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An investigation of the performance of novel chorded keyboards in combination with pointing input devices

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ABSTRACT

Rapid advances in computing power have driven the development of smaller and lighter technology products, with novel input devices constantly being produced in response to new user behaviors and usage contexts. The aim of this research was to investigate the feasibility of operating chorded keyboard control modules in concert with pointing devices such as styluses and mice. We compared combinations of two novel chorded keyboards with different pointing devices in hopes of finding a better combination for future electronic products. Twelve participants were recruited for simulation testing, and paired sample t testing was conducted to determine whether input and error rates for the novel keyboards were improved significantly over those of traditional input methods. The most efficient input device combination tested was the combination of a novel cross-shaped key keyboard and a stylus, suggesting the high potential for use of this combination with future mobile IT products.

1. Introduction

As the mobile era has progressed, communication between people and information technology (IT) products has increasingly relied on various types of input devices. The most common tasks carried out using computer input devices include positioning, selecting, and the input of graphics and data. In general, the operation of input devices is divided into two categories according to the situations in which they are used.

First, when a computer device is attached to a secured point on a fixed workstation, the usual means of operation is the combination of a pointing device (such as a mouse) and a text input device (such as a keyboard). The pointing device performs the functions of positioning, selecting, and graphics input, while the text input device is responsible for data input functions.

Second, when traveling or in unstable operating environments, computer devices often must accommodate user movements. In such scenarios, most input operations are dependent on a pointing device (such as a stylus) to complete all the input functions. However, a single pointing device has often proven unsatisfactory to those who frequently perform text input operations. This dissatisfaction is obvious enough from the continuous new introduction of plug-in type input devices. Simply put, in many increasingly common computer operating environments, a single input device is not ideally suited to many user operations.

Many portable computer devices currently on the market contain disjointed interfaces along with incompatible input devices. It might thus be necessary for future users to learn multiple input methods, and the importance of input method integration has thus been raised previously (Isokoski and Kaki, 2000). The present research accounted for the suitability of different devices for portable computer use and previous user experiences to exclude inappropriate input devices that are currently available on the market and to devise an initial concept for combining a chorded keyboard with stylus or mouse. The design of appropriate control motions for devices and technologies must consider multiple user characteristics such as sensations, cognitions, physiological performance, and anthropometry, among others. The input requirements for mobile IT products warrant specific attention from researchers in the modern mobile era, as the extrinsic limitations of input devices often force users to learn and adapt all over again. As it is, those input devices that are not significantly improved by the incorporation of new IT product concepts will hinder users with considerable challenge in terms of input efficiency.

Accordingly, the present research consisted of a comparison of the operating conditions for different combinations of two novel chorded keyboards with two different pointing devices in hopes of finding a better combination for future electronic products.

There have been few studies focusing on chorded keyboards in the past. Initially intended for special input purposes, the chorded

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keyboard has received renewed interest since the introduction of wearable computers. Studies by Bowen and Guinness (1965) and Conrad and Longman (1965) showed that the chorded keyboards held two distinct operational advantages over conventional keyboards: smaller space requirements and higher input efficiencies. The performance of chorded keyboards is also equal to or better than that of general sequential keyboards.

The present research developed a novel chorded keyboard as primary textual and numeric input device that meets the input efficiency and size reduction requirements of modern mobile IT products.

1.1. Research purpose

The aim of this research was to investigate the feasibility of operating chorded keyboard control modules in concert with pointing devices such as styluses and mice. A study conducted by Buxton and Myers (1986) indicated that during certain operations, higher efficiency is achieved with the simultaneous use of both hands than is achieved with one hand alone. Hence, we proposed an operating condition where the left hand operates the dependent modules through a chorded keyboard, while the right hand operates the control modules and pointing functions through a stylus or mouse. We also investigated whether the proposed combinations of different keyboards with a stylus or mouse were more efficient and ergonomic than the current form of encoded design.

The burden on the left hand is expected to be reduced with an improved work balance between the two hands in terms of movement and time demands. Revealing the optimal combination form would serve as a reference for the design of future mobile IT products. Experimental comparisons between two novel chorded keyboards combined with either a stylus or mouse were conducted to determine the optimal device combination in terms of high operational performance, low error rate, and high subjective satisfaction. The four main goals of this study were: (1) to determine the operational performance and error rate of the different novel keyboard with pointing device combinations; (2) to investigate how comprehensible such combinations are by determining whether practice results in significant performance improvement; (3) to observe the operating posture of users in order to reduce possible physical injuries; and (4) to survey user satisfaction to determine advantages and disadvantages for reference in future improvements.

1.2. Literature review

1.2.1. Chorded keyboard

The existence of keyboards dates back over a hundred years ago. Computer keyboards are the primary input devices for data entry operations, and the most commonly used keyboard among visual display terminal (VDT) operators is the conventional QWERTY keyboard, which is used by almost all computer users. Chorded keyboards, in contrast, use considerably fewer keys than conventional keyboards to produce similar inputs. The operation of chorded keyboards involves simultaneously pressing two to three keys in order to enter a single alphabetic or numeric character. For example, with one previously tested chorded keyboard, five keys could be used to produce 31 chord arrangements to represent alphabets, numbers, phrases, commands, or other strings (Noyes, 1983), and for some handicapped people, chorded keyboards have proven to be the only suitable type of keyboard for regular use. A study by Buxton (2002) suggested that the input method of chorded keyboards holds several advantages:

1. Chorded keyboards have fewer keys and are smaller in size than conventional keyboards, which make them far more suitable for portable use (Cumming, 1984).
2. Chorded keyboards support one-handed operation, which is beneficial to handicapped users (Kirschenbaum et al., 1986; Heusinkveld, 1988).
3. Chorded keyboards can be operated when the use is mobile or in an otherwise unstable environment.
4. The use of chorded keyboards results in reduced muscle fatigue and injuries in comparison to conventional keyboard use (Fisher and Bond, 1992).

In comparison to sequential keyboards, the speed (key strokes per minute, KSPM) of chorded keyboard operation is slower than that of sequential keyboards, but chorded keyboards provide higher data input volumes. In general, chorded keyboards are

Table 1
Analysis of one-hand and two-handed keyboards.

	Product	Factors
One-handed keyboards	Stealthy keyboard	The Stealthy keyboard proposed by Mckown was based on chorded keyboards (Mckown, 2000). The six buttons produce combinations to accommodate 36 characters, and functional buttons that switch input between alphabets and symbols are included The users need to learn different combinations for input, and adapt to new input methods
	Wrist PC keyboard	A small QWERTY keyboard designed to fit on the wrist (L3 system). The hand wearing Wrist PC keyboard holds the mobile device while the other hand performs one-handed input The one-handed input method and the small buttons lead to poor input efficiency
Two-handed keyboards	Mehring	Input function is achieved through contact of different conductors (Mehring, 2003). The conductors are distributed at the phalangeal joints and phalangeal regions to allow alphabetic or numeric input by combinations of rows and columns. It is difficult for the distal phalanges of the little finger and the ring finger to make contact with the three joints of the thumb. Additional training of user is required because of different special symbol distribution to normal keyboards; The relative positioning of keys and the large amount of conductors make the manufacturing of electric circuits difficult.
	AG-5	An input device developed based on the arcade machine joystick (Martinez et al., 2005). A trackball is also installed into the device that makes the AG-5 perform both the functions of keyboard and mouse. In terms of the keyboard, AG-f integrated buttons for independent keys and multiple valued keys. The most used alphabets are placed at the posterior for Touch-typing input, while the rest of the alphabets are arranged on the anterior. The anterior keys are not arranged according to typing layouts. In terms of operation, fast switching of fingers between the anterior and posterior is difficult. The employment of multiple valued keys also makes a poor symbol input performance by AG-5.