VOICER IN MOBILE PLATFORM TO FACILITATE COMMUNICATION FOR THE DISABLED

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ABSTRACT
This paper describes the development of a voicer, which is an Assistive Technology (AT) software focused on Augmentative and Alternative Communication (AAC). It aims to assist in the treatment of patients with conditions or limitations in oral language. The proposed voicer, called VoxLaPS, is an open source initiative implemented in the Android platform to be used with mobile devices that tend to be the future hardware tools to applications of accessibility. This study details the software engineering process applied in the development of the application, and also presents the first successful experimental with experts in the accessibility field. This work shows how the positive influence of the AT affects the disabled people's life, recovering their basic human skills, such as communication, inserting them into the digital world, and assisting them in the day-by-day tasks.

Categories and Subject Descriptors
D.3.3 [**Programming Languages**]: Java for Android.

General Terms
Human Factors, Experimentation.

Keywords
Assistive technology, Alternative Communication, Voicer.

1. INTRODUCTION
The number of people with some physical limitation in Brazil increased from 24.5 million, 14.5% of the population [6], to approximately 46 million in ten years [7], i.e. almost 24% of the population has some type of disability. More than 2.5 million of disabled people, among much specificity, present serious difficulties in communication and interaction with others. Thus, it shows the increasing importance of the Assistive Technology (AT), that through its resources and services, promote independence, life quality and social/digital inclusion to the disable people.

MEDES'13, October 28-31, 2013, Neumünster Abbey, Luxembourg.

The AT focused on communication is the Augmentative and Alternative Communication (AAC), which acts on the augment of communication skills, "is intended to people without functional speech or writing, or with discrepancy between their necessity and ability to speak and/or write" [2]. The AAC is a tool with great relevance to the educational and social inclusion, as it meets the most basic needs of interaction. Regarding the AAC products, voicers stand out. They are intended for people who have limitation or difficulty in express themselves through oral language. At this group are included conditions as autism, intellectual disability, cerebral palsy or aphasia, among others.

So, through the voicer, the user can express his thoughts, feelings and desires, by pressing keys, on which are placed images (pictures, symbols, figures, etc) or words, which correspond to the desired sound. The audio is reproduced by pre-recorded human voice files, or through a speech synthesizer, that is a computer program that generates voices by any text. However, there are only few free voicers, mostly of them are costly because are imported, thus becoming financially inaccessible to a large portion of the population.

Seeking to overcome this situation, some research institutes started to develop their own voicers (hardware components), but it proved to be impractical because of the high cost of electronic components, plus the time and manpower necessary to manufacturing it. Just with the recent expansion and hence the price reduction of the mobile devices such as Tablets and Smartphones, it began the exploration of voicers development based on software to these platforms.

There are already success stories such as Proloquo2Go [1] for the English language and Livox [8] for the Brazilian Portuguese (BP), but the solutions still are proprietary and expensive for the majority of the population. Then, a totally free solution, that offers basic communication boards and possibility of customization according to the user necessities, certainly will make it feasible to use voicers by the general public.

The main objective of this work is to implement and provide free of charge open source voicer, called VoxLaPS, for mobile devices. The idea is to assist in the treatment and communication of people with speech disabilities caused either by neurological, physical, emotional or cognitive factors, thus making them more independent and able to perform satisfactorily their basic daily activities.

2. MOTIVATION

There are several commercially available voicers. They differ in portability, number and way to access the messages, aesthetics and cost. However, all of them feature an inflexible platform, that is unable to adapt to the changes, and are quite costly. With the availability of a free voicer, obviously a greater number of people with speech difficulties or limitations could benefit from this technology. It is also know that Smartphones and Tablets are becoming more financially accessible, especially of the Android platform. Thus, this strategy clearly contributes to the social and digital inclusion of a large portion of the disabled population, and provides more independence in the interaction with society while gives the chance to handle a computational tool of relative complexity.

One great motivation for this research was the partnership with the Center for Development in Assistive Technology and Accessibility (NEDETA), Para State University, which is a reference center in AT [10]. NEDETA plans to use in the future the VoxLaPS in the treatment of patients with difficulties or limitations on the speech and on the communication. The results of the first experimental tests realized with VoxLaPS in field, will be presented and discussed later in this paper.

For the above reasons, this work presents itself as a popular social and digital initiative, as it is free of charge. And having NEDETA as partner and valuator, we intend to deliver a product that actually contributes to AT.

3. METHODOLOGY

The VoxLaPS prototype was implemented in three (3) parts: base, screen navigation and customization. What we call base is the main function of the voicer, that is sound generated by visual stimuli, and it is where the other two parts will be implemented. The second part takes care of the interactive screen navigation, increasing the possibilities of text be written or read during the use of the application. At last, the customization part, which allow adding and deleting buttons on the interactive screens.

Although the current focus is a Tablet application, the VoxLaPS can be easily adapted to other devices such as Smartphones, for example. To do this, it will require some adjustments, mainly in the screen resolution due the phone dimensions which is smaller than a Tablet. It's important to note that the VoxLaPS was specifically developed to the Android platform, version 2.2 to the most recent.

To develop this project we used the agile methodology. The agile methodology favors a more direct and constant interaction with the client, ensuring that the resulting product is in agreement with their criteria and expectations, and to provide more change control in the requirements and even in the project itself. This methodology helped in the correct implementation of each part of the project, since NEDETA can follow up the creation of every detail of the voicer, and made adjustments according to its opinion and interest in the AAC area.

So, after the completion of each part, tests were performed to evaluate the requirements of the customer (NEDETA) for the various pathologies that require the tool. This analysis was made by physical therapists, occupational therapists of different specialties, and also by speech therapists, students of occupational therapy, to gather beginner's perspective in this area. The idea was to identify inconsistencies and missing functions, so in the future the user can enjoy the best of the software.

4. VOICER PROTOTYPE

The Android platform is an operating system that runs in a Linux kernel, allowing software development in Java programming language, which controls the mobile device through libraries developed by Google [3]. For this reason, the development of the proposed voicer was based on the Java programming language for the Android platform.

4.1 Requirements

The requirements had some changes, which is normal in software development, mainly because it is an incremental development. Table 1 shows the final requirements elicited (collected) during the project.

Table 1. The voicer requirements.

N°	Requirement	Description
1	You must agree to click on all the buttons of the application.	Functional
2	Must possess a database of images.	Functional
3	The database should accept new data added by the user.	Functional
4	The database should come with basic information for using the application.	Functional
5	Must have interactive screens with buttons.	Functional
6	The interactive screens should resemble the communication boards.	Non-functional
7	Must have an interactive screen that acts as the main menu screens by separating the other categories.	Non-functional
8	Must navigate between all the interactive screens.	Functional
9	Must possess the text field to write the text to be synthesized.	Functional
10	By clicking a button interactive screens should write the text to be synthesized in the text field.	Functional
11	The buttons interactive screens must have colors based on the keys Ftizgerald.	Non-functional
12	The main screen of the application contains the text field, interactive screens and icons with specific functionalities.	Functional
13	Clicking on the icon  to read the entire text that exists in the text field.	Functional
14	Clicking on the icon to delete the last written text.	Functional
15	By clicking the icon  to return to the previous screen interactive that this.	Functional
16	By clicking the icon  to go to the next screen to which this interactive.	Functional
17	Clicking on the icon  to delete all the text that is in the text field.	Functional
18	Should allow the synthesis of the texts of the text field.	Functional
19	Should allow the synthesis to click each button interactive screen.	Functional
20	Should make customization to delete and add buttons interactive screens.	Non-functional
21	Must have an actionable menu for adding or deleting buttons of the interactive screen.	Functional
22	Must possess specific screen for adding buttons in the interactive screens.	Functional

23	It should be possible to select the screen where the buttons are added.	Functional
24	The addition of the buttons should be already contained by images or photos taken on the device at the time to customize.	Functional
25	Should allow the use of image files from the device.	Functional
26	Should allow the use of the device's camera for customization.	Functional
27	Should allow the use of the device's camera for customization. The addition of screen images must have fields: Name Image, Text, which will be assigned to image, screen, where the user will have the option to choose which view will add interactive buttons, a preview of where the image will be displayed that will be added to the button, the button image, which seek an image between the device has the Take Picture button, where we can take a picture of the image that will add to the button, and Save, which saves all the information added to the fields already mentioned.	Functional
28	Clicking on the menu should be allowed to exclude the selection and exclusion of selected button.	Functional
29	When you select a button to delete a message should appear confirming the deletion	Non-functional

Figure 1 explains the main use case diagram, which describes the application's main function, which is to perform communication.

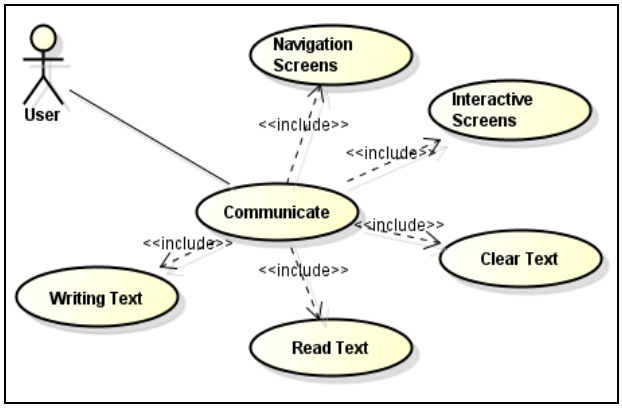

Figure 1. The main case diagram.

The five functions have the following objectives:

- Write text: Write the text associated with the button clicked for later reading.
- Read Text: Allow the synthesis of the written text.
- Clear Text: Delete all or part of the written text.
- Interactive Screens: Using interactive screens with board shaped buttons that contain images and associated texts and that accept clicking.
- Navigating Screens: Allow navigation between the interactive screens.

4.2 Database

It was necessary to create a Sqlite language database to support all the application functions. Figure 2 shows Entity Relationship (ER), which is used to demonstrate the conceptual model of the database. The database entities are: question, verb and expression phrases, adjective, people, action, feeling, food, numbers, letters, and the main menu, that relates to all entities. They all have basically the same attributes, namely: text, image, id, name and location. All the entities have a relationship with the main menu, as can be seen, and his relationship with this entity is 1 to N, which means that one element of the main menu references various elements of other entities.

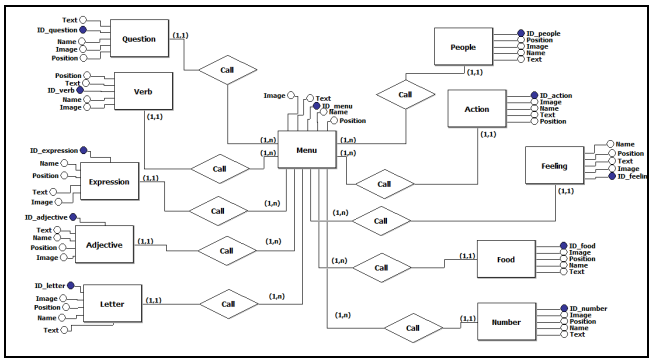

Figure 2. Entity Relationship database application.

Figure 3 describes the transformation of the ER model into the Relational Mode (RM), where entities were converted into tables and their attributes gained data type.

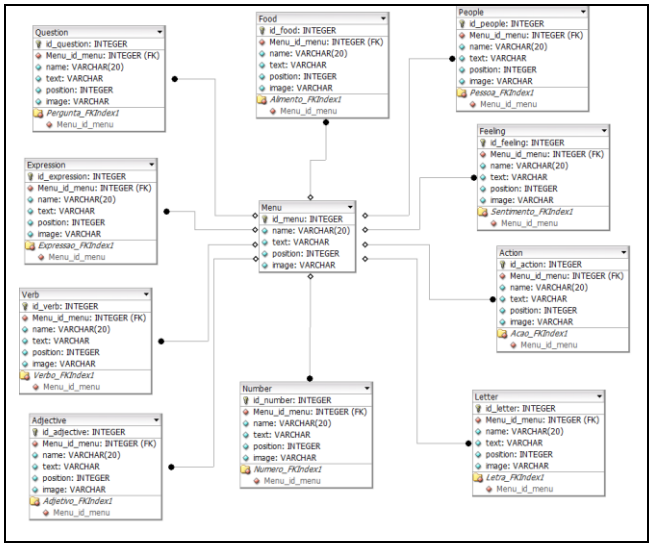

Figure 3. Relational Model database application.

4.3 Architecture

Figure 4 shows the software architecture. The main component VoxLaPS is connected to the BDVox database component and to an external component responsible for the synthesis function, for convenience, the SVOX program. The VoxLaPS also access the device functions, in this case, the camera and the file system.

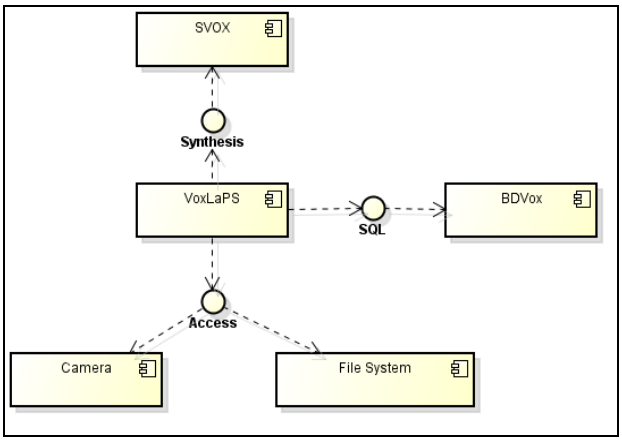

Figure 4. The software architecture.

4.4 Text to Speech

The voicer uses an external synthesizer to convert the written text into speech (audio). As we do not have an own synthesizer, we use the commercial SVOX program (the "Luciana" voice), since it is the only PB voice for Android [5]. This voice has a negligible cost for unlimited use, and after paying, you can download it again several times without making payment.

4.5 Operation

As mentioned, the prototype was divided into three parts, respectively, base, navigation screens and customization. The base part, an essential step for the operation process and adding other functions, was finished. But, unfortunately, in the period proposed for this project, it was not possible to finish the other two parts. However, these have been partially completed.

Figures 5-8 clarified the navigation function, which was necessary to choose the categories people, verbs and actions, respectively, to create the sentence “Mãe quero jogar” (or “Mom I want to play"). After that, the user can press the "play" bottom to synthesize the sentence. What is missing in the browsing function is to expand the number of buttons, allow the creation of new screens, and interactive navigation between them.

Figure 5. The application main screen.

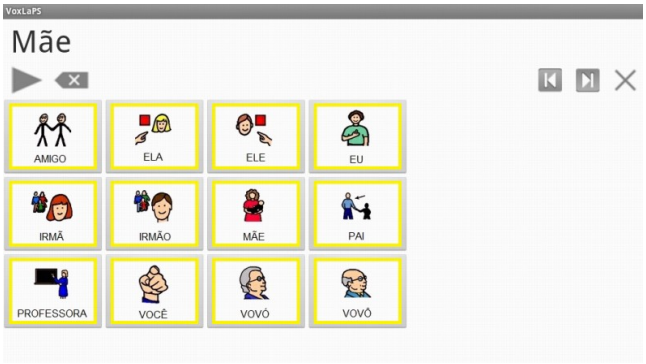

Figure 6. People category screen.

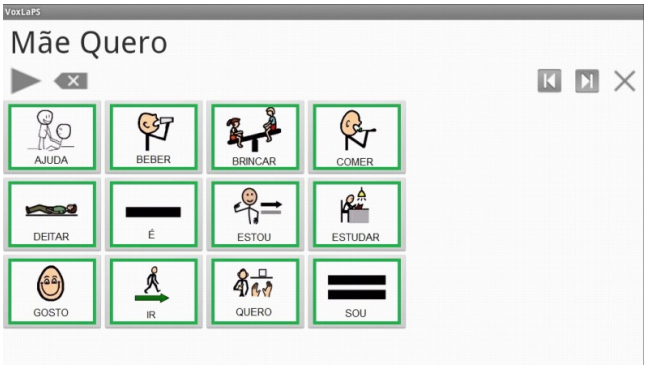

Figure 7. Verb category screen.

Figure 8. Action category screen.

It is recommended that the user has some knowledge in morphology, which is the study of the structure, formation and classification of words [9], to create the sentence correctly. However, colors have been used to facilitate the use by those who are illiterate. These colors are based on the Fitzgerald Color Coding Key, which allows individuals of all ages to structure the sentences through a visual guide to color. The Fitzgerald Key was developed by Edith Fitzgerald, deaf teacher, in order to provide deaf children ways to generate correct sentences in English, as well as find and correct errors [4].

Another feature already implemented allows the user to add new buttons at any category screen (vide Figure 9). The figure associated with the bottom can be obtained by the device's camera or from its file system.

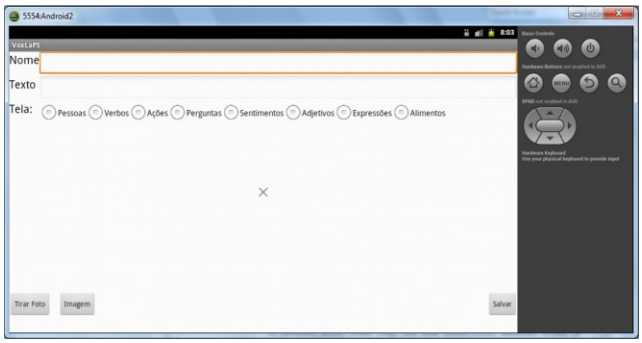

Figure 9. Screen to add new buttons.

5. EXPERIMENTAL RESULTS

The voicer prototype was testing by 14 experts in the accessibility field (professionals who work in the treatment of people with a disability). Each professional evaluated the software for 30 minutes according to their expertise and answered a questionnaire. Before leaving the professional freely to use the application and make their analysis, they were presented to the voicer functions.

Figure 10 shows that all the experts who participated in the tests found the voicer easy to handle and could use it without any trouble. However, the amount of 12 experts identified negative points in the software. It also makes clear that 100% of the experts indicated positives points. The strengths and weaknesses identified points are listed below.

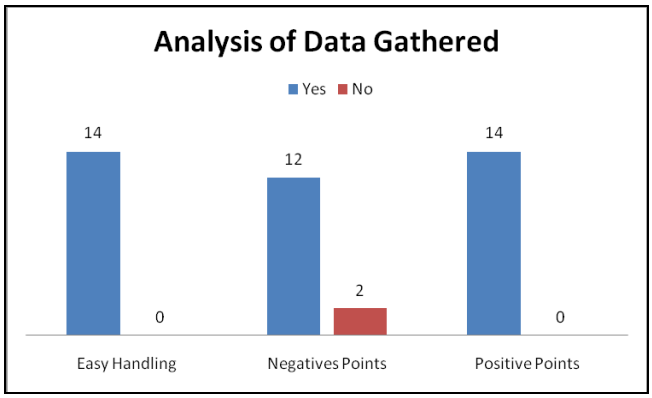

Figure 10. Results of the questionnaire.

- Positive points:

1. Playfulness;
2. The division into categories;
3. The division of categories by color;
4. Correct choice of images;
5. Good voice synthesizer;
6. The letters category;
7. The number of categories;
8. Simplicity;
9. Possibility of communication and literacy even with incomplete prototype;
10. Presents the basic categories for communication;
11. Possibility of forming sentences.

- Negative points:

1. The letter and number categories are read segmented / spelled when they should be read as a whole;
2. Fast rate speech;
3. Buttons with different sizes;
4. No feature to create new boards (interactive screens);
5. No feature to download pictures from the internet;
6. Few buttons for each category;
7. Low audio;
8. No feature to scan the buttons to increase the choice;
9. Synonyms and antonyms are not side by side;
10. Use of complex words;
11. No buttons for actions like up / down;
12. No buttons for specific needs, such as wheelchair;
13. No "space button" in the letter and number categories;
14. Not able to insert voice recording;
15. No button on each screen to report missing word or phrase;
16. Do not have a drive system scan using external trigger.

No experiments were performed with patients via NEDETA's own decision, which held that the prototype, as it is currently, does not have enough features to be used in actual treatments satisfactorily. Anyway, these results, even partial, showed that the prototype is being implemented in the right way, and is on track to benefit, assist and treat many people who need this software in your life. But it still has a lot to be corrected and improved.

6. CONCLUSIONS

With the partial results obtained, it is possible to say that the developed tool is of great importance and can assist in various treatments of diseases and limitations of speech. They also note that there are many features to be added in order to its usability and to cover the largest number of possible treatments, such as a universal CAA tool.

Note that the application was well received by specialists, as they indicated its benefits even in this incomplete version, and also stressed its simplicity and usability, showing that anyone can use without major difficulties.

This application not only encompasses the treatment of problems related to verbal language, but can be used as a methodological tool for literacy. It also indicates a major breakthrough in the area of non-proprietary software in CAA for mobile devices, because currently there are not many researches on this aspect by public institutions, either to the disabled person or not.

Beside it is very important that the application passes through more detailed testing with a large sample of users, mainly patients, in order to have a more complete evaluation.

This project has great future and can be expanded through a partnership with treatment centers and rehabilitation of people with disabilities, of all ages, and state hospitals, to cover different areas and medical patients.

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