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A Hybrid Neural Approach For Character Recognition System

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Abstract- **In this paper an attempt is made to develop English character recognition system. The paper describes the process of character recognition using the hybrid algorithm of Back Propagation and Genetic Algorithm for the recognition of uppercase alphabets. In the survey, it is found that back propagation is although an efficient technique for training multilayer feed forward network. But it suffers from scaling, local minima like problems. And also it is studied that Genetic Algorithm is good optimization technique. It is effective for global search of large, poorly understood spaces. The system is thrown through numbers of steps of character recognition system like preprocessing, segmentation and feature extraction. Distinctive features for each character are extracted. Those features are passed to hybrid algorithm of Back Propagation neural network and Genetic Algorithm. With the increasing growth of internet, also the demand of online information system has increased. There are various applications like in post offices; banks etc. where character recognition systems are used.**

Terms used: **Back propagation algorithm, Character recognition, Genetic algorithm, Hybrid.**

I. INTRODUCTION

The Recognition of characters is known to be one of the earliest applications of Artificial Neural Networks which partially emulate human thinking in the domain of artificial intelligence. Classical methods in pattern recognition do not as such suffice for the recognition of visual characters due to the reasons like, the 'same' characters differ in sizes, shapes and styles from person to person and even from time to time with the same person. There are no hard-and-fast rules that define the appearance of a visual character. Hence rules need to be heuristically deduced from samples [3]. The system was trained and evaluated with printed text, as well as several different forms of samples provided by giving input to the system. The need for character recognition software has increased much since the astounding growth of the Internet. With the Internet, the demand for online information has meant that what was once on paper is now desired in a digital format. Any pattern recognition system typically consists of a section which defines and extracts useful features from a pattern. Based on that features system is able to recognize the given input pattern. Depending on problems given, the number and variety of features differ according to the extracting methods and ways of representation.

In many practical applications, it is not unusual to encounter problems involving hundreds of features. One can think that every feature is meaningful for at least some of discriminations. However, it has been observed in practice that, beyond a certain point, the inclusion of additional features leads to worse rather than better performance and increase the processing time [11]. Thus the selection of features, i.e. keeping suitable features and omitting unnecessary or probably redundant ones, is a crucial step in a pattern recognition system design.

Character recognition can be divided into two major categories: typewritten and handwritten. As their names describe their natures, typewritten recognition recognizes a document that has been previously typed and scanned prior to recognition progress. Such a system would be used as a way to digitize books, documents and papers in libraries, government, or held by companies. In handwritten recognition, the system attempts to recognize a text that has been written by a human (not a machine) [8].

Advantages of character recognition are: reading postal address off envelopes, reading customer filled forms, archiving and retrieving text, digitizing libraries etc. Using OCR, the handwritten and machine written text could be stored into computers to generate databases of existing texts without using the keyboard. The modern version of OCR appeared in the middle of the 1940's with the development of the digital computers [7]. Since several character recognition systems for English were developed.

The various methods for character recognition have already been published [13] but the method presented here is advanced than those methods since English machine printed

data can be recognized with the help of a combination of artificial neural networks and genetic algorithm, this becomes the primary advantage of the method over other existing methods.

This paper is structured as follows: Section 2 contains the literature survey done for the approach. Section 3 presents a brief introduction of Character Recognition system. In Section 4 learning approaches Back Propagation and Genetic Algorithm are discussed. Section 5 has the details of proposed work. Section 6 includes the experiments carried out and the results. Finally, conclusion of the work in section 7.

II. RELATED WORK

Lot of work has been done in this field with the help of artificial neural network. ANN involves training of all characters. When unknown input given to the system ANN is able to find out the most probable character by generalization [17].Numerous techniques for character recognition have been investigated based on four general approaches of pattern recognition, as suggested by Rahuraj [14]: template matching, statistical techniques, structural techniques, and neural networks. Hidden Markov Model is a complete statistical model that tries to predict the unknown sequence. So it also tries to recognize the unknown character which is given as input [10, 9]. If the difference between unknown input and training data is large, the system may not behave well. Also the HMM model does not capture the correlations between letters [6].In earlier times, a template matching technique was used to recognize characters. In this technique patterns are just matched together as a human compare two structures with their exact features and characteristics matching. But problem in this method is that it provides no good way of doing normalization of characters. Although it is necessary to normalize the position and shape of pattern [18].

Alexander J. Faaborg proposed a technique to create an adaptive character recognition system using neural network. Back-Propagation neural Network with one hidden layer is used to create the system. System is trained and evaluated with printed and handwritten English alphabets. He showed in his experimental results that printed text gives better accuracy in recognition than handwritten characters, [1]. The back propagation algorithm changes the schematic of the perceptron by using a sigmoidal function. The advantage of the sigmoidal function is that the sigmoidal function is differentiable [19]. It works well on simple training problems. However, as the problem complexity increases (due to increased dimensionality and/or greater complexity of the data), the performance of back propagation falls off rapidly because of the fact that complex space have nearly global minima which are sparse among the local minima. Gradient search techniques tend to get trapped at local minima [5]. Also BPN suffers from the scaling problem. Neural networks with Back Propagation learning showed results by searching for various kinds of functions. However, the choice of the basic parameter (network topology, learning rate, initial weights) often already determines the success of the training process. The selection of these parameter follow in practical use rules of thumb, but their value is at most arguable [12].Since first attempts to combine GA and NN started in the late 1980s, other researchers have joined the movement and created a flood of journal articles, technical reports etc. A broad variety of problems have been investigated by different GANN approaches, such as face recognition [Hancock, 1991], animats [Maniezzo, 1994], classification of the normality of the thyroid gland [Schiffmann, 1993], color recipe prediction [Bishop, 1993] and many more. Also, a variety of different encoding strategies have been implemented [12].

Various techniques developed for character recognition but they do not involve any combination of artificial neural network and optimization technique such as Genetic Algorithm. An attempt is made to combine both back propagation and genetic algorithm for character recognition.

III. CHARACTER RECOGNITION

The Proposed character recognition system consists of 5 stages:

1. Data Collection
2. Preprocessing
3. Segmentation
4. Feature Extraction
5. Classification.

A typical OCR system consists of above stages given in Fig.1 and sometimes includes few extra stages. The recognition process starts with data collection stage. Data is collected in the form of images of different machine printed alphabets. Next in the preprocessing stage the data is converted into binary form. The images are noise free so no need to do extra preprocessing for removing noise. Segmentation is the most important part of OCR systems. This step involves localization of the limits of each character and to isolate them properly. In this the identification of the boundaries of the character and separating them for further processing. After segmentation a set of features are required for each character. In feature extraction stage each character is represented as a feature vector, which becomes its identity. This vector is used to distinguish the character from other characters. The features extracted from the images will be the inputs given to Genetic and Back Propagation algorithm for classification.

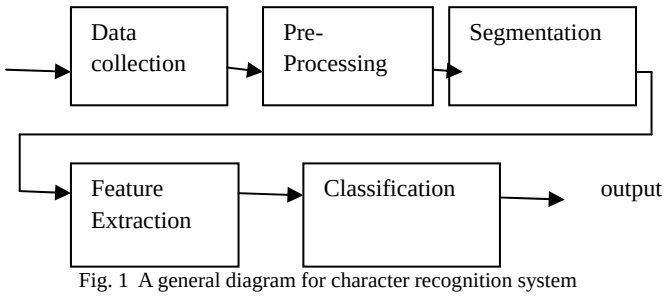

Fig. 1 A general diagram for character recognition system

IV. BACK PROPAGATION AND GENETIC ALGORITHM

One of the most important methods to train neural networks is Back Propagation Algorithm. It is a systematic method of training multilayer artificial neural networks. It is built on sound mathematical base. The back propagation is a gradient descent method in which gradient of the error is calculated with respect to the weights for a given input by propagating the error backwards from output layer to hidden layer and further to input layer. The error is calculated as:

$$E = \frac{1}{2} \sum (T_i - O_j)^2 \quad (1)$$

Where Tj is the target output and Oj is the output calculated by the network. This method adjusts the weights according to the error function. So, the combination of weights which minimizes the error function is considered to be a solution of the problem. As the gradient of the error function is to be calculated, it should be continuous and differentiable. Unlike perceptron where step function is used, the sigmoid function is used as an activation threshold for the network. Although Back propagation algorithm is an efficient technique applied to classification problems, system modeling, adaptive robotics control, but it does have some pitfalls. For one, BPN suffers from the scaling problem. It works well on simple training problems. However, as the problem complexity increases, the performance of back propagation falls off rapidly because of the fact that complex spaces have nearly global minima which are sparse among the local minima. Gradient search techniques tend to get trapped at local minima. When the nearly global minima are well hidden among the local minima, back propagation can end up bouncing between local minima without much overall improvement, thus making for very slow training [2].

Genetic Algorithms developed in 1970 by John Holland, are computerized search and optimization algorithm that mimic the principle of natural genetics and natural selection. Genetic algorithms are global search method. Genetic Algorithms perform directed random searches through a given set of alternatives to find the best alternative with respect to given criteria of fitness. Fitness is defined as a figure of merit which is to be either maximized or minimized. An initial population of chromosomes (set of strings) is taken to generate offspring (from fit parents) that competes for survival to make up the next generation of population. A genetic algorithm starts with a population (collection) of individuals, which evolves toward optimum solutions through the genetic operators (selection, crossover, mutation), inspired by biological processes [4]. Genetic algorithms offer a particularly attractive approach for this kind of problems since they are generally quite effective for rapid global search of large, nonlinear and poorly understood spaces. Moreover, genetic algorithms are very effective in solving large-scale problems [16]. As both learning techniques of artificial neural network have their own strengths and weaknesses.

So in the proposed work, integration of BP/GA learning method for a multilayer feed-forward network that blends the merits of both back propagation algorithm and genetic algorithm is given. It found an efficient algorithm for character recognition.

V. DESCRIPTION OF WORK

In this research work, character recognition of English alphabets will be done by training the system with the input data using Genetic algorithm and Back-propagation Neural Network. The neural network consists of 11 input neurons and 1 neuron in its output layer to identify the letter. The Neural network is 3 layered with Input layer, hidden layer and Output layer. The hidden layer consists of 6 neurons picked by experience and guess work. This number can also be increased if network has trouble in learning. The overall system consists of three steps. At the very outset some pre-processing are applied on the input image. Secondly character features are extracted, which will be taken as the input of the Back-propagation Neural Network (BPN) and Genetic Algorithm (GA) in the third step and classification is carried out by using BPN and GA [16]. With the help of this hybrid technique a system is developed which is helpful to recognize English characters by following the procedure of learning and training. In the proposed work the steps are followed as:

A. Data collection

The input data set is the machine printed English alphabets. Alphabets are in upper case. Data is in the form of images of different alphabets. Every isolated character image is in .jpg format. We take 10 sample of every character from A-Z for training the neural network and five samples are taken for testing. Every character is written in different style so that system is trained well by giving possible styles. The following are the some of the image samples of machine printed English characters:-

……

B. Preprocessing

Pre-processing aims to produce data that are easy for the OCR systems to operate accurately. It deals with technique for enhancing contrast; removing noise and isolating regions whose texture indicate a likelihood of character information. In preprocessing stage it is being normalized and removing all redundancy errors from the image and sends to next stage.

The following are main preprocessing steps:-

1) Firstly, that character is cropped i.e. extra pixels are removed from the character image.
2) Then, that RGB image is converted into Gray scale image.
3) After that, edges are finding out of that character.
4) Extra holes fill up from that character.
5) Bounding Boxes are made up of all characters. These boxes represent the area of whole character.

The following example represents the preprocessing steps of a character:-

(a&b) (c) (d&e)

Fig. 2 (a&b) Gray scale image& noise free image
(c) Highlighted edges
(d&e) Filled holes & bounded box

C. Segmentation

This step involves localization of the limits of each character and to isolate them properly. In this the identification of the boundaries of the character and separating them for further processing. With the segmentation we have the access of those values that are of our interest. In the segmentation process image is actually converted in the form of 0's and 1's. The pixel value is 1 where edge is found and 0 in the other positions. The segmented image is shown as follows:

Fig 3 Binary Image

D. Feature Extraction

After segmentation of character a set of features are required for each character. This step is heart of the system. In feature extraction stage each character is represented as a feature vector, which becomes its identity. This vector is used to distinguish the character from other characters. This step helps in classifying the characters based on their features. In fact, the main problem in character recognition system is the large variation in shapes within a class of character. This variation depends on font styles, document noise, photometric effect, document skew and poor image quality. The large variation in shapes makes it difficult to determine the number of features that are convenient prior to model building. Various shape based and boundary based features are taken from individual character. The various Moment based features like total Centroid, Eccentricity, Orientation, Kurtosis, Mean and Skewness are calculated from the character images:

1) Eccentricity

The eccentricity is the ratio of the distance between the foci of the ellipse and its major axis length.

2) Orientation

The angle between the *x*-axis and the major axis of the ellipse that has the same second-moments as the region.

3) Skewness

Skewness is a measure of the asymmetry of the data around the sample mean.

$$Y=E(x-\mu)^3)/\sigma^3 \qquad (2)$$

4) Kurtosis

Kurtosis is a measure of how outlier-prone a distribution is.

$$K=E(x-\mu)^4/\sigma^4 \qquad (3)$$

5) Centroid

Specifies the center of mass of the region

6) Mean and median

Mean is defined as the minimum and maximum gray level values. And median is the number of pixels with values above and below mean.

The features extracted from the images will be the inputs given to Genetic and Back Propagation algorithm. We will train the network based on these features and after training test them whether they should be properly recognized by the designed system or not.

E. Hybrid Algorithm

The hybrid algorithm of Back Propagation and Genetic algorithm will be designed to train and test the network. The algorithm follows the steps:

1) Coding

First the initial values are to be in some type of coding. Real number coding system is adopted in this work. This network is of configuration l-m-n.

Number of weights calculated as= ((l+n)*m)

2) Weight extraction

To determine the fitness value for each chromosome we extract weights from each of chromosome.

$$w_k = +x_{kd+2}10^{d-2} + x_{kd+3}10^{d-3} + ... + x_{(k+1)d} \;/10^{d-2}$$

$$if\ 5 <= x_{kd+1} <= 9 \qquad (4)$$

$$w_k = -x_{kd+2}10^{d-2} + x_{kd+3}10^{d-3} + ... + x_{(k+1)d} \;/10^{d-2}$$

$$if\ 0 <= x_{kd+1} <= 5 \qquad (5)$$

3) Fitness

The fitness function must be devised for each problem to be solved. First errors are calculated as:

$$E_1 = (T_{ij} - O_{ij})^2 + (T_{ij} - O_{ij})^2 \qquad (6)$$

$$E = \sqrt{(E_1 + E_2 + ... + E_n)} \;/n \qquad (7)$$

$$F = \frac{1}{E} \qquad (8)$$

4) Reproduction

In this step formation of mating pool is done. Mating pool is formed by excluding that chromosome with least fitness

value and replacing it with a duplicate copy of the chromosome reporting the highest fitness value. The three different operators of genetic algorithm are applied to update the population in the reproduction.

- Selection
- Crossover
- Mutation

5) Convergence

A population is said to be converged when 95% of individuals constituting the population share same fitness value.

The final outputs given by the algorithm are the final weights to be adjusted for the neural network. So in this hybrid approach we calculate fitness function using Genetic approach instead of weights as in Back propagation algorithm.

VI. EXPERIMENTAL RESULTS

In order to check the working of the algorithm, we developed the algorithm in MATLAB tool kit. The different images of characters in gray scale are collected and the basic steps of character recognition system are followed. In the feature extraction step 5 types of images are taken for 'A' character:

Fig. 4 Five images of A alphabet

The features extracted for A are:

[0.0083 0.0355 0 0.0123 0.0796 0.1310 0.0999 1.0000
0.1441 0.6659 0.0062;
0.0318 0.0318 0.0322 0.0449 0 0.1922 0.1509 1.0000
0.1848 0.6734 0.0382;
0.1000 0.1000 0.0998 0.1101 0 0.2292 0.1859 1.0000
0.2289 0.5666 0.1060;
0 0 0.0004 0.0149 0.7312 0.1662 0.1095 1.0000 0.1612
0.8770 0.0067;
0 0.0397 0.0001 0.0090 0.0194 0.1011 0.0717 1.0000
0.1273 0.4935 0.0070]

The extracted features are given as input to the system. Similarly the features of other characters from A-Z are extracted and given to system for training. The testing phase was to check the efficiency of the system to recognize the letters correctly. Using the proposed system, we could be able to recognize/classify approximately 512 out of 562 letters and efficiency of 91.1% is achieved.

TABLE 1

RESULT OBTAINED

Technique Used	**Total No. of character In Database**	**No. of Training character**	**No. of Testing character**	**Performance**
Back propagation hybrid with Genetic algorithm	1,083	562	512	91.1%

The following error vs. iteration graph is obtained after training the neural network by giving appropriate features of various alphabets.

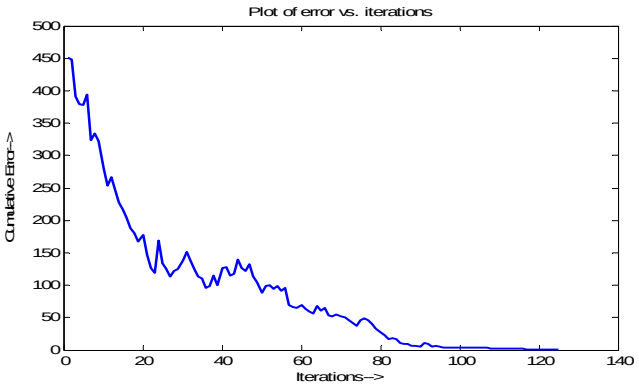

Fig. 5 The cumulative error values corresponding to iterations.

VII. CONCLUSION

We can conclude that we reached the computer to the human's brain by the importance use of isolated character recognition for different applications. This recognition starts with acquiring the image to be preprocessed throw a number of steps. The paper represents a new method of character recognition using hybrid technique of back propagation and genetic algorithm. On programming and testing the system offers good efficiency as compared to back propagation algorithm. In a final conclusion, neural network seems to be better than other techniques used for recognition. The future work will be considered by extending the system for other languages also.

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