ExtendedHand on Wheelchair

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ABSTRACT
In this paper, we present a novel welfare system which utilizes a spatial augmented reality technique. Hand is a crucial component in human-human communication. For example, we can intuitively indicate an object or place by reaching and pointing it to nearby partners. Unfortunately, for wheelchair users, such communication is often limited because their reaching ranges are narrow, and moving their bodies to the target is tiresome. To solve this issue, we propose a novel wheelchair system on which a battery-powered mobile projector is mounted. A user manipulates the projected virtual hand as an extension of the real one using a touch panel equipped on an armrest of the wheelchair. We implement our proposed system and demonstrate the effectiveness.

Author Keywords
Virtual hand; wheelchair; communication; tablet.

ACM Classification Keywords
H.5.2. Information Interfaces and Presentation (e.g. HCI): User Interfaces

INTRODUCTION
A wheelchair is one of the most important tool for people with disabilities in their legs to move around. However, because wheelchairs require a certain amount of space to move, users cannot approach to targets when there are not enough space. As a result, wheelchair users cannot reach on the targets by their hands for communication. Therefore, it is difficult for them to communicate smoothly with other people. To solve this important issue, we propose to mount a projector and a touch panel on a wheelchair. The projector superimposes a virtual hand image extended from the actual hand which manipulates the virtual hand in real-time based on the hand gesture on the touch panel. The projected virtual hand manipulation as an extension of the user's real hand was originally proposed by Ogawa et al. who realized the manipulation using computer vision-based hand recognition technique [2]. On the other hand, we apply the touch panel to recognize the user's hand gestures to make the gesture recognition independent from environment light conditions. As a result, a user of our system can communicate with a partner with a wider reaching area of a hand (Fig. 1).

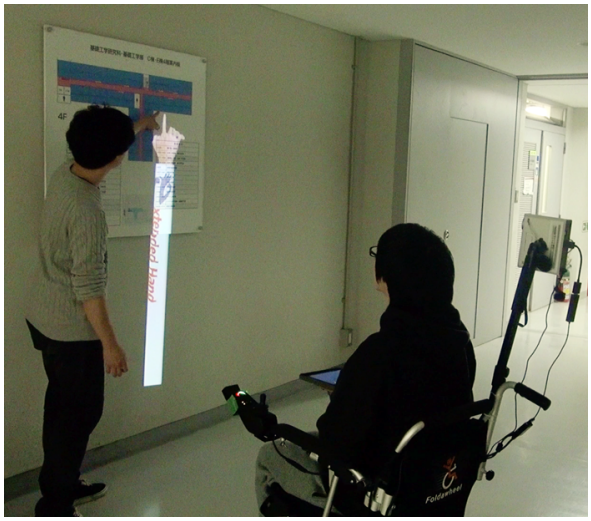

Figure 1. Communication support with our wheelchair system.

Upon mounting a projector on a wheelchair, there is a problem that the projected region is limited and fixed to the front of the wheelchair. This means that the reaching range of the virtual hand is significantly limited. Therefore, we propose to extend the projection range of the virtual hand by placing a pan-tilt mirror in front of the projector. As a result, projected images can be moved outside the frustum of the projector in both vertical and horizontal directions. This technique allows wheelchair users to manipulate their virtual hands in a wider area and to reach distant targets with them without moving nor turning their wheelchairs.

Collision with other people is a prominent concern for wheelchair users. The mounted projector can be used to display an arrow that indicates a future path of the wheelchair on the ground. Consequently, people surrounding the wheelchair can intuitively notice its path and safely avoid the collision.

We also give an application using a virtual hand as appliances manipulation. IoT (Internet of Things) era is coming, and variety of appliances are connecting to the internet. In this paper, we give an example to manipulate such appliances with projected virtual hand.

SYSTEM OVERVIEW
Figure 2 shows our prototype system, consisting of an electric wheelchair (Foldawheel, PW-999UL), a projector (ASUS,

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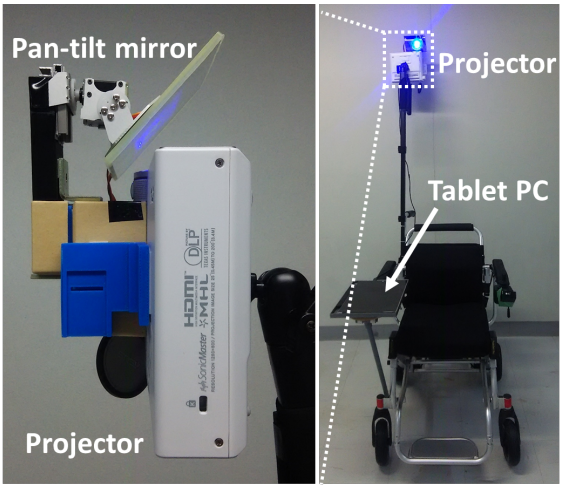

Figure 2. System overview

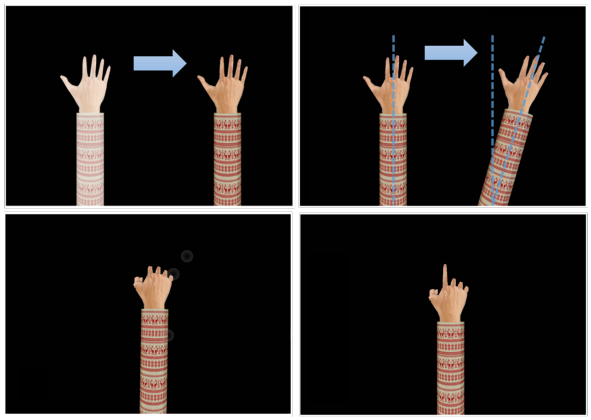

Figure 3. Manipulation of the virtual hand: (upper left)Translation, (upper right)Rotation, (lower left)Grasp, and (lower right)Pointing. The original hand model is provided from © 26°C(license:`https://creativecommons.org/licenses/by/4.0/`), we separate it into several parts and use them.

P3B) and a tablet computer (Microsoft, Surface Pro 3). Servo motor is controlled by an Arduino, which is connected to the tablet computer. A command to the servo motor is sent via the serial communication. We modified the wheelchair system so that we can control the wheelchair movement from the tablet computer via wireless communication.

EXTENSION OF A PROJECTABLE REGION

On simply mounting a projector on wheelchair, the projected region is fixed to the front of the wheelchair. As a result, the reachable range of the projected virtual hand is considerably restricted. Then, we propose to extend the projection range of the virtual hand by placing a pan-tilt mirror in front of the projector. This technique allows wheelchair users to obtain a communication method with hand in a wider area. Users can move the projected image in both vertical and horizontal directions by flick gesture on the touch panel. While the projected area of the virtual hand is extended, there is a problem that the projection image becomes diagonally when the projected area is moved in the horizontal direction. As a result, two problems occur. Firstly, the direction of the virtual hand is distorted. Secondly, the size of the virtual hand is changed. In the current system, users need to correct the direction and size of the virtual hand by setting values from a menu window or by using presetting values in order to solve the problems.

INTERACTION TECHNIQUE

Wheelchair

When users touch the screen and move thier fingers, the wheelchair moves in that direction. The number of touched fingers does not matter. The wheelchair also can move right or left forward. For example, the wheelchair moves right forward if users move thier fingers to the right while the wheelchair moves forward. users can stop the wheelchair by leaving their fingers from the touch panel.

Virtual hand

Fig. 3 shows the manipulation of the virtual hand. According to the 2D translation of users hand on the touch screen, the virtual hand translates towards the same direction with an amplified translation distance. The rotation of the virtual hand corresponds to the rotation of the users hand on the screen. All fingers are stretched out or completely bended respectively. In the case of one-point touch, the index finger is only stretched and the others are bent.

APPILICATIONS

We give two application examples using our system. First example is the display of a wheelchair course. Dancu presented a map navigation system for a bike using the projector[1]. On the other hand, we propose to display a future path of the wheelchair on the ground. By visualizing the wheelchair course on the road surface, wheelchair users can show their running direction to the people around. We expect to reduce the possibility of collision between wheelchair users and other people. Second example is the appliances operation by using a virtual hand. In the near future, variety of appliances are goning to connect to the internet. In such situations, users can control the appliances in remote by the projected hand. For instance, we move a cleaning robot to the specified position by using the virtual hand.

CONCLUSION

In this paper, we developed a novel wheelchair equipped with a projector, and proposed communication support using a virtual hand. Moreover, we presented application examples related to the proposed system and showed the feasibility of the future. We expect that the life environment of the wheelchair users is greatly improved.

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