Evaluating Web Usability Using Small Display Devices

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ABSTRACT
Usability is an important issue studied by many researchers and practitioners. Specifically, we are interested in evaluating web usability using small display devices.
In this paper we evaluate different type of navigation using small display devices: links, folio and search. In order to evaluate it, we propose a laboratory prototype.

Categories and Subject Descriptors
H.5.2 [**User Interfaces**]: Input devices and strategies - *PDA., small devices, touchscreen.* H.3.3. [**Information Storage and Retrieval**]: Information Search and Retrieval - *Search process*

General Terms
Documentation, Design, Human Factors.

Keywords
Usability testing, small display devices, PDA, laboratory testing, field-testing.

1. INTRODUCTION
In the last few years, mobile small devices have grown in popularity and became a helpful tool to everyone. It may be useful for the young boy who likes playing in the bus, or for the businessmen who needs to communicate with his office from the office of his client. Mobile devices enable users to access information and web-based services from any location either by PC or by small display devices. But, those mobile devices are restricted by small screen size, which limit the amount of information that can be displayed at same time. Therefore, it has become increasingly important to learn how to evaluate its use and how to design mobile devices functionalities. It is already proven that an attractive interface is not necessarily good and usable; therefore "a good graphic design and attractive displays can increase users´ satisfaction and thus improve productivity" [10].

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Magnusson [16] presents a graphic design menu, similar to a folio type menu, for small display devices, which makes a correspondence between a logical information view to a regular web browser, whether that information is viewed in a larger screen or in a small display device.

Andrews [1] explains the psychology of usable things presenting where the design of everyday things went wrong, like a remote control: "Some of the buttons on a VCR remote control are easy to understand, but other are unfathomable without the instruction manual". Starting in the mid of 80s and gaining strength in the 90s, the interface development community employed usability engineering methods to design and test software systems for ease of use, ease of learning, memorability, lack of errors, and satisfaction [17]. Usability practitioners of the 1990s considered two factors as measures of usability [3]: the ease of learning and the ease of use.

Learnability, flexibility and robustness are pointed out as three principles that support usability [10]. In this study there were taken into account learnability and flexibility. As learnability [10] is intended to be "the ease with which new users can begin effective interaction and achieve maximal performance. Flexibility is the multiplicity of ways in which the user and system exchange information."

Usability testing is an usual tool used to evaluate the usability of a mobile application in a development process. In fact, mobile and handheld usability testing could be even more important than computer-based usability testing. Webcredible [23] explain the main reasons for this:

- Increase of small display devices sales.
- Less experience of using small display devices to navigate on the web than using desktop computers.

In this paper we are interested in evaluate three type of web navigation and information search: links, folio and search.

With this paper we present a tool to analyse the layout navigation preferences of small devices users. This paper describes a prototype that may be used through the web.

In the following section, we analyse the literature related to usability testing in small display devices. In the section 3 we describe another two type of tools. Then we describe the experimental framework. This description was used as support to the implementation. Finally, the use of the prototype is described.

2. VISUALIZING INFORMATION IN SMALL DISPLAY DEVICES

Some studies had been made to analyse transformations of web pages layout from desktop for small devices. In order to solve this problem of visualizing information in small display devices, explore different perspectives of researchers [20][6][7]. They identified two dimensions to categorize the problem of presenting information in small device: adaptation place and type/level of manipulation. In the adaptation place, that it can be client, independent server or server, while in the type and level of manipulation can be scaling, converting and displaying. Kim and Albers [13] explored strengths and limitations of tables formatting choices. Lam and Baudisch [14] proposes a "Summary Thumbnails" that thumbnail views enhanced with readable text fragments. Baudisch and colleagues [4] proposes another solution, "Collapse-to-Zoom: Viewing Web Pages on Small Screen Devices by Interactively Removing Irrelevant Content" that is based on a hybrid between a marquee selection tool and a marking menu, called "marquee menu". Hoi [11] present an automatic document segmentation and presentation system (DSPS). "The system automatically divides a web document into different logical segments based on the display size of the devices and the hierarchical structure and content of the documents. Secondly, it extracts the summary and overview information from the logical segments to help users locate relevant information. Thirdly an interface for clear and user friendly presentation of the segments is created for rapid access to the desired information." We may conclude that there different perspectives and approaches to the problematic.

Not all the studies analyses the PDA and mobile phones or smart phones as the same kind of device (small display devices). Noirhomme-Fraiture and colleagues [18] explain that even if preceding recommendations are valid for PDA and mobile phone, problems appear differently, because the screen size is different. They describe two solutions for PDA and two solutions for mobile for time series visualization

3. USABILITY TESTING IN SMALL DISPLAY DEVICES

While general human-computer interaction methodology works well in a single, consistent context of use, with the mobile devices we simply do not know who the users are, where they are going to be, or what they want to do [3].

What is the criterion that is to be taken into account when analysing usability? The answer to the question is mentioned by various authors [2][12][17][20].

Focusing on the user, traditional usability can be characterized by the following, [17]: Learnability, Memorability, Efficiency, Errors and Satisfaction.

However, Seffah and colleagues [20] presents another concept for usability. Combining the various standards and models (like Nielson usability characteristics) they unified then into a single model of usability measurement. This model called Quality in Use Integrated Measurement (QUIM), include 10 usability factors: 1-Efficiency; 2-Effectiveness; 3-Productivity; 4-Satisfaction; 5-Learnability; 6-Safety; 7-Trustfulness; 8-Accessibility; 9-Universality; 10-Usefulness.

The results of a study of Kaikkonen and colleagues [12] had demonstrated that conducting a time-consuming field test might not be worthwhile when searching user interface flaws to improve user interaction. The main constrain of the small device is the size.

How usability can be tested? The usability testing is not a static work to the device with standard methods to analyse, regarding the various types of contents that can be displayed. I fact some studies have been made in that direction. Lee and Grice [15] propose a usability testing that combines heuristics, questionnaires, and scenarios for developing mobile applications. According to Andrews [1] there are three usability inspection methods: Heuristic Evaluation, Cognitive Walkthrough and Action Analysis. In Heuristic Evaluation a small set of evaluators examines interface and judges its compliance with recognized usability principles, while in Cognitive Walkthrough, exist a task-oriented walkthrough based on formal cognitive model of user behaviour (analyses learnability). On the other and, in Action Analysis is made an quantitative analysis of actions to predict time required for tasks, based on time estimates for typical interface actions (analyses efficiency).

In what concerns usability test, several researcher also analysed different type of platforms[5]. In fact, an extensive research of the empirical mobile usability studies is reported by [9]. For example, several researchers also proposed simulators in order to evaluate other models of navigation and presentation of information on small display devices.

In the last years, various researchers look for tools to usability evaluation. Some researchers use real devices to test and other use prototypes. Also the tests could be executed in laboratory environment or in field environment.

Openwave Phone Simulator is a free software development kit from Openwave Systems Inc. that makes creating innovative mobile applications even easier.

The advantage of this tool is the flexible and powerful programming capacities to the attest versions of the Openwave Mobile Browser and Openwave Mobile Messaging Client, as well as documentation and sample code for authoring wireless applications using XHTML/CSS and MMS-SMIL. A restriction of this tool is that's client software: Yu must install it and as a consequence the tests must been done in a lab.

Nielsen and his team [17], in their research used a regular Sony Ericsson T68i mobile. A mini-camera with a microphone was mounted on the mobile phone. The camera transmits a wireless video signal to a recorder. This configuration provides steady pictures that enable detailed analysis of screen content and user interaction.

The experience was taken in laboratory environment and in the field environment. The laboratory tests took place in a usability laboratory with four cameras recording the session. The field tests were conducted in a warehouse at the technical high school. The user was placed at a specified working area. During the test (in the laboratory and in the field), a test monitor and a logger must be present, which could to condition the behaviour.

The presented usability tools identify two dimensions: the test environment and the tool type (what tool and where test it).

4. WEB NAVIGATION

The researcher collects user's actions, for future use. Watters and Mackay [22] identified different feature items for each kind of navigation: scrolling, menu/options and search features.

- Scrolling has the following characteristics [21][23]:
- Scrolling slows time to complete tasks;
- Scrolling does not necessarily increases error rate;
- Scrolling requires use of stylus on PDA;
- Horizontal scrolling is hard for reading and comparison tasks;
- Vertical scrolling is adequate for skimming and scanning tasks;
- Paging gives better performance for users than scrolling;

Menus/Options (links and folders) have the following characteristics [21][23]:

- Feedback decreases error rate in menu selection
- Performance is better on shallow hierarchies

Search Features have the following characteristics[21][23]:

- Search used for text and lists
- There is an improvement over past search
- Breaking lists does not affect search effectiveness
- Small screen devices users' tend to use search often
- Search on small screen devices in tables may deteriorate performance

In order to analyse some of these statements details of the systems are presented elsewhere [21]. Nevertheless the main characteristics of the system are described in the following section.

5. FRAMEWORK AND PROTOTYPE DESCRIPTION

In this section, we present the used tool.

We choose MySQL as database management system, PHP as script language and Apache as Internet Web server. In fact, the choice decision has the language and database management system regarding the cost. The method used is an approach to the action analysis, because efficiency was analysed

The prototype simulates a PDA where participants were invited to accomplish some tasks based on questions. Users used information on the Web visualized on a PDA. They were asked to read the questions, navigate, find answers and write them in a text box. The questions used were concerned to a more generalist user as possible, so it was used questions to get information on restaurants, entertainment and pharmacies. In the described case, section 6, users should be able to achieve information about a specific restaurant in Lisbon. The following figure illustrates the target.

Figure 1 – Example of selected pointer

In this prototype, the main concern was presenting text and navigating through it. Four different presentations had been chosen: "Links", "Scroll", "Folio" and "Search". All the options of PDA prototype work by moving and pressing the left button on the screen. The right red button sends the screen to the root option. The Fig. 4 shows the prototype with an example of a selected pointer.

Users used one of the different choices to pursue the way of achieving the answer.

The first choice of navigation is "Links" (Fig.2) that consists in dividing the screen into two areas. The first area has the main list of subjects and second area illustrates the pointers for the chosen list. The second area shows the information that exists for the pointer.

the pointers for the selected folio. This option has horizontal scroll for the folders, because just three folios are shown at time. To do that, the user just has to click in the left and right yellow buttons, which are in the two ends of the folios.

Figure 2. "Link" navigation with the two zones;

In the "Scroll" (Figure 3) solution, the user sees all the links corresponding to the information in a screen, only ordered by subject. The user just has to scroll to the intended pointer. In this option, horizontal scroll is not available; therefore the vertical scroll was chosen.

Figure 3. "Scroll" navigation;

The "Folio" (Figure 4) option is based in the same principles as the "Links" option. There are a top zone with folios corresponding to the top subjects (top level) and underneath exists a second with all

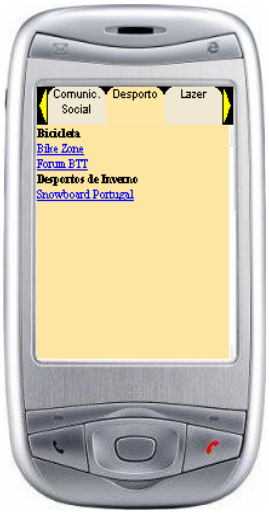

Figure 4. "Folio" navigation;

In the PDA prototype, there is another solution called "Search" (Figure 5). This option is very simple. The user has a text box on the top of the screen where he can type a word or a text, and the device searches all the pointers that have that word or works in the title or in the content.

Figure 5. "Search" navigation

A database has all the necessary information and collects the participant's answers.

For screen of the prototype there are tree main tables. A "directorio" table has all the subjects and sub-subjects. Is hierarchic structure where each subject has a parent level until the top level. For example, "Classical Music" has "Music" as parent and "Music" has "Culture" as parent. "Culture" is a top level therefore it does not have a parent level. Other table has all the

pointers and the code of the subject that it belongs. The last table called "atributos" has the attributes of each pointer. Each pointer can have one or more attributes, but each attribute belongs only of one pointer.

For the experiment there are two main tables. The first one has the tasks that the users (participants) must complete (the questions). Each register has other important information: one of the four navigation options that are presented to the user. The objective is making identical questions with different navigation options. When the user presses "enter" to validate the answer, the system records the date/time of that "enter". In this way it is possible to calculate the time of reply to each question. These times are recorded in another table ("tempos") that register the answers too.

There is another table that can be useful. This table records the searches make by the users when they uses the "search" navigation option. Its register the date/time too. With this table it's possible to know the difficulty that the user had to find a place using the "search" navigation option.

6. EXPERIMENT

The prototype development demonstrated that is possible to make a tool to reach a large range of potential users, like the Internet users. In order to test the tool, we recruited 8 students from architecture. Their mission was testing the integrity and reliability of this tool. The prototype works correctly and it is ready to be used in a laboratory context. This group also runs a pilot test where it was possible collecting data that will be analysed and presented in future work.

In order to evaluate the navigation type presented here the database was populated with data corresponding to a limited number of information. For example, the number of sites presented was limited to a number inferior to 100. 39 people used the tool.

H1) In what concerns web navigation, "Link" is slower compared to "Scrolling".

According to Badre [3], in the context of desktop computers, link (paging technique) is slower compared to scrolling.

ÃNOVA test allow rejecting the null hypothesis.

Navigation Type	Square Sum	df	Square Sum	F	p
Between groups	23,307	3	7,769	37,98	0,00
Residual (Inside Groups)	74,667	365	0,205		

Figure 6 – Analysis of Variance (ANOVA)

By comparing the time spent in each of the activities, scroll is the type of navigation that is more efficient.

Navigation Type	N	Average	Standard Deviation
Links	146	3.609	0.439
Folio	112	3.292	0.503
Search	73	3.670	0.430
Scroll	38	2.859	0.381

Figure 7 – Average time spent by type of navigation

H2) The most efficient is also the most effective way of navigation

Scroll is not only the most efficient but also the most effective type of navigating. In what concerns percentage of correct answers, scroll is the type of web navigation that allows the best performance.

Type of navigation	% Correct Answers
Links	87.18
Search	90.60
Folio	88.46
Scroll	100.00

Figure 8 – Percentage of correct answers

H3) There is coherence between real efficiency and perception of efficiency.

After using the prototype, it was asked to the participants what was the type of navigation that they preferred. "Link" was the preferred.

Type of navigation	No. Individuals	% Answers
Links	16	41.03
Folio	9	23.08
Scroll	8	20.51
Search	6	15.38
Total	39	100.00

Figure 9 – Users Preferences

As we may see, preferences by each type of navigation does not corresponds to the effectiveness and efficiency of each type of navigation.

H4) Quality of navigation is independent from the type of navigation

H_0: The number of wrong answer is independent from the type of navigation.

	Chi-quare	df	p
Person Chi -Square	5.8036	3	0.12158

Figure 10 – Person Chi-Square test

According to the Person Chi-Square test, we may not reject the null, hypothesis. Consequently, in spite of having differences between each type of navigation, we still have to admit that the type of navigation may not be related to the quality of the answers.

7. CONCLUSIONS

In this paper we presented two main contributions from a research.

The first one is a tool, employed to help users evaluation navigation type implemented in sites that are accessed by small display devices.

The second contribution results from the use of this tool.

In fact, we evaluate different type of navigation using small display devices. Those types of navigation are links, folio and search.

We concluded that each one Links is the more efficient and also the more effective type of navigation. But, results are not conclusive in what concerns effectiveness. On the other hand, preferences do not mach with effectiveness and efficiency.

Results presented here are legitimate for the specific situation presented here. For example, if the number of sites is enlarged for thousands, scroll may not be the more adequate type of navigation. On the other hand, the font, the character size and the number of words shown in each line or in each screen may also influence results.

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