Pregnancy Test for the Vision-Impaired Users

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Abstract. The vision-impaired people manage to cover most of their everyday needs with the help of technological equipment. Some needs, however, still require special attention: For example, commonly used pregnancy tests provide results that may be interpreted only visually. The users of these tests who are vision-impaired are dependent on a help of a sighted person which is a drastic invasion of users' privacy. This paper proposes a solution to this problem: A design of a prototype of a system allowing the vision-impaired users to interpret the results of a pregnancy test using a PC with scanner is presented and evaluated.

1 Introduction

A partial or total loss of sight severely limits the amount of information that a vision-impaired person may receive through a visual modality. This has a significant impact on a number of everyday activities, including reading printed text, navigation in the environment, or using medication.

This paper presents a project whose aim is to enable visually impaired women interpret the result of a pregnancy test in privacy, without any (direct) help of other people. A prototype of a system has been developed and subjected to a usability study. Our solution is based on the machine-performed interpretation of the visible patterns produced by commonly available pregnancy tests.

The suggested solutions were either the use of a scanner and a desktop application, or the use of a camera integrated in a mobile phone. We examined the advantages and disadvantages of both solutions.

The article begins with a short description of the background, followed by the report of the user research we performed. Then we describe the creation of the first prototype as well as its testing with the target group.

2 Background

Current state of the assistive technology allows the vision-impaired users access information by means of modality conversion [3]. Information presented in textual form is accessible by screen reader software with output via text-to-speech synthesis or on a Braille line. However, a number of activities remain in which the vision-impaired

C. Stephanidis (Ed.): Universal Access in HCI, Part IV, HCII 2011, LNCS 6768, pp. 335–344, 2011.

users rely on the help of the sighted people, such as navigation in unknown environment. Relying on others is not a significant problem unless some deeply personal and privacy-sensitive activity is involved, such as taking a pregnancy test.

Many types of pregnancy tests are available. They differ in various technical parameters such as their reliability or usage. They mostly use simple patterns (lines, plus or minus signs) to show the result. More advanced tests are based on digital processing and its direct interpretation (words "pregnant" or "not pregnant") [1]. None of them, however, offers a non-visual interpretation, such as sound or haptic output.

As a 2008 April Fools' Day joke, the ThinkGeek e-shop presented a pregnancy test with a USB connector [2], allegedly able to report the results via a personal computer. If it were true (and good practices of the accessibility design were employed), it would be an optimal solution to this problem.

3 Process of the Prototype Design

Our aim was to design a prototype of a desired application using User Centered Design (UCD) methodology [4], where the users, their understanding of the task, and their requirements are the most important aspects of the design. The user research is therefore one of the most important tools in the UCD.

Based on the user research we summarize the functions that our application should provide and describe how these functions would be used in a set of use cases and scenarios. Before an application is developed, one or several iterations of user interface prototyping are carried out. A prototype covers various aspects of how the user interacts with the application. The fidelity of the prototype is increased in each iteration. Low-fidelity prototypes are simple mock-ups, which can be easily changed or completely replaced if they do not prove to be well designed. More advanced prototypes (high fidelity prototype) are created later during the process. These can be so detailed that their look and feel could be easily confused with an actual, fully functioning application.

Before moving on to next prototype design level, each prototype needs to be tested by the users. The testing provides useful information about which parts of the prototype are well accepted by the users and which need to be changed. Using these results, the corrected prototype can be designed and the whole process is reiterated, until users' requirements are met.

In this paper we describe a user research we performed, the scenario of use we developed, and the design and a test of the first prototype. This resulted in a corrected version of the prototype, ready for further process.

4 User Research

The purpose of the user research was to gain insights into the current situation and position of the vision-impaired users regarding their experience with the pregnancy tests as well as their experience with the computing technology. We interviewed three people with a total loss of sight. All of them lived in the greater Prague area, Czech Republic.

Interviewee A. The first interviewee is a woman in her forties. She has not used a pregnancy test her whole life until recently, when she was provided with one at the doctor's. She believes that many blind women are not even aware of their existence and deal with the consequences when it is already late. She also thinks that there is currently no solution for visually impaired people available – the only option is to visit a doctor or get a help from acquaintances who can see.

The Interviewee A did some personal research and found out that the manuals how to use the specific tests are available on the internet. She would prefer that these manuals are available through the application, including the countdown timer. She does not directly refuse the option of anonymously sending the image of the test to a random person who can see to ask for the interpretation, but does not trust the provided anonymity.

The Interviewee A is very comfortable with using a scanner and a laptop with a screen reading program. These devices are very common to her and she believes that it is an essential equipment of every visually impaired person. She controls the laptop using keyboard only. She does not think that the scanner is capable of a high enough resolution that is needed to interpret a small test stripe. She also fears that it would be difficult to keep the scanner clean when scanning the test.

A mobile phone is very common equipment to her as well – she uses a completely ordinary phone with the Mobile Speak[1] software installed. However, she does not use the integrated camera at all because she is not capable of targeting a specific object. It seems that she can hardly imagine the capabilities of a camera or guess even an approximate composition of the taken image. She is willing to try to use it for this purpose though.

The combination of a camera on a mobile phone and a mobile application would be much preferred by the Interviewee A. The main reasons are the good portability of a phone and the distrust in scanner's capabilities.

Interviewee B. The Interviewee B is a middle aged man with a total loss of sight who has no experience with pregnancy test from a blind person's view. However, he believes that a special solution would be very useful.

He is highly skilled in controlling both mobile phone and PC with scanner; he even visited a special course where visually impaired people are taught these skills. However, he refuses to give any advices himself and leaves this matter exclusively to the experts in this field. He considers these devices as an absolute must for all blind people. Both devices communicate with him using reading software; he controls the mobile phone as an every other phone and laptop solely with keyboard.

The Interviewee B absolutely refuses using a camera and considers it a completely useless device for the blind people. On the other hand he highly supports the use of the scanner and the PC, mainly because of the fact that they are so widely available and used among the target group. He states that it is much simpler to put something on a scanner desk than target a desired object with a camera.

Interviewee C. The Interviewee C is a middle aged woman. She has a husband and a son, both sighted. She however feels that she as well as the other women would

[1] http://www.codefactory.es/en/

welcome the chance to be capable of interpreting the pregnancy test on their own. So far she has been dealing with the problem using a help of another person and claims it is the only option. She does not know what types of tests there are and how they are interpreted because she never actually needed to know. She finds the countdown timer a useless tool because she will use her mobile phone for that anyway, but a small database of tests manuals seems like a good idea to her.

The idea of sending the image anonymously for interpretation to another person seems rather ridiculous to her. She claims that the community in the Czech Republic is too small to keep it anonymous and thinks some women who are trying to get pregnant and use the test often would be embarrassed.

The Interviewee C owns a PC and a scanner, knows how to use them, but does not actually use them much anymore – she has no need for it since e-books became widely available. She has little understanding what the output of a scanner is. She understands that the output is directly a text that can be read by the screen reader. She uses a keyboard and a screen reader or Braille display to interact with the PC.

She thinks that not all visually impaired people should be expected to own these devices, because they are allowed to ask for compensation devices only once per 5 years.

She uses a mobile phone often, but does not use the integrated camera. She tried taking pictures a few times but never managed to target what she wanted. She claims that some blind people use it, but they only make abstract photographs and need other person to describe what is in it. Therefore she does not think the option of taking a picture of a taken test is an acceptable idea.

5 Summary

A pregnancy test for the visually impaired women would be a very welcome tool, as there is no solution of this problem yet. We did not find any unexpected problems in the user research that would not be obvious from the task description – we can stay focused on an application for getting the interpretation of visual information.

The manipulation with a standard PC, a scanner and a screen reader is a very common thing to most of the visually impaired people, however all of the interviewees agree that they do not and probably will not use the camera or a camera-phone, mainly because of their inability to target a desired object and choose an appropriate distance.

All the interviewees control the mobile phone and PC by keys and have reading software installed. Some use a Braille display.

No other options than scanning or taking a picture with a camera was suggested by any of the interviewees and they mostly prefer scanning. The idea of sending an anonymous image for interpretation raised concerns of privacy.

6 Requirements and Recommendations

All the interviewees require only the basic functionality, i.e. a simple program that will interpret the test result for them – whether it is positive or negative. They do not

refuse the other functions such as countdown timer or most common tests database and their manuals, but they hardly require them.

From the suggested options we use a scanner rather than a camera because of the technical limitations. The picture taken by visually impaired people will probably not have a high enough quality for a machine processing and therefore the application would not provide a reliable interpretation. Also, the option of sending the image anonymously for interpretation is unacceptable for various reasons given above.

7 Proposed Functionality

Based on the user research we summarized the functions that our application should provide and describe how they should be used in the following use cases and scenarios:

1. *Browse the database of tests*
   - *Find what types of tests the application supports*. Before the user wants to take a pregnancy test, she needs to know what types of tests the application supports. To do this, she opens the application database and "loops" through available test names.
   - *Find a user manual for a desired type of the test.* Once the user purchases a specific test, she needs to know how to use it. She opens the application database, selects the type she wants and has the detail open. Detail shows all the information needed for performing the test correctly.

2. *Countdown timer*
   - *Let the application count down the desired amount of time.* Once the test is taken, it is common that the user needs to wait a specific number of minutes before she can see the correct result. It is also common that the results should not be interpreted after a given number of minutes.
     i. The user selects the countdown time option, chooses the number of minutes for the first and optionally the number of minutes for the second alarm. Once the alarm rings, she can stop it.
     ii. Another option to use the countdown time feature is to start it right from a test detail screen. In this case, the numbers of minutes is automatically set according to the user manual in the database.

3. *Interpret a test*
   - *Open a scanned test in the application.* The user scans the test in another scanning program she is used to and saves it as an image. Then, in our application, she selects the option to open a file and chooses this image. The application will report whether the image was successfully open.
   - *Scan an image right inside the application.* The user selects the option to scan an image. The settings will be automatically set to common values with highest resolution possible. The user puts the test in the scanner and selects the start scanning option. The application will report whether the image was successfully scanned.

- *Define used test type.* The user needs to define the type of test she used, so that the application knows how to interpret the image data. She selects it from the database the way already described.
- *Interpret a test.* With image and test type defined, the user can order the interpretation to start. If the processing is successful, the application announces the result of the test (positive or negative) and the probability of correct answer (for example in the first month of pregnancy, only a very light stripe can be seen, which indicates a positive result). If it is unsuccessful, an error and its cause are reported. This can happen for example if the defined test type is not found in the image or if the check indicator (e. g. stripe that should always appear when taking the test) does not appear.

7.1 Prototype Design and Study

Since we are creating an application for people with significant vision impairments, we do not design a visual user interface. A Wizard-of-Oz protocol was used in this study: The experimenter observes the user's input and simulates the corresponding response.

The behavior of the application can be described by a state machine, where each node describes a certain state and has a label. Each edge is named according to what key it is connected and specifies the state that is reached upon pressing this key.

Although the state machine is what the application actually works like, it is not very comfortable and obvious to work with for the tester. The users also need to create a more suitable imagination about the application structure, which will be easier to comprehend and remember.

We therefore decided to visualize and design this state machine as a hierarchy of menus. Key UP and DOWN move between the menu items, ENTER confirms the selected choice, ESC or BACKSPACE work the same as selecting the "back" choice.

7.2 Testing

The user will not interact directly with this prototype. The user will use the controls that actually have no effect and the tester will simulate the application behavior by moving his position in the prototype and reading the labels for the current state. The actual scanning or text file browsing were skipped, since it is not in the scope of the low fidelity prototype.

The prototype has been tested with three female participants (30—50 years old) from Prague with total loss of sight. We concentrated on a single scenario that covered all the key points of its functionality. The task for all the participants was to:

1. See what types of tests the application supports and select one,
2. Have the application countdown desired amount of time,
3. Insert an image of the performed test,
4. Interpret the test and get its result.

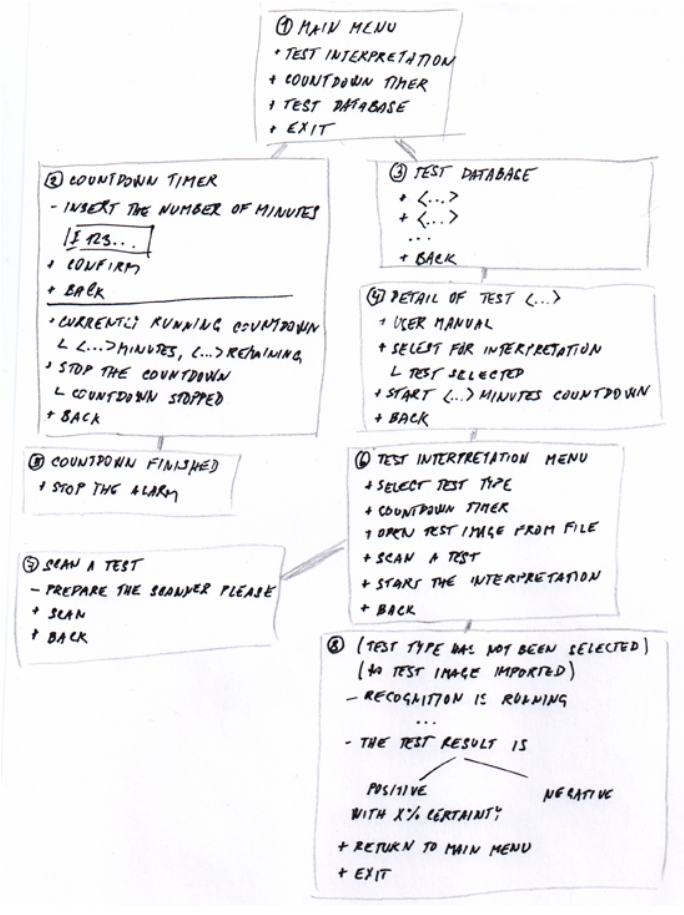

Fig. 1. Initial version of the prototype

User D. The testing took approximately an hour and was performed in a quiet gallery in a conservatory, where the User D spends much of her time and feels comfortable.

The testing was without problems until the user reached screen 4 (see Figure 1), where she could not identify the purpose of the button *Select this test type* and where she currently was in the application after selecting this. She did not remember the *Interpret test* option in the main menu and did not know how to continue. In this menu she also did not know what she will find exactly in the *User manual* option and thought that a more specific label should be used. She also wanted the application to start reading the manual after pressing the Enter key and not right upon the selection of this option.

She was confused by what happened when she pressed the Escape or Backspace keys, compared to the Back button – she got disoriented when she was back at the menu option where she came from instead of at the start of the menu.

The user did not understand the *Open image from file* option. After an explanation, she said, that she does know how to scan and save an image as an image file, because she only uses program which directly recognizes the text.

She suggested some change of labels to use words that are more commonly used by text to speech programs etc. She also suggested an option of finding an option in the menu by typing first letters of its name.

User E. The test with the second user took approximately 30 minutes and was performed at the user's home.

The User E was confused at some points when she did not know how to continue, and expected the application to guide her through by telling what keys to press for what option. She got disoriented by deeply nested submenus.

She suggested that the user manual should contain information about how to recognize what side of the pregnancy test she should put on the scanner. She also thought it could contain some hints how to scan the test without getting the scanner dirty and proposed for example using transparent foil.

She was also concerned about how the navigation in the longer text would work – whether she should use the key shortcuts she was used to from other applications or the application would have its own. (She is used to working with multiple text-to-speech programs because she also teaches other blind people to use them. She mentioned that each product utilizes slightly different sets of keyboard shortcuts).

The User E was happy about the fact that the application would also announce how clearly the result was visible, but she did not understand what the label *With certainty* means and suggested a more understandable label.

User F. The third test took about 20 minutes and was performed at the user's home**.**

The User F also suggested smaller depth of menu hierarchy. She was concerned about whether the application checks the stripe that indicates that the test was taken correctly and the result was correct.

After getting the test result, she wanted to save it, because she thought some women who would try to get pregnant and perform the test often would want to keep track about the dates and the results. She also said that she would like to have the images saved so that if she would not be sure about the correctness of the interpreted result by the application, she could show them to another person to check again.

7.3 Test Results and Recommendations

The depth of the menu hierarchy should be as small as possible and the application should guide the user in one way rather than leaving more options at one time open.

The application should give the user as much feedback as possible, so that she knows what is going on at all points. For example the countdown timer should give feedback every half minute, the interpreter of the results should announce whether the correct test indicator was found, and the application should announce what keys to press to continue at points where it is not completely obvious (e. g. "To go back to main menu, press enter, to exit the application, press Escape").

The revised structure of the application is shown in Figure 2. We will leave both options *Scan the test* and *Open test image from file* available. The Users E and F knew

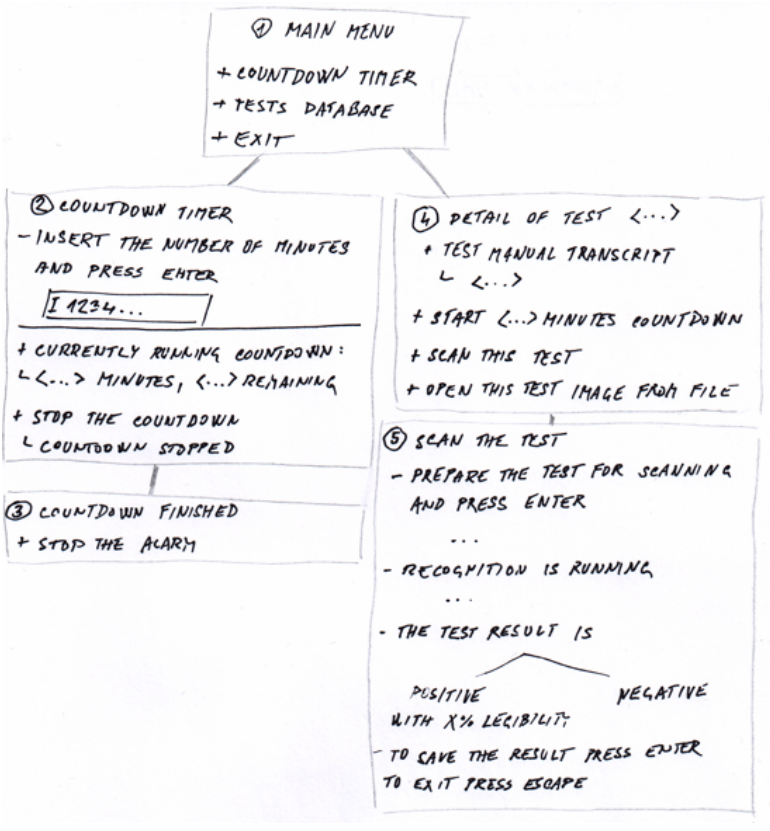

Fig. 2. Corrected version of the prototype, based on the results of the user test

how to save scanned image as an image file and thought they might need it someday. An option of saving the result will be added and tested in the next iterations.

Some labels were changed as suggested by all three users. They are used to some terminology used by many text-to-speech programs and know perfectly their meaning without having to think about it.

The control keys should also include TAB (with the same effect as the key DOWN) and typing of the first letters of a word should directly lead to a desired option. The *Back* option was removed because all the users were used to pressing Esc or Backspace keys and one extra item in menu delayed their navigation.

The user manual should provide more information specific to a visually impaired user than the one provided with the test, such as how to recognize what side of the test to put in the scanner.

The application should not repeat what menu the user just entered, because she already knows that from pressing the button. The first option should be selected after opening a new menu.

8 Conclusion

The paper aimed at informing the designers of a future system allowing the vision-impaired users to interpret the results of the commonly available pregnancy tests. The user research as well as the low-fidelity prototype testing provided useful insights into the given topic. The most important finding was that the need for a solution of the problem of pregnancy test interpretation by the vision-impaired users is real, since the currently available means of solving it reduce the privacy of the vision-impaired.

We found that we could achieve a solution by combination of common pregnancy tests and a scanner, a device commonly available and widely used among the target group. The software needed is a simple application that could interpret an image of a taken test. In this paper a prototype of a user interface of such an application has been described and as well as the related user research and testing.

Acknowledgments. This research has been partially supported by the MSMT under the research programs MSM 6840770014 and LC-06008 (Center for Computer Graphics). The topic for this project was suggested by a member of the target group.

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