The Study of Factors Affecting Minimum Center Distance of Mobile Touch Screen

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Abstract. The research takes the key center distance as the object and having a dynamic regulation through operation of performance result and get minimum center distance. Furthermore, the influence factors of the minimum center distance are explored based on the combination of the key speed and the subjective score. The results showed that: (1) the four assignments, discrete thumb, the thumb series, discrete index thumb and index series, have the minimum center distance that severally are: 4.17 mm, 6.30 mm, 3.38 mm and 5.40 mm. (2) The two factors of task type and operation finger have influence on minimum center distance. The results of this experiment can provide a scientific basis for the small key in touch screen and standardized design of the layout.

Keywords: Touch screen · Center distance

1 Introduction

With the development and popularization of smart phone more and more application transferred into mobile phone from computer in the field of social networking, such as shopping and so on. However, compared with the traditional computer screen, touch screen of mobile phone intelligent interactive space is much smaller. It's inevitable to rise new problem in operation between the rich content and the limited space, such as malfunction, low incoming efficiency (Wang Haiyan 2012). To this end, researchers have done a lot of research on the touch screen interaction problems, such as the influence factors of touch screen performance.

Related research has mainly focused on the impact of the size of key and the key spacing on the performance of the operation. For example, Parhi et al. (2006) used single click on the target (discrete) and serial click on the target (continuous), these two tasks were had a systematic research on the best mobile handheld touch key target size equipment under the single hand thumb operation. The result shows that subjects of the task completion time will reduce with the increase of the size of the object.

When the target is higher than a certain size (the size of discrete click operation button is 9.6 mm, the size of continuous click operation is 7.7 mm), it has no significant difference between various size level of click operation error. Key spacing refers to the distance between the two button edge that is another important design parameter frequently combined in size of the key. Zhang Wenlin (2011) recorded touch point offset,

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error rate and subjective assessment of the tested finger under the condition of in 3 key dimensions (4, 6 and 8 mm) and 3 kinds of spacing (0, 1 and 2 mm) using the thumb click task operation. The result shows that the size of the button has a significant impact on click operation drop point offset of click operation and error rate.

When the target size is larger, the placement of the offset and the error rate is lower. Besides, the effect of key space on performance is affected by the size of the button, when the key size is less than 6 mm, it should reduce the key space as much as possible to improve the operation correctness. Otherwise, the key space should be relaxed as much as possible.

Previous studies have verified that the size of key and the key space have a significant impact on the clicking operating performance of the touch screen. The larger the size of the target or the key space, the better the performance of the operation and the satisfaction of the subjective experience. However, further analysis shows that the existing studies have the following deficiencies. First of all, the key size and key space are independent research objects but they have reciprocal effect on both the spatial design and task performance in past study. Secondly, the best key is explored mainly through the control of fixed key size (key space level) and size he present study mainly through the control of a plurality of/key space level and click on the performance results of comprehensive comparison in each level. But these results can be different due to the different size of the variation level which leads to the instability results. Finally, the thumb was mostly used at click task operation in past research (Zhang Wenlin 2011; Park and Han 2010). The index finger is also used in the operation of finger except thumb in actual operation. In addition, although the clicking operation is the most basic operation mode and the actual operation is more complex, such as continuous digital input, text input, etc.

2 Experiment

2.1 Objective

This study will use the key center distance in touch screen as the research object through the operation of performance results to dynamically adjust the level of the center distance. Accomplish the operation of performance and subjective assessment results according to the thumb discrete, index finger discrete, thumb series and index series these four typical scenes.

2.2 Research Method

Subject. It have 31 internal students in the experiment (male: 16, female: 15) and they are all handedness who are at the age between 19–29 with normal vision and are able to use the mobile phone for the key operation. 14 of them had the experience of touch screen operation.

Experimental Equipment and Procedures. The experiment has four mobile phone running prototype test program, four mobile phone screen that have capacitive touch screen. The size of the screen is the representative in current market (mainly represents

the prophase research on Hangzhou mobile phone stores based on specific parameters). Details are in Table 1.

Table 1. Phone parameters

Model	Size (inch)	Resolution (pix)	Length width (mm)
SE LT18i	4.2	480 * 854	93 * 52
SE X10i	4	480 * 854	89 * 50
HTC G13	3.7	480 * 800	82 * 49
SamsungI9000	4	480 * 800	87 * 52

In this study, the prototype program is composited by the C# language button test program which can be run under the Android system. The program interface mainly includes task prompt area and key operation area and shows in the Table 1.

The contents of the task prompt area will present the corresponding operation based on different types of tasks.

The length and width of keys in the operating area are equal. The distance between keys is 0 pixels. Every key center distance adjustment is according to the results of task completion rate after accomplished key task as the red line represents the distance between the two key centers that shown in Fig. 1. The initial parameters involved are converted to the corresponding pixel values, in order to maintain consistency between the various mobile phones.

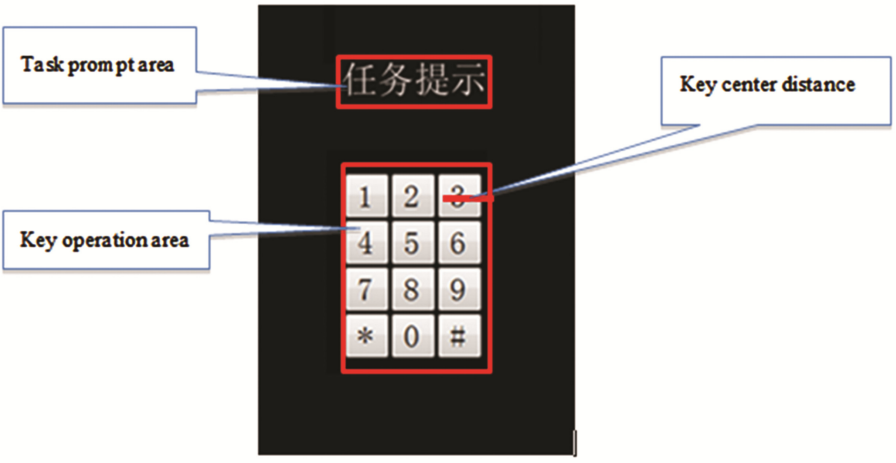

Fig. 1. Key test program of schematic diagram.

Experimental Variable and Design. The independent variables are operating finger and task type. Operating finger includes thumb and index finger of tested handedness. Task types include discrete tasks and a series of tasks. Four kinds of typical tasks are composed by two variables, which is the thumb discrete, thumb series, index discrete

and index series. The subjects are designed in the experiment. It means all the subjects are required to through task operation under these four scenarios.

The dependent variable includes task completion rate in different center distance and the current subjective evaluation scores, it recorded automatically by the prototype program. The task completion rate refers to the percentage of correct responses to the 20 key tasks in each center distance. Subjective evaluation score refers to the key comfortable score to each center distance (Grade 5 score, 1 point means not satisfied, 5 points means very satisfied). Previous studies have found that the best key size is about 10 mm (Parhi et al. 2006). So the initial center distance of this study is set to 10 mm. The experimental implementation is adjusted by binary method according to every 20 task performance results in the center distance. The specific methods are as follows.

Take the current center for 10 mm at the first task operation, when task correct rate >=90% after the 20 consecutive tasks operation, the next operation of the center distance adjust to the center point of 5 mm 0 and 10 mm, otherwise, it should adjust to 12.5 mm which is the center point 10 mm and 15 mm. Repeated cycle test until the correct rate of <90% when passing a center distance and stop the task when two consecutive central distance of the correct rate of operation is >=90%. Finally, the linear interpolation method is used to find the center distance of the 90% corresponding.

Experimental Task. Under the condition of the designated center distance, the subjects touched by thumb and index finger for 20 times in consecutive. This operation includes discrete tasks and series of tasks of the two tasks.

The discrete task requires subjects to continuously press the corresponding key quickly and accurately with using the pulp of thumb and index finger according to the procedures task were presented randomly in the mission area (for example: “1” content of the task is single digits or symbols).

Series tasks requires subjects to successively press the corresponding key quickly and accurately with using the pulp of thumb and index finger according to the procedures task were presented in the mission area t (for example: “246#” means the content of the task is 4 digit or character combination).

The maximum reminded duration time for discrete tasks is 3 s and 12 s respectively. The interval time of these two tasks are fixed for 2 s. The task failed when the task failed to complete the corresponding key operation according to the task instructions in the task display time.

Experimental Procedure. Before the experiment, the subjects signed the Agreement and the Statement and the User Background Questionnaire. The experimenter read the experimental guide language to the subjects and open test program with clicking “practice experience” after the subjects understood the instructions. The subjects did two tasks of the practice for 3 times respectively. In the formal experiment, the experimenter fills the experimental parameters. The subjects continuous operate for 20 times in the specified key center distance. The subjects give a comfort evaluation about the key, after the completion of the operation and adjust the center distance according to the correct result rate of the operation. Repeat until the completion of all tasks. After the completion of all tasks, the subjects signed the registration form then receive remuneration.

In the progress of the experiment, the subjects used their handedness to hold the mobile phone and keep doing single hand operation. In order to balance the influence of each level, the task type and the operation order of the fingers are using ABBA balance technique.

The experimental results were processed by the SPSS17.0 software package. The three data, outside of standard deviations (about 3.2%), were respectively disposal which used in the thumb and index finger discrete tasks. The data, a series of center distance, the corresponding task completion rate, and the subjective evaluation score, is obtained after each test in the experiment. We use linear interpolation method to convert the data into the corresponding subjective evaluation score the minimum effective center distance. The main methods are as follows.

First of all, make the center distance as the abscissa, the 20 task to operate the correct rate as the ordinate, draw a broken line. As it shows in Table 2, to determine a point which correct rate is less than 90% and is the minimum distance of center after passing the first turning point, solid circles such as the (42,80%) and (43100%) in the dotted circle. The 90% corresponding of maximum center distance is acquired according to linear interpolation method: the formula $(y - y0)/(x - x0) = (y1 - y0)/(x1 - x0)$.

Table 2. Results of mean value, standard deviation of the minimum center distance (M+SD) and other targets under the condition of four tasks

	Thumb		Index finger	
	Discrete	Series	Discrete	Series
Minimum center distance (mm)	4.17 (1.25)	6.30 (1.29)	3.38 (0.59)	5.40 (1.32)
Operating evaluation score (1–5)	2.7 (0.87)	3.4 (0.75)	2.4 (0.95)	3.2 (0.79)

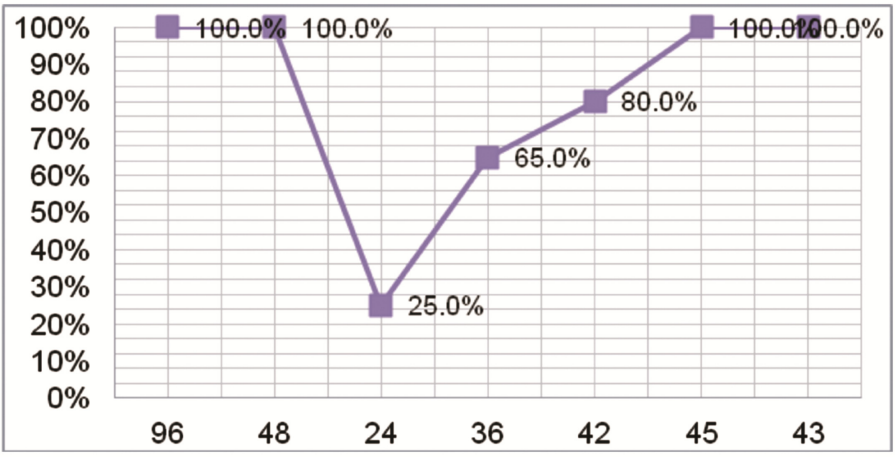

Fig. 2. Schematic diagram of minimum effective center distance

42.5 pixels of minimum center distance is based on the method above, and the mean value of the center corresponding to 42 and the 43 pixels is the current minimum center distance score (Fig. 2).

After the analysis above, we got minimum of center distance of four task scenarios (thumb discrete, index finger discrete, thumb series and the Index finger Series) according to the conversion rate of mobile phone pixel by pixel unit will center distance into mm. We got score data of the operation experience the mean and standard deviation of the results that are shown in Table 2.

3 Result

3.1 Minimum Center Distance

As it shown in Table 2, the results of the meaning value minimum center distance in 90% task completion rate is the index finger discrete (3.38 mm), thumb discrete (4.17 mm), index series (5.40 mm), and thumb series (6.30 mm). The analysis to the repeating method of minimum center distance of 2 (operation finger) *2 (task type) shows the nearly remarkable result: $F(1.30) = 17.58$, $p < .01$, $\eta 2 = 0.37$. The result shows that the minimum center distance required by thumb operation is significantly larger than the center distance required by the index finger operation. The main effect of type is significant: $F(1.30) = 206.92$, $p < .01$, $\eta 2 = 0.873$. It shows that the minimum center distance required by series of mission operations was significantly greater than that discrete tasks required from center distance. There was no significant interaction between finger and task type ($p > .05$).

3.2 Subjective Evaluation Score

It can be seen from Table 2 that the mean scores subjective feeling of the minimum key center under four kinds of task scenarios from high to low can be arranged as the thumb series (3.4), index finger series (3.2), thumb discrete (2.7) and index finger discrete (2.4).

The analysis of variance of repeated measurement on the subjective score were 2 (operation finger) *2 (task type), the main effect of finger operation is nearly significant, $F(1.30) = 3.97$, $p = 0.056$, $\eta 2 = 0.117$. It shows that the subjective feelings task operation with thumb of the subjects is better than the subjective feelings in the discrete task. The main effect of the task type is significant, $F(1.30) = 31.84$, $p < .01$, $\eta 2 = 0.515$. It shows that the subjective feeling of subjects in a series of task operation is better than it in the discrete tasks. There was no significant interaction between finger and task type ($p > .05$).

4 Conclusion

From the results above we can draw these conclusions:

The minimum of the key center distance results under the four task scenes, index finger discrete (3.38 mm), thumb discrete (4.17 mm), index series (5.40 mm) and the index finger series (6.30 mm) can be used as design basis when doing the design of

operation key which use the small capacitive touch screen as the representing. But the specific design should be based on these parameters. Should enlarge the distance between the center of the button as much as possible, to ensure that the user's higher subjective experience.

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