Robot Arm Operating Interface for Easy Grasping by Specifying the Gripping Width of End-effector

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Abstract

In Japan, cervical cord injuries affect roughly half of all patients with spinal cord injuries. High-Level spinal cord injuries make it particularly difficult for patients to pick up objects from the ground because of the functional impairment of the trunk. To help these people become more independent, welfare robot arms have been developed recently. In our lab, an interface has been proposed to control the robotic arm by drawing a line on a touch screen in order to grasp an object on the floor and deliver it to the user. This technique has a fixed closing width for grasping, making it challenging to use when the object's sizes change. Therefore, we proposed a method that allows the adjustment of the closing width according to the drawn line on the touch panel interface. As a result, we found that the grasping was still possible even the object was altered.

Keywords: Vision-based interface, Remote control, Eye in hand system, Welfare robot arm.

1. Introduction

Nowadays, there are many disabled people in Japan whose daily lives are limited by physical disabilities; in 2018, there were 4.36 million disabled people in Japan [1]. Which increasing year by year [2].

The spinal cord is primarily hurt when the spinal column is subjected to a powerful external force. Most of these injuries are caused by car accidents or falls from height, and many patients are injured at the C5 level [3]. Because the paralysis of C5 patients extends over almost their entire body from the chest down, it is difficult for them to pick up objects from the floor, grasp, and so on. In recent years, robotic arms mounted on wheelchairs have been introduced in nursing care situations to assist physically disabled people in their daily lives [4] [5].

For example, there are automatic operation interfaces using AR markers and interfaces that automatically grasp objects by recognizing them through the installation of multiple cameras [6] [7]. However, there is a possibility of maloperation or misidentification, and the use of multiple cameras limits the situations in which they can be used depending on the operation method. Our laboratory also proposed an operation interface in which a single 2D camera is mounted on the end-effector of a robot arm to perform grasping operations on objects in a work environment. However, the object is limited to the size because the closing width of the end-effector is constant during grasping.

In this study, we propose a new manipulation interface to extend our previous one and conduct an experiment with a healthy person.

2. Visual-based operating interface

In this study, a touch panel such as a tablet device is used as the input device. Since there is no need to grip the interface, even C5 level cervical cord injured patients can operate the device. In addition, they are accustomed to operating the interface because they use smartphones and other devices on a daily basis.

As it is relevant to the proposed method, we will briefly describe the previous methods. As a simple method for specifying a line indicating the target position is drawn on the touch panel. Consider the workspace with the origin on the floor shown in Fig. 1. A line is drawn on the operation screen to specify the hand target. The line and touched point on the screen are transformed into those on the floor. In Eq. (1) $\boldsymbol{x_c}$ is the coordinates of the camera attached to the end-effector of the robot arm in the workspace. $\boldsymbol{v}$ is the vector from the operation screen to the specified point and $\boldsymbol{x_i}$ is the point on the floor.

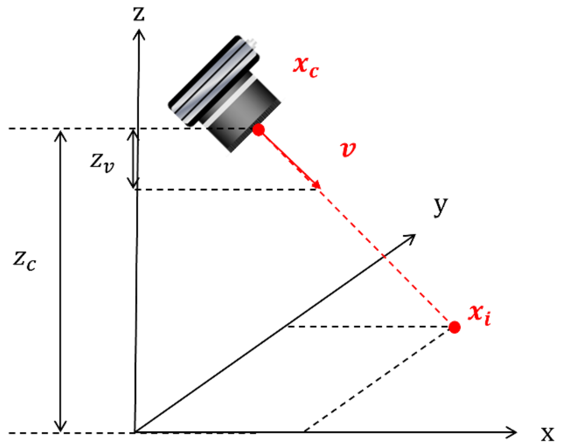


Fig.1 Working-space coordinates

$$\boldsymbol{x_i} = \frac{z_c}{z_v}\boldsymbol{v} + \boldsymbol{x_c} \tag{1}$$

In the previous method of our laboratory, the grasping closure width is constant. Therefore, if the size or characteristics of the target object change, the robot arm may not be able to grasp it.

This method includes a function that adjusts the end-grasping effector's width based on the length of the drawn line.

3. Experiment on healthy subjects

3.1. *Experimental apparatus*

The experimental setup is shown in Fig.2. The robot arm used in the experiment was myCobot280M5 manufactured by Elephant Robotics Co. The electric wheelchair was an EMC-250T manufactured by Imasen Electric Co.

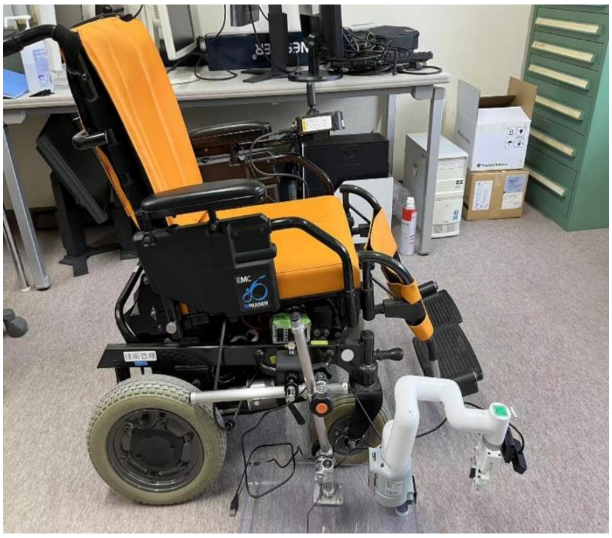
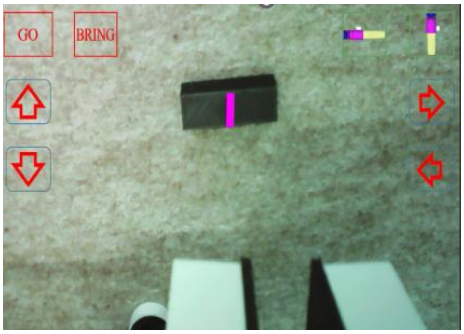


Fig.2 Experimental equipment.

3.2. *Experimental outline*

In this study, the experimental subject was a healthy person. In the experiment, two types of objects of different sizes were placed. The experiment's goal was to manipulate the end-effector by the proposed interface to grasp objects of different widths. The reason for conducting this test on healthy subjects is to confirm that grasping is possible when the size of the target object differs from that of the subject. The primary goal of this experiment is to demonstrate that grasping is indeed possible even when the targets are of different sizes. We also want to make sure that the calculated value in the program matches the actual value of the grasping closure width. As a result, an experiment was carried out in this paper with a healthy subject.

Because C5 level injured subjects have contractures in their fingers, subject was instructed to operate the touch panel with the second joint of their pinky finger for reproduction purposes. Since the maximum opening width of the end-effector of the robot arm used in the experiment is limited to 40 mm, the grasping objects in the horizontal plane are two objects with a length × width of 50 mm × 22 mm and 50 mm × 15 mm.



(a) By drawing a line along the object, the position and grasping posture are created.

(b) By pressing the GO button, the device is brought within 60mm of the object, and by pressing the BRING button, it is grabbed.

(c) Deliver the grasped object to the wheelchair passenger

Fig.3 View of grasping a 50 mm × 15 mm object

3.3. *Experimental results*

The grasping scenery of each object in the experiment is shown in Fig.3 and Fig.4 The operator specifies the target position and closing width by drawing a line as shown in Fig.3 and Fig.4 at the point where he/she wants to perform grasping.

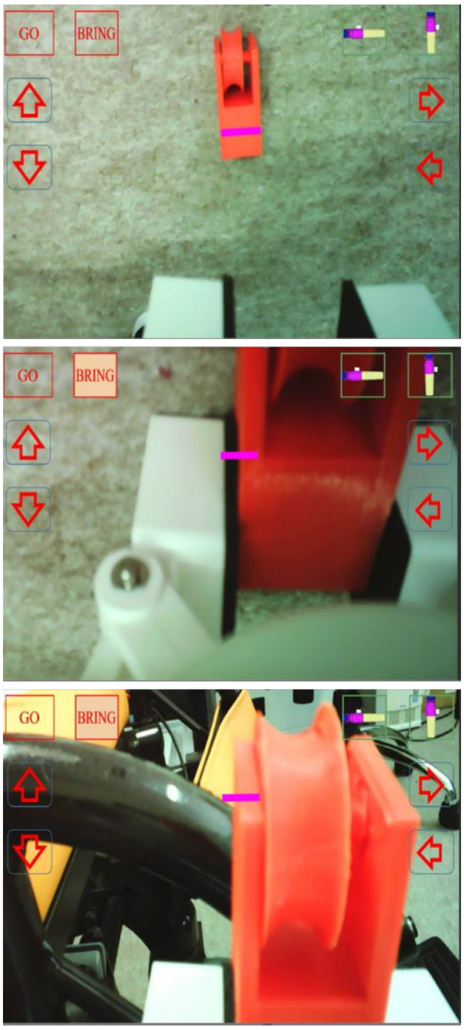


Fig.4 View of grasping a 50 mm × 22 mm object

The command values that specify the closing width of the hand calculated by the line drawn for each object are shown in Table.1.

Since the experiment was conducted twice for each object, the average value was calculated. D is the length of the drawn line, and v is the command value. For the 50 mm × 15 mm object, the program outputs a line length of 15.3 mm, which is close to the object; for the 50 mm × 22 mm object, the program outputs a line length of 22.6 mm, which is also close. Therefore, it was confirmed that grasping of the object is possible, and furthermore, the program outputs a value that is close to the actual value of the closing width for grasping calculated in the program.

Table.1 Experimental results for each object

Object	Command value v[-]	Length of line drawn D[mm]
50 mm × 15 mm	29	15.3
50 mm × 22 mm	43	22.6

4. Conclusion

Since many spinal cord injury patients are forced to live in wheelchairs or in bed, a robotic arm is needed to perform grasping of objects in daily life instead. We proposed an interface to specify the closing width of the robot arm's end-effector by drawing a line on the touch panel to a target object on the floor using a single camera. specifying the target position, grasping posture, and closing width of the robotic arm. We verified a method for grasping objects of different sizes by changing the closing width of the arm's grasp according to the length of the line drawn on the touch panel. On healthy subject, we performed experiments using targets of various sizes, and we confirmed that both the grasping width and the targets could be specified.

It has been demonstrated that even when the size of the target object varies, it is still possible to specify the closing width for grasping and to grasp an object. The closing width command to the robot arm must be adjustable in an environment with multiple objects and varied target hardness. Among other factors, it must be decided whether to specify the closing width as the robot arm approaches the object or just before it is grasped. As a result, taking into account the environment with its various objects, materials, etc. is also necessary in order to grasp an object more appropriately.

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