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N-Gram Language Model to Predict the Word Sequence in a Degraded Braille Document

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Abstract: ***This paper presents a feature extraction method for optical Braille recognition (OBR) system to locate, extract and convert the Braille cells in one sided Indian language Braille documents. The Braille cells are located by implementing a grid-box designed using physical properties of a Braille cell. A Braille document image is a compilation of group of six dots. The physical position of each dot and its relevance with other neighboring dots in a single cell gives various Braille characters. After the grid-box is mapped with the Braille cells in the document, the mesh characters are extracted and are then mapped with existing database to translate them in required text. Mapping of Braille cells with mesh box and separation of characters and words from a Braille document was a challenging task. The unwanted dots or degraded dots way result in incorrect mapping of characters. In this paper we have used N-gram Language Models to Predict the word Sequence in case of wrong mapping of characters in extraction and conversion of the Braille cells.***

Keywords: Braille, degradation, extraction, N-gram.

I. INTRODUCTION

Optical Braille Recognition (OBR) is a technique that translates the scanned Braille document into required text document. Braille documents are created by collection of embossed Braille cells. Each Braille cells are formed by six raised dots embossed on metal plate which signifies a particular character. Visually impaired people use these Braille embossed plates by sensing the presence of raised dots and recognize the character or word associated with each Braille cell. Recognition of a Braille cells are very crucial in conversion of Braille document to natural language.

Braille cell is a collection of six dots which are arranged in 3x2 matrix form as shown in figure-1(a). Each cell represents one character. Braille document has various encoding standards like grade-1, the grade-2 and grade-3. In grade-1 each Braille cell represents exactly one alphabet of natural language while in grade-2 it represents one word of natural language. In grade-1 the word "Hello" is represented with 5-Braille cells; while in grade-2 it is represented with only one cell.

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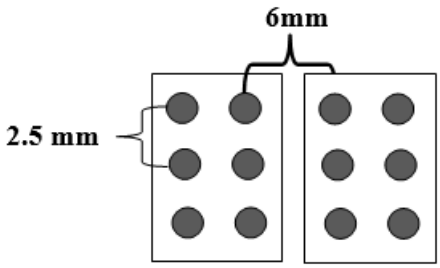

Figure1: (a) Braille cell (b) distance between each dot

The Braille cell box is of fixed size and has fixed physical properties. The exact distance among the two neighboring dots in a cell is fixed with 2.5 mm as shown in figure-1(b). Each dot of a cell is embossed with 1.6 mm diameter. The distance between the initial embossed dots of a first cell with its neighboring horizontal cells is 6mm. Similarly the distance between the initial embossed dots of a first cell with its neighboring vertical cells is 10mm.

One of the challenging tasks in OBR is segmenting and extracting Braille character cell by mapping it with a grid-box. The unwanted dots or degraded dots may not be mapped to correct character identification in a word. In such scenario we propose the N-gram Language Models to predict the word Sequence.

The steps followed for translating the Braille document to text by correcting wrongly mapped words are

1. Scan the document.
2. Preprocess the image to remove noise.
3. Remove skew generated in scanning.
4. Recognize the characters using mesh box.
5. Predict the words that are wrongly recognized.

In the previous papers we have worked on first 4 steps. In this paper we propose the N-gram model to predict the words that are wrongly recognized in translation process.

II. LITERATURE SURVEY

Bharat Kapse [1] explains the projected prefix matching approach in getting word prediction. The author uses B+ tree technique to symbolize the words in hierarchical and arranged fashion. The technique is very fast in predicting the word and is accomplished by applying the binary search method, and B+ tree. This technique is particularly used by visually blind users. It also helps in minimizing the time needed to type the whole word.

Guohong Fu [5] in his paper concentrates on an integrated prosodic word prediction to implement Chinese Script. The author also has proposed two word-based techniques for impelling this integrated prosodic of word prediction. In that the first one he implemented the concept of lexicalized hidden Markov models.

Whereas in the second technique is implemented from unknown word identification of the Chinese. Given a sequence of Chinese Script, the string c1c2…cn, and say it has one probable sequence of words W = w1w2 ... wm, that includes unknown prosodic words and also the known lexical words. This word prediction endeavor to recognize the best nearest word progression $\widehat{W}$ = w1w2...wm.

Kavita Asnani [9] has discussed the factors and parameters are used to construct a system, that is used to build the text data for generating predictions in instantaneous. In a technique like syntactic properties of a natural language that uses probability tables are used to make predictions. In semantic technique, every word are assigned semantic category and semantic clustering and classification is applied for word prediction.

Igor Schadle [6] has taken the advantage of n-gram statistical model which is applied on each letters and natural language processing to predict next upcoming word. He had presented the two predictive functions and the available Sibyl software that is applied in Kerpape French rehabilitation hub.

Minghui Wang [11] had used a Simple Recurrent Network (SRN) applied in Chinese for prediction of word. He implemented it in two levels, where in first level he predicts the key category of the next word. In the second level network, the next expected word is predicted.

Jolo Luis Garcia Rosa [8] has proposed a Bio-Pred, system that does connectionist natural language processing word prediction presented one word at a time using neurophysiologically motivated algorithm.

Zhengchen Zhang, [14] has combined the neighboring words that may be dependent associations into a prosodic word, while additional restrictions are added to clean up the technique. Experimental results demonstrate that the method achieved 0.918 and 0.901 on two corpora in association with term F-score.

III. WORD PREDICTION

The Word prediction techniques are commonly used in spelling checker, mobile phone, messaging applications, and related one [3]. Word prediction system performs the chore task of presumption of the preceding word that probably is going to carry on with some fragments of the initial text. This technique is called an inference by Markov Model. Such a Markov system is a stochastic model that illustrates probability of the sequence of potential events. This system forecast the future state considering that the next upcoming state depend on the state accomplished from the preceding events [3]. N-gram Model pursues the concept of Markov assumption properties.

N-gram Language Model:

The N-gram system gives the adjoining sequence of 'n' objects that is used in guessing the impending words from an input string of text [3]. It uses probabilistic language type technique in which the previous word is envisaged using the technique of a (n-1) order from markov model. The N-gram prediction for input sequence of text (W1, W2,…Wn-1) is estimated with the probability function P(Wn | W1 …. Wn-1) is given by the Bayes theorem as shown in equation-1

$$P(w) = \prod_{i=1}^{n} P(Wi \mid W1\text{K K } Wi-1) \quad \text{--- (1)}$$

The N-gram model is represented as n=1(unigram,) n=2 (bigram), also n=3 is represented as trigram system model. The probabilities are extorted through the training dataset that is used to devise the model. The given N-gram prediction technique presumes that the system can envisage the upcoming word in the next phrase by analyzing the preceding n-1 words (i.e. Markov approximation).

Unigram Model represents the fixed occurrences of the words. In the Braille article if a recognized word does not lead to any meaningful information then the meaningful word is predicted using previous n-1 words. In the said model the majority of frequent words that match the dictionary are predicted [3].

- **Image de-noising:**

Average filtering is used for image de-noising. The filter mask needed for average filter is shown in figure-1, which minimizes sharp variations of grey levels.

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

Figure-1: Average filter with size 3x3

The result after applying the average filtering on noisy Braille image is shown in figure-2.

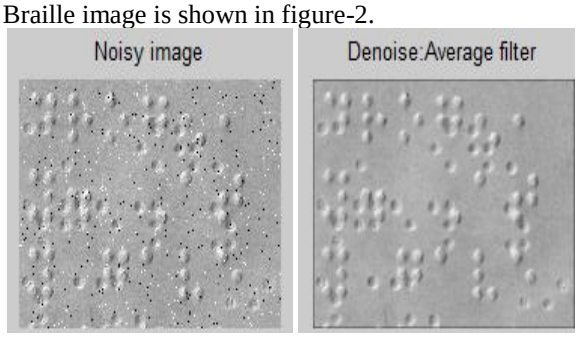
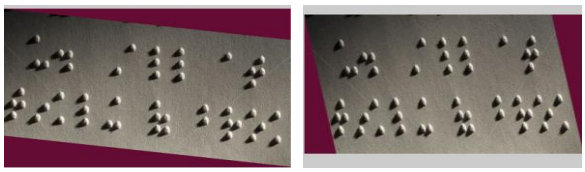


Figure-2: Image de-noise after average filtering.

- **Skew detection and correction**

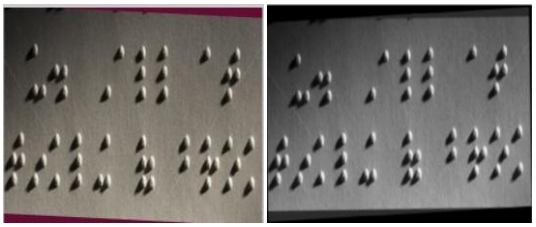
Due to improper scanning a skew can be introduced in clockwise or anticlockwise direction as shown in figure-3.



(a) Clockwise skew (b) Anticlockwise skew

Figure-3: Braille image with skew

The algorithm presented in previous paper uses the Sobel edge detector and Gaussian filter method to remove such a skew which is shown in figure-4.



(a) (b)

Figure-4: (a) Image with skew (b) Image after skew correction

The function 'imrotate()' of MATLAB is applied to eliminate the skew in the image. The direction and identified tilt angle was supplied as parameters.

- **Image segmentation and feature extraction**

After applying image smoothening methods, the image is segmented using the function 'strel()' as shown in the figure-5.

Figure-5: Segmented Image

Feature extraction is performed considering the physical properties of the Braille cell. A square mesh is applied to extort the cell details from the image which is shown in figure-6. The figure the white circle shows the mismatched dot with aligned square mesh.

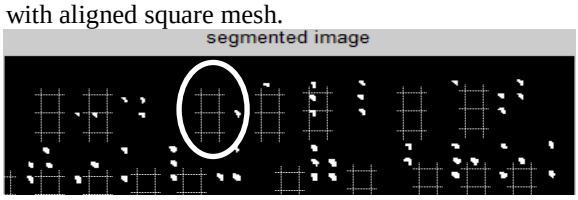


Figure-6: Square mesh and mismatched cell

The mismatched Braille cell as shown by circle in figure-6 is predicted using ngram word prediction considering the previous few Braille characters.

IV. RESULT ANALYSIS

In this section, we present recognition accuracy of Ngram model for the various sets of document images containing English and Hindi language with either single side embossing or double side embossing. Total four sets of documents are compared by applying translation without ngram and then with ngram model and the comparison is presented in table-1

TABLE-1: Results Obtained from Ngram model

Document type	# characters given	# characters recognized without ngram	# characters recognized with ngram	Comparative Accuracy %
English: single side embossing	525	512	523	97.89
English: Two side embossing	630	603	621	97.10
Hindi: single side embossing	589	575	581	98.96
Hindi: Two side embossing	488	443	471	94.05

Equation used to find comparative accuracy rate is shown in equation-1

$$\text{Accuracy} = \frac{characters\ recognized\ without\ ngram}{characters\ recognized\ with\ ngram} \times 100 \quad --(1)$$

The results form the table-1 shows that the accuracy rate was less in case of double side embossing images. And also it is concluded that translation of English Braille document has more accuracy rate comparing to Hindi Braille documents.

V. CONCLUSION

In this work an individual word is checked for correctness and if wrongly mapped then an N-gram word forecasting model is practiced to predict the word. Ngram based word guessing is efficient for Braille to English translation. it is very challenging if translation is to be done to other languages. However translation to other language can be improved by using linear interpolation model that combines unigram, the bigram and the trigram models. In a presented work, the single word prediction is performed whereas the group of words that also can be predicted to finish a sentence and also the article blocks can be merged with the best matching pattern or sequence.

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