

Android User Interface Analysis with Ergonomic and Quantitative method

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ABSTRACT

Background: Poorly designed mobile interface induces user's inconvenience. Therefore, it is important to understand user behaviors; how they touch or using the mobile phone screen. **Objective:** The purpose of this research is to analyze the physical characteristics of Korean users in terms of touching the mobile phone screen and to identify the area that can be touched easily(at ease). In addition the easily touchable area of the mobile screens is verified by comparing them with the actual app arrangement of mobile phone users in order to confirm that the area is frequently utilized on the mobile screens of users. **Method:** For the ergonomic analysis, the hand anthropometry data of 300 subjects was referred, and 112 participants who are using android phones participated in a survey and provided the image of their phone screen. As a result, the specific area, which can be touched easily without additional changes in holding postures, is visualized. **Results:** According to the result of ergonomic analysis, the number of apps which 5th percentile female could touch at ease is only 30% of 95th percentile male could. Kakaotalk app (free messaging app) was the most frequently used app for smartphone users (63.3%) and it is mostly placed in the easily touchable area which is visualized by heat map analysis. The location of preferred apps respect to the function of apps was also analyzed by the quantitative method. **Conclusion:** The result of this study could be applied to various industries such as interface design, mobile phone dimension, and phone accessories.

Keywords – Android interface, Ergonomic, mobile phone

1. Introduction

Recently, many companies have attempted to dominate the mobile platform via the launcher [1]. Unlike the iOS of Apple which is closed-source operating system, the Android is an open-source operating system; designed to be developed by anyone. Due to such characteristic, there are already dozens of launchers in Google play store developed by various developers. Facebook has launched a "Facebook Home" in April this year, however, the user satisfaction was poor. The main cause of such dissatisfaction is that the launcher was made without the consideration of users' usage patterns and mobile phone interface. Although many people use Facebook, Facebook is not the only app the users use[2]. Furthermore, the main function of the smartphone is calling, so that the calling function

should be prioritized, however, the Facebook home no longer allows users to call at the first depth of the screen. Frequently used menus were also located in the upper position of the screen. This might lead users into the inconvenience. Thus, it is a very urgent demarche to identify how users touch their phone and understand how they use their mobile screens because poorly designed interface induce user's inconvenience. Previous studies also identified such importance and studied this field. However, empirical studies related to the launcher has been conducted rarely [3]. Krüger and Böhrer reported that there is a certain pattern on the placement of the icons or apps by smartphone. First, users apt to arrange frequently used icons preferentially. Second, smart phone users have the tendency to make groups by using icons or apps that seem to be similar [4]. Neil reported that the more apps that are installed on smart phones screen, the more time and effort is needed to navigate. It became difficult to look for apps [5].

Kuflik et al have conducted research on the ways user's group apps with similar functions to improve the accessibility of the required apps [6]. Karlson et al reported that people prefer to operate smartphone with a single hand than by using both hands. In his research, he reported that people feel satisfaction by setting one hand free. He also found that there is an area so-called, "sweet spot" at which people can touch with high accuracy and easiness [7-9]. Previous studies analyzed the arrangement of the smartphone apps under the perspectives of behavioral science, or ergonomics. However, the usage behavior of users for specific launcher was hardly considered. Therefore, through this study, we collected 44 launcher screen and performed the survey to identify the usage pattern of smartphone users. In this study, we aim to present usage pattern for the smart phone development. Previous studies only focused on the western mobile phone users, and there was a limitation to verify how users utilize sweet spot (easily touchable area) on their screens. Therefore, in this study, we aim to analyze the physical characteristics of Korean users in touching their mobile screen and their sweet spots to be identified. Then, the spot will be verified by comparison for the actual app arrangement of mobile phone users in order to confirm that the area certainly is frequently used in users screen.

2. Method

The flow of this study is as follows. i) anthropometric dimension data of Korean people was utilized to identify the sweet spot for the phone screen touch ii) The spot was compared with actual app arrangement locations in order to verify its validity.

2.1 Ergonomic analysis with hand anthropometry

Most of the mobile phone users use the one hand or both hands when they grip their mobile phone. Thus, it is important to identify the anthropometric dimension associated with the hand in order to find area that can be touched easily. According to the result of expert interview, the length of thumb and thumb proximal phalange were determined to be important dimensions. 300 subject's hand anthropometry data from the Size Korea project data (National body dimension measurement) was utilized (Table 1). The length of the thumb was defined by the distance from the proximal flexion crease of thumb to the tip of the thumb, and the length of the thumb proximal phalange was defined by the distance from the proximal

interphalangeal joint crease to metacarpophalangeal joint crease of thumb (Figure 1). To identify how the users grip their mobile phones, pictures of 50 users' grip posture (one hand and both hand) were taken. When they grip their phone with one hand, the posture with the lower right corner of the mobile phone contacting the adductor pollicis of right hand while touching screen by thumb, was the most frequent (62%). In case of both hand usage, the posture with the lower corner of the phone contacting the adductor pollicis of right and left hand was most common(68%). Thus, these common posture was used for ergonomic analysis.

2.2 User survey

Total of 112 participants using android phones and living in Seoul metropolitan area joined the survey. The age of participant varied from 15 to 55 years old. For convenience of the smartphone launcher users, the survey was conducted via a mobile Web pages. Prior to the survey, a full explanation of the launcher and purpose of the study was provided to the participants. Questions about usage pattern and frequently used apps were asked. Lastly, we asked the participants to upload a file of a captured screenshot of their home screen currently in use, then we analyzed them with quantitative method.

2.3 Heat map analysis

The area where it is expected for users to touch at ease was verified in order to understand whether the area is frequently used in actual users screen or not, by conducting heat map analysis. Android launcher is composed of 4x4 matrix, so we created a matrix of 20x20 for mapping the screenshots provided by the users. Then we checked the frequency binomially: 0 or 1. If the application is located on the coordinate of 20x20 dimension, the certain coordinate was counted as 1, otherwise 0. With the help of this method, we could identified where new apps are disposed on users screen. Microsoft Excel 2013 was used to create the heat map.

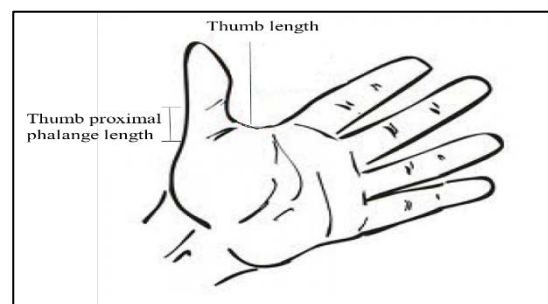


Figure 1 Hand dimensions for ergonomic analysis

3. Results

3.1 Ergonomic analysis

The thumb-related dimensions derived from hand anthropometry data are listed in the following table. In the length of thumb and thumb phalange, the male's length was statistically and significantly greater than female's length. The length of the thumb was 67.4mm for 95th percentile male and 53.7mm for 5th percentile male. In case of female, it was 67.4mm and 50.6mm respectively.

Table 1. Anthropometric dimension for Korean users (in mm)

Gender	Percentile	TL ^a	TPL ^b
Male	5	53.7	23.5
	95	67.4	34.8
Female	5	50.6	23.0
	95	61.6	32.0
Pooled	5	51.1	23.2
	95	66.0	34.3

^aTL : Thumb length, ^bTPL : Thumb proximal phalange length

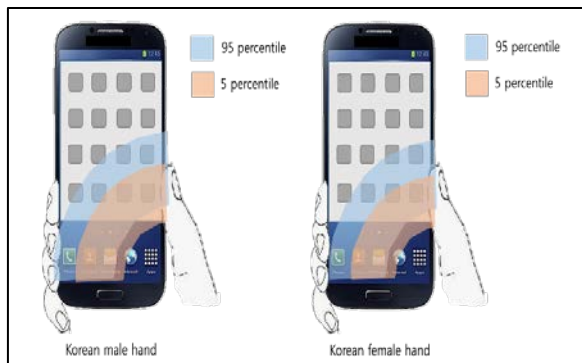


Figure 2. Easily touchable area for Korean users

In order to investigate the sweet spot of Korean population, the dimension criteria of mobile phone refers to the one of the most prevalently used phone in Korea, Samsung Galaxy S3, while the hand dimensions utilize the Korean hand anthropometric dimensions from Size Korea.

(Among the touchable area for thumb, the lower part of the first interphalangeal joint is excluded because the joint should be bended more than 90 degrees (flexion) for thumb to reach the area, which could lead to muscle fatigue). Blue-shade area is a touchable area for 95th percentile users for male and female populations. In case of 95th percentile male, it was found that they

could touch seven apps and dock bar button without changing grip posture when they grip the phone with one hand (Figure 2). On the other hand, in case of female 5th percentile, it seems that they can touch only two apps and some of dock bar icons without changing the grip and they are unable to launch the calling app which is located in the most left side by one hand grip.

3.2 Usage pattern analysis

112 people of 2:1 male to female ratio responded to the questionnaires. The range of ages are 20's (44.9%), 30's (44.9%), 40's (6.1%) and 50's (4.1 %). The ratio of 20's and 30's were high because they are the primary smartphone users. Participant's occupation ratio was followed: office workers (49.0%), housewives (38.8%), students (8.2 %), and others (4.1 %). The distribution of the duration of smartphone usage varies also. 21 of 50 people (41.8%) used their smartphone for less than a year, 3 people used theirs for 1-2 years (6.0 %), and 19 people (38.9%) used theirs more than three years.

Kakaotalk app (free messaging app) was most frequently used the app for smartphone users (63.3%), Facebook followed the next (14.3%). The widget has the advantage that it is executed in a specific position on launcher pages, thus it can be utilized quickly. Users had a mean 1.98 widgets (SD=1.34). The most frequently used widget was the scheduler (25%), followed by weather (17.1%), music player (15%) and Notepad (9.2%) widgets. Most users (71.4%) changed their wallpapers on the screen. Among them, 34.3% of the people use their wallpaper in landscape orientation, and 40% of the people used in portrait. In addition, users using portrait wallpapers had the tendency to place apps in the corner of the screen because they don't want their portraits to be hidden. In order to avoid the inconvenience of unintended app launch and security of personal information, user uses lock screen functions on their mobile phones (87.8%). The lock screen functions are either pattern lock (after you touch a particular pattern, the lock is released), password lock (specific password input), screen lock (sliding gesture on arbitrary screen estate or sliding a specific icon), face lock (face recognition), or recently popular fingerprint scanning types. According to the questionnaire survey, 40.8% of people prefer screen lock and 34.7% of people use pattern

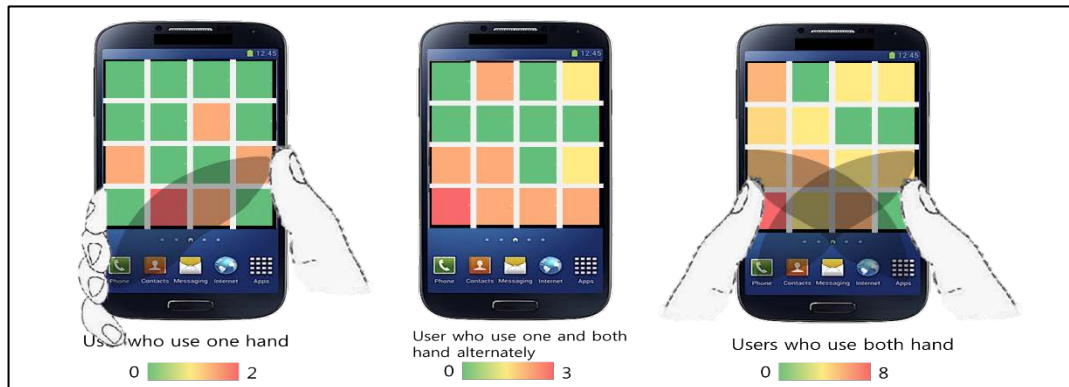


Figure 3. Location of frequently used apps in home screen

lock. The use of the method to unlock did not show statistically significant difference upon their age and genders. Users had 1.61 folders in average ($SD=3.09$) on their launcher screen, while the minimum number of folders was 0 and the maximum number of folders was 16.

3.3 heat map analysis

3.3.1 Arrangement tendency of frequently used apps

Kakaotalk (free messaging app) is the most frequently used app for the Korean smartphone users (63.3%), while Facebook followed (14.3%) as the second. The tendency of placements for the most habitually used apps varies upon the grip posture of mobile users. In case of one hand grip, the most frequently used apps were usually located on the lower center of the screen (Figure 3). On the other hand, in case of using both hand, the apps were usually located on the lower left corner of lower center of the screen.

Thus, it seems that users prefer to locate frequently used apps around a specific area (home button, the lower-left corner of the screen, lower right, right-center) to facilitate their touching action effortlessly. This tendency was consistent with the results of ergonomic analysis.

3.3.2 Arrangement of each type of application

It was possible to investigate that the desired app allocation varies depending on the nature of the application (Figure 4). As a result of the heat map analysis, SNS apps are placed more preferably at the upper left to the lower right corners. The traffic-related apps (such as notification of subway lines and buses) are located more on the lower left side. The financial apps (Internet banking, smart wallet) are located in the lower left or top center positions. In many cases, the portal apps such as Naver or Google were placed at the lower left corner. The camera apps showed a tendency to be located in the lower left position as well. Finally, in the case of the multimedia apps, they tend to be located on the right side of the screen in many cases.

IV. Discussion

Throughout this study, the easily touchable area, also known as sweet spot, for Korean people was derived by ergonomic analysis and the frequently used apps of Koreans were identified via a user survey. It was also confirmed that how users allocate and arrange their apps on mobile screens along with their personalization tendencies through analyzing the screen shots of mobile phones which users provided. According to the ergonomic analysis, it was noticeable that the number of apps which 5th percentile female could touch is merely 30% of what the 95th percentile male could. Therefore, when designing a mobile phone interface icons, the icons or buttons - which should be touched frequently, need to be located on the sweet spot, the easily touchable area (common part of the 5th percentile and the 95 percentile users touchable area) for users with various lengths of thumbs.

In this study, using a heat map, we analyzed where the users place their apps via a quantitative method. In case of the right handed users, the frequently used the app are mostly located in the lower center. This tendency was consistent with ergonomic analysis of this study, which is also similar to the studies of Kromer and Bomber. They reported that the users place significant icons in the lower part of the screen. Respect to Karson's study [7-9], he reported that users can touch the central portion of the screen easily with minimal errors. So, we expected many users to place their frequently used apps on the spot. Although Karson's results were confirmed in Shin's or Fukazawa's results that more important icon is placed in the center and arranged in the bottom right order from the top left, users' favorite icons from this study was not in the center; the favorite icon allocations in this study disagreed their result. Frequently used apps or icons were mainly placed in the lower center and the left side of the screen in particular. The reason why the users placed in this way may be affected by ergonomic

convenience. Hence, it is determined to be located on the lower center



Figure 4. Location of preferred apps according to function

of the screen. Moreover, the frequently used apps seemed to be arranged on the left side, possibly due to the easier noticeability in case of new notifications on left side when considering the gaze path of the users.

Many of the users have their wallpaper, especially family photos, in landscape orientation so they place important or frequently used icons at the edge or corner of their mobile screens in order to maximize the full view of the landscape image. In Karson's research, the left and right corners of the screens were classified as the place where it is hard to touch and causes errors. However, many users placed their favorite apps in the corner of their screens for customization of their mobile screens. The camera apps unveiled their tendency to be located in a particular spot. It was possible to grasp that many users place camera apps on the lower left part of the screen. This case may be related to the function of the camera apps. The camera apps are operated by one hand to take self-shooting. Moreover, in the case of multimedia apps, they tended to be located on the right side in many cases, because flicking to move from the NW to SE with one hand is more challenging than flicking operation from NE to SW. Thereby, users

seemed to consider various factors such as functionality of apps, ease of touch, and effect of wallpaper when they decide the position for their apps or interface customization.

V. CONCLUSION

In this study, through the ergonomic and quantitative method, we investigated where the easily touchable area - sweet spot, is for one hand and two hand grips. The sweet spots were found to be frequently used by comparing them with the heat map analysis from user's actual apps arrangement on their screen. It was also confirmed that user consider various aspects such as ergonomic convenience, functionalities of apps, and influence on the wallpaper when allocating their apps. By considering the sweet spots for Korean population, this result could be applied to various industries such as app designs, mobile phone dimensions, and furthermore phone accessories. For mobile phone developers, when designing the user interface of mobile phone, the sweet spot needs to be considered for the convenience of their users. For example, frequently used buttons such as

shutter of camera apps need to be located within the sweet spot for sweeter selfies.

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