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Handwritten Marathi character recognition using R-HOG Feature

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Abstract

We use the Rectangle Histogram Oriented Gradient representation as the basis for extraction of features. These algorithms require a few simple arithmetic operations per image pixel which makes them suitable for real-time applications. Our dataset consists of 8000 samples each of 40 basic handwritten Marathi characters. Among these 10 samples of each character from different writers are collected. All sample images of handwritten Marathi characters are normalized to 20×20 pixel size. The description of the algorithm and experiment with our data set is presented in this paper. Experimental results using Support Vector Machines (SVM) and feed-forward Artificial Neural Network (FFANN) classification techniques are presented. Our results demonstrate high performance of these features when classified using feed-forward Artificial Neural network, classification.

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Keywords: HOG Feature; SVM Classifier; Character Recognition; Handwritten Marathi Character

1. Introduction

In digital computer machine simulation of human reading has become a serious research topic. The main advantages of such an effort was not only difficult for simulating human reading but also the probability of efficient application

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in which printed and handwritten character present on document has to be transferred into machine understandable format. Automatic character recognition of handwritten and printed information on documents like envelopes, cheques, application forms of various filed, and other manuscripts has a variety of practical and commercial applications in banks, post offices, libraries, and publishing houses [1, 13]. Optical character recognition (OCR) is a field of research in image processing, artificial inelegancy, pattern recognition and machine learning [17]. Optical character recognition is a mechanism to convert machine handwritten or printed document file into editable text format.

The OCR divides in two categories: off-line and on-line character recognition. Off-line character recognition further sub divided into two parts, handwritten and machine printed character recognition. In handwritten character recognition, there are lots of problem as compared to machine printed document because different peoples have different writing styles, the size of pen-tip and some people have skewness in their writing. All these challenges make the researchers to work towards the solution of the problem. India is a multi-lingual multi-script country and there are twenty two languages. Eleven scripts are used to write these languages. Devanagari script is an oldest one which is used to write many languages such as Hindi, Nepali, Marathi, Sindhi and Sanskrit. 300 million people use the Devanagari script for documentation in central and northern parts of India. A detailed survey report on various work conducted on recognition of Indian scripts is represented in [3].

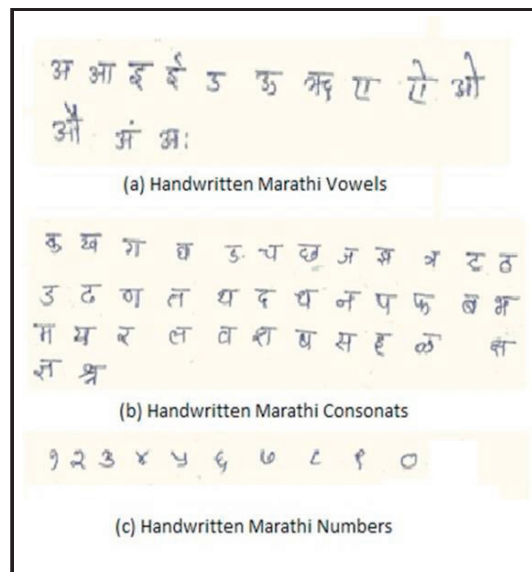


Fig. 1. Sample Handwritten Marathi characters

Devanagari script has a complex composition of its constituent symbols. This script (Marathi) has 13 vowels and 36 consonants as shown in the Figure 1. basic handwritten Marathi characters. Marathi basic character can be written as unique letters, by using a mixture of diacritical marks such as line, curve and circles which are written below, before, after or above the consonant. Sometimes more than consonants and vowels can combine to take new shapes, these combined new shape are known as compound characters. All the characters have at upper top side horizontal line known as Shirorekha. In constant handwriting of Marathi character, from left to right direction. The headline of one character joins with another words headline of the next or previous of the same word. In this case, multiple modified shape and character in a word appear as a single linked component joined through the common headline or Shirorekha. Also in Marathi character there are consonants, component characters and vowel modifiers, numerals, there are many similar fashioned characters[18].All these variations make the handwritten Marathi character recognition, more a challenging problem.

2. Related Work

In the survey of literature, we found that many researchers has done work to words the handwritten Devanagari characters (HDC). The research work on character recognition of Devanagari script was started in 1970, where Sinha R. K. and Mahabala [4] presented a syntactic pattern analysis system for the recognition of Devanagari character (DC). The first research on handwritten Devanagari character was published in Sethi I. K. and Chatterjee B. [5]. After that researchers started working on the recognition of handwritten Devanagari characters and tried to solve the problem associated with them. Zoning based approach for printed kannada numeral recognition was proposed by Ravinda Hegadi [6], in which the features such as the zones where the end points stretch out and the regions that each numeral generates were used to recognize the Kannada numerals.

A Support Vector Machine (SVM) k -NN based classifier using Zernike moment as features for recognition was proposed by kale et al. [7]. They normalized character image into 30×30 pixels images and divided them into zones. Zernike moment features were extracted from each zone. Wahi et. al. [8] used wavelet transform and Zernike moments based features Using Neural network classifier to recognize handwritten Tamil pattern recognition. In this work author used wavelet transform to reduce the image size and to maintain the accuracy and time needed for processing. The work proposed by Shelke and Apte [2] for handwritten Marathi compound characters work on wavelet features approach for recognition mechanism and uses neural network classifier. Chain code based approach for printed Bengali character Recognition was proposed by Sikadar et al. [9], in which the character features are classified into the small size of levels, high levels features was calculated based on pixel arrangement and thickness, while the lower levels features was calculated using a chain code technique.

Text line extraction for historical document images was proposed by Saabni et al. [10], in which they computed energy map of text image. Study and analysis of Devanagari handwritten character Recognition Techniques by Raman et al. [3] describes the current techniques and their status.

R. S. Hegadi and P.M. Kamble [1] proposed multi-layer feed-forward neural network based classification for recognition of Marathi handwritten numerals. In this experiment they segmented each handwritten Marathi numeral from the paper sheet and it is reshaped to 7×5 pixels using cubic interpolation. These resized numerals were converted into a vector with 35 values. These vector values were used as input to train the neural network. In another work by R. S. Hegadi [12] a multilayer feed-forward neural network is used for the classification of printed Kannada numerals. This work was carried out using all the existing fonts of printed Kannada numerals and this algorithm could recognize all the numerals. Handwritten Marathi basic character recognition using statistical method is proposed by Kamble P. M. and Hegadi R. S. [13]. In this work they calculated the eccentricity, orientation and mass of character feature, minimum distance was used for classification. SHI et al. [11] was proposed by character recognition from Natural Scenes using multi-scale graph-matching based kernel. In this experiment they propose multi scale graph- matching based kernel for scene character recognition. Here each image is represented by several graphs associated with multi scale image grids. They calculate best find match for each node in the graph and compute similarity kernel for SVM.

A template matching based approach was proposed by R. S. Hegadi [14] for the recognition of Kannada numerals. This method uses the correlation coefficient for matching the numeral. This method achieved an accuracy of 91 %. Azmi and Nasien [15] was proposed FCC to extract feature of English character and feed forward back propagation neural network based classification. Confidence-scoring post-processing for off-line handwritten character recognition verification was proposed by Pitrelli and Perrine [16]. In this they evaluated likelihood Rations scoring function and estimated posterior probabilities of correctness. Using the post-processor in conjunction with neural-net based recognizer on mixed case letters, they achieve 95% correct recognition and 8.7% false rejection.

3. Proposed Method

3.1. Dataset preparation and pre-processing

Equations Dataset is prepared from handwriting of different persons belonging to different age groups. In this work we only used basic 40 handwritten Marathi characters as shown in Figure 1. 10 samples of each Marathi character have been written by each person leading to 400 (10×40) Marathi handwritten characters in A4 size sheet. The characters are written in such way that they do not overlap. After that this sheet is scanned and saved as jpeg image. The main objectives of pre-processing are noise reduction, connect broken tiny character, edge detection, region

filling, normalization and segmentation. They are segmented using bounding box. The separated character are further cropped and then passed to normalization.

The cropped characters are in different sizes, because handwritten style of each writer is dissimilar. Normalization is applied on each character to bring all the character in uniform size. These are converted into binary images by choosing threshold value of 0.8. This process converts the image into two components, namely, the object component and background. The object component contains the characters and background contains the noise and other unwanted information. Handwritten character shows various undesirable effects like small unwanted strokes, gaps or breaks which occur due to binarization. Many times when a character is handwritten, it exhibits lesser width at the curvature than the other part of the character. This point is more likely to break during binarization. Hence a 3×3 averaging operator is implemented before binarization, which blurs the image resulting into bridging small gaps and retaining the actual shape of the character. It also removes pepper noise. The unwanted strokes occur more often between the pen lifting and placing points and their occurrence depend upon the writing style and the ink viscosity. These strokes may result into unwanted feature detection after binarization. This is done by using morphological opening operator. Morphological opening removes thin protrusions, breaks thin connections and smooth the object contour. Now these characters may be subjected to feature extraction stage.

3.2. Feature extraction

The feature extraction is an most important part of any recognition system. Transforming the input data into the set of features is called as feature extraction. When performing analysis of handwritten Marathi characters data one of the major problems is number of characters involved. The minimum number of features handwritten characters that are useful in identifying in pattern classes. Rectangle Histogram Oriented Gradient (R-HOG) is used to detect and extract feature of handwritten Marathi character. Gradient measures the direction and magnitude [17] of the maximum variation in intensity in a small zone of each pixel gradients are calculated using Sobel filter. The Sobel kernel used to calculate the horizontal (H) and vertical (H^T) components of the gradients are shown in Figure 2.

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

(a)

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

(b)

Fig. 2. Sobel Mask for gradient (a) Horizontal Component and (b) Vertical Component.

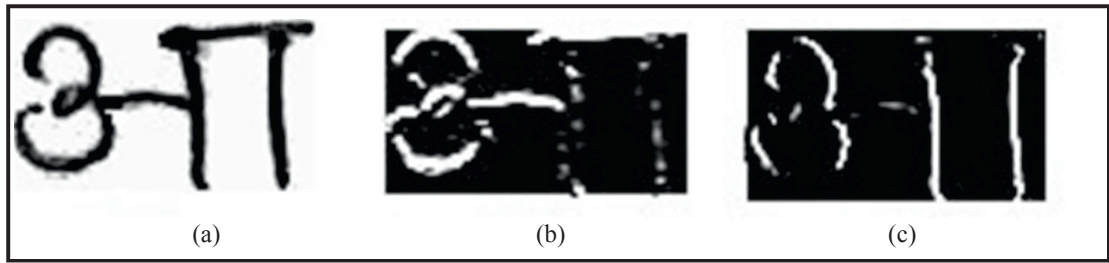


Fig. 3. a) Original Marathi handwritten character; b) Filtered image of the vertical Sobel Mask; c) Filtered image of the horizontal Sobel Mask.

Fig. 3 shows the Original handwritten Marathi Character \square_r and its components of gradients, calculated by using Sobel mask. Each pixel zone is convolved with these templates to determine these H and H^T components, G_x and G_y respectively.

$$G_x(x, y) = H * I(x, y) \text{ and } G_y(x, y) = H^T * I(x, y) \quad (1)$$

In the Equation (1) $I(x, y)$ is the cropped single character, H and H^T is the mask which calculate the gradient of G_x and G_y respectively. The gradient $G(x, y)$ of a character is given by

$$G(x, y) = \sqrt{(G_x^2(x, y) + G_y^2(x, y))} \quad (2)$$

Now, the orientation of gradient magnitude is computed as

$$\theta(x, y) = \tan^{-1} \frac{G_x(x, y)}{G_y(x, y)} \quad (3)$$

Bins of histogram of all blocks, denoted as bin_k , can be computed using the block size of character. Following Equation can be used to compute the feature HOG of each handwritten Marathi character.

$$\psi = \begin{cases} G(x, y), & \text{if } \theta(x, y) \in bin_k \\ 0, & \text{otherwise} \end{cases}$$

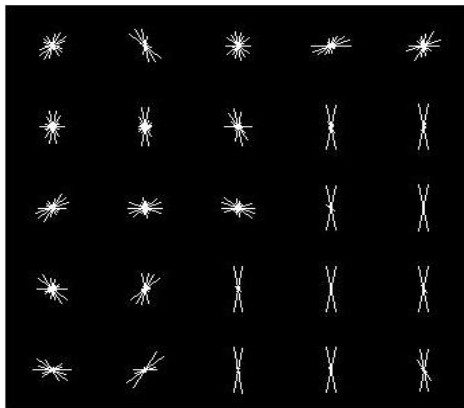


Fig. 4. Rectangle HOG of 4×4 block size of handwritten Marathi character ३१.

4. Classification

4.1. Support Vector Machine (SVM)

The main objective of character recognition system is to achieve robust performance to identification of character, given huge amount of training samples. With this concept as the SVMs capable of learning to achieve good generalization error-free recognition on these handwritten character datasets.

Without any prior knowledge of data, SVMs is helpful to achieve robust performance. The concept of an SVM resolve a classify the hyper plane with maximum margin between the two classes in the feature space, by navigating the input data onto a higher dimensional feature space, which are nonlinearly connected to the input space [3]. A maximal margin hyper plane of SMV in feature space is built with kernel function in gene space. Without any computations in the higher dimensional feature space by using kernel functions in the input space the optimal separating hyper plane can be calculated. We used in character classification Radial Basis Function kernels as given below:

$$K(x, y) = \exp\left(-\frac{\|xy\|^2}{2\sigma^2}\right) \tag{4}$$

A binary classification of handwritten Marathi character can be used in SVM elementary form. In handwritten Marathi characters there are multi class problems which resolved by using the one-against-one approach or one-against-the-rest approach [19]. In our experiment due to simplicity and quick performance of Linear Kernel is used in SVM. In linear SVM there is no choices for kernel parameter while it is essential to select the value for the soft margin (C) in prior. Then, given training data of handwritten Marathi character with feature vectors x_i is assigned to class $y_i \in \{-1, 1\}$ for $i = 1, 2, 3, \dots, n$, the support vector machines solve.

$$\text{minimize} = \frac{1}{2} \|\omega\|^2 + c \sum_{i=1}^n \xi_i, \text{ such that } y_i(k(\omega, x_i) + b) \geq 1; \xi_i \geq 0 \tag{5}$$

Where ω is a vector and ζ is a l -dimensional vector in the same feature space as the x_i . For given linear classifier, the values b and ω determine a hyper plane in the original feature space.

4.2. Feed Forward Artificial Neural Network (FFANN)

Each character extracted from the process described in above section will be converted into Rectangle Histogram Oriented Gradient (R-HOG). There will be 576 values in this HOG vector which will be input features for the neural

network based classification. A multilayer feed-forward neural network is used with 10 hidden layer for the classification purpose.

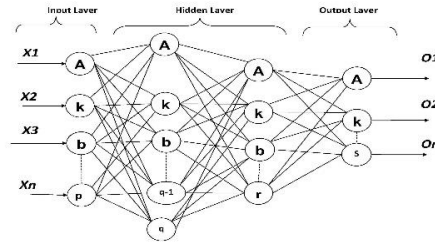


Fig. 5. Architecture of multilayer feed-forward neural network.

Typical multilayer feed-forward neural network architecture is shown Figure 5. MLPs are the most commonly found feed-forward networks. The MLPs shown in Figure 5 has three types of layer, namely input layer, hidden layer and output layer [1]. The neurons in input layer will buffer the signals $x_i = (1, 2, 3, \dots, n)$ for classification of these signals to neurons in the hidden layer. The input signals x_i , are summed up for every neuron j present in the hidden after weighting them by using strengths of the corresponding connections $\Delta\omega_j$ the input layer and derives its output y_j , as a summing function f , as shown in Figure 6.

$$y_i = f\left(\sum_{i=1}^n \omega_{ji} x_i\right) \tag{6}$$

Where f may be a simple function for threshold or a sigmoid, hyperbolic tangent or it may be a radial basis function. The output of neurons corresponding to the output layer may be computed in a simple way. The back propagation algorithm which is a gradient descent algorithm, is generally used MLP training algorithm. It results in change $\Delta\omega_j$, also known as weight of connection between neurons i and j as follow:

$$\Delta\omega_{ij} = \eta \delta_j x_i \tag{7}$$

Where η is learning rule parameters and the feature δ depends on neuron j , such as a hidden neuron or an input neuron. For the output neurons

$$\delta_j = \left(\frac{\partial f}{\partial net_j}\right) (y^{(t)}_j - y_j) \tag{8}$$

$$\delta_j = \left(\frac{\partial f}{\partial net_j}\right) \sum_q \omega_{jq} \delta_q \tag{9}$$

Where net_j in the Equation (8) is x_i total weighted sum of the input signals to the neurons j and $y_j^{(t)}$ is the for neurons j 's target output. Since hidden neurons do not have target output, as in Equation (9), the weighted sum replaces the difference among the target and actual output of the hidden neurons, j by the weighted sum by the δ_q . These terms were already obtained for neurons q which is connected to the output of j . In the process the δ will be computed for every neurons at every layer and updated weights are determined iteratively for every connection. The process of

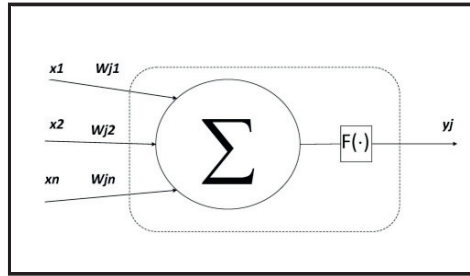


Fig. 6. Details of process in perception

updating the weights can occur after presentation of every training pattern, known as pattern based training. Once all the training patterns have been presented to the MLP, the training epoch completes. The network training process may be seeded up by adding a commonly adopted method known as "momentum" term as given in Equation (10), which effectively lets the change in the new weight due to change in previous weights.

$$\Delta w_{ij}(I + 1) = \eta \delta_j x_i \mu \Delta w_{ij}(I) \quad (10)$$

where $\Delta w_{ij}(I + 1)$ and $\Delta w_{ij}(I)$ are change in weight in epochs $(I+1)$ respectively, and μ is "momentum" coefficient.

5. Result and Discussion

In order to classify the handwritten Marathi character and evaluate the performance of the techniques, the experimentation is carried out using Matlab 8.0 tool. 200 set of 40 handwritten characters of Marathi language were used for this experimentation, out of which 4000 characters were used as training samples and 4000 characters as testing samples. From the training sets of each character R-HOG feature were obtained and value is computed for each character. Again these features were computed for each character from the 4000 characters testing samples and distance is computed between each of these character and the values obtained from training samples. Classification is carried out based on the feed-forward neural network and support vector machine. Table 1 shows the classification accuracies FAR, TAR and FRR. It can be noticed that the characters such as ढ, र and ष were classified with very high rate accuracy, where as our technique has performed very poor for the characters like ण, भ, व and ञ.

Table 1: The Classification accuracy of FAR, TAR and FRR of handwritten Marathi character.

Classification Method	FAR	FRR	TAR
FFANN	10.95%	8.14%	97.15%
SVM	15.95%	9.14%	95.64%

The performance of feed forward neural network is better as compared to the classification using Support Vector machine.

6. Conclusion and Future Work

This paper presents a system for handwritten Marathi character recognition. The system has been evaluated on a large amount of handwritten Marathi characters. From the results as shown in Table 1 it can be concluded that the use of R-HOG based feature extraction method and FFANN based classification will be more effective with increased processing speed and accuracy.

References

1. R. S. Hegadi and P. M. Kamble, "Recognition of marathi handwritten numerals using multi-layer feed-forward neural network," in *World Congress on Computing and Communication Technologies (WCCCT)*, IEEE, 2014, pp. 21–24.
2. S. Shelke and S. Apte, "Multistage handwritten marathi compound character recognition using neural networks," *Journal of Pattern Recognition Research*, Vol. 2, pp. 253–268, 2011.
3. Raman Nitin Kali and Gandhi Subham and Khurana Jitender "Study and analysis of Devanagari handwritten character recognition techniques," *International Journal of Science and Research*, vol.2, Issue 6, 2013.
4. Sinha R. K. and Mahabala, "Machine recognition of devnagari script," *IEEE System Man Cyber*, pp. 435–441, 1979.
5. Sethi I. K. and Chatterjee B., "Machine recognition of constrained hand printed Devnagari," *Pattern Recogniton*, Vol. 9, pp. 69–75, 1977.
6. R. S. Hegadi, "Recognition of printed Kannada numerals based on zoning method," *International Journal of Computer Application*, pp. 4–8, 2012.
7. K. V. Kale, P. D. Deshmukh, S. V. Chavan, M. M. Kazi, and Y. S. Rode, "Zernike moment feature extraction for handwritten devanagari (Marathi) compound character recognition," *International Journal of Advanced Research in Artificial Intelligence, Elsevier*, Vol. 3, no. 1, pp. 68–78, 2014.
8. A. Wahi, S. Sundaramurthy, and P. Ponnusamy, "A comparative study for handwritten tamil character recognition using wavelet transform and zernike moments," *International Journal of Open Information Technologies*, Vol. 2, no. 4, pp. 30–35, 2014.
9. A. Sikdar, S. Banerjee, P. Roy, S. Mukherjee, and M. Das, "Bengali printed character recognition using a feature based chain code method," *Advances in Image and Video Processing*, Vol. 2, no. 3, pp. 01–09, 2014.
10. R. Saabni, A. Asi, and J. El-Sana, "Text line extraction for historical document images," *Pattern Recognition Letters*, Vol. 35, pp. 23–33, 2014.
11. C. Z. Shi, C.-H. Wang, B.-H. Xiao, Y. Zhang, and S. Gao, "Multi-scale graph-matching based kernel for character recognition from natural scenes", *Acta Automatica Sinica*, Vol. 40, no. 4, pp. 751–756, 2014.
12. Ravindra S. Heagadi, "Classification of kannada numerals using multi-layer neural network," in *Proceedings of International Conference on Advances in Computing*, Springer, 2012, pp-963--968.
13. P. M. Kamble and R. S. Hegadi, "Handwritten marathi basic character recognition using statistical method," in *Emerging Research in Computing, Information, Communication and Applications. Elsevier 2014*, Vol. 3, 2014, pp. 28–33.
14. R. S. Hegadi, "Template matching approach for printed kannada numerals recognition," in *Computatinal Intelligence and Information Technology*. Springer, 2011, pp. 648–651.
15. A. N. Azmi and D. Nasien, "Feature vector of binary image using freeman chain code (FCC) representation based on structural classifier," *Int. J. Advance Soft Computer Application*. Vol.6, No.2, pp. 30--35, 2014.
16. J. F. Pitrelli and M. P. Perrone, "Confidence-scoring post- processing for off-line handwritten-character recognition verification," in *Seventh International Conference on Document Analysis and Recognition, IEEE*, 2003, pp. 278–282.
17. N. Dalal and B. Triggs, "Histograms of oriented gradients for human detection," in *IEEE Computer Society Conference on Computer Vision and Pattern Recognition, IEEE*, Vol. 1, 2005, pp. 886–893.
18. Vikas j Dongare and Vikas H. Mankar "A Review of Research on Devanagari character Recogniton", *International journal of Computer Application*, Vol. 2 No.14 pp. 8-15.
19. Sandhya Arora, Debotosh Bhattacharjee, Mita Nasipuri, M. Kundu and D. K.Basu, "Performance Comparison of SVM and ANN for handwritten devanagari character recognition", *Int. J. Comp. Science*, Vol. 7, Issue 3, 2010, pp. 18-22. Issue 3, May 2010. pp.18-22.