Development of distance recognition using an ocellus camera for an autonomous personal robot

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Abstract: We are attempting to develop an autonomous personal robot that has the ability to perform practical tasks in a human living environment by using information derived from sensors. When a robot operates in a human environment, the issue of safety must be considered in regard to its autonomous movement. Thus, robots absolutely require systems that can recognize the external world and perform correct driving control. We have thus developed a navigation system for an autonomous robot. The system requires only image data captured by an ocellus CCD camera. In this system, we allow the robot to search for obstacles present on the floor. Then, the robot obtains distance recognition necessary for evasion of the object, including data of the obstacle's width, height, and depth by calculating the angles of images taken by the CCD camera. We applied the system to a robot in an indoor environment and evaluated its performance, and we consider the resulting problems in the discussion of our experimental results.

Keywords: Personal robot, Autonomous driving, Ocellus camera

I. Introduction

There is an increasing need for robots working in the fields of home assistance, medical care, and welfare of the aging. Such robotic technology is already seeing practical use in industry. However, such robots are less useful for tasks in the home. Therefore, in our laboratory, we are attempting to develop drive-type personal robots with working autonomy that are safe and reliable as well as useful to humans.

Our robot has a drive mechanism of two front wheels and two back wheels. The two front wheels are attached to a motor, which operates them independently, while the back wheels are castors. DC servo motors are used for the robot's drive mechanism, and position control and speed control are achieved by the control system of the drive mechanism. One CCD camera is installed on the head of the robot. It can be rotated to all sides by two DC motors. This camera is able to make an image of about 300,000 pixels. All devices are controlled by a personal computer, and lead batteries supply electric power. Fig.1 shows the appearance of our robot.

In this research, we focus on the recognition of stationary obstacles, which is necessary for safe locomotion, and the acquisition of a sense of distance for the movement of the robot. Humans use sight for much of their object recognition, and we designed a robot to perform similar recognition with the use of an ocellus camera.

In this system, after a stationary object is detected, the relative distance between the robot and an object is obtained by calculating the angle of the CCD camera. Then, the stationary object is evaded by the proposed method.

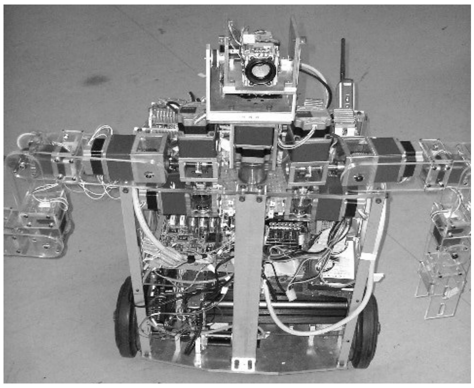

Fig.1. Robot appearance

II. Distance recognition system

1. Outline

In order to detect obstacles, first, the system transforms an RGB image to an HSV image. Next, the system extracts as obstacles those pixel groups that are much different from the main background pixels. The system obtains the distance to the extracted objects by calculating the angle of the object in relation to the CCD camera. This system consists of a system that extracting a stationary object and calculates its distance from the robot.

2. Image Acquisition

The image obtained by the CCD camera is read into a PC in the robot. This visual processing system uses 24-bit color images sized at 320×240 pixels.

3. Extraction of a stationary object

To extract a stationary object, we sample the floor region under a certain environment and we set any region other than the floor area to be recognized as an obstacle region.

3.1 Image conversion

For efficiency of processing, the system converts 24-bit RGB image data into HSV data.

3.2 Extraction of floor region

The system samples a group of image pixels in a rectangular region at the bottom center of an image. The system uses the group of image data inside this region as its sample image data, as well as the deflection calculated by the sample data. The system extracts the floor region in terms of the difference of all pixels in the image.

3.3 Label processing

Label processing is processing to acquire a number that is peculiar to each existing connection ingredient in an image, and can be used to classify pixels. In this system, we can recognize a region other than the floor as one lump based on the floor region image which we extracted. When areas of the pixel group labeled in this way are greater than a threshold amount, the robot recognizes it as an obstacle.

Fig. 2 shows the extraction of a stationary object by label processing.

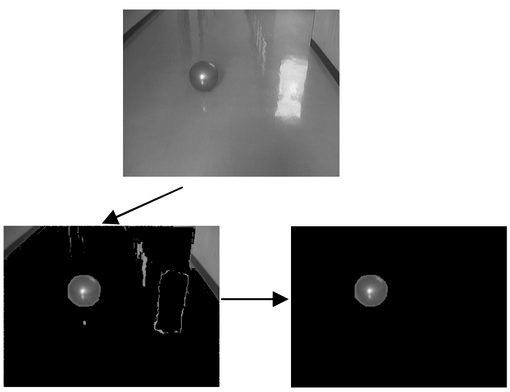

Fig. 2. Extraction of a stationary object

4. Distance recognition

In our past study, to obtain distance recognition we used parallax between two images. But, this method did not estimate the shape of objects; therefore, the precision of distance recognition was often poor. For this reason, we added a process to estimate the shape of objects. Below, we show both methods of distance recognition.

4.1 Distance recognition using parallax between two images

We define the lower side of a group of image pixels as the distance to an object, and the system presumes the width of the obstacle based on the width of an object group of image pixels. In addition, we define the uppermost part of the object group of image pixels as the height or a depth of an object. The robot runs on the floor, and presumes the height of an object based on the position of the change in the image pixel group. In Fig. 3, we obtained images at position1 and position2. For the calculation of each value, we used the position of the camera, the focus distance, and angle of view.

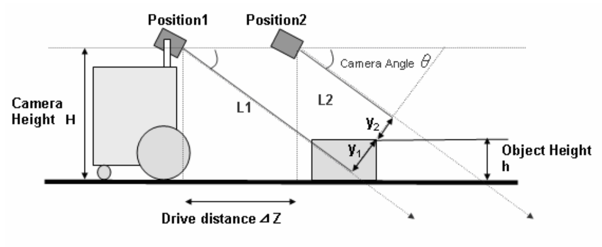

Fig. 3. The parallax method for obtaining distance recognition

4.2 Distance recognition using estimation of the shape of objects

To estimate the shape of objects, we apply a Hough transformation to an object image extracted with the parallax method. Then, we examine the characteristics of the object and judge its shape. Finally, we obtain the distance to the object. We describe each processing step below.

(1) Hough transformation processing

The Hough transformation is an effective method to detect straight lines or circles from points lying scattered in an image. Before we apply the Hough transformation, we preprocess for reasons of

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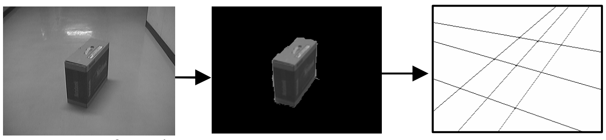
stabilization. First, an object extraction image is transformed into a gray-scale image. Then, we add edge-enhancement processing, binary-image processing, narrowing-line processing and noise-removal processing. Fig. 4 shows the Hough transformation processing.



(a) Transforming to gray-scale image (b)Extraction of object (c) Hough trans-formation

Fig.4. Hough transformation processing

(2) A shape estimate method

First, we apply the Hough transformation of straight lines. As a characteristic of rectangular parallelepipeds, there are three parallel straight lines unless we look at them from the front. When three parallel straight lines are provided by Hough transformation of the straight line, we recognize that it is a rectangular parallelepiped shape. In other cases, we apply the Hough transformation of circles. We recognize that it is a sphere when a circle is detected by Hough transformation of circles.

(3) Calculating the distance for a stationary object

After estimating the shape of an object, we calculate the distance according to its shape. In the case of a rectangular parallelepiped shape, we calculate the distance to an object, and its width, height and depth. We calculate points of intersection from the straight line that we got by Hough transformation and we use the coordinates of their points that are necessary for calculation, as we show Fig. 5. In the case of a sphere, we calculate the distance to the object and its width using a central coordinate and the radius provided by Hough transformation of circles.

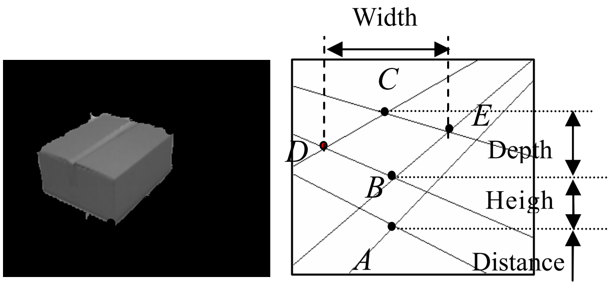


Fig.5. Calculation point

5. Experiment

5.1 Method of experiment

To evaluate this system, we tested whether the system could recognize the shape of an object and obtain the distance from it. We tested it by the two methods explained above. Because this system aims at stationary object avoidance, we evaluated the distance recognition in terms of whether it was sufficiently price to avoid the object.

The environment of the experiment uses the same floor pattern as on 3F of Kyushu Institute of Technology. We put a box on the floor and the robot adapted to this environment.

5.2 Result of experiment

The results of the experiments are shown below. Table 1 is the result using parallax between two images and Table 2 is the result using estimation of the shape of an object.

Table 1. The result using parallax between two images

	Measured data[cm]	Output data[cm]
Distance	120	117
Height	20	25
Width	65	69
Depth	66	55

Table 2. The result using estimation of the shape of objects

	Measured data[cm]	Output data[cm]
Distance	120	119
Height	20	21
Width	65	64
Depth	66	65

Comparing the two results, the method using estimation of the shape of an object has better precision than the method using parallax between two images in obtaining the obstacle's height and depth. We obtained similar results for other objects. This method has sufficient precision for stationary object avoidance. But, estimation of the shape of an object isn't always successful because more straight lines than required are detected.

Ⅲ. Method of evasion of stationary objects

The robot has the data which express a particular human living space, called a limited two-dimensional space map. The present position of the robot and a destination position are set on the limited two-dimensional space map. The robot calculates the movement course to the destination and moves. When information about immovable obstacles is detected, it can calculate a movement route avoiding those obstacles by the movement path-finding system.

In the system of evasion of stationary objects, we write the information provided by distance recognition into the limited two-dimensional space map. Then, it calculates the evasion course by the movement path-finding system, and the robot evades the stationary obstacles and moves.

To evaluate this system, we adapted the same environment which is defined in the experiment of section II. Fig. 6 shows the result.

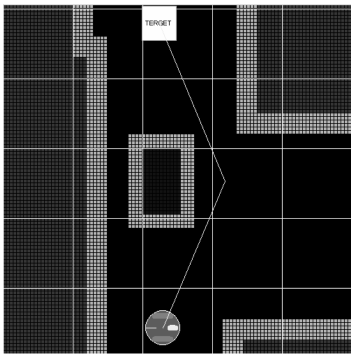


Fig.6. Robot's path avoiding a detected object

Ⅳ. Conclusions

We developed a recognition system for stationary obstacles, which is necessary for safe locomotion of a robot. The developed system has sufficient utility in an indoor environment. Our next object of study is to increase the number of kind of shapes recognized by the system. Then, we will store them in a knowledge database and make use them in the knowledge acquisition of the robot.

References

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