Integrating Isometric Joysticks into Mobile Phones for Text Entry

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Abstract

We are investigating a new gestural text entry method for mobile phones that uses an isometric joystick and therefore consumes very little physical space. We have created a high-fidelity mobile phone prototype with two embedded isometric joysticks, one on the front for use with the thumb, and another on the back for use with the index finger. The joysticks can be used to enter text using a special version of the EdgeWrite text entry method. In our proposed studies, we would like to investigate the performance of using the joysticks as text input devices in stationary and mobile situations. With our prototype, the authors were able to write at ~12 wpm with the front joystick, and ~7 wpm with the back joystick. These numbers are sure to improve as further refinements are made.

Keywords

Text entry, text input, gestures, unistrokes, isometric joysticks, mobile phones, cell phones, pointing, crossing, EdgeWrite, Pebbles.

ACM Classification Keywords

H.5.2. Information interfaces and presentation: User interfaces – *Input devices and strategies*.

Introduction

Text entry on mobile phones is commonly accomplished by pressing buttons on the keypad. These keypad-based methods have a number of drawbacks, including:

- The inability to write by feel: users generally need to look at the keypad to locate the appropriate keys to press, or at the screen to check the proposed text for methods that disambiguate key sequences (e.g. T9);

- Low physical stability: on-the-go users might find it difficult to press small keys while walking or riding;

- Large physical footprint: keypads consume precious device real-estate which is limited on small devices to begin with. By contrast, isometric joysticks are extremely compact, making them suitable for small devices.

We propose to use the isometric joystick together with EdgeWrite for text entry. EdgeWrite [15, 16] is a gesture-based text entry method originally designed for handheld devices that provides high accuracy and physical stability for people with motor impairments or people "on the go". Its unistroke alphabet, which uses gestures comprised of straight lines in a square, was originally designed to leverage physical edges for greater stability when entering text. In our case, we do not use physical edges but instead rely on *crossing* to stroke, somewhat analogous to "virtual edges."

We are investigating the use of the joystick at two positions. The first position is the conventional joystick location above the phone keypad. At this position, the joystick is operated by the thumb (Figures 1a, c). The second position is on the back of the phone where the joystick is operated by the index finger (Figures 1b, d).

To the best of our knowledge, neither isometric joysticks nor continuous rate-controlled joysticks have been used or studied for text entry on mobile phones. The joysticks currently found on mobile phones are essentially 4-way switches, which only allow the user to move in four directions. Therefore, such joysticks offer a limited degree of control. On the other hand, isometric and rate-controlled joysticks offer more flexibility and sensitivity. The joystick may be used not only for text entry, but also for other operations of the phone. And since they offer continuous control, such joysticks are excellent devices for video games, which are currently emerging for the mobile market.

When using a joystick to enter text, the user can operate the joystick using the same hand that holds the phone. Since isometric joysticks work by measuring force, the operating finger stays stationary on the joystick, as opposed to having to move around over the keypad when using keypad-based text entry methods. This may make it easier for people to enter text while walking. Furthermore, the joystick takes very little space, and if the keypad could be eliminated, then devices could have proportionally larger screens, or the devices themselves could be smaller. Putting text entry on the back of device might have the advantage of freeing up even more of the front for the display or for other purposes, but clearly, you cannot see the joystick when it is on the back, so a method with some tactility is required. To date, there has been little study of how best to do text entry on the backs of devices.

Related Work

There is a lot of research on pointing using the isometric joystick. The TrackPoint, a well-known example, was introduced by IBM [1] as an integrated

Figure 1a. front view. Almost all of the original phone components are preserved. The LCD screen is fully functional. The two joysticks communicate with a computer through a PS/2 connection using the cable at the bottom of the phone.
b. back view.
c. the thumb operating the front joystick.
d. the index finger operating the back joystick.

The back joystick is designed for use with the right hand. It is at about one-fourth of the width of the phone from the right edge.

The front joystick replaces the phone's original 4-way joystick.

pointing device within the keyboard which reduced the switching time between pointing and typing. Although originally designed for desktop computing, Silfverberg et al. [11] showed that the joystick could also be used for pointing on handheld devices.

Silfverberg [9] also found that the performance of keypad-based text entry methods during blind use depend on keypads with high tactility. Oulasvirta [6] pointed out that people can usually only maintain visual focus on the phone for a few seconds under typical "phone-using" environments, such as on the street or on a bus. Gestural text entry methods that can be performed by feel, such as EdgeWrite, are therefore attractive candidates for use on mobile phones.

Trackball EdgeWrite [15] is a recent version of EdgeWrite that works well for pointing devices without physical edges, like trackballs and isometric joysticks. It uses *crossing* to create character strokes, eliminating the need for accurate homing using the joystick which, as Mithal and Douglas [5] suggested, is difficult to achieve. There are many text entry methods for mobile devices, and interested readers are directed to MacKenzie and Soukoreff's text entry's overview [3].

There has been work on utilizing the backs of handheld devices, but not for gestural text entry. Silfverberg et al. [10] proposed mounting two touch pads on the back of

handheld devices for zooming and panning. Schwesig et al. [8] have created a prototype of a bendable computer that uses a touchpad on its back for 2D positioning. They have also created a selection-based (not gestural) text entry method for use with the touch pad. The method, however, seemed to be only suitable for writing a few words. Hiraoka et al. [2] have also integrated a touchpad-like device on the back of a cell phone prototype.

Widgor and Balakrishnan [14] have devised a chording text input method for mobile phones. They added three dedicated buttons on the back of the phone for this purpose. The GKOS [13] is a 6-key keyboard designed to be placed on the back of a variety of devices. It also uses chording to enter text.

The Prototype
To our knowledge, our attempt is the first to integrate isometric joysticks into a mobile phone for text entry. We built our prototype out of a real mobile phone, the Red·E SC1100 which came with Microsoft's Windows Mobile 2003 Smartphone Developer Kit. IBM donated some of their TrackPoint isometric joysticks, which are commonly found in their ThinkPad notebook computers.

The wiring of the joystick circuits required careful planning since we did not want to damage the original hardware. Our prototype preserves almost all of the original components of the phone. In particular, we wanted to make sure the LCD screen continued to work so we could use it as the display in our user studies. The keypad circuit was removed from the phone to make space for the installation of the front joystick, disabling the keys. But we kept the keypad itself to ensure a familiar appearance of the phone. Integrating

the back joystick was more straightforward, and only involved removing an internal speaker and drilling a hole in the casing.

Signals describing the two joysticks' movements are transmitted to a remote computer through a PS/2 connection via a cable at the bottom of the phone, as shown in Figure 1a. The computer translates the movement into character strokes, recognizes them as the appropriate characters using the EdgeWrite software, and then sends the recognized characters back to the phone. We wrote a special program that runs on the phone, which is also our user test software, to receive and display those characters on the phone's screen.

EdgeWrite has a number of adjustable features that makes writing using joysticks relatively easy. In particular, the sensitivity of the joystick and the size of the virtual writing space can be changed to allow the strokes to be created more comfortably and accurately. Also, parameters of the underlying crossing technique can be adjusted for greater accuracy and control.

When we first used the back joystick, we found it preferable to write the letters in a visually-oriented manner as if one were looking *through* the device, rather than in a motor-oriented manner which would be in mirror-image. This preferred orientation is consistent with prior findings [7]. This also means that the joystick's left and right directions are interchanged. We also found that we should rotate the EdgeWrite square, since the index finger utilizes the back joystick at an angle when holding the phone naturally (Figure 1d). We therefore refined EdgeWrite by adding the ability to reflect the input both horizontally and vertically and

Figure 2. A sample screen shown to participants

also to rotate it arbitrarily clockwise or counter-clockwise. Not surprisingly, the optimal rotation needed for each person varies depending on their hand size and position. The first author, whose hands are smaller than average, found it most comfortable to use a 22 degree rotation, while the second author prefers 35 degrees. We are, therefore, still investigating how much the ideal rotation should be, while we continue to fine-tune our prototype's hardware and software to prepare it for upcoming user studies.

Planned Evaluations

Currently, we have two studies in mind. The first study focuses on evaluating the usability, accuracy and performance of the joysticks for text entry while sitting. The second study will be a walking study where the participants will enter text "on the go". To make the study environment as realistic as possible, we will introduce physical obstacles and possibly environmental nuisances as attention-distracting elements. Visual distraction is one of the most important factors that we would like to study. We would like to investigate how our proposed method using the isometric joystick will compare to those using the keypad under distracting situations similar to those in the real world.

Through the studies, we want to find out how our method will compare to keypad-based methods such as Multi-tap and T9. We also want to explore how well the back joystick version will work for users, and how it will compare to the front joystick. The user test screen will look similar to the one shown in Figure 2.

Pilot Study Results

We conducted a short pilot study to assess the joysticks' performance. We were especially interested

to know about the speed of the back joystick, as such a joystick has not been studied. Each of the first two authors wrote 8 phrases that were randomly selected from a phrase set designed by MacKenzie and Soukoreff [4]. For the front joystick, the first author wrote at 12.9 wpm with an uncorrected error rate (UER) [12] of 1.7%. The second author wrote at 11.0 wpm (UER 2.9%). For the back joystick, the first author attained 7.9 wpm (UER 2.5%). The second author's speed was 6.5 wpm (UER 1.9%). Although these speeds were not particularly high, they can probably be improved with further refinements to our system. It is interesting in itself that writing with an isometric joystick is possible, even on the back of a device.

Our pilot study results showed that the speed of the back joystick was slower than that of the front joystick, by about 40%. We believe the main reason is that the index finger is not as dexterous as the thumb when the hand is holding the phone, as the muscles of the index finger are considerably restricted by the other non-moving fingers holding the phone. Also, we found the index finger slips off the joystick occasionally, probably because it was sometimes difficult to maintain enough force on the back joystick.

Conclusion

In this paper, we have presented a new gestural text entry technique for mobile phones that uses an isometric joystick on both the front and the back of the device. We designed and built a fully-functional prototype using a real mobile phone. Next, we will study this technique's usability in stationary and mobile settings. We believe that isometric joysticks can serve as a favorable text input techniques for mobile phones.

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