Enhanced portable text to speech converter for visually impaired

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Abstract: The handwritten text reader is designed to help the visually impaired listen to an audio read-back of printed and handwritten scanned text. A hand-held page scanner is used to scan the text to be read. The image from the scanner is sent to the application in the paired Android phone over Bluetooth. An open source optical character recognition (OCR) engine, Tesseract is used to extract the text from the image, and this extracted text is converted to speech. Tesseract OCR engine is further trained to recognise handwritten text for a specific user. This OCR engine is trained with handwritten datasets. In addition to English, the application supports two regional languages – Hindi and Bengali.

Keywords: handwriting recognition; Tesseract; OCR; optical character recognition; text to speech; Android; visually impaired.


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1 Introduction

Visually impaired people cannot read handwritten or printed text and depend on a third person. Although Braille books are available, they are expensive and most of the blind people cannot read Braille. Using technologies like optical character recognition (OCR) and text to speech (TTS), a system can be developed which will help the visually impaired listen to an audio read-back of any text from documents, books or newspapers. This system has two main modules: extracting the text from an image, converting the text to speech.

Tesseract is an optical character recognition engine which is considered one of the most accurate open source engines available now. To recognise text from an image, adaptive thresholding is first done in Tesseract to convert the input image to a binary image. Connected component analysis is done to store the outlines of each component. According to the character spacing, lines of text are broken into words. Text recognition is carried out in two steps for more accuracy. The same sequence of steps is followed to recognise both printed and handwritten text. However, the OCR engine is trained with user-specific training data to recognise handwritten text.

Text to speech (TTS) API is used to convert the extracted text into speech. The following operations are carried out on the input text: detection, analysis, normalisation and linearisation. Following these steps, speech is synthesised on performing phonetic analysis and acoustic processing. A model of the vocal tract is used to produce the voice output.

The organisation of this paper is as follows. In Section 2, a detailed literature survey regarding the existing systems has been presented, followed by Section 3 that describes the system design, Section 4 that discusses the implementation of the proposed system. The results are discussed in Section 5. Finally, Section 6 concludes the work.

2 Related works

Handwritten text reader for the visually impaired is an extension of the system that was developed to help the visually impaired listen to an audio read-back of printed text only Ragavi et al. (2016). This extension adds two main functionalities: recognition of handwritten text, support for two regional languages (Hindi, Bengali).

An overview of Tesseract OCR engine has been given by Smith (2007). Sasirekha and Chandra (2012) have described the process of text to speech synthesis. Mithe et al. (2013) have proposed an Android application which obtains images from high-resolution mobile phone cameras, and performs image to speech conversion. This application is proposed for use in fields like office automation, banking etc. This system is not suitable for visually impaired people because they have difficulty in capturing pictures of the text with mobile phone cameras. Gaudissart et al. (2005) have proposed a similar system named SYPOLE which performs the same function, but uses a personal digital assistant.
Selvaraj and N. Bhalaji (PDA). The input image is the picture captured by an embedded camera in the PDA, which makes this system also not feasible for visually impaired people.

Rakshit and Basu (2010) have described the process of training Tesseract OCR engine to recognise handwritten text. Tesseract is trained with user-specific handwriting samples of two groups of data. The first group contains isolated lower case characters and the second group contains free-flow text. The overall accuracy of the system was found to be 78.39%. The Tesseract training process can be split into three modules: a collection of dataset, labelling training data, training the data using Tesseract OCR engine.

3 System design

Using the hand-held page scanner, the visually impaired can scan documents containing printed or handwritten text. The scanned image is then sent to the Android mobile phone that is paired with the scanner over Bluetooth.

Figure 1 Architecture of handwritten-text reader

The Android application developed obtains the language of the text to be processed – English, Hindi or Bengali from the user as voice input. The application then opens the most recently received scanned image from the Bluetooth folder and performs OCR and speech synthesis. Since Tesseract cannot recognise handwritten text, it has been trained to create a new language set for identifying handwritten text. If the scanned image contains handwritten English text, Tesseract uses the trained data file, created after the collection of datasets, the labelling of trained data and the training
of Tesseract OCR engine, for performing character recognition. If the scanned image
contains printed English, Hindi or Bengali text, then the existing trained data file
available for these languages is used while performing OCR.

The architecture of the system shown in Figure 1 describes the steps involved in the
training of Tesseract to identify English handwritten text. This training step is skipped for
the scanned images with printed text in English, Hindi or Bengali and so the
existing trained data files available are used for character recognition.

Tesseract can be trained to identify and perform OCR on new languages. It can
also be trained to recognise handwritten text in languages other than English. Languages
other than English, Hindi and Bengali can be included into the system provided
TextToSpeech library supports the languages. If the languages are not supported by
the TextToSpeech library, transliteration must be performed or external libraries must be
imported.

3.1 Algorithm

The flow diagram of the Handwritten-text reader is shown in Figure 2.

Step 1: Scan the document containing printed or handwritten text using the hand-held
page scanner and transfer the scanned image to the Android mobile phone that is paired
with the scanner over Bluetooth.

Step 2: The Android application developed greets the user and obtains the input language
i.e., the language of the scanned text from the user.

Step 3: The application then opens the most recently received scanned image from the
Bluetooth folder using LastModifiedFileComparator library of Apache.

Step 4: If the scanned image contains printed text, the TessBaseAPI library of
Tesseract uses the existing trained data file available for the input language to perform
OCR.

Step 5: If the scanned image contains English handwritten text, the trained data file
generated after the manual training of Tesseract is used for performing OCR.

Step 6: The editable text output of the OCR is converted to speech and conveyed to the
visually impaired using TextToSpeech library of Java.

3.2 Description of the algorithm

Tesseract assumes that its input is a binary image with optional polygonal text regions
defined (Marosi, 2007). The first step of processing is a connected component analysis in
which outlines of the components are stored. Tesseract was probably the first OCR
engine able to handle white-on-black text so trivially. At this stage, outlines are gathered
together, purely by nesting, into Blobs. Blobs are organised into text lines, and the lines
and regions are analysed for fixed pitch or proportional text. Text lines are broken into
words differently according to the kind of character spacing. Fixed pitch text is chopped
immediately by character cells.
The proportional text is broken into words using definite spaces and fuzzy spaces. Recognition then proceeds as a two-pass process (Pazio et al., 2007). In the first pass, an attempt is made to recognise each word in turn. Each word that is satisfactory is passed to an adaptive classifier as training data. The adaptive classifier then gets a chance to more accurately recognise text lower down the page. Since the adaptive classifier may have learned something useful too late to make a contribution near the top of the page, a second pass is run over the page, in which words that were not recognised well enough are recognised again. A final phase resolves fuzzy spaces, and checks alternative hypotheses for the x-height to locate smallcap text. It is clearly explained in Figure 3.

Figure 2 Flow diagram of the system
4 Implementation

For training Tesseract (Chandran et al., 2015; Rakshit et al., 2009) datasets containing isolated and free flow text must be collected from different users using the portable scanner device. It is shown in Figure 4.

These datasets should then be labelled using box editors. Once the datasets are ready, Tesseract can be trained to recognise handwritten text. These three steps are explained in detail in this section.

4.1 Collection of dataset

For the collection of the dataset, it was concentrated on lower case characters. There were 13 handwritten document pages in lowercase that are collected from each user in two types of handwritten datasets. In the first dataset, we collected six pages of isolated handwritten lowercase characters as shown in Figure 5 and in the second dataset, 7 pages of free-flow handwritten text were collected from the user as shown in Figure 6.
4.2 Labelling training data

Training samples should be labelled. This process is done using a box editor called jTessBoxEditor. The following command generates box files for each image.

```
tesseract engp.hw.exp0.jpg engp.hw.exp0 batch.nochop makebox
```

```
tesseract engp.hw.exp19.jpg engp.hw.exp19 batch.nochop makebox
```

Box file is a text file which contains each character in the training image, one per line with the coordinates of the bounding box around the character. In jTessBoxEditor, the
Bounding boxes can be merged, split, inserted or deleted as needed for incorrectly recognised characters as shown in Figure 7.

**Figure 7** Screenshot of jTessBoxEditor (see online version for colours)

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### 4.3 Training Tesseract OCR engine

The steps in training Tesseract OCR Engine is explained in detail in this section (Banerjee, 2010). The first step is to run the Tesseract engine in training mode using the following command:

```
tesseract engp.hw.exp0.jpg eng2.hw.exp0 nobatch box.train
```

The next step is to generate the unicharset file using the following command:

```
unicharset_extractor engp.hw.exp0.box engp.hw.exp1.box . . . engp.hw.exp11.box engp.hw.exp19.box
```

‘shapeclustering’ command generates the shape table:

```
shapeclustering -F font_properties -U unicharset engp.hw.exp0.tr.engp.hw.exp19.tr
```

‘cntraining’ command is used for character normalization:

```
cntraining engp.hw.exp0.tr.engp.hw.exp19.tr
```

Finally, combine_tessdata command is given:

```
combine_tessdata eng2.
```

This command generates the engp.traineddata file, which is placed in the Assets folder in the Android studio project. This system is able to support two regional languages – Hindi and Bengali. The training data for Hindi and Bengali is added to Assets folder in Android Studio. When the user selects Hindi or Bengali, the appropriate training data is selected and optical character recognition is performed using it.
5 Results

The results observed using the scanner has been compared with the existing system that used a 5 Mega Pixel phone camera for image capturing of the page. A sample image with 90 words is considered for comparison. The result of the comparison is shown in Table 1.

<table>
<thead>
<tr>
<th>Comparison parameters</th>
<th>Portable scanner</th>
<th>Camera</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image size</td>
<td>0.45 MB</td>
<td>1.4 MB</td>
</tr>
<tr>
<td>Accuracy</td>
<td>98%</td>
<td>85%</td>
</tr>
<tr>
<td>Delay</td>
<td>7 s</td>
<td>12 s</td>
</tr>
</tbody>
</table>

The accuracy of the system is determined by the following formula:

\[
\text{Accuracy} \% = \frac{\text{Number of errors in recognition}}{\text{Total number of words}} \times 100
\]

The number of errors in using the scanner is 1 word and for phone camera is 13 words for the considered sample 90 words file. The delay parameter specifies the delay for speech output which is 7 s for the scanner and 12 s for a phone camera. The observed results have shown that the size of the scanned image is lesser than the camera image. Also, the processing speed is lesser in the proposed system. The results show that the accuracy of recognition is more than the existing system.

The screenshot of the application after performing OCR of a sample printed English text is shown in Figure 8. The scanned image used in the application is displayed as an image view at the bottom left corner of the application for reference.

On pressing the button on the top, the application begins performing OCR and speech synthesis of the recently received image without any further manual intervention. Figure 9 shows the application after performing OCR of a sample handwritten English text.

The application after performing OCR of a sample printed Hindi text and a sample printed Bengali (Shahiduzzaman, 2015) text are shown in Figures 10 and 11, respectively.

The accuracy of an OCR system can be measured on character level or word level. A system is said to be 99% accurate if 1 out of 100 characters are uncertain or incorrect and 99.9% accurate if 1 out of 1000 characters is uncertain or incorrect. To attain word level accuracy, the system should allow for the proper, relevant words to be found like city names, person names etc. There is no simple way to measure word level accuracy. Therefore, an intelligent, fuzzy search technology must be used for the same.

The system has been tested with 3 OCR engines say, Tesseract, ABBYY and Microsoft Oxford OCR engines. The accuracy of the system has been for the languages Hindi and Bengali. Also, the character recognition for handwritten text is performed and the results in terms of accuracy are measured. Table 2 shows the accuracy comparison between the Tesseract OCR Engine used in the project and the other commercial OCR engines available.
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Figure 8  Scanned image and screenshot showing the optical character recognition of English printed text (see online version for colours)

Eye disorders which can lead to visual impairments can include retinal degeneration, albinism, cataracts, glaucoma, macular problems that occur in visual disturbances, central disorder, diabetes retinopathy, congenital disorders, and infection. Visual impairment can also be caused by brain and nerve disorders, in which case it is usually termed cerebral visual impairment.

Visual impairments may take many forms and be of varying degrees. Visual acuity alone is not always a good predictor of the degree of problems a person may have.

Figure 9  Scanned image and the screenshot showing the optical character recognition of English handwritten text (see online version for colours)
Figure 10  Scanned image and the screenshots showing the optical character recognition of Hindi printed text (see online version for colours)

Figure 11  Scanned image and the screenshots showing the optical character recognition of Bengali printed text (see online version for colours)

Table 2  Comparison of OCR engines

<table>
<thead>
<tr>
<th>Language</th>
<th>Tesseract OCR engine</th>
<th>ABBYY OCR engine</th>
<th>Microsoft Oxford</th>
</tr>
</thead>
<tbody>
<tr>
<td>English Handwriting</td>
<td>88.6%</td>
<td>77.3%</td>
<td>73.5%</td>
</tr>
<tr>
<td>Hindi</td>
<td>82.4%</td>
<td>Not supported</td>
<td>Not supported</td>
</tr>
<tr>
<td>Bengali</td>
<td>84.3%</td>
<td>Not supported</td>
<td>Not supported</td>
</tr>
</tbody>
</table>
6 Conclusion

The portable text to speech converter has been implemented for handwritten text for visually impaired people. This system can help the visually impaired people to learn from audio read-back of any scanned text, by sending the image from the scanner to Android mobile phone via Bluetooth. The major advantage of this system is it uses the document scanner which can scan the entire page; therefore, the visually impaired people can easily scan the document without the need to focus on the document.

Additionally, the application supports regional languages – Hindi and Bengali. Moreover, the scanned image may contain text with background pictures which are simply ignored and only the text in the scanned image is extracted by the application to be converted to speech. This project is implemented using a handheld page or document scanner, an external Bluetooth module when the scanner does not have an inbuilt Bluetooth module, an Android application to perform OCR and speech synthesis and an Android mobile phone. The cost involved in developing the system is significantly low and the system provides a friendly user interface for the visually impaired people.

References


