Development of an Autonomous-Drive Personal Robot
"Improve the Accuracy of Object Area Determination by Boundary Detection"

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Abstract

We are developing an autonomous personal robot that able to perform practical tasks in a human environment based on information derived from camera images and the Laser Range Sensor (LRS). It is very important that the robot be able to move autonomously in a human environment, and to select a specific target object from among the many objects. This environmental recognition system is composed of an autonomous driving system and an object recognition system. So we confirmed the effectiveness of the object recognition system by the experimental results.

Keywords: Personal robot, Monocular camera, Image processing, Object recognition.

1. Introduction

In the near future, some autonomous self-driving robots are expected to provide various services in human living environments. For this to occur, the robots will need to gain a grasp of the human environment. Therefore, the systems to provide environmental recognition based on image information are being widely studied. However, it is very difficult to recognize all driving environments from image information only. So far, no prospects for such a system have emerged. Here, we report on the development of an autonomous personal robot able to autonomously perform practical tasks in human environment based on the several information that are derived from the camera images and the Laser Range Sensor (LRS) which is used to acquire two-dimensional distance information.

The system for this robot is composed of an autonomous run system for movement and an object recognition system for the recognition and grasping of an object. First, the autonomous run system decides upon a robot driving command based on information in the limited space map. Information such as walls and barricades are set to the map, and the data obtained from the CCD camera are compared against the map data. The route is decided, and the robot drives. The object recognition system is composed an object-recognition processing part and a location-information acquisition, processing part, both of which use the monocular camera and the LRS. An object is recognized and identified using range information obtained from LRS in addition to the processed image data provided by the camera. The robot performs a grasping operation for the object according to this system.

This study is related to object recognition during an object manipulation process of the robot. Currently, the portion of the object manipulation, processing part is a problem of holding and judgment bottles were placed on the desk against the instructions of the user on whether or not the operation target object. In this study, we pay attention to work on object recognition of environment recognition processing parts, especially the object area determination processing of plastic bottles in the image obtained from the camera.

2. System of Robot

Our robot as shown in Fig.1has a drive mechanism consisting of two front and two back wheels. The front wheels are attached to a motor that operates the wheels on either side independently, while the back wheels function as castor wheels. This method has the advantage of allowing a small turning radius. In addition, to acquire image information, both a single CCD camera with approximately 2,000,000 pixels and an LRS are installed on the head of the robot and can be rotated to all sides by two motors. DC servo motors are used in the robot's drive mechanism. The position and speed control are achieved by the control system of the drive mechanism. The robot also has two arms and hands equipped with sensors, which enable it to respond to the various demands of humans. Finally, an installed wireless LAN can provide remote control for humans. All devices are controlled by a Personal Computer (PC), and the lead batteries are used to supply the robot's electric power.

3. Object Recognition System

3.1. *Outline of the autonomous system*

We have developed an object recognition system for a robot that can acquire the target object position with image information captured by monocular CCD camera and range information obtained by LRS. This system

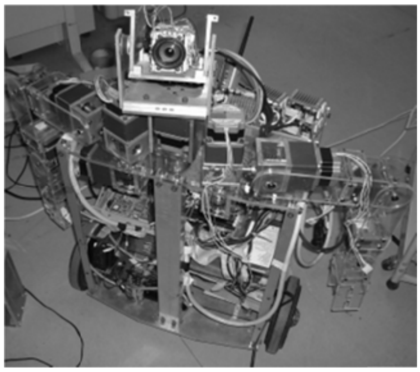

Fig.1. System Structure of Robot.

can acquire the object position on the assumption, for example, that the object is placed on a desk. First, the robot has recognized the single object in the form, the color and the local character of the object. Next, the system then acquires the location information of the object by using LRS with the recognized object. Afterwards, the arm is driven based on the location information, and the object can be grasped and held. The flow chart for the object recognition and holding object system is shown in Fig. 2.

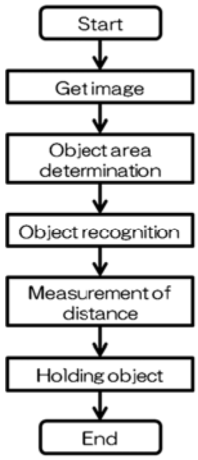

Fig.2. Flow chart of recognition and holding object.

3.2. *The method for object recognition*

In this section, we explain the method for object recognition and the process of the object recognition system is shown in Fig. 3.

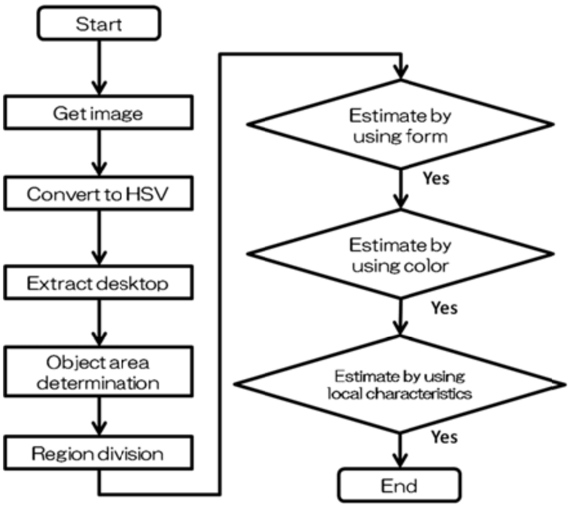

Fig.3. Process of object recognition system.

In this study, we pay attention to working on the object area determination processing of the plastic bottles in the image obtained from the camera. The robot requires to accurately recognize the object area when the object recognition. This processing is important in object recognition, because the robot cannot compare the form, the color and the local object characteristics in the image with the target object if the robot cannot recognize the object area exactly. The conventional object area determination processing is able to accurately recognize the object area when there is only one object or there are some objects which are not overlapping objects in the image. However, the object area determination processing has a problem that the robot cannot take out a plastic bottle area in the image if plural bottles overlap each other on the desk. In order to solve this problem, we attempt to add new processing that to detect the border between overlapping objects. So, we focused on the function of the camera, particularly the use of the zoom function. More specifically, we constructed a system that detects the boundary by displaying a border part between objects by using the camera zoom.

3.3. *The method for object area determination*

The flow for the processing to detect the border for determination the object area is shown in Fig. 4.

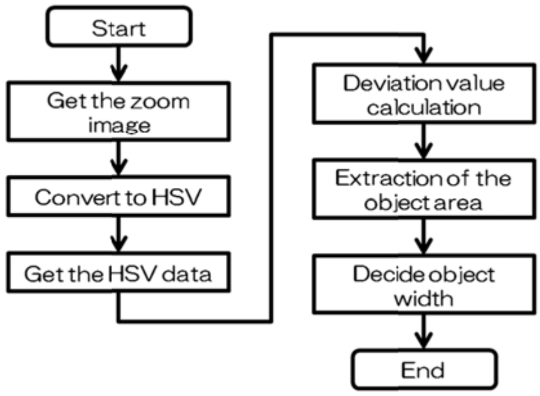

Fig.4. Process of detection the border flow.

3.3.1. *Convert to HSV processing part*

This processing part converts images a color from RGB model to HSV model. The HSV color model means Hue, Saturation and Value. This model is often used by people who are selecting colors from a color wheel or palette, because it corresponds better to how people experience color than the RGB color space does. [1] The equations for conversion are shown in Eq. (1) ~ (4).

$$max = max(R, G, B),$$
$$min = min(R, G, B). \qquad (1)$$

Hue calculation

$$H = 0 \; (max = min),$$
$$H = \left(\frac{G-B}{max-min}\right) \times 60 \;\; (max = R),$$
$$H = \left(2 + \frac{B-R}{max-min}\right) \times 60 \;\; (max = G),$$
$$H = \left(4 + \frac{R-G}{max-min}\right) \times 60 \;\; (max = B). \qquad (2)$$

Saturation calculation

$$S = 0 \;\; (max = min),$$
$$S = \left(\frac{max-min}{max}\right) \;\; (max \neq min). \qquad (3)$$

Value calculation

$$V = max. \qquad (4)$$

3.3.2. *Get the HSV data and deviation value calculation processing part*

This processing part gets the HSV data and deviation value calculation. After the HSV conversion, set a rectangular area in the image. In addition, HSV data in the rectangular area are obtained and calculated each deviation value.

3.3.3. *Extraction of the object area processing part*

This processing part extracts the object area in the zoom image. First, this part compares the HSV data of the rectangular adjacency relationship for pixels with the deviation value. So, the rectangular adjacency pixels are considered to be an object same as the object in the rectangle, if the HSV data of the rectangular adjacency pixels are the value in the deviation value. The object area is extracted by repeatedly executing such processing.

3.3.4. *Decide object width processing part*

This processing part detects a border part between objects by detection the right and left ends of the object area. So, the object width is decided by the detection border.

4. Experiment of system evaluation

4.1. *The method of experiment*

We performed the following experiment to evaluate the performance of object area determination. Fig. 5 shows the experimental environment when the object is a plastic bottle. Its location was set three objects on a single-color desk in the laboratory. The detected object area is displayed on the image color classification. Getting result compares with the precedence research.

4.2. *Result of experiment*

The Fig. 6 shows the experimental result. This research can accurately recognize the single object area overlapping plural objects by detecting the border between objects.

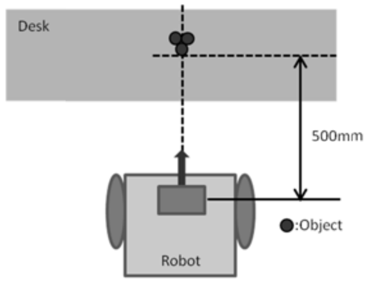

Fig. 5. The experimental environment.

(a) Source (b) Conventional (c) Proposed

Fig. 6. Experiment results.

5. Conclusion

In this paper, we propose object recognition system that accurately recognizes the object area by detection the border between overlapping objects. This object recognition is detection the boundary by displaying a border part between objects by using the camera zoom. As a result, precision of object recognition improved. However, this system cannot recognize same objects. In the future we will try the solution to this problem.

References

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