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Invited Paper

Extending Three-Dimensional Space Touch Interaction using Hand Gesture

Hayato Takahashi[1, a], Seiichi Serikawa[2,b], Yuhki Kitazono[1,c]

[1]National Institute of Technology, Kitakyushu College, 5-20-1 Shii, Kokuraminami-ku, Kitakyushu-city, Fukuoka, 802-0985, Japan

[2]Kyushu Institute of Technology, 1-1 Sensui-cho, Tobata, Kitakyushu, Fukuoka, 804-8550, Japan

[a]ad1513ht@apps.kct.ac.jp, [b]serikawa@elcs.kyutech.ac.jp, [c]kitazono@kct.ac.jp

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Abstract. In this study, we aimed to integrate multi-touch gesture with hand gesture and make a new input method. Multi-touch gesture and hand gesture have been studied separately, however, these could be integrated, and it would be a new interaction way for computer. We made projection-type touch screen and a hand gesture recognition device with sensors; pressure sensor, bend sensor, and acceleration sensor. User can input coordinate by touching, and simultaneously input action by performing hand gesture. On this interface, user inputs touch data with infrared LED which is attached to his fingertips of the glove type device. By using infrared light to detect touch point, user can interact with touch display without contact. This interface is suited for interacting 3D objects in computer. We demonstrate interacting with 3D object in application we made. In the end of this paper, we consider how to improve this interface.

1. Introduction

While multi-touch display is commonplace for human computer interaction, it is still difficult to interact with three-dimensional space by using only touch interface. Multi-touch interaction enables the user to interact intuitively rather than mouse or keyboard. The merit of the touch interface is intuitive coordinate input. However, it is hard to provide various operations by touch interface as many as mouse or keyboard. This is due to that multi-touch interaction needs graphical user interface for operation to provide non-intuitive action. For instance, displayed software keyboard on screen is necessary to input characters with touch interface. Furthermore, even generally utilized operations, such as copy and paste, need to be selected from the displayed menu. Touch interface is suited for use on visually indicated application. Touch gestures such as swipe, double tap, rotate, pinch, and hold are available on such application, and these are very intuitive way to interact with objects in virtual space. There have been several researches which aim to expand touch interaction pattern and takes different approaches, changing input mode by recognizing specified gesture as start-up gesture[1], design gesture pattern to be performed by both hand[2], identify gestures by other factors such as contact size of touching finger[3], or such as touching object like a nail, knuckle, and so on[4]. While multi-touch interface is suited for inputting coordinate data, the variety of input pattern is certainly less than mouse or keyboard.

Besides, also hand gesture is very efficient way to interact with virtual three-dimensional space. It is possible to three-dimensional coordinate data by capturing hand in 3D data, so user can interact very intuitively with objects in virtual space. Even hand gesture is efficient way for interacting with 3D space, it is difficult to use only it. This is due to that the accuracy of pointing is lower compared to input like mouse or touch display. About Leap Motion, which is a hand gesture recognition device, Coelho concluded it is effective for manipulation to a single object, but mouse is still more useful in manipulation to multiple objects[5]. Hand gesture provides various input by hand gesture can recognize various intuitive actions for three-dimensional space manipulation, but it has the drawback of pointing accuracy.

Basing on this current situation, we propose an interface which integrates the touch display with hand gesture. On this interface, user can interact by both touch and hand gesture simultaneously. Operational information of the hand gesture is integrated with information about the touch points. By including such information, touch operation pattern is expanded without getting complicated. We have developed integrated interface for 2D application in previous research[6]. In this study, we improve the interface to facilitate manipulation into three-dimensional space.

2. Screen Projection Type Interface

2.1 System Configuration

In previous research, we have developed touch display by using FTIR method[7]. The table top type display with the FTIR display was medium size of 40cm × 40cm, however, by applying the touch detection with infrared camera, it is possible to create an even larger screen. Touch gesture and hand gesture operations are very suitable for manipulating objects in 3D space, since input in the Z axis direction can also be performed by hand gesture on input of X - Y coordinates by touch.

In this research, we made screen projection type multi-touch display and glove type hand gesture recognition device.

2.2 Screen Projection Type Multi-Touch Display

We have made screen projection type multi-touch display using projector, infrared camera, infrared LED. The configuration of the display is shown in Fig. 1. The display is projected by rear projection and the position of the light of the infrared LED attached to the fingertip by the user is read by the infrared camera and the touch point is detected based on the position of the screen in the image which has been calibrated beforehand.

In this study, we used a tracing paper on the projection screen to make a screen with a width of 180cm × height of 85cm. The actual projection screen is shown in Fig. 2. The tracing paper is suitable for rear projection, and images are clearly displayed as shown in Fig. 2.

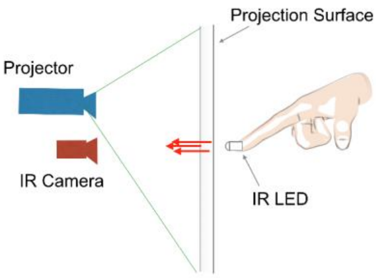

Fig. 1. Configuration of screen

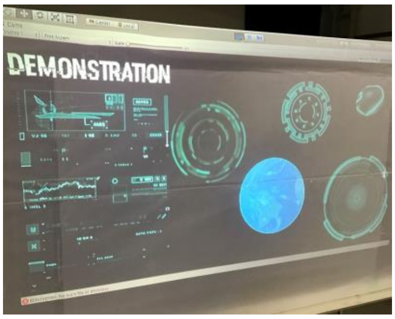

Fig. 2. Projected screen

When the screen was touched, in other words, when the infrared ray from fingertips is emitted, images like those shown in Fig. 3 can be acquired, by capturing infrared camera.

Fig. 4 shows an image obtained by photographing the same state with a camera capable of taking an infrared ray and visible light. In this way, since visible light including the light from the projector is not reflected on the infrared camera, and the moving object emitting infrared rays such as electric light is removed by background removal function. And then, the touch point can be taken out accurately.

Fig. 3. Infrared only image

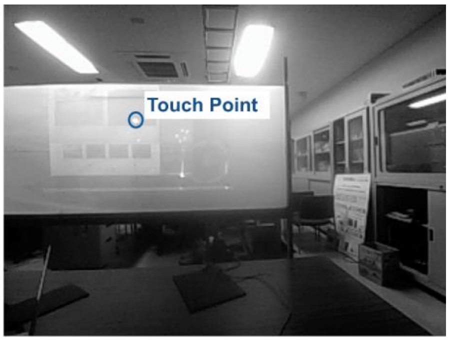

Fig. 4. Infrared and visible light image

TBeta[8] was used to calibrate the touch area of the screen by this image and convert it appropriately to application coordinates. Fig. 5 shows a screen as a result of processing the state of Fig. 3 using T-Beta. As shown in the upper left corner of the figure, only the touch points can be detected, and the screen positions in the image are correlated by calibration beforehand so that the touch on the projection screen corresponds to the coordinates in the application. By using the coordinate information, it is possible to use the touch operation in the application as shown in Fig. 6.

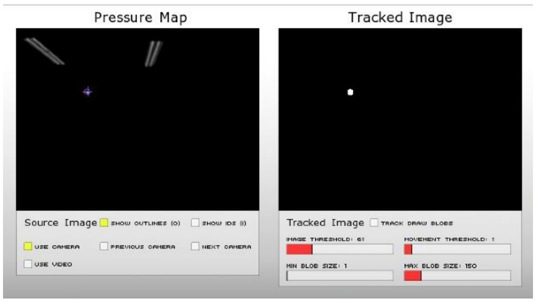

Fig. 5. Processed on TBeta

Fig. 6. Touching screen

2.3 Hand Gesture Recognition Device

In this research, the hand gesture was recognized by acquiring the bending and stretching state of the fingers by using sensors. In order to further simplify attachment of sensors to hands, a recognition device was manufactured by a method of embedding a sensor in a glove.

Fig. 7 shows the fabricated glove-type device. Bending sensors are built in the right index finger and right hand ring finger, respectively, and a pressure sensitive sensor is built inside the right thumb. Switch on the side of the index finger on the left hand, acceleration sensor on the back of the hand. Chip type infrared LEDs are attached to the fingertips of the middle finger and the thumb of the right hand, and the index finger of the left hand.

The infrared LED attached to the fingertip is used to input the touch interaction to the projection screen, and the position of the emitting LED is captured by the infrared camera. In addition, Fig. 8 shows a state in which this LED lighting state is photographed by a camera capable of taking an infrared ray.

When the LED is constantly lit, the touch input is always performed and touch input such as "touch" or "release" cannot be performed. Therefore, a bending sensor of an index finger is used as a switch in order to turn on the LED at an arbitrary timing. In this glove type device, when inflected 30 degrees or more from the second joint of the index finger, all the infrared LEDs are turned on.

The bending sensor of the ring finger of the right hand and the pressure sensor of the thumb are used for inputting the analog value. The acceleration sensor attached to the left hand is used to input tilt information to the 3D object. If the input value was absolute inclination, it is always necessary to pay attention to the inclination of the left hand while the user is performing touch operation. Therefore, in order to input arbitrary inclination information, a switch attached to the left index finger is used. Pressing the switch of the left index finger acquires the inclination information at that time and inputs the relative inclination from the new origin while holding the inclination as the origin and pressing the button.

The hand gesture input is performed using these infrared LEDs, bending sensor, pressure sensitive sensor, and acceleration sensor.

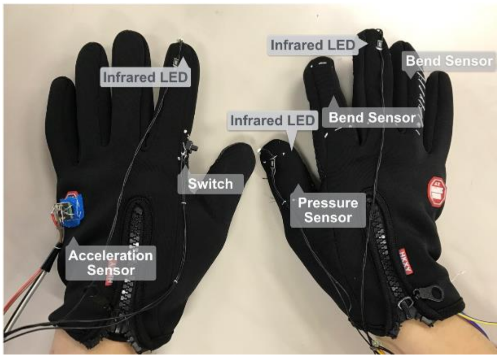

Fig. 7. Glove type device

Fig. 8. Infrared emitting LED

3. GUI Application

We developed a GUI application that takes advantage of the features of interface created in this research. The operation appearance of the application is shown in Fig. 9a.

In the screen of the application, a circular object of plane, 3D model and window are displayed in 3D space. When the right index finger is bent and an infrared LED attached to the fingertip of the glove is irradiated, a touch point is displayed as shown in Fig. 9b. It also supports multi-touch, user can also touch two fingers as shown in Fig. 9c by turning the infrared LED of the right middle finger and thumb toward the screen. The circle object and the 3D object can be moved by dragging while touching the object, and the 3D object is moved in Fig. 9d.

The operation by dragging is only the movement of the XY coordinates with respect to the screen, but the movement on the Z axis can be operated by the bending sensor attached to the ring finger. Once user bend the ring finger while he is selecting an object by touching it, it shifts to the movement mode to the far side, and the object is moved to the back side as shown in Fig. 9e depending on the state of extension from the bent state. Also, if user stretches the finger straight while selecting the target, the movement to the near side is performed by the degree of bending from the extended state.

The inclination of 3D objects can also be controlled. By using the acceleration sensor attached to the left hand and touching the object and pressing the switch on the left side index finger in the selected state, the inclination at that time is set to zero, and the relative angle from there is input. In accordance with the input of the inclination, it is possible to control the inclination of the 3D object as shown in Fig. 9f. Finally, to delete an object in the application, you can operate by pushing the pressure sensor attached to the right hand thumb and clicking on it. When touching the object to be selected and pushing the pressure sensor a certain amount or more, it is possible to delete the object as shown in Figs. 9g and 9h. This is the operation content of the GUI application developed above.

As seen in the operation of this application, this interface can perform various action inputs without displaying a menu or complicated operation during touch operation. "Movement on the Z axis coordinate" which is the operation content of this application is a place which is difficult for the touch interface and it is difficult to operate in the Z axis direction by touch which is input only on the X – Y

(a) Application appearance

(b) Single touch

(c) Multi touch

(d) Dragging 3D object

(e) Z-axis movement of object

(f) Controlling tilt of object by hand gesture

(g) Pressure sensor is clicked

(h) Circle object was eliminated

Fig. 9. GUI application on screen interface

coordinate on the screen. However, by using the bending sensor, it realizes it while having affinity with the touch input. Also, it is difficult to realize inclination input of a 3D object with a touch interface, and in many cases, inputting inclination is performed by using a slide bar or the like. However, by using the input by the inclination sensor, the inclination can be intuitively controlled both visually and sensually.

4. Conclusion

In this research, we proposed a method for integrating touch gesture and hand gesture, and developed GUI application using them. The features of these input methods compared with existing ones are that they compensate problems such as the limit of expansion of gesture pattern of touch display and the accuracy of the pointing operation by hand gesture by integrating both input methods.

With the development of 3DCG, opportunities to control objects in three-dimensional space in computers are increasing, but in such fields still the mouse / keyboard is the main operation interface, touch gesture · hand gesture is Even in situations where it is suitable, it is currently difficult to apply due to the problems as described above. The interface shown in this paper has a possibility to be a solution to these tasks.

In order to make the interface shown in this research more practical, further improvement needs to be done in the future.

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