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Novel tap operation on capacitive touch screen for people with visual impairment

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Abstract

We propose a novel tap method for a capacitive touch screen, which is called inverse tap (iTap). Because this is operated as follows: a finger is removed from a screen first, and then put on it, different from normal tap. It enables the people with visual impairment to find a braille on a touch screen and operate a button, after remembering a button and a function layout. It also enables drivers to operate a car audio and an A/C through a touch screen instrument panel after a quick look at it while driving when they can not close watch on it.

CCS Concepts

• ***Human-centered computing*** → ***Human computer interaction (HCI);***

1. Introduction

There are two types of touch detection on a touch screen, pressure sensitive and capacitive types. There is also a 3D Touch function, which is installed on the Apple iPhone6s to iPhoneXS. A PC and a cell phone always have physical buttons such as a keyboard and a call button, but a touch screen device usually does not. However, if you move your finger to find the place you want to tap while touching a screen, it must be recognized as swipe. It means it is difficult to operate through a capacitive touch screen without seeing and just after a quick look at the screen. Note that, pressure sensitive screen devices and 3D Touch applications can allow these operations. Of course, research and development for the people with visual impairment are also performed (e.g. [LMH18], [WWJ*09]), however a simple capacitive touch screen device has already become popular as a smartphone, and also a car instrument panel. In this paper, we propose a novel tap method for a capacitive touch screen, which is called inverse tap (iTap). For this, a finger is removed from the screen first, and then put back on it, different from a normal tap. This enables the people with visual impairment to find and operate a button on a touch screen, after remembering a button and a function layout. Of course, it may be necessary for sound and vibration feedback to be provided to notify completion of the operation. In addition, this process would also enable drivers to operate a car audio and an air conditioner through a touch screen instrument panel after a quick look at it while driving when they can not close watch on it.

2. New tap

First, some physical objects like braille are placed on a touch screen, and normal tap and swipe operations are disabled. When

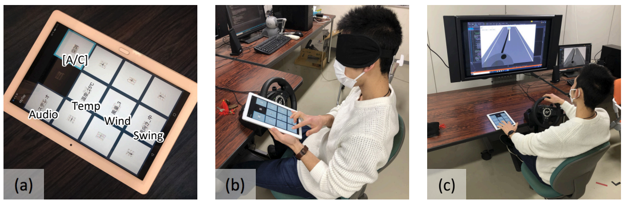

Figure 1: *Novel iTap: (a) An experiment application, (b) Appearance of an experiment, (c) Next experiment in progress.*

the following operations are performed, they are judged as iTap operations.

1. Touch a screen with finger(s)
2. Move finger(s) to find a point to operate while touching
3. Release a finger from a screen at the point
4. Touch the same point on a screen within a certain time

Android Studio's onTouchEvent is used to implement this idea. There are several types of events, which are called actions, and the actions can be obtained by getActionMasked().

- ACTION_DOWN: one touch when there is no prior touch
- ACTION_UP: no touch after one touch
- ACTION_POINTER_DOWN: add a touch when touch(es)
- ACTION_POINTER_UP: remove a touch when some touches
- ACTION_MOVE: move while touch(es)

Figure 2 shows a flowchart of iTap operation. The process is divided into two parts: a candidate processing part and a final judgment part. Variables u, d in the flowchart are sets of a touch po-

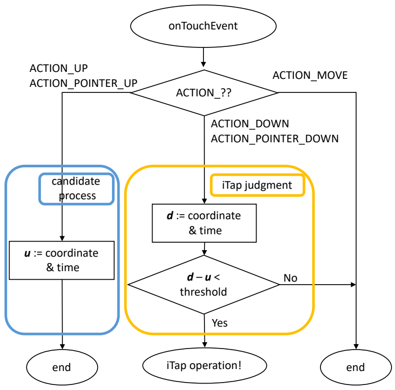

Figure 2: *iTap flowchart*

sition coordinate and time as global variables, and initial values are $-\infty$ (this means x, y coordinates and time are the minimum values in the program). The inequality $(d - u < threshold)$ indicates that the operation is iTap when the distance between the coordinates is less than the threshold value and the difference between the times is less than the threshold value. Operating iTap continuously in a certain time is recognized as a double iTap. Figure 3 shows a flowchart of the double iTap operation. Variable a is a set of a center coordinate between u, d and average time of u, d as global variables, and the initial value is also $-\infty$. The inequality $(average(u, d) - a < threshold)$ indicates whether the operation is double iTap or single iTap.

3. Experiment

First, the screen is divided into 12 button areas by referring to the numeric keypad of a phone and a calculator, and a physical object like braille is pasted on the center of each button so that people with visual impairment can find the button without looking at the screen (Figure 1(a)). When any operation is performed, a vibration notification is also given. In this experiment, it is assumed that in using an audio device a subject selects the desired music, adjusts the volume, and sets the play order for the audio. For an air conditioner controller, it is assumed a subject controls temperature, wind

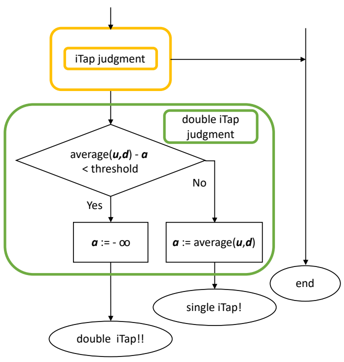

Figure 3: *A part of double iTap flowchart*

Table 1: *Experiment result (times)*

subject	A	B	C	D	E	F	G	H	I	ave.
normal: wrong	0	0	2	6	1	2	4	2	5	2.44
normal: correct	7	7	7	4	4	5	1	7	1	4.78
iTap: wrong	0	0	0	0	0	0	1	2	1	0.44
iTap: correct	11	11	9	10	6	9	5	9	5	8.33

speed, and swing direction. Before starting the experiment, each subject was instructed on how to operate iTap, and a training time was provided to remember the button layout. The subjects were nine Japanese university students who were asked to wear a blindfolds (Figure 1(b)). The experiment procedure for both normal tap and iTap application is as follows:

1. repeat following steps in one minute
   - take an operation task (ex. turn-up volume)
   - execute the task, and report
2. record the number of times of correct and wrong operation

The result of the experiment is shown in Table 1. The average number of wrong iTap operations was about two less than the normal operations. More than half of the subjects did not make any mistakes in iTap operation. The average number of correct iTap operations was more than the normal operations by about 3.5 operations, and tasks were executed earlier in the second half of the iTap experiment. It is suggested that iTap is easier to operate compared to normal tap in a blind situation.

4. Conclusion

In this research, we proposed a novel tap method for people with visual impairment that can be operated without looking at a capacitive touch screen, and we confirmed usefulness of iTap in the experiment. A person can iTap also while supporting their hand by another finger on a screen. In the future, we would also like to consider new operation methods equivalent to swipe and press & hold. We are also progressing an experiment while driving with a quick look at a touch screen instrument panel in a car (Figure 1(c)).

Acknowledgement

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