Improving Handheld Devices Usability for Text Input Entry

Addis Seifu
Department of Information Technology, Unity University, Addis Ababa, Ethiopia
nati20046@gmail.com

Dagmawi Lemma
Department of Computer Science, Addis Ababa University, Ethiopia
dagmawil@yahoo.com

Abstract

The most common form of text entry on computing devices is a keyboard/keypad. It bridges the interaction between the user and the device during inputting alphanumeric values. Different key layouts are available such as QWERTY, Dvorak, multi-taping, T-9, etc., among which the QWERTY is most known and used. Even though several layouts have been researched with the objective of balancing size against usability, most digital devices (including small handheld devices) inherit the QWERTY key layout which is originally designed for typewriters. However, since this layout originally was designed for slowing down the typing speed of the user with the intention of avoiding key jamming, it does not consider the characteristics of digital devices.

In this research, we investigated and measured the performance of key layout on digital devices and introduced a new category in the alphabetically arranged key layout – the Alpha layout. Through experimental research, learnability rate of the Alpha layout reached to 35% while on the QWERTY, 25% learnability has been recorded after the users practiced the text to be entered. Users were able to type 0.78 characters per second (c/s) on the Alpha while on the QWERTY, they were able to type 0.70 c/s. Error rate on Alpha is minimal to be 1.1628% than QWERTY, which is 1.6279%. Though the usability attributes measured in this work seem to indicate the usability of the device with marginal difference, we imply that as the familiarity to the Alpha layout increases, users would be more efficient with less error.

Keywords: Usability; Experimental Research Method; Handheld Device; Virtual Keyboard; Keyboard Design; Keyboard Optimization

1. Introduction

The demand for handheld devices is increasing from time to time. Since these devices are alert, they do have the potential to respond quickly for a given activity. They can be used to assist user's day-to-day routines. Furthermore, handheld devices are appearing to be very suitable for accessing information [2] (reading emails, text messaging, reading news, etc.), especially when the user is seeking a time slot during bus ride, while waiting in line, etc. [3].

Many mobile services such as text/instant messaging, email, web surfing, and diary operations require users to be able to enter text on devices. Text messaging has even overtaken voice calling as the dominant use of mobile phones for many users [4]. These devices let users to author complex texts and small documents on their handheld devices.

In this paper, we look into optimization factors related to usability of text entry and proposed a new text entry method that is small, fast, and easy-to-use. The paper is organized as follows: Section 2 presents the background information regarding text input entry and related efforts. Section 3 assesses literature review and Section 4 related works in text input entry to learn from prior works. The proposed solution is detailed in Section 5. Section 6 deals with prototype developed as a proof of concept. Section 7 explains the collected data, and Section 8 is about the experiments conducted. Finally, concluding remarks are given in Section 9.

2. Background

Many attempts were made at the creation of typing machines. In 1868 Christopher Latham Sholes (a Milwaukee publisher, politician and philosopher) patented his typewriter. Because he was assisted by Carlos Glidden, the typewriter was named the "Sholes Gliden" machine [5]. In 1873, the "Sholes Gliden" machine was improved with features of printing both upper and lower case letters using shift key (the previous version only printed upper case letters). In 1878, after the enhancement, the "Remington No 2" was introduced [5]. One of the major drawbacks of Remington No 2 was that the actual printing could not be seen by the user (typist) as it was printed at the back of the paper and this was solved in 1883.

However, another problem that persists was key jamming, which occurs when a new key was pressed before the previous key arm returns. Sholes solved this problem by experimenting with the most common English two-letter sequences and assigning the most frequent couples to opposite sides of the keyboard [5]. This resulted in the QWERTY layout, which was optimal in avoiding key jamming by deliberately reducing the typing speed. Sholes's solution did not eliminate the problem completely, but it was greatly reduced. The Sholes design was present on the first typewriters that entered business offices and many typists were trained (by the Remington Company) for this keyboard. This provided the Sholes layout a great initial advantage to be known by many users [5].

QWERTY layout, named after the top-left six letters, was already known in 1893 as the "universal" layout. Nowadays, the QWERTY layout is adapted even by small handheld devices. However, such adaptation is not founded on researched justification and it is without the profound consideration of the usability attributes. Or the adaptation has some logical flaw regarding the typing speed optimization. For instance, as it is indicated in [1], one of the factors that play a role in speed optimization is balancing load on left and right hand by ranking frequency of letters. However, this may not be an appropriate factor for small handheld devices as most users do typing on such devices using only one hand.

Adapting the QWERTY layout to small handheld devices affects their usability. While the usability of a product is defined in terms of learnability, memorability, efficiency, error, and satisfaction, applications of a specific layout on small handheld devices affects all these usability attributes.

3. Literature Review

The literature review in this section briefly discusses the origin and concurrent improvements made on QWERTY, keyboard and keypad layout types and evaluation, user typing behavior, and keyboard/keypad layout design considerations.

3.1 Hand Movement and Key Layouts

Hand movement is one of the concerns during key layout design. DVORAK keyboard was designed to reduce finger movements. 70% of typing is done at the home row, 22% is done at the top row, and only 8% requires the bottom row. In the QWERTY layout, these values are 32%, 52% and 16%, respectively. On QWERTY, there are only 300 English words that can be typed by the home keys (without any finger movement), but on the DSK it is around 5,000. Also a comparison with Fitt's law is in favor of DVORAK layout, that less hand movement is needed [5].

In addition to QWERTY layout for mobile text input entry, the most widespread mobile text entry systems are Half-QWERTY, Mini-QWERTY, multi-tap and T9 on a mobile phone number pad (keys 1-9). These layouts have been used on physical as well as virtual keypads. Also in order to assimilate the text entry, apart from using physical layouts, virtual keyboards have become common on smart phones and tablets.

3.2 Typing Behavior

User typing behavior is considered typing as a process of reading a text and simultaneously copying it to the device through the provided key layout. Dictation and voice has drawback that an external source influences the behavior of the typist. While reading, the subject is fully self-directed in his/her actions and that is why only the activity of copy typing is considered. User typing behaviors are explained using Information flow and Fitt's Law.

Typing is considered as the process of reading a text and as the same time pressing its respective keys on the available key layout. In this process, there are 5 different phases [8]: character recognition, storage buffer, motor program, keystroke, and sensory feedback.

Fitts' Law [6] is a model of human performance that has an extensive history of empirical validation [7]. Fitts' Law models the time that a person needs to touch a key accurately, depending on the distance between the keys and the size of the key.

Different designing considerations are proposed. We considered the following as design issues: Character recognition, Motor program, and usability attributes, specifically learnability.

3.3 Text Entry on Mobile Devices

Text entry on mobile phones has always been a compromise between the space allocated to text entry and the size of the device. With finger-controlled touch screens becoming dominant in the late 2000 [10], this problem was exaggerated by the lack of precision when using relatively large blunt fingertips to tap small on-screen buttons and the lack of tactile feedback from touch screens. This combination led to higher error rates on touch screen phones than on physical keyboards [10] and many users using landscape mode to gain larger keyboards at the expense of application display space.

4. Related Work

Recent advances in computing technology have led to a dramatic increase in the availability of hand-held computing devices. These advancements are towards the development of smaller and more mobile devices. This trend has forced manufacturers to consider alternative methods of text input entry. A wide variety of keyboard designs, differing in the organization of the alphanumeric characters such as QWERTY, ABC, Dvorak, FITALY, etc., and the manner with which the alphanumeric characters are selected (e.g., tapping, gestures, etc.) are being explored [11, 12, 13].

In former text entry performance studies using various keyboard layouts, the QWERTY style has consistently outperformed other designs in terms of both speed and accuracy [11, 14]. For instance, in a study of five soft keyboard designs, MacKenzie *et al.* [14] showed that the QWERTY yielded an average text entry rate of 21.1 wpm, with the runner-up (ABC keyboard) attaining an average of only 10.7 wpm. This performance advantage is apparently due to the subject’s familiarity with computer keyboards [14].

As indicated in [14], QWERTY becomes the dominant layout for text input entry for decades. This performance advantage is apparently due to the subject’s familiarity with computer keyboards. That is, typing on a desk top computer transfers to stylus tapping on soft keyboards. It is important to show, however, that the nature and extent of this transference is not yet known. Tapping on a soft keyboard with a stylus is different than touch-typing on a standard keyboard. These small devices use one-handed input, and due to the lack of tactile feedback, it requires continuous visual guidance of the finger or stylus.

5. The Proposed Solution

Provided the flexibility of producing a variety of layouts, we have adapted the alphabetic layout with major modification with the consideration of learnability. Finger-controlled touch screens to tap small on-screen buttons were dominant in the late 2000 [10]. For novice users of virtual keyboards, speed is determined mostly by the needs to search and find target keys rather than by the amount of motor movement. A keyboard optimized by movement efficiency only may look rather arbitrary to a novice user and hence be difficult to search. We explored the possibility of easing the novice user’s search process by introducing alphabetical ordering to a keyboard layout. We called it alpha layout as shown in Figure 1.

Figure 1: Alpha Key Layout

Ease of learning refers to the novice user's experience on the initial part of the learning curve as shown in Figure 2 [9]. Highly learnable interface has a steep incline for the first part of the learning curve and allows users to reach a reasonable level of usage proficiency within a short time.

An arrangement that minimizes the maximum inter-key distance is a matrix that is roughly 6x4 keys, a layout consistent with the constraint, one/two finger typing.

There are two space keys in the layout, shown in Figure 1. The user is free to choose any one of them. The optimal choice depends on both the preceding and following keys to the Space key. For example, for the sequence of A–space–S (Figure 1), the left Space key is the best choice. However, the left space key is not the optimal choice if the tapping sequence is K–space–X.

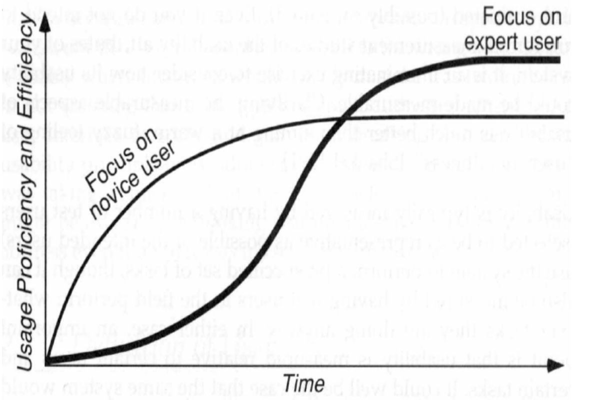

Figure 2: Learning curves for a hypothetical system that focuses on the novice user, being easy to learn but less efficient to use, as well as one that is hard to learn but highly efficient for expert users.

6. Prototype

After defining key layout design requirements, we come up with the prototype defined in Figure 3.

A virtual keypad prototype is developed for the proposed new layout using Android programming language (Eclipse Juno). Android 2.2 is used to maintain compatibility with different mobile phones.

The proposed solution is comprehensive and challenging to implement all the functionalities of a key pad. Therefore, we only implemented keys for alphabetic values, as shown in Figure 2.

The prototype is implemented on Samsung Ace 5830 android mobile phone. The test is also conducted on the same environment.

User Study and Procedures

Users were requested to insert the "the quick brown fox jumps over the lazy dog" statement on the provided text area using touch typing. A user handles the phone with his/her one hand and the other hand is used to type by pointing/pressing the key. Before they start typing, they have to press the "Start" button to grasp the initial time and then when they finalize, they have to press the "Stop" button to measure the total elapsed time for typing.

Figure 3: Alpha Prototype

7. Collected Data

We used cluster random sampling technique to select our sample. By subdividing the population into novice and expert users, we took samples based on their years of experience and the type of job. From novice users, we took 10 high school students with typing experience ranging from 2 – 50 days and 10 experienced typists were taken with 5 – 7 years of typing experience. In addition, the experienced users use typing as their daily income.

8. Experiment

Experiment I

For our first study, we evaluated 10 typists, expert users for 35 minutes using off-the-shelf application called Mavis Beacon, version 20. This application is commonly used to teach and evaluate typing speed of QWERTY layout.

The experiment has 4 sessions. Three sessions to evaluate their level of expertise that is beginner, intermediate, and advanced typing test using the application; and the fourth is to evaluate how memorable the keys are when a specific letter location is asked by covering the entire keyboard.

Result I

We showed that as the level of the test is getting advanced, from intermediate test to advanced test, the results are variant on the error rate and performances (wpm). We got an average result of 32 wpm, average error rate is 92 and constant response for session 4 test, which are they try to remember their finger movement when a specific letter location is asked by covering the keyboard.

Experiment II

This experiment was conducted on novice users. We let them to see only two letters which are not alphabetically ordered on four different QWERTY keyboards. By taking the visible letter as a reference, they were asked to determine the location of the requested letter to the right or to the left of visible letter.

Result II

Experiment II result analysis shows that for keyboard test 1, there are 11 correct and 9 wrong responses; for keyboard 3, 17 correct and 3 wrong responses and 13 correct and 7 wrong responses for keyboard 3. Table 1 presents the experiment II result analysis.

Table 1: Experiment II Analysis

	Keyboard 1	%	Keyboard 2	%	Keyboard 3	%	Keyboard 4	%
Correct Response	11	55%	17	85%	13	65%	13	65%
Wrong Response	9	45%	3	15%	7	35%	7	35%
Total Hit	20	100%	20	100%	20	100%	20	100%

The above analysis shows that the maximum level achieved is 65%. Even though the figure seems high, we can maximize the memorability of the keyboard by selecting and redesigning the layout.

Experiment III

Five different tests are performed on both Alpha and QWERTY layout. Tested users are novice users.

Result III

Through experimental research, the result confirmed the improvement attained from the revised key layout. The efficiency attribute has been improved by 35% on the Alpha layout while on the QWERTY users, a 25% improvement has been recorded after the users learn the layout. Also after the users learn the layout, they were able to attain a typing speed of 0.78c/s on the Alpha while their typing speed on QWERTY is 0.70c/s. Error rate on Alpha is also minimal to be 1.1628% than QWERTY which is 1.6279%. This implies that as the Alpha layout is more learned, users would be more efficient with less error.

9. Conclusion

Users, both novice and expert, are tested on QWERTY from the perspective of usability attributes. Data collected during the test are analyzed and taken as an input for the design of the Alpha layout. Users are then tested on the derived layout. This research introduced a new category in the alphabetically arranged key layout. As shown in the result analysis, typing improvement (learning) is enhanced by 25 seconds with Alpha whereas it is 19.1 seconds with the QWERTY layout (Figure 4). In addition, error rate is less in Alpha (1.163%, Figure 5) compared to the error rate of QWERTY (1.628%, Figure 5) and ease of learning is improved by 13% than QWERTY. Typing speed as well improved with Alpha (0.78 CPS, Figure 6) and less in QWERTY (0.70 CPS Figure 6)

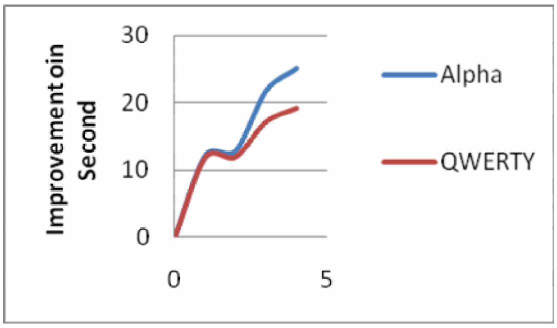

Figure 4: Average Typing Improvement (Learning)

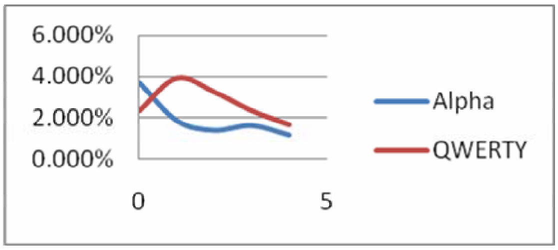

Figure 5: Average Typing Error

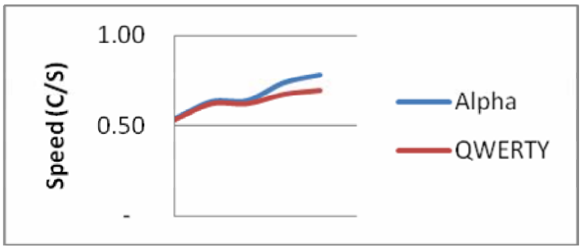

Figure 6: Average Typing Speed (Characters per Second)

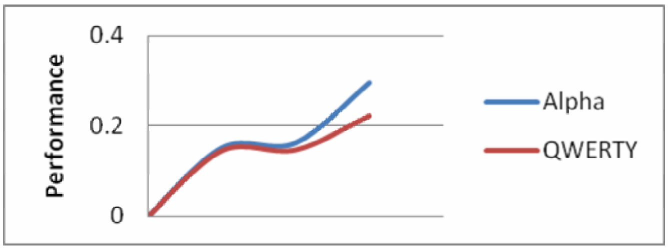

Figure7: Average Typing Performance

From these, we concluded that as the user gets more experience, the error rate of Alpha will be minimized, ease of learning and typing speed will be increased.

This layout will be applicable on smart phones as well as any digital device that has the functionality of integrating keypad for text entry; we can use the popularity of virtual key pad in order to apply the proposed key layout together with the QWERTY layout so that the user can select the type of key layout as preferred.

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