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Recognition of Odia Vowels using Clonal Selection Algorithm Based FLANN Model

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***Abstract*— Recognition of handwritten character is still a challenging problem due to a number of variations found in writing style. This paper aims to develop a robust model for the recognition of handwritten character using functional link artificial neural network (FLANN) as classifier. The weights of the FLANN classifier are further optimized by using clonal selection algorithm (CSA) which is inspired by the clonal selection theory of acquired immunity. Discrete wavelet transform (DWT) is used to extract features from the handwritten characters and principal Component Analysis (PCA) is used to further reduce the number of features. The proposed model is applied on dataset containing 1200 samples of Odia handwritten vowels. recognition accuracy of 85.75% is achieved with the proposed model on test dataset.**

Keywords*— Handwritten character recognition; Discrete wavelet transform (DWT); Functional link artificial neural network (FLANN); Clonal Selection Algorithm (CSA)

I. INTRODUCTION

Two or more techniques can be integrated with an objective to overcome the weakness of one technique with the strength of other to produce optimum solution. In literature several research works have been reported using integration of two or more techniques. In this paper two techniques FLANN and CSA are integrated to build a robust model for the recognition of handwritten Odia vowels. CSA has been used in applications power forecast [1], brain MR image segmentation [2], hydro thermal scheduling[3], power generator maintenance [4], automatic clustering [5], virus detection [6], vehicle scheduling[7], construction site utilization planning [8], non-linear channel equalization[9]. DWT transform is used for the extraction of features from the images of the vowels.

Most of the reported works have used multilayer network and SVM as the classifier. But the complexity of the multilayer neural network is more when the number of input features grows on. Hence in this paper, functional link artificial neural network (FLANN), having single layer and single neuron is proposed for recognition of hand written Odia vowels. FLANN has been successfully applied in many applications like channel equalization [10][11],stock market prediction [12][13], detection of impulse noise in images [14] and classification of micro array data [15]. Generally FLANN is having its own updation rule, known as delta learning. In order to avoid the chances of falling to local minima problem, the weights of FLANN are optimized using real coded genetics algorithm (RCGA). Wavelet transform has been applied in applications like tumour tissue identification [19], character recognition [20],[24] license plate localization[21],[22] and analysis of protein sequence[23]. Being motivated by the results of WT, the features of Odia vowels are extracted using WT in this paper.

The paper is organized as follows: Section I presents introduction and related work on hybrid models for character recognition. Section II discusses the dataset, preprocessing, feature extraction and feature reduction step. Section III describes the recognition phase. Section IV shows the simulation study and experimental results. Conclusion and future scope of the research are discussed in section V and VI.

II. DATASET, PREPROCESSING AND FEATURE EXTRACTION

A. Dataset

The dataset used in this paper is taken from computer vision and pattern recognition centre of NIT Rourkela. The database contains 1200 samples of Odia handwritten vowels. All the samples of the database belong to twelve classes (1-12). Each vowel (1-12) appears 120 times in the database. 80% of the dataset are used for training and the rest are used for testing. Few samples of Odia vowels are shown in Fig.1.

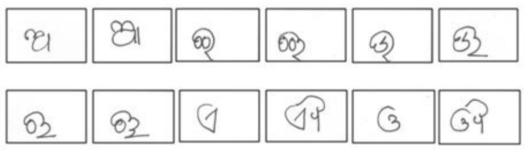

Fig.1. Samples of Odia handwritten vowels

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B. Preprocessing

Pre-processing is a series of operations which include background noise reduction, filtering, original image restoration etc which are performed on the input image. This step is carried out for improving the quality of the image before the application of other character recognition steps. In this paper first the data is normalized to a standard size of 64X64 pixels. Then the gray scale image of the data is generated by using Mean filtering method. The normalized images of the vowels are shown in Fig.2.

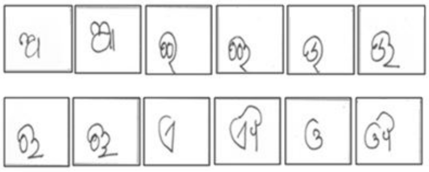

Fig.2. Image of Odia Vowels after normalization

C. Feature extraction by using discrete wavelet transform

Feature extraction is carried out to find important features to be used in the recognition phase. In this paper DWT based approach is used for feature extraction. In DWT, a time-scale representation of the digital signal is obtained using digital filtering techniques [16][17][18] and [19]. Due to the better energy compaction property of wavelet transform it provides substantial improvement in picture quality at high compression ratio. In DWT 1-D wavelet transform is applied along the rows of the image for obtaining 2-D DWT decomposition. The results obtained are then decomposed along the columns which split the given input image into four decomposed sub band images. The sub band images are represented as LL, LH, HL and HH frequency bands. 2-D DWT decomposes the image into two parts: approximation and detailed part. Approximation part contains a low frequency sub- band LL and detailed part contains three high frequency sub bands LH, HL and HH. The process is repeated to obtain multiple scale wavelet decomposition.

Any given signal can be decomposed by DWT into a set of basic functions called wavelets. It is realized from a single prototype wavelet ψ(t) by mother wavelet using dilations and shifting. DWT requires a two-dimensional scaling function, ϕ(u, v) and three two-dimensional wavelet functions, ψH(u,v), ψV(u,v), and ψD(u, v). They are represented as the products of two one-dimensional functions,

$$\phi(u,v) = \phi(u)\phi(v)$$
$$\psi H(u,v) = \psi(u)\phi(v)$$
$$\psi V(u,v) = \phi(u)\psi(v)$$
$$\psi D(u,v) = \psi(u)\psi(v) \quad (1)$$

where ϕ(·) is a one-dimensional scaling function and ψ(·) is a one dimensional wavelet function. These wavelets measure intensity functional variations along different directions. ψH measures variations along columns, ψV measures variations along rows and ψD measures variations along diagonals.

The two-dimensional discrete scale and translated basis functions are defined as

$$\phi_{j,m,n}(u,v) = 2^{j/2}\phi(2^j u - m, 2^j v - n \quad (2)$$
$$\psi^i_{j,m,n}(u,v) = 2^{j/2}\psi^i(2^j u - m, 2^j v - n), i \in \{H,V,D\} \quad (3)$$

Where j is a scale and m, n are the translation quantities. The transform of image f(u,v) of size M X N is expressed as

$$W_\phi(j_0,m,n) = \frac{1}{\sqrt{MN}}\sum_{u=0}^{M-1}\sum_{v=0}^{N-1} f(u,v)\phi_{j_0,m,n}(u,v), \quad (4)$$
$$W^i_\psi(j,m,n) = \frac{1}{\sqrt{MN}}\sum_{u=0}^{M-1}\sum_{v=0}^{N-1} f(u,v)\psi^i_{j,m,n}(u,v), i = \{H,V,D\}, \quad (5)$$

Where $W_\phi(j_0,m,n)$ represents approximation part of image f(u,v) and $W^i_\psi(j,m,n)$ represents horizontal, vertical and diagonal parts.

III. Classification

A) Functional Link Artificial Neural Network

Functional link artificial neural network is a higher order neural network (HON) [25][26][27][28] used for several applications like classification, planning, system identification, intelligent pressure sensor, electric load forecasting, intelligent sensor, insecurity estimation etc. In this paper FLANN is used for the classification task. FLANN has only one neural element and link which makes it simpler than multilayer artificial neural network (MLANN). FLANN needs less number of iterations and computation in training phase. It can handle non-linear problems with faster rate of convergence with less complexity. In FLANN the dimension of input space is increased by extending the input vectors with a suitable enhanced representation of input vectors. A single layer model based on trigonometric expansion is presented below

For the input pattern

$$Z = [z_0, z_1 \dots z_n] \quad (6)$$

The enhanced pattern using trigonometric function for z_i is represented as

$$Z_i = [z_i \ \sin(\pi z_i) \ \cos(\pi z_i) \ \sin(3\pi z_i) \ \cos(3\pi z_i)] \quad (7)$$

where $0 \le i \le n$

Fig. 3 shows the architecture of FLANN classifier. The extended inputs are multiplied by a set of weights calculated by using eq. (8). The outputs obtained are summed to produce the estimated output. The estimated outputs are compared with