EasyChair Preprint

№ 4370

An Efficient Approach for Handwritten Devanagari Script Recognition

Manoj Sonkusare, Roopam Gupta and Asmita Moghe

October 12, 2020

An efficient approach for Handwritten Devanagari Script Recognition

Manoj Sonkusare[1], Roopam Gupta[2], Asmita Moghe[3]

[1]Research Scholar, [2]Professor, [3]Professor,
[1,2,3] Department of IT, Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal, India
sonkusare_manoj@rediffmail.com

Abstract. Handwritten text recognition is a challenging task because of the vast changes in writing styles. In India, a massive number of people use Devanagari Script to write their documents, but due to large complexity, research work accomplished on this script is much lesser as compared to English script. Hence, recognition of handwritten Devanagari Script is amongst the most demanding research areas in the field of image processing. Feature extraction and recognition are key steps of OCR which affects the accuracy of the character recognition system. This paper gives an efficient approach for handwritten Devanagari script recognition based on various parameters like database used, sample size, training and test set ratio, class size, data normalization size, recognition accuracy, etc.

Keywords: OCR, Devanagari Script, ANN, DCNN, CNN, KNN, SVM, DBN.

1 Introduction

Optical Character Recognition (OCR) is a technique to turn the scanned image of handwritten or printed text into a digital form. Handwritten character recognition is active field of research which possesses a substantial importance in digital image processing. It has many applications such as automation of various organizations like post offices, government and private offices, searching data from documents and books, processing of cheque in banks, etc. Handwritten character recognition and printed character recognition are two types of OCR [1], [2]. Printed text recognition is almost a resolved job. However, because of the vast changes in writing styles, the handwritten text recognition is a challenging job. Hence, handwritten character recognition is presently a vital field of research [3].

Either online or offline both types of handwritten characters can be supported by the recognition system. In the former case, the current information is available as coordinates of pens tip as a function of time however, in later case the image of handwritten paper is required in digital form [4] as shown in figure 1 below:

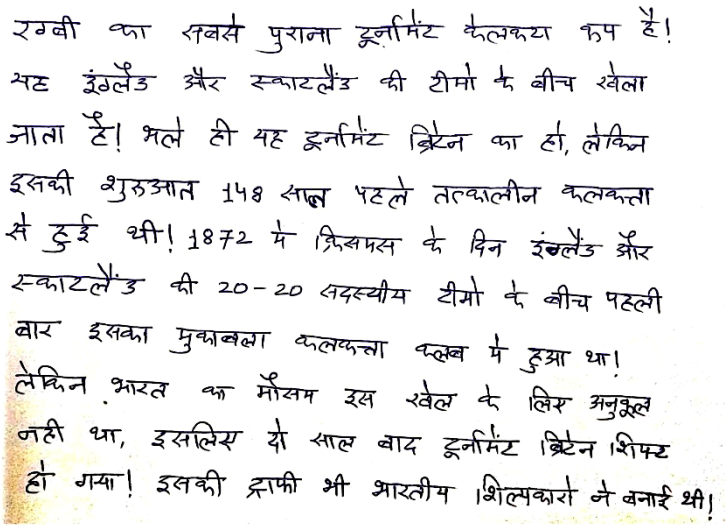

Fig.1. Contemporary handwriting in Devanagari Script.

However, due to gradual progressive growth of handwritten Devanagari character recognition, it is presently new and challenging area. Although many handwritten Devanagari character recognition methods have already been introduced till date, but it is still a complex task to process its documents because of large character set, linguistic based criticalities, and use of shirorekha [5].

Almost all of the classification techniques in the OCR deals with a numerous number of classes and finds discrimination between classes. There are numerous classification techniques available such as, SVM, ANN, KNN, RBM, CNN, and Hybrid Classifier [6]-[8].

The purpose of this paper is to find out most accurate classification approach based on various parameters like database used, sample size, training and test set ratio, class size, data normalization size, recognition accuracy, etc. The intention of this paper is to direct the researchers who are pursuing their work in the similar field.

The paper is managed in the subsequent manner: Section 2 illustrates basic information about Devanagari script. Section 3 shows the literature review on Devanagari script. Finally, in last section we discuss conclusion and future scope of the research.

2 Introduction to Devanagari Script

Every Indian language is extracted from Brahmi script and has a phonetic base. India has 10 major scripts that is, Gujarati, Kannada, Oriya, Telugu, Gurumukhi, Tamil, Bangla, Malayalam, Urdu and Devanagari. From these scripts, many official languages are extracted. Approximately half of the Indians use Devanagari script

and it is used in more than 100 languages like, Hindi, Nepali, Marathi, Haryanvi, Rajasthani, Gujarati, Kashmiri, Bhojpuri, and Sanskrit, etc [9]. It has 49 primary characters from which 13 are vowels, 36 are consonants and 14 are modifiers as shown in figure 2.

Fig.2. Vowels, Consonants and modifiers of Devanagari script.

"Shirorekha" or "Matra" is also present in Devanagari script. Devanagari words are divided into 3 parts: a core strip containing base characters, a Bottom strip with lower modifier, and Top strip having upper modifier as displayed in figure 3.

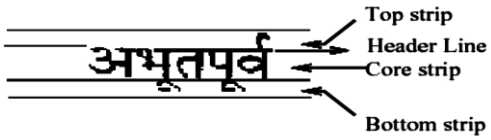

Fig.3. Devanagari word strips

3 Literature Review

In this segment we discussed distinct segmentation, feature extraction, recognition & classification techniques. After that we discussed recent work on the recognition of Devanagari handwritten character using Deep learning and other recognition techniques for better accuracy:

The basic pattern recognition ideas, understanding of various research models and related algorithms for classification and clustering are introduced in [7]. The paper presents the algorithms for the classification, regression, clustering, parsing and sequence labeling on pattern recognition.

There are three steps in segmentation: Line, Word and Character detection and segmentation. In [10], horizontal projection profile method for line, vertical

projection profile method for word and both horizontal and vertical projection profile method to segment characters from words. In [11], new segmentation techniques are suggested, in which scanned handwritten image is divided into lines, these lines to words and words to characters.

The feature and template-based method was applied for older Devanagari character recognition. In template-based method, each input letter is matched with a standard template pattern of characters and similarity between two patterns is used to decide which letter it is. The results of older OCRs were enhanced by making use of feature-based method in addition to traditional template-based method [12], [13]. Feature-based methods find the unique aspect of letters and these aspects are then used in classification.

The performance of recognition system is improved by using principal component analysis and Linear Discriminant Analysis [14]. In which, chain coding, edge detection and direction feature techniques are used for extraction of raw features which are then reduced by LDA and PCA. The SVM is employed for classification of characters. The new techniques of Devanagari OCR such as training, feature extraction, classification and matching are presented in [15]. A comparative study concerning feature extraction approaches and classifiers on Devanagari OCR is explained in [16].

Authors discussed, Euclidean distance based KNN techniques for feature extraction, which achieved higher recognition rate than SVM [17]. In [18], curvatures and gradient features are extracted and applied on Euclidean Distance Neighbor based Kohonen NN. In [19], features are detected from lines and curves by using Hough transform and classification is accomplished by SVM. The accuracy secured from these two methods is up to 90%.

Fuzzy technique is used in [20], for recognition of Hindi handwritten characters and secured accuracy of 90.65 percent for handwritten Devanagri characters. In [21], Hindi OCR is developed by removal of shirorekha in preprocessing stage, K - means clustering approach is used for feature extraction and linear kernel based technique is used for classification.

A pre-trained model using transfer learning for DCNN is presented in [22]. Convolutional, pooling and fully connected layers of CNN are applied for feature extraction, reduction of dimensions and image representation. In this work, 15 epochs are implemented for each of 7 (AlexNet, Vgg 11, Vgg 16, Vgg 19, DenseNet 121, DenseNet 201, and Inception V3) pre-trained models. Out of all 7 models Inception V3 have maximum accuracy of 99% and AlexNet is faster ConvNet.

The Hindi handwritten character recognition model, is presented in [23]. The 4 CNN layers and 3 fully connected layers as well as Pooling and Flattening are the two operations applied in this model. The 3 main operations are applied on each CNN layer, which are filter kernel, ReLU activation function, and pooling operation. 32 kernels of size 3x3 each is applied on the first two layers and 64 kernels of size 3x3 is applied on the third and fourth layers. The ReLU activation function is applied on the second operation to get non-linearity and at last pooling operation to reduce the size of feature vectors. The flattened output from the last CNN layer is given to 3 fully connected layers, then batch normalization is applied.

The third layer is the output layer that represents output of each class using SoftMax activation function. The model achieved the recognition accuracy of 98.94%.

An OCR system is presented in [5], which identifies and classifies Shirorekha-Less character of handwritten Sanskrit, Hindi and Marathi image documents using support vector machine. The system uses scanned images of handwritten documents written by two writers in these languages, the documents must have no character/word with overlapped shirorekha or touch each other and must have straight shirorekha. The model increased the scope of using diverse set of sample images only and found very encouraging results of 98.35%.

A strong algorithm in Devanagari and Latin scripts for segmentation and recognition is proposed in [24]. In which, primary segmentation paths are acquired through structural property, joined and overlapped characters are segmented using graph distance and then SVM classifier validates the segmentation results. KNN classifier is utilized for handwritten and printed input characters and obtained recognition rates of 98.26% for CPAR database.

A model developed to recognize handwritten Devanagari characters using deep learning is proposed in [25]. The two steps of experiments are performed on V2DMDCHAR and ISIDCHAR databases with six different network architectures (NA1 to NA6). In the first step identifying the best NA for the database, and then the best-observed NA is tested with six different optimizers (adaptive gradient methods). The highest result of 96.02% has been obtained using NA6 and RMSProp optimizer. The effect of layer-wise training is observed in the second step with the best NA and best optimizer selected in the first step and obtained 98% accuracy.

A hybrid model is implemented with KNN and ANN classifier for recognition of the individual vowel and consonant in [26]. These individual vowel and consonant can be used to identify inferred words. To implement a sophisticated Hindi OCR, different methods on segmentations, features extraction, and classification have been studied and applied. In past research, the KNN technique has been used, but this model uses a hybrid technique which contains neural networks and KNN. Proposed model provides 97.4% results as compared to 94.5% for past techniques.

Three different network BLSTM, CNN and a hybrid CNN-BLSTM of various depths are implemented in [27]. The recognition accuracy of CNN continuously increases by increasing the convolutional layers and it reaches maximum 94.91% and 95.81% with 5 convolutional and 2 fully connected layers. After addition of 2 more convolution layers, the results drop to 92.35% and 93.28% respectively. At this stage, with increasing the number of images in training set, the recognition results get increased to 96.09%.

Deep learning model is presented in [28]. In this model after preprocessing the character image, the deep belief network is trained using Restricted Boltzmann Machines. RBM is unsupervised learning algorithm that can extract very distinguishable features for handwritten Devanagari characters, numerals, vowel modifiers, and compound characters. The network weights are then fine tune by back propagation algorithm to improve the recognition rate. Experimental results after fine tuning gives accuracy of (91.81%).

Table 1. Comparison of various recognition techniques based on various parameters

S. No	Work	Database used	Sample Size, Training Set, Test Set & Ratio, Class Size	Data Normalization Size	Feature Extraction	Classifier & Accuracy %
1	Nagender Aneja et. al. [22], (2019)	Acharya, Pant & Gyawali Database	92000 samples, 78200 training set, 13800 test set, (85:15), 46 classes	32x32 pixels,	The best features are generated by the network from raw data	DCNN 99%
2	B. Baranidharan et.al. [23], (2020)	Acharya, Pant & Gyawali Database	92000 samples, 78200 training set, 13800 test set, (85:15), 46 classes	32x32 pixels,	The best features are generated by the network from raw data	CNN 98.94%
3	Shalini Puri et. al. [5], (2019)	60 Document images	60 Documents image samples, (Ratio 60:40), 51 classes	-	Geometric based features	SVM 98.35%
4	Parul sahare et. al. [24], (2018)	CPAR Dongre & Mankar Proprietary database	83300 samples, 20305 samples, 350 samples, (Ratio 90:10), 59 classes	-	Fixed center distance, Fixed center cut, Neighbor-hood counts based feature	K-NN 98.26%
5	Mahesh Jangid et. al. [25], (2018)	ISIDCHAR V2DMDCHAR	36172 samples, 20305 samples,	64x64x 64	DCNN find the best features automati-cally	DCNN 98%

			(Ratio 70:30), 47 classes			
6	Anupama Thakur et. al. [26], (2019)	CPAR Dongre & Mankar Proprietary database	83300 samples, 20305 samples, 350 samples, (Ratio 90:10), 59 classes	-	Fixed center distance, Fixed center cut, Neighbor-hood counts based feature	Hybrid (KNN + ANN) 97.4%
7	Bappaditya Chakraborty et.al. [27], (2018)	Own Database Database1 Database2 and Database3	30408, 36172, 58451 samples respectively, (Training, validation and test set ratio 60:20:20), 49,47,49 classes	32x32	The best features are generated by the network from raw data	CNN 96.09%
8	S. Prabhanjan et.al. [28], (2017)	ISI Kolkota, CPAR, & Own dataset	45200 samples, 33900 training set, 11300 test set, (Ratio 75:25), 113 classes (includes all types of Characters)	30x40	RBM extracts meaningful features from the data	DBN 91.81%

5. Conclusion and Future Scope

This paper presents a comparison on handwritten Devanagari script recognizers based on various parameters as shown in Table 1. The study concludes that large number of resent research work is being done in this area using Deep learning and provides better results than traditional techniques. The survey also shows that Deep

learning using DCNN, achieved highest recognition rate of 99%. The forthcoming scope in this area is as follows:

- The system can be extended for character recognition / text detection in scene images.
- The proposed system can be extended to design a complete handwritten document recognizing system using Devanagari and Latin script.

References

1. Arica, N., Vural, F.Y.: An Overview of Character Recognition Focused on Off-line Handwriting. IEEE Transactions on Systems man and cybernetics 31(2), 216 – 233 (2001).
2. Kumar, M., Jindal, M.K., Sharma, R.K.: Review on OCR for Handwritten Indian Scripts Character Recognition. In: Nagamalai, D., Renault, E, Dhanushkodi, M. (Eds.): DPPR 2011, CCIS, vol. 205, pp. 268–276. Springer, Heidelberg 2011.
3. Bhunia, A.K., Roy, P.P., Mohta, A., Pal, U.: Cross-language framework for word recognition and spotting of indic. script. Pattern Recognition 79, 12-31 (2018).
4. Singh, P.K., Sarkar, R., Nasipuri, M.: Offline script identification from multilingual Indic-script documents: A State-of-the-art. Computer Science Review 15-16, 1-28 (2015).
5. Puri, S., Singh, S.P.: An efficient Devanagari character classification in printed and handwritten documents using SVM. In: Bundele, M., Dey, N., Madria, S.K. (eds.): International Conference on Pervasive Computing Advances and Applications 2019, Procedia Computer Science, vol. 152, pp. 111-121, Elsevier, (2019).
6. Gour, R, Chouhan, V.S.: Classifiers in Image processing. International Journal on Future Revolution in Computer Science & Communication Engineering 3(6), 22-24 (2017).
7. Sharma, P., Kaur, M.: Classification in Pattern Recognition: A Review. International Journal of Advance Research in Computer Science & Software Engineering 3(4), 298-306 (2013).
8. Mane, D.T., Kulkarni, U.V.: Visualizing and Understanding Customized Convolutional Neural Network for Recognition of Handwritten Marathi Numerals. In: Singh, V., Asari, V.K., Patel, R.B., Sidike, P. (eds.): International Conference on Computational Intelligence and Data Science, vol. 132, pp.1123-1137, Elsevier, (2018).
9. Sharma, R., Kaushik, B.N., Gondhi, N.K.: Devanagari and Gurmukhi Script Recognition in the Context of Machine Learning Classifiers: Mini Review. Journal of Artificial Intelligence 11(2), 65-70 (2018).
10. Kant, A.J., Vyavahare, A.J.: Devanagari OCR Using Projection Profile Segmentation Method. International Research Journal of Engineering and Technology (IRJET) 03(7), 132-134 (2016).
11. Garg, N.K., Kaur, L., Jindal, M.K.: Segmentation of Handwritten Hindi Text. International Journal of Computer Applications 01(4), 19-23 (2010).

12. Pal, U., Chaudhuri, B.B.: Indian script character recognition: a survey. Pattern Recognition 37(9), 1887-1899 (2004).
13. Bansal, V., Sinha RMK: Integrating knowledge sources in Devanagari text recognition system. IEEE Transactions on Systems, Man, and Cybernetics-Part A 30(4), 500-505 (2000).
14. Sithole, S., Jadhav, S.: Recognition of Handwritten Devanagari characters using Linear Discriminant Analysis. In: Second International Conference on Inventive Systems and Control, pp. 100-103, IEEE, Coimbatore, India (2018).
15. Jayadevan, R., Kolhe, S.R., Patil, P.M., Pal, U.: Offline recognition of Devanagari script: A survey. IEEE Transactions on Systems, Man, and Cybernetics-Part C 41(6), 782–796, (2011).
16. Indian, A., Bhatia, K.: A survey of offline handwritten Hindi character recognition. In: The Proceedings of Third International Conference on Advances in Computing Communication & Automation, pp. 1–6, IEEE, Dehradun, India (2017).
17. Holambe, A.K.N., Thool, R.C., Jagade, S.M.: A brief review and survey of feature extraction methods for Devnagari OCR. Ninth International Conference on ICT and Knowledge Engineering, pp. 99–104, IEEE, Bangkok, Thailand (2011).
18. Holambe, Thool: Comparative Study of devanagri handwritten & printed character & Numerals recognition using nearest neighbor classifiers. In: The Proceedings of 3rd International Conference on Computer Science and Information Technology, pp. 426-430, IEEE, Chengdu, China (2010).
19. Nene, A., Palkar, A., Nagarhalli, M., Misri, R., Kone, S.: Survey on handwritten devanagari character recognition. International Education & Research Journal [IERJ] 03(3), 45-46 (2017).
20. Hanmandalu, M., Murthy, O.V.R., Madasu, V.K.: Fuzzy Model based recognition of handwritten Hindi characters. In: The Proceedings of 9th Biennial Conference of the Australian Pattern Recognition Society on Digital Image Computing Techniques and Applications (DICTA), pp. 454-461, IEEE, Glenelg, Australia (2007).
21. Gaur, A., Yadav, S.: Handwritten Hindi character recognition using K-means clustering and SVM. In: The Proceedings of Fourth International Symposium on Emerging Trends and Technologies in Libraries and Information Services, pp. 65–70, IEEE, Noida, India (2015).
22. Aneja, N., Aneja, S.: Transfer Learning using CNN for Handwritten Devanagari Character Recognition. In: The Proceedings of 1st International Conference on Advances in Information Technology (ICAIT), pp. 293-296, IEEE, Chikmagalur, India (2019).
23. Baranidharana, B., Kandpal, A., Chakravorty, A.: Hindi Handwritten Character Recognition using CNN. International Journal of Advanced Science and Technology 29(06), 58-66 (2020).
24. Sahare, P., Dhok, S.B.: Multilingual character Segmentation and Recognition schemes for Indian document images. IEEE Trans. 06, 10603-10617 (2018).
25. Jangid, M., Shrivastava, S.: Handwritten Devanagari Character Recognition Using Layer-Wise Training of Deep Convolutional Neural Networks and Adaptive Gradient Methods. Journal of Imaging 4(2), 1-14 (2018).

26. Thakur, A., Kaur, A.: Devanagari Handwritten Character Recognition Using Neural Network. International Journal of Scientific & Technology Research 8(10), 1736-1744 (2019).
27. Chakraborty, B., Shaw, B., Aich, J., Bhattacharya, U., Parui, S.K.: Does Deeper Network Lead to Better Accuracy: A Case Study on Handwritten Devanagari Characters. In: The Proceedings of 13th IAPR International Workshop on Document Analysis and Systems, pp. 411-416, IEEE, Vienna, Austria (2018).
28. Prabhanjan, S., Dinesh, R.: Deep Learning Approach for Devanagari Script Recognition. International Journal of Image and Graphics 17(3), 1750016-1 - 1750016-20 (2017).