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Adaptive Neuro Fuzzy Inference System based Optical Character Recognition

Sandhya Balakrishnan P K[1], Dr.L.Pavithira[2]

[1]Research Scholar, Department of Computer Science,
CMS College of Science and Commerce, Coimbatore.
[2]Associate Professor, Department of Computer Science,
CMS College of Science and Commerce, Coimbatore.

ABSTRACT

Optical character recognition (OCR) is becoming a powerful tool in the field of Character Recognition, now a days. In the existing globalized environment, OCR can play a vital role in different application fields. Basically, OCR technique converts images into editable format. This technique converts images in the form of documents such as we can edit, modify and store data more safely for long time. We need to train our classifier in case we are considering using data mining techniques for such purposes. There are several established generic classification techniques that can be used together with feature extraction mechanisms but it is important to know which of them do better under which circumstances. This paper describes the application of adaptive neuro-fuzzy inference system (ANFIS) model for classification of machine printed characters. Decision making was performed in two stages: feature extraction using the zoning technique and the ANFIS trained with the backpropagation gradient descent method in combination with the least squares method. To improve diagnostic accuracy, the sixth ANFIS classifier (combining ANFIS) was trained using the outputs of the five ANFIS classifiers as input data. The proposed ANFIS model combined the neural network adaptive capabilities and the fuzzy logic qualitative approach. Some conclusions concerning the saliency of features on classification were obtained through analysis of the ANFIS. The performance of the ANFIS model was evaluated in terms of training performance and classification accuracies and the results confirmed that the proposed ANFIS model has potential in classifying the machine printed characters.

Keywords: Adaptive Neuro-Fuzzy Inference System, ANFIS, Zoning.

I INTRODUCTION

Now a days, globalization is reaching to a great level. In this globalized environment, character recognition techniques also getting a valuable demand in number of application areas. OCR is an effective technique which converts image into suitable format such that data can be edit, modify and stored. This technique performs several operations such as, scans the input image, processes over the scanned image thereby image gets converted into portable formats .For instance, the hard copy of old historical books, novels, etc.. cannot be stored safely for a long time. Rather, its safety has limitations. If we apply OCR technique

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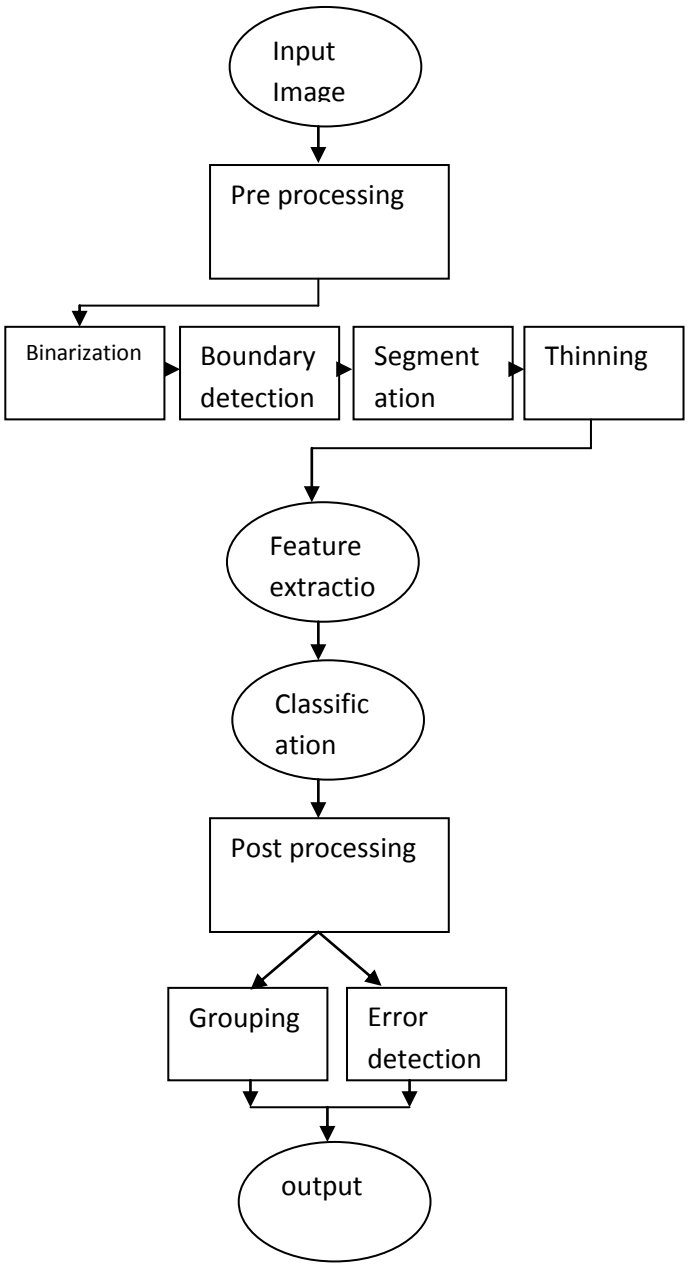

Fig 1. Stages of the OCR system

for such cases, the different historical documents can be stored, modified for a long time. OCR also having variety of applications in almost all fields, including security. OCR implementation helps us to edit, store and process over the scanned data more effectively. User can handle the stored data whenever he wants with the internet support. So Optical character recognition is most successful application used in pattern recognition. A typical OCR system consists of the following basic components: Pre-processing, Feature Extraction, Classification and Post- processing.

The process of converting an text image or printed text into computer redable and editable format[1] starts with scaning and loading the image and recognising each character independently and accurately. Human can easily

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detect a character at the first see, but a computer or digital system can not do it unless it is familiar or trained with previous records. There are many algorithms, ways and methods of doing such job. Artificial intelligence[2] has a field of pattern recognition for recognising patterns such as character,face, image,voice etc. Artificial neural network[3], support vector machine[4] and various data mining techniques are being used for character recognition. Adaptive neuro fuzzy inference system (ANFIS)[5] is now a advance field of artificial intelligence. Various types of problems are being solved by ANFIS. Being a current important issue, there are a lot of research works on optical character recognition.

In [6] proposes a portable model kit that would convert the text in source material into speech and also converts the speech given by the user into text. The technique of Optical Character Recognition is used to convert the image captured from the source material into text format suitable for synthesis in successive stage. The converted text format is processed using Hidden Markov Model based text-to-speech synthesis to produce the equivalent speech signal. This enables the blind person to listen to the information in text format. Hidden Markov Model based speech-to-text synthesis is used to enable the blind person to respond to text information or transcribe his speech signal into textual information. In [7] describes in detail the Feature extraction process, which is carried out by some conventional with two novel enhancements to Structural Features like detection of vertical line in a character and detection of open space in lower zone of a character . Classification process is completed by implementing a novel combination of Binary tree and Nai ¨ ve Bayesian classifier, which has never been used for Oriya script earlier. In [8] presents a comparative study of four most reported as high primitive printed Arabic Character Recognition works (Hamdi et al. [9], Marwa et al. [10], Marwa et al. [11] and Andrey et al. [12]). The motivation was the lack of independent comparative study between recent algorithms for researchers to depend on. A new noise-free generated dataset of 7 font types is used for evaluation.

The paper is divided into five sections thus: Introduction, Pre-processing, Zoning feature extraction, ANFIS classification and conclusion.

II PROPOSED SYSTEM

PREPROCESSING

Preprocessing is one of the important parts in image recog- nition. It applies a number of operations on grey and binary images for making them more readable for the software. The major role of the preprocessing is to filter out the impurities from the image and also to performing smoothing and normalization as shown in Figure 2(a). We acquired image, via HD camera or scanned the assessment sheet of student. Firstly it will resized the whole image and reduced it into 0.6 scale of the original image. In second step of the process we take its complement and convert the RGB to equivalent HSV color space image. HSV values returned in MxNx3 image array, which controls the saturation, hue and also the value component of the image. As this is color based segmentation. We requested children to use color pen for their work task. We then selected H channel as it helped us in segmenting characters from the sheet as shown in Figure 2(b). In next step we binaries and applied threshold to image as

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shown in Figure 2(c). In next step we take the complement of the image for box removal as shown in Figure 2(d).

After this, morphological operation is applied to character to extract its skeleton. By performing this process we will be able to obtain neat and tidy edges of the character. We have applied thin operation we have set the value ranging from n to infinity so that operation will repeat until the image has no longer change. After extraction of the skeleton we removed unwanted components such as lines and dots, which are not key to the overall shape of the image, or small branches shorter than required for this we have applied bridge operation to the thinned image so that it

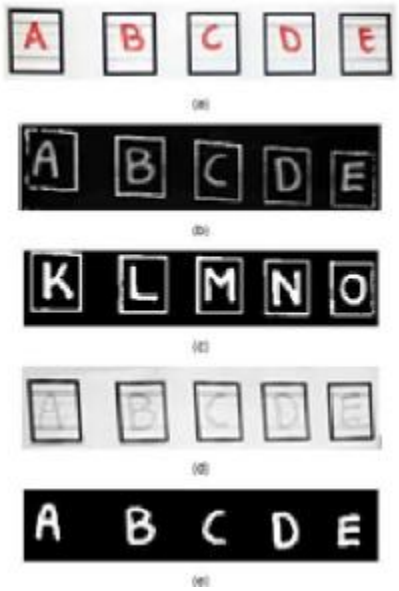

Fig. 2: Processed Results after applying different operations

will bridge previously unconnected pixels and set n value to 7. Then we have remove all the connected components or objects by using binary area open function it will remove all the pixel which are less then value of pixel set by us. As this is 2D image we have set value 8. Final result after applying all the morphological operation process which are discussed are depicted in Figure 3.

Fig. 3: Skeleton of Character B and C

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After extraction skeleton of character we observed that after zooming the image. Some pixel were not connected due to application of other morphological operation. Unconnected pixels are highlighted in yellow box which can been seen in Figure 4.

Fig. 4: Skeleton of Character B and C

After removal of all the unwanted components from the image and to join the unconnected pixels we dilate the image. So that it gradually increases the pixel at the border of the image. We have used diamond shape as a parameter for this process. Final shape of the character is depicted in Figure 5.

Fig. 5: Skeleton of Character B and C

After getting the actual shape of the alphabets we segmented the letter from the assessment sheet. We created a function which will first segment the characters in rows which are separated in red color and then by using mix max function. We have segmented characters in column as shown in green color. Column wise segmented in highlighted in green colour as shown in Figure 6.

Fig. 6: Skeleton of Characters

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After segmentation we reduced the picture of segmented characters to 42x24 as shown in Figure 7.

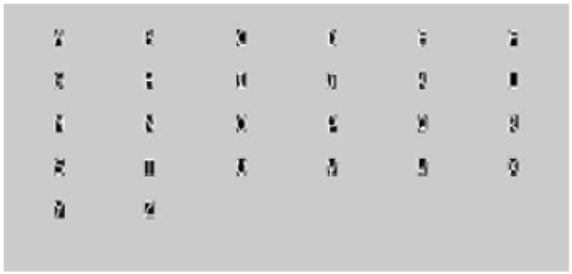

Fig. 7: Segmented skeleton of Characters

III FEATURE EXTRACTION

In this paper, zoning technique is implemented for feature extraction of segmented character for OCR. In this feature extraction technique we have divided character image into zones. From each zone average value is computed giving a feature vector of length (n*m) extracted features are stored in feature vector. In our proposed method each zone has 10 horizontal lines and the foreground pixels present long each horizontal is then summed to obtain 10 sub features values from each zone. These values are averaged to form a single feature value and placed in the corresponding zone. This procedure is repeated for all zones. There could be some zones which have white boxes means that they are empty. The feature value of those areas will be zero. The goal of zoning is to obtain the local characteristics instead of global characteristics. Sum of each zone pixels were calculated and then they were divided with the total number of pixels to get the zone features.

Algorithm 1 Feature extraction Method Zoning

1: **Input**: Segmented Image I8.

2: **Output**: Feature extraction Method Zoning applied over I_8.

3: functionzoneFeatures = getZoneFeatures(bw)

4: [rc] = size(bw)

5: d = r _ c

6: midR = round(r/2)

7: midC = round(c/2)

8: zone1 = bw(1 : midR, 1 : midC)

9: zone2 = bw(midR + 1 : end, 1 : midC)

10: zone3 = bw(1 : midR, midC + 1 : end)

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11: zone4 = bw(midR + 1 : end, midC + 1 : end)

12: zone1 = sum(sum(zone1))

13: zone2 = sum(sum(zone2))

14: zone3 = sum(sum(zone3))

15: zone4 = sum(sum(zone4))

16: totalPixels = zone1 + zone2 + zone3 + zone4

17: zoneFeatures = [zone1/totalPixels zone2/totalPixelszone3/totalPixelszone4/totalPixels zone1/dzone2/dzone3/dzone4/d]

IV CLASSIFICATION

The adaptive network-based fuzzy inference systems (ANFIS) is used to solve problems related to parameter identification. This parameter identification is done through a hybrid learning rule combining the back-propagation gradient descent and a least-squares method. ANFIS is basically a *graphical* network representation of Sugeno-type fuzzy systems endowed with the neural learning capabilities. The network is comprised of nodes with specific functions collected in layers. ANFIS is able to construct a network realization of IF / THEN rules.

Consider a Sugeno type of fuzzy system having the rule base

1. If x is $A1$ and y is $B1$, then $f_1 = c_{11}x+c_{12}y+c_{10}$

2. If x is $A2$ and y is $B2$, then $f_2 = c_{21}x+c_{22}y+c_{20}$

Let the membership functions of fuzzy sets Ai, Bi, i=1,2, be , μ_{Ai} μ_{Bi}.

In evaluating the rules, choose *product* for T-norm (logical *and*).

1. Evaluating the rule premises results in

$$w_i = \mu_{A_i}(x)\mu_{B_i}(y),\ i=1,2. \quad (1)$$

2. Evaluating the implication and the rule consequences gives

$$f(x,y) = \frac{w_1(x,y)f_1(x,y)+w_2(x,y)f_2(x,y)}{w_1(x,y)+w_2(x,y)}. \quad (2)$$

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Or leaving the arguments out

$$f = \frac{w_1 f_1 + w_2 f_2}{w_1 + w_2} \quad (3)$$

This can be separated to phases by first defining

$$\overline{w}_i = \frac{w_i}{w_1 + w_2} \quad (4)$$

Then *f* can be written as

$$f = \overline{w}_1 f_1 + \overline{w}_2 f_2 \quad (5)$$

All computations can be presented in a diagram form. ANFIS normally has 5 layers of neurons of which neurons in the same layer are of the same function family.

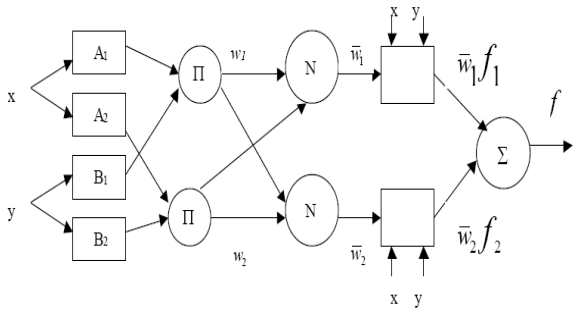

Fig 8: Structure of the ANFIS network.

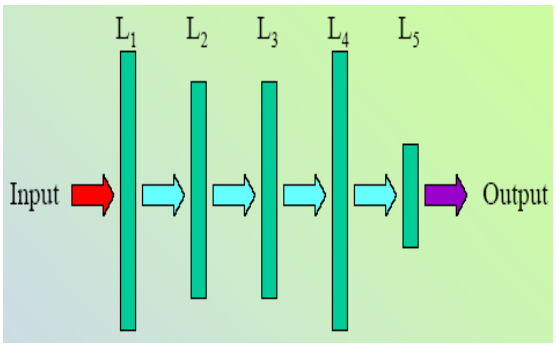

Fig 9: ANFIS Architecture

Layer 1 (L1): Each node generates the membership grades of a linguistic label. An example of a membership function is the generalised *bell function*:

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$$\mu(x) = \frac{1}{1 + \left|\frac{x-c}{a}\right|^{2b}} \quad (6)$$

where {*a*, *b*, *c*} is the parameter set. As the values of the parameters change, the shape of the bell-shaped function varies. Parameters in that layer are called *premise parameters*.

Layer 2 (L2): Each node calculates the firing strength of each rule using the *min* or *prod* operator. In general, any other fuzzy AND operation can be used.

Layer 3 (L3): The nodes calculate the ratios of the rule's firing strength to the sum of all the rules firing strength. The result is a *normalised firing strength*.

Layer 4 (L4): The nodes compute a parameter function on the layer 3 output. Parameters in this layer are called *consequent parameters*.

Layer 5 (L5): Normally a single node that aggregates the overall outputas the summation of all incoming signals

The ANFIS learning algorithm

When the premise parameters are fixed, the overall output is a linear combination of the consequent parameters. In symbols, the output *f* can be written as $f = (\bar{w}_1 x)c_{11} + (\bar{w}_1 y)c_{12} + \bar{w}_1 c_{10} + (\bar{w}_2 x)c_{21} + (\bar{w}_2 y)c_{22} + \bar{w}_2 c_{20}$ which is linear in the consequent parameters c_{ij} (i = 1,2, j = 0,1,2). A hybrid algorithm adjusts the consequent parameters c_{ij} in a forward pass and the premise parameters {a_i, b_i, c_i} in a backward pass. In the forward pass the network inputs propagate forward until layer 4, where the consequent parameters are identified by the least-squares method. In the backward pass, the error signals propagate backwards and the premise parameters are updated by gradient descent.

Because the update rules for the premise and consequent parameters are decoupled in the hybrid learning rule, a computational speedup may be possible by using variants of the gradient method or other optimisation techniques on the premise parameters.

V RESULT ANALYSIS

We present our results below where Table I depicts the result of evaluation. We use zoning feature extraction technique with ANFIS classifier. We observe that zoning with ANFIS classifier registered accuracy of 96% such that 24/26 capital English letter are correctly identified. We also achieve accuracy of 98% such that 25/26 small English letter are correctly identified. We compared our proposed method with the literature work LBP feature extraction with Neural network classifier and our proposed method registered better classification accuracy.

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TABLE I: Results of zoning with ANFIS Classifier compared with LBP with NN classifier

Methods	Accuracy (%)	Correctly Identified
LBP + NN (capital letters)	0.77	20/26
LBP + NN (capital letters)	0.73	19/26
Zoning + ANFIS (capital letters)	0.92	24/26
Zoning + ANFIS (capital letters)	0.96	25/26

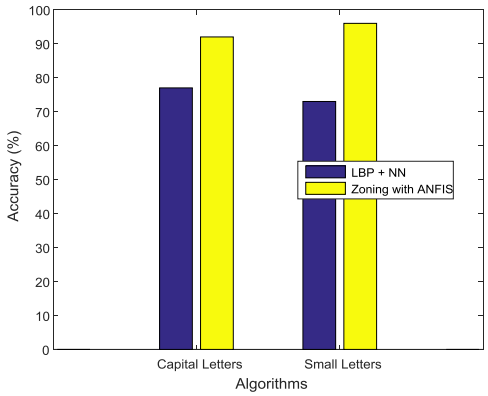

Fig 10: Accuracy comparison

Total classification accuracy obtained for zoning features were classified using the proposed ANFIS model, is shown in figure 10.

VI CONCLUSION

Optical character recognition is a complex task. It may not be easy all the time as image contains noise and complete noise removal is not possible. In this paper, a system is showed for recognising optical character using adaptive neuro fuzzy model (ANFIS). There are some works on OCR using ANFIS for different language. Proposed method works on english character and shows more than 98% accuracy. In future, we will work on the comparison of proposed ANFIS and some optimization techniques to find out the best soft computing technique.

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