Thumb Reach of Indonesian Young Adult When Interacting with Touchscreen of Single-Handed Device: A Preliminary Study

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Abstract. This study is a preliminary survey on thumb reach of Indonesian population when interacting with single-handed device. This study was aimed to know the thumb reach envelope on the screen of mobile phone. The correlation between the thumb reach vs. the hand length and thumb length was also identified. Thirty young adults participated in the study. All participants had normal body stature and were right-handed person. In the observational phase, the participant was asked to colour the canvas area on the screen of the mobile phone by using his/her thumb. The participant had to complete the task by applying the single hand interaction. The participant should grab the mobile phone as he/she use it normally in his/ her daily activities. The thumb reach envelope of participants was identified from the coloured area of the canvas. The results of this study found that participants with a large hand length and thumb length tend to have a large thumb reach. The results of this study also show the thumb reach area of the participants is forming an elliptical shape that runs from the northeast to southwest on the device screen.

1. Introduction

Nowadays we can find people use mobile device everywhere. It is easy to find people interact with their mobile device on the bus, train, and other public transportation. They use the mobile device while sitting, standing, and walking. Few studies found people grasp their mobile device in many postures, such as: single hand, two hands, and in cradle mode [1, 2, 3]. Another survey found people use their mobile device in a flat or tilt position on a table, especially if they are interacting with tablets [4].

Few observations found people can easily change their ways in interacting with the mobile device from one posture to another one very often. It is easy to find individuals using one hand at an initial time, and then using their other hand, then moving to cradle posture, and then going back to the initial posture [2]. Another study observed the use of two thumbs, one thumb and one finger found that all participants used at least two methods [5]. Overall, those observations also obtained that most people use their thumbs and index fingers to interact with the screen of their devices [2, 5].

In the survey on the one-hand interaction, few researchers confirmed that people commonly use their thumb to interact with the touchscreen of mobile devices [2, 3]. It seems reasonable since the use of the thumb in one-handed interaction was considered to be more effective than the use of stylus or index finger [6]. People used their thumb in various posture to gain a more accurate touching point on the screen [7]. It is also possible to see that the thumb posture is depend on the position of touching target. Furthermore, a different thumb posture would show a different fingertip contact area size and shape [8].

Survey on the thumb reach performed by Otten et al. [9] seems to be the first effort of functional anthropometry of thumb since commonly many data collections on human body and its specific parts,
included foot, hand, and other parts, were done in a structural state. The methodology developed by Otten et al. [9] can be used as a guideline for collecting the data of thumb reach envelope for a specific application [10]. Besides, the results of Otten et al. [9] study are useful for handheld device designers and engineers.

The current study focused on the measurement of the thumb reach for the mobile phone use since it is one of the mobile device that are largely used by people in whole world now. A recent development of mobile phone showed that its size is larger and larger than it in few years ago. Accordingly, it is easy to find people using a mobile phone that its size is larger than their hand size. A bigger size of mobile phone may be nice in visual aspect, but it is possible to be a problem since the users commonly use it in single-hand posture, especially for users with small hand size. People with a large hand size tend to have larger thumb reach than people with a small hand size [8]. Considering this phenomenon, this study was aimed to identify the thumb reach of Indonesian young adult when interacting with their mobile phone in single hand posture.

2. Materials and Method

Thirty individuals (15 males), aged in the range of 18 and 20 years old, participated in this study. All participants were students of Industrial Engineering Department at the University of Trunojoyo Madura. There are no specific requirements for participants in this study, except they should have a normal body stature and dominantly use their right hand to perform their daily activities.

The data acquisition was done at the Laboratory of Ergonomics and Work System Design, University of Trunojoyo Madura. The procedures were adopted from the study of Umami et al. [11] and Otten et al. [9]. The procedures have been simplified in order that the participants can easily complete the required task. Besides, few equipment was used to collect the required data such as digital scanner and mobile phone.

A Canon LiDE 210 digital scanner was used to capture the participants’ hand image. The hand length and thumb length dimensions were measured from the digital hand images by using an image-based measurement software from the ImageJ (available at http://rsbweb.nih.gov/ij/). Some pertinent measurements on the image saved from the Drau application was also measured by using the software.

A Samsung Galaxy mobile phone was used in the observation. Dimensional specification of the mobile phone was shown in Table 1.

| Dimensional specification of mobile phone used in the observation. |
|---------------------------------------------------------------|
| **Body dimensions**                                           |
| Length : 121.5 mm                                             |
| Width : 63.1 mm                                               |
| Thickness: 10.5 mm                                            |
| **Screen size**                                               |
| Diagonal : 101.6 mm (4 inch)                                  |
| Height : 87 mm                                                 |
| Width : 52.5 mm                                                |
| **Distance between the screen edges and device edges**        |
| Top : 17.75                                                   |
| Bottom : 16.75                                                |
| Right : 5.3 mm                                                |
| Left : 5.3 mm                                                 |

A drawing application, Drau v1.3.5 which is available at Google Play Store™, was installed on the mobile phone. A canvas with 200 cells (20 cells high and 10 cells wide; each cell has 4.35 mm high and 5.25 mm wide) was set up on the display and used to identify the thumb reach (Fig. 1).

In the observational phase, the participant was asked to grab the mobile phone in one hand as he/she normally hold it in their daily use. Then the participant was asked to swipe his/her thumb on the canvas. The participant should keep the position of the mobile phone during he/she was completing the task.
Figure 1. Cells in canvas of Drau application (Reproduced from Umami et al. [11])

Thumb reach envelope is obtained from the area that could be reached by the participants’ thumb on
the screen. The line generated by the participants’ thumb swipe showed the track of contact center
between the thumb and screen. Each cell that was covered by the line of the closed curve drawn by the
participant (based on researcher’s judgment) was included in the individual participant’s thumb reach.
The covered area is classified as the comfortable area. The maximum thumb reach was defined as the
farthest distance that could be comfortably reached by the thumb of participant. The maximum thumb
reach was measured from bottom-right of the mobile phone.

The strength of correlation between the maximum thumb reach and the hand length and thumb length
was determined by using Person’s correlation analysis. The area that could be reached by the participants
was identified by using heat map analysis. The shape of the reachable area was done by inspecting the
heat map visually. The percentage of participants who could comfortably reach an individual area (cell)
on mobile phone the screen was also possible to be represented by different colour on the heat map.

3. Results and Discussion
This study measured the hand length and thumb length participants. The survey found the mean and
standard deviation of the hand length and thumb length of the participants are 169.76 mm (SD = 33.63
mm) and 61.06 mm (SD = 4.24 mm) respectively. The thumb reach measurements found the average of
the participants thumb reach is 56.93 mm (SD = 5.50 mm).

The Pearson’s correlation analysis showed that there is no significant correlation between the
maximum thumb reach vs. the hand length and thumb length. The current study found the coefficient of
correlation are 0.36 and 0.25 respectively (p > 0.05). From these findings, it is hard to say that people
with a larger hand length and thumb length tend to have a larger thumb reach. The results are in
accordance to the conclusions obtained by Kim and Jung’s [12] study, in which they found that the hand
size does not affect the thumb reach. The findings of this study are in contrary to that of Otten et al. [9]
and Umami et al. [11] that clearly concluded the existence of significant, but weak, correlation between
the maximum thumb reach and length of the thumb. Based on the results of the current study and the
selected previous studies, it is possible to summarize that there are few factors affecting the thumb reach
are of the mobile phone users. According to Otten et al. [9], the discrepancy might be caused by few
factors, such as the way participants hold the mobile phone, participant’s experience with touchscreen
device and possibility of misunderstood the instructions during the survey.

A heat map analysis done in this study found the percentage of participants that could comfortably
reach an individual cell on the canvas at the screen (Fig. 2). From Fig. 2, it is possible to see that there
is no participant that could reach all areas on the screen easily. This finding is similar to the finding of
Umami et al. [11] that observed the Portuguese young adults. However, this result shows more cells in
the centre of the screen were easily reached by participants of the current study than those that were
reached by participants of the corresponding study by Umami et al. [11]. It is also possible to state that the result of the current study has a little difference from the study of Otten et al. [9] which found few participants could reach all areas on the screen. The differences may occur due to the differences on the size of the device used in the experiment and the way participants grasping their mobile devices in the observational phase.

![Heat map analysis for the percentage of participants that comfortably reached cells on the screen](image)

**Figure 2.** Heat map analysis for the percentage of participants that comfortably reached cells on the screen

The heat map analysis showed that 80% of the participants can comfortably touch an area between 30.0 and 86.6 mm from the bottom and between 9.7 and 51.7 mm from the right (Fig. 2). From Fig. 2, it is possible to see that the thumb reach area of participants is forming an elliptical shape running from the bottom-left to the top-right of the screen. This result is similar to the finding of Karlson et al. [13], Otten et al. [9] and Umami et al. [11]. This finding is reasonable since the thumb movements along the axis running from northeast (top-right) to southwest (bottom-left) is perceived as easier for the right-handed users than those from northwest (top-left) to southeast (bottom-right) [13]. It should be noted that from the physiological perspective, such movements follow the abduction and adduction [9]. In accordance to Otten et al. [9] and Umami et al. [11], the elliptical shape of the reached area is the easiest area covered by the thumb movement toward and away from the palm.

Overall, the thumb reach of participants in the current study is farther than that of Otten et al.’s study [9] and Umami et al.’s study [11]. Besides, there are also differences in the touchable area between the both studies and the current one.
4. Conclusions
This study is a preliminary survey on the thumb reach envelope of Indonesian population for interaction with single-handed device. The main objective of this study is to identify the thumb reach envelope of Indonesian young adults when using their single-handed device. It was identified that 80% of the participants could comfortably touch an area between 30.0 and 86.6 mm from the bottom and between 9.7 and 51.7 mm from the right edge of the mobile phone. The results of this study also show the thumb reach area of the participants is an elliptical shape that runs from the northeast to southwest on the device screen. The elliptical shape of the reached area indicates the easiest area that can be covered by the thumb movement toward and away from the palm for the right-handed users.

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