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Printed and Handwritten Character & Number Recognition of Devanagari Script using Gradient Features

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ABSTRACT
In this paper we are extracting feature of handwritten and ISM printed characters of devanagri script. we are extracting Gradient feature of the devanagari script ,for that we are using two operators i.e. Sobel and Robert operator respectively . Here we are computing gradient in 8,12,16,32 directions and getting different feature vectors respectively. We are using each directional vector separately for classification.

Keywords
Sobel , Robert, gradient, shirorekha,

INTRODUCTION
Handwritten recognition is a challenging task in pattern recognition. Researchers for the recognition of Indic Languages and scripts are comparatively less with other languages. A survey on the handwritten recognition has been carried by Plamondon et al [1], Koerich et al [2] and Arica et al [3]. A review on work done for the character recognition before 1990 is reported by Govindan et al [4].The detail survey about the work done for Indian languages script recognition is made by Pal et al [5]. The work on machine printed Devanagari has been made by Bansal et al [6], Pal et al [7] and Chaudhuri et al [8]. The work on handwritten Devanagari numeral is carried by Hanmandlu et al[9] and Bajaj et al[10]. Some models that have been implemented for the Hand written Character Recognition system are described in [11,12,13,14].A character recognition system consist of three main components, they are preprocessing, feature extraction and classification.

1. DEVANAGARI SCRIPT AND DATA COLLECTION
Devanagari is the script for Hindi, Sanskrit, Marathi, and Nepali languages. Devanagari script is a logical composition of its constituent symbols in two dimensions .It is an alphabetic script. Devanagari has 11 vowels and 33 simple consonants. Besides the consonants and the vowels, other constituent symbols in Devanagari are set of vowel modifiers called *matra* (placed to the left, right, above, or at the bottom of a character or *conjunct*), pure-consonant (also called half-letters) which when combined with other consonants yield conjuncts. A horizontal line called shirorekha (a header line) runs through the entire span of work[15]. Some illustrations are given in Figure 1.

अ	आ	इ	ई	उ	ऊ	ए	ऐ	ओ	औ	अं	अः
	ा	ि	ी	ु	ू	े	ै	ो	ौ	ं	ः
क	का	कि	की	कु	कू	के	कै	को	कौ	कं	कः
क	ख	ग	घ	ङ	च	छ	ज	झ	त्र	ट	ठ
ड	ढ	ण	त	थ	द	ध	।	प	फ	ब	भ
म	य	र	ल	व	श	ष	स	ह	ज्ञ		

Figure.1.Characters and matra for devnagari Script.

In the present work we have developed printed and handwritten database. For printed we have used different ISM office fonts. For handwritten we have collect data from people of different age groups and from different profession. We have visited primary school, secondary school, High school, Government offices, Adult Education Night school for collecting data. This data were scanned at 300 dpi using a HP flatbed scanner and stored as gray-level images. A few samples from this database are shown in Figure 2 .and Figure 3. The preprocessing steps performed in this work are steps for rectification of distorted images, improving the quality of images for ensuring better quality edges in the subsequent edge determination step and size normalization. Here we are using both database for our results.

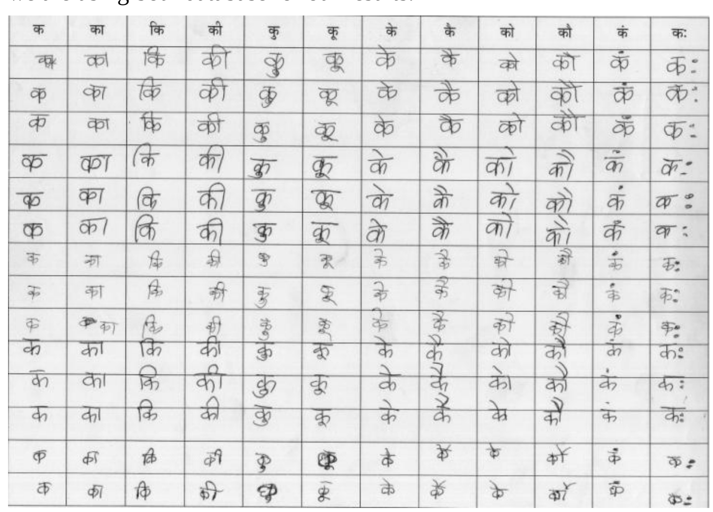


Figure.2. Data sheet for Devanagari Character

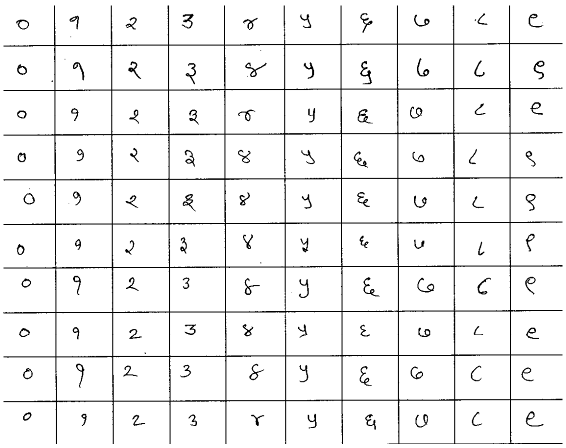


Figure.3. Data Sheet for Devanagri Numbers.

2. FEATURE EXTRACTION

Here we are extracting gradient feature by using Sobel and Robert operator.

The Sobel operator uses two templates to compute the gradient components in horizontal and vertical directions respectively[17]. The Templates are shown in Figure 4 and two gradient components at location (i, j) are calculated by:

$$g_v(i,j) = f(i-1,j+1) + 2f(i,j+1) + f(i+1,j+1) - f(i-1,j-1) - 2f(i,j-1) - f(i+1,j-1) \quad (1)$$

$$g_h(i,j) = f(i-1,j-1) + 2f(i-1,j) + f(i-1,j+1) - f(i+1,j-1) - 2f(i+1,j) - f(i+1,j+1) \quad (2)$$

The gradient strength and the direction are calculated as:

$$G(i,j) = \sqrt{g_v^2(i,j) + g_h^2(i,j)} \quad (3)$$

$$\theta = arc\tan\frac{g_v(i,j)}{g_h(i,j)} \quad (4)$$

The Roberts operator[17] templates are shown in Figure 5. The gradient components at location (i, f) are calculated by:

$$g_v(i,j) = f(i+1,j) - f(i,j+1) \quad (5)$$

$$g_h(i,j) = f(i+1,j+1) - f(i,j) \quad (6)$$

The gradient strength and the direction calculation are the same as eq. 3 and eq.4.

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

Vertical Template

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

Horizontal Template

Figure 4. Sobel Operator Template

-1	0
0	1

Horizontal Template

0	-1
1	0

Vertical Template

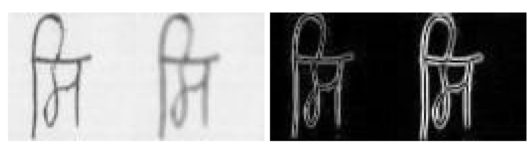
Figure 5. Roberts Operator Templates.

If the character image is binary. We convert it into pseudo grayscale. The boundary of the character is located and then gravity center size normalization is applied to obtain a normalized image of size 49x49. The grayscale of the output image is calculated via two dimensional linear interpolation. Now the normalized image is smoothed by 2x 2 and 3 X3 mean filters.

In order to extract, gradient feature we are using two operators separately i.e. Robert operator and Sobel operator, which forms two separate gradient vectors ,which are used to get gradient at each image pixel separately . Now we define L direction with an equal interval $2\Pi/L$ and decompose the gradient vector into its two nearest direction. We use the decomposition method proposed by Lin et. al [18],

In this way we obtain a L-dimensional gradient code. we divide the 49 X 49 normalized image equally into 15 x 15 sub blocks, with in each sub block the L dimensional gradient code are summed up and then the resolution of sub block is down sampled to 7x7 by a Gaussian filter, resulting in a ***d*** dimensional gradient feature where ***d*** = 7x7xL.

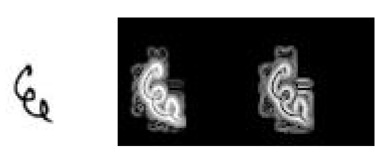
Here we will use L=8, 12, 16, 32 and calculate on both operators Sobel and Robert separately.



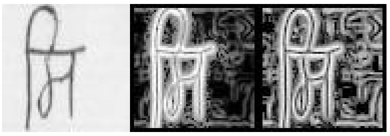
(a) (b) (c) (d)

(a1) (b1) (c1) (d1)

Figure.6.(a,a1)Original Image, (b,b1)Smoothed Image (c,c1)Robert operated ,(d,d1)Sobel operated



Original Robert Sobel



Original Robert Sobel

Figure.7.Example of Gradient Images.

3. SUPPORT VECTOR MACHINES

We are using SVM design algorithm for a problem.

Algorithm: suppose we are given a set of examples $(x_1, y_1),...,(x_1, y_1), x \in R^N, y_i \in \{-1,+1\}$. The functions of the form $\operatorname{sgn}((w.x)+b)$, in addition we impose the condition.

$$\inf_{i=1,...,l} |(w.x_i)+b| = 1. \quad (7)$$

We would like to find a decision function $f_{w,b}$ with the properties $f_{w,b}(x_i) = y_{i;}\ i = 1,...,l$. If this function exists, condition (7) implies.

$$y_1((w.x_1)+b) \geq 1, \quad i = 1,...,l. \quad (8)$$

To allow for possibilities of violating Equation 8, variables are introduced like

$$\varepsilon_i \geq o, \quad i = 1,...,1 \quad (9)$$

To get

$$y_1((w.x_i)+b) \geq 1 - \varepsilon_i, \ i = 1,...,l. \quad (10)$$

The support vector approach for minimizing the generalization error consists of the following:

Minimize : $$\Phi(w,\varepsilon) = (w.w) + c\sum_{i=1}^{l}\varepsilon_i \quad (11)$$

subject to the constraints (9) and (10)

It can be shown that minimizing the first term in equation 11, amounts to minimizing the VC-dimension, and minimizing the second term corresponds to minimizing the misclassification error [16].The solution gives rise to a decision function of the form:

$$f(x) = \operatorname{sgn}\left[\sum_{i=1}^{l} y_i\alpha_i(x.x_i)+b\right]. \quad (12)$$

Only a small fraction of the α_i coefficients are non-zero. The corresponding pairs of x_i entries are known as Support Vector's and they fully define the decision function.

4. RESULT AND OBSERVATION

Data used for the present work were collected from different individuals. We considered 5000 basic characters (vowels as well as consonants) and 1000 numerical samples of Devnagari for the experiment of the proposed work.we also formed printed database of ISM office fonts, in which we have used font size of 16 and different fonts.We have use sobel (3 X 3) and robert (2 X 2)operator separetely for L=***8,12,16,32 dimension*** for extracting gradient features respectively .we get by experiment ***d***=392,***d***=588,***d***=784,***d***=1568 differnet dimensional vectors, we are taking each individualy for our classification and get the following results on both datasets using SVM classifier.

Table 1. Result Using Sobel Operator Showing % of Accuracy

L=	8	12	16	32
Handwritten Dataset (Character)	94 %	94.76%	96%	97%
Handwritten Dataset (Numerals)	94.2%	94.44%	95%	96%
Printed ISM Dataset (Character)	98%	98%	98.45%	98.78%
Printed ISM Dataset (Numerals)	97%	97%	98.05%	98.0 %

Table2. Result Using Robert Operator Showing % of Accuracy

L=	8	12	16	32
Handwritten Dataset (Character)	94.45 %	95.06%	95.67%	96.09%
Handwritten Dataset (Numerals)	94%	96%	95%	97%
Printed ISM Dataset (Character)	97%	98%	98.02%	98.0%
Printed ISM Dataset (Numerals)	96%	95%	96.05%	97.0 %

5. CONCLUSION

The experimentation is carried out on our own dataset. We have two dataset i.e. Printed and handwritten. We get high accuracy in printed dataset then in handwritten. As the value of L-dimensional gradient code increases the accuracy also increases, here we are getting high accuracy in case of Sobel operator.

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