A GUI Movement System by Back-of-Device Interaction for One-Handed Operation on a Large Screen Smartphone

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Abstract
The use of large screen smartphones has been increasing yearly. When people operate smartphones with one hand, several usability problems can occur due to the posture of the user’s hand when holding the device. Among those problems, a significant one we have noticed was that it is difficult to reach the top of the screen with thumb. In this paper, we propose a system to assist the one-handed operation of comparatively large smartphones by pulling down the GUI on the screen by back-of-device operation using one’s finger (excluding the thumb). In this study, we implemented the system with an application for iOS and a sensor module. After this, we conducted an experiment to investigate the performance and effectiveness of this system on usability by comparing it with Apple’s Reachability. Consequently, our system enables the participants to point more rapidly in the upper half area of screen than Reachability. On the other hand, the participants touched slower in the lower half area than Reachability. We will improve the usability of this system by using a pressure-sensitive touch panel instead of a photo-reflective sensor.

Keywords: user-interface, smartphone, back-of-device

1 Introduction
The size of smartphones screens have been increasing since smartphones were first introduced. Large screen have some advantages in legibility for instance, by displaying characters and images larger. Whereas in terms of usability for users having relatively small hands, a large screen has the disadvantage that when they hold and operate smartphone with one hand, the area their thumb can reach is limited. There is ample research and several examples that assist one-handed operation of a large screen smartphone using the front touchscreen [1][6]. In these ways, a thumb is the only digit used in almost all operation. Based on this, we assume that using the fingers other than the thumb in the area except the front touchscreen is an effective way to improve one-handed operation. This is, as it were, role-sharing of the fingers. In this paper, we introduce a back-of-device (BoD) interaction system that enables users to reach and tap the whole of the screen easily, enhancing usability of a large smartphone during one-handed operation.

2 Prototype system
Figure 3 shows the system flow of our system. As a solution to the unreachable area problem, we used a method that moves the GUI in the thumb’s unreachable area downward and enables the user to touch them within the reachable area. We implemented a prototype for iPhone6, which consists of a sensor module and a smartphone running our application (Figure 1). The sensor module is consisted of a photo-reflective sensor (ROAM Corp.’s RPR-220) and BLE module (ASAKUSAGIKEN Corp.’s BLEserial2). Due to the characteristic of the photo-reflective sensor, we captured the data of an absolute distance from the sensor to the index finger.

Figure 1: Moving of index finger on back of the device (left) and the GUI on the front screen (right).

3 Performance evaluation experiment
Experiment
We conducted an experiment to investigate the operational
performance of this system. Nine participants (five males and four females, aged 22-35) took part in this experiment. This experiment consisted of performance check tests and a questionnaire about using a smartphone on a daily basis. In the tests, we asked participants to do a simple pointing task and recorded the time taken and accuracy rate. In addition, to compare the performance of our system and Apple’s Reachability, we asked participants to do the same content and the same amount of tasks using both of the two systems.

Result and discussion
Some of the participants used their left hand to do the tasks. Therefore, we flipped the data of the participants horizontally. Figure 2 shows the average pointing time and error rate with the depth of a color per cell on the screen. In the figure of the pointing time, the average pointing time is longer, the darker the color. We numbered each cells filled on the screen as in the left of Figure 2. In the figure of the error rate, the rate is higher for the darker the color it is. The average pointing time for all cells on the whole screen (cell IDs 1-112) using our system is 1188.28 milliseconds (SD = 259.83), and that using Reachability is 1114.41 milliseconds (SD = 167.07). Similarly, in the upper half part of the screen (cell IDs 1-56), the average pointing time using ours is 1408.67 milliseconds (SD = 320.00) and for using Reachability is 1529.13 milliseconds (SD = 235.71). In the lower half part (cell IDs 56-112), using ours is 975.62 milliseconds (SD = 282.43) and using Reachability is 714.25 milliseconds (SD = 114.60).

From the result comparing these two systems in the upper area and the lower area, our system is demonstrated to be more effective in the upper half area of the screen than Reachability. However, in the lower area, Reachability is estimated to be more effective. One reason for this result is that the posture of their hand while they touch the target appearing in lower area was difficult. As mentioned in the experiment category, our prototype did not have the function switching this interaction between ON and OFF. Therefore when they touched the target appearing nearby the lower edge, they should move their index finger up on the back of device to pull up the GUI. In Figure 2, a rightmost line of both the pointing time and the error rate has particularly dark color on either case using either our system or Reachability. From this, it can be determined that this was the hardest area for the participants to operate speedily and accurately.

4 Conclusion and Future work
The first point is that in the upper half area on the screen, there is a possibility that this system allows users to reach more rapidly with their thumb than Reachability. However, in the lower half part of screen, we left some problems with this prototype. Secondly, the area unreachable with the thumb is not only the area near by the top of the screen but also the right and left edge of the screen. Additionally, the result in the questionnaire we carried out at the same time as the experiment, all the participants answered the function moving the GUI horizontally may effective.

As immediate future work, we will implement another prototype using a touch panel in order to control the moving and stopping more easily, and will also add a function to move the GUI horizontally.

References