Maloperation Prevention Filter for Touchscreen Used in Robot Arm

L. Yang1, *, T. Ichikawa1, Y. Miyawaki1, R. Sakamoto2, N. Kato1, K. Yano1 and S. Shimada3
1Graduate School of Engineering, Mie University, 1577 Kurimamachiya-cho, Tsu-city, Mie, 514-8507, Japan
2Mie University Hospital, 2-174 Edobashi, Tsu-city, Mie, 514-8507, Japan
3Technotools Corporation, Higashi-Naganuma, Inagi-city, Tokyo, 206-0802, Japan

*ljyang@robot.mach.mie-u.ac.jp

Abstract. In recent years, robot arms are being developed for self-reliance supporting for those who are unable to move without using an electric wheelchair or live a bedridden life. For example, mounting a robot arm on an electric wheelchair or bedside could help the limb disabled people to perform daily activities without nursing. However, the existing robot arms are mainly using traditional operation interfaces like keyboards or joysticks. Under different scenarios, some patients with upper limb disabilities such as contracture cannot operate such interfaces smoothly. In this study, in order to reduce the difficulty in operating robot arms, we developed a new kind of operation system using smartphone touchscreen as screen joystick operating interface. Meanwhile, the system includes a filter which detects and adjusts maloperation due to the capacitive touchscreen panel with high maloperation rate. Finally, an operating test was conducted by a patient with upper limb disabilities, and the effectiveness of this study was shown from the evaluation of the trajectory of robot hands from the initial position to the aim position. In the future, we are planning to develop an innovate operation system for a robot arm which is mounted on the wheelchair, with the effectiveness confirm by several operation tests.

1. Introduction
Among the disabled people in Japan, around 50% of them are with limb disability. Among the people with limb disability, robot arms are developed for self-reliance supporting for those who are unable to move without using a wheelchair or live a bedridden life [1][2][3]. To counter with the issue, practice like mounting a robot arm to wheelchair or bedside could help the limb disabled people to do some basic things without nursing such as holding a cup or picking up items from the floor.

Currently, the extant robot arms are mainly using the traditional operation interface like keyboards or joysticks. Under different scenarios, some patients with upper limb disabilities cannot operate such interfaces smoothly. For this problem, some new type of operating interface to operate robot arms was developed recently. However, even the number of keys was reduced, for patients with upper limb disability, it is still hard to handle. In addition, an interface using the 3D mouse as the input device which does not require the mode switching operation has been developed [4]. However, in the case of cervical spinal cord injured persons, it is difficult for them to grasp the object due to the contracture of the wrist joint which leads to limited range of motion of the finger joints. On the other hand, interfaces which
operate robot arms by recognizing voice commands are also being developed [5]. But this pattern can only recognize limited simple commands which are not sufficient for practical use.

As we mentioned above, since the range of motion of the finger joints is restricted by the contracture of the wrist joint, the person with cervical spinal injury can’t touch the screen with the fingertip, but can use the second joint of the little finger shown in Figure 1. Therefore, it is difficult for him to hold the interface, and it is necessary to design an interface that enables simple operation for the person with cervical cord injury. In this study, in order to reduce the difficulty in operating robot arms, we developed a new kinds of operation system which use smartphone touchscreen as the operating interface.

![Figure 1](image1.jpg)  
(a) Figure of view from above  
(b) Figure of view from the side

Figure 1. Operation of a smartphone by cervical spinal cord injured person

2. Specifications of operating system

The configuration of the robot arm operation system in this study is shown in Figure 2. The operating device is Apple's iPhone 7. The operation screen is displayed in the web browser of the device which is connecting with WebIOPi, a software supported by Raspberry Pi. When the operation was detected, the input information will be sent to the Raspberry Pi. After this, by using I²C interface of WebIOPi, the input information will be sent to Digispark, which could be used as a USB gamepad emulator. Therefore, the system allows us to control the robot arm that was designed to be operated by a gamepad.

![Figure 2](image2.jpg)

Figure 2. Configuration of the robot arm operation system

Figure 3 shows the GUI (graphical user interface) used in this study which was developed by HTML and JavaScript. Meanwhile, the Table 1 shows the specification of developed operation screen.
3. Operation verification

3.1 Operation check
In order to verify the operation of proposed interface, we did a verification experiment shown in Figure 4. During the operation check, the robot arm was mounted on origin. Meanwhile, as the task of experiment, the operator should operate the robot arm by using the proposed interface to move the robot hand from initial position to target position. The robot arm used in this experiment was Udero [6], which is developed by TechnoTools, shown in Figure 5. The specifications of Udero is shown in Table 2.

3.2 Introduce of maloperation filter
During the operation check, we noted that because of the operating system is using capacitive touchscreen panel as the interface, an unconscious touch from operator will lead the movement of robot arm immediately. It is dangerous in practical use. In order to solve this problem, we decided to introduce a maloperation filter into the proposed system.
Figure 4. Experimental task

Figure 5. Robot arm “Udero”

Table 2. Specification of Udero

| DOF                          | Specification             |
|------------------------------|---------------------------|
| Max Reach                    | 4 (Arm) + 3 (Wrist) + 1 (Hand) | 885 [mm]   |
| Weight                       |                           | 6.0 [kg]   |
| Max Payload                  |                           | 1.0 [kg]   |
| Max Rotation Speed           |                           | 60 [deg/s] |

3.2.1 The algorithm of maloperation filter. In this study, we avoid the maloperation by judging the displacement between the first touching point and the origin of operable range. If the displacement between the first touching point and the origin exceed the threshold, the operation will be judged as maloperation and the joystick will maintain the neutral state. Here, we set the threshold as the 20% of the radius of operable range. Figure 6 shows the flowchart of maloperation prevention filter.

\[ t : \text{Time} \]
\[ P_t : \text{Touched position in } t \]
\[ r : \text{Threshold of max distance} \]

Figure 6. Flowchart of maloperation prevention filter
3.2.2 Performance of maloperation prevention filter. Figure 7 shows operation screen of the operation system with and without the maloperation filter. The real time input of gamepad emulator is enclosed by the red box. In the case of the operation system without filter, we can note that the coordinate will be updated immediately even the first touch point is far away from the origin. By contrast, in the case of the operation system with maloperation filter, if the first touch point is far away from the origin, the coordinate of touch point will not be updated and the joystick will keep the neutral state.

![Operation Screenshots](image)

(a) Without filter  
(b) With filter

**Figure 7.** Comparison of operation screenshots

4. Comparative operation experiment

4.1 Experimental outline

The experimental subject was a patient with cervical spinal injury, and the experiments were conducted three times by operating the robot arm hand from start point to the target point (same as Figure 4). We measured the trajectory of robot hand in real time. Also, as an operation condition, in order to simulate the maloperation, the operator should place the smartphone on his knee without looking at the touch screen during the operation. As a procedure of the experiment, experiments by the operation system without the filter were performed after the experiment of the operation system with filter. In addition, experiments were conducted in a condition that the subject were sufficiently accustomed to the operation.

4.2 Experimental result

Figure 8 shows the results of comparative operation experiment in 3 times respectively. In Figure 8, the brown line represents the moving trajectory of robot hand in case of operation system without the maloperation filter. The blue line represents the move track of robot hand in case of the operation system with the maloperation filter. And the red dash line represents the ideal moving trajectory.

According to the results shown in Figure 8, we note that the proposed operation system can suit the patient with a cervical spinal injury. Particularly, by using the proposed maloperation filter, the real trajectory is close to the ideal trajectory.
5. Conclusion

By using robot arm, patients with upper limb dysfunction such as cervical spinal cord injury are able to conduct daily activities independently. However, the existing robot arms are mainly using the traditional operation interface like keyboards or joysticks which may be difficult for them to handle. In order to solve this problem, in this study, we proposed a new kind of operation system which use smartphone as the operating interface. On the other hand, we also proposed a maloperation filter which could avoid the maloperation caused by unconscious touch. Finally, we conducted a comparative operation experiment to verify the effectiveness of this research. As the result of experiment, the proposed operation system is suit for patients with upper limb dysfunction and the maloperation filter is also functional. As the future work, we are planning to develop an innovate operation system for robot arm which is mounted on a wheelchair, with the effectiveness confirming by several operation tests.

Reference

[1] Kenji Chihara, Katsutoshi Fujii: Development of a High-Performance Electric Wheelchair, Research report of Gifu Prefectural research institute of information technology, pp.51-56 (2007)
[2] Yuki Suga, Wei Wang, Shigeki Sugano: Development of Light-Weight Robot Arm Mounted on Wheel Chair with Storage Mechanism, The Robotics and Mechatronics Conference, 1A1-14D (2009)
[3] Natsuki Yamanobe, Yujin Wakita: Daily Life Support for Persons with Upper-limb Disabilities by Robotic Arm, The 24th Annual Conference of the Japanese Society for Artificial Intelligence, 1H2-NFC3b-10 (2010)
[4] Kousuke Ichikawa, Tetsusi Oka, Keisuke Matsusima: The evaluation of manipulator operation interface using 3D mouse, The 78th National Convention of IPSJ, 2Y-01 (2016)
[5] Hairong Jiang, Ting Zhang, Juan Wachs, Bradley Duerstock: Enhanced control of a wheelchair-mounted robotic manipulator using 3-D vision and multimodal interaction, Computer Vision and Image Understanding, Vol.149, pp.21-31 (2016)
[6] Eito Tanaka, Tomoya Ichikawa, Ryota Sakamoto, Ken’ichi Yano, Shintaro Shimada: 7-DOF robot arm "Udero" for self-reliance support of disabled persons, The 17th SICE System Integration Division Annual Conference, (2016)