Assistive Text Reader for Visually Impaired Users

Xinyan Luo
Aalto University
Espoo, Finland
xinyan.luo@aalto.fi

Federico Macchi
Aalto University
Espoo, Finland
federico.macchi@aalto.fi

Ling Sun
Aalto University
Espoo, Finland
ling.sun@aalto.fi

Tutor:
Iyena Hirskyj-Douglas
Aalto University
Espoo, Finland
ilyena.hirskyj-douglas@aalto.fi

ABSTRACT

In this paper, we present an assistive text reader designed from a user-centered perspective to support Visually Impaired (VI) people in the reading of printed materials. We used an open-ended questionnaire to understand the current situations and alternatives for VI users and made sure that there is a market need on. Based on this knowledge, we built and tested our prototype with 15 non-VI users. The majority of them gave rather positive feedback on the accuracy and the natural-sounding voice of the device, but also some issues were highlighted.

ACM Classification Keywords

H.5.2 Information Interfaces and Presentation HCI: User Interfaces

INTRODUCTION

The World Health Organization (WHO) [2] estimates that 1.3 billion people suffer from some form of visual impairment. In today's digital world, Visually Impaired users have access to a broad collection of books in different audio and electronic formats [1]. However, the majority of textual materials are still published in the traditional way, especially reference books and dictionaries. In particular, for those students who are visual-impaired or blind, they need to have access to the printed materials. Correspondingly, the literacy and reading skills are fundamental to their studies. However, the current situation is either relying on braille or other VI assistive device like finger reader [5]. Moreover, braille is not good enough to reach the optimal reading efficiency [3]. For the current situation of finger readers, Pooja Deole and Shruti Kulkarni acknowledge that it is difficult to get accurate text since the definition of images taken by the camera cannot adjust to different finger length [4]. Therefore, the Text Reader device has the purpose to provide an additional alternative to consult printed texts.

The study is conducted in three parts. We first did initial user research by delivering out the questionnaire. Then we made a low-fidelity prototype, which was made of cardboard to test out the height, size, and camera settings. Thirdly, we did the pilot testing with 15 non-VI users on the functionality and haptic experience. The key contributions of this report are to understand the VI users' need and design for accessibility and inclusion.

USER RESEARCH

To identify obstacles in current reading aids, we delivered an online questionnaire (See Appendix "Questionnaire") with eight closed questions and two open questions to multiple Visually-impaired support groups through Facebook. Our questions, drawn from the literature and observations, and focused on the current use of assistive devices to read books, their use scenarios and their coverage of varieties of books. Four participants age ranged from 27 to 62, three of which are from the USA, and one is from England. All respondents were unable to read without assistive devices.

Three out of four informants indicated that they do not read printed books. They usually rely on Braille, Audiobook and Kindle ebooks. These are the most common assistive tools for VI users to read. Accordingly, we could infer that: Visually impaired people only have limited access to printed books, because of the lack of assistive devices to increase the accessibility for reading textbooks. This directly leads to the fact that VI users barely read textual materials. As validated from the gathered answers, when asking about their opinions on an assistive text reader device, these participants expressed:"*It would increase the selection*","*It may be helpful for reading reference books, dictionaries, textbooks not easily accessible that are only available in print*". The results of the questionnaire support the inference that visually impaired people need access to read printed books as normal people.

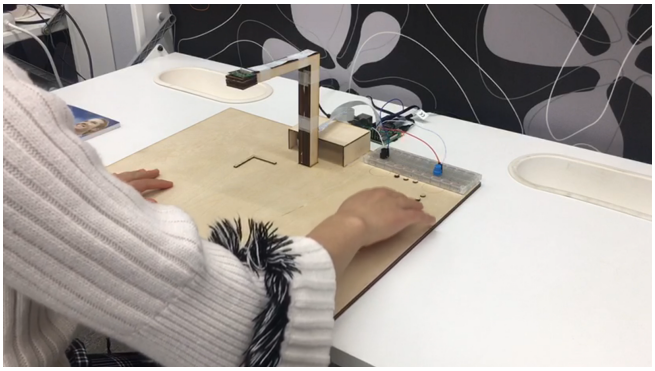

Figure 1. The final wooden prototype.

When it comes to the current assistive technologies for reading, all participants mentioned that they use voice-over. Specifically, two participants indicated that voice-over technologies are essential in any assistive device.

CONCEPT

The Assistive Text Reader is a device designed to be placed in a stable and fixed environment for example in a library. The prototype is entirely made of wood, with an arm to hold the camera and a small box to contain the necessary hardware. The base of the prototype contains haptic guides to help the users in the usage of it. They are used to guide the users to the buttons and assist the users in the positioning of the book/document on the base. The two buttons are for receiving the voice instruction and triggering the text-to-speech mechanism. Figure 2 depicts the appearance of the prototype. Figure 1 shows the built prototype, based on the blueprint seen in Figure 2.

The device has two main features:

1. Text Extraction
2. Text to Speech synthesis

Text Extraction is an automatized process that recognizes the presence of a text inside an image and extracts it by digitizing it. Text to Speech is the transformation of a digitized text into a human-like speech.

SOFTWARE

The software is a Python script that will handle the phases mentioned above; first, it will acquire the image through the camera, then encode it and send it to the cloud, where the computation will be executed. Then, once the speech is ready and encoded it will be played to the users. A scheme of the algorithm is as follows:

$take\_picture()$
$data \leftarrow encode\_picture(picture)$
$text \leftarrow send\_to\_server(data)$
$speech \leftarrow send\_to\_server(text)$
$play(speech)$

HARDWARE

The hardware used in the prototype is:

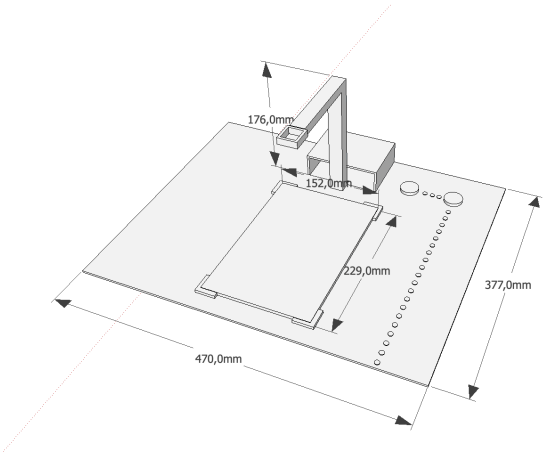

Figure 2. The blueprint of the final wooden prototype.

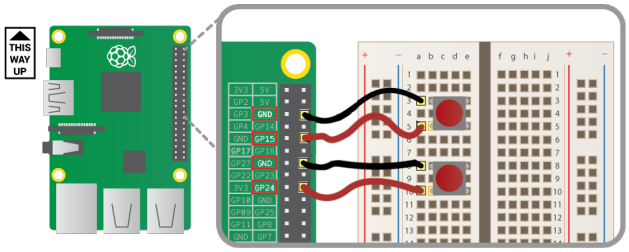

Figure 3. The blueprint of the final wooden prototype.

- Raspberry PI Model 3B+
- PiCamera
- Circuital parts:
  - Breadboard (1x)
  - Push buttons (2x)
  - Wires (4x)

Refer to Figure 3 for the circuit wiring.

EVALUATION & USER TESTING

The device was tested on 15 participants[1] to collect feedback and further improve it. The users were encouraged to explore and discover the features of the device alone or with little guidance. The test comprised of one Scenario whose goal was to read a page of a book that we provided using the device. Some users decided to try the device closing their eyes, while others focused on the implemented functions and how to improve those. The entire testing session took around one and half hour. Each participant spent from 5 to 10 minutes interacting with the device. After each test, we held some semi-structured interviews with the participant asking for feedback regarding the overall usability of the device.

[1]The participants were not Visually Impaired people, but with some experience in the field of HCI.

RESULTS

Generally, all the participants were impressed with our prototype and its natural sounding voice. The accuracy of text-to-speech transformation was also beyond their expectations. In addition, the operation of the device is somewhat intuitive and simple. However, some problems were highlighted:

- No PAUSE/STOP button
- No READ AGAIN button
- No MODIFY SPEED button
- No page number in the speech

At the moment of the testing[2], there was no solution to pause or stop the audio or to read again a part of the page. Some users also noted that there was no way to modify the speed of the playback. Finally, they also expressed their concerns regarding the absence of the page number in the audio. For a VI user, this means that they have to count the pages themselves and this might cause an unnecessary mental load. Sometimes, due to the still immature text extraction technology, if there is a figure or the text appears in a particular format, the digitized text will not start from the beginning.

CONCLUSION

In this paper, we presented an innovative device with the ambitious aim of helping VI people in the reading printed text. Although the device has some potentials, we are fully aware of its limitations; the dimensions of the device make it feasible to apply in particular settings, such as libraries with dedicated sections or offices. Moreover, due to technological limitations, the digitized text is not highly reliable; sometimes the results are almost perfect, but in other cases the result is not accurate enough to let the person understand the content of the page[3]. Additionally, due to the different positioning of the page number in every book, it is difficult, if not impossible, to indicate the users the current page that is being read. Finally, we acknowledge the lacking of proper user testing with the intended users of the device; we failed to recruit VI users to participate in our experiment due to the challenges involved in recruiting such a user group.

During the final development phase, we also discovered an alternative usage of the device; it can be used also by people who are learning a language that has a different alphabet/character set than their own. It is particularly useful for languages such as Japanese since the device is able to recognize and read its characters to the user that will then learn how to read and pronounce those.

ACKNOWLEDGMENTS

We would like to thank our tutor for giving us always valid suggestions. This honest advice, along with our team collaborative efforts, brought this Assistive Text Reader to life. We sincerely wish this reader would benefit Visually Impaired users.

[2]Some of the features are being implemented; in particular, with the use of a rotary potentiometer instead of a simple button, it will be possible to rotate it to adjust the playback speed and pressing it again during the reading will pause the reading.

[3]For example, we noted that it is impossible to read correctly tables or diagrams - the device reads the words, but it fails to recognize and tell the users that the data are inserted in a table or diagram.

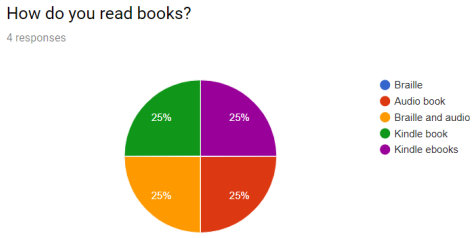

Figure 4. How VI users read books.

REFERENCES

1. 2016. How Do People Who Are Blind Or Visually Impaired Read Printed Text? Website. (15 September 2016). Retrieved May 20, 2019 from **https://sandysview1.wordpress.com/2016/09/15/how-do-people-who-are-blind-or-visually-impaired-read-printed-te**
2. 2018. Vision impairment and blindness. Website. (11 October 2018). Retrieved May 20, 2019 from **https://www.who.int/news-room/fact-sheets/detail/blindness-and-visual-impairment**.
3. R. Ryles. 1996. The Impact of Braille Reading Skills on Employment, Income, Education, and Reading Habits. (May 1996). Retrieved May 20, 2019 from **http://mountbattenbrailler.com/Docs/papers/Ryles_study.pdf**.
4. Roy Shilkrot, Jochen Huber, Meng Ee Wong, Pattie Maes, and Suranga Nanayakkara. 2015. FingerReader: A Wearable Device to Explore Printed Text on the Go. 2363–2372. DOI: **http://dx.doi.org/10.1145/2702123.2702421**
5. C. Willings. 2017. Reading Efficiency. Website. (18 October 2017). Retrieved May 20, 2019 from **https://www.teachingvisuallyimpaired.com/reading-efficiency.html**.

APPENDIX

QUESTIONNAIRE

The questionnaire used during the research phase can be consulted here: https://forms.gle/7x99BLoPPirZQVkt8 From it, we collected some insights shown below. The most used technology used by VI users is the iPhone's VoiceOver. Regarding the reading, users expressed their preference towards e-books in the Kindle (or similar) format (See Figure 4). Most of the users do not go to libraries and do not read hard copies of books. Regarding the device itself, half of the users either believe they already have access to all the books they want or prefer to purchase or download e-books from libraries. The other half is positive but points out that it might cause some issues since the low automation of the tasks, for instance, the fact that the VI person has to operate the device autonomously, flip the pages, position the book correctly and similar factors.

VIDEO

A video of the working prototype can be consulted here: https://drive.google.com/open?id=1DO_9yqXCI3ZUt28N1DBO-Wa7uD8-RLUO