Mobile Text-Entry Models for People with Disabilities

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ABSTRACT

Motivation – To provide suitable mobile text-entry interfaces for the disabled, designed considering their capabilities and needs.

Research approach – We analyzed 20 blind users and the difficulties they face with traditional text-entry approaches. We designed a new text-entry method, modelled accordingly to the design guidelines retrieved from the user studies and evaluated in comparison to the traditional approach through user evaluation. The navigation model presented shows to be effective both on keypad and touch screen based devices.

Findings/Design – Results show that if the user's limitations and capacities are taken into account, the first approach with the mobile device is subtle and the learning curve is accentuated. In opposite to traditional approaches, the theoretical values are likely to be achieved.

Research limitations/Implications – As the available set of target users is limited, the user studies were made with five users per group (3 groups/15 users).

Originality/Value – The research presents an innovative text-entry method and its comparison with commonly used methods. We also present a solution to provide text input in touch screen mobile devices for blind users.

Take away message – If the interaction is designed with the end users in mind, the best theoretical values are likely to be achieved.

Keywords

Mobile, Text-Entry, Accessibility, Blind, Usability.

INTRODUCTION

Nowadays, we can find ourselves surrounded by technology, whether in public spaces, our homes or even within our body space. Although a few years ago computers were meant to be used only in static environments, the extraordinary development on mobile technology dictated the success of mobile computing devices. Overall, communication technology development and component miniaturization were the main cause for the mobile technology success and its enormous society penetration. These small, portable and stylish devices extend our capacities through several different scopes within our daily life. Considering available functionalities, these devices are increasingly becoming similar to desktop computers. Therefore, we are now able to edit a document in a mobile device and send it to a colleague in another country. Besides making calls or sending text messages, these mobile devices allow users to navigate on the Internet use a GPS system or manage important and crucial information like contacts and e-mails. Besides that evolution on mobile devices, we can find several services only accessible by SMS. Indeed, and the most important and basic function, one can be always available and communicate with anyone in the world just by pressing a number. While the majority of the population is able to operate both static and mobile devices, there is still a large set of users that is not able to do so. Therefore, although it is important to evaluate and improve the interaction between the mobile device and the common user, it is urgent to study and enable mobile device usage by those who are unable to do so.

Mobile device interaction is still highly visual demanding whether considering output (information on the screen), input (association between letters and keys) but also the generality of the interaction processes (i.e., menu interaction). In particular, blind users have great difficulties to interact with mobile devices and execute those tasks as the mobile interaction design is misaligned with their capabilities and needs. Although there are some hardware and software solutions to bridge the gap between blind users and mobile devices, they are insufficient and do not promote real mobile accessibility. Thus, it is important to align interaction design with the user's characteristics, needs and capabilities, aiming at an accessible mobile interaction.

We tackle the aforementioned issue by redesigning the interaction between the user and the mobile device, reducing the cognitive load associated with actual interaction and simultaneously exploring and maximizing the (over-)developed communication channels. In this paper, we present an alternative text-entry model designed to be aligned with the target user's abilities, reducing the memorization needs and exploring the user's capacities. The approach is instantiated in two different prototypes: a keypad-based prototype and a touch screen based one. We present user evaluation studies that support our design guidelines and the developed method, comparing it with the traditional approach.

MOBILE TEXT-ENTRY SYSTEMS

Nowadays, we can find some products that aim at offering mobile device control to blind users. Actually, a blind user can be able to use a mobile phone. However, we believe that the restrictions and barriers that they have to overcome to achieve this goal are huge. Text input on mobile phones is commonly achieved through a multi tap system where groups of 3 or 4 letters are assigned to each key; pressing consecutively the same key allows the user to go through all the letters available on that key. Existing text-entry approaches rely on the ability to see the sentence evolution and the keypad. With experience, a user can be able to achieve some success without looking to the keypad but this is only achieved after years of successful and feedback-rich usage and even an expert requires occasional confirmation. Although multi tap system is a very practical method for most of the users, those with visual impairments face several difficulties to use it. No information about letter displacement on the keypad is available and no feedback is offered about the entry evolution.

Mobile Devices for the Blind

There are two types of available solutions: hardware adaptations (special Braille-based devices) and software adaptations (screen readers). They represent two opposite approaches as one is a total modification from the traditional mobile devices while the other relies on the addition of a software feedback layer to the existent mobile solutions.

Alternative devices were developed to overcome the difficulties arising from visual impairments. Typically, these products' goal is to serve as a Personal Digital Assistant (PDA) providing functionalities like Contact Management, Calculator, Notes, Clock or sending and receiving short text messages (SMS). They normally allow connection to a desktop computer or a cell phone, acting as an interaction bridge between the visually impaired individual and the device. They normally allow the connection to regular mobile devices through a docking station or Bluetooth and rely on a Braille keyboard for input tasks and Braille output support as well as voice feedback (synthetic speech). These kinds of devices share the same flaws: the large size, weight and the prohibitive costs when compared with regular mobile devices. Although it is true that blind users can use Braille-based devices to accomplish their goals, it is also true that these devices are too heavy and large to be carriable and used while on-the-move. Also, considering a usual scenario where a blind user handles a cane with one hand, it is impossible to operate this kind of devices. These solutions are unsuitable for a mobile context. In a totally different scope are the screen readers, solutions that can be used in a regular mobile device, giving the users feedback on screen evolution and replacing visual feedback. Although screen readers make possible for a blind user to use a mobile device, they still require for the user to memorize letter's placement. This approach tries to focus on the emulation of the interaction traditionally realized by full capable individuals. This emulation is advantageous as it provides the possible users with access to the same applications a full-capable individual interacts with. However, the downside is that the achieved interaction and control is restricted to the one achieved by full capable individuals although the user needs are greater and capacities are lower.

NAVTAP – A SUITABLE APPROACH

It is urgent to find solutions that approach blind users and mobile devices. We study regular mobile devices and how can them be used by a blind user, relying on voice feedback to replace the information on the screen and featuring text-entry methods that eliminate the cognitive load on the keypad and explore the users (over)-developed capabilities. These studies aim at presenting models to enable the development of suitable interfaces for the disabled yet maintaining the set of functionalities. Regular text-entry methods available on mobile phones are adapted to the visually capable users that, without visual barriers, are able to just look to the keypad and know what key(s) to press to enter the desired letter. The same information is not available to a blind user. Regular mobile keypads provide a small mark on key '5' to work as a position reference, but although this reference gives them a notion of finger position in the keypad, they still have absolutely no information about letter layout. To increase this problem, the special characters keys are different between mobile phones. Some users memorize the letters' position on the keys, but even expert users on SMS messages need to sometimes look to their keypad and display to guarantee that the message is correctly written. Users are able to acquire this expertise by using the text-entry method and receiving feedback. Only then, they can start to write text without constant visual contact. Even with screen readers the users need to remember the keyboard disposition since feedback is only given after each letter/word is written. Although experienced users can eventually operate this kind of solution, inexperienced users often give up as mistakes recurrently occur leading the user to feel uncomfortable and fearful of using the application. With screen readers, the best approach blind users can have is the "trial-error" approach. For a certain letter they can try pressing the keys and hear the audio feedback, and if they press a wrong key, they will have an error and will have to clear the letter they just entered. To circumvent the lack of visual feedback, both output and input information must be offered through available channels. It is important to notice that possible communication channels, like tact or audition, are over-developed and the users are likely to perform better than a full capable user if the interaction is based on those senses. By adapting the interaction processes we minimize stress scenarios and encourage learning.

NavTap (Lagoá, 2007) is a text-entry method that tries to cope with the stated problems. The main idea behind it is that the users can navigate through the letters in the alphabet, therefore eliminating any need to remember which letters are associated to each key. For that we redefined the functions associated with the keys in the mobile phone keypad**.**

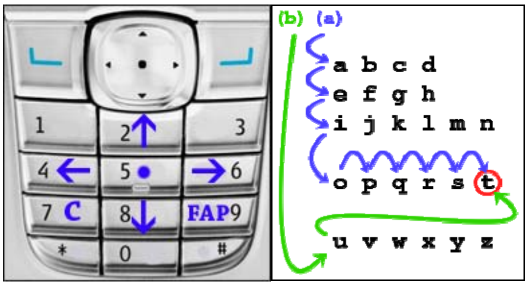

Figure 1: NavTap navigation scenarios to letter 't'

As we can see in Fig. 1, taking advantage of the mark on key 5, we can map a cursor using the keys 2, 4, 6 and 8. Keys 4 and 6 allow the user to navigate horizontally through the letters in the alphabet and keys 2 and 8 allow him to jump between vowels (if the mobile device features a joystick, it can also be used), making them key points in the alphabet. This navigation method requires no memorization as in a worst case scenario, even users with low alphabet mental model can just navigate straight forward until they reach the desired letter. Users that detain a richer alphabet mental mapping can use the shortest path to the desired letters (Fig. 1). In scenario (a) only two directions are used ("down" and "right"), and in scenario (b) we extend it to all four directions allowing the user to reach the letter 't' in only 2 key strokes instead of the 9 key strokes associated with scenario (a). Finally, users can totally rely on the audio feedback to read the letters before accepting them, drastically reducing the number of errors and on the other hand increasing the text-entry task success and consequently increasing the motivation to improve writing skills.

NAVTOUCH – ENABLING TOUCH INTERACTION

Touch screens have showed to be a successful and enthusiastic way of human computer interaction. Due to their fast learning curve, novice users benefit most from the directness of touch screen displays. The ability to directly touch and manipulate data on the screen without using any intermediary devices is a very strong appeal. However, these devices face several interaction issues, once again augmented in text input scenarios. While they also restrict the interaction performed by full capable users, blind individuals are disabled to interact as no feedback is offered. The problem in this scenario is even more drastic than when a physical keypad is available as the keys give the user the required cues to select targets (although obligating to memorize the associations).

Although pointing or selecting may be impossible, performing a gesture is not. We present an approach similar to NavTap (**NavTouch**) that uses the user's capacity to perform a directional gesture and through it navigate in the alphabet (similarly to the keypad based approach). Once again, the user is not forced to memorize or guess any location in the screen as the interaction is limited to directional strokes (Fig. 2).

Figure 2: Directional gestures

(Right, Left, Down, Up)

Special actions are linked to the screen corners as those are easily identified. After performing a gesture, if the user keeps pressing the screen, the navigation will continue automatically in last direction. The bottom right corner of the screen erases the last character entered and the bottom left corner of the screen enters a space or other special characters. In contrast to keypad, where the user has to find the right key to press, with these gestures that extra cognitive load does not exist.

USER EVALUATION

To validate our approach, we performed trials with the target population (Fig. 3). The evaluation group was composed by three groups of five users with no previous experience in mobile text-entry. This guaranteed that all users were at the same starting point in the beginning of the evaluation. The trials were performed in a formation center for blind users, in a controlled and quiet environment. Each group of users was assigned to a specific input method: MultiTap (traditionally used), NavTap or NavTouch. All of them featured voice feedback. Each text-entry method test lasted for three sessions (three days with a day in between) in which users performed a set of tasks consisting of writing specific sentences (different between sessions). The first session had a training period in the appropriate text-entry method.

The first relevant result retrieved from the undertaken evaluation was the time required by the users to get acquaintance with the methods. Although we determine the same training time (20 minutes), with the two proposed approaches the users were prepared for the test a few minutes (about 5) after getting instructed. Overall, after the twenty minutes training session the users argued to be ready and prepared to write the test

Figure 3: Blind User Testing NavTouch

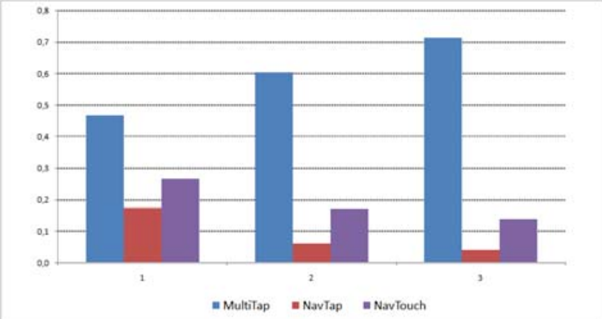

Figure 4 – Error Rate registered in 3 sessions with the 3 methods

sentences. However, even after the training session, the number of errors committed using the traditional MultiTap method is very high (Fig. 4). The users did not completely memorize the keypad layout and were recursively obligated to guess a key and with the audio feedback try to recover the error and find the desired letter.

Keystrokes per character (KSPC) is the number of keystrokes, on average, to generate each character of text in a given language using a given text entry technique (Mackenzie, 2007). Theoretically, the best value for MultiTap is reduced when compared to NavTap, as some letters require several keystrokes in the latter. In average, MultiTap requires 2,13 KSPC for the entire alphabet as NavTap requires 2,75 KSPC. However, although in a first approach, the users are likely to follow a naïve approach with NavTap and NavTouch, the learning curve is accentuated. On the other hand, the difficulties found with MultiTap make the user uncomfortable and unconfident with his interaction, which ruins the learning process (Fig.5).

With NavTap and NavTouch, the users find shorter paths and rapidly enrich their mental model, improving their performance and overall satisfaction. As an example, Figure 6 presents the theoretical values for three different types of navigation and the mean value obtained in the three sessions with NavTouch method (from the 5 users). Naïve method represents a navigation using only the “Right” direction (represents a weak alphabet mental model but likely to be the starting

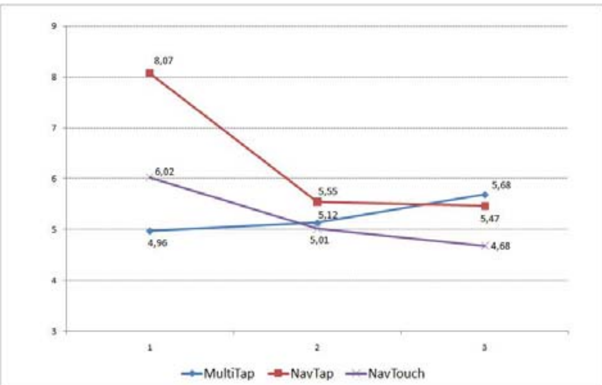

Figure 5 – KSPC registered in 3 sessions with the 3 methods

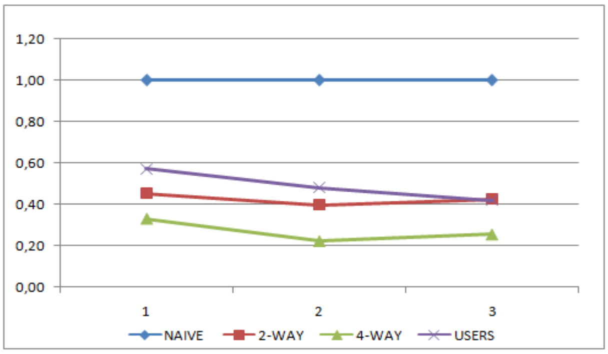

Figure 6 – KSPC Scenarios Comparison *(NavTouch)*

point for a novice); 2-Way represents a navigation using the “Right” and “Down” directions (the user use the vowels as reference points improving their navigation); 4-Way represents the best case scenario where the four directions are used. All the values are normalized as a percentage of the worst case scenario (Naïve navigation) and we dismissed the erroneous actions (only letters produced correctly were considered). As it can be observed, the users improve their navigation and outperform the theoretical 2-Way scenario with three evaluation sessions.

The navigation model presented is easy to use in a first contact and shows a good learning curve. The users are likely to approach the theoretical values (best paths). On the other hand, the MultiTap method is error prone and unsuitable for the target population. Overall, it is important to highlight that all the users were interested in continue using the proposed methods (none was able to write text with their mobile phones before the trials).

CONCLUSIONS

Text-entry interfaces that consider the users’ needs and capabilities are likely to ease the first contact and allow performance improvement. Considering text input for blind users, results showed that, if the cognitive load is removed and the users are presented with easier and user-centered interfaces, success is achieved as the first contact has a small error rate and the learning curve is accentuated. It is therefore possible to offer blind users with effective interfaces that require no extra hardware and permit usage by a wide set of users even those with no previous acquaintance with mobile devices.

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