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Object Manipulation by Absolute Pointing with a Smartphone Orientation

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Abstract

The purpose of this study is to use smartphones to operate various devices in a room. There are many electronic devices such as air conditioners and audio-visual devices in people's living spaces. These devices have an interface that can be operated remotely, however, they are inconvenient because they vary from device to device. It is necessary to enable seamless operation. The voice operation method is a popular solution to solve this problem. However, there are the following problems: The instruction pattern is limited and cannot be used by multiple users at the same time. To solve this problem, this paper proposes a method to identify the location pointed by the user by the orientation of the smartphone. The orientation can be measured with a standard smartphone sensor. This method allows controller integration and simultaneous use by multiple users.

Keywords: pointing, sensing, smartphone, gyro sensor, interactive

Introduction

The number of home appliances are increasing that can be connected to the network because of IoT, and the cooperation with computers has expanded. For example, TVs, air conditioners, lighting, etc. In recent years, devices that allow these computers to be operated by voice have become widespread, e.g. Google Home (https://store.google.com/jp/product/google_home), Amazon Echo (https://www.amazon.com/b/?ie=UTF8&node=9818047011). However, the method of operation by voice is restricted to only performing operations that are easily expressed by voice, it is difficult for many people to simultaneously carry out operations and it is vulnerable to noise.

Another object manipulation method is the pointing operation. Wilson et al. (Wilson & Shafer 2013) proposed a method for measuring the position of a location at which a user is pointing by observing with cameras the infrared light emitted from the device possessed by the user. Seifert et al. (Seifert & Rukzio 2013) proposed a method to determine the position pointed at with a laser beam, to manipulate the object located at that position with a smartphone. However, these methods have problems, such as the need to observe with a camera the terminal position of the light emitted from a device and the use of specialist equipment that are costly when many people wish to use them. To solve the problem, the goal of this study was to realize a pointing operation method that only requires smartphones.

The pointing operation can be used in a greater variety of environments than voice commands. In addition, an implementation that uses only a smartphone achieves low cost and allows simultaneous use by many people. Furthermore, by dynamically changing controller parts such as the buttons displayed on the smartphone, different operations can be realized for each operation target device. So far, we have proposed a method with visual feedback, e.g. mouse cursor (Sato, Kitamura & Matsushita 2018) (see Figure 1) and a method without visual feedback, e.g. operation of home appliances (Sato & Matsushita 2019) (see Figure 1). These methods use same technique, but the effect is not same because we correct behavior based on visual information, the accuracy of operation changes depending on the presence or absence of visual feedback.

(a) With visual feedback (b) Without visual feedback

Figure 1. The proposed method for operating computers by pointing with a smartphone's gyro sensor.

Technical Details

In the proposed method, a virtual two-dimensional orthogonal coordinate system and two reference points on the coordinate system are defined. Then, based on the value of the gyro sensor when the user directs the smartphone to a reference point, the position

pointed to is calculated by linearly converting the value of the gyro sensor. As a matter of caution, here, the proposed method is left-handed, according to the development environment (Processing.org (https://processing.org/)) in which the coordinate system is implemented. That is, when the coordinate plane is viewed from the front, the x-axis is to the right and the y-axis is to the bottom. We use the following expressions for calculation:

$$x = w_1 + \frac{w_2 - w_1}{\dagger_2 - \dagger_1}(\dagger - \dagger_1)$$

$$y = h_1 + \frac{h_2 - h_1}{\beta_2 - \beta_1}(\beta - \beta_1)$$

In this formula, x, y are the x - and y -coordinates of the coordinate system that contains the position pointed to by the user. w_1, h_1 and w_2, and h_2 are the x, y coordinates of the respective reference points. $\dagger_1$, $\dagger_2$ and β_1, and β_2 indicate the $\dagger$, β values of the gyro sensor when pointing to the respective reference points.

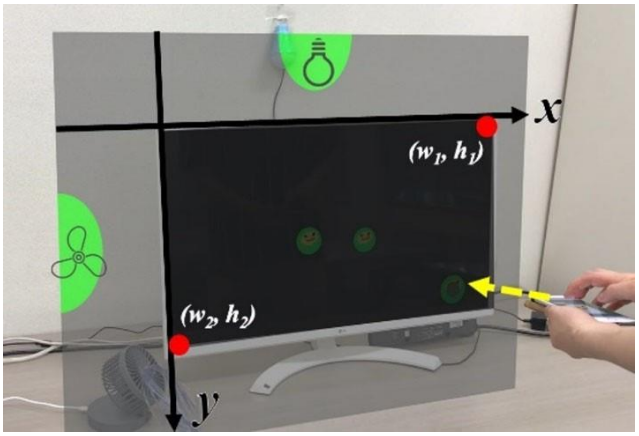


Figure 2. The virtual plane in the proposed method. Red circles represent reference points. Green semicircles represent positions of the fan or light.

The proposed method consists of a relay server, a main system, and an application that operates on a smartphone. The operating procedure of our proposed system is as follows.

(1) Connect the server and the main system application.
(2) Read a QR code using the smartphone. Then, the smartphone-side application and the server are connected.
(3) Point the smartphone to each respective reference point and register by tapping the screen each time.
(4) Point the smartphone as desired by the user.

Since step (1) of the procedure only needs to be performed once by the system installer, subsequent users who perform the pointing can start from step (2). The role of the application that operates on the smartphone is to transmit the value of the gyro sensor, the tap status of the screen, and the information necessary for the operation of the device to the main system via the relay server. The application can also dynamically arrange control buttons on the screen of the smartphone.

Because this application is not complex, it can be used on any smartphone if implemented as a web application. The role of the main system in the proposed method

is to calculate the coordinates pointed to by the user. If the purpose is to operate the cursor, move the cursor to the calculated coordinates, and if the purpose is to operate home appliances, operate the object that at the coordinates. (see Figure 2).

Experiment

We experimented pointing tasks, which is the cases with feedback. To confirm the ease of pointing at an intended region, we conducted an experiment that measured the time taken to click on circles with radii of 20, 50, and 100px on a 800px × times 800px screen. There were 10 targets for each radius. The times improved greatly as the target became larger. When the radius was 20px, the average time was 2275.5ms (the fastest was 1514.4, the slowest was 3872.6); when it was 50px, the time was 1421.7ms (1005.2, 2119.3, ibid); and it was 100px, the time was 1073.8ms (838.4, 1511.4, ibid) (see Figure 3). Given that the participants were using our system for the first time, the results suggest that this system is useful for pointing.

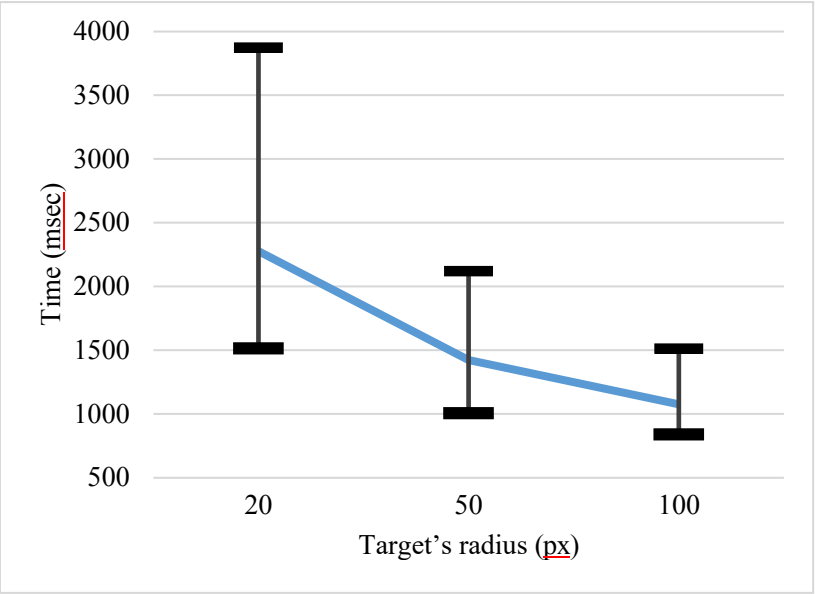
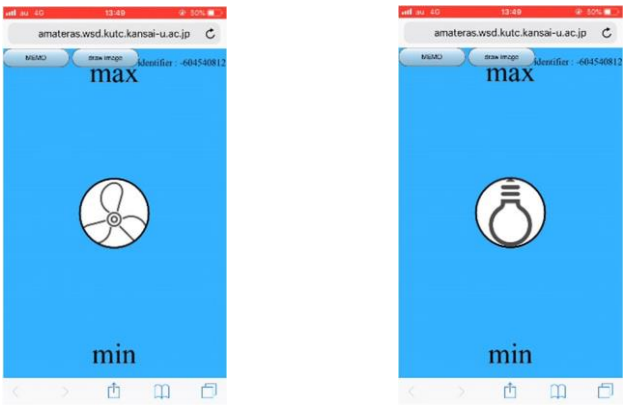


Figure 3. The result of pointing experiment. In this experiment, we measured the time taken to click on circles.

Application

As an example of utilizing the proposed method, we realized three object operations: display, light, and fan. First, on the display, the user can operate the cursor by pointing. In addition, it is also possible to place a picture drawn by hand at the indicated position on the display. If you have a picture drawn by someone on the display, you can place the cursor on the picture and tap the smartphone several times to capture the picture and keep track of your pointer. When the fan or light can be operated by pointing the smartphone to each, an image notifying the user of this is displayed on the screen of the smartphone (see Figure 4). When you tap the smartphone while operating the fan, the fan turns on and the wind blows in the system shown on the display. Point the smartphone at the light and tap to turn on the light. The display also becomes brighter simultaneously.



(a) When facing the fan (b) When facing the light

Figure 4. Interfaces of the application that operates on a smartphone. The operable object is displayed.

Conclusion

We propose a method that involves pointing using a smartphone. Our system can calculate the coordinates that the user is pointing to, so the user can manipulate the actual object. In future work, we plan to conduct experiments to show how much error there is in the action carried out by the user, and to develop a method that can detect locations not only on a plane but also in 3D space.

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