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Zone-Features' based Nearest Neighbor Classification of Images of Kannada Printed and Handwritten Vowel and Consonant Primitives By

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Abstract

The characters of any languages having scripts are formed by basic units called primitives.It is necessary to practice writing the primitives and their appropriate combinations while writing different characters. In order to automate character generation, primitives" recognition becomes important. In this paper, we propose a zone-features based nearest neighbor classification of Kannada printed and handwritten vowel and consonant primitives. The normalized character image is divided into 49 zones, each of size 4x4 pixels. The classifier based on nearest neighbor using Euclidean distances is deployed. Experiments are performed on images of printed and handwritten primitives of Kannada vowels and consonants. We have considered 9120 images of printed and 3800 images of handwritten 38 primitives. A K-fold cross validation method is used for computation of results. We have observed average recognition accuracies are in the range [90

Index terms— classification, feature extraction, K_Fold c r o s s validation, majority voting, nearest neighbor, printed primitives, handwritten primitives.

1 Introduction

atural language processing (NLP) is a field of computer science that deals with understanding and generation of natural languages. Natural language understanding enables computers to understand the natural language and extract meaning from it. Natural language generation involves both spoken and written information. Some applications of both text to speech and speech to text conversion are man-machine interfaces to computers, systems that read and understand printed and hand written text, speed understanding system, text analysis and understanding systems,computer aided instruction systems etc. Ediphones and Dictaphones are examples of speech to text conversion systems.

India is a multi lingual and multi script country with 22 scheduled languages. Every state has its lang-The alphabet of a language is divided into basic characters called vowels and consonants. Two or more basic characters are combined to form compound characters. We recall here the way we have learnt the alphabet and started writing the text in a language, in kindergarten schools, children are made to practice writing the characters and thereby memorize them. The character writing involves combining the primitives. Every character written from an alphabet follows a definite way and depends upon the type of the writer, whether left-hand-writer or right-handwriter. The character generation at once is different from how it is written. Each character in the alphabet has definite way of writing it and is combination of sub parts called primitives. This combination of primitives is a systematic approach in generating or building the characters. The character construction is basic to any medium of learning. While reading, we read the whole character and while writing or constructing a character, we write primitives in an order.

The automation of character construction requires the recognition of primitives from the database of primitives in a language. Many researchers have worked on character recognition, wherein the whole character is considered

as one single unit. The focus of the present work is to recognize the images of primitives of Kannada language useful in the construction of characters using syntactic approach. The work is useful for novice learners, multimedia applications, translateration and translation etc. The automated script writing and learning by taking technological leverage is considered a new area of research.

In this paper, we have considered the different font types and font sizes of vowels and consonants characters supported by Kannada language software, namely, Nudi and Baraha. We have identified with the help of language experts the primitives of vowels and consonants and manually separated and their images are stored. These images of primitives are preprocessed through binarization, thinning and resizing. The simple zone based features are obtained for these primitives. Nearest neighbor classification is adopted with Euclidean distance measure for recognition of primitives. We have tested for all the combinations of printed primitives with different fonts" types and sizes.

The remaining part of the paper is organized into four sections. Section 2 deals with detailed survey on automatic primitive recognition. Section 3 deals with the proposed methodology, wherein different stages of the methodology are discussed. The experimental results and discussion are given in section 4. Conclusion and Future work are given in Section 5.

2 II.

3 Literature Survey

To know the state-of-the-art in automatic primitive recognition, we carried out the literature survey and following isthe gist of cited papers.

[Leena R Ragha, et. al, 2010] have investigated the moments features on Kannada handwritten basic character set of 49 letters. Four directional images using Gabor wavelets from the dynamically preprocessed original images are found. Then moments features are extracted from them. The comparison of moments features of 4 directional images with original images when tested on Multi Layer Perceptron with Back Propagation Neural Network shows an average improvement of 13% from 72% to 85%. The mean performance of the system with these two features together obtained is 92%.

[**??**arthik Sheshadri et.al, 2010] have proposed Kannada Character Recognition method based on kmeans clustering. A segmentation technique to decompose each character into components from three base classes is used to reduce the magnitude of the problem. The k-Means clustering technique provides a natural degree of font independence and this is used to reduce the size of the training data set to about one-tenth of those used in related works. Accuracy comparisons with related work, shows that the proposed method yields a better peak accuracy. The relative merits of probabilistic and geometric seeding in k-means are also discussed.

[Leena R Ragha, et. al, 2011] have presented the use of moments features on Kannada Kagunita. Four directional images are found using Gabor wavelets from the dynamically preprocessed original image. The Kagunita set is analysed and the regions with vowel and consonant information are identified and cut from the preprocessed original image to form a set of cut images. Moments and statistical features are extracted from original images, directional images and cut images. These features are used for both vowel and consonant recognition using multi-layer perceptron with backpropagation learning. **??**Sangame S.K, et. al, 2011] have presented an unconstrained handwritten Kannada basic character recognition using invariant moments and chain code features. Invariant moments feature are extracted from zoned images and chain code. A Euclidean distance based K-NN classifier is used to classify the handwritten Kannada vowels. The method is invariant to size, slant, orientation and translation.

[B.V. **??**handra et. al, 2011] have proposed zone based features for recognition of the mixer of handwritten and printed Kannada digits. The kNN and SVM are used to classify the mixed handwritten and printed Kannadadigits. The reported recognition rates are 97.32% and 98.30% for mixed handwritten and printed Kannada digits using KNN and SVM classifiers respectively.

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Volume XIV Issue IV Version I The result is computed using five-fold cross validation. The mean performance of the recognition reported for the two shape based features together is 98.45% and 93.92%, for numeral characters and vowels, respectively. The mean recognition rate of 95% is obtained for both vowels and characters taken together.

[K S Prasanna Kumar et. al, 2012] have presented an algorithm to optical character recognition (OCR) for Kannada numerals. The segmentation of a numeral into four equal parts and one of these parts i.e., left bottom segment, is used to extract recognition features. A conflict resolution algorithm is proposed to resolve the conflicting features. A minimum number of features are extracted so as to improve the response time.

[Umapada Pal et. al, 2012] have given a stateof-the-art survey about the techniques available in the area of offline handwriting recognition (OHR) in Indian regional scripts. Various feature extraction and classification techniques associated with the offline handwriting recognition of the regional scripts are discussed in this survey. A separate section is dedicated to the observations made, future scope, and existing difficulties related to handwriting recognition in Indian regional scripts.

[Kauleshwar ??rasad, et.al, 2013] [G. G. ??ajput et.al, 2013] have proposed a zone based method for recognition of handwritten characters in Kannada language. The normalized character image is divided into 64 zones and each is of size 8x8 pixels. For each zone,from left to right and from top to bottom, the crack code, representing the line between the object pixel and the background (the crack), is generated by traversing it in anticlockwise direction. A feature vector of size 512 is obtained for each character. A multi-class SVM is used for the classification purpose. The data set has 24500 images with 500 samples of each character. Five-fold cross validation is used and yielded 87.24% recognition accuracy. [Swapnil A. Vaidya et. al, 2013] have given an overview of the ongoing research in OCR systems for Kannada scripts. They have provided a starting point for the researchers in the field of OCR. The state-of-the-art OCR techniques used in recognition of Kannada scripts, recognition accuracies and the resources available are discussedin fair detail.

[H. Imran Khan et. al, 2013] have proposed a chain code based feature extraction method for developing HCR system. A eight -neighborhood method is implemented, which allows generation of eight different codes for each character. These codes are used as features of the characters" images. These features are used for training and testing the k-Nearest Neighbor (KNN) classifier. ??Nithya E. et.al, 2013] have proposed an OCR system for complex printed Kannada characters. The input to the system is a scanned image of a page of text containing complex Kannada characters and the output is in a machine editable form. The pre-processing step converts the input document into binary form. The lines from the document image are extracted and further segmented into the lines, characters and sub characters. The histogram and connected component methods are used for segmentation and correlation is used for recognition of characters.

[Mamatha.H.R. et, al, 2013] have attempted to measure the performance of the classifier by testing with twodifferent datasets of different sizes. A framework based on the combined concepts of decision fusion and feature fusion for the isolated handwritten Kannada numerals classification is proposed. The combined approach has increased the recognition accuracy by 13.95%. are segmented and the result is displayed along with a vocal output. ??Sandhya.N et.al, 2014] have proposed a new classification method for Kannada characters, which is used as a preliminary step for recognition. An analysis of Kannada characters is carried out. The syntactic features are identified. At first, the basic features and their exact positions in the characters are identified and recorded. Further, by using a decision tree, the characters are classified. The experimental results show that the syntactic based method using basic features gives good contribution and reliability for Kannada character classification.

From the literature survey, it is observed that researchers have worked on Kannada character recognition. The feature extraction techniques such as template matching, Zernike moments, geometric moment invariants, directional, positional, Fourier transform, etc are used. The classification techniques such as, neural network, support vector machines, nearest neighbor, etc are used. No specific work is observed on recognition of Kannada language primitives in the light of character construction is cited in the literature [1][2][3][4][5][6][7][8][9][10][11][12][13][14][15][16][17][18]. This is the motivation for the present work on printed and handwritten Kannada language vowels and consonants primitives" recognition.

5 III.

6 Proposed Methodology

The proposed methodology consists of four major steps, namely, identifying the primitives in printed and handwritten Kannada vowels and consonants and obtaining their images, preprocessing of primitives" images, primitives" recognition and classification of primitives. The steps are shown in the Figure 1. This step consists of two tasks, namely, identifying primitives of printed as well as handwritten Kannada vowels and consonants and obtaining their images.

7 i. Identified Primitives

The Kannada language characters are classified into Swaras (vowels), Vyanjanas (consonants), Yogavaahakas (partly vowels and partly consonants), Kagunitha (combination of consonants and vowels) and Wothakshara (conjunct consonants) as given in Table ??. Kannada language script consists of more than 250 basic, modified and compound character shapes giving rise to 18511 distinct characters. We have used the word Kannada and Kannada language interchangeably in this paper. Kannada characters are curve shaped with some regions highly denser than others. Some shapes are wider and some are longer than others, as visible in Table1.

8 Table 1 : Kannada Vowels, Consonants and Sample Kagunitha

We have consulted the Kannada language experts and identified the primitives. These 38 primitives are categorized into basic primitives (BP) and character cum primitives (CcP) as shown in the Figure 2. A single primitive, which is also a complete vowel or complete consonant, is defined as Character cum Primitive. One or more basic primitives are joined at appropriate positions to form the given vowels and consonants. It is also observed that symmetry exists in most of the Kannada characters. Since there is no standard database available for Kannada primitives, we have created a database of primitives for printed and handwritten Kannada vowels and

consonants in consultation with language experts. We have identified 38 primitives to construct all the Kannada vowels and consonants and are given in Table 2. For example, the basic primitives required for constructing the two vowels (pronounced as "e") and (pronounced as "aou") are given in Box2. The "+" symbol represents the connection of primitives at appropriate positions for constructing a character. A We have preprocessed the images of the primitives to make them suitable for feature extraction. Preprocessing involves binarization, noise reduction, size normalization and thinning. The binarization is categorized into two main classes, namely, global and local. We have adopted global approach for converting gray scale image to binary image. Image binarization is performed using Otsu's method. The salt and pepper noise present in the image is removed by applying median filter. The process of thinning involves reducing thickness of each line of the pattern to just a single pixel wide is carried out. Size normalization is required as the size of the primitives vary from one vowel to another. In order to bring uniformity among the images of primitives, each image is normalized to the size of 28*28 after finding the bounding box of each image without disturbing the aspect ratio using bilinear standard transformation. The images of primitive obtained after applying all the preprocessing steps to a given sample primitive is shown in Box 3. A total of 49 features values are extracted from each primitive and this will serve as the feature vector. The feature vector for image (i) denoted by Fi = {z1, z2, z3 ? z49}, where zi denotes ith zone value. There could be some zones, which do not contain any part of the primitive at all; therefore the corresponding zone value in the feature vector is zero. The set of feature vectors obtained from the training samples is used as the Knowledge Base (KB). This knowledge base is used to recognize the test samples. We have used nearest neighbor classifier for recognition. Step 1. Accept and preprocess the input image to eliminate the noise using median filter and perform thinning.

Step 2. Fit the input image in a bounding box and crop the image to resize to 28*28 pixels.

Step 3. Extract 49 zone values, define feature vector and store.

Step 4 . Repeat steps 1 to 3 until the training images are exhausted.

Step 5. Accept the test sample.

Step 6. Compute Euclidean distance of the test sample with all the trained images.

Step 7. Declare the class of the primitive as the class with minimum distance using Nearest neighbor classification.

Step 8. Repeat steps 5 and 7 until test images are exhausted.

Step 9. Obtain the accuracy of classification.

9 Stop.

The accuracy of the classifier is evaluated through k-fold cross-validation method. In this method, each time one of the k subsets of images is used as the test set of images and the other (k-1) subsets are put IV.

10 Results and Discussion

In experimentation of the methodology, we have considered 60 font styles and 100 font sizes. The different combinations are tried and are as given in Table 3. We have totally five combinations of font styles and font sizes. The bit 0 indicates varying and 1 indicates constant. The experimentation is done on 9120 (38*240) images of printed Kannada vowel primitives. We have considered 240 images with varying font size and font styles for each primitive. The font size and font styles used are given in Table 4. The entire image set is partitioned into training set and test set and classified using K-fold cross validation method. An experiment is carried out for a total of 39 primitives out of which 14 are character cum primitives and 24 are basic primitives. The image data set has 1520 (38*40) images. For example, we have considered 40 images of font size 60 and font style -Nudi 0.1. The zones based features and nearest neighbor classifier have given 100% recognition accuracy for both the types of primitives. Table 5 gives the results obtained for Character cum Primitives and Table 6 gives the results obtained for Basic primitives. 4, are considered. The classifier is subjected to k-fold crossvalidation. We have considered 1520 primitive images in each validation step for training and 760 primitive images for testing. Table 7 and Table **??** give recognition accuracy for this combination of CcP and BP primitives using 3-fold cross validation method. The range of recognition accuracies obtained for both, character cum primitives and basic primitives are given in Table 15. 12 show the results for both varying font sizes and font styles using 5-fold cross validation using Euclidean distance. The recognition accuracy obtained for basic primitives and for character cum primitives is given in Table 15. An experiment is carried out on 3900 (39*100) images. We have considered100 images of 10 font styles and 10 varying sizes, for each font style, as given in Table 4, for each primitive. Table 13 and Table 14 show the results for both varying font sizes and font styles using 5-fold cross validation using Euclidean distance. The recognition accuracy obtained for basic primitives and for character cum primitives is given in Table 15. V.

11 Conclusion

We have proposed a zone features based methodology for recognition of both printed and handwritten 38 primitives of 49 Kannada vowels and consonants together. Zones of 4*4 and images of 28*28 are used. The nearest neighbor classifier is used with Euclidean distance measure. The accuracy of the classifier is verified with k-fold cross validation, for k = 2,3 and 5. We have experimented with four combinations of font sizes and font

styles for printed primitives and obtained average recognition accuracy in the range [89%, 94%]. Further, we have obtained accuracy in the range [90%, 94%]for handwritten primitives. This work is basic to automation of writing of Kannada kagunitha and wothakshara"s. [1]

Figure 1:

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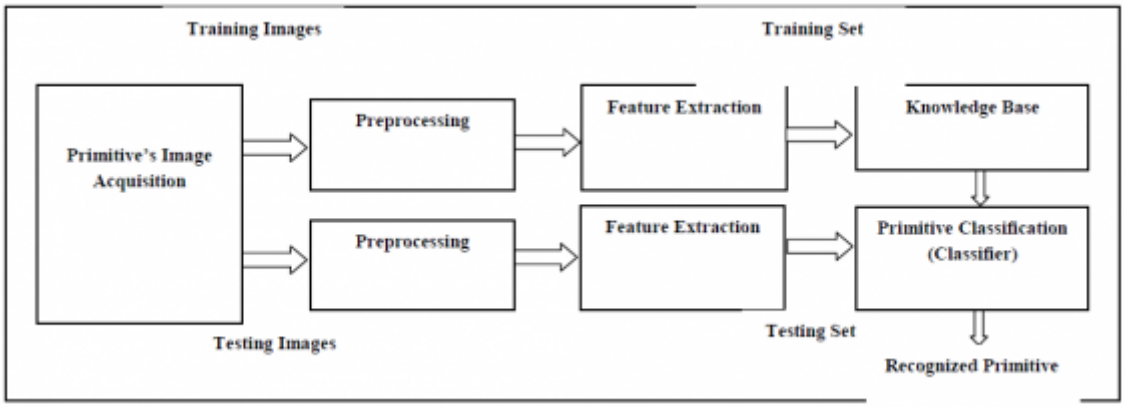
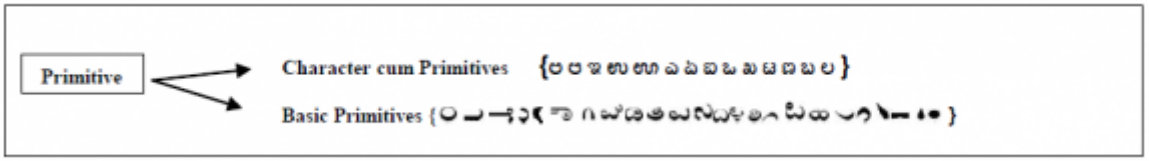
1

Figure 2: Figure 1 :



2

Figure 3: GlobalFigure 2 :



2

Figure 4: GlobalBox 2 :

3

Figure 5: Box 3 :

35 

Figure 6: Figure 3 :FFigure. 5 :

41 

Figure 7: 4 :Algorithm 1 :

Figure 8:

Figure 9: Firstly, a training

2

Figure 10: Table 2 :

3

Combinations	Font Size(S)	Font Styles(F)	Remarks
1.	0	0	Both Font Size and Font Style are Fixed
2.	0	1	Font Size is Fixed and Font Style is Varied
3.	1	0	Font Size is Varied and Font Style is Fixed
4.	1	1	Both Font Size and Font Style are Varied (Nonuniform mix)
5.	1	1	Both Font Size and Font Style are Varied (Uniform mix)

Figure 11: Table 3 :

4

Sl No	Font Size	Font Style
1.	12,14,16,??,110 (100 sizes)	Baraha 01
2.	12,14,16,??,110 (100 sizes)	Baraha 02
.....	12,14,16,??,110 (100 sizes)	?..
.....	12,14,16,??,110 (100 sizes)	Baraha 30
.....	12,14,16,??,110 (100 sizes)	Nudi 01
.....	12,14,16,??,110 (100 sizes)	?..
60.	12,14,16,??,110 (100 sizes)	Nudi 30
a) Both Font Size and Font Style Fixed		

Figure 12: Table 4 :

5

Year 2014 48 Volume XIV Issue IV Version I D D D D) F Global Journal of Computer Science and Technology (	Same Size and Same Font Primitive P1 P2 P3 P4 P5 P6 P7 P8 P9 P10 P11 P12 P13 P14 Average Image size=28*28 Zone=4*4 No of Samples=38*40=1520 Classification Accuracy (%) 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100

Figure 13: Table 5 :

6

Same Size and Same Font			
Image size=28*28 Zone=4*4 No of Samples=38*40=1520			
Primitive	Classification Accuracy(%)	Primitive	Classification Accuracy(%)
P15	100	P27	100
P16	100	P28	100
P17	100	P29	100
P18	100	P30	100
P19	100	P31	100
P20	100	P32	100
P21	100	P33	100
P22	100	P34	100
P23	100	P35	100
P24	100	P36	100
P25	100	P37	100
P26	100	P38	100
Average		100	

b) Font Size Fixed and Font Style Varied

An experiment is carried out for 2280 (38*60) images.

Figure 14: Table 6 :

7

3-Fold cross validation of CcP's 3_Fold Cross Validation

Same Size and Different Font using Euclidean Distance

Primitive P1 P2 P3 P4 P5 P6 P7 P8 P9 P10 P11 P12 P13 P14 Average Image size=28*28 Zone size=4*4 N

Same Size and Different Font using Euclidean Distance

Image size=28*28 Zone size=4*4 No of Samples=38*60=2280

Primitive	1_Fold	2_Fold	3_Fold
P15	75	80	85
P16	85	95	80
P17	100	100	100
P18	85	80	80
P19	80	60	60

Figure 15: Table 7 :

9

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4-Fold cross validation of CcP's 2_Fold Cross Validation Different Size and Same Font using Eu

Primitive P1 P2 P3 P4 P5 P6 P7 P8 P9 P10 P11 P12 P13 P14 Average	1_Fold 100 95 100 100 100 100 100 100 100 100 100 100 100 10

Different Size and Same Font using Euclidean Distance
Image size=28*28 Zone size=4*4 No of Samples=38*40=1520

Primitive	1_Fold	2_Fold	Average
P15	100	100	100
P16	100	100	100
P17	100	100	100
P18	100	100	100
P19	100	100	100

Figure 16: Table 9 :

12

5-Fold cross validation of BP's (Non -uniform mix) 5_Fold Cross Validation Different Size and Differe

Image size=28*28 Zone size=4*4 No of Samples=38*100=3800

Primitive	1_Fold	2_Fold	3_Fold	4_Fold	5_Fold
P15	100	100	100	100	90
P16	90	95	100	100	100
P17	100	100	100	100	100
P18	95	90	100	100	100
P19	90	90	95	100	80
P20	90	90	100	100	90

Figure 17: Table 12 :

13

5_Fold Cross Validation

Different Size and Different Font using Euclidean Distance

Image size=28*28 Zone size=4*4 No of Samples=38*100=3800

Primitive	1_Fold	2_Fold	3_Fold	4_Fold	5_Fold	Average
1	100	100	100	90	100	98
2	95	100	100	90	100	97
3	100	95	100	90	90	95
4	100	95	100	100	100	99
5	100	100	100	100	100	100
6	100	100	95	100	90	97
7	100	100	100	100	95	99
8	100	90	100	90	85	93
9	90	100	100	90	100	96
10	100	90	95	100	95	96
11	100	100	90	100	85	95
12	100	100	90	85	90	93
13	100	100	90	95	95	96
14	95	100	100	95	95	97
Average	98.571429	97.857143	97.142857	94.642857	94.285714	96.5

Figure 18: Table 13 :

14

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5-Fold cross validation of BP's(Uniform mix) 5_Fold Cross Validation Different Size a

Image size=28*28 Zone size=4*4 No of Samples=38*100=3800

Primitive	1_Fold	2_Fold	3_Fold	4_Fold	5_Fold
P15	95	85	70	75	60
P16	90	85	95	100	90
P17	100	90	95	100	95
P18	85	95	95	100	95
P19	80	95	100	100	100
P20	100	90	90	100	85

Figure 19: Table 14 :

15

Combinations	Printed Basic Primitives Euclidean Distance Range	Avg	Printed Character cum Primitives Euclidean Distance Range	Avg
Both Font Size and Font Style are Fixed	100%	100%	100%	100%
Font Size is Fixed and Font Style is Varied	25%–93%	76%	63%–98%	82%
Font Size is Varied and Font Style is Fixed	68%-100%	97%	98%-100%	99%
Both Font Size and Font Style are Varied(Non-uniform	38%-100%	90%	93%-100%	97%
Both Font Size and Font Style are Varied(Uniform mix)	44%-100%	88%	93%-100%	87%
Average		90%		93%
	Handwritten Basic Primitives Euclidean Distance		Handwritten Character cum Primitives Euclidean Distance	
Average	93%		94%	

Figure 20: Table 15 :

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