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Optimal control location for the customer-oriented design of smart phones

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ABSTRACT

Recently, the smart phone has become a representative device in information communication. The smart phone generally adopts a full touch-screen panel that reflects the growing need for improved multimedia access. In the interest of customer-oriented design, HCI features such as controllability and a menu structure have to be properly considered. Among the numerous factors that have an effect on the controllability when using smart phones, the effects of the phone size, user's hand length and control location are investigated in this paper. Moreover, an effort was made to determine the changes in the user preference according to the control location. A series of experiments were conducted, in which preference scores were measured. It was found that the product width and thickness have significant effects on the user preference. Specifically, the effect of the product width is greater than that of thickness. However, the optimal control location varies little regardless of phone size and hand length. A desirable phone size was defined for the customer-oriented development of smart phones. Iso-preference contour plots in the form of a rotated ellipse were derived by the Support Vector Regression (SVR) method while the difference in sensitivity was assessed with respect to the meridian (horizontal and vertical directions). The concept of the preferable control zone was developed by linking the critical points in four directions despite the difference in the angle of rotation. In addition, the situation where the product is concurrently controlled by both hands was investigated. The results of the study are expected to aid in defining the size of handheld information communication devices such as smart phones and PDAs. It is also expected that the optimal control location and proposed contours can guide the designer to optimally layout various functions of the menu on the display.

1. Introduction

Recently, the use of digital gadgets has been growing exponentially and this has led to the rapid expansion of the consumer market. In particular, the development of small size products which are both portable and wireless such as mobile phones has been remarkable. With the advancement of digital technology, new control types have been developed to accommodate numerous functions in the confined product control space. The display parts have also become larger and have been integrated with the control parts that were traditionally separated. Advances in touch-screen technology have rapidly accelerated this phenomenon. The concept of the mobile phone terminal with full-size touch screen brought sensational customer responses since the design can be adapted to suit user requirements. The full-size touch screen phone can be said to be one of the most successful devices that allow the user to express their tastes [23].

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The smart phone to which the touch screen technology is applied is a representative device for information computing, specifically, for pervasive, anytime and anywhere computing. It is truly pervasive because it allows us to communicate with others, while obtaining information and managing everyday tasks. In other words, the smart phone offers communication, connectivity and content consumption supporting social interactions between individuals and groups [2]. Moreover, the smart phone's emerging capabilities are fueling a rise in its use as an input device for such resources as situated displays, vending machines and home appliances. Due to its prevalence, the smart phone has great potential to be the default physical interface for ubiquitous computing applications [1].

As the digital industry's competitive paradigm shifts from producer-oriented to customer-oriented, the driving success of ubiquitous computing is associated with usability [17,27]. Usability issues have become a core competency that is necessary for mobile businesses to survive in the wireless economy. User-centered design approaches incorporate usability in the context of user requirements, goals and tasks as early as possible into the design of a system [15]. In the case of mobile phones, the smart phone with a touch-screen enhanced the usability through its instinctive use and met the requirements of a larger display reflecting increasing multimedia needs [9]. Moreover, smart phones incorporating many ubiquitous computing applications have emerged and the models with an adjustable interface considering the usability and user experience have been extensively marketed.

There is a considerable history of research on the usability of mobile computing [4]. Even quite early work should still be of interest to those who develop mobile information services. In the 1980s and 1990s, much work was done on the comprehension of the information displayed on small screens. Previous research on mobile phones mainly focused on the improvement of the mobile web interface, identifying affective design features, the development of new applications and packaging [30].

It became clear that the user would want to use mobile devices for more than simple text messaging and voice telephony. For this reason the wider usability issues of the mobile web interface of smart phones should be considered. Jones et al. [12] designed a tool that enabled the user to more easily navigate a website using a small screen device [22]. With such web interface studies, the interactions between the user and smart phones need to be addressed for the design of such devices [5].

Meanwhile, user satisfaction with products is defined as the perceived image or impression of a product felt by users [7,10]. User satisfaction is a very broad concept that includes a variety of different aspects such as usability, price, and functionality. Related research attempted to identify some of the design features of a mobile phone. Han et al. [11] derived an empirical model linking the design features to the level of user satisfaction. This approach provided information about the affective design features. However, the question of how to apply these features in ubiquitous computing environment still remains to be answered. During the 1990s, several technology innovators began producing handheld digital information applications. Kamba et al. [14] experimented with transparent widgets which could be displayed 'on-top' of the information that was already being shown to the user.

In addition, grip studies or the packaging of mobile phones have been dealt with and these studies discovered that the grip style strongly influenced the controllability and resulting user performance. Pelosi et al. [25] described the mobile phone grip postures in a sample population of 100 subjects. The two main grip styles that are suitable for mobile packaging were found to depend mainly on the form factor and size. The objectives of these studies were the demonstration of an optimal interface by revealing what is close to both mental and physical models of users. However, the outcomes of these studies have limitations when it comes to applying them concretely to the development of a new mobile phone with optimal controllability.

Due to the increasing competition in the new mobile market, manufacturers are gearing toward a customer-oriented approach in their product design. Also, consumers seem to perceive the hardware, software, and information service of a mobile phone as a single entity. Based on this premise, the objective of this study is to find the critical factors that enhance the controllability of the mobile device. This study first measured the subjects' preference toward the simulated use of smart phones in order to quantify the controllability which is affected by the form factor, control location, and hand length, and secondly, to find the significant factors that make their optimal control possible.

To achieve this goal, the size factor which affects the controllability and grip posture of the input device was selected. Then, the desirable product size that guarantees favorable user satisfaction was defined. Finally, the optimal control location was derived in the form of iso-response contours and the preferable control zone in a simple quadrangle form. A verification study was also conducted to provide an objective performance comparison in addition to the subjective user evaluation. It should be noted that the results obtained pertaining to the use of a single hand were extended to the use of both hands.

The result of this study can be utilized as elementary data when designing or modifying mobile packages. Specifically, it is expected that designers will be able to effectively arrange the functions on a touch screen display according to the product size and user characteristics.

2. Method

2.1. Market research

There are many information computing devices including mobile phones which utilize the hand grip control. The aim of this study, through market research, was to observe the characteristics of product use in the market and to make relevant