Text Editing in Digital Terrestrial Television: a comparison of three interfaces

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Abstract
The aim of this paper is to compare three different text editing interfaces for Digital Terrestrial Television. The study shows a significant relationship between users' level of experience in text editing using mobile phone and their favourite interface. Moreover, the analysis demonstrates that there is no relationship between users' level of experience and the editing problems they encountered.

Keywords
Digital Terrestrial Television, remote control, text input, graphical interface.

1. Introduction

By the end of 2012, there will be the European migration from traditional analogical broadcast system to Digital Terrestrial Television (DTT). This means that all television channels will be broadcasted digitally.

Every country fixed a different date for the so-called "switch off". In Italy it will be at the end of 2008.

Besides the technical details, the main innovation will be the enhanced interactivity: by simply connecting a set-top-box to a television, users will be able to enjoy additional content and interactive applications. Furthermore, via a return channel, users will be able to send data to broadcaster (for example to participate in quizzes, to vote, to play games and so on). For this reason public funding were released by the Italian government to support the new market, in order to increase sales of interactive DTT set-top-boxes and to spread T-Government services to all kinds of users: young and old, expert and naive.

We can imagine a future scenario, in which, for example, an elderly person has to fill records to book a medical examination by DTT. The only device she has to interact with the DTT is the remote control.

We can suppose that young people are facilitated in editing text using a remote control because of their familiarity in sending Short Message System (SMS) with a mobile phone. Instead, DTT will involve an enlarged target, so is important to study criticalities in text editing both for expert and inexpert users. As a consequence it is fundamental to design a usable graphical interface for text editing.

The aim of this paper is to evaluate three different text input interfaces, in order to find out if there is an easy and fast way to edit text using a remote control.

This paper is organised as follows: in Section 2 we present some related works concerning text input methods, in Section 3 we describe the three different input interfaces that we evaluated, in Section 4 we detail the experimental design. In Section 5 we analyse the results and, finally, in Section 6 and in Section 7 we present our planned future work and conclusions.

2. Related Works and Issues

Several studies concerning methods for text entry have been undertaken within the HCI field (MacKenzie, I.S.E., 2002). Most of the researched methods are not suited for the home entertainment context. In fact, they require input devices very different from a handheld DTT remote control, such as a stylus (Zhai, S., et al., 2003) or a QWERTY keyboard (Karat, C.M., et al., 1999).

Considering the hardware restrictions of set-top-boxes and TV, the only current way to edit text within a DTT is through a remote control (see Fig. 1).

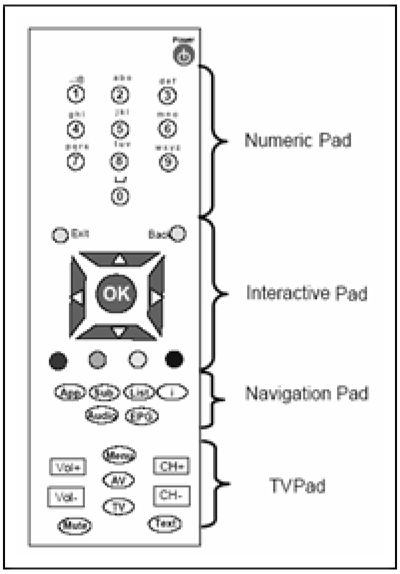

Fig. 1 – Typical DTT remote control (DGTVi D-Book, 2004)

The alpha-numerical keys of DTT remote control can be compared to mobile phones keys so we started our analysis from the previous researches on text editing using a mobile phone keypad.
Several works in text editing using mobile phone are significantly related to this project. For example, Pavlovych & Stuerzlinger (2004) studied a new model for predicting text entry speed on a 12-button mobile phone keypad. Silfverberg, MacKenzie & Korhonen (2000) and Butts & Cockburn (2002) evaluated three text input techniques on mobile phones: two-keys, multi-press with timeout and multi-press with next button input methods. Subjective ratings of the three methods did not yield significant differences and the experimental users rated all three text input methods frustrating.
An innovative study regarding text entry using a remote control was conducted by Ingmarsson, Dinka, & Zhai (2004). They tested the performance of a novel text input method for interactive TV: The Numpad Typer (TNT). Within TNT the TV screen shows letters and special characters chunked into six groups: the user has to press two numeric keys to produce a letter on the screen. The first one selects a group while the second one selects the character. Despite TNT performance was comparable or superior to the current PDA hand writing or multi-tap methods, the study evaluated only a small group of users familiar both with QWERTY keyboards and T9 system on their own mobile phone.
The aim of our project is instead to evaluate input methods currently available on Italian DTT interactive applications for both expert and naive users. In our research we want to investigate if there are the same criticalities in text editing using Digital Terrestrial Television, considering also peculiar problems of DTT context of use. Moreover we want to understand if the level of experience in the use of mobile phone to send SMS can influence users' performance.
For example, one of the main issues when entering text on mobile phones is the mapping between letters and keys. In fact, each key is mapped to at least three letters, following the ETSI ES 202 130 V1.1.1 (2003-10) standard for character repertories. This consists of a set of ordering rules and assignments to the 12-keys telephone keypad. On a DTT remote control we found the same mapping, even if there are some differences regarding special characters (i.e. @, !, etc.), because, currently, there are not standards for remote control numeric keypads. The mandatory keys and key events available to the application are very limited and thus keys and key events may vary from manufacturer to manufacturer. In order to fill the gap, the DGTVi society[1] published a reference guide (DGTVi D-Book, 2004) concerning DTT receivers and remote control, aimed at Italian application developers and users.
Another issue that should be taken into account is the focus of users attention. When using a mobile phone users' attention is focused on a single device (the mobile phone itself), while in the DTT context, a user has to pay attention both to the screen and to the handheld remote control.
Finally, a peculiar usability problem on DTT is the long latency time between user input and screen feedback. As usability studies demonstrate (Miller, 1968), it is fundamental to reduce this latency time: typically latency should be less than one second in order to keep a user's attention.

3. Text Input Method

In this paper we compare three different interfaces for text editing using a DTT remote control. Two of them (see sub-Section 3.1 and sub-Section 3.2) follow the mobile phone text entry paradigm called multi-press with timeout. Instead, the last one (see sub-Section 3.3) follows the keyboard typewriter paradigm. Each of these techniques is detailed below.

3.1 Multi-press with timeout interface

In the multi-press with timeout technique, a user cycles through letters by pressing several times a single key. If the user does not press any key during a predefined time (timeout) the interface will select the character currently on screen. For example, to edit "CDE", the user must press the "3"-key once, then wait for the time-out to expire. Then she must press the "3"-key twice. Finally, once the timeout has expired, she must press the "3"-key three times.
In our multi-press with timeout interface (see Fig. 2), a text box shows the user the cycling of the alpha-numeric character mapped to the key that she is pressing. The cancel function is associated to the yellow button on the interactive keypad, represented by a yellow icon on the TV screen.

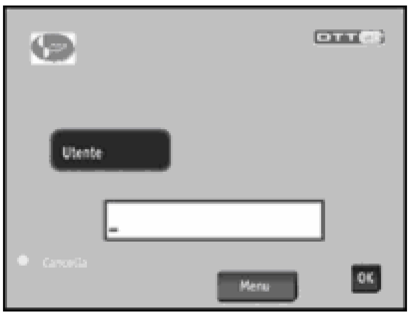

Fig. 2 - Multi-press with timeout keyboard

[1] http://www.dgtvi.it

3.2 Multi-press with timeout and visual feedback interface

This interface is a variation of the multi-press with timeout technique based on a representation of the numeric keypad of the remote control on the TV screen (see Fig. 3). In this way the user gets a visual feedback regarding the character she is selecting by watching the cycling of the alpha-numeric character both on the text box area and on the numeric pad representation.

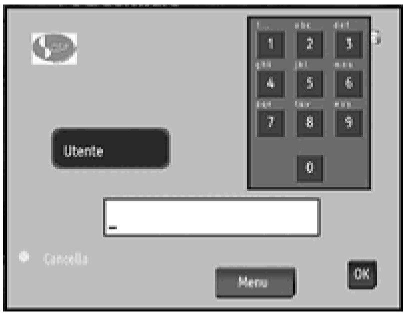

Fig. 3 - Multi-press with timeout and visual feedback keyboard

3.3 Virtual keyboard

In the virtual keyboard interface, the user navigates a virtual keyboard on the TV screen using the arrows keys of the interactive keypad and selects the right alpha-numeric character pressing the "OK" button (see Fig. 4). Once she has selected the character, this appears on the text box area. The cancel function is associated to the "Canc" virtual key on the TV interface.

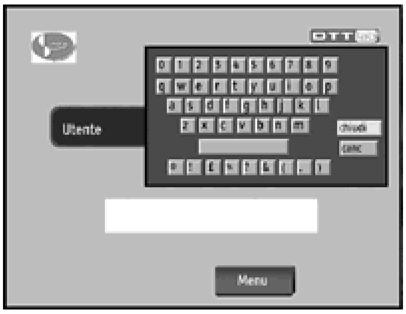

Fig. 4 - Virtual keyboard

4. Experimental Design

The aim of this evaluation is to determine whether there are meaningful differences between the efficiency and the effectiveness of the three text editing interfaces. The experiment was conducted using a within-group design, with the interface type as an independent variable. As mentioned before, the possible interface type were multi-press with timeout, multi-press with timeout and visual feedback and virtual keyboard.

Thirty-six subjects (selected considering their level of experience in typing SMS) participated to the experiment solving six tasks (two with each interface). The order in which the users experienced the three interfaces as well as the order of tasks was random, to minimize learning effects.

The subjects were divided into two sub-groups (eighteen users each), according to the different level of experience in entering text using a mobile phone. We considered as expert users who send more than 5 SMS per week and as naive all the others. The expert user group included 10 male and 8 female, aged 18-50 while the naive user group included 8 male and 10 female, aged 43-80.

4.2 Procedure

The evaluation was conducted in the laboratory room of the DTTLab[2] - one of the permanent research groups of the CSP[3] research centre- showing the interfaces on a TV (Medion – 42'') connected to a DTT set-top-box (ADB-Embox).

Users were given a introductory letter to explain the aim of the test, and clarify that the purpose of the experiment was to evaluate three different text editing interfaces, not their ability. Then they were given a DTT remote control (see Fig.5) to interact with the text input applications interfaces.

Each subject was asked to solve two tasks using each interface: *i*) in Task 1 (T. 1) the user had to enter an e-mail address (*pippo@libero.com*); *ii*) in Task 2 (T. 2) the user had to type a short Italian sentence (*sole e neve*).

Fig. 5 – ADB Embox remote control

Naive users were given a training period of 5 minutes, to familiarise with the input method.

Each test session was video recorded, in order to measure both user's performance and time spent to complete each task. Moreover we asked users to express their thoughts and questions aloud, to make a qualitative evaluation.

After the users completed the test, they were asked to fill in a short questionnaire to choose their

[2] http://www.dttlab.it is a CSP permanent laboratory on Digital Terrestrial Television.

[3] http://www.csp.it/en/

favourite text editing interface and to detail the problems found. In particular the questionnaire was divided into three sections: the first section concerned social-demographical data (age, gender, profession and number of SMS sent per week), the second one had multiple choices questions (user's favourite interface, problems in the use of each interface, etc.) and the last one was dedicated to users' comments.

5. Results

The analysis showed that all the tested interfaces failed, mainly because of the delay of the set-top-box.

In particular, both the multi-press with timeout interfaces had these main problems:

- **Localization of special characters key**. All inexpert users and two expert users needed help to find the symbols key (in our application they were on "1"-key);
- **Number of key pressures in order to select a special character**. Once they were told where a special character was, users speculated on how many times they had to press the key to find the required special characters ("@" and "."). In fact, special characters' order of appearance is not standard neither on current mobile phones nor on DTT applications. All inexpert users stopped pressing "1"-key after three pressures, while expert users cycled through the special characters until they found the right one;
- **Localization of the cancel key**. Although a yellow icon on the TV screen advised the users that the cancel function was associated to the yellow button on the DTT remote control, most of the users (both expert and naive) needed help to find the cancel key. The problem was that the users looked at the remote control instead of the TV screen;
- **Localization of the blank key**. All inexpert users needed help to find the blank key even if it was associated to the standard "0"-key (like on mobile phones). Instead, expert users had no problems in finding it.

The virtual keyboard interface showed instead these problems:

- **Confirm the right character**. Even if during the training time users were told to press the "OK"-key to confirm the selection, both expert and inexpert users frequently forgot to press it.
- **Slowness of text editing and frustration**. The average time spent in completing both tasks using the virtual keyboard interface was higher than the average time spent in completing the tasks using the other two interfaces (see Table 1). Even if at the beginning users were enthusiastic of the easiness of interaction, later most of them became frustrated by the long time required to complete the tasks.
- **Localization of the blank button**. The virtual keyboard interface layout (see Fig. 4) follows the typewriter metaphor therefore the blank button is represented by a bar button without any label. Despite that most of the inexpert users (60%) did not understand the metaphor and, consequently, did not find the blank button.

		Expert	**In-expert**	**Total**
Multi-press	T. 1	55.45	151.4	93.8
	T. 2	23.2	75.9	48.8
Multi-press with visual feedback	T. 1	93	173.4	119.8
	T. 2	42.6	85	66.3
Virtual keyboard	T. 1	106.6	187.8	131.6
	T. 2	63.9	156.3	104

Table 1 - Average time per task in seconds

Considering the difficulties expressed by the users in the questionnaire, we did not find meaningful differences in problems underlined both by expert and inexpert users: 1) multi-press with timeout ($X^2 = 4.267$, $df = 5$, $N = 36$, $p = 0.512$); 2) multi-press with timeout with visual feedback ($X^2 = 5.026$, $df = 5$, $N = 36$, $p = 0.413$); 3) virtual keyboard interfaces ($X^2 = 8.356$, $df = 5$, $N = 36$, $p = 0.138$).
Besides, we analysed the performance results of each interface, focusing on efficiency and effectiveness.

Regarding the **efficiency**, we calculated the average time spent to complete each task, the percentage of completed tasks and the average number of characters typed per second (cps). Examining the average time per task (see Table 1), we found that the multi press with timeout interface got the best performance (almost half the time of virtual keyboard).
The percentage of uncompleted tasks was lower in multi-press with timeout interface than in virtual keyboard and in multi-press with timeout and visual feedback interfaces (see Table 2). In particular, the percentage of uncompleted tasks (in all interfaces) for naive users is higher than the expert users' one. Due to the different number of completed tasks between the two sub-groups, we could not make an

analysis of variance (ANOVA) between expert and naive users' performance.

		Expert	In-expert	Total
Multi-press	T. 1	0%	33.34%	16.6%
	T. 2	0%	5.5%	2.78%
Multi-press with visual feedback	T. 1	0%	50%	25%
	T. 2	0%	5.5%	2.78 %
Virtual keyboard	T.1	0%	55.5%	27.7%
	T.2	5.5%	27.78%	16.67%

Table 2 – Percentage of uncompleted task

Finally, we considered the average character per second. Multi-press with timeout interface was the highest performing again (see table 3). Both for Task 1 (see Fig. 6) and Task 2 (see Fig. 7), the gap between expert users' cps and inexpert users' cps is very wide. Instead, we could not notice any significant gap between expert and inexpert users' cps in the other two interfaces.

		Expert	Inexpert	Total
Multi-press	T. 1	0.29	0.17	0.15
	T. 2	0.48	0.26	0.17
Multi-press with feedback	T. 1	0.10	0.09	0.08
	T. 2	0.14	0.13	0.07
Virtual keyboard	T. 1	0.17	0.13	0.12
	T. 2	0.22	0.16	0.1

Table 3 – Average character per second (cps)

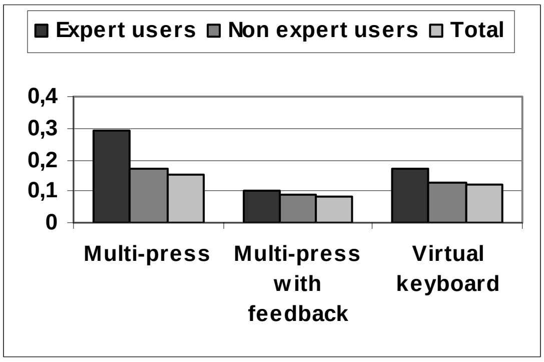

Fig. 6 – Average character per second (cps) in Task 1

The results of our studies can be compared, with some caution, to the results of previous researches. For example, the TNT method (see Section 2) has better performance regarding cps (between 0.77 cps and 1.47 cps) but it is not realistic. In fact, this method recognizes users' mistakes and do not move forward in the text since the correct letter has not been entered. In this way the users had no need to look for the cancel button on the remote control to correct the wrong character. Therefore the expert performance in our multi-press interface is comparable to TNT one. We can also compare our study to Graffiti and Jot input technique (Sears, A. & Arora, R., 2002). Text entry speed with this method is in the range of 0.36-1.73 cps, comparable to the best performance of our multi-press interface. Finally the estimated speed of multi-press on a mobile phone (1.73-2.04 cps) is meaningfully higher than on a DTT handheld. However, this result can be explained considering DTT latency limitations (see Section 2).

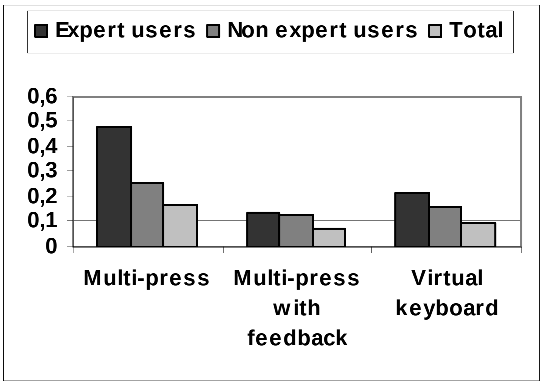

Fig. 7 – Average character per second (cps) in Task 2

Summing up, considering average time, percentage of uncompleted task and cps, multi-press interface scored the best result in terms of efficiency.

Regarding **effectiveness**, we analysed the average number of mistakes made during the text editing. Both expert and inexpert users made less mistakes using the virtual keyboard than using the other two interfaces (see Table 4). This is due to the features of this interface: all symbols and alpha-numeric characters are shown and users do not have to cycle trough the letters.

		Expert	In-expert	Total
Multi-press	T. 1	3	9	5.27
	T.2	1	2	2
Multi-press with visual feedback	T. 1	7	16	10
	T. 2	4	6	5
Virtual keyboard	T. 1	1	2	1
	T. 2	0	2	1

Table 4 – Average errors per task

Questionnaires data were analysed to determine **users' satisfaction**. A meaningful relationship emerged between users' level of experience and favourite interface (X^2 = 10.909, df = 4, N = 36, p = 0.028). Both expert and inexpert users rated the multi-press with timeout interface as their favourite one (see Table 5). Making a sub-group analysis (see Fig. 8), we found that 83.33% of the expert users preferred the multi-press interface because it was the fastest one and the most similar to mobile phones text entry methods. Instead, just 38.89% of inexpert users chose the multi-press with timeout interface, while 22.22% preferred the virtual keyboard and 27.77% liked all of them.

	Espert	In-expert	Total
Multi-press	83.33	38.89	61.11
Multi-press with visual feedback	11.11	5.56	8.33
Virtual keyboard	0	22.22	11.11
All	5.56	27.77	16.67
No one	0	5.56	2.78

Table 5 –Cross-table: subjective ratings for each interface and users' experience level

It is reasonable to suppose that inexpert users encountered problems with all the interfaces but they did not chose the "No one" answer because of the so called "social desiderability" (Roccato, 2003).

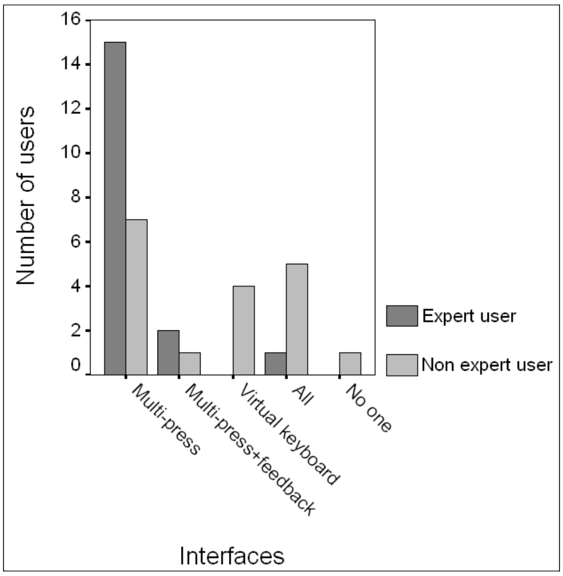

Fig. 8 – Subjective ratings for each interface and users' experience level

6. Future Work

During the first evaluation of text editing using a DTT remote control, we identified the number of presses required to select a special character as the main problem of the multi-press with timeout interface (both with and without visual feedback). We guess that it would be more complicated to type a special character when entering a password (because the text is starred). Our further work will therefore focus on evaluating efficiency and effectiveness of password entry interfaces on a DTT handheld.

Moreover, we are looking for a better solution to communicate to users how to cancel, to insert the blank and to find the desired special characters.

7. Conclusions

In this paper we compared three different interfaces for text entry using a DTT remote control. Results showed that all the interfaces had some usability problems.

Despite considering both expert and inexpert users, multi-press interface emerged as the best one because of:

- the less average time per task;
- the higher user satisfaction (see Fig. 8);
- the higher cps.

Moreover a meaningful relationship was found between users' level of experience in entering text on mobile phones and the interface user indicated as their favorite one. Instead, we did not notice a significant relationship between users' level of experience and type of editing problems expressed in the questionnaires.

Comparing our study to some previous analysis on other input methods, the TNT method had better performance regarding cps but it is not realistic. We also compared our study to Graffiti and Jot input technique and their text entry speed is comparable to the best performance of our multi-press interface. Finally is worthy pointing out how the estimated speed of multi-press on a mobile phone is significantly higher than on a DTT remote control.

The results of our research can be explained considering DTT limitations:

- **the mapping between letters and keys.** Each key is mapped to at least three letters and currently there is not a standard for remote control numeric keypad;
- **the focus of user's attention**. In a DTT context the user has to pay attention both to the screen and to the remote control.
- **the latency time**. Users have to wait a long time to see on the screen the result of their input.

Despite DTT limitations, the multi-press with timeout interface had the best performance regarding efficiency and user's satisfaction. We are aware that we can not consider the multi press with timeout interface as a final solution to text input on a DTT remote control. In fact, we guess that it will not be suitable, for example, when text is starred (editing a password).

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