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Recognition of Vowels using Curvature approach and Genetic algorithm based FLANN model

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Abstract— **There is numerous applications of handwritten character in digital world. Recognition of hand written character is a challenging problem due to a number of factors associated with it like variation in writing style, slant angle, noise in the images etc. The difficultness of the recognition system increases if such factors are associated with the character as compared to recognition system associated with constrained characters. This paper aims at development of a robust model for the recognition of handwritten characters. The three generic steps of character recognition: preprocessing, feature extraction and recognition are carried out in developing the model. In feature extraction curvature based approach is employed to extract features from the scanned characters. For recognition genetic algorithm (GA) based functional link artificial neural network (GA_FLANN) is used. The inputs of functional link artificial neural network (FLANN) are extended using trigonometric expansion and the weights of the FLANN model is optimized with GA. The proposed model is applied on the dataset consisting of 1440 numbers of Odia vowels. The result obtained is also compared with GA_FLANN models based on other expansions like power series (FLANN_P) Legendre polynomial (FLANN_L) and Chebyshev (FLANN_C). An accuracy of 89.58 % is achieved with the proposed model.**

Keywords— ***Recognition; Genetic Algorithm(GA), Curvature Approach; Principal Component Analysis; Functional Link Artificial Neural Network (FLANN).***

I. INTRODUCTION

Recognition of handwritten character has several applications in present digital world. Development of an efficient recognition system is more difficult if the character is unconstrained. The main problem with handwritten vowels recognition system is with the variation found in handwritten vowels. Variation in handwritten vowels is due to different writing styles, the context of the digit, Medias and devices used. The scanned image may be of different size, slant and strokes. So a sophisticated vowels recognition system is required for correct identification of handwritten characters. Character recognition system basically includes three steps: preprocessing, feature extraction and recognition as shown in Fig.1. The main objective of preprocessing phase is to enhance the quality of scanned image so that is can be handled easily without any complexity in subsequent phase. The second step extracts important features from the scanned image. The third step is used for recognition of characters using features obtained from the previous step. In this papercurvature based approach is used to extract important features from the character image and GA_FLANN model is used for recognition of Odia vowels where the weights of the FLANN model are optimized with GA.

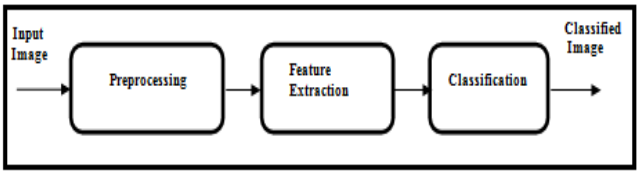

Fig.1. Basic steps of character recognition system

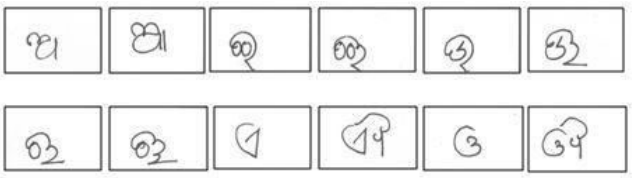

Fig. 2 Vowels of Odia Script

The paper is organized as follows: Literature review related character recognition, curvature approach and motivation is described in section II. Proposed model is described in section III. Basic concept of FFT is described in section IV followed by feature reduction in section V. Section VI describes recognition of vowels using GA_FLANN hybrid model. Section VII describes experimental results followed by conclusions .

I. Literature review

Extensive research work has been carried out in the field of character recognition. Some of the methodologies that has been carried out by different authors in the field of character recognition are as follows

In [1] the authors developed a GA–based feature selection algorithm where feature subsets are evaluated using index which measures statistical properties of the feature subset. The proposed model is applied on handwritten digits and handwritten letters. A

system is developed [2] using genetic algorithms (GA) and deep convolutional neural networks (CNN) for recognition of facial feature where the weights of CNN is optimized with GA. The proposed system is applied on UCF50 dataset. In [3] the authors employed a two-stage hybrid recognition system which combines statistical and structural recognition methods to recognize car number plate. GA is used for optimization problem. Ovunc Polat et.al [4] developed an approach for 3D object and Hand written recognition system using genetic algorithm and general regression neural network (GRNN). In [5] a hybrid model is proposed for constraint optimization problem using particle swarm optimization (PSO) and GA. From literature curvature approach [15-16] and FLANN [11-14] has been successfully used in many applications to solve non linear problem But there are very limited works on Odia vowel recognition system with curvature approach and GA based FLANN classifier. The proposed system aims to develop a robust model for recognition of Odia vowels using curvature approach and GA_FLANN model with trigonometric expansion. The proposed model is applied on the dataset consisting of 1440 number of vowels. Each sample of the dataset corresponds to one out of twelve classes.

PROPOSED SYSTEM

The proposed system includes all generic phases of character recognition. In the first step the images of the characters are normalized into 64x64 pixels size and the images are smoothened using median filtering. In the second step curvature based approach is used to extract important features important from the character images. The features of the extracted images are further reduced using PCA. In the third phase GA_FLANN classifier is used for recognition of vowels. The block diagram of the proposed system is shown in fig 3.

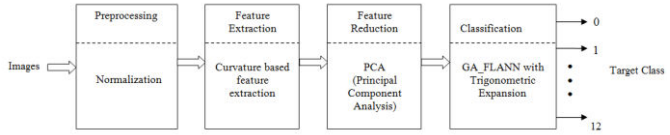

Fig.3. Block Diagram of proposed recognition system

I. FEATURE EXTRACTION AND REDUCTION

A. *Curvature based feature extraction*

The feature extraction process by using Curvature approach is based on bi quadratic interpolation method [15]. The calculation of curvature feature depends on the eight neighborhood pixels of a pixel. The neighborhood of a pixel u_0 and their corresponding pixel value f_k is shown in figure 4. F

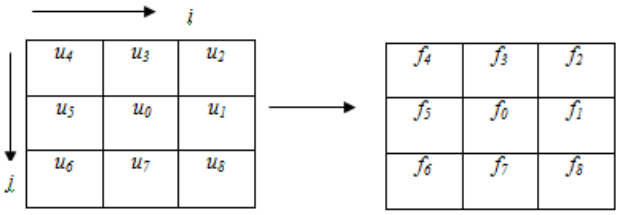

Fig. 4 Representation of pixel with neighborhood pixels.The curvature c at u_0 in a gray scale image [16] is defined as

$$c = -2(a_{01}^2 a_{02} - a_{01}a_{10}a_{11} + a_{01}^2 a_{02})/(a_{10}^2 + a_{01}^2)^{3/2} \quad (1)$$

Where

$$\begin{aligned} a_{10} &= (f_1 - f_5)/2) \\ a_{20} &= (f_1 + f_5 - 2f_0)/2) \\ a_{01} &= (f_3 - f_7)/2 \\ a_{02} &= (f_3 + f_7 - 2f_0)/2) \\ a_{11} &= (f_2 - f_8) - (f_4 - f_6)/4 \end{aligned} \quad (2)$$

B. *Feature Reduction using PCA*

Each image of the character consists of 2195 number of features. To reduce the computational complexity of the recognition system the features are further reduced from 2196 to 33 in numbers using PCA.

I. functional link artificial neural network (FLANN) model for RECOGITION

Functional link artificial neural network is a higher order neural network. It has only one neural element and link which makes it simpler than ANN. FLANN needs less number of iterations and computation in training phase. There are several applications of FLANN like classification, planning, system identification, intelligent pressure sensor, electric load forecasting, intelligent sensor, insecurity estimation etc. It can handle non-linear problems with less complexity. FLANN is a flat network with no hidden layer which makes the training algorithm less complex. In FLANN the dimension of input space is increased by extending the input vectors with a suitable enhanced representation of input vectors. The inputs of FLANN are functionally expanded in a nonlinear fashion such as trigonometric (FLLANN_T), power series (FLANN_P) Legendre polynomial (FLANN_L) or Chebyshev (FLANN_C) functional expansion [19]. The architecture of the FLANN model trigonometrically expanded to five terms is shown in

figure 3. The input z_i trigonometrically expanded into five terms is represented in FLANN as

$Z_i =$

$$[z_i \quad \sin(\pi z_i) \quad \cos(\pi z_i) \quad \sin(3\pi z_i) \quad \cos(3\pi z_i)] \tag{7}$$

where $0 \leq i \leq n$

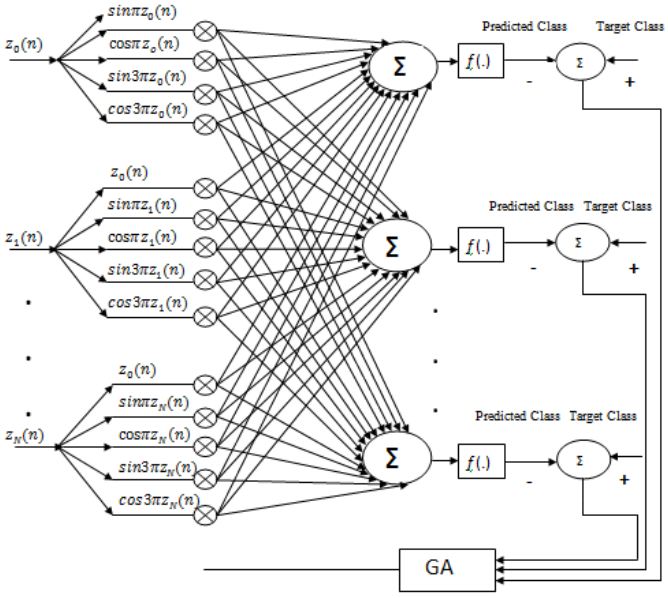

Fig. 5 A five input trigonometric expansion based

FLANN based genetics algorithm

The basic steps of FLANN based genetics algorithm is as follows

(a) At first the weights of the FLANN model is Initialised with random numbers ranging from -0.5 to +0.5. from a population of C chromosems. Each chromosome represets a weight sets of the FLANN model.

(b) Apply K numbers of input patterns to the FLANN model, each containing 33 features extracted from handwritten vowels. Expand each element of feature vector trigonometrically to five non linear values.

(c) Multiply the expanded inputs with the corresponding weghts to obtain partial sums. Add the partials sums to get feature vector with each element of the member of population and then the partial sums add together to determine the estimated outputs y_i as

$$y_i = \sum_{n=1}^{N} w_n x_n \tag{3}$$

(d) Compare the i th output of the model with the corresponding desired outputs and generate K errors. The i th error is given as

$$e_i(n) = d(n) - y_i(n) \tag{4}$$

(e) Calculate the fitness value in terms of the MSE (Mean Square Error). The MSE for a set of parameters corresponding to i^{th} member is determined by using (11).

$$MSE(i) = \frac{\sum_{k=1}^{K} {e_i}^2}{K} \tag{5}$$

Repeat the process for N times

(f) Minimize the MSE using GA

(g) Carryout the selection, crossover and mutation operation for GA to minimize the error and repeat the process till minimum MSE is reached which gives suitable set of weights for the GA_FLANN model.

Simulation and Experimental Results:

The proposed system is simulated using MATLAB. At fist the images of the vowels are normalized. Important features of the vowels are extracted using curvature approach and further reduced using PCA. The dataset is divided into two proportions. 90% of the dataset is used for training and 10% of the dataset is used for testing the proposed system. In recognition phase the inputs of the FLANN are functionally extended using trigonometric expansion. The weights of the FLANN model are initialized randomly and logsigmoid activation function is used to calculate the estimated output. The generated errors are then used to adjust the weights of the model using GA. 2000 number of iteration is used to reach the convergence level. The confusion matrices is obtained by taking average of ten independent run for training and testing dataset using hybrid GA_FLANN classifier for all class are shown in Table I and Table II respectively. Classification accuracy of each class is shown in table III for training and testing dataset. The result obtained using GA_FLANN based on trigonometric expansion is also compared with other expansion methods. Table IV shows the comparison of accuracy among the GA_FLANN based expansion models.

TABLE I. CONFUSION MATRIX OF TRAINING DATASET USING GA_FLANN CLASSIFIER

Class	class1	Class2	Class3	Class4	Class5	Class6	Class7	Class8	Class9	Class10	Class11	Class12
Class1	101	2	1	0	0	0	1	0	0	0	1	2
Class2	2	103	0	0	0	0	0	1	0	0	0	2
Class3	0	0	104	2	0	1	1	0	0	0	0	0
Class4	0	0	1	103	2	1	0	0	0	0	1	0
Class5	1	1	0	0	101	1	1	1	0	0	1	1
Class6	0	0	1	1	2	102	0	2	0	0	0	0
Class7	0	0	2	1	2	1	100	2	0	0	0	0
Class8	0	0	2	1	2	3	2	98	0	0	0	0
Class9	0	0	0	0	0	0	1	1	103	3	0	0
Class10	1	0	0	0	0	0	0	0	1	106	0	0
Class11	2	2	0	0	0	0	0	0	0	0	102	2
Class12	1	2	0	0	0	2	0	0	0	0	2	101

TABLE II. CONFUSION MATRIX OF TESTING DATASET USING GA_FLANN CLASSIFIER

Class	Class1	Class2	Class3	Class4	Class5	Class6	Class7	Class8	Class9	Class10	Class11	Class12
Class1	11	1	0	0	0	0	0	0	0	0	0	0
Class2	1	11	0	0	0	0	0	0	0	0	0	0
Class3	0	0	10	1	0	0	1	0	0	0	0	0
Class4	0	0	0	11	1	0	0	0	0	0	0	0
Class5	0	0	0	0	12	0	0	0	0	0	0	0
Class6	0	0	0	0	1	10	1	0	0	0	0	0
Class7	0	0	0	0	0	0	11	1	0	0	0	0
Class8	0	0	0	0	0	0	1	11	0	0	0	0
Class9	0	0	0	0	0	1	0	0	10	1	0	0
Class10	0	0	0	0	0	0	0	0	1	11	0	0
Class11	0	0	0	0	0	0	0	0	0	0	11	1
Class12	0	1	0	0	0	0	0	0	0	0	1	10

TABLE III. ACCURACY OF EACH CLASS USING GA_FLANN CLASSIFIER FOR TRAINING AND TESTING DATASET

Class	Training			Testing		
	Total Sample	Correct Class	Accuracy	Total Sample	Correct Class	Accuracy
Class1	108	101	0.94	12	11	0.92
Class2	108	103	0.95	12	11	0.92
Class3	108	104	0.96	12	10	0.83
Class4	108	103	0.94	12	11	0.92
Class5	108	101	0.94	12	12	100
Class6	108	102	0.94	12	10	0.83
Class7	108	100	0.93	12	11	0.92
Class8	108	98	0.91	12	11	0.92
Class9	108	103	0.95	12	10	0.83
Class10	108	106	0.98	12	11	0.92

Class11	108	102	0.94	12	11	0.92
Classs12	108	101	0.94	12	10	0.83
Total Accuracy			94.44%	Total Accuracy	89.58%	

TABLE IV. ACCURACY OF GA_FLANN WITH DIFFERENT EXPANSION

Sl .no	Classifier	Total Sample	Correct Class	Accuracy
1	GA_FLANN_T	144	134	89.58
2	GA_FLANN_P	144	126	88.23
3	GA_FLANN_L	144	119	85.40
	GA_FLANN_C	144	114	84.5

VII. CONCLUSION

An efficient recognition system is proposed in this paper using curvature approach and GA_FLANN based on trigonometric expansion. The proposed model is applied on Odia dataset consisting of 1440 number of vowels. Preprocessing is carried out to enhance the quality of the images of the vowels. Features are extracted and reduced using FFT and PCA respectively. FLANN classifier based on trigonometric expansion is applied on the reduced features. The weights of the GA_FLANN model are optimized with GA. A comparative study is carried out among the FLAN classifiers with different expansions. From the experimental result it is found that a combination of curvature approach and FLANN classifier with trigonometric expansion yields a better result as compared to other expansions. The accuracy is found to be 89.58% with the proposed model. Hence the proposed system can be effectively used for the recognition of handwritten Odia vowels.

CONCLUSIONREFENCES

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