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Touch panel usability of elderly and children

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ABSTRACT

The purpose of this study is to test the usability for the elderly, young adult and children using four different-sized touch panels and to provide suggestions for the elderly and children when using a touch panel. We set the subjects the tasks of dragging, rotating and scaling as quickly and as accurately as possible using different-sized touch panels. In addition to compare the operating performance values for different tasks for the three age groups, this study also recorded the subjects' hand movements. The results showed that the age and touch screen size had a significant effect on operating performance using the 4.3-in., 10.1-in., 23-in., and 42-in. touch panels. In addition, the average performance value on the touch panels using two hands was higher than the performance using one hand. Some useful and ergonomic interface design guidelines for the elderly and children were also proposed in this study.

1. Introduction

At the beginning of its development, touch panel technology was frequently used in public places, and it has become popular in individuals' everyday lives. For example, touch panels are often used in museums or as exhibition navigation guides and to display or sell goods in department stores. After the successive launches of the iPhone in 2007 and the iPad in 2010, touch panels have begun to be implemented in applications for personal use. A survey by the Nielsen Company showed that three-fifths of all mobile phone users in the United States use a smartphone. Moreover, in 2013, 34% of all adults in the United States own a tablet computer; almost double the 18% figure from April 2012 (The Nielsen Company, 2013). Given the popularity of the touch panel, many studies have analyzed touch panel usability, including studies comparing the performance of operating tasks, one- and two-hand gestures, differently sized touch panels, different age groups, and the design considerations for touch-panel interfaces.

1.1. Fitts' law in touch panel usability

Regarding the measurements of human–computer interaction, Fitts' Law, which was proposed by Fitts in 1954 (Fitts, 1992; Fitts & Peterson, 1964), is frequently used for measuring user-interface usability, operability, and performance. Fitts researched the information capacity of human–machine interaction under conditions of controlled tolerance range and amplitude, and experimentally defined the relationships between performance value (Ip), time (t), tolerance range (W) and amplitude (A). For instance, Mackenzie, Seller and Buxton (1991) compared the pointing and dragging performance of a mouse, a trackball, and a stylus with a tablet computer based on Fitts' Law. Whisenand and Emurian (1996) used Fitts' Law formula to measure the efficiency of a pointing task when using a mouse on a desktop computer. MacKenzie and Buxton (1992) extended Fitts' Law to a two-dimensional movement task on an interactive computing system, and results showed a significant improvement in the model's performance allowed by the suggested changes. Similarly, Murata (1999) adopted Fitts' Law to define the effective target width in a two-dimensional pointing task on a desktop computer. Then Murata and Iwase (2001) continued to use Fitts' Law for a three-dimensional pointing task and a measurement system. With interaction techniques rapidly growing and the vast array of touch-panel technology and mobile devices, Fitts' Law is further employed to demonstrate the usability of touch panels and operation performance. That is, based on Fitts' law, Sears and Shneiderman (1991) compared the operation performance of a mouse with that of stabilized and non-stabilized touch screens and indicated that the predictable positioning times when interacting with a touchscreen was necessary to take into consideration. Forlines et al. (2007), who compared the performance of one-hand or two-hand direct-touch operations and mouse input on tabletop displays, summarized the Fitts' Law parameters for both mouse input and touch operation. Murata and Iwase (2005) considered

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the angle effect of Fitts' Law in a comparison of the pointing tasks when using a mouse and a touch panel among three differently aged groups. Similarly, (Murata and Takahashi (2008) defined the optimal slope of the touch panel interface in Fitt's Law in accordance with the performance of pointing time of a touch panel and a mouse. In addition to the pointing and dragging operations on touch panels that were mainly performed in the studies related to Fitts' Law, other studies have explored the topic of operation gestures on touch panels. Schmidt, Block, and Gellersen (2009) investigated direct and indirect zooming and dragging operations on large touch panels. Wobbrock, Morris, and Wilson (2009) analyzed and characterized touch gestures, including "drag," "zoom," "rotate," and "press and tap" tasks using a Microsoft Surface prototype (24" × 18") and represented these as implications for tabletop users. Studies on other types of touch panel usability have also examined the topic of one-hand and two-hand gestures on touch panels, including Brandl et al. (2008), who found that coordinating a stylus with one hand was more efficient than using a stylus and touch with two hands on a 30-in. tabletop computer, and Kin, Agrawala and DeRose (2009), who compared the operating efficiency of a mouse, one-touch, two-touch, and multi-touch and found that touch was faster than using a mouse and that the operating speed when using two hands was faster than when using one hand on a 42-in. touch panel. Furthermore, among different touch-panel products, portable products are primarily smartphones, pocket PCs, and tablet PCs. Hence some studies have dealt with different sizes of touch panels. Sweeney and Crestani (2006) focused on exploring the efficiency of differently sized touch panels, i.e., mobile phones (1.69″ × 1.37″), PDAs (3.18″ × 2.38″), and laptop computers (11.25″ × 8.5″), for the purpose of investigating the relationship between the search results summary size and screen size. To date, driven by the series of iPhone and Android phone products, the panel size of smartphones currently on the market has increased to at least 3.5-in. Subsequently, some brands have launched panels larger than 3.5-in. Smartphone panels 5.3-in. in size can be found, and 4-in. is the current popular size. Tablet computers in the market include the iPad 2 at 9.7-in. (Apple Inc., 2011) as well as tablets from SAMSUNG (2012), Acer Inc. (2012), ASUSTeK Computer Inc. (2011), and ViewSonic® International Corporation (2012) that are all approximately 10-in. in size. In addition to small-sized touch screens, other large-sized screens are used in different contexts, i.e., between 20-in. and 42-in. According to Fitts' Law, the same task on different sizes of touch screens takes different amounts of time to complete given the different screen display proportions. Logically, different sizes of touch screens may have different usability, indicating that a user's performance with different sizes of touch screens should be different. In addition, the configuration of the interface designed for different sizes of touch panels may affect usability (Mackenzie et al., 1991). Nevertheless, existing studies on the usability of the touch panel have primarily experimented only on touch panels of the same size or the small range of differently sized touch panels, thus not revealing the usability for the great diversity of touch panels available.

1.2. Touch screen user interfaces for the elderly and for children

In addition to being frequently used by young people, touch panels are also good for the elderly and for children. The touch interface is easy for the elderly to learn and use, and degradation in their bodily functions does not affect usability (Juha Häikiö et al., 2007). Some studies have compared the performance of the touch panel and the other input devices for users of different ages. Murata and Iwase (2005) and Murata and Takahashi (2008) compared the performance of pointing time when using a mouse and a touch panel between young and older adults, respectively. Both studies found that the difference in performance between the elderly and the other younger groups when using a touch panel was smaller than using a mouse. Stößel, Wandke, and Blessing (2010) compared finger-gesture performance on the touch panel between older users and younger adults, and found that a gesture-based interaction with a touch panel is an appropriate input method for the elderly. In terms of usability and design considerations, with respect to age-related functional decline, Murata and Iwase (2005) proposed an interface design guideline for touch panels that was specific to the elderly and that included target size, target distance, the angle of the line from the starting point to the target, and click position. Correspondingly, by adjusting the touch-panel interface, usability issues can also be improved. Armstrong et al. (2010) indicated that smartphones can effectively solve the difficulties that the elderly often encounter when using a traditional mobile phone, such as font size and buttons that are too small and being presented with too many options. Because a smartphone is a touch panel, the panel's font can be directly amplified and the phone's features can be customized, thus improving phone usability for the elderly. Touch panels are often used in children's education. Twining et al. (2005) found that the application of the tablet computer in children's education can motivate learning and have a positive influence on learning outcomes. Chang and Sheu (2002) designed a set of digital learning programs that link the electronic schoolbag through wireless technology, reducing the weight of children's school bags and enabling children to learn with no restrictions on time and space. Thus, the courses are more interesting and vivid, leading to an enhanced learning outcome. Doukas et al. (2010) proposed a concept for a future classroom using wireless transmission technology to enable the tablet PC to serve as a schoolbag for students, and the results showed that students were motivated and actively participated in classroom activities. Although the content designed for digital learning is able to enhance children's learning, the usability of a touch panel is more important. The usability of a touch panel is related to the design of the interface, including its size or the interaction mode provided. Romeo et al. (2003) studied children's interaction with touch panels and recommended the use of larger icons and a basic input method when applying the technology to teaching. McKnight and Fitton (2010) instructed children to perform various touching operations using text and voice and found that the touch panel was easy for the children to use and that they were able to distinguish among different operations. Studies on the application of the touch panel for the elderly and children are fairly good. However, somewhat surprisingly, there has been very little research investigating the appropriate touch-panel usability for the elderly and children; in addition, the existing research lacks investigation into design considerations and guidelines for these older and younger touch-panel users.

Based on the above viewpoints, the purpose of this study is to use Fitts' Law as the design approach to test the usability for the elderly, young adult and children using differently sized touch panels and to provide design suggestions for the elderly and children when using a touch panel.

2. Methods

Four touch panels of different sizes, including 4.3-in., 10.1-in., 23-in., and 42-in., were selected for use in this study. Considering the touch operations for the four different sizes of touch panels, Wobbrock et al. (2009) and Microsoft (2013) distinguished and categorized "pan," "zoom," "rotate," and "press and tap" as frequently used operations when using tabletop screens and mobile devices. Thus, unlike many usability studies that used Fitts' Law and mainly focused on measuring the pointing and dragging efficiency, in this study, the "pan" and "press and tap" operations