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An Algorithmic Approach for Double Sided Braille Dot Recognition Using Image Processing Techniques

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***Abstract*— Braille is a tactile format of written communication for people with low vision and blindness worldwide. Optical Braille recognition (OBR) system acquires and pre-processes the Braille documents to convert it into its equivalent natural text. The Braille documents are of two types, single sided and double sided Braille. In single sided Braille document embossing is created on one side, thus the recognition is easier as compared to double sided Braille document since in the later case the embossing is done on both side of the document with a small diagonal offset. This paper presents an efficient and a new algorithmic approach for the recognition of double sided embossed Braille document, with simple Braille dot analysis, based on the variation in the gray level values of the Braille image due to the protrusions and depressions created on the original Braille document. The work in this paper has two main tasks, first is to recognize the printed Braille dots and second is to differentiate them as recto and verso dots. This involves few processes such as, thresholding, centroid detection, mask design, placement of designed mask on the centroid detected dots and differentiating recto dots from verso dots. Dots from the interpoint Braille document can be separated into recto and verso dots with a single scan and with the average processing time of 5.6 seconds. The experiments carried out on the developed database and obtained an excellent recognition rate of 99%.**

***Keywords*— Braille, Inter-point braille, Dot Detection, Thresholding and OBR.**

I. INTRODUCTION

Braille is a tactile format of written communication for people with low vision and blindness worldwide. Braille is understandable by visually impaired people, however, vision people need not be able to understand these codes, and thus the development of Braille recognition systems can bridge the communication gap between the visually impaired and vision people. The Braille system, devised in 1821 by Frenchman Louis Braille, is a method that is widely used by blind people to read and write. Each Braille character or "cell" is made up of six dots, arranged in a rectangle containing two columns of three dots each as shown in Fig 1.

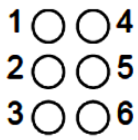

Fig. 1 Braille cell

A dot may be raised at any of the six positions to form sixty four combinations (including the combination in which no dots are raised). For reference purposes, a particular combination may be described by naming the positions where dots are raised, the positions being universally numbered 1 through 3 from top to bottom on the left, and 4 through 6 from top to bottom on the right [8].

The Braille dot dimensioning has been formatized according to the tactile resolution of the Fingertips of an individual. The horizontal and vertical distance between the dots in a character, the distance between cells representing a word and the interline distance were also specified by the Library of Congress as shown in Fig.2.

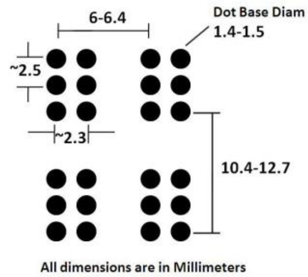

Fig. 2 Braille Cell Dimensions.

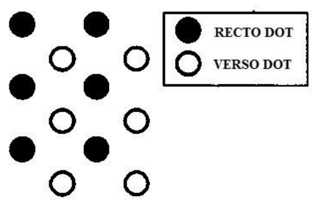

Fig. 3 Inter-point Braille.

The dot's height is approximately 0.02 inches (0.5 mm); the horizontal and vertical spacing between dot centers within a Braille cell is approximately 0.1 inches (2.5 mm), the blank space between dots on adjacent cells is approximately 0.15 inches (3.75 mm) horizontally and 0.2 inches (5.0 mm) vertically. A standard Braille page is 11 inches by 11.5 inches and it typically has a maximum of 40 to 43 Braille cells per line and 25 lines [2]. The single sided Braille documents generally consume a lot of space and hence to overcome this problem most Braille documents are printed in an inter-point. Here the embossing is done on both the sides of a page, with a slight diagonal offset to prevent the dots on each side of the Braille page from interfering with each other as shown in Fig. 3 [10].

Many documents are printed in inter-point form, meaning they are double-sided. As such, the depressions of the Braille of one side appear interlaid with the protruding Braille of the other side and Braille is generally printed on paper, with no ink to produce contrast between the raised characters and the background paper. However, imperfections in the page can appear in a scan or image of the page. Braille image acquisition is an important constituent in Braille dot recognition. Due to high-precision requirement for image acquisition in Braille recognition, this part needs to accurately provide high quality and clear embossing Braille image to locate the Braille dots in later stage. Due to these factors it is needed to develop an algorithm for double sided Braille dot.

Various authors have proposed different methods for braille dots detection like distinguishing convex points from concave points by the highlight and shadow patters generated by exposing the braille points to LED lights [1], dot detection of braille images using a mixture of beta distributions [4], template matching with cross correlation [5].

The average simulation time taken by all the above approaches is quite large. Motivated by this in this paper we present a method of Braille dot recognition that aims at differentiating the braille dots by detecting the centroid of the each dots and placing the mask on the centroid detected dots to separate the double sided braille pages into recto and verso dots in less time. Each of those steps will be discussed in more detail in the following sections. Section 2 gives the brief overview of some related works, in section 3 the proposed work will be discussed. Section 4 gives the experimental results obtained by applying proposed algorithm on developed database. In Section 5, we provide conclusions and directions for future work.

II. REVIEW OF LITERATURE

This section gives the overall view of the work done by various authors in separating the recto dots from verso dots from an inter-point Braille image.

In [4], the author proposed a method for dot detection of braille images using a mixture of beta distributions. Image preprocessing stages are not incorporated in this method as the use of stability thresholding for a mixture of beta distributions to initiate the process of a multi-mode estimator in order to create threshold values. First the thresholding is proposed on the scanned braille image in order to segment it into three classes of pixels; a mid-gray background, a pair of light area and dark area for each recto and verso dot. Then for detecting the recto and verso dots from double sided braille documents a grid is formed to accomplish the detection of dots for each box in the grid, a test is carried out to decide whether it holds a recto dot or verso dot.

In [1], a method for distinguishing convex points from concave points by the highlight and shadow patters generated by exposing the braille points to LED lights is proposed. This work describes a method of reading information recorded on both sides of paper by scanning only one side and recognition accuracy estimates for slanting Braille lines and deteriorated Braille points. This work uses the fact that the patters of reflected light strength from convex and concave points differ allows separate detection of convex and concave points.

J. Mennens et.al [5], presented an earlier approach for double sided Braille page recognition. They addressed the problem of low frequency distortions (shadows) on the Braille page caused by the tensions in the Braille paper's surface, made by the deformations of this surface by subtracting a local averaged image from the original. The image is divided into sub-images and grids are calculated for each sub image separately in order to minimize the deformation of the grid when Braille characters are positioned. These grids are then taken together in horizontal and vertical strips. Horizontal strips contain vertical grid lines and vertical strips contain horizontal grid lines.

Lines will then be grouped in atoms. An atoms is a group of lines that belongs to a single Braille cell. In order to work with a rotated grid, deviation over sum of rows is calculated. Each time the image is slanted one pixel in the vertical direction, the deviation over the sum of rows is calculated. A maximum is obtained when the dots are aligned horizontally. In the digitized braille page, dots are represented with light and dark areas. Then the areas are classified by making a three value image. The resulting image has five values: regions with value +2(recto) and -2(verso) are called core regions, regions with value -1(recto) and +1(verso) are called side-lobes and 0 is background. Grid lines are then searched by making histograms of rows and columns.

Abdul Malik Al-Salman et.al [3], developed an Arabic OBR system that is able to recognize both single-sided and double-sided Arabic Braille documents from a single scan. First an image of a Braille document page is obtained using a flatbed scanner. Second the image is converted to a gray color. Following that any white or black frames are cropped. The image is then thresholded so that only three classes of regions exits: dark, light and background. This algorithm takes into the account the implication that if the bright region comes at top and the dark one comes at bottom then it is a recto dot, and the converse situation results in a verso dot. Also it takes into account that the average dot height is 8 pixels. Bright pixels are assigned the value+1 and dark pixels are assigned the values-1.

Abdul Malik S, Al-salman [7] presented a new algorithm for Braille cells recognition using image processing technique. The Braille image is segmented using a stability thresholding method with a beta distribution. To ensure correct detection and extraction of dots composing Braille cells a grid is formed to contain the Braille dots. Then the recto dot is identified by a light region that exits below a dark region. After having recto,

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verso dots, Braille cells are then recognized based on the standard regrouping of dots.

In [6], the approach uses the binarized image for dot recognition. The proposed algorithm used as improvised segmentation technique which considered a histogram made up of only those pixels that lie at or near the edges of the Braille dots. The resulting histograms contains sharpen peaks and lower valleys. To determine which pixels lie on or near the edge, the Laplacian of Gaussian operator is applied to the entire image to identify the edge pixels. The average gray level of these edge pixels will then be used as the global threshold value. Based on the boundary co-ordinates information and the illumination characteristics, two standard templates were constructed to represent the front-face dots and the back face dots. The templates were then applied to every position of the image and evaluated the correlation at each pixel position. Depending on the correlation values, the front faced and back faced dots are extracted.

III. PROPOSED WORK

The algorithm has been developed to separate the recto and verso dots from double sided Braille document. It comprises of various steps as, Braille image acquisition through the scanner, image preprocessing for converting the RGB image to gray level image, image thresholding for extracting the shadow patterns, median filtering for removing the left over noise of thresholding, centroid detection, designing the mask, placement of mask over the centroid extracted image and recto/verso dot separation. The block diagram representation for the developed algorithm is shown in Fig. 4. In this section, we describe each stage of the proposed system in detail.

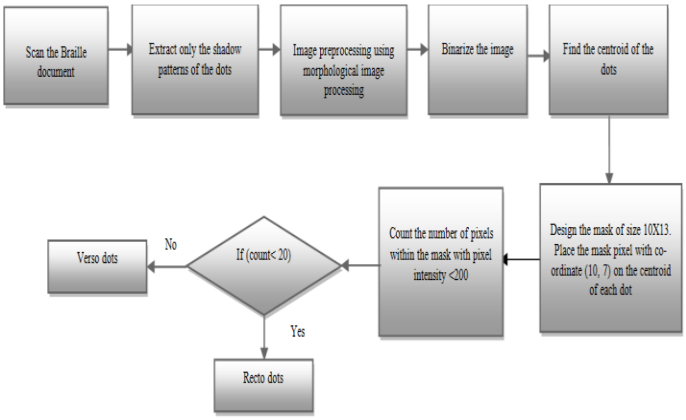

Fig. 4 Block diagram representation for recto verso separation

A. Braille image acquisition

The Braille documents are acquired through the HP scan jet 3400C scanner with the resolution of 1700X1502 and the image is stored in JPEG format. The acquired Braille documents are double sided Braille in grade-I. The scanned Braille images consists of three types of pixels which are, a mid-gray background, a light area and dark area for each recto and verso dot. The differences in the grey levels in the image appear due to the presence of protrusions and the depressions on the surface of the Braille document. In the scanning direction (vertical) the Recto dot (protrusions) contains dark area followed by the light region and verso dots (depressions) contain light area followed by the dark region [10]. Some scanners may produce the reverse. The order in which the light and dark areas appear for each dot depends upon the model of scanner used for scanning Braille documents. The areas in the image corresponding to protrusions and depression are shown in Fig. 5.

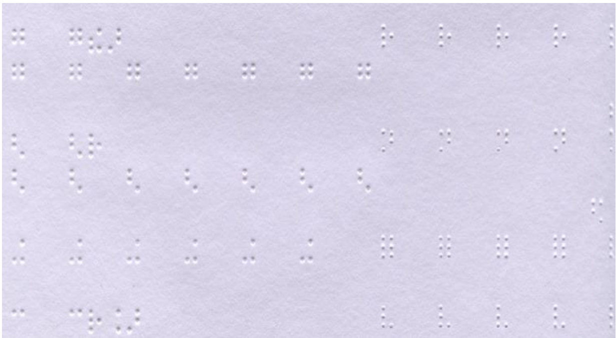

Fig. 5 Part of Scanned Braille image representing recto and verso dots.

B. Converting the Image to Gray Level

Inside a computer system, colored images are stored in 3-D arrays while gray level images are stored in 2-D arrays. Dealing with 2-D arrays is much easier and faster [3]. Therefore, the first step in the proposed system converts colored scanned images to gray level so that any pixel value in the image falls within the range 0- 255 as could be seen in Fig. 6.

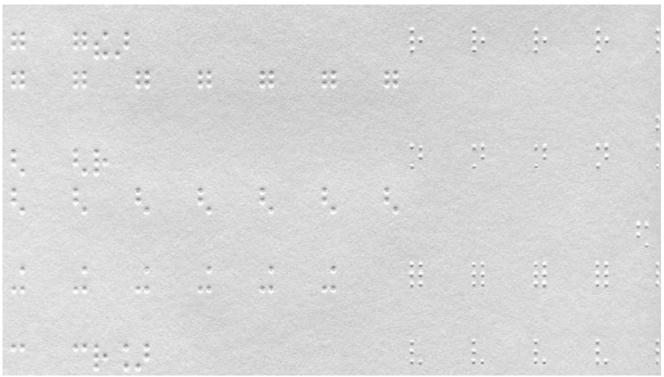

Fig. 6 Gray scale image.

C. Image thresholding to extract shadow patterns

A Braille image analysis and recognition system includes several image processing techniques, beginning with digitization of the document and ending with Braille recognition and natural language processing. Thresholding is one of the image processing techniques used for obtaining a binary image from its gray scale one. Thresholding is done based on the variation of intensity between the recto and verso dots pixels and the background pixels. To differentiate the pixels we are interested in from the rest, we performed a comparison of each pixel intensity value with respect to a *threshold*. The threshold value is taken as max (I (i, j))-10 after the detailed analysis of the Braille image. Where I (i, j) is the original Braille image. If the pixel intensity reaches more than the threshold value, then those pixels are equalized to 1 and for those pixels with intensity less than the threshold value are made 0. The thresholding of braille image can be quite critical in that it will affect the performance of successive steps such as segmentation of the document into text objects. The deformations in the character shapes as a consequence of incorrect thresholding are also the main reasons of OBR performance deterioration. The Fig. 7 shows the thresholded Braille image.

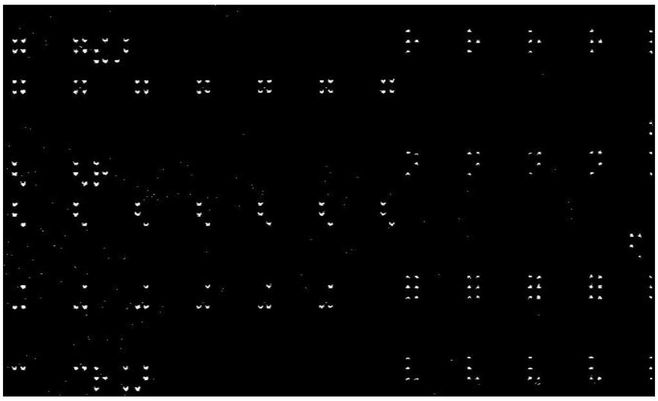

Fig. 7 Thresholded Braille image.

D. Median filtering.

Median Filter is a simple and non-linear filter which is based on order statistics. Median filtering is very widely used in digital image processing because it preserves edges while removing impulse noise that are caused by the amount of intensity variation between one pixel and the other pixel. Median filters give better result in the presence of impulse noise since it appears as white and black dots superimposed on an image [9]. Later on, the enhancement of dot shape by using the morphological operations – i.e. series of erosion and dilation operations using the square shape is done and the results are obtained as shown in Fig. 8.

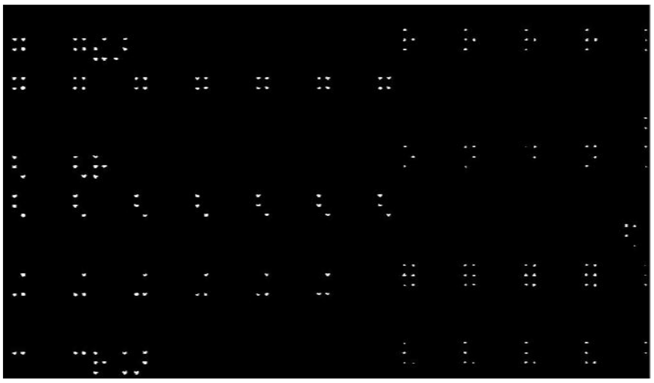

Fig. 8 Median filtered image.

E. Centroid detection.

The function of this process is to extract the Braille dots from the binarised image. The median filtered Braille image is free from the impulse noise and thereby giving the clear dot locations. The total number of dots in the Braille documents is detected and the centroid co-ordinates of each dots are determined using the area of each dot. The Fig. 9 shows the centroid detected image.

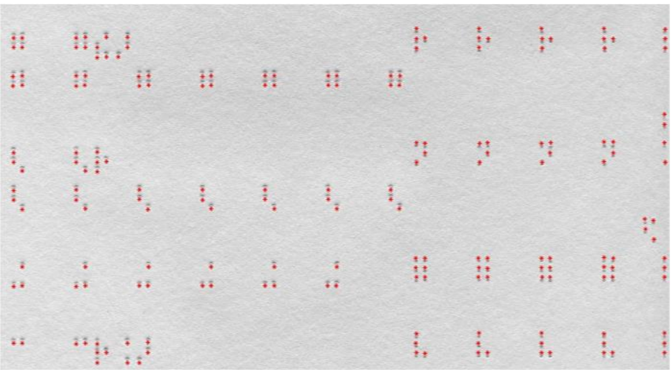

Fig. 9 Centroid detected image.

F. Mask design and placement.

The mask design and placement process to determine the recto and verso dots in the scanned image based on standard dimensions of Braille documents is described in this section. The experimental observation has motivated us to design the mask of size 10x13 for recto and verso dot separation. Mask is designed with height nine pixels above the centroid and six pixels width on both sides of the centroid. The mask is placed over the centroid detected image, in such a way that the centroid is made to coincide with the (10, 7) co-ordinate of the mask. Resultant output after placing the mask on the centroid detected image is shown in Fig. 10.

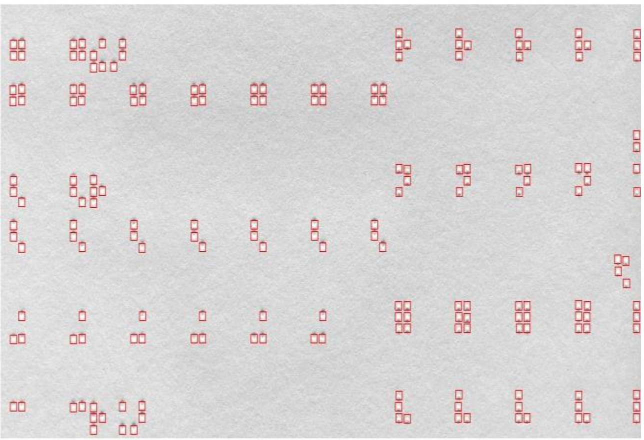

Fig. 10 Mask placed on the dots

G. Recto and Verso dot separation.

As the dots are embossed on both sides of a Braille page, the dots on the front-side and on the back-side must be separated before translating it into text. Dots on the front side are raised above the page and those on the back-side made holes on the front side. These protrusions and depressions of the dots reflect the illumination light in two different angles, creating an illuminated hole on the captured dot image for those front faced Braille dots and at the bottom half for those back-faced dots. Using the illumination characteristics, the position of the illuminated hole can be used as the feature to distinguish the front-faced and back-faced dots. The mask is placed on the dots where the centroid of the dots is determined. The number of pixel values having intensity value less than 200 within the mask is checked. If the pixel count value is less than 20 or if the region contained within the mask has more number of pixels values as dark then such a dot is recognized as a recto dot. The recto dot recognized is separated from the double sided Braille document using the centroid values. Conversely if the region contained within the mask has more number of constant grey level values then it is recognized as a verso dot. Thus the separations of recto and verso dots are achieved and then it will be drawn on the output image in the same location as shown in Fig. 11 and 12.

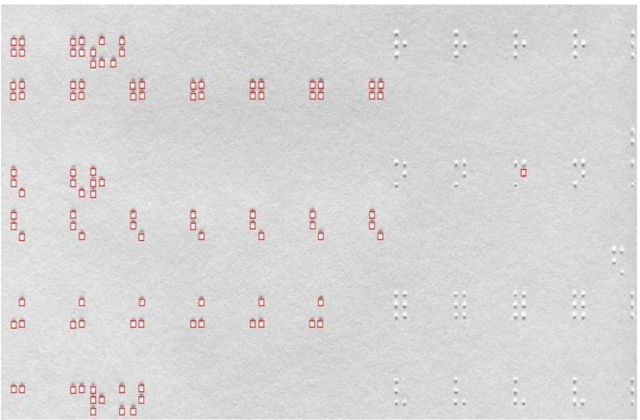

Fig. 11 Recto image.

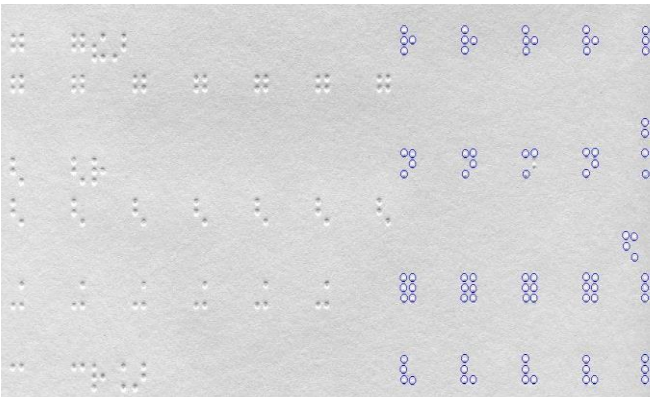

Fig. 12 Verso image.

IV. EXPERIMENTAL RESULTS

The proposed algorithm detects the dots in embossed double sided Braille document acquired through an optical A4 scanner and differentiates it into two images consisting of recto and verso dots.

As the dots on both sides of the page are visible from one side, both sides of the page can be recognized in a single scan. Algorithm is applied on the developed database and results are obtained with the accuracy of 99%. Due to the prolong use of Braille pages, protrusion height decreases, resulting in the flat region in the recognition of the dots. Thus causing erroneous output at those regions. The results are compared for developed database and are tabulated in the table 1.

Database	Theoretical calculation		Simulation result	
	Recto dots	**Verso dots**	**Recto dots**	**Verso dots**
1	105	89	106	88
2	136	189	136	188
3	143	159	144	158
4	83	156	83	156
5	127	95	128	93

Table 1: Comparison of theoretical and simulation results

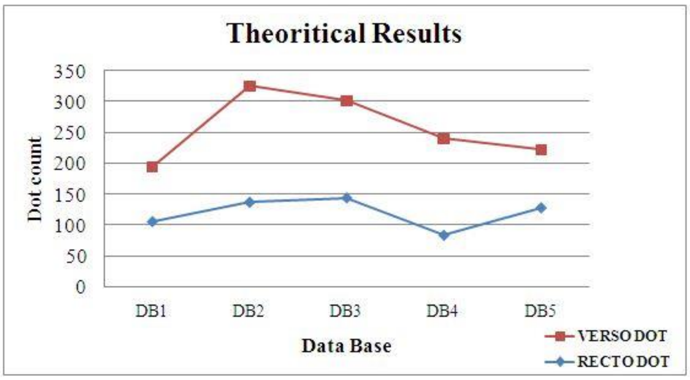

Fig. 13 Graphical analysis of Theoretical results

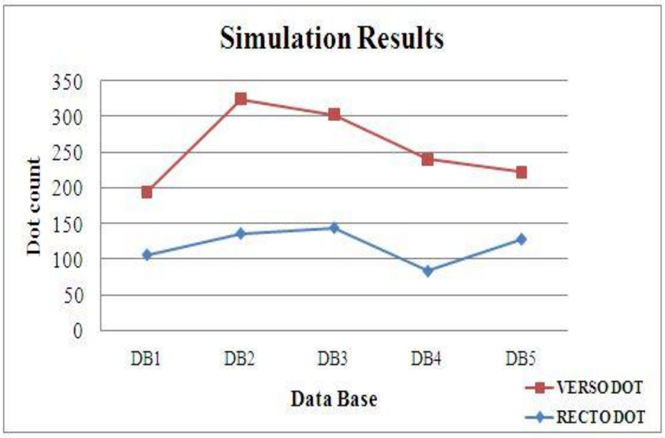

Fig. 14 Graphical analysis of Simulation results

The experimental result reveals that the dots on the original image and the detected image will have almost the same count, except in few cases that the recto dots appear as verso dots and vice versa as shown in Fig. 13 and Fig. 14 respectively. This can attributed to the quality of the Braille document.

V. CONCLUSION AND FUTURE WORK

This paper describes the new approach to differentiate the dots in the embossed double sided Braille documents acquired using the commercially available scanner. The proposed algorithm gives the clear dot recognition even in the presence of cracks created during the braille dots embossing process. The algorithm can be applied for any language immaterial of grades of Braille. The limitation being that during the braille image acquisition through the scanner, illumination of light on the depressions will be more and if there exists more number of recto and verso dots on the braille documents will create an ambiguity while detecting the centroid and to differentiate the recto and verso dot.

As a future work, the converted recto and verso dots can be converted to Braille cells and then to equivalent text conversion by defining the appropriate translation rules. The work can be extended to convert braille text to speech output.

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REFERENCES

[1] Oyama, Y., T. Tajima, and H. Koga, "Character Recognition of Mixed Convex- Concave Braille Points and Legibility of Deteriorated Braille Points", System and Computer in Japan, Vol. 28, No. 2, 1997.

[2] T.Shreekanth and V.Udayashankara, "A Review on software algorithms for optical recognition of embossed Braille characters", International Journal of computer applications (0975-8887), Vol.81-No.3, November 2013.

[3] Abdul Malik Al-Salman, Yosef Alohai, Mohammed Alkanhal and Abdulla Airajith. "An Arabic Optical Braille Recognition System". ICTA 2007 April 12-14

[4] Amany Al-Saleh, Ali El-Zaart and Abdul Malik Al-Salman, "Dot Detection of Braille Images Using A Mixture of Beta Distributions" , 2011 Journal of Computer Science ISSN 1549-3636 pp-1749-1759.

[5] Jan Mennens "Optical recognition of Braille writing", IEEE 1993. pp 428-431.

[6] C. Ng, V.Ng and Y.Lau, "Regular feature extraction for recognition of Braille". Third International conference on computational Intelligence and Multimedia Applications, 1999. ICCIMA '99 Proceedings, Page 302—306, 1999.

[7] AbdulMalik S. Al-Salman, Ali El-Zaart, Yousef Al-Suhaibani, Khaled Al-Hokail, AbdulAziz O. Al-Qabbany. "An Efficient Braille Cells Recognition". IEEE-2010.

[8] Ritchings, R.T., Antonacopoulos, A., Drakopoulos, D.: "Analysis of Scanned Braille Documents", In: Dengel, A., Spitz, A.L. (eds.): Document Analysis Systems, World Scientific Publishing Company (1995) 413–421.

[9] R.C.Gonzalez and R.E. Woods, Digital image processing, "Digital Image Processing", 2nd edition, Prentice Hall, 2002.

[10] A. Antonacopoulos and D. Bridson "A Robust Braille Recognition System". Document Analysis Systems VI, A. Dengel and S. Marinai (Eds.), Springer Lecture Notes in Computer Science, LNCS 3163, 2004, pp. 533-545.