TECHNIUM
Romanian Journal of Applied Sciences and Technology
ISSN: 2668-778X

vol. 16 / 2023

The 7th International Conference on Science Technology

organized by
Faculty of Social Science and
Law Universitas Negeri Manado and
Consortium of International Conference
on Science and Technology

The Innovation Breakthrough in Digital and Disruptive Era

PLUS COMMUNICATION

International Communication & PR

Technium: Romanian Journal of
Applied Sciences and Technology
Vol. 16, 106-111, October, 2023
ISSN: 2668-778X
www.techniumscience.com

One Line Plus Soft Keyboard Layout for Smartwatches Text Entry

Eka Prakarsa Mandyartha[1], Fawwaz Ali Akbar[1], and Auliya Arkhan[1]

[1]Universitas Pembangunan Nasional "Veteran" Jawa Timur, Department of Informatics, Surabaya, Indonesia

Abstract. The "One Line Plus" soft keyboard layout inspired by One Line and T9 layouts. This innovative design condenses the button layout into a single line, maximizing button size for ease of use. The implementation includes essential features like enter and autocorrect buttons to enhance user experience. Performance testing involving 31 participants was conducted to evaluate the effectiveness of the layout. The results showed an average words per minute (WPM) of 8.8 and a total character count of 43.48, with the highest WPM of 16 and character count of 89, and the lowest WPM of 4 and character count of 16. The analysis grouped participants based on their background, experience with smartwatches, and typing intensity. Notably, the group with frequent typing experience on smartwatches achieved the highest WPM of 11.3 and character count of 53.4, indicating the layout's efficacy for proficient users. The System Usability Scale (SUS) evaluation yielded an average score of 89.35, indicating the layout's successful usability. These findings demonstrate the potential of the One Line Plus soft keyboard layout for enhancing text entry on smartwatches.

1 Introduction

In recent years, technological advancements have given rise to numerous portable devices with touch screens, such as smartwatches. The presence of these devices has greatly facilitated rapid and easy access to information and various applications. However, one of the challenges faced in using these ultra-small touch screen devices is text input. The limited screen space poses difficulties for users in employing efficient text input methods, particularly when utilizing standard QWERTY keyboards that consume a significant portion of the screen, leading to reduced efficiency and user convenience in text input [1]. As a result, there arises a requirement for an inventive and efficient keyboard layout design that can improve the text input experience on smartwatches.

Considerable attention has been devoted to researching effective text input solutions for ultra-small touch screen devices in the technology field. Numerous studies are dedicated to introducing innovative and intuitive input alternatives. An innovative soft keyboard named the 1Line keyboard [2] was introduced. Remarkably, this soft keyboard presents a QWERTY layout seamlessly condensed into a single row encompassing merely eight buttons, consequently occupying a mere 40% of the standard iPad QWERTY keyboard's height. This ingenious design effectively addresses the challenge of space consumption on portable touch screen devices. The sizes of these eight buttons are strategically determined based on users' cognitive perception of the QWERTY layout on the iPad. The system employs a novel button sequence differentiation mechanism to accurately distinguish the words typed by the users. Moreover, the keyboard allows users to employ flick gestures for swift deletion and space insertion, alongside tapping the bezel below the keyboard to input spaces conveniently. The comprehensive evaluation results demonstrate the quick adaptability of participants to the 1Line keyboard, leading to typing speeds surpassing 30 words per minute within a mere five 20-minute typing sessions. Remarkably, employing a keystroke-level model, the anticipated maximum text input speed by proficient users utilizing the 1Line keyboard is estimated to achieve an impressive 66-68 words per minute.

A study conducted by MacKenzie et al. [3] introduced a text input method named H4-Writer, utilizing a set of four buttons which is considered to be the most efficient and swift approach. This innovative method incorporates Huffman encoding to associate sequences of terminal buttons with letters, providing users full access to error correction, punctuation, numbers, modes, and other functionalities. Remarkably, users rapidly acquire proficiency in memorizing these button sequences, enabling text input without the need to visually monitor the screen. With a remarkable KSPC (Keystrokes per Character) of 2.321, the effort required for text input proves comparable to multitap methods on phone keypads, yet the H4-Writer method utilizes merely four buttons compared to the nine buttons required in multitap methods. Over the course of a long-term study involving six participants, an impressive average text input speed of 20.4 words per minute was observed during the 10th session, boasting an error rate below 1%. In a bid to enhance external validity, longer sessions encompassing the

Technium: Romanian Journal of Applied Sciences and Technology
Vol. 16, 106-111, October, 2023
ISSN: 2668-778X
www.techniumscience.com

input of punctuation and other symbols were incorporated. Interestingly, the text input speed experienced only a minimal decline of approximately 3 words per minute, thereby indicating the rapid mastery of required skills by the participants to proficiently employ the advanced features of the H4-Writer method.

ZoomBoard [4] was introduced as an interaction technique for soft keyboards, facilitating text input on ultra-small devices like Sony SmartWatch and Apple iPod Nano. Despite the impressive computational capabilities of these devices, their potential was restricted due to the lack of efficient text input methods. The research introduces the ZoomBoard technique, incorporating an iterative zoom approach to enlarge the minuscule-sized keys into a comfortable and operable size. Remarkably, the ZoomBoard design adheres to the QWERTY layout, thus facilitating user familiarity and leveraging their pre-existing skills. To assess its efficacy, text input experiments were conducted on a remarkably diminutive 16 x 6 mm keyboard - smaller than a U.S. penny coin. Following eight training sessions, users achieved an impressive average of 9.3 words per minute with accuracy levels comparable to full-sized physical keyboards. These compelling outcomes underscore the superiority of the ZoomBoard technique over existing mobile text input methods.

Dunlop et al. [5] conducted a study aimed at enhancing the text input experience on smartwatches. With smartwatches now granting users access to various smartphone applications right from their wrists, eliminating the need to interact with their smartphones, there arises a critical need for efficient text input methods that enable users to respond to messages and enter text directly on the device. To address this issue, the study introduced specific requirements for text input on smartwatches, including an optimized alphabetic layout. Additionally, the researchers presented a prototype implementation and sought early feedback from users. Although the study encountered certain challenges, the obtained feedback demonstrated that the smartwatch's text input could achieve adequate quality and speed. This encouraging outcome encourages further research in the pursuit of developing superior text input techniques for future smartwatches.

A novel text input technique designed for wristwatches featuring a 1.5-inch touch screen has been introduced by Cho et al [6]. The majority of commercially available wristwatches, including popular models like Galaxy Gear and Omate, possess compact touch screens that lack sufficient space for a reduced QWERTY keyboard. Additionally, commonly employed virtual button-based methods rely on precise touch location differentiation, demanding users to exercise caution when interacting with specific areas on the touch screen. Consequently, these approaches prove unsuitable for devices with petite touch screens in dynamic settings. As an innovative alternative, the proposed text input technique allows users to interact almost anywhere on the touch screen, facilitating text entry through direction-based drag input without necessitating precise touch location attention. To validate its practicality, the proposed method was implemented and evaluated on a commercially available wristwatch equipped with a 1.54-inch touch screen. The results highlight promising potential for developing more efficient and practical text input methodologies tailored to wristwatch devices featuring small touch screens in future applications.

A study has been conducted to address the text input challenges on ultra-small touch screen devices, such as smartwatches [7]. The ultra-small form factor of such devices necessitates exceptional compactness and lightweight design to ensure user comfort during wear. However, due to their diminutive size, users often encounter difficulties in accurately selecting the appropriate keys, leading to impractical text input experiences. To overcome this limitation, the researchers proposed a solution called Flickey, a QWERTY-based soft keyboard that leverages flick gestures for key selection on ultra-small touch screen devices. Flickey's flick-based selection mechanism, complemented by its callout technique, facilitates easier interaction with the compact keyboard. To assess Flickey's performance and usability, the researchers developed a prototype and conducted comparative experiments with two pre-existing keyboard types. The research findings demonstrate Flickey's superior performance, particularly as the keyboard size decreases. This pioneering discovery significantly contributes to the advancement of more efficient user-device interactions for ultra-small touch screen devices like smartwatches in future applications.

The concept of the One Line Soft Keyboard with T9-Keys Layout was introduced by Mandyartha et al [8]. The design concept aims to optimize screen space utilization on smartwatches while adopting a familiar and commonly used button layout for users. With experienced authors contributing to this research, the study endeavors to make notable strides in advancing user-smartwatch interaction paradigms for the future.

This study focuses on the development of a prototype keyboard layout intended for smartwatches. The layout, known as "One Line Plus," was adapted from [2] and [8]. Implementation of the One Line Plus prototype layout took place within a web-based system. Subsequently, typing tests were performed on the web platform to determine the words per minute (WPM) and the total number of characters successfully entered using the One Line Plus layout. The study culminates in a usability testing phase, where respondent evaluations are gathered to gauge the effectiveness and user-friendliness of the keyboard.

2 Prototype Design Development

In this study, the prototype design is based on the dimensions of the Apple smartwatch, specifically the iWatch series 8. According to Apple's official website, the iWatch series 8 features a screen resolution of 396 × 484 pixels with a viewport size of 197 × 162 pixels. Additionally, other iWatch series, such as SE and Ultra, have screen resolutions of 368 × 448 pixels and

Technium: Romanian Journal of
Applied Sciences and Technology
Vol. 16, 106-111, October, 2023
ISSN: 2668-778X
www.techniumscience.com

410 × 502 pixels, respectively. See Fig. 1. In this stage, we design the keyboard wireframe for the smartwatch.

Fig. 1. The screen size of the iWatch.

1.1 Keyboard Wireframe

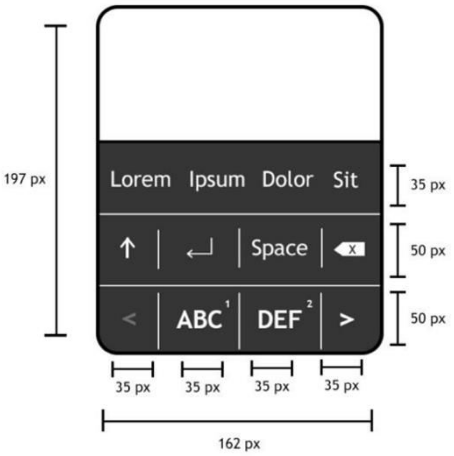

Fig. 2. Wireframe One Line Plus Layout.

Based on the selected screen size in the prototype design of this study, the viewport size for iWatch series 8 is 197 × 162 pixels. With this size in mind, we carefully considered the dimensions of each keyboard button to ensure that users can accurately interact with them. Each keyboard button has a size of 50 × 35 pixels, while the text suggestions have a size of 35 × 35 pixels. See Fig. 2.

According to Google's user interface design guidelines on the official https://m2.material.io website, Google recommends that devices with screen sizes ranging from 0 to 599dp use a maximum of four columns in the layout. Therefore, in accordance with these guidelines, One Line Plus keyboard is created with 4 columns of touch buttons, arranged in 3 rows. The bottom row serves as the letter typing buttons and includes swipe buttons for navigating to the next or previous group character. The middle row is designated for symbol, number, space, and backspace buttons. Finally, the top row functions as an auto-complete feature to expedite and simplify the typing process.

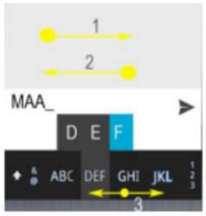

Fig. 3. One Line with T9 Keys Layout [8].

The design of the One Line Plus keyboard is inspired by the T9 layout model. Based on this model, we have developed a prototype design that combines elements from the 1Line [2] and T9 – layout [8] (See Fig. 3), reorganizing the T9 layout model into a single line. The text entry mechanism for this prototype keyboard bears resemblance to T9, where a single press corresponds to the first letter on a button, two presses to the second letter, and so forth. Users have the flexibility to navigate to the next or previous button to switch to another alphabet letter. Additionally, this prototype incorporates text autocomplete functionality to expedite the typing process on smartwatch devices.

1.2 Levenshtein Distance Algorithm

The application of the Levenshtein Distance algorithm serves as an effective technique for text prediction in auto-complete feature, enabling the system to rectify typing errors made by users. By employing this algorithm, the inputted letters are grouped and analyzed, and the system generates appropriate word suggestions closely related to the inputted letters.

Implementation of the Levenshtein Distance Algorithm for text prediction involves two main steps, e.g., building the word index to be tested and calculating the Levenshtein distance between the words entered by the user and the words in the index [9]. With this implementation, when users type text on a device or application that incorporates auto-complete functionality, the algorithm will search for the closest words in the index and provide appropriate auto-complete suggestions based on the user's input [10].

Implementing the Levenshtein Distance Algorithm for auto-completion text can assist users in typing more quickly and accurately, enhancing their overall experience when interacting with One Line Plus.

2 Result and Discussion

The implementation of the One Line Plus Soft Keyboard prototype design utilizes the React.js framework library. The buttons include auto complete, capslock, enter, space, backspace, letters, and numbers. The layout is divided into three sections: the top section, middle section, and bottom section. The top section serves as the location for auto complete buttons. The middle section contains functional buttons such as capslock, enter, space, and backspace. Meanwhile, the bottom section houses letter, number, and symbol buttons that are swipable. See Fig. 4.

Fig. 4. One Line Plus Layout Design.

Performance testing was performed to evaluate how effective and user-friendly the One Line Plus prototype layout design is. Two tests were conducted in this study. The first test was the typing test, which aimed to measure the words per minute (WPM) score and the total number of characters successfully typed using the One Line Plus layout. The next evaluation is the Usability Testing, in which the System Usability Scale (SUS) is utilized as a reference. It comprises 10 questions and 5 response options. The responses include "Strongly Disagree (SD)", "Disagree (D)", "Neutral (N)", "Agree (A)", and "Strongly Agree (SA)". A system that indicates satisfactory performance should have a SUS score above 68. Conversely, if the SUS score falls below 68, it indicates potential issues with the system. Scores above 70 are generally considered above average, while scores above 80 indicate a highly usable system.

The performance test involved a group of respondents comprising both students and non-students, aged between 20-23. The average age of the respondents was 22 years, with the majority being 21 individuals aged 22 years, including 9 females and 22 males. The respondents' occupational/educational backgrounds were categorized into two choices: IT and non-IT, with 10 individuals from the IT field and 21 individuals from the non-IT field. Moreover, the respondents were asked about their smartwatch usage experience, with 12 individuals claiming ownership of a smartwatch and 19 individuals not owning one. The intensity level of the respondents in typing on the smartwatch device was also measured on a scale of 1 to 5. The majority of respondents, 16 individuals, gave a score of 1, indicating that they never typed using any smartwatch.

2.1 The Typing Test

The average results for words per minute (WPM) and total characters typed using the One Line Plus Soft Keyboard layout were approximately 8.8 WPM and 43.48 characters, respectively. Shown in Table 1.

Table 1. The average outcomes for the words per minute (WPM) score and the total number of characters correctly typed using the One Line Plus layout.

Average	Score
Word per Minute (WPM)	8.8
Total Characters Typed	43.48

Table 2 presents the sample outcomes derived from the typing test. The maximum achieved performance was 16 WPM with 89 characters typed, whereas the minimum was 4 WPM with 16 characters typed.

Table 2. Sample results obtained of the typing test.

Name	Age	WPM	Characters
R1	23	16	83
R2	22	12	65
R3	22	9	47
R4	22	14	72
R5	22	6	27
R6	22	7	37
R7	22	6	31
R8	21	6	28
R9	22	9	47
R10	21	16	89
R11	22	5	25

To gain more insights, the respondents will be grouped based on their background, smartwatch ownership experience, and intensity of typing using a smartwatch. This classification aims to identify the group with the highest WPM and total characters typed. The first group consists of respondents with IT and non-IT backgrounds. Based on the data analysis, the non-IT group showed higher average results with WPM at 8.95 and a total of 42.8 characters typed. Meanwhile, the IT group had an average WPM of 8.5 and a total of 44.9 characters typed.

The second group is divided into two based on their experience with smartwatch ownership: those who have a smartwatch and those who do not. Respondents with a smartwatch achieved an average WPM of 10.5 and a total of 49.91 characters typed. On the other hand, respondents without a smartwatch achieved an average WPM of 7 and a total of 39.42 characters typed.

The third group is based on the intensity of respondents' typing using the smartwatch. As no respondents gave a scale value of 5, this group is divided into two categories: those who gave a scale value of 1 and 2, classified as "rarely," and those who gave a scale value of 3 and 4, classified as "frequently." The "rarely" category had an average WPM of 7.54 and a total of 38.76 characters typed. On the other hand, the "frequently" category had an average WPM of 11.3 and a total of 53.4 characters typed.

Based on the results, the group that achieved the highest average WPM and total characters is the third group in the "frequently" category. In comparison, the "rarely" category only had an average of 8.2 WPM and 33.2 characters typed. The "frequently" category achieved an average WPM of 11.3 and a total of 53.4 characters typed. Additionally, significant differences are observed in the second group between those who own a smartwatch and those who do not. The group with a smartwatch had a higher average with 10.5 WPM and 49.91 characters typed, while the category without a smartwatch had an average of 7 WPM and 39.42 characters typed.

2.2 Usability Testing

Table 3 shows the 10 items of the SUS questionnaire along with their respective scores.

Table 3. SUS Questionnaire Items with Scores.

Questionnaire Items	SUS Score
1. If I have a smartwatch, I would use this keyboard layout.	84.7
2. I found some unnecessary buttons in the keyboard layout features.	96
3. I believe this keyboard layout is easy to use.	92.7
4. I think I need technical support to be able to use this keyboard layout.	86.3
5. I feel that the functional buttons in this keyboard layout are well-integrated.	87.1
6. I think there are too many inconsistencies in this keyboard layout.	87.1
7. I imagine most people would learn to use this keyboard layout quickly.	88.7
8. I feel that this keyboard layout is very complicated to use.	93.5
9. I feel that I can type easily when using this keyboard layout on a smartwatch device.	88.7
10. I need to learn many things before I can use this keyboard layout.	88.7
Average	**89.35**

Based on the SUS scores obtained, the average SUS score is 89.35, indicating that the system is performing well.

3 Conclusion

The typing test results indicated that the group of respondents with frequent typing intensity using a smartwatch achieved the highest WPM and character count values. This implies that respondents' occupational/educational background and experience with using a smartwatch do not necessarily guarantee ease of comprehension and typing on a small screen. This observation is supported by the relatively similar typing test results among the different groups of respondents in the conducted grouping process. Moreover, the Layout One Line Plus Soft Keyboard achieved a System Usability Scale (SUS) score of 89.35, indicating that the system is performing effectively. The results indicate that the One Line Plus soft keyboard layout has the potential to enhance text entry on smartwatches.

References

1. K. B. Min and J. Seo, IEEE Access **9**, 75187 (2021)
2. F. C. Y. Li, R. T. Guy, K. Yatani, and K. N. Truong, *The 1line keyboard: a QWERTY layout in a single line*, in Proceedings of the 24th annual ACM symposium on User interface software and technology, 16 Oct 2011, (2011)
3. I. S. MacKenzie, R. W. Soukoreff, and J. Helga, *1 thumb, 4 buttons, 20 words per minute: design and evaluation of H4-writer*, in Proceedings of the 24th annual ACM symposium on User interface software and technology, 16 Oct 2011, (2011)
4. S. Oney, C. Harrison, A. Ogan, and J. Wiese, *ZoomBoard: a diminutive qwerty soft keyboard using iterative zooming for ultra-small devices*, in Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, 27 April 2013, (2013)
5. M. D. Dunlop, A. Komninos, and N. Durga, *Towards high quality text entry on smartwatches*, in CHI'14 Extended Abstracts on Human Factors in Computing Systems, 26 April 2014, (2014)
6. H. Cho, M. Kim, and K. Seo, *A text entry technique for wrist-worn watches with tiny touchscreens*, in Adjunct Proceedings of the 27th Annual ACM Symposium on User Interface Software and Technology, 5 Oct 2014, (2014)
7. A. Ishii, H. Hakoda, and B. Shizuki, *Flickey: Flick-Based QWERTY Software Keyboard for Ultra-small Touch Screen Devices*, in Human-Computer Interaction. Interaction Technologies: 20th International Conference, HCI International 2018, 15-20 July 2018, Las Vegas, NV, USA (2018)

8. E. P. Mandyartha, P. W. Atmaja, H. E.Wahanani, M. H. P. Swari, *One Line Soft Keyboard with T9-keys Layout Proposal on Smartwatch Touch Screen Device*, in IOP Conference Series: Materials Science and Engineering 2021, 1 May 2021, (2021)
9. S. Zhang, Y. Hu, and G. Bian, *Research on string similarity algorithm based on Levenshtein Distance*, in 2017 IEEE 2nd Advanced Information Technology, Electronic and Automation Control Conference (IAEAC), 25 March 2017, (2017)
10. Y. Hu, X. Jing, Y. Ko, and JT. Rayz, *Misspelling correction with pre-trained contextual language model*, in 2020 ieee 19th international conference on cognitive informatics & cognitive computing (icci* cc), 26 Sep 2020, (2020)