Isolated Handwritten Kannada Consonants Recognition using Discrete Curvelet Transform

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ABSTRACT
In this paper, an attempt is made to develop an algorithm for the recognition of handwritten Kannada consonants characters using Second Generation Discrete Curvelet Transform (DCTG2). Images are made noise free by using median filter and images are normalized into 64x64 pixels. Curvelet transform with different scales are applied to the input images to generate the curvelet coefficients. Then the Standard deviation are computed for the curvelet coefficients to form feature vector of size 20 and KNN classifier with two fold cross validation is used for the recognition of handwritten Kannada consonants. A sample of 200 images is collected for each of the 34 consonant characters amounting to 6800 sample images. The experiment is carried out for the proposed algorithm on 6800 samples collected. The average recognition accuracy of 92.56 % is obtained and compared with other existing system and found to be an efficient algorithm with respect to feature size. The proposed algorithm is independent of the thinning and skew of the characters.

Keywords
Kannada character Recognition, Curvelets, Standard deviation, KNN classifier.

1. INTRODUCTION
Handwritten Character Recognition is one of the important area of document image processing, since it provides a solution for document classifications, office automation, bank check reading, reading of the customer filled forms and many more . Advancement of e-technology has made the revolution on every field in general and document automation in particular. This revolution made to develop an OCR system for different languages and scripts for printed and hand printed documents to process automatically. Even though reasonably good OCR systems are available in the market for local and universal languages/scripts, the recognition rate drastically drops down for hand printed documents due to the variations in the writing styles of individuals at different times and different moods. Many researchers have developed the character and numeral recognition systems by using template matching, spatial features, Fourier and shape descriptors, Invariant moments, central moments, Zernike moments and modified invariant moments, structural / statistical, Zoning features and their combinations etc. Different pattern classifiers like neural networks, Hidden Markov model, Fuzzy and SVM classifier are used. Details of these methods can be found in [1]. Any recognition system of hand printed character must address the problem of unconstrained shapes, variation in writing style, intensity strokes, scale and orientations. To simplify the task, often unconstrained character recognition systems are designed [2]. Extensive work has been carried out to develop an OCR system for recognition of Indian languages. However, a negligible amount of work can be seen on Kannada character recognition system. This motivated to attempt the problem of hand printed Kannada character recognition as the initial step towards Kannada OCR system. In this paper an algorithm is designed based on second generation discrete curvelet transform for recognition of hand printed Kannada consonants.

2. LITERATURE REVIEW
For Kannada and English character recognition, Dhandra et al [3] have used zone based pixel density feature set of size 64 and achieved the 73.33% recognition accuracy for Kannada consonants using SVM classifier. Sanjeev Kunte et al. [4] have proposed an OCR system for the recognition of basic characters of printed Kannada text, which works for different font size and font style. Each image is characterized by using Hu's invariant and Zernike moments. They have achieved the recognition accuracy of 96.8% with Neural Network classifier. Dhandra et al.[5] have used Discrete Curvelet Transforms as feature vector for bilingual and Trilingual script (Kannada,English and telgu) Identification and reported 94.19%,95.24% recognition accuracy using Nearest Neighbor classifier. The features used in this algorithm are derived from the Discrete Curvelet Transform (DCVT), introduced by Candes and Donoho in [6]. Here the curvelet transform function is applied on the given image and the coefficients are obtained. The obtained coefficients are used as the feature vector for recognition of Kannada consonants. Dhandra et al. [7], have proposed modified invariant moments features for isolated printed multi font/size Kannada vowels and numerals recognition and reported 97.8% accuracy. Rajput et al. [8] have proposed Fourier descriptors and zone based chain code features of size 608 for handwritten Kannada numerals and vowels recognition and achieved the recognition accuracy of 98.45% and 93.92% respectively. Their accuracy is reasonably high but at the same time complexity of the algorithm is high due to large feature set. Hence, from the above it is clear that the algorithms designed for Kannada characters recognition suffers either from the recognition accuracy or from the time and space complexity. Hence, there is a need to develop an efficient algorithm to recognize the Kannada characters effectively with minimum number of features. The observation on characters reveals that the structures of Kannada characters are circles, holes and curvature in nature. This observation made us to use the second generation discrete curvelet transform features to recognize the hand printed isolated Kannada characters .As an initial effort the algorithm is designed for recognition of Kannada consonants.

Section 3 of this paper contains the data collection, pre-processing methods and proposed methodology. Section 4 is devoted for feature extraction method and designing of the

proposed algorithm for hand printed Kannada consonant character recognition system. The experimental results obtained are presented in Section 5. Comparative analysis is given in Section 6 and Conclusion is presented in Section 7.

3. DATA COLLECTION AND PREPROCESSING

It is observed that, the standard database for Kannada character is not available. Hence, the data collection is made and created the own database. Totally 6800 consonant images are collected from the varies professionals belonging to Primary Schools, High Schools and Colleges. These are scanned through a flat bed HP scanner at 300 dpi which usually yields a low noise and good quality document image. The consonants were cropped up manually and stored as gray scale images. Binarization of image is performed using Otsu's global thresholding method and is stored in bmp file format. The raw input of the digitizer typically contains noise due to erratic hand movements and inaccuracies in digitization of the actual input. The noise present in the image is removed by applying median filter. A minimum bounding box is then fitted to the consonant. To bring uniformity among the consonant the cropped consonant image is normalized to 64x64 pixels. A Sample image of the handwritten Kannada consonant is shown in Fig 1.

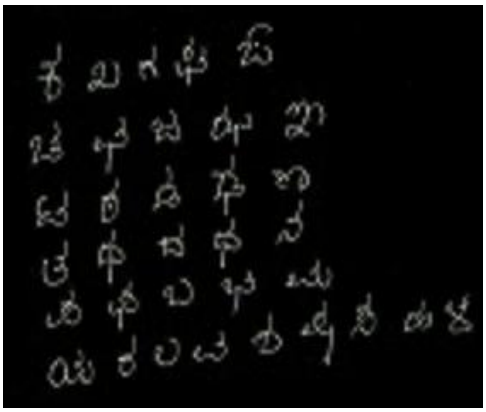

Fig. 1: Handwritten Kannada Consonants

3.1 PROPOSED METHODOLOGY

In this paper we exclusively focus on the Discrete Curvelet Transform with the Wrapping Technique. The input given to the Curvelet Transform based on wrapping of Fourier samples is a 2-D image in the form of a Cartesian array represented as $f[m, n]$ where $0 \le m < M$, $0 \le n < N$. The algorithm generates the output as number of curvelet coefficients which indexed by a scale j, an orientation l and two spatial location parameters (k1, *K2*). In order to obtain the curvelet texture descriptor, a number of statistical operations are applied to the coefficients generated as the output. The coefficients of the Discrete Curvelet Transform can be defined by the following equation (1)

$$C^{D}(j,l,k_1,k_2) = \sum_{\substack{0\le m<M \\ 0\le n<N}} [m,n]\emptyset^{D} j,l,k_1,k_2[m,n] \qquad (1)$$

Here, each $\emptyset^{D} j,l,k_1,k_2[m,n]$ is a digital curvelet waveform. If the frequency responses of curvelets at different scales and orientations are combined, a rectangular frequency tiling that covers the whole image in the spectral domain (Figure 2) is obtained. The curvelet spectra cover the entire frequency plane of the image. Thus there is no loss of information like in the case of Gabor filters.

Good results can be obtained if the Curvelet Algorithm is used with images which contain a large number of C^2 curves (i.e. an image which has a large number of long edges)

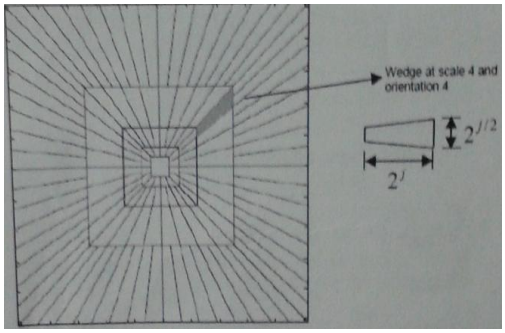

Fig 2: Rectangular frequency tilling of an image with 5 level curvelets

4. FEATURE EXTRACTION

The Kannada handwritten characters have curves and straight lines, so curvelet transform is designed to extract the features, since it allows edges and other singularities along the lines in a more efficient way than other transforms. Hence, in this paper, focus is made on the Discrete Curvelet Transform with the Wrapping Technique. For extracting the features, a wrapping based discrete curvelet transform is used and it can be found in by Candes and Donoho [9]. Curvelet coefficients have different scales and angles. Two parameters are involved in the implementation of curvelet transform: number of scales and number of angles at the coarsest level. Energy of these coefficients is different for different coefficients based on angles and scales. In the proposed method 64X64 image blocks is decomposed into four scales using real-valued curvelets. The number of second coarsest level angles used is 8. After the application of curvelet transform on the input image, one subband at the coarsest and one subband at the finest level of curvelet decompositions are obtained. Different subbands are obtained at each level for the other levels of curvelet decomposition.The number of wedges(subband) is $N_j = 4.2^{\lceil j/2 \rceil}$ at the scale 2^{-j} .When a scale is 1 ,2,3 and 4 then the number of wedges are 4 ,8,16 and 16 respectively. All the coefficients obtained cannot be used in the feature vector as it will increase the size of the feature vector drastically and also the time taken for feature vector formation. Hence, for extracting the potential features and also reducing the size of the feature vector for each sample, the standard deviation is obtained for the first half of the total subbands at each of the remaining scales except scale 1. Only the first half of the total subbands are considered, since curvelet angle at θ produces the same coefficients at the angle (θ+π) in the frequency domain. Hence, considering half of the total number of subbands at each scale reduces the total computation time for the feature vector formation without loss of the information contained in an image. For the finest and the coarsest subbands the standard deviation calculated is 20 used directly in the feature vector. The feature extraction and recognition process is given in Algorithm-4.1 & 4.2.

A. Training Phase

Algorithm-4.1: Feature Extraction Method

Input : Pre processed isolated Handwritten Kannada Consonant character image

Output : Feature library.

Start :

1. Preprocessed image 64X64 pixels
2. Apply Wrapping based discrete Curvelet Transform on the preprocessed image.
3. Different numbers of sub bands are obtained at each level for the other levels of the curvelet decomposition.
4. The scale of 2, 3, 4 and angular orientations 4 are used for 'wedges'. Obtain the curvelets coefficient for each wedge.
5. Compute standard deviations of the curvelet coefficients of the first half of the total subbands (except for scale=1), obtained in step 4 to get feature set of size 20.
6. Repeat the Steps 1 to 5 for all the training images.
7. Computed standard deviations of the curvelet coefficients of feature vector size 20, as the features stored in train library in the database.

End.

B. Testing Phase

Algorithm-4.2: Recognition of Handwritten Kannada Consonants

Input : Isolated test Consonant images.

Output : Recognition of the input Consonant.

Start:

1. Extract the features as obtained in Algorithm-4.1.

2. Store these feature vectors in test library database.

3. Compute the distance between the feature vector of the test image stored in the test library and with the feature vector of the trained image stored in the train library.

4. Obtain the minimum distance computed in the step 3. Recognize the consonant as the label of the train image corresponding to the minimum distances.

End.

5. EXPERIMENTAL RESULTS

The proposed algorithm is executed on a database of 6800 isolated handwritten Kannada consonants images, with 200 images representing each class/consonants. For measuring the performance of an algorithm all preprocessed images are normalized to varies size 40x40, 50x50, 60x60, 64x64, 80x80 and 90x90 sizes and experiment is carried out using wrapping based discrete curvelete transform on the preprocessed images. Optimum image size obtained is for 64x64. A total of 6800 character images of Kannada consonants characters are classified using KNN classifier. The performance of an algorithm is tested using 2-fold cross validation. The average recognition rate for Kannada consonants is 92.56 from the experiment. The classification results of consonants are presented in Table 1.

Table-1: Percentage of Recognition Accuracy for Handwritten Kannada Consonants with KNN Classifier.

Training samples=3400, Test samples=3400, Number of features=20			
Handwritten Kannada Consonants	**No. of sample Trained**	**No. of sample Tested**	**Percentage of Recognition Accuracy with KNN classifier**
	100	100	86
	100	100	100
	100	100	100
	100	100	88
	100	100	100
	100	100	92
	100	100	100
	100	100	94
	100	100	100
	100	100	100
	100	100	100
	100	100	84
	100	100	80
	100	100	92
	100	100	100
	100	100	100
	100	100	86
	100	100	92
	100	100	90
	100	100	95
	100	100	86
	100	100	99
	100	100	72
	100	100	86
	100	100	99
	100	100	98
	100	100	84
	100	100	98
	100	100	100
	100	100	99
	100	100	78
	100	100	91
	100	100	79
	100	100	99
Average Percentage of Recognition Accuracy			92.56

6. COMPARITIVE ANALYSIS

The Table-2 and Graph–1 shows comparative analysis of proposed method with other existing methods. From the comparative study it is seen that proposed method shows better recognition rate with less number of feature dimension compare to other existing methods.

7. CONCLUSION

An algorithm proposed here for recognition of handwritten Kannada consonants using Curvelet transform has exhibited the average percentage of recognition accuracy as 92.56% with KNN classifier with 2-fold cross validation. The proposed method is compared with other existing methods in terms of size of feature vector and recognition rate and is found to be very good. The proposed method has shown the encouraging results for recognition of Kannada consonants with less number of feature vectors. The novelty of the proposed method is free from thinning and skew images of characters. From the character set, it is clear that certain consonants are similar in shape which makes the recognition task difficult. .Hence to improve the recognition rates we are working by fine tuning the feature set and then using multilevel classification strategy to recognize the characters efficiently. The proposed method is to be extended by considering the entire character set as well as large database of handwritten character samples.

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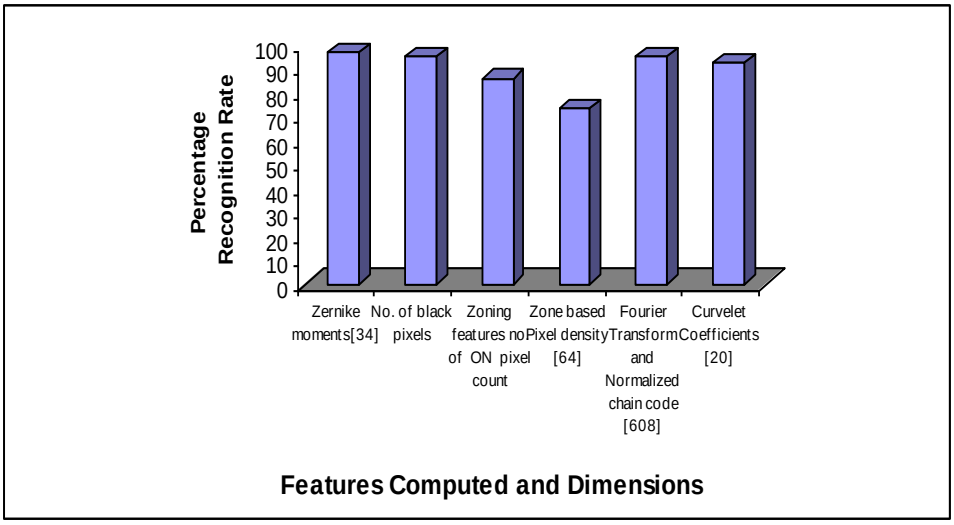
Table-2: Comparative Analysis of Handwritten Kannada consonants with Other Existing Methods.

Authors	Characters Considered	Features Computed & Dimensions	Classifier	Character Recognition Rate
R. Sanjeev Kunte et al [5]	All printed Characters	Zernike moments[34]	RBF neural network	96.8%
Karthik Sheshadri et al [19]	All printed Characters	No. of black pixels	K-Means	95%
T V Ashwin et al [21]	All printed Characters	Zoning features no. of ON pixel count	SVM	86.11%
B.V.Dhandra et al [2]	Handwritten Consonants [28 classes]	Zone based Pixel density [64]	SVM	73.33%
G.G.Rajput et al [14]	Handwritten vowels and numerals	Fourier Transform and Normalized chain code [608]	SVM	95%
Proposed system	Handwritten Consonants characters	Curvelet Coefficients [20]	KNN	92.56%



Graph – 1: Comparative Analysis of Handwritten Kannada consonants with Other Existing Methods.