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Design of Handwritten Character Detection Using SVM Classifier

Ashish Sharma¹, Bharti², Dr. Naveen Dhillon³

P.G. Student, Department of Electronics & Communication Engineering, Ramgarhia Institute of Engineering & Technology, Phagwara, Punjab, India¹

Assistant Professor, Department of Electronics & Communication Engineering, Ramgarhia Institute of Engineering & Technology, Phagwara, Punjab, India²

Principal, Ramgarhia Institute of Engineering & Technology, Phagwara, Punjab, India³

ABSTRACT: Character recognition systems translate such scanned images of printed, typewritten or handwritten documents into machine encoded text. This translated machine encoded text can be easily edited, searched and can be processed in many other ways according to requirements. Character recognition systems translate such scanned images of printed, typewritten or handwritten documents into machine encoded text. This translated machine encoded text can be easily edited, searched and can be processed in many other ways according to requirements. Picture information is improved with the help of a technique named image preprocessing. This picture data is used as input. For the next processing of the input image, image preprocessing technique also improves the characteristics qualities of the picture. Binarization, normalization and noise elimination are some important phases of image preprocessing technique. The representation of samples as points in space that are mapped such that the samples of individual categories can be differentiated using a major vector is known as SVM model. The support vectors are at similar distances from major vector both from left and right directions from that major vector. The proposed technique is implemented in MATLAB and it is analyzed that proposed method give high accuracy, precision and recall as compared to existing method.

KEYWORDS: Character Detection, Devanagari, Segmentation, SVM

I. INTRODUCTION

In India, there are multiple languages and scripts. India has 22 officially recognized languages which is more than any other country in the world. One of the characterizing parts of Indian script is the collection of sounds it needs to assist. Since there is usually a letter for every one of the phonemes in Indian dialects, the set of alphabets will in general be very huge. Bramhi script is recognized as the mother of the majority of the Indian dialects. Indian scripts are utilized for two particular major linguistic groups, Indo-European dialects in the northern part, and Dravidian dialects in the southern part. Devanagari is the most famous Indian script. It consists of 11 vowels and 33 consonants.

These sorts of basic characters, compound characters and modifiers occur both in Devanagari as well as in other scripts. Hindi, Indian National Language, is written in the Devnagari script. Devnagari is the mother script of Marathi, Sanskrit and Nepali language also. In addition to this, Hindi is the third most mainstream language all over the globe [4]. Figures 1 to 4 represent a sample of Devnagari character set.



Figure 1: Devanagari vowels.



क	ख	ग	घ	ङ	च	छ	ज	झ	ञ	ट	ठ
ड	ढ	ण	त	थ	द	ध	न	प	फ	ब	भ
म	य	र	ल	व	स	ष	श	ह	क्ष	त्र	ज्ञ

Figure 2: Devanagari consonants.

०	१	२	३	४	५	६	७	८	९
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Figure 3: Devanagari numerals

।	।	।	।	।	।	।	।	।	।
---	---	---	---	---	---	---	---	---	---

Figure 4: Modifiers

In Devanagari script, every character has a horizontal line at the upper portion, termed as Shirorekha or headline. English characters don't have such a trait. This is a distinguishing feature using which English can be extracted from these scripts. In successive handwriting, in the left-to-right direction, shirorekha of a single character connects with the shirorekha of the earlier or subsequent letter of the similar word. This is the reason that many characters and modified shapes in a word seem like a solo linked element combined through the mutual shirorekha. Every character and modified shape within a word seems like hanging from the theoreticalshirorekha of the word.

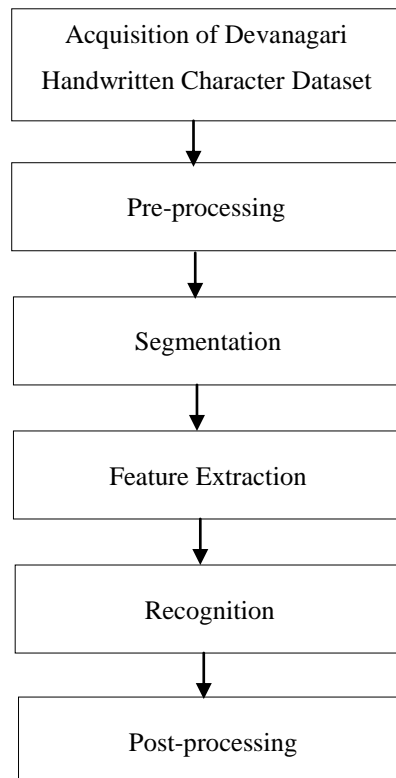


Figure 5: General Process of Devanagari Character Recognition



Following is the detailed description of every stage applied in Devanagari Character Recognition process:

a. DHC (Devanagari Handwritten Character) Dataset: The first step towards handwritten Devnagari character recognition is the collection of a suitable dataset. In order to create the DHC dataset, the different types of handwritten Devanagari characters are collected from different people from a variety of fields. After this, the scanning and cropping of these Handwritten documents is carried out physically for single characters. Devanagari Handwritten Character Dataset consists of thousands of images, with some images carrying consonant characters while rest to numeral characters.

b. Image Pre-processing: The pre-processing includes a sequence of steps which are applied on the scanned input image. This step is mainly concerned with improving the image quality and making it suitable for the segmentation process [6]. An image is pre-processed by applying so many operations on it. Some fundamental steps in image pre-processing are:

Binarization: Binarization is an important step in which the grayscale image is converted into a binary image termed as black and white image. A binary image is additionally known as a Bi-level or a two-level image. Binarization is generally carried out using a thresholding method. In thresholding, values of pixels more than a threshold are typified as white while the values below threshold level are characterized as black.

Removal of Noise: The pre-processing stage improves the quality level of the raw input image and add important data to it. Scanned documents may be degraded due to many factors such as dust, spots, dots, or lines. These factors are categorized as noise which significantly affects the recognition results. To continuously make it suitable for further processing, a scanned image must be free of any type of noise. Methods of image enhancement are implemented to enhance the image being observed by a machines or human beings. Different smoothing and non-linear functions, such as morphological operations, are used to reduce noise.

Skew Correction: The main objective of Skew correction is to correct the text line in scanned images of documents to make them horizontally aligned in the course of scanning. It is also possible to apply the skew correction on the document or line level. The pre-processing stage generally applies a global skew correction on the document level.

Thinning: In thinning, the main concern is to reduce the thick object to a line like object. The obtained image is also known as the skeleton of an object. Reducing the amount of memory needed to store thinned image, data transferring and processing time is the main benefit of thinning [7].

Normalization: All writers have their unique style of writing. This method aims at removing these sorts of differences from the original data. The normalization stage is concerned with eliminating the variations that not only make the categorization difficult but also reduce the recognition rate of the same characters or words written by various writers.

c. Segmentation: In Segmentation, the image is divided into different required objects. Automatic segmentation in image analysis is quite a complex job. The major purpose of segmentation is to isolate each character from background and from other characters as well. The segmentation process can be further divided into the following key operations:

Line Segmentation: Line segmentation generally applies a horizontal scanning technique for segmenting the text paragraphs into lines. Segmentation process for extracting lines from text blocks applies horizontal scanning beginning at the top of the scanned document, until it detects the last line containing whole white pixels, prior to the detection of a Black pixel row. The scanning goes on continuously till the detection of the first line comprising all white pixels shortly after the end of the last row of black pixels. It determines a line, and is finally taken out. This entire cycle is repeated on the whole text page so that every text line on that specific page/paragraph can be segmented.

Segmentation of Words: Once the line segmentation is performed, the separate words embedded in every line are segmented. This task is carried out by applying a vertical scanning technique. Vertical scanning applies only to the line width [8].

Segmentation of Characters: After segmenting words from text lines, one more segmentation method is implemented for extracting the separate characters out of the segmented words. Prior to applying word segmentation at character level, the header line or shirorekha is detected and eliminated. In this method, the rows are found with the maximal number of black pixels within a word.

d. Features Extraction: The role of features in a handwriting recognition system is huge. This process is concerned with increasing the recognition rate by representing the data in competent manner. In this process, the valuable data is extracted from the rough data. This process is applied to find discriminating features that differentiate each group of characters/objects. The handwritten character recognition frameworks make use of two main feature extraction schemes, namely holistic and analytic. Holistic recognition scheme considers every word as a class and recognizes it as whole word. However, the analytic recognition scheme depends on recognition free from character segmentation.

e. Recognition: Recognizing handwritten Hindi characters is not an easy job. The Devanagari characters may be scripted in different size, direction, width, arrangement and measurement. This may cause infinite variations [10]. In recognition phase, different types of classifier models are used. Classifier models generally apply two sorts of learning methods:

Supervised learning: Supervised learning allows machines to learn the features from labeled training data. The efficiency level of supervised learning is analyzed from the features learned on the test data for which the correct classification during learning does not occur. The success level on test data computes the performance of the machine which has learned from the features. Some popular examples of supervised learning are SVM, HMM etc.

Unsupervised learning: In machine learning, unsupervised learning is implemented to obtain inferences from datasets comprising input data without labeled responses. Clustering is most commonly used unsupervised learning approach. This approach is concerned with analyzing testing data to locate hidden patterns or grouping in data.

f. Post-processing: Post-processing is the final stage in Devanagari character recognition. Few recognized characters can be appropriated due to misclassification and segmentation. The pre-processing step is applied for correcting these recognition errors. Post-processing is generally performed by using two most popular approaches to rectify recognition errors. These approaches are known as statistical approach and dictionary lookup approach.

II. LITERATURE REVIEW

Brijeshwar Dessai, et.al (2019) focused on constructing OPR system based on CNN for Handwritten Devanagari Script so that the characters were recognized in accurate way [16]. Convolutional Neural Networks (CNN) that had more efficiency to classify the image classification than Support Vector Machine (SVM) and Artificial Neural Network (ANNs). Also, the complexity was maximized as a header line was present for every word and uniqueness in writing style. The effectiveness of presented system was enhanced to recognize the Devanagari characters.

Vivek Kumar Verma, et.al (2015) suggested a system to recognize different font of characters that assisted in enhancing the accuracy of OCR system [17]. The suggested system utilized to demonstrate the adequacy method in order to identify the character for number of font styles in Hindi script. The results indicated that this system was proved appropriate to control the script styles information for Devanagari script. The accuracy was improved using a process. For which, a notion was generated for discovery emphasis words including Bold, Italic and underline words. The benchmark testing was conducted by considering the extensive Devanagari font styles. The text style in Hindi script record was recognized for improving the execution of the suggested system.

Sneha Shitole, et.al (2018) discussed that the HCR of Devanagari script was the significant field of research in the pattern recognition. The PCA and LDA had intended for increasing the performance of the recognition system [18]. There were 3 dissimilar feature extraction techniques implemented for extracting the raw attributes. The Linear Discriminant Analysis (LDA) had mitigated these attributes. The Support Vector Machine (SVM) was deployed for categorizing the LDA and characters. The outcomes revealed that the LDA had performed more efficiently in comparison with the PCA.

Prashant M. Kakde, et.al (2016) described that an active field of research was the CR. The deployment and comparison of PSO and SVM had performed in this approach [19]. The input character was taken using an android phone and the Devnagari character which were identified, revealed on MATLAB software. The PHP language was executed so that the android device was integrated with MATLAB. The experimental results represented that greater accuracy was obtained from the particle swarm optimization (PSO) method in contrast to support vector machines (SVM). The accuracy was enhanced up to 90% on the real time system.

Saurabh Farkya, et.al (2015) emphasized on utilizing the HCR system for Devanagari. Text to Speech System was a modified version of Optical Character Recognition (OCR) system for which the mutilation of blind people was considered [20]. The surveys demonstrated the efficacy and robustness of SVM to handle an enormous amount of attributes. The classification was carried out using support vector machines (SVM). In Transform domain, wavelet transform was deployed as it was capable of maintaining global attribute in diverse scale. The structural domain made the employment of gradient and distance profile attributes because local features of the characters were shown by them. Morphological operation and thinning methods were deployed to carry out the pre-processing. The self-developed database having fifty samples per character taken from 10 diverse individuals had applied to execute the training.

Mahesh Jangid, et.al (2016) intended an algorithm for estimating the same character pairs in Devanagari Script. The confusion matrix was discovered for recognizing seven pairs [21]. The shape of similar shape characters was slightly different under the recognition stage. Thus, the confusion was occurred in the classification method. Prior to it, more attributes were extracted using critical region. In order to estimate the critical region, Fisher discrimination function was exploited. The attributes were extracted from standard Devanagari database with the help of novel masking scheme. The identification rate was computed 96.58 % when the enhancement to recognize the similar character was found 81.94%.

SushamaShelke, et.al (2016) projected some methods to optimize the accuracy of recognition. First of all, the characters were pre-classified into diverse classes [22]. For this purpose, different structural attributes were utilized. Afterward, optimized feature extraction methods were employed with the intention of extracting the attributes. At last, the neural network (NN) was applied to recognize the character. The deployment of a number of NNs and their analysis had done in this approach. The outcomes exhibited that the recognition rate was enhanced by the means of optimization. The maximum identification rate was acquired using Elman BPNN in comparison with other networks.

Aarati Mohite, et.al (2018) presented a system to identify the handwritten Devanagari character for which CNN was implemented. The transfer learning of pretrained architecture such as Alexnet, Googlenet, ResNet was utilized for our application [23]. The Convolutional Neural Network (CNN) model was constructed and the time was saved with the help of Pre-trained architecture. There was a necessity of GPU having better performance with great computational potential because of the maximization of database. The accuracy was enhanced by inserting more samples in the database in order to train the images. More preprocessing algorithms were employed prior to implement the DL network. The presented approach provided 91.23% precision while recognizing the Devanagari characters.

SushamaShelke, et.al (2018) introduced the rotation invariant feature extraction methods for handwritten Devanagari characters [24]. This paper made the deployment of various methods namely DCT, DFT and DWT. Additionally, the extraction of their convolved attributes was also performed. It was indicated in the outcomes that attributes of Convolved Wavelet coefficient were proved efficient to extract the rotation invariant attributes in comparison with other transforms. This transform had potential to control the rotation from -30 degrees to +30 degrees in effective way and categorize the character exactly.

Nikita Singh, et.al (2018) recommended an approach in order to recognize the handwritten Devanagari character. The variant of curves were utilized to reveal the shape variance of the character in Devanagari script [25]. The feature extraction scheme was applied in piecewise manner to differentiate these characters. The piecewise HOG technique was executed using image partitioning method. The neural network (NN) was trained through a feature vector that had Histogram of Oriented Gradients (HOG) attributes of all partitions. The greatest precision achieved using the recommended approach was counted 99.27% during training. This approach also assisted in identifying various handwritten Devanagari characters and provided the average accuracy around 97.06%. The recommended approach was proved valuable in the application for blind people for reading the handwritten contents.

III. PROPOSED METHODOLOGY

Automated Devanagari character recognition is an innovative, prominent and challenging area in today's digitized world, which has evolved through the combination of artificial intelligence, pattern recognition, machine learning and data mining concepts. Optical Character Recognition (OCR) systems of non-Indic languages, such as, English, Chinese, Japanese, Korean, German etc. are already mature as compared to Indic scripts. Because of initial slow progressive growth and much ignorance, Devanagari recognition and classification systems are getting a good deal of attention nowadays. Although many offline Devanagari OCR methods have already been introduced in recent years, yet it is still a big challenge to process its documents due to linguistic based criticalities, large character set, complex conjuncts, typical geometric structure of character, zone-based form, and use of shirorekha (top line). In addition to these complexities, the processing of unconstrained Devanagari handwritten character recognition is always found much harder than the printed ones.

Therefore, an efficient Devanagari Character Classification using Support Vector Machine (CC-SVM) method is proposed in this paper, which preprocesses the offline scanned imaged documents, normalizes them, segments them using projection profile, removes top line, obtains Shirorekha-Less (SL) characters, extracts their features, and finally, recognizes the SL characters by using SVM classifier. Such method makes use of a pseudo-thesaurus, which stores a set of pre-defined character classes. The segmented SL characters are matched with the shirorekha based pre-defined characters. If that SL character is found same as the pre-defined character, then it is categorized into that pre-defined character category, otherwise, not.

1. Image preprocessing

After acquiring the scanned text document image preprocessing is performed. At this time, all the variables and counters are initialized, and paths are set to get input images and to store the output variables. All the noise contents and undesired outliers are removed. Its skew is corrected and image is normalized. Further, such image is converted from RGB to gray level image through which the binary image is obtained.

2. Image segmentation

The obtained pre-processed binary image is segmented further to extract the lines, words and characters by using the project profiles. Firstly, the image is segmented through horizontal projection profile, so that all the lines are detected and located in bounding boxes. This is performed because text lines contain high density of black pixels as compared to the gaps existing between the adjacent lines. After such line detection, words are detected and located in bounding boxes by using vertical projection profile. To locate and detect all the characters and their upper/left/right modifiers (or parts), the top lines are removed from image word by word by using horizontal profiling. For this, each top line is first located and then all pixels are made zeroed because it contains the highest density of black pixels in a word.

3. Feature extraction and classification

During this step, the features of all SL character images are extracted. For this, the values are represented in the (rows \times columns) matrix, where the number of rows is equal to number of columns. A character geometrical structure consumes a number of black pixels, which are depicted by its corresponding values, and then their geometric based features are extracted. These extracted features of SL characters and SL modified characters are used to train SVM classifier. Here a pseudo thesaurus is used, which is used to store the pre-defined character classes. Finally, the SL characters and SL characters with 2/more components are matched against these categories.

IV. RESULT AND DISCUSSION

It is seen that very promising classification results have been obtained on CC-SVM. The obtained classification results of proposed system have been compared with the accuracy results of other existing recognition methods. Many existing recognition techniques on Devanagari script, and Hindi, Sanskrit and Marathi languages were discussed and compared with each other for many different parameters.

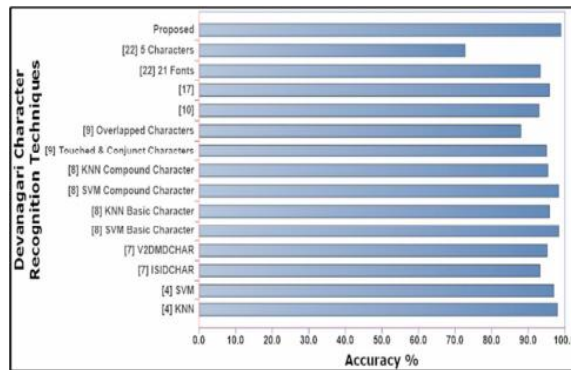


Figure 6: Result comparison of proposed method with existing Devanagari OCR techniques.

In Fig. 6, the proposed system accuracy is compared with the results of SVM and KNN [4], ISIDCHAR and V2DMDCHAR datasets [7], SVM and KNN for basic and compound characters [8], results of overlapped, touched and compound characters [9], SVM [10], combined SVM and quadratic [17], and results for 5 characters and 21 fonts by using feature based classification [22]. Fig. 7 depicts the comparative analysis of proposed method with existing OCR techniques for handwritten Hindi and Sanskrit documents. Here the proposed system accuracy is compared with the results of Hindi OCR by using rule-based classifier [12], Hindi OCR by using RFMLP, FSVM, FRSVM and FMRF [14], and Hindi and Sanskrit OCR without relevance feedback [21]. The proposed method results better than other existing techniques.

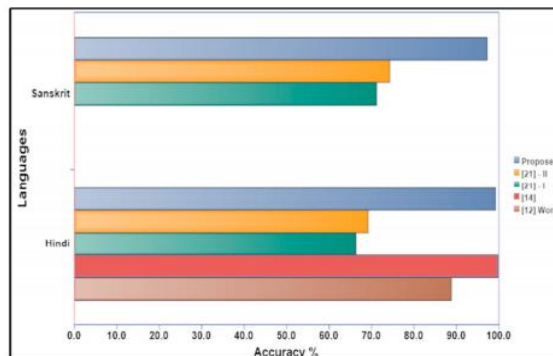


Figure 7: Result comparison of proposed method

V. CONCLUSION

In this work, an efficient Devanagari character classification system using SVM was proposed, which recognized and classified SL characters and modified SL characters of scanned mono-lingual printed and handwritten Hindi, Sanskrit and Marathi document images. This system was implemented on diverse data sets of three languages and found very promising results for Hindi and Marathi than Sanskrit. The reason behind the misclassification of Sanskrit characters was their typical character geometrical structure and use of many complex conjuncts. Further this system was compared with many other existing Devanagari OCR based techniques. These techniques were also elaborated and compared with each other for different parameters. In future, the proposed system will be improved for a large set of printed and handwritten document images.

- Recognition and classification of image words.
- Improving the system for multi-fonts and italics text.



- Extending the work for imaged document classification.
- Making the proposed system generic for the inclusion of other Indic and non-Indic scripts.

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