Three-dimensional object recognition using an LRS

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Abstract: Image information provided by cameras is strongly affected by environmental influence of an object's circumjacent circumference. Therefore, in this study, we integrate distance information provided from a laser range sensor (LRS) and image information provided by a camera. This combination reduced environmental influence. This system consists of an object extraction section and a recognition processing section, and we are now developing the object extraction section. First, the object extraction section performs region splitting of image information provided by a camera. The distance information that was provided from the LRS is converted into a set of three-dimensional coordinates that matched the camera image. The integrated processing matches distance information with the image which did the region splitting. And it calculates the distance to each area. It integrates all of the converted information and extracts the object from the integrated information. In this study we inspected the effectiveness of the system by performing an object extraction experiment using the combined integrated distance information and image information. From these results, we have learned how to remove a background and a floor surface by using the distance information, and simpler object extraction was enabled.

Keywords: Object recognition, LRS, robot.

I. INTRODUCTION

The robot market is increasing yearly now. In particular, the demand for robots useful in daily life is increasing. However, in a human living space, the environment is complicated by many factors. Therefore, object recognition using cameras is performed, but the recognition is complicated by the influence of factors such as environmental light, background and patterns on an object. In this study we aimed at the development of an object recognition system that is not influenced by these factors.

II. System Architecture

1. Outline

Fig. 1 shows a schematic of the system architecture. This system consists of an object extraction section and a recognition processing section.

In the object extraction section, the system performs region splitting of the image information provided by a camera. The distance information that is provided from the LRS is converted into a set of three-dimensional coordinates that match the camera image. The integrated processing matches the distance information and the image as divided into regions and calculates the distance to each area.

The system integrates the converted information. The object extraction section then uses the integrated information.

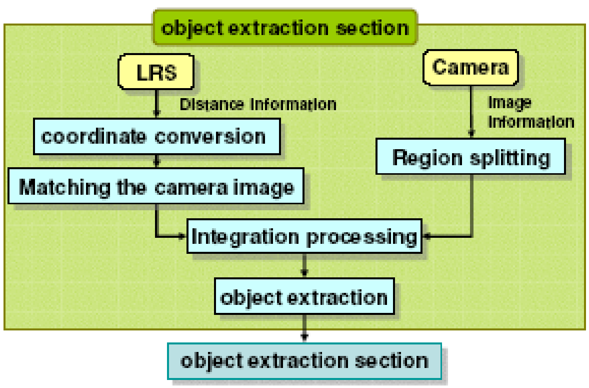

Fig. 1 Schematic of the system architecture

2. Outline of the LRS

Fig. 2 shows the overview of the LRS. This is a noncontact laser measuring system that irradiates an object with an infrared laser (wavelength: 785 [mm]). The distance from the object to the LRS is measured according to the time it takes for light to travel from the object to the LRS. The LRS scans the horizontal space at certain intervals, 0.36[°] (360[°]/1024) to 240[°], and detects the distance and the direction to the object. The detectable distance is 20 ～ 4000 [mm], and the detectable resolution is 1 [mm]. The measuring error is a few millimeters for a reflective white object but is larger for a black object because of light absorption.

Fig. 2 Scanning laser range sensor

III. Region splitting

The system performs region splitting to extract an object based on image information provided by a camera. In this study it divided a histogram into three domains of R, G, and B elements and then put them together.

Fig. 3 shows an experimental environment in which we photographed an object with a camera and experimented with region splitting.. We fixed the camera on a tripod and photographed the object, which was a can sitting on a box. The camera was inclined at a 30-degree angle.

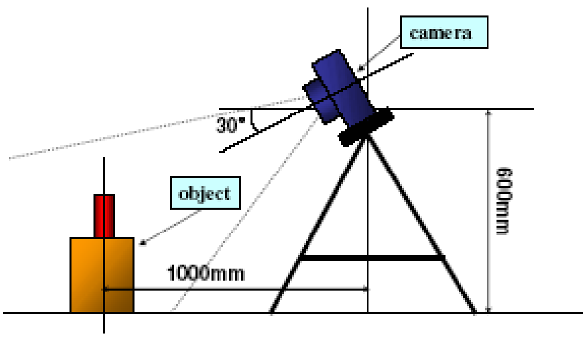

Fig. 3 Experimental region splitting

Fig. 4 shows an original image. Fig. 5 shows an image processed after region splitting. Generally the image was easy to obtain, although there was a part that had been mixed in with the floor aspect depending on circumstances.

Fig. 4 Original image

Fig. 4 Processed image after region splitting

IV. LRS

We performed a measurement experiment using the LRS to inspect the effectiveness of the distance information to be provided by the LRS. The distance information that was provided by the LRS was converted into a set of three-dimensional coordinates that matched the camera image.

1. Measurement experimentation of LRS

We performed a measurement experiment using the LRS in an environment that matched that used in the experiment of region splitting (Fig. 6). The LRS was able to acquire two-dimensional distance information. Therefore it acquired three-dimensional distance information because the LRS rotated at the angle of depression changed 20 degrees to 70 degrees by one angle.

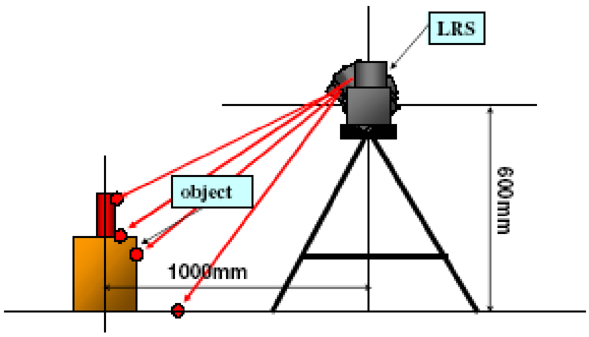

Fig. 6 Measurement experimentation using the LRS

2. Three-dimensional coordinate transformation

The data provided from the measurement experiment using the LRS tell the distance from the LRS. This data was converted into three-dimensional coordinates. The conversion of the three-dimensional coordinates is derived from the distance data and the horizontal and perpendicular angles of the provided data.

Fig. 7 shows the result of converting distance information into three-dimensional coordinates when an object is viewed from the front. Some errors were seen in data of the floor surface. However, the system measured the box and can quite well.

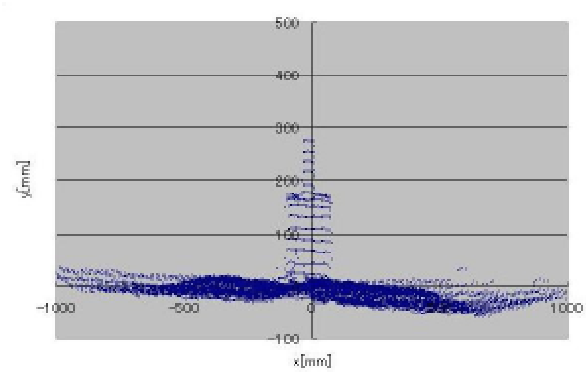

Fig. 7 Result of converting distance information into three-dimensional coordinates

3. Matching the camera image

The system successfully matched the LRS data to the camera image by integrating the camera image with the LRS data. First, a perspective projection face of the same aspect ratio as a camera image was set. It is matched the converted into the three-dimensional coordinate. Then the system matched the perspective projection face with a camera image. The LRS data was then matched with the camera image.

V. Integration processing

We performed integrated processing of distance information and image information. During preprocessing, image information was processed according to region splitting, and distance information was converted into three-dimensional coordinates and matched with the camera image. With these two sets pf data, we performed integrated processing as follows. Fig. 8 shows a diagram of integrated processing.

□. We calculated a number of LRS data and a total of distance in the area.

□. We calculated the average distance of these data. It is distances from the LRS to points indicated the LRS data of area.

□. In the area that LRS data are not included, these distances not calculated.

□. We performed processing of □ ~ □ for all areas.

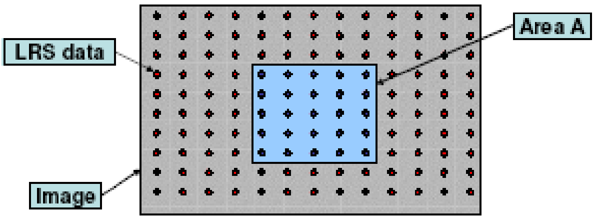

Fig. 8 Data integration processing

VI. Experiment of the object extraction

We performed an object extraction experiment to inspect the effectiveness of integrating the data of the distance information and image information. We experimented twice with different objects. In experiment 1, we used a single-color object, because it is easy to extract image information with just one color (Fig. 9). In Experiment 2, we used an object that had a variety of colors, because it is difficult to extract image information in that case (Fig. 10). We performed the experiments in the same environment that we used for region splitting and the experiment of LRS measurement.

Fig. 9 Object 1

Fig. 10 Object 2

1. Experiment 1

This experiment used an object with a single color. Fig. 11 shows the original image. Fig. 12 shows the image that was generated by integration processing. Fig. 13 shows the object with the data about the floor surface (equal to or less than 15 mm in height) removed from the integrated data. Fig. 14 shows the object with the data about the background removed (more than 1,500 mm in depth).

We were able to extract the object in experiment 1 well. It is likely that the object's single color worked well in the region splitting and integrated processing.

Fig. 11 Original image (Experiment 1)

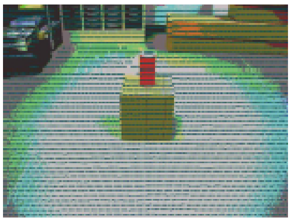

Fig. 12 Integration processing (Experiment 1)

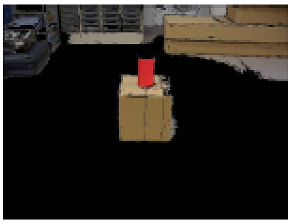

Fig. 13 Floor surface removed (Experiment 1)

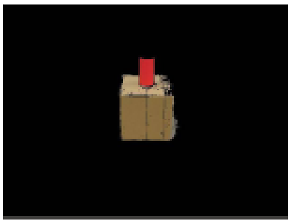

Fig. 14 Background removed (Experiment 1)

2. Experiment 2

This experiment used an object with a variety of colors. The process was the same as in experiment 1. Fig. 15 shows the original image. Fig. 16 is the image that was generated by integration processing. Fig. 17 shows the object with the data about the floor surface removed from the integrated data. Fig. 18 shows the object with the background data removed..

The image generated in experiment 2 is missing a part of the object. This probably occurred because the area of some of the colors was so small that LRS data could not be generated, and the area near the floor surface was deleted with the floor.

Fig. 15 Original image (Experiment 2)

Fig. 16 Integration processing (Experiment 2)

Fig. 17 Floor surface re moved (Experiment 2)

Fig. 18 Background removed (Experiment 2)

VII. Conclusion

In this study, we developed a three-dimensional object recognition system that uses distance information to be provided by an LRS and image information to be provided by a camera. This system consists of an object extraction section and a recognition processing section.

We inspected the effectiveness of the system by performing an object extraction experiment using the information that integrated distance information with image information. From these results, we could remove the background and floor surface by using the distance information. Simpler object extraction was enabled. Even in cases when it was difficult to extract from image information, we were able to extract an image of the object.

We will continue to test the system in a more complicated environment, for example, with a complicated background and with the color of the object resembling the color of the background. Development of the recognition processing section will occur in the future.