An Improved Zone Based Hybrid Feature Extraction Model for Handwritten Alphabets Recognition using Euler Number

Om Prakash Sharma, M. K. Ghose, Krishna Bikram Shah

Abstract:- ***This paper presents an Improved Zone based Hybrid Feature Extraction Model using Euler Number, which not only improves the feature extraction process which was implemented in Diagonal Based Feature Extraction [1] but also helps in efficient classification of the handwritten alphabets. The use of Euler Number in addition to zoning increases the speed and the accuracy of the classifier as we are able to reduce the search space by dividing the character set into three groups.***

Index Terms:- Handwritten Character Recognition, Feature Extraction, Binary Image, Euler Number, Feed Forward Neural Networks.

I. INTRODUCTION

Character recognition plays an important role in this modern world where there are heterogeneous representation of text based information. It is the mechanical or electronic translation of handwritten, typewritten or printed text into machine editable formats. Character recognition also popularly referred as optical character recognition (OCR) is a field of research that has immense potential in future where we want to track and locate every piece of information being exchanged. The problem with the hand written text is due to uncertainties such as variation in calligraphy over period of time, similarity in text, variation in styles of writing as shown in Fig. I. These have made hand written text continues to be challenging area of research work. Given a grey scale image of characters as input the task is to recognise the character and assign the corresponding ASCII values to the recognized characters. In general the character recognition is basically classified into two types: offline handwritten text recognition, online handwritten text recognition. [1] Offline means the text written on the plain paper or sheet and then the writing is usually captured optically by a scanner and the completed writing is available as an image. Online means the text written on any digital devices such as tablets using stylus i.e. the two dimensional coordinates of successive points are represented as a function of time and the order of strokes made by the writer are also available. The on-line methods have been shown to be superior to their off-line counterparts in recognizing handwritten characters due to the temporal information available with the former [3] [4]. However, in the off-line systems, the neural networks have been successfully used to yield comparably high recognition accuracy levels. The potential of offline method is immense as the applications have increasing exponentially, such as in the mail sorting, bank processing, document reading and postal address. As a result, the off-line handwriting recognition continues to be an active area for research towards exploring the newer techniques that would improve recognition accuracy [5] [6].

Fig. I: Image showing variation in styles of writing

OCR Systems consist of four major phase: Pre-processing, Segmentation, Feature Extraction, and Classification.

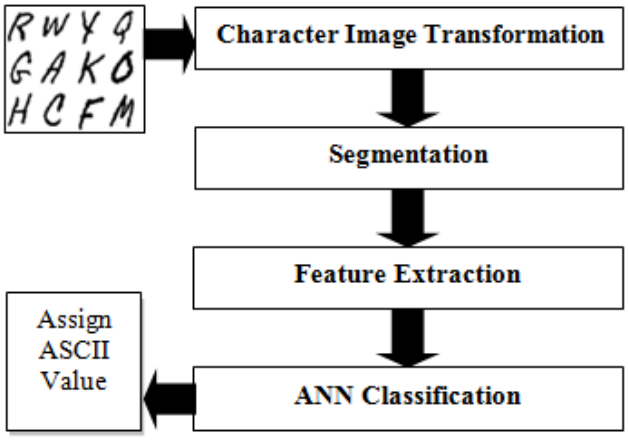

Fig. II: Major Phases of OCR System

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Om Prakash Sharma, Department of Computer Science and Engineering, Sikkim Manipal Institute of Technology, Majitar, Sikkim, India, (e-mail: opskpg@gmail.com).

Dr. M. K. Ghose, Department of Computer Science and Engineering, Sikkim Manipal Institute of Technology, Majitar, Sikkim, India, (e-mail: mkghose@smuhmts.edu).

Krishna Bikram Shah, Department of Computer Science and Engineering, Sikkim Manipal Institute of Technology, Majitar, Sikkim, India, (e-mail: krishnabikramshah@gmail.com).

II. MAJOR PHASES OF OCR SYSTEM

Pre-processing

The goal of pre-processing is to simplify the pattern recognition problem without missing any vital information. It reduces the noises and inconsistent data [7]. It enhances the image and prepares it for the next steps. The steps in preprocessing involve:

- Binarization- It refers to the conversion of grey scale image into binary forms. Binsrization/Thresholding converts the grey scale image to binary, by changing the foreground pixels(text characters) to black and background to white [8]. Many algorithms are involved in binarization. Among them the most popular are global thresholding (OTSU method) and local thresholding (Niblack, Sauvola and Bernsen Method).

  g(x,y)= 1, if f(x,y) >=T where T is threshold value.

  0, otherwise
- Noise Removal- We use some filtering technique like spatial domain filter-mean and median filters and frequency domain filter- Gaussian low pass filter and Butterworth low pass filter.
- Thinning- This is the process by which a one-pixel width representation of an image is obtained while the correctness of the image and its end points are preserved. Thinning process simplifies the further analysis [8].

Segmentation

Segmentation is an integral part of any text based recognition system. Proper segmentation assures efficiency of classification and subsequent recognition [7]. Accuracy of character recognition heavily depends upon segmentation phase. Incorrect segmentation leads to incorrect recognition. Segmentation phase include line segmentation, character and word segmentation [9]. It is important to obtain complete segmented character without any noise to ensure quality feature extraction. Image segmentation can be classified into three broad categories: top down, bottom-up and hybrid techniques. Run Length Smearing Algorithm (RLSA) is one of the most widely used top-down algorithms.

Normalization

The results of segmentation process provides isolated characters which are ready to pass through feature extraction stage, thus the isolated characters are reduced to a specific size depending on the methods used. The segmentation process essentially renders the image in the form of m*n matrix. These matrices are then generally normalized by reducing the size and removing the redundant information from the image without loosing any important information [10].

Feature Extraction

Feature extraction is the process in which the measurement of the normalized data is considered to form a feature vector. The feature vector is then used by classifiers to recognize the input unit with target output unit, that is, it becomes easier for the classifier to classify between different classes by looking at these features as it allows fairly easy to distinguish [1]. The set of features that are used makes up feature vector representing each member of the population. Pattern recognition system classifies each member of the population on the basis of information present in the feature vector.

Selection of feature is the single most important factor in achieving high recognition in performance in character recognition system [10]. Different feature extraction are designed for different representation of the characters, such as solid binary characters, characters contours, thinned characters or gray sub-images of each individual character. The different feature extraction methods fulfil this requirement at varying degree, depending on the specific problem recognition and the available data [1].

Feature extraction is an important step in achieving good performance of OCR systems. However the other steps of pattern recognition are equally important when they will be used in an optimized way to obtain the best possible performance in terms of accuracy.

The major goal of feature extraction is to extract a set of features, which maximizes the recognition rate with the least amount of elements. Due to the nature of handwriting with its high degree of variability and imprecision obtaining these features, is a difficult task. Feature extraction methods are based on mostly two types of features: statistical and structural features.

Representation of a character image by statistical distribution of points takes care of style variations to some extent. The major statistical features used for character representation are: Zoning, Projections and Profiles and Crossings and Distances [13, 14].

Characters can be represented by structural features with high tolerance to distortions and style variations. They encode some knowledge about the structure of the object or may provide some knowledge as to what sort of components make up that object.

Structural features are based on topological and geometrical properties of the character, such as aspect ratio, cross points, loops, branch points, strokes and their directions, inflection between two points, horizontal curves at top or bottom, etc. [13, 14].

The various methods of feature extraction works on grey images, while others works on 4-connected or 8-connected symbols segmented from binary raster image, thinned symbols or skeletons or symbol contours. The method that are suitable for gray scale images are used for binary representation little or no change in computation steps [1].

Classification

Classification is the last stage where we train the neural net using the feature vectors obtained during feature extraction method against the required targets. To optimize the whole recognition process, several combination methods of multilayer perceptron have been devised.

III. FEATURE EXTRACTION METHOD

Several methods of feature extraction for character recognition have been in operation over past few decades [10]. The widely used feature extraction methods are: Template matching, Unitary Transforms, Projection Histograms, Zoning, Geometric Moments and Zernike Moments.

Dinesh et al [15] have used horizontal/vertical strokes, and end points as the potential features for recognition and reported a recognition accuracy of 90.50% for handwritten Kannada numerals. However, this method uses the thinning process which results in the loss of features [1].

U. Pal et al [16] have proposed zoning and directional chain code features and considered a feature vector of length 100 for handwritten numeral recognition and have reported a high level of recognition accuracy. However, the feature extraction process is complex and time consuming [1].

Anita Pal et al [12] have proposed the features extraction from Boundary tracing and their Fourier Descriptors. Also an analysis has been carried out to determine the number of hidden layer nodes to achieve high performance of back propagation network. A recognition accuracy of 94% has been reported for handwritten English characters with less training time.

E. Srinivasan et al [1] have proposed diagonal based feature extraction for handwritten alphabets recognition system using neural network and from the test results it has been identified that the diagonal method of feature extraction yields the highest recognition accuracy of 97.8 % for 54 features and 98.5% for 69 features.

Zoning

Zoning is one of the feature most popular and simple to implement feature extraction method. The commercial OCR system developed by CALERA used Zoning mechanism on binary characters [10]. An (n*m) grid is superimposed on the character image and then for each zone average value is computed giving a feature vector of length (n*m), if required further we can compute the average on this zone again in row wise and column wise respectively.

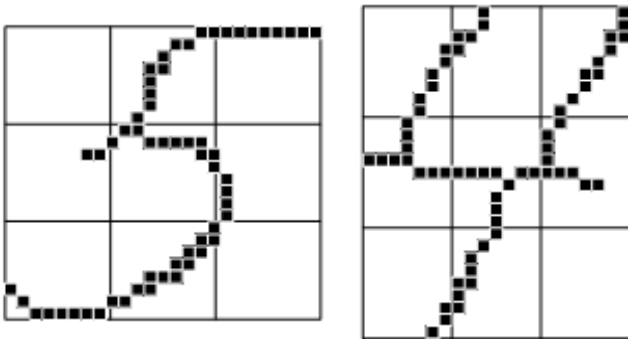

Fig. III: Zoning of Characters [5]

Euler Number

Euler Number is defined as number of connected components in the image minus the number of holes. This will divide the characters into 3 groups [2]:

- Euler number equal one and this contains: s, S, f, F, G, h, H, j, J, k, K, l, L, z, Z, x, X, c, C, v, V, n, N, m, M, w, W, E, r, t, T, y, Y, u, U, i, I.
- Euler number equal zero and this contains: q, Q, R, o, O, p, P, a, A, d, D, g, b.
- Euler number equal minus one and this contains: B.

Euler Number Computation [17][18]

Euler Number = ¼(X – V+2Z) for 4 connectivity
Euler Number = ¼(X – V –2Z) for 8 connectivity
i.e. Euler number = ¼(convexities – concavities+2*diagonal)

where,

X = the number of occurrences of the 2x2 pattern (i.e. the number of convexities)

$$\begin{vmatrix}0 & 0\\ 0 & 1\end{vmatrix}\begin{vmatrix}0 & 0\\ 1 & 0\end{vmatrix}\begin{vmatrix}1 & 0\\ 0 & 0\end{vmatrix}\begin{vmatrix}0 & 1\\ 0 & 0\end{vmatrix}$$

V= the number of occurrences of the 2x2 pattern (i.e. the number concavities)

$$\begin{vmatrix}1 & 1\\ 1 & 0\end{vmatrix}\begin{vmatrix}1 & 1\\ 0 & 1\end{vmatrix}\begin{vmatrix}0 & 1\\ 1 & 1\end{vmatrix}\begin{vmatrix}1 & 0\\ 1 & 1\end{vmatrix}$$

Z= the number of occurrences of the 2x2 pattern (i.e. the number diagonals)

$$\begin{vmatrix}1 & 0\\ 0 & 1\end{vmatrix}\begin{vmatrix}0 & 1\\ 1 & 0\end{vmatrix}$$

Fig. IV: Binary Object

When the above binary object (i.e. fig. 4.) was given as an input to the Matlab to compute the Euler Number the result obtained is;

Number of object = 1
Number of holes = 1
Euler Number = 0

IV. PURPOSED FEATURE EXTRACTION MODEL

Here, we have a new and an improved approach to feature extraction is proposed which may be efficient as compared to former methods. In this proposed approach first we compute the Euler Number. Based on the result of computation whether the result is positive or negative or zero, will divide the character set into three groups. After the categorization we go for Diagonal based feature Extraction method as implemented by J. Pradeep, E. Shrinivasan and H. Himavathi [1]. In this feature extraction process, the individual segmented characters are first resized into a size 90x60 pixel and then the Euler Number is computed for the character to identify in which class it belongs. After the reults it is then followed by the diagonal based zoning operation is carried where an image is further divided into 54 equal zones, each of size 10x10 pixels. The features are extracted from the pixels of each zone by moving along its 10X10 pixels.

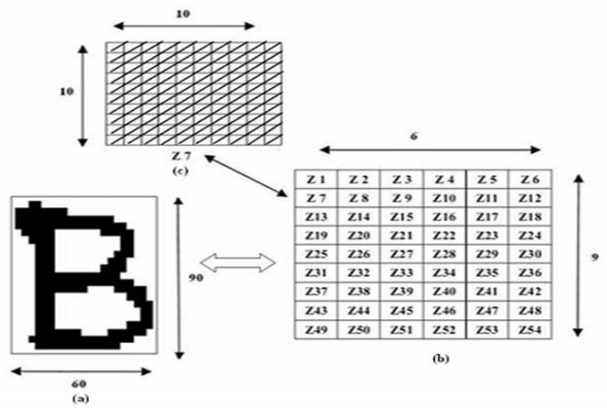

Fig. V: Diagonal Based Zoning Operation [1]

Each zone has 10 horizontal lines and the foreground pixels present long each horizontal line is summed to get a single sub-feature, thus 10 sub-features are obtained from the each zone. These 10 sub-features values are averaged to form a single feature value and placed in the corresponding zone. This procedure is sequentially repeated for all the zones. There could be some zones which are empty of foreground pixels. The feature values corresponding to these zones are zero. Finally, 54 features are extracted for each character. In addition, 9 and 6 features are obtained by averaging the values placed in zones row-wise and column-wise, respectively. As result, every character is represented by 69, that is, 54 +15 features [1, 11]. These extracted features are used to train a feed forward back propagation neural network for performing classification and recognition tasks.

V. CLASSIFICATION

A feed forward back propagation neural network having two hidden layers with architecture of 69-100-100-26 is used to perform the classification. The hidden layers use log sigmoid activation function, and the output layer is a competitive layer, as one of the characters is to be identified. The feature vector is denoted as p where p = (x1,x2,x3,.....xd) where x denotes features and d is the number of zones into which each character is divided. The number of input neurons is determined by length of the feature vector d. The total numbers of characters t determines the number of neurons in the output layer [6]. MLPs has to be so designed or framed that the recognition system should be 50% faster than the individual MLPs, while retaining the recognition rate at its highest value.

The network training parameters are:

Input nodes: 69
Hidden nodes: 100 each
Output nodes: 26 (alphabets)
Training Algorithm: Gradient Descent with Momentum Training and Adaptive Learning
Perform function: Mean Square Error
Training Goal Achieved: 0.000001
Training Epochs: 100000
Training Momentum Constant: 0.9
Training Learning Rate: 0.01

VI. RESULT AND DISCUSSION

Recognition system has been implemented using Matlab 7.5. The scanned image and the image drawn using paint application is given as an input to the feed forward neural net architecture where it is first converted from .png to .tiff file and then it is resized to a standard format of 60*90 pixels image followed by the thresholding/binarization operation which uses 'otsu' algorithm to scaled it into 0 and 1 binary image.

The structure of neural network includes an input layer with 69 inputs including row wise and column wise features, two hidden layers each with 100 neurons and an output layer with 26 neurons. The gradient descent back propagation method with momentum and adaptive learning rate and log-sigmoid transfer functions is used for neural network training [1]. Neural network has been trained using known dataset. A recognition system using two different features, one simple diagonal based feature and the other includes the Euler number. In both the cases size of feature vectors is same; the results obtained using these two different types of feature extraction are summarized in Table I & II.

Table I. Recognition result/time elapsed obtained based on diagonal based feature extraction

Alphabets	Diagonal Based Result	Elapsed Time (in seconds)
A	Recognised	0.4935
B	Recognised	0.7075
D	Recognised	0.6037
E	Recognised	0.6055
P	Recognised	1.4506
Q	Recognised	0.1766
M	Recognised	0.6070
S	Recognised	1.9696
T	Recognised	0.1781
Y	Recognised	1.9688
Z	Recognised	0.5088

Table II. Recognition result/time elapsed obtained based on hybrid based feature extraction

Alphabets	Hybrid Based Result	Elapsed Time (in seconds)
A	Recognised	0.4207
B	Recognised	0.1953
D	Recognised	0.5103

E	Recoginsed	0.1941
P	Recognised	0.2986
Q	Recognised	0.1941
M	Recognised	1.0355
S	Recognised	0.4055
T	Recognised	0.5103
Y	Recognised	0.1941
Z	Recognised	0.1721

VII. CONCLUSION

A new type of feature extraction, namely, an efficient feature extraction method is proposed which can give high recognition accuracy while requiring less time for training and classification both as compare to the diagonal based feature extraction method which gives upto 98.5% accuracy requiring less time for training [1]. The performance of the network has been simulated using Matlab 7.5. To simplify the project it has been restricted to few character sets. The constraints are posed to clear the concept behind new model. It can be said that the model is not a complete mechanism to character recognition. The system performs very well during classification for these limited set of characters. It not only yields higher levels of recognition accuracy but the overall time efficiency has increased as compared to the systems employing the diagonal based feature extraction [1] or any other conventional methods of feature extraction.

So, using the Euler Number computation which is good in categorizing the alphabets into different groups with zone based feature extraction method will be effective process increasing the accuracy and speed.

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