Comparative Study on User Preference of Handheld Device based on Grip Types

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ABSTRACT

This study mainly aims to investigate critical factors that enhance usability and propose the preference contour of control location for the handheld device according to the grip posture. To achieve these goals, the grip postures while using the handheld devices were firstly categorized based on representative user activity and product geometry features. As a result, a hierarchical tree of grip posture classification was constructed. Meanwhile, an empirical test was conducted through a series of selection task on the handheld device interface. The grip type (three types of both hands grip), form factor (product width and thickness) and user's hand length were manipulated as an independent variable. The subjective preference score was measured to evaluate the user satisfaction according to different control locations. The results of experiment show that the form factor had a significant effect on user preference. In addition, iso-preference contours employed by Support Vector Machine (SVM) were derived to suggest the preferable control zone. This research will be expected to contribute to practical guidelines for the layout of various functions on a display.

Keywords: Handheld device, Grip posture, Preference contours, ESK-JES Joint Session

1. Introduction

The interactions between display, control and human characteristics have to be considered during product development process. One of the numerous goals of the product designer would be to provide the proper interface for increasing user satisfaction [1]. Unfortunately, in spite of advancement of the manufacturing technology, there are products which have improper interface and are manufactured without the consideration of user-oriented perspectives. The products lacking consideration of user characteristics may have the limitation in the effective use of the products [2].

Recently, the development and prevalence of small size products which are portable and wireless such as mobile phones is considerably remarkable. These products are generally referred to as handheld devices. Handheld means small enough to fit on hand and without a necessary for either power or connectivity [3]. Therefore, handheld devices are extremely portable, self-contained information management and communication device. They are useful for quick access to personal data, usage of multimedia function and lookups of information using the wireless Web.

Meanwhile, the previous studies on usability for small product control mainly focused on hand tools [4, 5]. These studies were carried out to optimize the handle shape, size, anatomical structure of the hand, human capacity and the tasks. Such approaches failed to reflect the characteristics of the handheld devices. Controlling the handheld products is conducted not by hand motion but rather fingertip motion.

Moreover, it is impossible to find optimal control location without consideration on grip activity. Grip posture is an important factor of product design for user satisfaction. In handheld devices such as camcorders or mobile phones, users must perform controlling tasks while maintaining simultaneous grip function [6]. A better understanding is needed on the various factors that may affect the user satisfaction in designing the control interface of handheld product.

Ergonomic features which have to be considered using handheld products are related to hand and finger control strategy, display and control types, grip posture, user's anthropometric data, and so on. The objective of this study is to categorize the grip postures while using the handheld device. Furthermore, preference contour of control location
2. Grip classification

First of all, the classification structure was constructed using the criteria on power and precision grip based on previous study [7]. In addition to these traditional basic criteria, some new criteria were added for the purpose of this research. Thus the control location, using hand (both hands, single hand), and the number of control fingers were selected as the criteria.

A hierarchical tree of grip posture classification for handheld control was developed as shown in Figure 1. With the two basic categories according to the hand role, the taxonomy begins. As one moves down the tree, details of the task, product geometry features related to control were significantly considered. Task requirements and the factors related to control play an important role in the taxonomy. In case of the grip control, Is a product controlled by a single hand or both hands? Do two hands play an actual role or only support in controlling the product? These subsidiary choices were occurred to determine the final grip type.

The grip posture for handheld control is ultimately influenced by the user activity. According to the user activity, there are numerous variations on the same grip posture. The representative activity is thus determined to avoid the inevitable variations which could emerge in the process of grip classification.

3. Method

3.1 Subjects

Eleven males and ten females participated voluntarily. All had a corrected visual acuity of over 1.0. The average ages for the males and females were 30.5 and 24.4 years, respectively. In addition, the hand length was measured for each participant. The hand length varied from 155 to 186 mm with a mean of 171.8 mm and a standard deviation of 9.3 mm. All subjects were regular users of handheld devices. They felt no particular inconvenience in their hand movement and had no musculoskeletal diseases.

3.2 Tasks

The tasks were basically identical to the previous studies [8, 9]. During this experiment, the subjects were asked to perform the menu selection in the use of handheld devices by both hands. The both hands grip provides the convenience in multi-tasking environment. The subjects thus held an experimental prototype in their both hands and then press the control location using their thumb. For providing an apparent designation, the prototype was used with horizontal and vertical lines as illustrated in Figure 2.

![Figure 1. A hierarchical tree of grip posture](image-url)
3.3 Experimental design

For defining the range of experimental object size, the preliminary market research was conducted. As a result, width and thickness of object which determined the form factor were selected as independent variables. The product width was manipulated at seven levels: 40, 60, 80, 100, 120, 140 and 160 mm. The thickness was varied among the levels of 5, 15, 25 and 35 mm. Meanwhile, the length of object was set to 100 mm based on the market research.

The grip type and hand length reflected on human characteristics were also adopted as independent variables. As seen in Figure 1, the grip type for 5, 6 and 7 was determined to apply on both hands and grip control. The hand length was classified into four levels: under 25th, 25-50th, 50-75th and over 75th percentile.

The subjective preference score on the control locations was measured as a dependent variable. The absolute preference score was assessed on a scale of 0 (least preferred) to 100 (most preferred).

3.4 Environment and procedure

Before performing the main tasks, the subjects were briefed on the experimental tasks, grip types and precautions. The participants then entered into a quiet room where they sat on a comfortable chair. During the test session, the subjects were asked to the consecutive menu selection tasks contacted in a 10 x 10 mm area on the experimental prototype as described in Figure 2. Moreover, the participants performed the tasks as naturally as they could, favoring accuracy to speed.

The experimenter collected the axes of control location and preference score after the subjects completed each trial. This procedure was repeated for twenty eight different sizes of the prototype and three grip types based on a random order. Furthermore, the participants took a rest for fifteen minutes after finishing half of the total trials to minimize physical fatigue.

3.5 Data analysis

The support vector machine (SVM) has been one of the most useful tools for pattern recognition function and prediction of linear or non-linear regression [10]. The aim of this analysis classifies into groups of similar cases among the data where it is called clustering. Additionally, the SVM is utilized to identify the distribution of data within the input space, known as density estimation. The iso-preference contour was derived through projection the distribution from high dimensional space to two or three dimension for the purpose of visualization.

4. Results

The results were analyzed by grip classification since the role of hand was different according to the grip type. The significance of experimental variables was verified through ANOVA test. As a result, there are no statistically significant differences in preference relative to hand length in all grip types. However, product width, thickness and an interaction between width and thickness were found to be significant in all grip types.

As a result of post-hoc analysis, the product size has a little effect on user preference. Just when thickness is over 25mm, the preference becomes low in all grip types. Although the form factors which include width and thickness have significant impact on preference in ANOVA, it is not apparent to classify the product size into desirable and undesirable. All given experimental form factors thus can be roughly grouped as the desirable product size.

The preference contour plots for both hands in all grip types are separately described as seen in Figure 3, 4 and 5. It was found that the optimal control locations that indicate the highest preference score are almost the same regardless of subjects’ hand length and product size in all grip types. The pattern of changes in the vertical and horizontal direction seems to be very similar. Additionally, the contour plots of right and left hands seem to be apparently
symmetric.

![Figure 3. Preference contour plot by SVM for grip type 5](image)

![Figure 4. Preference contour plot by SVM for grip type 6](image)

![Figure 5. Preference contour plot by SVM for grip type 7](image)

5. Discussion and Conclusion

Both hands control is beneficial for performing the multi-layered and complex task. The human characteristic such as a hand length is not a significant factor determining the optimal control location. The human characteristic only effects on the overall control area. In other words, the hand length plays an important role in relatively lower preference zone yielded fewer than 60. The pattern of preference on the thumb is very similar regardless of the grip type. This result implies on the possibility of mathematical modeling for thumb control.

The previous studies [8, 9] derived the discomfort area or preferable zone based on a single hand control. It is notable that the control area of both hands is somewhat larger than that of a single hand control at the same level of preference. The reason for this is that as the product is supported by both hands, the degree of freedom in finger movement relatively increases. Actually, the grip posture for both hands is influenced by the role of fingers for stable grip and resistance to slipping.

The results of this study can be utilized as elementary data while designing the interface for handheld devices. It is further expected that designers will be able to derive the preferable control zones according to the product size and user characteristics and properly arrange functions, applications and menus.

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