Efficient Braille cell segmentation by Enhancing the dots using Sobel operator.

Vishwanath Venkatesh Murthy
Department of Computer Science and Applications
Bangalore University
Bengaluru, India
vm.rnsit@gmail.com

M Hanumanthappa
Department of Computer Science and Applications
Bangalore University
Bengaluru, India
hanu6572@hotmail.com

Abstract— **the Optical Braille Recognition (OBR) system is used to convert Braille document into natural text. The Braille characters are represented by a cell produced by embossing of dots with three rows and two columns each. OBR system recognizes these cells and translated them into text. The very first stage of OBR is the image acquisition. The image acquisition is performed using different devices like CCD camera, Digital camera, Mobile Phones and Scanners. The major problems of scanning are the degradation of dots representing a cell, unwanted extra appearance of dots or uneven spacing between dots. The main aim of this paper is to apply preprocessing techniques and apply the algorithm to enhance the degraded dots that uses Sobel operator to help in segmentation of the Braille cells.**

Keywords—Braille, degradation, edge detection, Histogram Sobel, Equalization, gradient, extraction, sharpening filters, preprocessing.

I. INTRODUCTION

The Braille cell that recognizes the natural language character or a word is represented by the collection of six embossed dots. Generally the Braille plates get deteriorates over the time due to their property [4]. Hence it is very significant need to have a system to recognize and convert the Braille documents into natural text to preserve it. Such a preserved documents and be reproduced into Braille documents on demand and can be made available to visually impaired people [9].

OBR system has five different stages namely i) Image acquisition, ii) Preprocessing, iii) Image segmentation, iv) Feature extraction and finally v) Translating to text. Image generally Image acquisition is performed by scanning [4]. Improper Scanning due to human errors can produce some impulse noise. Noise may be introduced even because of deteriorated dots of Braille plates in origin [9]. This paper uses the image preprocessing techniques to enhance the deprived dots that will help in recognizing the Braille cell.

This research paper is structured in 4 segments. Section-I gives the introduction and necessity of Braille to text translation and need of preprocessing. Section-II shows literature survey showing the prominent work of various authors who have used different preprocessing techniques for image enhancement. The Section-III shows the application of dot enhancement. The section-IV represents the results and conclusion.

II. LITERATURE SURVEY

SOWMYA M S in her paper has implemented the different spatial domain enhancement techniques, smoothing filters and sharpening filters [7]. Special domain technique include histogram equalization, enhancement using Smoothing filters include box filter, weighted average filter, Gaussian filter, Median filter. The enhancement using Sharpening filters like Unsharp masking, Highboost filtering, Laplacian filter, Roberts filter, [7] Sobel filter and Prewitt filter. In histogram equalization the enhanced output taken by a transformation function of equation-1.

$$s=T(r); \text{ where } 0 \le r \le L\text{-}1 \qquad \text{-- (1)}$$

The inverse [7] transformation back is represented by equation-2.

$$r = T\text{ - }1(s); 0 \le s \le L\text{-}1 \qquad \text{-- (2)}$$

The probability [7] density function ps(s) can be calculated by the equation-3.

$$Ps(s) = pr(r) \frac{dr}{ds} \qquad \text{-- (3)}$$

Whereas the transformed variable represented by 's', is calculated using the equation-4,

$$s = T(r) = (L-1)\int_0^r \Pr(w)\,dw \qquad \text{-- (4)}$$

Author has implemented Smoothing filters for reducing vague impression and noise reduction [7]. Blurring method is used for removal of miniature details from an image earlier to object extraction. One of the smoothing filters used is the box filter, in which the charge of every pixel of an image is replaced by the average gray levels of the neighborhood filter mask. The weighted average filter is used by the author that multiplies the pixels by special coefficients that introduce more weight to some pixels (centre pixel) than the others, which ultimately helps in blurring. Further the zero-mean discrete Gaussian function is used to smoothen the image by restoring each image pixel with a weighted average of the adjacent pixels [7]. This process helps in decreasing the weight attached to a neighbor with distance towards the central pixel.

The author also has used the sharpening filters that highlight fine detail present in an image [7]. One of the sharpening spatial filters used by author is un-sharp masking which is expressed in the equation-5.

$$\text{Gmask}(x, y) = f(x, y) - f'(x, y) \qquad \text{-- (5)}$$

Where, gmask(x, y) represents sharpened output image [7]. Blurred image is given by f'(x, y) for an original image f(x, y). Other sharpening filters used are the Laplacian, Sobel, Prewitt's and Roberts filters with mask are used for edge detection.

Padmavathi S in her paper has used the Prewitt filter operator [5] with 3x3 kernels that are convolved for the image A to find approximation of two derivatives, to get i) horizontal changes (Gx) and ii) vertical changes (Gy) as given in figure-1.

.

$$\text{Gx} = \begin{array}{|c|c|c|} \hline -1 & 0 & +1 \\ \hline -1 & 0 & +1 \\ \hline -1 & 0 & +1 \\ \hline \end{array} * A$$

$$\text{Gy} = \begin{array}{|c|c|c|} \hline +1 & +1 & +1 \\ \hline 0 & 0 & 0 \\ \hline -1 & -1 & -1 \\ \hline \end{array} * A$$

Figure-1: Prewitt filter with size 3x3

Where '*' denotes convolution [5]. The output gradient approximations are combined to find gradient magnitude, using Equation-6.

$$G = \left(G_x^2 + G_y^2\right)^{0.5} \qquad \text{-- (6)}$$

If the output magnitude value is more than the threshold 'T' then, edge is detected [5].

Antonacopoulos A, in his paper has divided the Braille image into a window of 32×32 pixel regions [1]. He has compared the various ranges of sets grey levels noted in the region against corresponding ranges that are probable for a particular feature is present or not. For these regions, the different threshold values are applied to each pixel to produce an image with only white, black and mid-grey values. To detect the impressions author has verified the check, if a white region is found above the black connected components within the given limits, a depression is identified [1]. Similar method is used to identify the protrusion. Two parallel grids are used to separate front dots and background dots.

S. D. Al Shamma in his paper has used canny method for edge detection [6]. The local maxima of the gradient for input image is first calculated using derivative of the Gaussian filter with two thresholds; to find strong and weak edges. This method sows only the edges of dots and not actually the whole dots [6]. To fill edged dots for identifying Braille cell dots the imfill () function of Matlab is applied. The filtering function is applied further to remove unwanted micro objects that are not actually the part of dots. To extract the Braille cell, 95x80 pixels frame size is used with 200 dpi resolution. Experimental results on single sided computer embossed plates scanned from flat bed scanner have shown more than 99% accuracy in the paper [6].

Mousa in his paper has extracted the dot information by computing the centroid for the circular geometrical shape [2] of area with both 'Cx' and 'Cy' co-ordinates representing the x and y coordinate values for the centroid of a given shape-f as given in equation-7, 8 and 9.

$$Cx = \frac{1}{A}\int x\,dA \qquad \text{-- (7)}$$

$$Cy = \frac{1}{A}\int y\,dA \qquad \text{-- (8)}$$

$$A = \int f(x)\,dx \qquad \text{-- (9)}$$

Where, A represents the area of function f [2]. In digitization step, the rotation angle is calculated and dot alignment is performed with two edge lines d_{edge} and d_{dot} as given in equation-10 and 11.

$$d_{edge} = \sqrt{\left(x1_{edge} - x2_{edge}\right)^2 + \left(y1_{edge} - y2_{edge}\right)^2} \text{-- (10)}$$

$$d_{dot} = \sqrt{(x1_{dot} - x2_{dot})^2 + (y1_{dot} - y2_{dot})^2} \qquad \text{-- (11)}$$

After this dot alignment process the image filling is applied to make the dots bold, sharp, and clear for cell identification [2]. An experimental result shows the accuracy ranges approximately between 94.4% up to 99.8%.

III. BRAILLE DOT ENHANCEMENT

Material used for Braille documents consists of generally metal plate or the plastic plate. The heat produced during

the scanning process may reduce the quality and resolution of the Braille dots of the original plastic document. Even the light produced in scanning also can degrade the embossed dots on metal plates. Sometimes the original plate itself may be degraded due to environment effects. Such plated when scanned produce noise in the obtained image. [10] In this paper we have introduced an algorithm to enhance the degraded dots of Braille cell and the results are shown. The Matlab version R2014a is used for all the experiential results.

Algorithm for dot enhancement
1. Scan the document to get color image.
2. Convert to grayscale and obtain the histogram
3. Obtain the binary image with proper threshold
4. Apply Sobel filters to detect dots
5. Get the binary gradient to Dilate the image
6. Fill the image to enhance dot detection
7. Smoothen the Braille cells

In the first step we begin with reading the original color image using imread () function. The original image is given in figure-1.
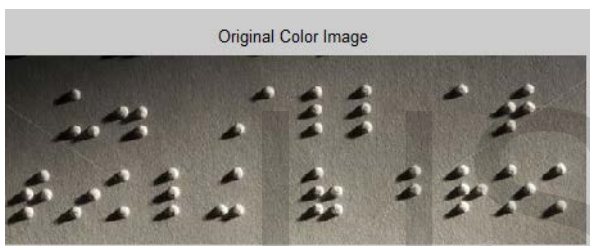

Figure-1: Original color image

In the next step the color image is translated to grayscale image and histogram is obtained with function imhist (greyImage). The obtained histogram is shown in the figure-2.

In the third step, the binary image obtained by applying the function im2bw (greyImage, 0.7) is shown in the figure-3. The optimal threshold value 0.7 is used for binarization to get the dot pattern. Binarized image include some deteriorated dot patterns and also include the unwanted dots. Sobel operator is applied to enhance the dots in the obtained binary image.
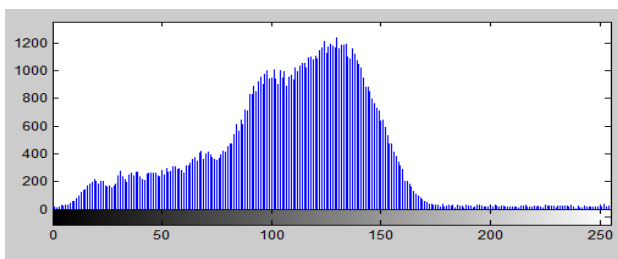

Figure-2: Histogram of Braille document

Figure-3: Binary image

The Braille cell to be segmented diverges deeply in contrast from that of the background image. In step-4, Variations in contrast are identified using Sobel operators. Sobel operator function calculates the gradient of the resultant binary image. The threshold values are calculated using edge and Sobel operator. This threshold is then applied to obtain a binary mask representing the segmented cell as shown in figure-4.
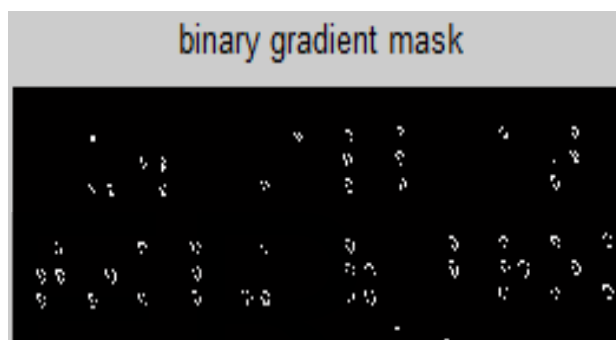

Figure-4: Binary gradient Mask using Sobel filter

The binary gradient mask obtained when compared with original image, some gaps between the dots are introduced [8]. In fifth step, to remove these gaps the Sobel image obtained is dilated by creating linear structuring using strel('line', 3, 90) function followed by imdilate() function that actually dilates the image. The resultant dilated image is shown in figure-5.
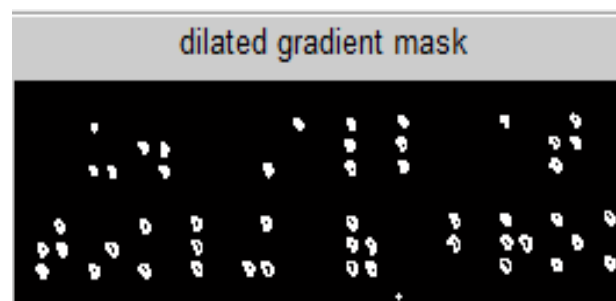

Figure-5: Braille image after image dilation

The dilated image mask [8] shows the quality outline of the dot. Still there are holes in the interior of the dot. Hence to enhance the Braille cell detection, there is a need to enhance the dots by filling the holes in dots. In the sixth step holes in dots are filled using the function imfill ().The resultant dilated image is shown in figure-6.
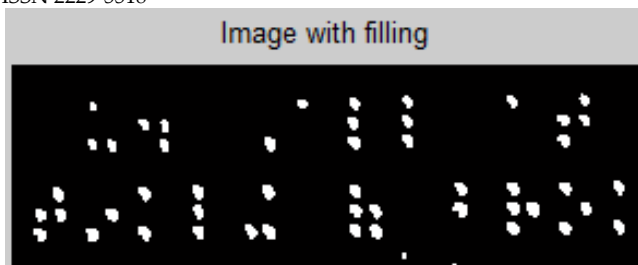
Figure-6: Image with filled holes

In the final step the image smoothened to make segmented object look very natural by eroding the image two times using diamond structuring element and strel() function [8]. The smoothened image is shown in figure-7.
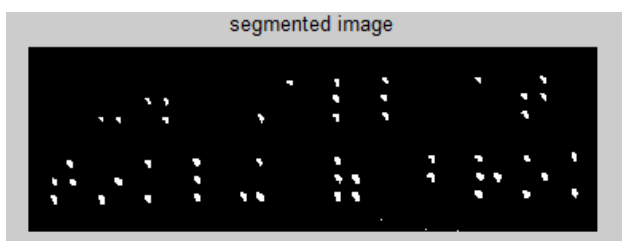

Figure-7: Image with filled holes

The segmented image further can be used for the feature extraction to identify the dots and translating into natural text.

IV. RESULTS AND CONCLUSION

The accuracy of dot enhancement is tested on 5 different images with some inhabitant percentage of degradation on MATLAB. The results of successful segmentation accuracy are shown in the Table-1.

Table-1: Dot enhancement accuracy results

Degradation percentage	Dot enhancement accuracy
1 %	100 %
5 %	99.5 %
8 %	66.2 %
10 %	17 %
> 15 %	0 %

In this paper we have assumed that the scan documents do not contain any skew. In future work we plan to take the skewed image and apply the different algorithms for skew detection and correction [9]. Also we will compare these algorithms to find the efficient method of skew detection and correction after evaluating on MATLAB.

References

[1] Antonacopoulos A., Bridson D. (2004) A Robust Braille Recognition System. In: Marinai S., Dengel A.R. (eds) Document Analysis Systems VI. DAS 2004. Lecture Notes in Computer Science, vol 3163. Springer, Berlin, Heidelberg

[2] Mousa, A & Hiary, Hazem & Alomari, Raja & Alnemer, Loai. (2013). Smart Braille System Recognizer. International Journal of Computer Science Issues. 10.

[3] M. Wajid, M. Waris Abdullah and O. Farooq, "Imprinted Braille-character pattern recognition using image processing techniques," *2011 International Conference on Image Information Processing*, Himachal Pradesh, 2011, pp. 1-5. doi: 10.1109/ICIIP.2011.6108954

[4] M. Hanumanthappa and V. V. Murthy, "Optical Braille recognition and its correspondence in the conversion of Braille script to text — A literature review," 2016 International Conference on Computation System and Information Technology for Sustainable Solutions (CSITSS), Bangalore, 2016, pp. 297-301. doi: 10.1109/CSITSS.2016.7779374

[5] Padmavathi, S.;S, Manojna K. S.; Sphoorthy Reddy, "Conversion of Braille to Text in English, Hindi and Tamil Languages", 2013, International Journal of Computer Science, Engineering and Applications (IJCSEA), Vol.3, No.3, June 2013; eprint arXiv:1307.2997, doi:10.5121/ijcsea.2013.330.

[6] S. D. Al-Shamma and S. Fathi, "Arabic Braille Recognition and transcription into text and voice," *2010, 5th Cairo International Biomedical Engineering Conference*, Cairo, 2010, pp. 227-231. doi: 10.1109/CIBEC.2010.5716095

[7] SOWMYA. M. S. and SHREEKANTH.T, "Comparative Study on Braille Image Enhancement Using Spatial Domain Enhancement Techniques", 2014, International Journal of Engineering Science and Innovative Technology (IJESIT) Volume 3, Issue 1, January 2014, ISSN: 2319-5967 ISO 9001:2008 Certified

[8] Srinath.S , C.N. Ravi kumar, "Knowledge based Inter-point Braille document Analysis and Recognition", 2014, International Journal of Computer Science and Information Technologies(IJCSIT), Vol. 5 (6) , 2014, 7729-7732.

[9] Vishwanath Venkatesh Murthy; Hanumanthappa, M. "Pre-Processing The Braille Image For Improving Optical Braille Recognition Performance". 2017, International Journal of Advanced Research in Computer Science, v.8, n.7, p.561-564, aug. 2017. ISSN-0976-5697. doi:http://dx.doi.org/10.26483/ijarcs.v8i7.4

[10] Nagesh B S, Dr. N P Kavya, Dr. N C Naveen "A Study on Applying Association Mining Technique on Endoscopic Videos" International Journal of Latest Technology in Engineering, Management & Applied Science-IJLTEMAS vol.7 issue 1, pp.22-27 2018