SoftTouchpad: A new input touchpad for text editing and positioning

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***Abstract*—We present a new method for text editing operations, introducing a new keyboard with a touchpad that allows user to move a cursor in a way to pointing and selecting text in the same way as it would on a notebook. It permits to perform also some editing actions (such as cut, copy and paste), in a way that allow user to use both QWERTY and this one, with a simple switch between them.**

Our Touchpad keyboard was compared in a user study with traditional keyboard (QWERTY). The results show generally advantages for our design in term of accuracy, but also in speed our method can be the best with some editing operations.

I. Introduction

In last years the idea of having to use different text editing methods has arisen, since in modern ones there are several problems, such as the problem of the fat finger.

Let's imagine a similar scenario: we want to write a long enough text with our smartphone, since the default QWERTY keyboard of our smartphone has buttons that are too small compared to our fingers, it turns out to be very annoying and difficult to comfortably write / edit the text and therefore there may be some typos. To be able to make changes, we must move the finger until selecting the character taken into consideration, delete it and insert the correct character. This modification is quite intuitive but inconvenient, both in terms of time and in terms of convenience.

Another problem of editing operations is the selection of a certain number of characters in a text. In the traditional method, to select a portion of text, we have to long-press on text and then move right and left cursors to adjust the selection. This operation results to be unintuitive and very slow.

Hence the idea of being able to emulate what the concept of a mouse is. Use a trackpad as for notebooks, with a pointer that is able to select precisely and conveniently the characters or phrase we want to change.

Given the accuracy and familiarity with the touchpad, the new method may be more efficient than the traditional method, making text selection on mobile devices almost on par with selection on notebooks. Here we present a Touchpad keyboard designed to improve the performance of editing operations. It works as a traditional touchpad, enabling the movement of a mouse cursor and interacting with the edit text as a traditional mouse. The paper is structured in 6 sections. Section 2 describes the related works about our technique. Section 3 is the central part of paper, that describes the proposed solution. Section 4 tells the reader how the experiment was designed and carried out. The section 5 reports results about statistical analysis of dependent variables and discussion about final considerations. The last section summarizes what we developed and experimented.

II. Related works

The purpose of this section is to facilitate smartphone text editing task giving some results of previous studies.

Several researches have been done on text editing and positioning. H.Le et al. in [1] implemented several gestures for a fully touch-sensitive smartphone, in the way of perform text editing with shortcuts like the ones on a laptop.

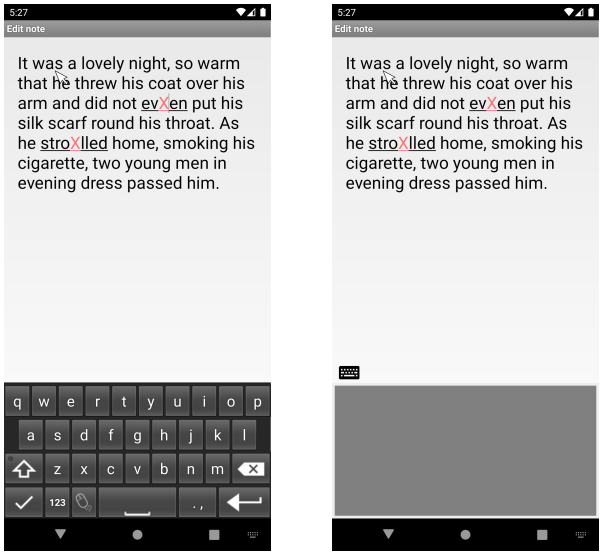
Zhang et al. in [2] has proposed a new keyboard gesture system for more effective text editing. The design contains totally new gestures, including the ring gesture and others to be able to control the cursor. Other gestures are to represent the basic operations, that is to copy, paste, cut and cancel. From their results, it appears that it turns out to be 20% faster than other methods.

Ando et al. in [3] presented a new method to perform the selection operation and basic commands by tilting the device, called Press & Tilt. The user can perform various operations, including cursor navigation or text selection by tilting the device while pressing a button on the keyboard. When the button is released, basic operations such as copying, searching and translating are performed based on the selected text. Obviously the command executed depends on the key pressed.

Fuccella et al. in [4] has implemented a text editing system via gesture, implemented as an Android Service where it can be used in any text editing operation. The gestures are represented above the virtual keyboard and translated as commands to move the cursor, make selections and so on. Their results resulted in a 13-14% performance improvement, depending on the font size.

III. Proposal

Proposal section wants to describe our proposed solution, highlighting the major difficulties encountered and how they were solved.



(a) QWERTY keyboard (b) Touchpad keyboard

Fig. 1: Keyboards

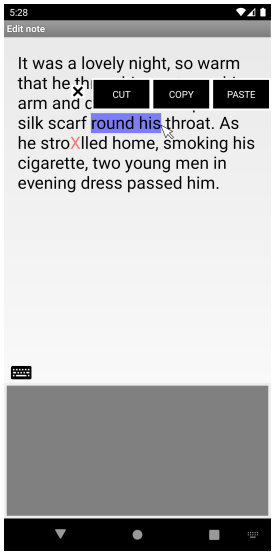


Fig. 2: Text selection

Both QWERTY keyboard and Touchpad keyboard was thought for Android mobile devices, using Java and XML layout in Android Studio IDE. They was designed by an Android Service, with a simple switch between them.
The QWERTY keyboard was implemented by customizing Android *Soft Keyboard* sample project, introducing a key for switching from/to the other keyboard, while Touchpad keyboard was implemented from scratch using a simple colored background for design the touchpad, and a standard image for drawing mouse cursor. The latter was developed as an *AccessibilityService* using the Android library. In Figure 1 it can be observed the design of the Touchpad and QWERTY keyboard.

The touchpad developed permit to perform the typical operations of a notebook touchpad. In particular it allows the movement of the cursor, click on text positioning the text cursor, and allows to select the text (including text editing operations). Touchpad keyboard allows to move the cursor by entering in the touchpad area (Figure 1.b) and move the finger. The pointer of the appearing cursor will move according to the movement of the finger on the X-axis and Y-axis. Details on the operations are shown in Table I. Our keyboard allows to perform the operations in following ways:

- **Text positioning** - When the cursor pointer is in arrow mode, it is possible to place the cursor on a certain character.
- **Text selection** - When the cursor pointer is in selection mode (one finger touch and moving cursor), it is possible to select a portion of text. In Figure 2 it can be observed a screenshot of this operation.
- **Editing operations** - When the text is selected, Cut, Copy and Paste buttons appear on top of selected text and it is possible to perform editing operations clicking on them.

Action	Touch Operation	Text Operation
Dragging	Moving Cursor	.
Single tap	Single click	Text Positioning
Single tap + Dragging	Single Click + Moving	Text Selection

TABLE I: Mapping Operations

IV. Evaluation

We designed a user-study whose objective was to compare the performance of text editing with the standard method (QWERTY keyboard) and our method (Touchpad keyboard).

A. Partecipants

We recruited 12 participants (8 males and 4 females) among students in our university. Their ages ranged from 20 to 25. Partecipation was voluntary and participants were unpaid. All partecipants had previous experience with mobile devices and touch-screens. All of them had at least some experience with mouse. However, only some of them had used or emulated mouse on a smartphone.

B. Apparatus

The device used for the experiment was a OnePlus 7 Pro 256GB with a 6.67” display and resolution of 3120x1440 pixels. The device ran the Android 11.0 Operating System.
The experimental software was composed of:

- QWERTY keyboard: the simple soft keyboard with the baseline layout, taken by *SoftKeyboard* project.
- Touchpad keyboard: a keyboard composed only with an area that simulate the mouse touchpad of notebooks.
- Input text: a simple editable input text to perform editing operations.

The keyboards were implemented as an Android Input Method Service and both had the same size. The input text was developed to allow our participants to perform six sub-tasks. The Main Activity created a log file for each task, reporting the values of dependent variables (Effective speed, ER).

Task	Title	Description	Presented Text	Final Text
1	ERASE CHARACTER	Erase the X letters from the text	It was a lovely night, so warm that he threw his coat over his arm and did not evXen put his silk scarf round his throat. As he stroXlled home, smoking his cigarette, two young men in evening dress passed him.	It was a lovely night, so warm that he threw his coat over his arm and did not even put his silk scarf round his throat. As he strolled home, smoking his cigarette, two young men in evening dress passed him.
2	ERASE WORD		It was a lovely night, so warm that he threw his coat over his arm and did not even put his silk scarf XXXXXX round his throat. As he strolled home, smoking his cigarette, two young men in evening dress passed him.	It was a lovely night, so warm that he threw his coat over his arm and did not even put his silk scarf round his throat. As he strolled home, smoking his cigarette, two young men in evening dress passed him.
3	ERASE PHRASE		It was a lovely night, so warm that he threw his coat over his arm and did not even put his silk scarf round his throat. As he XXXXX XXXXX strolled home, smoking his cigarette, two young men in evening dress passed him.	It was a lovely night, so warm that he threw his coat over his arm and did not even put his silk scarf round his throat. As he strolled home, smoking his cigarette, two young men in evening dress passed him.
4	MOVE WORD(Cut and Paste)	Carry out a cut operation near the word highlighted in green and a paste operation near the green bar	It was a lovely night, so warm that he threw his coat over his arm and did not even his put / silk scarf round his throat. As he strolled home, smoking his cigarette, two young men in evening dress passed him.	It was a lovely night, so warm that he threw his coat over his arm and did not even put his silk scarf round his throat. As he strolled home, smoking his cigarette, two young men in evening dress passed him.
5	COPY-PASTE	Make a copy operation near the word highlighted in green and a paste operation near the green bar	It was a nice night, so warm that he threw his coat over his lovely arm and did not even his put silk scarf round his throat. As he strolled home, smoking his cigarette, two young l men in evening dress passed him.	It was a nice night, so warm that he threw his coat over his lovely arm and did not even his put silk scarf round his throat. As he strolled home, smoking his cigarette, two young lovely men in evening dress passed him.
6	TEXT CORRECTION	Fix the two text errors	It was a lovely night, so warXm that he threw his coat over his arm and did not even put his silk scarf round his throat. As he strolled home, smoking XXXX his cigarette, two young men in evening dress passed him.	It was a lovely night, so warm that he threw his coat over his arm and did not even put his silk scarf round his throat. As he strolled home, smoking his cigarette, two young men in evening dress passed him.

TABLE II: Editing Task List

C. Procedure

All participants completed an initial questionnaire by entering their personal information and previous experiences related to the experiment. Only after completing the questionnaire, they were able to start the experiment with a training phase, where each participant practised with the keyboard unfamiliar to him/her (Touchpad keyboard) for ten minutes each. During practice, participants were explained all of details provided by the keyboard and were invited to execute them. Participants were encouraged to ask any questions about the training before the beginning of the task. The experiment took place in a classroom from University of Salerno. The participant were able to hold the device in the way they want and sit as comfortably as possible, in order to make them feel suitable. The experiment is conducted on two conditions (one for each keyboard) by all the participants.
Operating with the Touchpad keyboard, the participants will have the device on which the experiment will be carried out, where for each task there will be a particular text. There was six sub-tasks to be done,described in Table II, *ERASE CHARACTER*, *ERASE WORD*, *ERASE PHRASE*, *MOVE WORD(Cut and Paste)*, *COPY-PASTE*, *TEXT CORRECTION* where each of this task includes the *SELECTION* operation. For each task, a given operation will be performed in the text, where a specific word will be cut/copy/selected and so on. Before each Task, it is decided to what size (Small, Medium and Large) you want to set the font of each sub-task, organizing them in such a way as to make a different order for each participant.
Test conditions were balanced between participants and they are shown in Table III:

Participant	Training font	Block-Font Order	Technique Order
1	m	s-m-l	touchpad-qwerty
2	m	s-l-m	touchpad-qwerty
3	m	l-m-s	touchpad-qwerty
4	m	l-s-m	touchpad-qwerty
5	m	m-s-l	touchpad-qwerty
6	m	m-l-s	touchpad-qwerty
7	m	s-m-l	qwerty-touchpad
8	m	s-l-m	qwerty-touchpad
9	m	l-m-s	qwerty-touchpad
10	m	l-s-m	qwerty-touchpad
11	m	m-s-l	qwerty-touchpad
12	m	m-l-s	qwerty-touchpad

TABLE III: Counterbalancing

For each text that was presented for the task, errors was colored respectively to improve readability, convenience and above all to make the participant understand how to carry out the task. The duration of the activity, recorded to calculate the typing speed, has been established as follows: it starts when the user has pressed on the list to select a sub-task, perform the first touch operation on the displayed text and it ends when the user finishes the activity or when it performs the activity incorrectly and, if so, when you suddenly quit the activity. At the end of the experiment, participants were asked to fill out two usability questionnaires (one for Keyboard and for SoftTouchpad) in order to obtain participant's opinion on usability. The questions were retrieved from the SUS [5] (System Usability Scale), where it mainly consists of 10 questions that measure the usability of the system. The questionnaire consisted of statements on which participants express their level of agreement on a 5-level Likert scale. We also collected some views and comments in free form in another questionnaire, in which we asked to express the preference between Touchpad and QWERTY in terms of speed, accuracy and comfort.

D. Design

The experiment was a two-factor within-subjects. The tested factors was the *Input Method* with the following two levels: QWERTY and Touchpad keyboard and *Text size* with 3 modes: small(3mm), medium(4mm) and large(5.5mm).
The dependent variables were the Effective Speed (determined at the first touch on the sub-task screen) and Accuracy (in terms of Error Rate, where each sub-tasks is represented by Error State, that is Completed or Failed). From the results of each participant, the average of each sub-task is calculated, thus obtaining the performance. Finally, an average was made between all the participants' performances, obtaining a final value.

V. Results and Discussions

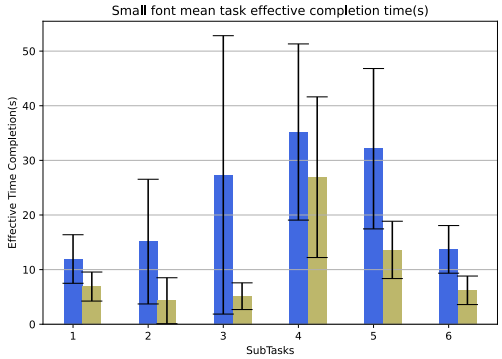
The experiment lasted about 40 minutes per participant. Our research hypothesis is:

- ***H0: There is no difference between SoftTouchpad and Keyboard in terms of speed and accuracy.***
- ***Ha: There is a significant difference between SoftTouchpad and Keyboard in terms of speed and accuracy.***

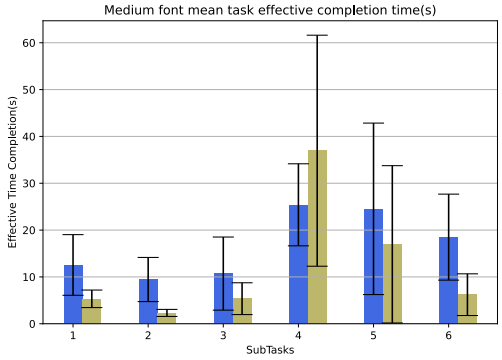
We used ANOVA test to validate our results. For significant main effect, we used Scheffé post-hoc tests. The alpha level was set to 0.05.

A. Effective speed

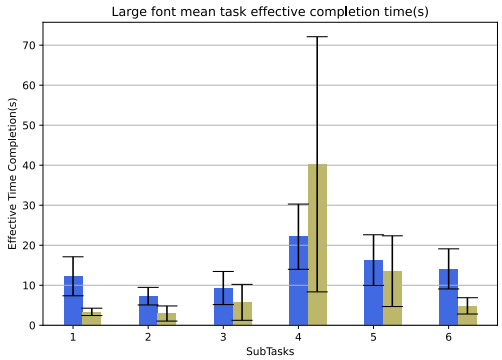
The results of mean speeds for each font and sub-tasks used are reported in Figure 3, while the results of mean speeds for each font only is reported in Figure 4. The fastest method was QWERTY, with mean time of 11.49 seconds, while Touchpad method had mean time of 17.66 seconds.
Even if, in some tasks (e.g. *Cut & Paste*), Touchpad method was faster than QWERTY. In terms of tasks, the fastest was the *ERASE WORD* for both methods, while the slowest was the *Cut & Paste*.



(a) Small



(b) Medium



(c) Large

Fig. 3: Mean speed for each font

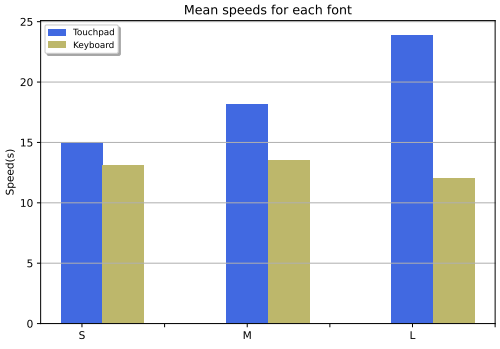
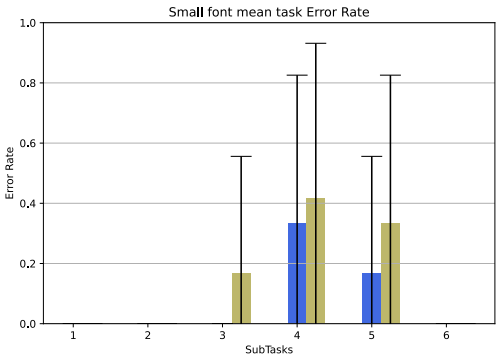


Fig. 4: Mean completion times

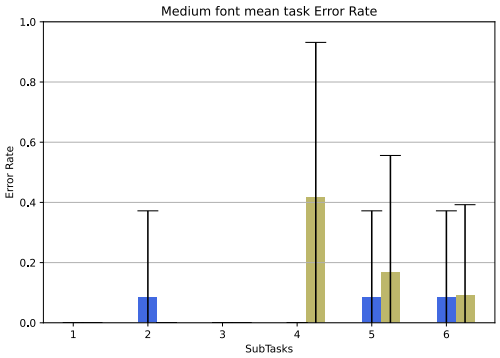
B. Error rate

The results of error rate for each font and each sub-tasks is reported in Figure 5, while the results of mean error rate for each font only is reported in Figure 6. The lowest error rate was discovered in Touchpad method with mean of about 5%, while in QWERTY method the mean of error rate was about 12%.

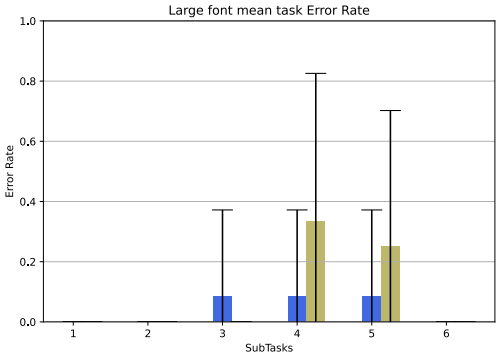
In terms of tasks, the lowest error rate was found in *ERASE CHARACTER* for both methods, while the highest was found in *Cut & Paste* task, always for both methods.



(a) Small



(b) Medium



(c) Large

Fig. 5: Mean error rate for each font

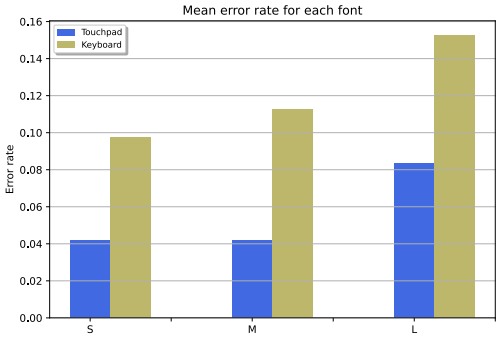


Fig. 6: Mean error rate

C. ANOVA and Scheffé Post-Hoc

The results of ANOVA test are as follows:
The effect of method on effective speed was statistically significant ($F_{1,11} = 20.095$, $p < .001$). The effect of font on effective speed was not statistically significant ($F_{2,22} = 2.619$, $p > .05$). The *method* $\times$ *font* interaction effect was statistically significant ($F_{2,22} = 9.794$, $p < .001$).

In Scheffé Post-Hoc test, we found the following pairs as significant:

- **Pair (1,3)** : Touchpad/Large and Touchpad/Small
- **Pair (3,4)** : Touchpad/Small and QWERTY/Large
- **Pair (3,5)** : Touchpad/Small and QWERTY/Medium
- **Pair (6,5)** : Touchpad/Small and QWERTY/Small

D. Questionnaire Results

From a first demographic questionnaire, it is immediately evident that most of the participants have positive previous experiences both with mobile touchscreen keyboards (QWERTY) and with physical keyboards (the average on Likert scale is respectively 4 and 4.6). On the other hand, there is a clear difference in the mouse experience relative to mobile devices (obtaining an average of 2.25). Finally, all participants are asked to choose their preferred choice between Mouse and Touch, where it is noted that 60% of participants prefer the Touchscreen and only 40% prefer the Mouse.
After the experiment, the participants carried out three other questionnaires, two of which are aimed to have knowledge of the usability of both methods and the last questionnaire relating to the final considerations of the participants.
The two usability questionnaires follow the SUS [5] (System Usability Scale) standard which, through ten standard questions, comprehensively assess the participant's vision of usability. As you can see in Figure 7, there are the averages of the answers for each question, both for SUS Touchpad and SUS QWERTY. The final results of SUS questionnaires are in mean 70.63 for Touchpad and 85.42 for Keyboard.For the final questionnaire, for the final questionnaire, the participants were asked to express their preference between Touchpad and QWERTY. The results showed that 11 participants preferred to use QWERTY, while only 1 preferred Touchpad. 7 participants prefer QWERTY in terms of speed, while 5 prefer Touchpad. 9 participants preferred Touchpad in terms of accuracy, while 3 preferred QWERTY. 7 participants prefer QWERTY in terms of comfort, while 5 prefer Touchpad.

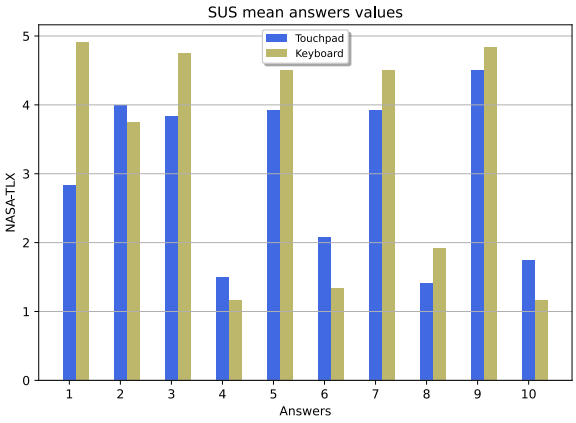


Fig. 7: SUS mean answers values

VI. Conclusion

From experiment results and final questionnaires, was found that Touchpad method improve the text editing operations. In particular, our method resulted the best method for accuracy, given the lowest error rate founded. Otherwise, QWERTY method resulted in best speed, but not in all tasks. In fact, as discussed in Section 5.A, in some tasks our method performed better in terms of both speed and error rate.
Furthermore, our method can be adapted also on different fonts of displayed text, and our experiment resulted in better accuracy and speed when the text was smaller. This can be an advantage especially when it is present the 'Fat finger' problem.
In conclusion, the results have been satisfactory. Moreover we could consider to evaluate a longer use of our method in order to accustom a user for a longer time to this technique that, from the results obtained, seems to point to an excellent use, especially in certain operations.
An idea for a future development might be to integrate our method with traditional method in a better way, in order to allow user to use both the proposed method and the traditional method, so that the user can be supported during the migration to the new text editing method.

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