Development of a self-care robot
-Study of automatic holding of object using Robotic arm-

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Abstract

This paper describes the development of a self-care support robot, developed to support elderly people with mobility problems. The Kitasap2 consists of a host computer and the physical body of a robot equipped with a robotic arm. The two are connected by a wireless LAN. The robotic arm has six degrees of freedom and is equipped with a robotic hand having three fingers. This paper describes the development of the ability of the robotic arm to hold and transport an object so as to reduce the user's operational load. It is necessary that such an operation be based on easily given instructions from the user. Therefore, we have developed systems in which selection and the recognition of the object are carried out using images provided by an omni-directional camera and a CCD camera.

1. Introduction

Currently, the birthrate in Japan continues to decline, while the proportion of elderly people increases. As the population of older people increases, so does the number of elderly with mobility problems. In the near future, we will see an increased burden placed on attendants of the elderly as a result of the falling birthrate. The quality of life of the immobile elderly could be improved by assistance from a robot capable of doing housework. The development of a "self-care support robot" that supports an elderly person's independence can help to decrease a helper's workload.

We have developed the self-care support robot Kitasap2 and exhibited it in the "Prototype Robot Exhibition" at Aichi Expo 2005. Kitasap2 was developed through a commission from NEDO (New Energy and Industrial Technology Development Organization).

This paper describes the development of the ability of the robotic arm to hold and transport an object so as to reduce the user's operational load.

It is necessary that such an operation be based on easily given instructions from the user. Therefore, we have developed systems in which selection and the recognition of the object are carried out using images provided by an omni-directional camera and a CCD camera.

2. System Architecture

The Kitasap2 consists of a host computer and the physical body of a robot equipped with a robotic arm. The two are connected through a wireless LAN. The robotic arm has six degrees of freedom and is equipped with a robotic hand having three fingers. The robot also has various sensors, including an omni-directional camera (at the top of the robot), a small CCD camera (inside the robotic hand), a laser range sensor, and some encoders.

All of the robot's devices are controlled by the computer. Lithium-ion batteries supply the robot's electric power.

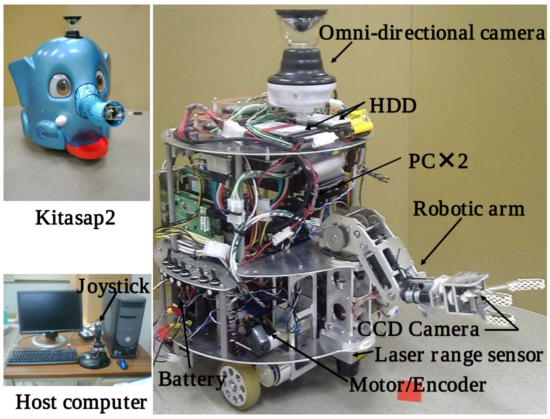

Fig. 1 Overview of the Robot system

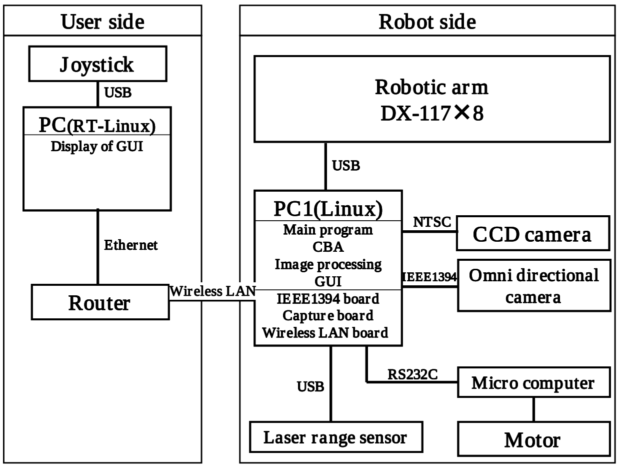

Fig. 2 System Structure of the robot

3. Robotic arm

3.1 Structure of the Robotic arm

Many degrees of freedom are required for the robotic arm to hold an object automatically. So far, it has been necessary to move the physical body of the robot in order to hold an object because its degree of freedom was not sufficient.

Recently, we produced a robot arm that has six degrees of freedom and a total length of 450 millimeters, and we mounted it on Kitasap2. Fig. 1 shows a comparison between the old and new robotic arms.

The robotic arm is equipped with a robotic hand having three fingers. Each finger has two joints and can grab objects like a human finger. Moreover, a CCD camera that is used to recognize an object is mounted inside the robotic hand.

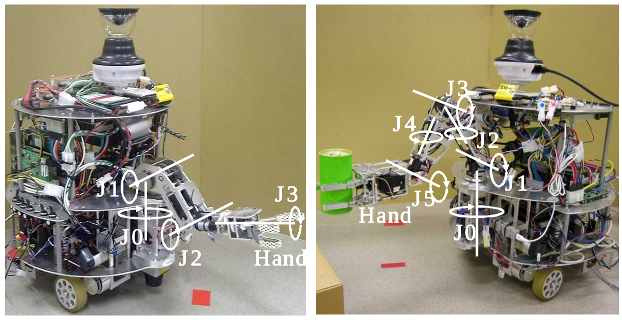

Fig. 3 Comparison between old and new robotic arm

3.2 The Actuator

We adopted the actuator "Dynamixel DX-117," made by ROBOTIS, to provide the power for each joint of the robotic arm. The DX-117 is an actuator composed of a microcomputer, motor, gears and an angle sensor.

Moreover, because this actuator uses RS485 for the communication method, the actuator for each joint is connected as a multidrop link. For this reason, the actuator’s wiring can be simple. Specifically, this is because the control calculation for the angle of each joint can be done on the actuator side by using the DX-117. Previously, this calculation had been done on the PC side, requiring that the load of the calculation be large.

3.3 Kinematics

To perform the calculation processing easily, the calculation of the inverse kinematics of the robotic arm was carried out according to the following method.

The wrist of the robotic arm moves up and down in a vertical direction and extends and retracts horizontally while the position of the wrist remains horizontal. Moreover, the robotic arm rotates around the J0 axis.

The calculation involves, first, subtracting the length of the wrist from the point of the fingers (X_e, Z_e), to give the point of the wrist joint (X_6, Z_6). Next, we draw a circle whose center is located at point2 (X_2, Z_2), with its radius being equal to the length of link A. Next, we draw a circle whose center is located at point 6 (X_6, Z_6) with its radius being equal to the length of link B.

Finally, we decide on the point of the elbow joint (X_4, Z_4) and the angle of each joint of the arm.

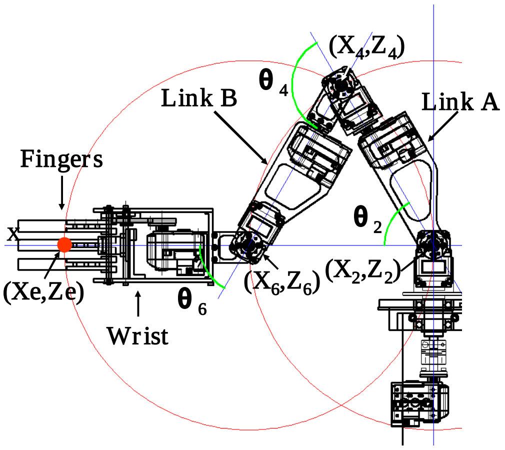

Fig. 4 Kinematics

4. The automatic holding system

In this system, we first select the object whose image is obtained by the omni-directional camera. Next, the object is recognized based on the CCD image. This allows the robotic arm to be adjusted automatically and to automatically grasp the object.

4.1 System for selecting the object

This system uses the image obtained from a perspective projection conversion from the omni-directional image obtained by the omni-directional camera.

First, the object is displayed like the image shown in Fig. 5(L) when it is put front of the robot. The user selects the object he wants to hold by clicking its image. Then, the system gets pixel information (RGB data) from the clicked point and memorizes the color information about the object. Finally, this color information is converted into HSV data.

4.2 System for recognizing the object

This system uses the image obtained by the CCD camera and the color information about the object. First, the object is displayed like the image shown in Fig. 5(C). Next, all pixel data about the image is converted into HSV data and compared with the color information about the object. Then, a group of pixels similar to the color of the object is recognized as the object. Next, the center position of the recognized object and image are displayed on the image, as shown in Fig. 5(R).

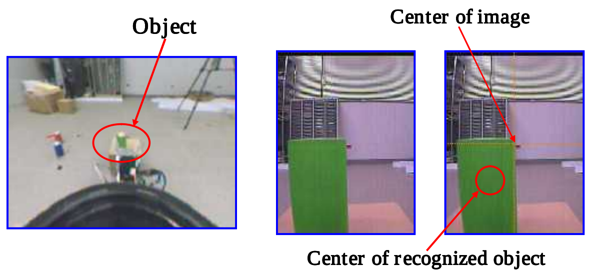

Fig. 5 The image obtained by the omni-directional camera (L).and the image obtained by CCD camera (C),(R).

4.3 Automatic holding

When the object is selected and recognized, the angles of the robotic arm's joints are adjusted automatically.

First, when the object is put in front of the robot, the robotic arm's position is as shown in Fig. 6①. Then, the robotic arm is adjusted to the center position of the recognized object, corresponding to the center of the image supplied by the CCD camera. (Fig. 6②) Next, the hand is extended horizontally, and the object is grasped by the robot. Finally, the fingers close tightly, and the holding operation is completed(Fig.6③).

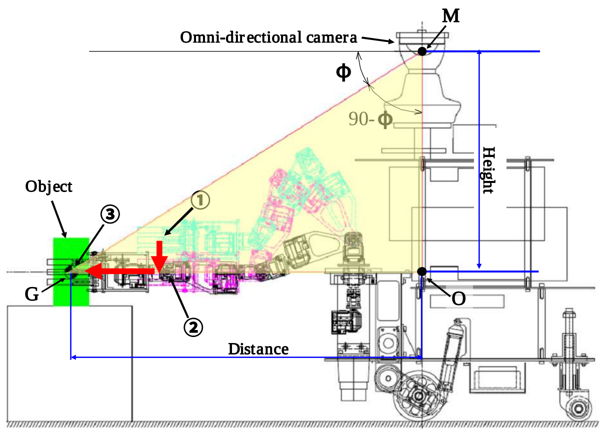

Fig. 6 Automatic holding

5. Experiment

The experimental environment is shown in Fig. 7(a). The object is put in front of the robot, where is displayed like the images shown in Fig. 7(b),(c). We directed the arm to hold the green object that was put in front of the robot.

First, the robotic arm was adjusted to the center position of the recognized object, corresponding to the center of the image supplied by the CCD camera. The wrist of the robotic arm moved up and down in a vertical direction while its position remained horizontal. Next, the robotic arm rotated around the J0 axis. Fig. 8 shows the change in the image when the robotic arm automatically adjusted.

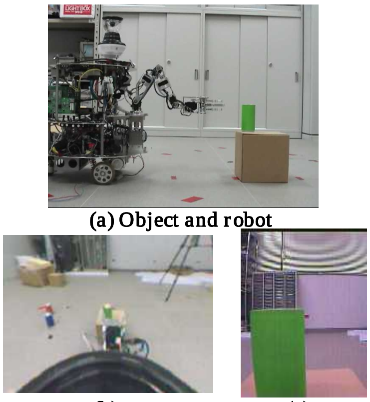

Fig. 7 Experimental environment

Fig. 9 shows the appearance of the experiment while the object was being held. The robotic arm as it adjusted to the center position of the recognized object is shown in images (1) to (3). Next, the arm’s appearance when the wrist was extended and held the object is shown in images (4) to (6). Finally, the arm’s appearance when the fingers are closed tightly and the robotic arm returns to its original position is shown in images (7) to (9).

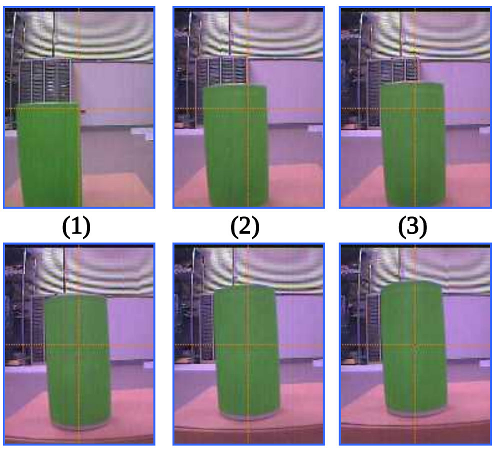

Fig. 8 Center correction

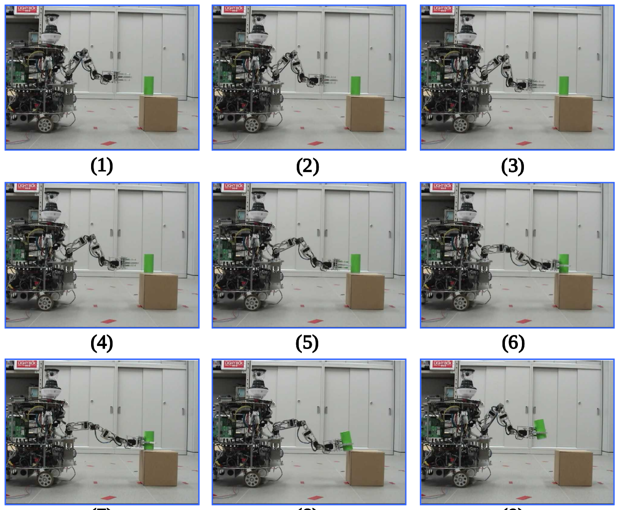

Fig. 9 Experiment of automatic holding of the object

6. Conclusion

We have developed a system for a robotic arm that automatically holds an object in order to reduce a user's operational load.

The developed system is able to select and recognize an object in an image obtained by an omni-directional camera and a CCD camera. In addition, the robotic arm can be adjusted automatically to grasp the object.

Our next subject of study will be to develop another method for the recognition of the object.

Acknowledgment

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References

[1] Kazumasa Yamazawa, Yoshio Onoe, Naokazu Yokoya, and Haruo Takemura: "Telepresence by Real-Time View-Dependent Image Generation from Omnidirectional Images", Systems and Computers in Japan, Vol.31, No.6, pp.56-64 (2000.6).