Translating Braille Grade-1 and Grade-2 word to English word.

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Abstract— Braille is a tactile approach that is developed for visually impaired people, to enable them read and write. Braille system is a collection of cells, where each cell represents the pattern of combination of six raised dots imprinted on a metallic plate. These plates are generally bulky and maintaining or distributing them from one part to another part of the globe is a risky and challenging task. In the previous paper the conversion of a single Braille cell engraved on metallic plate to a natural language character like English was published. This paper proposes a technique for converting the words in Braille system to English words that can be easily distributed over network. Results are implemented using MATLAB. The Braille plates are first scanned, and next preprocessing techniques named adaptive histogram, Laplacian and Sobel filters are performed to eliminating the noise and hence amplify the dot patterns. The thresholding minima in histogram is used for smooth edge detection. Further feature extraction techniques are performed using Convolution Neural Network method. The character patterns are classified and recognized using Classification and Regression Trees (CART) classifier. The recognized characters are mapped to the respective word as a result. Accuracy of the proposed algorithm is 100% for Kaggle website whereas it is between 97 to 98.5% for scanned documents.

Keywords— Adaptive histogram equalization, Braille, CART, Contractions, CNN, CLAHE, Gradient, kernel, Laplacian, Sobel, Threshold, transformation. kernel

I. INTRODUCTION

The Braille is a tactile method that is used by the visually weakened people [7]. Each Braille character is a combination of six elevated dots with 3x2 matrix which are embossed on paper or metal plate. Braille documents are produced in grade_1 and grade_2 form. The Words in grade_1 system is spelled completely as letter-for-letter. The grade_1, which is called uncontracted Braille includes alphabets, digits, or punctuations. Contracted Braille also called as grade-2 Braille includes "shorthand". According to French script and its location inside the character ordering; the dot configurations inside the cell were allocated to characters with underlined alphabets and 'w' is designated to the end [4].

The Grade_1 Braille alphabets which are exhibited in the figure-1 uses a special logical structure. First only the higher 4 dot samples are used to represent the preliminary alphabet set from (a till j) or digits limit (1–9 and 0). These dots do not follow any obvious order, but initial three letters (abc) and the first three vowels (aei) are represented by only two dots. The further set (k to t) are plotted similarly to the script range (a to j). This is done by adding one more dot in last row. The last set of the character range (u to v) then (x to z) leaving 'w' are included with one additional dot. Letter 'w' is represented by adding dot at place 2 of final row against of initial position [8].

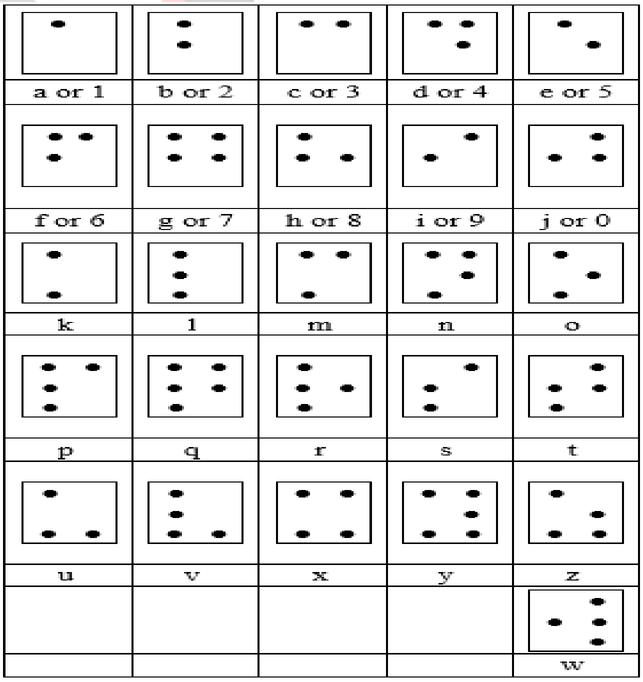

Figure-1: Initial 10 alphabets of Grade-1 Braille Characters.

To make a distinction from alphabet pattern or a number pattern, the pattern forms used are shown in the table-1.

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Table-1: Grade-1 format patterns to identify number and Capital letters.

⠠	⠼
Next Capital	Next Number

Braille also uses overall 12 cell patterns to represent the punctuation symbols as indicated in the table-2.

Table-2: Grade-1 Braille Character pattern to represent punctuation marks.

⠂	⠆	⠄
Comma (,)	Semicolon (;)	Apostrophe (`)
⠲	⠖	⠦
Full stop(.)	Exclamation(!)	question mark (?) / open quote (“)
⠒	⠤	⠨
Colon (:)	Hyphen (-)	Decimal point (.)
⠴	⠶	⠌
Closing quote (”)	Parenthesis ({)	Slash (/)

The Punctuation formats shown changes for language to language.

The Grade_2 Braille are used to represent “contractions” for the regularly-appearing words. This contracted Grade 2 braille is most frequently in books, public signage, and menu of hotels and restaurants [2]. It comprises 26 basic letters of the alphabet, punctuation, and contractions. The sample contractions are as shown in figure-2.

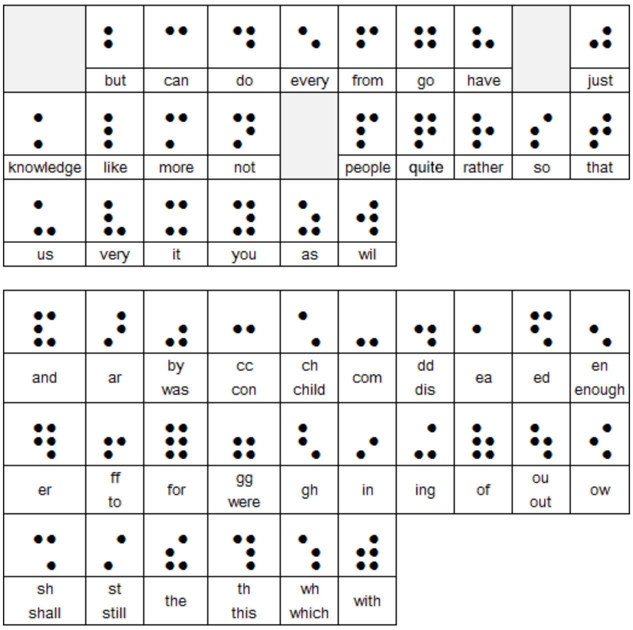

Figure-2: Contracted Braille

The paper is arranged into 4 sections. Section- ‘I’ introduce about grade_1 and grade_2 Braille document. Section- ‘II’ stretches the outline of related work that shows the conversion of Braille to English word. In Section- ‘III’, the comparison and findings are debated. Finally, the section- ‘IV’ outlines the conclusion of the work [9].

II. RELATED WORK

The proposed approach starts with scanned image obtained from Braille document consisting of one sentence. The following algorithm is used for translating the Braille image to related sentence in English:

- *Scan the Braille document into an image.*
- *Pre-process the image for Contrast Enhancement using Normal and Adaptive Histogram*
- *Apply Laplacian and Sobel operators.*
- *Perform Segmentation using Braille threshold Algorithm*
- *Extract the braille cells using Neural Regression Classifier.*
- *The characters are identified using the classifier CART (Classification and Regression Trees).*

The various steps of algorithm are visualized in figure-3.

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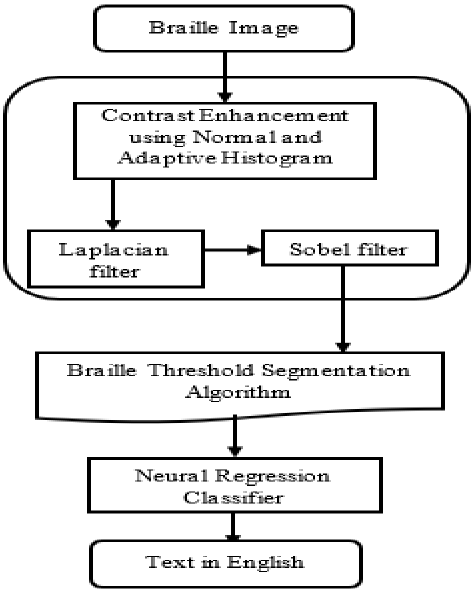

Figure-3: Proposed algorithm

Initially the scanned Braille image is input the system. These scanned images are tarnished primarily due to the following issues:

- Noise
- Low contrast.

Noise generated in the image due to the quality of metal plate on which Braille document is embossed. The noise may be introduced by scanners itself while scanning the documents. Hence noise removal is a basic target of pre-processing. Noise can be produced before scanning or during scanning in an image. Some of the noise observed in Braille scanned images are like tilt angle of document, overlapping of pattern due to background spots, the dark patches present on the plate that many time are not the part of textual. Low contrast may appear due to the uneven and inconsistent brightness or contrast introduced during scanning [6].

This algorithm performs contrast enhancement using the techniques of Normal and Adaptive Histogram along with Laplacian and Sobel operators for removal of noise. The original image considered for the enhancement is shown in figure-4.

Figure-4: Contracted Grade-1 Braille document.

The first image (a) is scanned from the Grade-1 Braille document whereas second image is from Grade-2 Braille document.

The contrast enhancement is image manipulation defined by a function ***f***, as shown in figure-2 that maps a pixel from input to the corresponding output which is known as transformation function. The term x_i and y_i *(i = 0, 1, …, N-1)* show the pixel intensities. Here N represents the number of pixels and L represents various gray levels in an image.

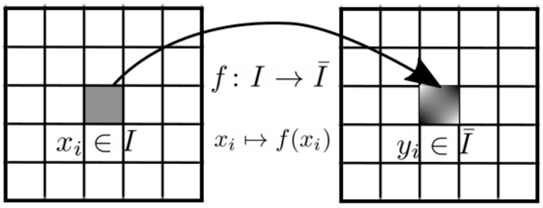

Figure-5: Contrast enhancement function f.

The output function f as shown in figure-5 is also responsible for histogram modification of the input image. The histogram and non-normalized cumulative distribution {discrete mass distribution/ Cumulative distribution function (CDF)} function of a particular grey level *l* (x_i, keep in mind that more than one pixel can have same grey level) is defined as in equation-1.

$$H(l) = n_l, \quad l = 0, 1, \cdots, L-1, \quad C(l) = \sum_{k=0}^{l} H(k), \qquad \text{-- (1)}$$

where 'n_l' represents the number with grey level *l* and *C(l)* represents the cumulative distribution up to the grey level *l*.

- **Adaptive Histogram Equalization**

To avoid the problem of over enhancement, the concept of Adaptive Histogram Equalization (AHE) was introduced. AHE is performing enhancement in several patches. It performs histogram equalization in local neighborhood of each pixel to avoid the over enhancement [10].

AHE performs well and able to enhance the small-scale pixels and reduces the contrast at high scale. However, AHE produces the noise components in constant/homogeneous regions.

To overcome this problem, CLAHE (Contrast Limited AHE) was introduced. CLAHE clips the histogram at a predefined value in the local region before computing the Cumulative distribution function CDF. The clipping to the modification of cumulative distribution function and the corresponding transformation function. The outcome of CLAHE depends on two parameters, the neighborhood size and clipping value.

Figures 6 and 7 show the outcomes regarding CLAHE. From figure 6, we can conclude that CLAHE performs better compared to the normal Histogram.

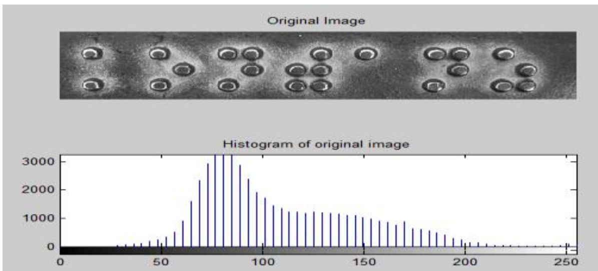

Figure-6: Original Scanned image-1 and its Histogram.

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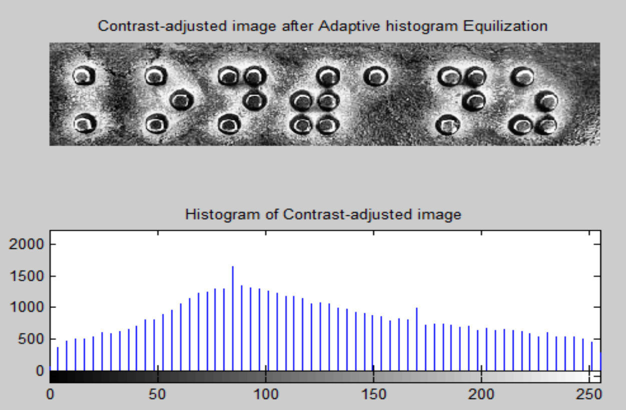


Figure-7: Contrast adjusted image and its Histogram

Once the contrast adjustment is performed, next step is to apply Laplacian function for edge detection. The Laplacian filter method for edge detector process is applied to figure out the second derivatives of the image, calculating the proportion for what the initial derivatives change. This regulates if a there is a change in neighboring pixel values are due to a continuous or edge progression. Thus, the threshold value for this image can be located at the minima of level 250 from the histogram as shown in figure 7.

The following array is a sample of a 3x3 kernel for the Laplacian filter as shown in matrix equation2.

$$\begin{bmatrix} 0 & -1 & 0 \\ -1 & 4 & -1 \\ 0 & -1 & 0 \end{bmatrix} \quad \text{-----} \ (2)$$

The Sobel operator is a derivate mask or a 3×3 convolution kernel as shown in figure-8 and is used for horizontal or vertical edge detection.

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

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

Figure-8: Horizontal and Vertical Sobel kernels

After Computing the Gradient approximation and magnitude of vector the resultant Filtered image is shown in figure-9. For smooth edge detection the thresholding value is adjusted to 250 as the minima in the histogram of figure-5 is located 250, approximately, and the resultant edge detected image is shown in figure-10.

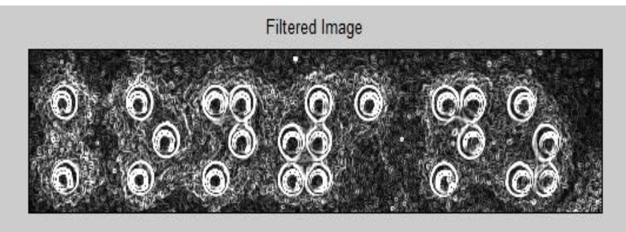


Figure-9: Filtered image

Figure-10: Edge detection by Sobel filter

The CNN (Convolutional Neural Networks) model is seen as a grouping of two techniques: the first one a feature extraction part and another is a classification part [5]. The convolution and pooling layers accomplish the feature extraction. The results of the feature extraction are used to map the Braille cells [1]. The located Braille cells are shown in the figure-11.

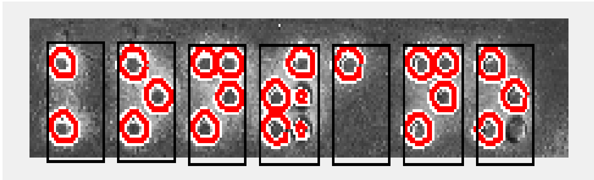
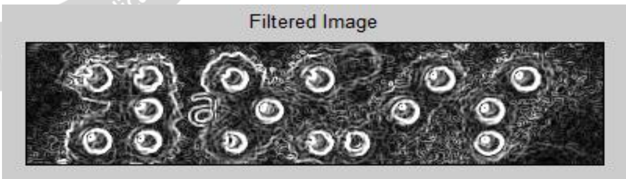


Figure-11: Cell detection with CNN feature extraction

The identified cells represent the word "KON WITH ANO". In this the cell "::" represents a contraction word "WITH". Also, we can see that last cell is not correctly recognized by the system.

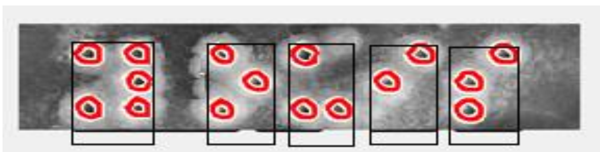
Similarly, we have applied the same techniques on another scanned image2. The output of each step carried out is shown together in figure-12.

(a) Original Image pattern of a sentence



(b) Filtered Image

(c) Sobel Edge detection



(d) Cell detection

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Figure-12: Grade-1 to sentence conversion steps for scanned image-2

In the figure-11, the identified cells represent the word "YOUIS" after mapping with English dataset, which represents the person's name.

III. RESULTS AND DISCUSSION

Braille Dataset is taken from the known website "Kaggle", which are openly accessible [3]. Apart from Kaggle website, few scanned images representing some words are used as dataset. To evaluate the efficacy of the Braille system, the real catalog of Braille characters is linked to the acquired output in the proposed system.

Sample example of the original image and correctly identified words are shown in figure-13(a) and figure-13(b).

(a) Scanned image-1

Identified word: "KON WITH ANO"
Correct word: "KON WITH ANZ"

(b) Scanned image-2

Identified word: "YOUIS"
Correct word: "YOUIS"

Figure-13: Output for scanned image-2

- **Evaluation metrics**

Results of Data set are compared using Accuracy, Precision, Recall and F1 score as represented in equation-3 to equation-6.

$$\text{Accuracy} = \frac{\textit{Total cells correctly recognized}}{\textit{Total no of cells input}} \text{ x } 100 \text{ --(3)}$$

$$\text{Precision} = \frac{TP}{TP+FP} \text{ --(4)}$$

$$\text{Sensitivity/Recall} = \frac{TP}{TP+FN} \text{ --(5)}$$

$$\text{F1} - \text{score} = \frac{2 \textit{ x Precision x Recall}}{\textit{Precision+Recall}} \text{ --(6)}$$

Here TP stands for the correctly identifying the dots, TN stands for correct detection of the background. FP stands for "Number of dots wrongly identified from the background" and FN stands for "Number of dots not identified in background". The values obtained are shown in table-3.

Table-3: Results of TP, FP, TN, FN

Dataset	Total dots	TP	FP	FN
Kaggle website	153	153	0	0
Dataset-1	39	38	0	1
Dataset-2	65	64	1	1

The results of accuracy, precision and Recall parameters on various Braille datasets are shown in table-4.

Table-4: Results obtained for Grade-1 Braille.

Dataset	Accuracy	Precision	Recall	F1
Kaggle website	100%	1.0	1.0	1.0
Dataset-1	97.43%	1.0	0.98	0.99
Dataset-2	98.46	0.98	0.98	0.98

The results shows that the quality of the image hampers the Accuracy. These results substantiate the pertinency of the proposed approach Single sided Braille Document translation.

IV. CONCLUSION AND FUTURE WORK

This paper focuses on the conversion of scanned Braille documents to text in English language. Public database from Kaggle website along with Grade-1 and grade-2 single sided Braille documents are used as dataset in this paper. The scanned documents are preprocessed using adaptive histogram, Laplacian, and Sobel filters. The segmentation is applied using thresholding minima and further the subsequent feature extraction is performed using Convolution Neural Networks method. To recognize the Braille cell patterns Classification and Regression Trees (CART) classifier is used. Subsequent results shoes that single character recognition from Kaggle website is 100%. Accuracy of Document_1 and Document_2 is 97% to 98.5%. The recognition of dot will be affected in grade_1 and grade_2 scanned image if traditional dimension is not echoed in the actual input document, that might have been from the noise introduced at the time of scanning. To examine the efficiency of the system, we have used the accuracy, precision, recall, and F1-score. The results confirms that the proposed methods are more effective in recognizing the cells. The size of the dataset is also a factor for the performance of the system. As the dataset size increases, the accuracy increases, and higher accuracy can be obtained for larger dataset when compared to datasets with smaller number of training images.

The paper could be extended for recognizing double sided contracted Braille documents to English manuscripts for identification of words and for the whole document at once.

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