Implementation of Braille image Denoising.

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***Abstract*—**Braille is the tactile system used by visually impaired that is understood by the sense of touch. There are many government institutions and public libraries had printed Braille books and are still printing. The Father of Braille script Louis Braille; in his era many his associates have written Braille books based on dictations of others. Preserving Braille documents is a challenging task. Braille plates are susceptible to wear due to humidity and may get damage, deterioration of paper and binding materials. Hence there is a growing need for converting Braille to natural text. Optical Braille Recognition (OBR) system is used to convert Braille document into natural text. The OBR process starts by image acquisition performed using different devices like Digital camera, cell phone camera or Scanners. The image acquisition is suffered by noise like uneven light during acquisition, tilted image, and degraded dots. The main aim of this paper is to apply preprocessing techniques and denoise the image caused due to uneven light introduced during scanning.

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

I. INTRODUCTION

The Braille is the tactile writing system consisting of cells made of six embossed dots each representing the natural language character or a word [13]. The different pattern of raised dots is used to represent the different character patterns. Braille language has many standards of representation as grade-1, grade-2 and grade-3. In grade-1, each cell of six dots maps into only one letter, number or a punctuation mark. In grade-2 uses contractions where, each cell represents one word instead of character. The grade-3 uses many more contractions and a shorthand method for Braille. Grade-3 is generally used by individuals for their personal database and convenience and hence it is kept away from the publication. Initially there was 8-dot cell; but due to difficulty in remembering the patterns six dots cell become popular and accepted by the universe [7].
Braille plates have a tendency of getting deteriorating over the time due to environmental effects [9]. The deterioration can happen due to ecological changes like hotness and moisture, microbe damage, mold, and so on. Another major problem in preserving the documents for years would be flattening of the raised dot print from regular use or storage. According to Dorothy Blunt [4], "Braille documents Storing Braille books upright causes the signatures to rip through the binding straps from the weight of the pages". Another kind of deterioration is observed with paper used in older Braille materials as many respondents have complained of brittle paper as older books contain acidic content in the used paper [5]. There are many institutions having libraries with collections ranging from 300 to 50,000 books. Preserving such huge collection needs lot of space and running cost. Basic preservation including training of caretaker on periodic cleaning instructions for controlling hotness and moisture, microbe damage, light, air pollutant control, emergency reclaim of wet Braille volumes, and emergency reclaim of rotting Braille volumes.
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 [7]. Similar to OCR we have OBR stands for optical Braille recognition system which translates the Braille image to natural language text. OBR system has five different stages namely i) Image acquisition, ii) Preprocessing, iii) Image segmentation, iv) Feature extraction and finally v) Translating to text.
During Image acquisition stage [7] some impulse noise may get introduced due to various reasons like human error, uneven light during acquisition, tilted image and degraded dots [9]. Image denoising can be achieved by image filtering such as Gaussian filtering, anisotropic filtering. However, image denoisng could also be achieved by other approaches like wavelet thresholding. This paper discusses and implements preprocessing techniques for image denoising which can enhance the second stage of OBR system.
This research paper is structured in 4 segments. Section-I gives the introduction and necessity of Braille to text translation. Section-II shows literature survey showing the prominent work of various authors who have used different preprocessing techniques for image denoising. The Section-III shows the application of denoising techniques. The section-IV represents results and conclusion.

II. LITERATURE SURVEY

S. Padmavathi [9] in her paper has implemented the Gaussian filter to smoothen the image by removing unwanted dots. The smoothened image is further subjected to morphological opening using an erosion method as show in the equation-1.

$$A.B = (A\Theta B)\oplus B \quad \text{-- (1)}$$

Researcher has first used the prewitt filter to obtain an edge detected binary image with set of two 3x3 kernels which are coil together with an acquired image A [9]. It calculates the

Gx (horizontal changes) and Gy (vertical changes) as shown in figure-1.

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$$Gx = \begin{bmatrix} -1 & 0 & +1 \\ -1 & 0 & +1 \\ -1 & 0 & +1 \end{bmatrix} * A$$

$$Gy = \begin{bmatrix} +1 & +1 & +1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix} * A$$

Figure-1: Prewitt filter with size 3x3

Where coiling is performed using the '*' operator. Further these derivatives are used to get gradient magnitude, using equation-2 [9].

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

If the output magnitude value is above threshold 'T' then, the author concludes that the edge is detected [9]. This enhance image is further used in segmenting the Braille cells and extraction of text pattern. Noise filtering was achieved through the low-pass filter, Gaussian blur and edge detection was acquired using Sobel operator [5].

Amany Al saleh, in his paper has developed thresholding stability technique with Beta distribution to estimate thresholds. The algorithm goes through each and every modes of the histogram for purpose of estimating the two thresholds [2]. Initially author estimates threshold points $T1^0$ and $T2^0$ by finding the maximum value of the histogram as shown in equation-3 and 4.

$$T_1^0 = \sum_{i=0}^{MaxIndex}(i * h(i)) / \sum_{i=0}^{MaxIndex} h(i) \quad \text{-- (3)}$$

$$T_2^0 = \sum_{i=MaxIndex}^{255}(i * h(i)) / \sum_{i=MaxIndex}^{255} h(i) \quad \text{-- (4)}$$

T_1^0 and T_1^0 are used find α and β and prior probability (P) using equation-5 and 6, for mode (i =1, 2, 3).

$$\alpha = m_1^k(m_1^k - m_2^k)/(m_2^k - (m_1^k)^2) \quad \text{-- (5)}$$

$$\beta = (m_1^k - 1)(m_2^k - m_1^k)/(m_2^k - (m_1^k)^2) \quad \text{-- (6)}$$

Prior probability P is calculated using equation-7.

$$P_i = \sum_{j=Mode\ i} h(x_j) / \sum_{j=0}^{255} h(x_j), i = 1,2,3 \quad \text{-- (7)}$$

Finally author has detected the recto and verso dots using grid by selecting the initial point just above the first Braille dot of first cell from processed image. During line by line scan, a light region of dot is recognized as part of a recto dot and other as verso dot. This recognized dot is treated as initial recto dot on the first line of a scanned Braille document [2].

HIND MOWAFAQ [3] in his paper has used canny's edge detector method to recognize the edges searching for local maxima of the gradient of the scanned image. The slope is designed along with the derivative obtained by Gaussian filter. The algorithm considers two values of threshold to detect strong and delicate edges, also mine the fragile borders during the process of production only when they are relative to strong edges. Hence the algorithm has fewer chances to get effected by the noise, also sense real weak edges. The blunt points are not clearly recognized; whereas there is second step that attempts to amplify the contrast of the Braille dots [3].

Antonopoulos [1] in his paper has proposed a local adaptive thresholding method where Braille preprocessing is performed using sharpening filters like Unsharp-masking; High-Boost filter and High-Frequency Emphasis filter on different threshold values and the original image attributes are added back to the result. This helps to preserve the dot components in processed image. The system converges at D0= 85, for an A (boost-factor) = 1.05. When threshold value increases, the background gray intensity gets reduced and separation of dots is improved [1].

In High-Frequency Emphasis filtering, the prominence is on the high-pass filtering function. This is computed by multiplying the filter function using a constant b≥1 and again by adding an offset (A). This increases the gray-intensity of the dot components. Which helps is reducing salt paper noise [1].

The experimental study proves that the routine of the high frequency emphasis filtering approach with Gaussian high pass filter gives better performance compared to other approaches for Braille image enhancement [1].

S. D. Al Shamma in his paper has used canny method for edge detection [10]. The local maxima of the ramp for input image is first obtained using derivative obtained by the Gaussian filter with two values of threshold; to obtain the strong and frail edges. This method shows 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 [10].

III. APPLICATION OF DENOISING TECHNIQUES

Denoising is performed using various linear filters that include weighted average filter, box filter, Gaussian filter, mean filter, Laplacian filter and also non linear filters like median filter, min filter, entropy filter.

Average filtering is the low pass filtering used for burring and noise reduction. Average filter is computed by replacing the intensity of each pixel in an image with mean of the gray pixel levels in the neighboring pixels defined by the filter mask as shown in figure-2. This filter helps in reduced sharp transition of grey levels [11].

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$$\begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix} * \frac{1}{9}$$

Fig.2:Average filter with size 3x3

The average filtering applied on noisy Braille image is shown in figure-3.

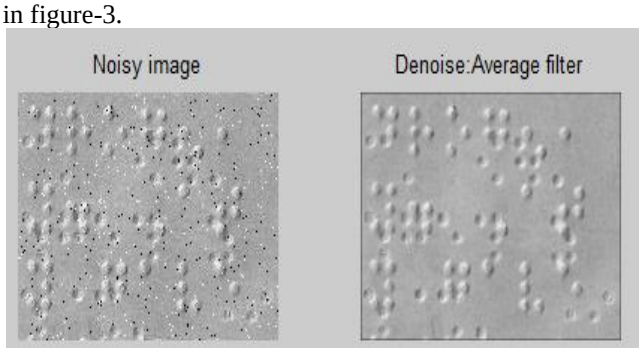


Fig.3: Denoised image after average filtering

In weighted average filter [11], the pixels are multiplied by various coefficients that increase weight of some pixels by ignoring others, helps in reducing blurring within the smoothing process. Weighted Filter mask is shown in figure-4.

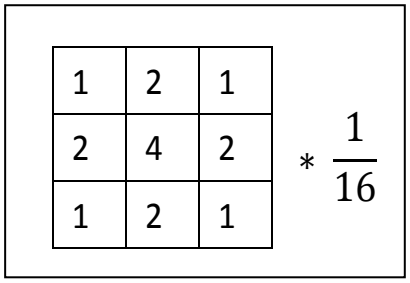
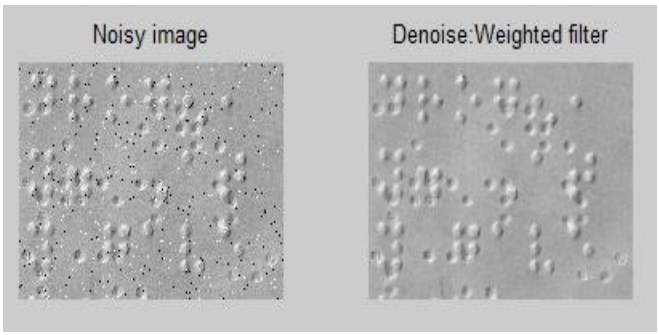


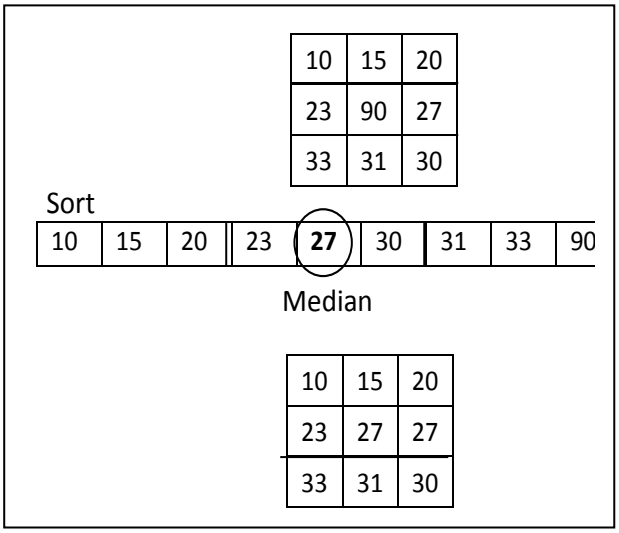
Fig.4:Weighted filter mask

The average filtering applied on noisy Braille image is shown in figure-5.



Figu.5: Denoised image after weighted filter

The median filter classified under nonlinear filter is used extensively in digital image processing. the median filter as shown in figure-6, preserves the edges while removing noise that are caused by the amount of intensity variation between one pixel and the other pixel. All other filtering methods adversely affect the edges and can't preserve them even though Edges encourages significant importance on the visual manifestation of images [11]. With median filtering larger neighborhoods will produce more severe smoothing. To obtain the Median, initially all the pixel values are sorted in increasing order. The mean then calculated and then it replaces the with the pixel value at the middle of the mask. The central value 90 in figure-7 is replaced by median 27.



The Results of median filtering implemented on Matlab are shown in figure-7.

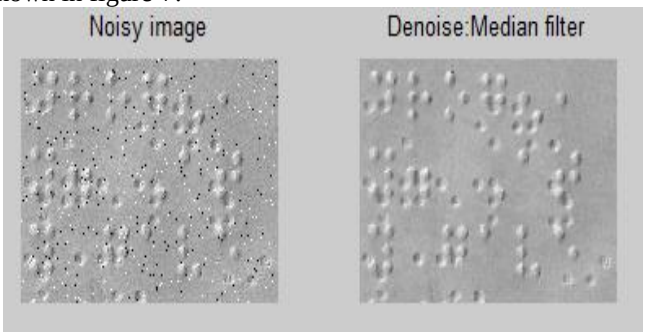
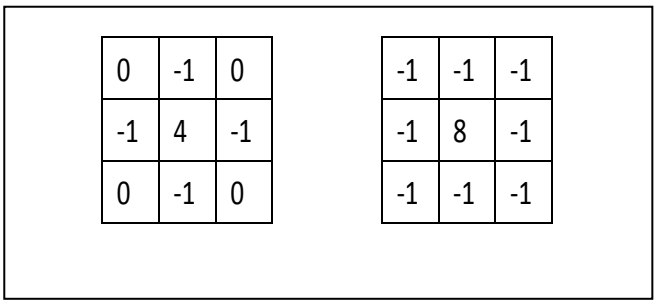


Fig.7: Denoised image after median filter

The Laplacian filter is [11] an isotropic and second order derivative edge enhancement filter that normally prominence to lines, points on lines, and edges in the image and restrain the uniform and efficiently varying regions. Laplacian mask as shown in figure-8 uses a rotation invariant to denoise the image.



This filter calculates the second derivatives of an image, which helps detect the rate of change in first derivatives which ultimately helps in determining whether a change contributed to adjacent pixel values is an edge or a continuous progression. The Results of Laplacian filtering implemented on Matlab are shown in figure-9.

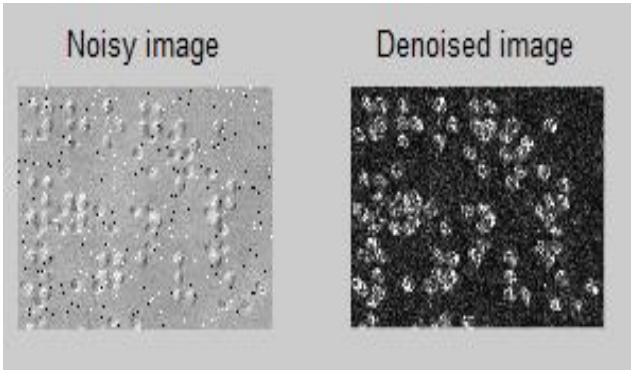


Fig.9: Denoised image after Laplacian filter

The Sobel filter [13] is a non-linear edge enhancement algorithm used in image processing. Technically, it is a discrete differentiation operator to be applied to estimating rough gradient of an image intensity function. For every dot point of the image, the Sobel operator returns the result to corresponding gradient vector or else the given vector norm. The Sobel operator masks are represented in the figure-10.

-1	-2	-1
0	0	0
1	2	1

-1	0	1
-2	0	2
-1	0	1

Fig.10: Sobel filter with size 3x3

The Results of Sobel filtering implemented in Matlab are shown in figure-11.

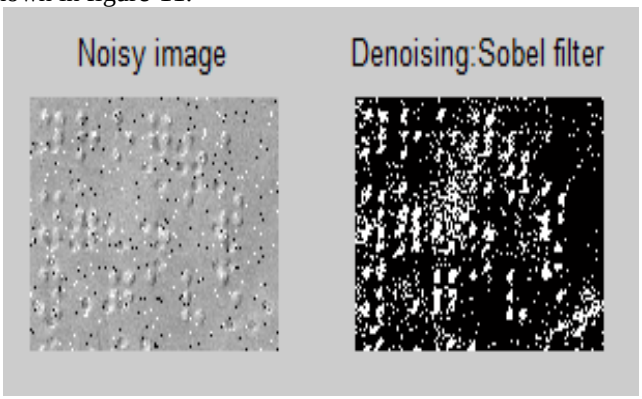


Fig.11: Denoised image after Laplacian filter

The Roberts cross [11], non-linear edge detector filter were used in image processing for edge detection. Robert cross operator was proposed by Lawrence Roberts, where intensity is considered to be differential operator. The main objective of the Roberts cross operator is to get estimate slope of an image through discrete differentiation which is achieved by computing the sum of the squares of the differences between diagonally adjacent pixels for edge-sharpening and isolation [11].

IV. RESULTS AND CONCLUSION

The accuracy of dot enhancement will be tested for all the various filtering techniques. The use of better filtering technique will enhance the Braille segmentation method and finally improve the Optical Braille recognition system. In this paper we have assumed that the scan documents do not contain any skew. In future work we plan to use one of the best filtering techniques to enhance the image and ultimately the output image further will be evaluated for removing any unwanted dots present in the filtered image.

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