shows the present position of the robot calculated by the template match and the blue circle shows the destination.

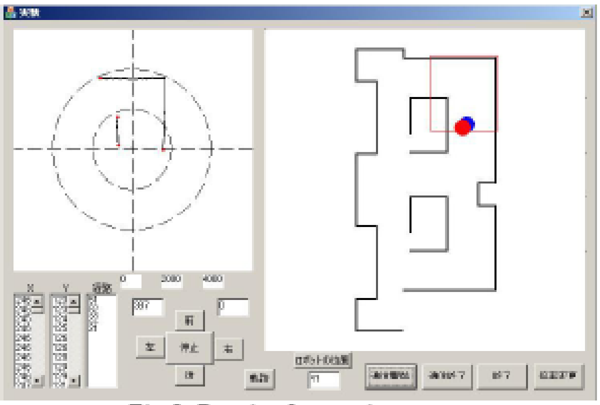

Fig.8. Result of control program

3. Consideration

During the robot is rotating at the divergence position, the robot sometimes fails to find its current posture because the environment recognition failed. When the robot is rotating, the laser sensor can measure only one of walls, it is impossible to measure the other wall. Therefore, the distance data image becomes small, and the failure of the template matching increases. Once the robot loses its current posture, it never finds self-posture. As the robot often violates the constraint on the angle during rotation, this may occur. It is expected that making robot interrupt rotation and recognize its posture will improve this problem.

V. CONCLUSION

In this research, the environment recognition was achieved by matching the environmental map image and the distance image acquired from the laser sensor. The present position of the robot could be calculated at any time based on the template matching. Moreover, the robot was able to move to the destination along the route calculated by the A-star algorithm.

At present, it is able to find and avoid a static obstacle not contacting with a boundary, but several difficult cases must be coped including movable obstacles, obstacles contacting with a boundary and objects with deformable parts or changeable state such as doors.

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