

A Book Reading Magnifier for Low Vision Persons on Smartphones and Tablets

Makoto J. Hirayama

Faculty of Information Science and Technology
Osaka Institute of Technology,
Osaka, Japan
makoto.hirayama@oit.ac.jp

Abstract—Book reading magnifier for low vision people was implemented as an application of smartphones or electronic tablets. Pages of books are captured by camera and the images of texts are magnified by the proposed devices. To read texts in the sequence of sentences in a book, the software recognizes and analyzes structures of book pages. To recognize lines of book texts, histograms of black and white is used. Using the devices, users enabled to move the magnified screens of book pages smoothly along a text line direction of reading sequences.

Keywords—book reading magnifier; low vision; electronic tablet; smartphone; image processing; accessibility;

I. INTRODUCTION

Low vision persons including elders often use a magnifier to read texts on papers [1][2][3]. If his/her sight is very low, a book reading magnifier equipment, with a large screen and a moving stage on which a book is placed, may be used, although it is large and expensive [4][5]. Electronic books on electronic tablets are good for low vision persons because their texts can be resized. Furthermore, a reading function by speech synthesis technology may be able to be used.

However, many books have still been printed on papers [6]. Thus, low vision persons need magnifiers. Elders often use loupe, i. e., magnifying glass. Magnifying systems using smartphones, tablets, or display device are used, too [7]. But, they must be hold by one hand and must be moved smoothly keeping an exact direction, an exact timing of reading, and an exact distance between the loupe and the paper. It is difficult, and it becomes frustration or stress.

Therefore, a book reading magnifier application for low vision persons is proposed.

II. SPECIFICATION OF PROPOSED APPLICATION

A. Functions of the application

The main function of the proposed application is simple, that is, magnifying book texts for low vision persons. The function is same as a magnifying glass (loupe). A book page image captured from an inbuilt camera of a smartphone (or a tablet) is magnified and displayed on the smartphone display. Vertical or horizontal flipping on the screen by a finger scrolls the magnified image.

The difference from normal magnifiers is that it recognizes and analyzes structures of book pages especially for textual lines. Since it focuses on Japanese novel books or newspapers, only Japanese vertical writing is supported, so far. Japanese horizontal writing used mainly for technical books etc. will be supported in near future.

Figure 1 shows an example screens of the proposed application implemented on a smartphone (Apple iPhone). The figure shows an image of a book page captured by a camera installed in the smartphone. Figure 2 shows another example screen during reading books by a user.

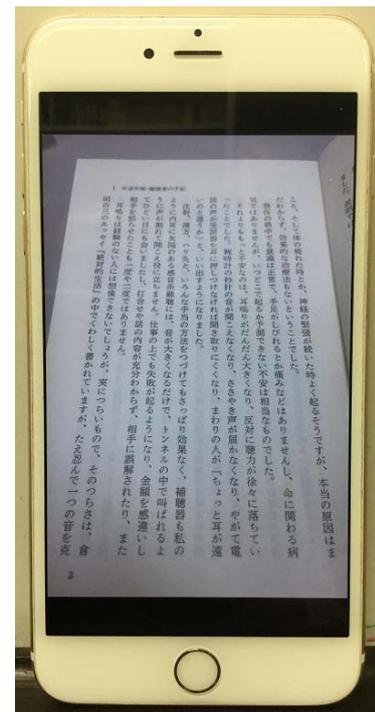


Fig. 1. Example screen – A captured book page.

To use the application, a user starts the application by double-tap on the application icon. Next, he/she captures a page of a book. The application analyzes the page and aligns it to grid. Then, he/she points starting point of reading. It is

usually the first character of the first line on the page. Then, the magnified first character is displayed on the top of the screen. By vertical scrolling actions (flipping), next characters are appeared continuously on the screen until the line was read. Note that the usual reading direction of Japanese novel or newspaper is vertical. At the end of the line, by a horizontal scrolling action (flipping), the screen jumped to the first character of the second line. Thus, he/she can read texts smoothly and fast without stress.

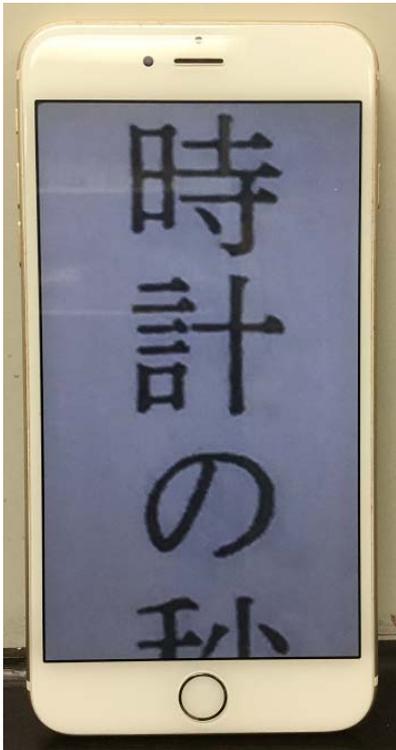


Fig. 2. Example screen – Magnified book texts

III. DEVELOPMENT

A. Development Platform and Environment

Target devices of the proposed application is smartphones and tablets. So far, the application is implemented on iOS. That is, it runs on Apple's iPhone or iPad. In near future, the same application will be implemented on Android.

Development environment for iOS is standard one. The newest versions of software at this moment are used. A Macintosh computer is used. Its operating system is macOS 10.13 (High Sierra). An integrated software development environment Xcode version 9.1 is used for programming. As a programming language, Swift version 4.0 is used. As the target operating system for iPhone and iPad, iOS 11 (version 11.1.1, now) is used.

B. Frameworks

Application frameworks (Software Development Kit; SDK) for iOS is called as Cocoa Touch. Its version number is same

as its operating system, that is, 11. Cocoa Touch has several sets of class libraries called as frameworks. *UIKit* framework is the most important for our development. It handles visuals on screen. Image data is stored as a *UIImage* object and displayed using a *UIImageView* object. It also has an inbuilt camera interface *UIImagePickerController*. Using these objects, camera inputs, image handling, and screen outputs can be done. In addition, *Core Graphics*, *Core Image*, and *AVFoundation* frameworks are useful for image processing.

C. OpenCV

In parts, a computer vision library OpenCV (Version 3.3) is used for image processing. Since OpenCV is a library written in and used with programming language C++, wrapper functions must be written for using with Swift. They bridge Swift statements into C++ through Objective-C. An *UIImage* object for iOS is converted to a *cv::Mat* type which is used for an image object in OpenCV. OpenCV has many popular and rich image processing functions so that they are partly used as well as iOS native libraries to reduce coding time.

D. MATLAB

A mathematical computing software MATLAB (Mathworks, Inc.) is used to test algorithms before implementations. This is useful to test ideas quickly. The current version of MATLAB is 2017b. *Image Processing Toolbox*, which is a library for image processing, is used together with MATLAB.

IV. PROCESSING FLOW AND ALGORITHMS

A. Overall processing flow

Figure 3 shows the overall processing flow of a program. When the program is initiated, initialization is done. Then, a user captures a book page using an inbuilt camera on a smartphone or a tablet. Next, reprocessing of image data is done to the captured image data. Then, its page structure is analyzed. And then, magnification, which is the main function of this application, is done. The user reads a book page by scrolling the magnified page. When a page is read from the first line to the last line, the user capture the next page image. These process is repeated until a book is finished to be read or the application is closed.

B. Preprocessing

Preprocessing in this case means that applying image processing to a captured camera image in JPEG format before processing for analyzing structure of textual lines of book pages.

The first thing to do is a format conversion, JPEG data in a *UIImage* object is converted to *CGImage* in *Core Graphics* framework to do pixel level processing. Also, *CIImage* for iOS based image processing and *cv::Mat* matrix objects are prepared to use *Core Image* framework and OpenCV libraries.

Second, a full color image from the camera is converted to a gray scale image, as color is not needed to read texts. Also, this gray scale image is converted to a black and white binary image using an appropriate threshold depending on lighting.

White is color of a white paper of a book. Black is an ink color for printed texts.

Third, a textual area is extracted from a whole camera image. It is assumed that 1) a large area in the center is a book page, 2) only 1 page is included in a captured image, 3) a textual area is a rectangle shape, 4) paper color is white and printed ink is black, 5) there are margins around a textual area. Using these characteristics, a textual area is extracted, then outer areas of the textual area, that is, page margins, front and back covers, tables on the background, are all discarded. The textual area is deformed to a strict rectangle to adjust a warp. If the textual area extraction was failed by a bad image from the camera, a user gets a message to request recapturing a same book page.

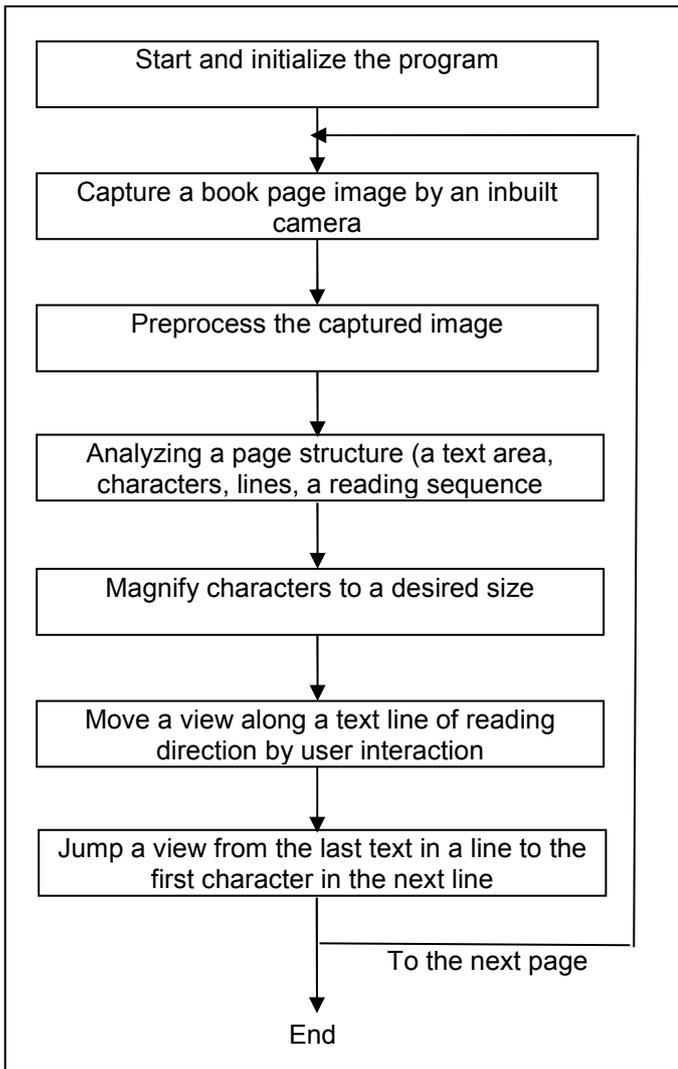


Fig. 3 Overall processing flow of the software

C. Textual Line Detection

The essence of the proposed application is page image analysis of books, especially for detecting lines of texts. The basic algorithm used in this application is a histogram of black and white. Since characters on page are lined up, when black dots are counted along a vertical line of pixels, black dots are

relatively many if texts are printed, and black dots are very few between text lines. This simple algorithm for detecting text lines works well, so far, although a type of books is limited to Japanese novels which have only Japanese texts without figures. The histogram can also be useful for page alignment to reshape a captured image to rectangle and to adjust slants.

As only Japanese vertical writing is supported so far, the right line is the first line and the top of the line is the first character to be started to be read. Coordinates of all textual line positions are memorized for later use.

Figure 4 shows an example of textual area extraction and textual line detections.

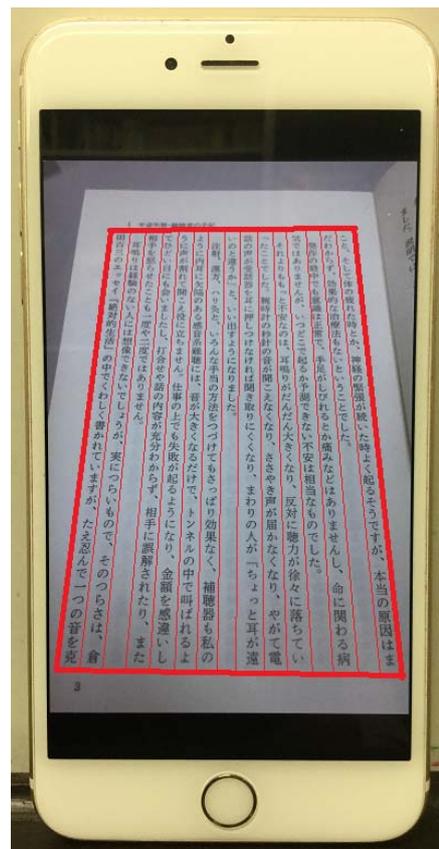


Fig. 4 An example of textual area extraction and textual line detections

D. Magnification and display

The textual area is magnified and displayed on screen. Magnifying ratio can be changed using pinch in and out gestures. In the initial screen, the first character on the page is displayed. An appropriate magnifying ratio is depending on levels of low vision. If low vision is not serious like normal elder persons, the magnifying ratio similar with loupe may be used. In this case, the magnifying ratio may be 1.5 through 4.5. If low vision is serious and sight is narrow, magnification around x10.0 or more may be needed. If the sight is narrow, displaying only 1 character at a time may be appropriate.

E. Scrolling textual lines

To read books, magnified characters must be scrolled along textual lines. Vertical scrolling by a finger can be done. Characters are always displayed on the center of screen. During vertical scrolling, the movement is always along a straight line. By horizontal scrolling, the first character of the next reading line is displayed. Then, vertical scrolling again to read the next line. Once a page is completed to be read, capturing the next page is done by a user, and then, a same operation with the first line is repeated.

Automatic scrolling is supported. In this mode, a user does not need to scroll always. One page can be read without interaction.

V. EVALUATION

Basic functions of the proposed application were checked. A page of figure 1 and other pages in the same book was checked. The application worked well as expected. The prototype application was evaluated by one low vision person. By hearing, it is confirmed that it can be used as a book reading magnifier and it is useful and handy.

So far, functions of the application are in a primitive level. Quantitative analysis will be done with more users soon. Usability and effectiveness evaluations with low vision persons will be planned.

VI. CONCLUSION

Basic functions of the proposed application were checked. Figure 1 More varieties of book images will be checked soon.

Providing services for disabled persons becomes an important social issue. A convention^[8] and laws^[9] have been developed and several supporting systems are under development. This application will help serious low vision persons to read books.

REFERENCES

- [1] Hillman JS, Aids for low vision in the elderly, *Br Med J* 1988, 296, pp. 102-103.
- [2] Temel A. Low vision aids: evaluation of 185 patients. *Ophthalmic Physiol Opt* 1989; 9: 327-331.
- [3] G. H. M. B. Van Rens, R. J. M. Chmielowski, & W. A. J. G. Lemmens, "Result obtained with low vision aids," *Documenta Ophthalmologica*, 78, 205-210, 1991.
- [4] Shigeki Morita, "Optical Assist Devices for Low Vision Persons – Book Reading Magnifiers and others," 8th Technical Interest Group Meeting of IIEEJ Visual and Hearing Impaired Support, No. 6, p. 1-5, 2016. (In Japanese)
- [5] Shigeki Morita, "You can read and write with book reading magnifiers – points of selection and use, Daikatsuji, 2000. (In Japanese)
- [6] Kinki Research Council for Information Services for Visually Impaired Persons, *Visually Impaired Persons Service Manual 2007*, Dokusho-Kobo, 2006. (In Japanese)
- [7] Miyake, Hayashi, Noda, Kashiwase, A new trial of a low vision aid using iPad, *Visually impaired rehabilitation research convention*, 21(0), 2012, p. 128. (In Japanese)
- [8] The United Nations, *Convention on the Rights of Persons with Disabilities*, 2006.
- [9] The National Diet of Japan, *Law for eliminating discrimination against people with disabilities, Japanese Law, Heisei 25 year, No. 65, 2013.*