Ergonomics and Usability in Sound Dimension: Evaluation of a Haptic and Acoustic Interface Application for Mobile Devices

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Abstract. This paper addresses the usability evaluation results performed in an application for mobile devices. The referred application uses haptic and audio interfaces to provide access to web content. Based on the model of listening mechanisms proposed by Schaeffer, the researchers' team responsible for this project, sought to ally the fundamentals of Software Engineering, Ergonomics and Usability Engineering to the purpose of broadening the possibility of using and handling mobile technologies that allow access to information available in telematics environments by means of synthesis and voice recognition, including also tactile commands. The ergonomic and usability evaluation of the application was performed by specialists in the software engineering field having Nielsen´s heuristics and normative proposals by NBR-9241-11:2002 as bases. The results of the evaluation performed in the application, as well as the modifications done in it are presented in this paper towards contributing with information inherent to the practical application of usability concepts in human-computer interfaces development.

Keywords: Usability, Haptic Interface, Audio Interface, Mobile Devices.

1 Introduction

Research involving human perception to establish the communication between people via technological resources is a challenge for researchers in the Software Engineering, Ergonomic and Usability Engineering fields, because they demand a collective effort to develop and even evaluate a product with generic characteristics.

With the evolution of computational technology, and consequently the evolution of human-computer interfaces, the haptic interfaces emerged as a quite interesting option of interactivity. According to Hayward et al.[1], the haptic interfaces allow human-computer communication by touch and, more commonly, in answer of the user movements. When it refers to mobile devices, such as smartphones and tablets, for instance, using the fingers to touch the screen and interact with the device makes this interaction quite natural and intuitive.

A. Marcus (Ed.): DUXU 2014, Part II, LNCS 8518, pp. 193–202, 2014.
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Regarding to audio-based interface, Saddik et al.[2] affirm that the audio-based interaction between a computer and a human is another important field related to human-computer interfaces. That field deals with the information acquired by different audio signals. The nature of audio signals may not be so variable like visual signals, and the information obtained by audio signals can be quite reliable, useful, and in some cases the sole providers of information. Voice recognition, signal detection based on human noises (laugh, cry, whisper, and cough), musical interaction and voice synthesis are some of the fields of research related to human-computer interaction based on audio.

Saddik et al.[2] affirm still that such technologies can be used quite successfully for human-computer interaction by people that have some kind of disability, as observed in the Ronzhin and Karpov´s work[3], where a physically-impaired man was able to interact with a computer using his voice and performing movements with his head.

Considering the technological evolutions previously mentioned, and consequently the new ways of human-computer interaction, it is considered quite important the application of usability concepts for the development of systems for mobile devices that use the related haptic technologies and interaction by audio; because if it used without any standards, it is possible that, instead of making the work easier for the user, it could even make it more complex.

Based on the model of listening mechanisms proposed by Schaeffer[4], identified as: hear, listen, recognize and understand, the researchers' team responsible by the development of the application, sought to ally the Software Engineering, Ergonomic and Usability Engineering fundamentals to the purpose of broadening the possibility of using and handling mobile technologies that allow access to information available in the web environment through voice synthesis and recognition including also the use of tactile commands.

According to Sharp, Rogers and Preece[5] "Usability is a key concept in the Human X Machine interaction field and deals with the design of systems that are easy to learn and use". It is understood that usability deals not only with computational systems. Due to its origin be strongly linked with ergonomics, the human being is one of the variables studied in usability, because it is he/she who will interact with these systems.

Rebelo[6] indicates to be two the groups of goals that help orient the computational project: the usability goals and the goals arising from human experience. Sharp, Rogers e Preece[5] explain that the goals arising from human experience, as the name suggests, are related to the quality of user experience. The authors mention also that the usability goals concern the pursuit of efficiency, efficacy, security, utility, learning and memorization by the user towards the system.

An effective system does what it is expected of it. It must provide a guaranteed learning that allows the user to get access to necessary information to perform his activities. While efficacy proposes to do the right things to reach the aim, another important element that composes usability is efficiency. According to the ISO 9241-11[7], efficiency is the measure that relates the level of efficacy reached with the used resources.

An appliance that does not meet the usability goal has big chances of not being used, once it does not satisfy the user's needs completely.

The learning facility, according to Dias[8], refers to as " a system must be easy to learn in a way that the user is able to quickly explore it and perform his tasks with it".

Other element that usability covers is the user satisfaction, which refers to user perceptions, feelings and opinions about the system. Those opinions can differ among the users relating to the quality of use, in other words, the same system can be excellent for some people and inadequate or unaccepted for others. The user is subjectively satisfied with the system when the time spent interacting with it is considered pleasurable[8].

The strong point of this paper is that it is driven by concepts of heuristics evaluation developed by Jakob Nielsen and Rolf Molich[9] that consists in "systematical inspection of interactive systems, whose aim is to identify usability problems that, posteriorly, will be analyzed and corrected during the system development process."[8].

That method consists in the participation of an evaluators' group in the usability evaluation process. The people who are part of it can be both usability experts and people who have little or no experience in the area. The evaluation includes the interactive use of the system through the interface based on a list of heuristic criteria recognized by researchers and professionals in the usability field. From that criteria list, understood as an evaluation or metrics guide, it can analyze the system's conditions of use and produce a report that provides indications of points of improvements, doubts, and not accordance with the project[6].

For the usability evaluation considering the concepts previously mentioned, it was chosen an application that was initially designed to be used under an Android system; and the access to it is done by haptic commands and audio commands that takes the user to interact with three distinct features: a) a collaborative encyclopedia that allows users to search about terms and articles desired - called Wikisonora; b) a network of sound sites that allows users to publish and search exclusive contents administered by application users – called Netsonora; c) access to a social network widely used that allows users to post messages and receive messages using only audio – in that case, the Twitter.

Therefore, the aim of this work consisted on explaining the obtained results during the evaluation of the application with haptic and audio interfaces developed for mobile devices using ergonomics concepts and usability techniques based mainly on ISO 9241-11[7] and on Nielsen´s heuristics[9]; and address information inherent to the performed adjustments in the application due to the results observed in the evaluation.

2 Methodology

The ergonomic and usability evaluation of the application was performed by specialists in the software engineering field, and it was based on Nielsen´s heuristics[9] and the normatives proposed by NBR-9241-11:2002. The specialists' team did direct observations from the use of the application in a laboratory considering the applicable items of Nielsen´s heuristics. The ISO 9241-11[7] was applied measuring the extension in which the intended aims of use were reached (Efficacy), by the resources spent to reach the intended aims (Efficiency) and by the extension in which the user considers acceptable the use of the product (Satisfaction).

For the usability evaluation of the application with haptic and audio interface, a work plan was elaborated to help the specialists during the analysis of relevant characteristics of the product.

Following the orientations covered by ISO 9241-11[7] and the highlighted subsidies by Cybis, Betiol and Faust[1] the work plan included the following items:

1. Analysis of Evaluation Context: in this stage it is done a description about the target product of evaluation and also a description about the environment in which the product will be observed. In this case, the analyzed product was an application for mobile devices that uses voice recognition and synthesis to give access to web content. The application was installed in a smartphone Samsung GT-S6102B with Android operational system version 2.3.6. The observation of the experiment happened in a directed environment, in that case, a laboratory of research;
2. Choosing of the evaluators' team: formed by one software engineer and an usability specialist, responsible by the direct observation of the application;
3. Analysis of the system operation context: practice based on direct observation and register of the results found during the handling of the application on a mobile device;
4. Analysis of the available knowledge: procedure that mobilizes the evaluators in search of specific knowledge for identification of expected qualities for the interface and application usability (in that case it is highlighted the use of Nielsen´s heuristics evaluation techniques[9]);
5. A meeting for preparations to the evaluation; in which the evaluators defined criteria and design scenarios for the application use;
6. Performing of evaluation: moment of collecting relevant information arising of performing each stage of the application use;
7. Writing of report: the moment in which the evaluation synthesis was performed and transformed in explicit knowledge to be shared with all those concerned by the results;
8. Meeting for the presenting of the report: critical moment when the information found was confronted with the developers' team expectations. Diagnostics were exposed as suggestions for new adjustments.

From that methodological characterization, the application was used as a model for study and evaluation of accordance with their ergonomics and usability criteria under the perception of computation area professionals. The specialists' team did direct observations analyzing each guideline previously identified related to interaction with the system and attributing a value for the guidelines being: Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree.

The guidelines are categorized by 10 usability principles:

1. **Visibility of system status:** moment in which the evaluators observed if the application informed what action was performed by the user, so it was possible to inform his position in the application. It was observed also if the feedback suggested future actions to the user;

2. **Match between system and the real world:** the evaluators observed **if** the application used natural and comprehensive language during the interaction by audio;
3. **User control and freedom:** it was done an observation of the possibility of the application to provide non-hierarquical accesses that allows a free navigation by the user;
4. **Consistency and standards:** the evaluators investigated if the application showed clearly the intention of patterns of existing commands, in other words, they verified if the available commands could be used in the same way in different sections of the application;
5. **Recognition and error prevention:** this item was evaluated to verify the possibility that the information returned by audio could induce the user to make mistakes;
6. **Help users recognize, diagnose, and recover from errors:** the evaluators verified the existence of message alerts and audio signals with the function of indicating possible errors from the user;
7. **Recognition rather than recall:** The evaluators firstly considered if the menu by audio and the options available in the device interface were easy to access and understandable for the use of the application. The specialists also considered the ergonomic aspect of the mobile device used for the specified test;
8. **Flexibility and efficiency of use:** the evaluators sought to identify points that influenced in a negative way the efficiency of the application and the level of satisfaction generated by the use of the application;
9. **Aesthetic and minimalist design** (focus in haptic and audio principles): the evaluators verified if unnecessary information was informed to the user;
10. **Help and documentation:** the evaluators checked the existence of help documentation or tutorial by audio that guided the application use ;

The ISO 9241-11[7] was applied measuring the extension in which the intended aims of use were reached (Efficacy), by the resources spent to reach the intended aims (Efficiency) and by the extension in which the user considers acceptable the use of the product (Satisfaction).

3 Results and Discussion

The results here presented are based on identifying the impact that the usability problems have upon the productivity of the task. The usability problems are classified as: (1) Barrier – more serious problem that can make the user give up the use of the system. (2) Obstacle – medium problem because the user needs help to continue; and (3) Noise – small problem because the user is able to pass by the difficulty with minimum effort. For each one of these arguments it was established a scale of intensity varying between 1(one) and 3(three), in other words, from minor to major intensity. Therefore, the most relevant items identified as usability problems of the application, became integrated in the evaluative board having the ten Nielsen´s heuristics[9]. Finally, the resultant information showed a summary of the global usability of the application, and it had information about the efficacy, efficiency and satisfaction level under the opinion of the evaluators.

The usability requirements specification followed the model proposed by ISO 9241-11[7] that defines the intended aims and the context of use, and besides that, specifies the level of measures and criteria for efficacy, efficiency and satisfaction for a product in development.

The Table 1 shows the results related to usability items based on Nielsen´s heuristics found by evaluators[9]:

Table 1. Feedback of evaluators after evaluation of application by observation and use in laboratory

Usability items – Nielsen´s heuristics	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Visibility of system	33,33%	66,66%			
Match between system and the real world	66,66%	33,33%			
User control and freedom	50%	50%			
Consistency and standards	100%				
Recognition and error prevention				100%	
Help users recognize, diagnose, and recover from errors	50%	50%			
Recognition rather than recall	50%	50%			
Flexibility and efficiency of use		33,33%		33,33%	33,33%
Aesthetic and minimalist design				50%	50%
Help and documentation		100,00%			

From the highlighted results in the previous table the next text intends to expose the resultant information during the evaluation of the application based on argumentation of specialists.

Related to the item "Visibility of System", the evaluators observed efficacy in the procedure considering that the aims were reached when they used the HELP command in the application exactly in the section where they were positioned. With a previous configuration of the HELP messages, it is possible to guide and inform the user about the next steps to be done for performing a wanted task through the related commands. Observations related to efficiency were done considering the need to obtain help through sequential explanations by audio format, during the running of the application. The time spent for learning, due to being fast, influenced positively in the evaluators' satisfaction in that situation.

About the item "Match between system and the real world", the evaluators observed that the efficiency of return is affected by the quality of the network connection. It was verified, also, if the movements done by the user to activate the haptic commands were associated with the intention of it. It was noticed that the definition showed to the user in the initial HELP was standardized for the SHAKING movement to interrupt the voice returning, and SLIDING THE FINGER UNDER THE SCREEN, to activate the voice

recognition (and then, speak a command). The evaluators understood that these movements matched the intentions of the users. And finally, when they sought to identify if the audio commands were associated with real situations of solicitation of information, they could note that that item was reached, as the voice commands used have a direct matching with actions of the real world (Examples of commands: Search, More, Relate, Repeat, Help, Wiki, Net, Twitter, etc.). The efficiency of the applied commands was observed by the low charge of required memorization, considering the matching of commands with the respective actions.

The item “User control and freedom” brought data about the efficacy of it that was noticed by the following fact: independently of the localization of the user in the application, with a simple command it is possible to move through the sections easily and the memorization charge of the commands was low. The evaluators related also that the application provides non-hierarquical access that allows the user to retake the task in an initial stage at any moment. However, the user can face difficulty of navigation in the application in case of not being familiarized with the necessary commands to perform that procedure. The efficiency of this item can be improved by the increase of use of the application and by the dedicated time on listening the instructions.

In the item "Consistency and standards" it was verified that the previous study to obtain system requirements sought to identify generic commands for situations of access and control of application independently of the section that is being used. Each new command requires a greater memorization charge by the user. Therefore, commands for specific situations were cautiously added keeping direct matching with its function. The Table 2 shows the matching among the commands and the respective sections:

Table 2. Standard of defined commands for different sections of the application

WikiSonora	NetSonora	Twitter
Search*	Search*	Listen
Relate	More*	More*
More*	Back*	Post
Back*	Repeat*	
Repeat*	Topics	
1º, 2º, 3º *	1º, 2º, 3º *	

Obs: The commands with * (asterisk) were designed to be used generically

In the item "Recognition and error prevention" the evaluators noticed that being the application based on audio, the developers had the care of elaborating explanatory phrases, audio and haptic return capable of helping and informing correctly what is happening for the user. The efficiency of the application is decreased facing situations where there are external sound noises, or lack of habit by the user with the synthesized voice used by the application. The alternative found in this case, is to ask the user to pronounce the REPEAT command, for the application to repeat the last phrase pronounced.

In the item "Help users recognize, diagnose, and recover from errors", the evaluators concluded that the application had that resource, because the signals happened and indicated to the user how to proceed in each specific case. It was proved that the application emits sound beeps, some of them followed by synthesized speech to assure the orientation of the user related to what he must do. However, to have a full use of the cited returns, the user must understand that some situations do not depend only on the application, but also on external situations, such as network connections and existence of content in the database.

In the item "Recognition rather than recall", the evaluators concluded that the application was accessed easily using the mobile device, and the designed interface, although simple, conducted the user simultaneously by audio and video through the features.

In the item "Flexibility and efficiency of use", the evaluators observed that the application does not optimize the most frequent actions of the user. That observation took the developers to do new studies for matching actions and patterns of behaviors of the user while using the application. According to the developers, that implementation will happen in a next stage of the development. Other important data found was related to the presentation of efficiency shortcuts for the user. In that case, the answer was positive, however it is necessary that the user call out the HELP command and be patient to listen to the instructions, because they are done by audio. Also according to the observation of evaluators, the fact related to the initial access of the application showed a particular case: For visually-impaired people, an extra application is necessary to access the application target of evaluation. This difficulty is not detected by non visually-impaired people. For hearing-impaired people, the application does not offer any alternative of use. Finally, the evaluators checked if there was a reduction in the time of navigation according to the increase of frequency of use. In that case it was noticed a gradual improvement in the time of navigation and moving between the sections Wikisonora, NetSonora and Twitter. The efficiency of use increased each time that the following highlighted sequence was understood and used: 1 – Understanding the general concept of the application use; 2 – Hearing the presented information in the application in case of doubt; 3 – Associating the sequence of basic commands of navigation in the application; 4 – Using frequently the application; 5 – Having consciousness about the need of attention to the command sequence, to avoid decreasing the efficiency of the application. Tedium and distraction decrease the efficiency of acts.

In the item “Aesthetic and minimalist design” the evaluators observed that all the design of the application was based on using only the essential features for interaction with the user. The highlight in this case is the elaboration of texts, because according to the developers, those must be written very clearly and succinctly. Also in that context, the evaluators noticed that the application does not create situations that allow users to get lost among the commands, not being required to restart the activities constantly. However, if the user needs to speak the commands without looking at the screen of the smartphone, he will need to pay attention to the sequence of the applied commands. In case of distraction by the user, he/she has the option to invoke the initial command to retake the activities (Example: Begin, Topics, Back).

Finally, in the last item “Help and documentation”, the evaluators observed the existence of a collection of explanatory videos that guides the user for the complete use of the application. The suggestion of the evaluators is to make materials available in text format for the ones that choose to read them. The evaluators noticed that there exists some basic videos, answers via audio stored in database and audio parts of videos that explain the application and attempt to support visually-impaired people on understanding how to use the application. Again, the evaluators highlight the need of written documentation.

The obtained data indicated the need of performing some adjustments in the application. That information allowed relevant modifications in the application related to screen configurations, sounds, speed of answers and compatibility in general. The application showed itself effective when there are good conditions of network connection while doing the proposed tasks for the evaluation. The highlight goes to the item HELP, that guides the user in a practical way when it is required orally in any point of the application running, identifying the section where the user is. In terms of efficiency, it was noticed the need of training for the user to recognize the commands in a natural way and do not think about what command should be applied. The efficacy and the efficiency of the application depends directly on the quality of the network connection, therefore this can cause discomfort to the user and influence directly in the satisfaction level of use. About the item User Satisfaction, it was evaluated as positive by the specialists, because during the running of the application it was possible to notice the quality of help to the user both in a synthesis speech and in an explanatory video inside the application.

4 Final Remarks

From the information generated by the work plan report for the evaluation, the developers’ team performed necessary configurations in the application, and did the register of amplitude of use found in the project, because all the work done could also be used by a target audience composed by visually-impaired people. From those findings emerged a greater project that aims to integrate computational elements for the recovery of textual contents stored in a specific database, that is done by the application, to attend the visually-impaired audience considering items of technical quality and mainly the necessary quality parameters for the elaboration of texts to be recovered and used by that audience. It is important to highlight that the evaluation results, as well as the suggested modifications in the application, contributed with information inherent to the practical application of usability concepts in development of human-computer interfaces.

References

1. Hayward, V., Astley, O.R., Cruz-Hernandez, M., Grant, D., Robles-De-La-Torre, G.: Haptic interfaces and devices. Sensor Review 24(1), 16–29 (2004)
2. Saddik, A.E., Orozco, M., Eid, M., Cha, J.: Haptics: General Principles, 1st edn. Springer, Heidelberg (2011)

3. Ronzhin, A., Karpov, A.: Assistive multimodal system based on speech recognition and head tracking. In: Proceedings of 13th European Signal Processing Conference, Antalya (2005)
4. Schaeffer, P.: Traité des objets musicaux: essai interdisciplines. Nouvelle Édition. Éditions du Seuil, Paris (1966)
5. Sharp, H., Rogers, Y., Preece, J.: Interaction Design: Beyond -Human Computer Interaction, 2nd edn. Wiley (March 2007)
6. Rebelo, I.B.: Interação entre Homem e Computador e procedimentos de Avaliação. Centro Euroamericano UNIEURO (2007), xxx. Última atualização 2009. Disponível também em: http://pt.scribd.com/doc/19653938/IHC-Interacao-entre-Homem-e-Computador-ApostilaTASIIHC20092 (acesso em: December 17, 2013)
7. ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. NBR 9241-11: Ergonomic for Office Work with Visual Display Terminal (VTDs) /Part 11. 2002. Based on ISO 9241-11:1998
8. Dias, C.: Usabilidade na Web, 2nd edn. Alta Books, Jacaré (2007)
9. Nielsen, J., Molich, R.: Heuristic evaluation of user interfaces. In: Proc. ACM CHI 1990 Conf., Seattle, WA, April 1-5, pp. 249–256 (1990)
10. Cybis, W., Betiol, A.H., Faust, R.: Ergonomia e Usabilidade: Conhecimentos, Métodos e Aplicações, 2nd edn. Novatec Editora, São Paulo (2010)