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Projection Profiling Based Sinhala Braille Character Recognition and Conversion

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Abstract: The instantaneous conversion of written Braille characters to readable, colloquial text of the particular language it was written in, has been a hurdle for many sighted personal. Various solutions have been proposed in this regard and many solutions are available to convert Braille to different languages. However, there are very few attempts to do the same for Sinhala Braille symbols and at present widely using conversion method is to use an individual well versed in both Sinhala language as well as Sinhala Braille characters. As such, a considerable delay occurs in the translation process. Hence the visually impaired academics and students, as well as soldiers visually impaired due to war, who work with Braille encounter many hardships. Their teachers and superiors also have faced numerous problems as they are unable to understand Braille. One such consequence is that students sitting for exams face delays in receiving exam results as translation from Braille to Sinhala introduces additional delays in addition to often the context being lost in translation.

Proposed conversion engine will easily convert the Sinhala Braille text on papers to the corresponding Sinhala text and will assist the learning and communication processes of visually impaired citizens of Sri Lanka. The Braille printed documents to be converted through this software need to be subjected to image pre-processing, projection profiling and Braille recognition processes, capturing a picture of the Braille characters on a sheet initiates the process. Six dots are used to create Braille symbols. This system identifies these distinct symbols using a specially constructed framework and algorithms, followed by comparing them against a database of symbols in the recognition process and the final output is derived using the Sinhala alphabet.

Keywords: Braille symbols, image pre-processing, projection profiling

Introduction

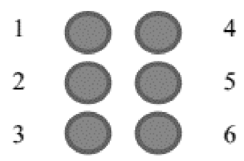

Figure 1. A Braille cell

There are not many person able to read Braille. Therefore it is necessary to research, assistive technology to translate Braille in to text to make it easier to read (Subur, Sardjono, and Mardiyanto, 2016). Simply, the paper communication between the visually impaired people and non-blind people have become a problem that need to be addressed (Perera, and Wanniarachchi, 2018). Braille recognition systems can bridge the communication gap between the visually impaired and people with unimpaired vision. By being a digital guide to non-Braille academics, this system is expected to expedite the exam paper evaluation process of visually impaired students so that the release schedule for them occur parallelly with the ordinary students and therefore shall effectively reduce or abolish the waiting time for their results. Also the visually impaired Sri Lankan citizens can move forward in their life at the same pace with general public. It also could work as a more credible method of translation which avoids the inaccuracies caused by human errors in the process of manual translation. Hence, it possesses the effect of assisting visually impaired student to fill the gap faced when navigating in a fast paced digitally integrated modern society.

There have been attempts to recognize Braille documents using the setups of a camera (Subur, Sardjono and Mardiyanto, 2016; Taha, 2014; Venugopal-Wairagade, 2016) and commercially available scanners (Wong, Abdulla and Hussmann, 2004; Antonacopoulos and Bridson, 2004; De Silva, Srilal, Athapaththu and Ranathunga, 2016) for different llanguages world wide (AlSaleh, El-Zaart and Al-Salman 2011; Shreekanth and Udayashankara, 2015; Kitchings, Antonacopoulos and Drakopoulos, 1995). This paper presents a method of Braille cell extraction from a digitized single sided Braille paper followed by the recognition of Braille character patterns. This aims at generating quick results for the sighted persons who need to understand visually impaired persons.

Section II of this paper will present the methodology proposed and the algorithms involved describing all the four main system processes. Section III presents test results, which are discussed in the same section.

Methodology

The embossing of Braille dots can be on a single side or on both the sides of the Braille sheet. The data contained in the single sided Braille document is less than a double-sided Braille document for the obvious reason that the information present is only on one side. However, single sided Braille paper is simpler in nature to scan via image processing techniques. Therefore, henceforth the research is focused on the single sided Braille documents.

The development was done in the C++ development environment with OpenCV image processing library. The system goes through four (04) major steps as shown in Figure 2.

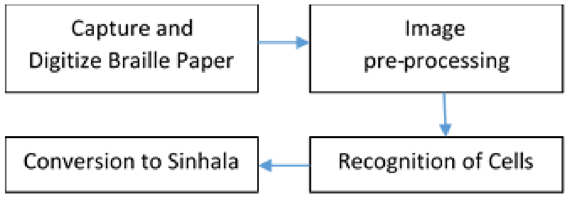

Figure 2. System process and features

A. Capture and digitization of Braille paper

For this research it is used single sided Braille documents written in Sinhala language. Also can use either standard document scanners or specially designed Braille document digitizer for acquiring the input image before the preprocessing task. The Braille document digitizer illuminates the Braille paper with LED in Green colour light and captures the image using Nikon D3400 24.2 MP Digital SLR Camera for obtaining relatively high resolution image. Several light sources and colours were tested and it was found that Green light was best suited to providing a high degree of contrast between the raised Braille portions of the paper and the flat ones. LED strips are positioned all around the interior to provide illumination from each edge of the Braille paper and to get highlighted the embossed dots.

Figure 3 shows the digitizer based input acquisition.

The scanner was constructed to extract the best possible image in terms of pixel density and clarity, accommodating the optimal focal length for the camera used and to mount the camera so as to eliminate movements that may introduce errors. The interior of the scanner was sealed from external influences such as wind and light that might interfere in the image processing. The tray for placing documents is designed to enable the rapid placement of the Braille document in the correct position, correct alignment and correct orientation every single time.

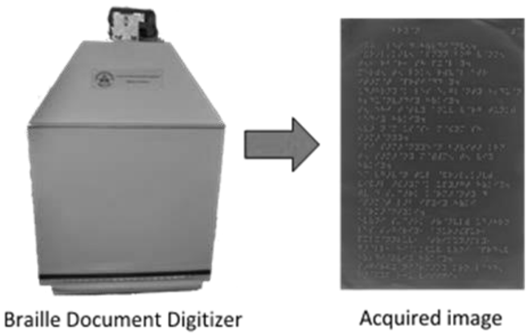

Figure 3. Digitizer based input acquisition

The resultant scanner mechanism is capable of capturing Braille sheets with a high degree of clarity and speed without compromising the integrity of the paper and embossed characters than any external or flatbed scanner. It does the process much faster owing to the extremely fast image capture time of the digital camera and the possibility of immediately accessing the image afterwards.

B. Image pre-processing

The acquired image is now subjected to image preprocessing. Initially, crop the full Braille cell area or required area to be converted from the input image using OpenCV implementations. If there is any rotation on the input image, corrections could be done. De-skewed image is now converted in to a grayscale image using OpenCV *CV_RGB2GRAY* implementation. Next, the grayscale image is converted in to a binary image using *cvThreshold* function. At this stage all the embossed Braille dots that were present in the cropped image is represented in black dots with few unwanted noise. To remove that noise it is used the Erosion followed by Dilation on binary image using *cvErode* and *cvDilate*. By now there is an image which is noise free / less to further process. Figure 5 represents the pictorial flow of image pre-processing processes.

C Recognition of cells

On noise filtered binary images it is performed a full horizontal projection profiling comparing against the cell height in pixels, to identify the Braille rows without partial data on the cropped input image. Identified rows are shown in Figure 4.

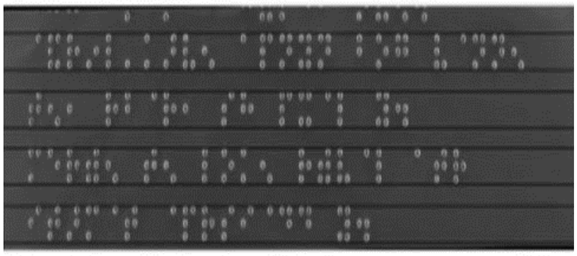

Figure 4. Identifying rows

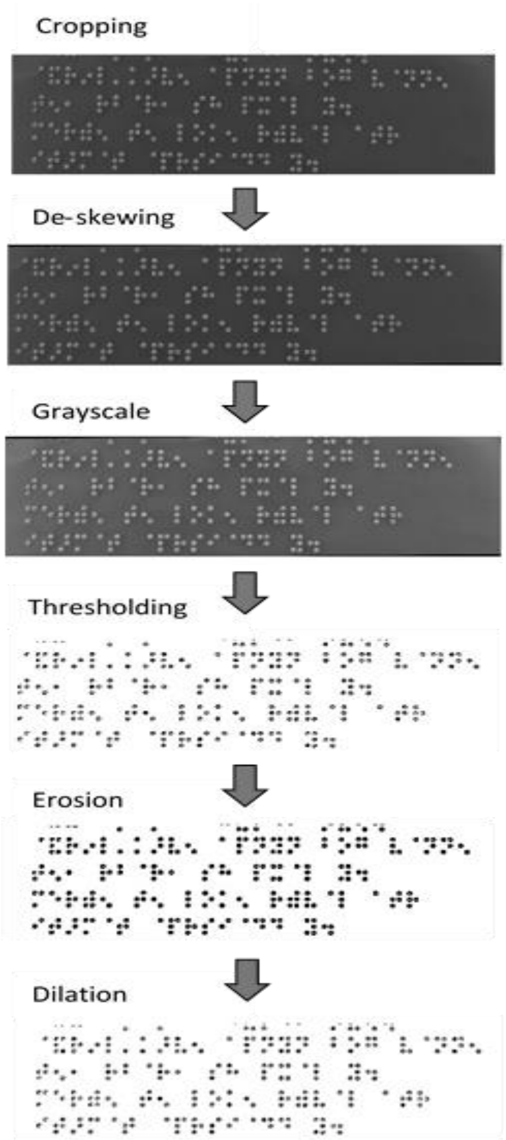

Figure 5. The flow of image pre-processing

Now perform a vertical projection profiling on each identified row comparing against the cell width in pixels, to derive best left and right boundaries for each and every Braille symbol. At the end it has the coordinates of the four (04) edges of all the Braille cells on the selected area to be recognized. Best possible left and right boundaries are shown in Figure 6.

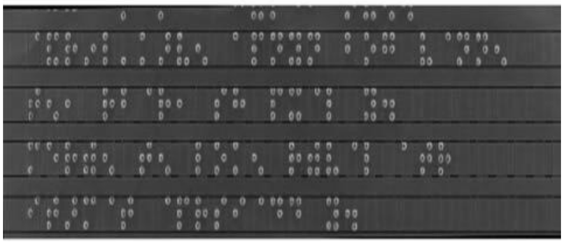

Figure 6. Identifying all cell boundaries

D. Conversion to Sinhala

It is assigned an integer to each dot segment of a single cell as shown in Figure 7.

1 32	4 4
2 16	5 2
3 8	6 1

Figure 7. Assigned integer to each dot segment

If a binary data is present on each dot segment, add corresponding integers together. All the final integers are mapped to the Sinhala Alphabet. Complexity of Sinhala Braille to represent Sinhala text is also addressed in this way. As an example Sinhala characters with upper and lowers connections (Figure 8) get broken down as single characters in Braille. After mapping each and every connection from the Sinhala alphabet, the final Sinhala letter is displayed to the user.

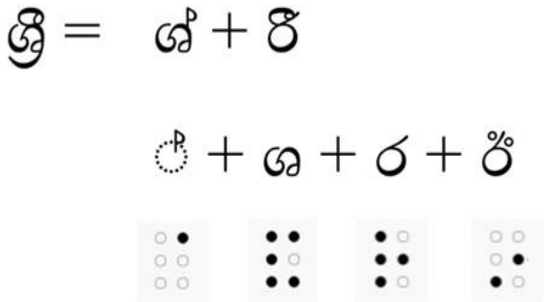

Figure 8. How Sinhala "" character is represented in Sinhala Braille system

After mapping all the Sinhala Braille letter combinations to the Sinhala alphabet, the final output is displayed as shown in Figure 9.

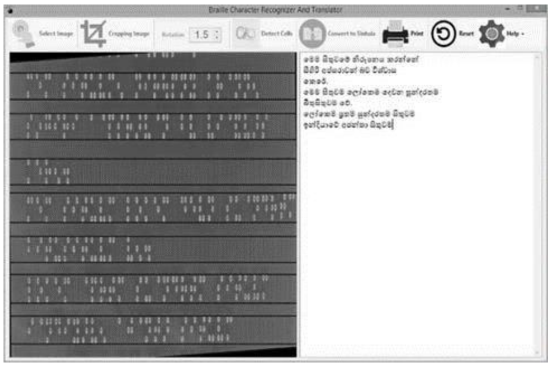

Figure 9. Visualization of converted output

Results and Discussion

The system has been tested with a wide variety of single sided, scanned, printed and typed Sinhala and other languages' Braille documents. Character translation achieved up to 92% success rate. Typical failure cases in the single sided documents such as worn marks, paper defects and noises, directly affected on the success rate.

Conversion of other global languages' Braille documents to relevant native languages also showed with promising results using the same algorithms. Few results can be shown as follows (Figure 10).

Figure 10. Support for native languages globally

The system was found to be simple and easily usable with minimal instruction. When used in conjunction with other Sinhala to Braille conversion tools, it proved to be helpful, enabling even the military personnel who are visually impaired due to the war to integrate back to the society and to be productive with a purpose.

Our further work is focused to recognize doble sided Braille documents, carry out noise cancellation process and gain higher success rate in character recognition. In future iterations, it is envisioned to modify the enclosure to reduce the size and make it more compact, based on a more suitable higher resolution camera and to deploy the system as a Cloud Service to be used by other organizations globally. The ultimate aim being to make the system ubiquitous, simple, mass producible and to make it possible to have a device present for the use in any institution or individual who works with visually impaired citizens.

Conclusion

Along with these features now there is a rapid, user friendly, easy to use and cost effective, all in one system which has quick response time based on the user experience. Also, the combined algorithms have the potential to solve the problems in vegetation counting, hand writing segmentation, number plate recognition, aerial image analysis, remote sensing and inscription character recognition etc.

This paper proposed an algorithm to optically recognise embossed single sided Braille documents through image processing and do so in an easily accessible manner. Thus, it would be possible for the visually impaired to be more productive and engage more with the society at large and move forward with their lives at the same pace as else, as epitomised by the nature of the ever-integrated digital world we live in.

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