Offline Recognition of Handwritten Devanagari Words using Recurrent Neural Network

Subhash V. Pingale[1], Rutuja N. Benkar[2], Rajan S. Jamgekar[3]
[1,2,3]*Computer science & Engineering Department, Solapur University*
SKN Sinhgad College of Engineering, Korti, Pandharpur, MS, India
[1]rutujabenkar06@gmail.com, [2]sub.pingale83@gmail.com, [3]rs.jamgekar@gmail.com

Abstract - Character recognition systems for various languages have gain importance in recent decades and are the area of deep interest for many researchers. English Character Recognition (CR) has been widely concentrated on in the last half century and advanced to a level, adequate to create innovation driven applications. Be that, as it may same is not the situation for Indian language which has large variety of structure and calculations. Indian language show incredible difficulties to an OCR planner because of the vast number of letters in the letters in order, the refined routes in which they join, and the confused graphemes they result in. Devanagari (Marathi) is the language of India, talked by more than 100 million individuals, so by giving unique consideration record recovery, examination of rich antiquated and present day Indian writing can be successfully done. The system is proposed in this paper based on Recurrent Neural Network (RNN) where RNN is extended to Bidirectional Recurrent Neural Network (BRNN) for directly transcribing handwritten data. This paper is planned to serve as a guide for users working in the Handwritten Devanagari language Recognition region. An outline of frameworks is displayed and the accessible methods are looked into. The working flow of proposed system is examined and bearings for future explores are proposed.

Keywords - Handwritten Devanagari Words, offline handwriting recognition, Preprocessing, segmentation, Recurrent Neural Network, Classification.

I. INTRODUCTION

Handwritten character recognition is the capacity of an application to get and decipher coherent manually written contribution from sources, for example paper. Bank Cheques, photos, touch-screens and different gadgets. Devanagari Characters are more complex for recognition than relating English characters because of numerous conceivable varieties all together also number, bearing and state of the constituent strokes. As of late, a great deal of research has been done here. Manually written content recognition can be grouped based upon two noteworthy criteria: the information obtaining process (on-line or disconnected) and the content sort (machine-printed or transcribed). For acknowledgment of manually written Marathi Characters there are four noteworthy stages,

1. Preprocessing
2. Segmentation
3. Feature Extraction
4. Recognition

The following sections present a study of literature survey done so far on the off-line Handwritten Devanagari Character Recognition. There are two Types of Handwritten Recognition as shown in Figure 1. In online recognition, a time series of coordinates representing the movement of the pen tip is captured, while in the offline case, only an image of the text is available. Because of the greater ease of extracting relevant features online recognition generally yields better results. So far, the majority of systems have tackled the easier of the two problems, namely, the on-line problem where the time ordering of strokes is available as well as pen up/down information; overlapping strokes can easily be distinguished and stroke positions are accurately known. On the other hand, offline systems have to cope with the large varieties of pen type, wide strokes which overlap and a lack of ordering information. Thus, the research in Offline recognition is more complex than the On-line version. The main disadvantage of on-line handwriting recognition is that the writer is required to use special equipment. So offline handwriting recognition is preferred.

HMMs are able to segment and recognize at the same time, which is one reason for their popularity in handwriting recognition. The idea of applying HMMs to handwriting recognition was originally motivated by their success in speech recognition, where a similar conflict exists between recognition and segmentation. HMMs have several well-known drawbacks. One of these is that they assume that the probability of each observation depends only on the current state, which makes contextual effects difficult to model. Another is that HMMs are generative, while discriminative models generally give better performance in labeling and classification tasks. Recurrent neural networks (RNNs) do not suffer from these limitations and would therefore seem a promising alternative to HMMs.

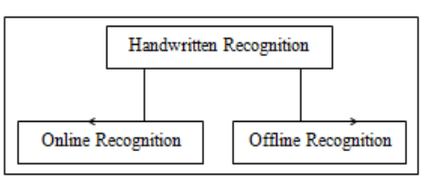


Fig. 1 Types of Handwritten Recognition

Recurrent neural networks (RNN) have been successfully applied for recognition of cursive handwritten documents, both in English and Arabic scripts. Ability of RNNs to model context in sequence data like speech and text makes them a suitable candidate to develop OCR systems for printed Devanagari scripts. A regular recurrent neural network (RNN) is extended to a bidirectional recurrent neural network (BRNN). The BRNN can be trained without the limitation of using input information just up to a preset future frame. This is accomplished by training it simultaneously in positive and negative time direction. Bidirectional Long Short Term Memory (BLSTM) architecture was employed to recognize printed Devanagari text.

II. LITERATURE SURVEY

This section presents detail investigation of different division and recognition methods. It likewise furnishes with the subtle elements of the considerable number of strategies or idea utilized by different specialists as a part of different periods of hand written Devanagari recognition.

This paper consist the idea of regular expression to group the info image in recognition phase which is priory changed over into 0's and 1's in segmentation stage [3]. This code of 0's and 1's is perceived by minimum edit distance algorithm in [4], [8], where great measure of exactness is watched. The creators in [5] take single character image as information and code is produced in view of removed physical features, the acknowledgment of which is being finished by tree classifiers. An incorporated approach for segmentation and acknowledgment is depicted in [6], where Ostu's strategy is utilized for binarization, Robert channels were utilized for highlight extraction. The character picture is perceived by quadratic classifiers. The approach depends on single character as info. The [7] recommends a framework that believers input image into pseudo characters and applies HMM classifiers on the premise of the feeds of the pseudo character.

In [9] concocted an unadulterated acknowledgment framework in light of neural network with one shrouded layer in which the view based elements and shadow based feature were separated. [10] has displayed a relative consequences of different elements extricated from the specimen contribution over which SVM and MLP classifiers are utilized for recognition. A relative study of 12 distinct classifiers used to perceive transcribed character with 2-set of elements extricated is done in [11]. The author has additionally introduced the aftereffect of correlation. [12] proposed a division model where flat projection was utilized for header line identification and form following calculation was utilized to section the modifiers. In [11] had thought of a segmentation framework that portion line, word, character and modifiers. They utilized vertical and flat profiles for segmentation. The framework has put limitation on the measure of skew present in the content by constraining it to the stature of the character consonant.

The work reported in [6] presents a two-stage classification approach for handwritten Devanagari characters. The first stage is using structural properties like shirorekha and spine in a character. A differential distance based technique is designed to find a near straight line for shirorekha and spine. The second stage exploits intersection features of characters, which are then fed to a feed forward neural network (FFNN) for further classification. This approach has been tested for 50000 samples and got 89.12% success.

HMM are used to recognize the on-line and off-line handwritten texts acquired from a whiteboard and text document. Recognizing Handwritten Devanagari words using Recurrent Neural Network 415 pseudo characters are trained in [7]. The word level recognition is done on the basis of string edit distance. The system is based on the combination of several individual classifiers of diverse nature. Recognizers based on different architectures (hidden Markov models and bidirectional long short-term memory networks) and on different sets of features (extracted from on-line and off-line data) are used in the combination. In order to increase the diversity of the underlying classifiers in cursive handwriting recognition, commercial recognition systems have been included in the combined system. It leads to a final word level accuracy of 86.16%. This value is significantly higher than the performance of the best individual classifier (81.26%).

III.SEGMENTATION AND RECOGNITION METHODS

Segmentation & Recognition are two most important part of all recognition system. A result of recognition highly depends on the accuracy of segmentation. Thus, it is very important to choose a best segmentation and a best recognition method. In this below section, we present the existing segmentation strategies and the different recognition methods that can be used by the researchers.

A. Segmentation Methods

Segmentation in any recognition system consist of dividing the Handwritten Devanagari language into first lines, the lines are further divided into words from which the different modifiers & conjuncts are separated.

Contour Tracing Algorithm and More neighborhoods Tracing Algorithm [10], [14]. The method is used for detecting the point of intersection of image of modifiers with the character image. The algorithm needs the coordinates of an image pixel that lies on the contour and returns the positions (row, column) of all the connected points by checking the continuity of the input pixel around its N x N neighborhood.

• The region of interest is searched for a first transition between background and object, i.e. a transition from (logical) white to black if dark objects are to be segmented, black to white for light objects.

• As soon as the transition has been found, the algorithm searches for the next neighbor of the same (logical) color with respect to the connectedness definition used.

In this case, only border pixels are accepted as neighbors i.e., pixels adjacent to at least one pixel of the other (logical) color.

• Contour tracing ends when the algorithm reaches its starting point i.e., the pixel where the first transition has been found.

B. Recognition Methods

Recognition phase is applied after the various features of an input image is extracted and finally the input image has to be classified/recognized by comparing its features with those in the system's database. This can be majorly done by using different image classifiers to classify the input image into various classes based on their matched features or by using neural networks which train the system first and then it is tested over the input image. Also, many systems are based on recognition using Genetic algorithm.

Artificial Neural Networks (ANNs) a neural network is a set of connected input/output units in which each connection has a weight associated with it. During the learning phase the network by table 1 given below.

TABLE I
COMPARISON OF RECOGNITION METHODS

Type of recognition methods	**Sub type**	**Advantages**	**Disadvantages**
Artificial Neural Network	Feed forward NN	Simple to implement as compared to other ANN.	Suitable for simple recognition patterns.
	Back Propagation NN	High accuracy can be obtained	Difficult to implement.

IV. PROPOSED SYSTEM

The proposed system architecture is shown in Figure 2. The proposed system first performs pre-processing on selected input. Pre-processing first perform gray scale on scanned input image. It generates gray scale image as a result. The next step is to perform binarization on gray scale image. On binarized output perform thinning. The result of thinning gives as an input to segmentation. Segmentation divides word into characters. Extract the features from segmented word and generate the template. The generated template gives as an input to recognition operation. In the recognition operation it compare generated template to the training dataset and produce the closest match as a result.

A. Proposed Algorithm

The handwriting recognition process should include the following steps:

1. Read the image of the handwriting text.
2. Scan that image with scanning resolution of 300 dpi and a gray scale bit depth of eight.
3. Convert that image into black and white (Binarization).
4. Apply the pre-processing techniques over that image such as thinning.

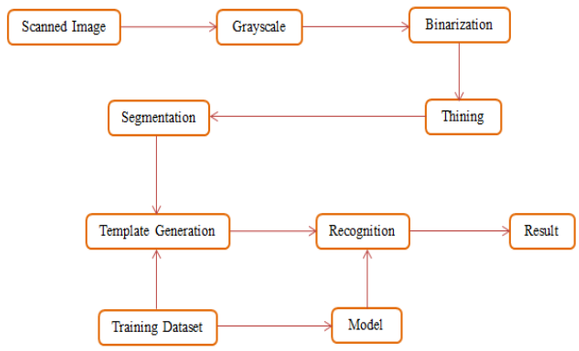


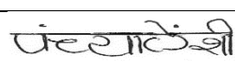
Fig.2 System Architecture

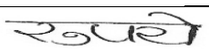
5. Then resulting sequence of feature vectors is scanned in opposite directions by the hidden layers.
6. The BLSTM layers output feed forward to the output layer.
7. Output layer produces a probability distribution over character transcriptions.
8. This distribution is passed to the dictionary and language model using the token passing algorithm.
9. Finally, the token passing algorithm obtains the final word sequence.

V. RESULT AND EVALUATION

The work tested on approximately sample images. Since the samples were hand written the experimental results provide a good estimate of the performance of the work. An analysis of the results has been tabulated as below. Each of the characters was tested for 10 samples.

TABLE III
RESULT ANALYSIS

Input word	**Success In Recognition**	
	Traditional System	**Proposed System**
	90%	93%

	92%	96%
	93%	94%
	91%	93%
	93%	95%
	94%	94%

System Modelling:
System S can be defined as:

S = {Input, Output}

The mathematical relation between input "I" and output "O" can be stated as:

$$Oi = \{|O| \mid Pi >= Pt \text{ where } i= 1 \text{ to } m\} \forall I$$

Where m = W
Pi > = pt (default T (Threshold))
W - Words present in the image
Where Input I = {Un, Im }
Un is the set of users.
Hence U= {U1, U2, U3…Un}
Im is the set of images.
Hence P= {I1, I2, I3…In}

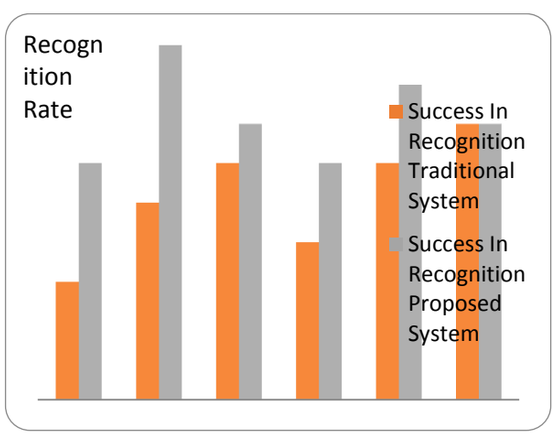


Fig.3 Recognition Rates in Traditional & proposed system

VI. CONCLUSION

As Handwritten Devanagari Script Recognition has a big scope in numerous ranges. The researchers should use the most efficient techniques to get the desired results. the handwritten Devanagari word recognition is difficult task. So in this system, the gray scale method, Thresholding Algorithm & thinning algorithm is used as preprocessing Techniques. After segmentation of words Features of those words are extracted & training set is generated. This dataset is written by different writers. Finally RNN Classifier is built to recognize the input word.

The future scope is to use the words containing upper and lower modifiers and also complex words from the database for recognition. Apply more preprocessing techniques, feature extraction techniques to improve the result. Also recognize the Handwritten Devanagari multiple lines.

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