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Hand Written Character Recognition using VNP based Segmentation and Artificial Neural Network

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ABSTRACT

The choice of techniques used to segment the word into character and extract the features are the main factors to judge the capability and the recognition accuracy of a Hand Written Character Recognition System. Character Recognition is the important stage in image processing applications such as OCR, License Plate Recognition, Electronic processing of checks in banks, form processing, and label and barcode recognition. The main focus of this work is to use VNP algorithm to segment the preprocessed hand written image into characters. Features are extracted by binarization. The recognition of hand written character image has been done by using multi-layered feed forward artificial neural network. Very promising results are achieved when VNP segmentation algorithm and binarization features and the multilayer feed forward neural network is used to recognize the handwritten characters.

Keywords: Handwritten Character Recognition, Preprocessing, Segmentation, VNP, Feature Extraction, Recognition, BPNN.

INTRODUCTION

Humans are best at recognizing faces and complex patterns. Although it is clear that people are good at recognizing patterns, it is not at all obvious how patterns are coded or decoded by a human brain.

Handwritten Character Recognition is an important area in image processing and pattern recognition field. It is a wide field that covers all sort of character recognition via machine in various application domains. The goal of this area of pattern recognition is to translate human readable characters to machine readable characters. Today, we have automatic character recognizers that help humans in variety of practical and commercial applications.

Handwritten characters are non-uniform in nature, as a particular character can be written in different styles and sizes by different writers and even the same writer can write the same character in different styles at different times. Handwritten characters are also vague in nature as there may not be smooth curves or perfectly straight lines all the time.

For character recognition the first step involves the preprocessing of the input images . This step is to enhance the characters and the text i.e. if there is any distortion or noise, reduction of the same in the image acquired will be done in this step. Either an input pattern is identified as a member of the predefined class or the pattern is assigned an unknown class if its class is not already stored in the database. The ability of training and identifying is converted into machine systems using the Artificial Neural Networks. The basic function for the hand written character recognition system is to compare the input text which is to be recognized with the characters already stored in the database and it recognizes the best matching character as output even at different writing styles and sizes. Hand written character recognition is a challenging task as text written by different people is varied in their styles. We have explained a neural network based approach for efficient hand written character recognition.

Pre-Processing, Segmentation, Feature Extraction and Back Propagation Algorithm are the steps in the implementation.

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RELATED WORK

The offline character recognition is an active area of research these days. As compared to machine printed character recognition, the work done by the researchers in the area of handwritten character recognition is very limited as mentioned by Apurva A.Desai [5].

In 2002, Kundu & Chen [6] used HMM to recognize 100 postal words and reported 88.2% accuracy.

Binod Kumar [6] uses HMM model on the English character alphabets and gets 93.24% accuracy. For the letters „A" and „W", the recognition rate is found to be very low, because of a lot of variations in writing style of these letters.

Gunjan et. Al [1] uses the back propagation algorithm for Hindi character recognition. Each character is entered as an input vector of 49X1. Total 1000 (200 for each character) samples were used for classification. Out of these 1000 samples 60 % were used for training, 20% for validation and rest 20% were used for testing.

Richard [4] uses the dissection technique of segmentation. By *dissection* is meant the decomposition of the image into a sequence of sub images using general features segmentation is a complex process, and there is a need for a term such as "dissection" to distinguish the image-cutting sub process from the overall segmentation,

In their formulation the segmentation stage consisted of three steps:

1. Detection of the start of a character.
2. A decision to begin testing for the end of a character (called sectioning).
3. Detection of end-of-character.

S. Chitrakala [2] proposed an algorithm called VNP (Visited Neighbor Pixel) algorithm, which is an improvement over vertical projection profile and it works by segmenting adjacent characters with minimum threshold based on connectedness of the pixels.

PROPOSED METHODOLOGY

We will discuss Segmentation, feature extraction and back propagation neural network in this implementation.

Preprocessing relates to the removal of noise and variation in handwritten word patterns. Preprocessing may itself be broken down into smaller tasks such as noise removal, thinning, edge detection, resizing etc to enhance the quality of images and to correct distortion.

Segmentation decomposes an image of sequence of characters into sub images of individual character.

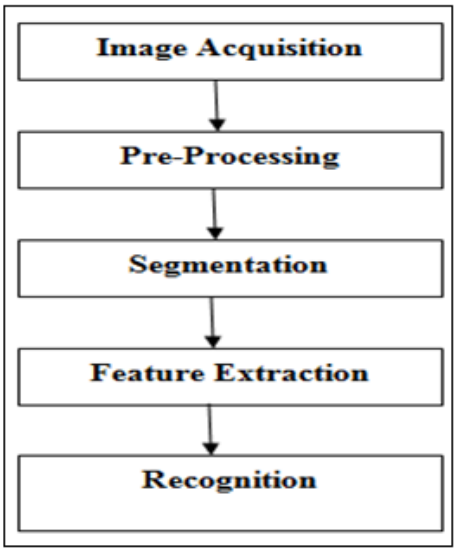

Fig1. *Proposed Methodology*

For segmenting the image of sequence of characters, we have used VNP (Visited Neighbor Pixel) algorithm which is an improvement over vertical projection profile, and classified under dissection based segmentation approaches, wherein the image is split up into meaningful components. Algorithm that follows in next section will explain visited neighbor pixel algorithm more clearly.

VNP Algorithm

We use the Visited Neighbor Pixel (VNP) algorithm in the segmentation.

Segmentation

It is an operation that decomposes an image of sequence of characters into sub images of individual character.

Fig2. *Segmentation Example*

S.Chitrakala [2] proposed an algorithm called VNP (Visited Neighbor Pixel) algorithm, which is an improvement over vertical projection profile and it works by segmenting adjacent characters with minimum threshold based on connectedness of the pixels.

The proposed VNP method is classified under dissection based segmentation approaches, wherein the image is split up into meaningful components.

Algorithm: Visited neighbor pixel algorithm

Functions:

STORE (x,y):Stores the pixel corresponding to location*(x,y)*

visited (x,y): Checks if the pixel *(x,y)* has been visited

height (w): Returns the height of the word *w*

value (x,y): Returns the value of the pixel (0-black or 1-

white)

Input:

w: Segmented word

Output:

xmin: Left most point of the character

xmax: Right most point of character

ymin: Top most point of character

ymax: Bottom most point of character

Start

For word w

//Storing first pixel of character

For x = 1

For-Each row y

// black pixel encountered

If value (x,y) == 0 // Start of the character

Then STORE (x,y)

xmin = x

End If

End For

End For

For column x = 2: n

For-Each e (x,y) == 0

//Checking for neighbor black pixel

If (!value (x !1, y)|| ! value(x ! 1, y ± 1)||

! value (x, y ± 1))

If (visited (x !1, y)|| visited (x, y ± 1)) = = 0)

STORE (x, y)

Else

//Absence of neighbor pixels

xmax = x

End If

End For

End For

// Computing boundaries of bounding box

yn = height (w)

For-Each row y from column

If (x, y) = = 0 **break**

STORE (x,y)

ymin = y

For y = yn; y>1; y-1

If ((x, y) = = 0&& (xmax + 1, y)…0)

ymax = y

End If

End For

End For

End

In the proposed algorithm the segmented a black pixel is detected. This pixel marks the beginning of the character as depicted in Fig. 3a and it is temporarily stored in an otherwise empty image of the same size and width as the segmented word. The scan progresses iteratively, checking for the presence of black pixels neighboring the already visited black pixels. The end of the character is determined as the column where no more neighboring black pixels exist.

Fig. 3a Fig. 3b Fig. 3c

Difficulty arises in identifying the bounds for separating the characters. The VNP algorithm proves to be advantageous in such cases, by checking for the condition of adjacency with the visited pixels. This row *y* If *value* gives a clear indication of segmentation as shown in Fig. 3b. After estimating the start and end point of a character, the columns corresponding to the starting and the ending point are

used as reference lines and scanning is done horizontally from the top to the bottom. When a black pixel is encountered, the corresponding scan line is marked as the top boundary of the character and then scanning continues horizontally from the bottom boundary of the word to the top. Every time a pixel is encountered, the presence of its adjacent pixels is checked. If it has adjacent pixels falling outside the right boundary of the character, the pixel is assumed to belong to another character and is ignored. This solves the problem of segmenting character when pixels of adjacent characters fall on the same scan line. The scanning proceeds till a pixel which has either no adjacent pixels or whose adjacent pixels fall within the character's boundary is encountered. The row corresponding to the pixel is marked as the bottom boundary as shown in Fig. 3c.

Hence, the boundaries of the character are defined and the character is segmented along them.

BPNN

Back Propagation Neural Network (BPNN) is a multilayered, feed forward Neural Network (NN). BPNN consists of an input layer, one or more hidden layer and an output layer. The layers contain identical computing nodes called neurons which are connected in such way that the output neuron in one layer sends signal to the input layer of every neuron in the next layer. The input layer of the network serves as the signal receptor while the output layer passes out the result from the network.

For Hand Written Character recognition we used a three layer BPNN as the classifier, the number of nodes in the input layer is equal to the dimension of the feature vector that characterizes the character image space. The number of the nodes in the hidden layer is set by trial and error method during training. The number of nodes in the output layer is equal to the number of the images in the database. During the training process, the BPNN learning algorithm adjusts the weights and the bias of each of the neurons in order to minimize the Mean Square Error (MSE) between the targets and predicted output. In the recognition phase, the features from the query character image that is to be tested is fed to the neural network without giving any target output. BPNN testing algorithm finds the closest pattern matching using the weights and the thresholds that have been stored and provides the corresponding recognized character.

EXPERIMENTS AND RESULTS

The image of handwritten text is preprocessed and segmented into individual characters and are recognized by a neural network.

In the preprocessing phase, the input image of handwritten character in .bmp format from the local

Database is converted to grayscale format by using "rgb2gray" function of MATLAB shown in Fig 4.

Binarization is an important image processing step in which the pixel values are separated into two groups; white as background and black as foreground. Only two colors, white and black, can be present in a binary image.

It is assumed that the intensity of the text is less than that of background i.e. the input image has black foreground pixels and white background pixels. The colors can be inverted if the input image has text intensity more than that of background.

After the binarization of the text image, binarized image is used for segmenting the words into characters. Segmented characters are shown in the Fig 5.

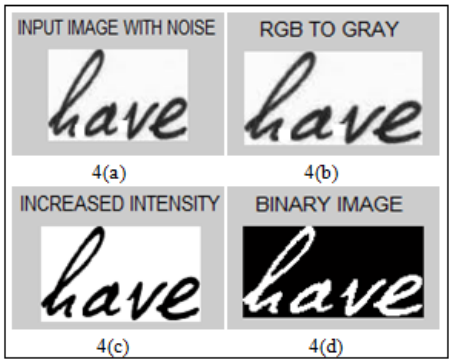

Fig4. *Preprocessed Image*

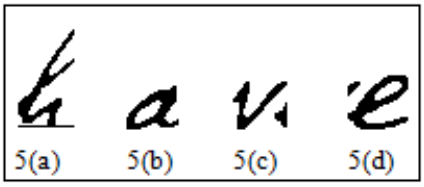

Fig5. *Segmented Word into Characters*

Now, binarized segmented character is resized into 7*5 matrix where '0' indicates the presence of white pixel and '1' represents the black pixel. This binary matrix of size 7*5 is then reshaped in a row first manner to a binary matrix of size 35*1 by using 'reshape' function of MATLAB. Now, resulted matrix is used to train the neural network.

TESTING RESULT OF HAND WRITTEN CHARACTER USING BPNN

The size of the input layer depends on the size of the sample presented at the input and the size of the output layer is decided in accordance with the number of output classes in which each of the input patterns is to be classified. In the proposed experiment, the feature vector of each of the 26 character images is of size 35×1. Hence, 35 neurons are used in the input layer and 10 neurons are used in the output layer of the neural network.

In case of back-propagation neural networks, universally accepted cost function to measure the generalization performance is MSE. The lower value of the cost function indicates that the neural network is capable of mapping the input and output in a right manner. The acceptable threshold for the MSE (cost function value) has been selected as 0.001 and the training of the neural network will come to an end when the error becomes less than or equal to this threshold value. The performance value indicates the extent of training of the network. A low performance value (36) indicates that the network has been trained properly.

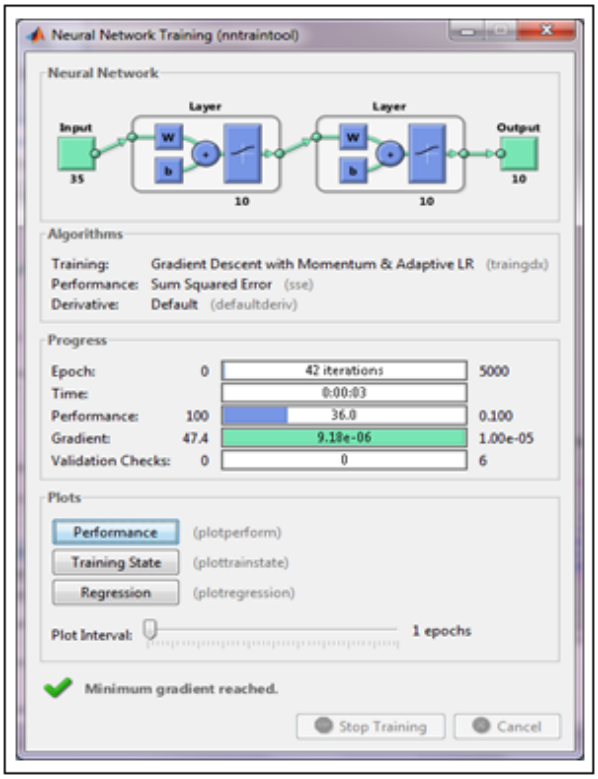

Fig6. *Training performance of the Network*

The performance of the neural network classifier also depends on the number of training iterations required to train the network. Too less number of training epochs result in a poorly trained network due to under-fitting of the network. On the other hand, too many training epochs result in poor generalization due to over-fitting of the network.

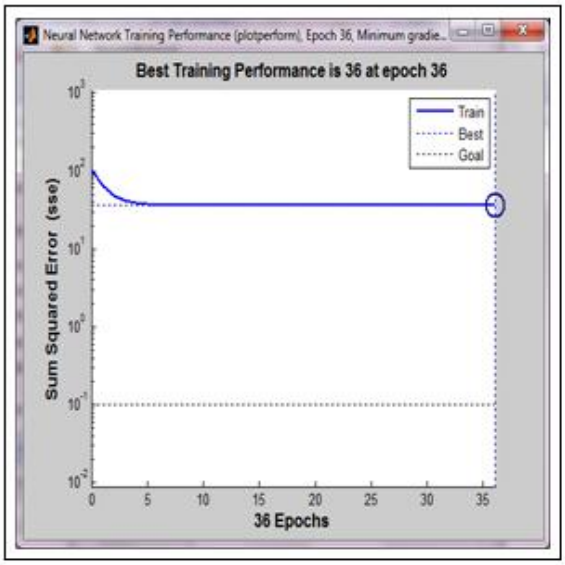

Fig7. *Performance Graph*

The network learning iterations must be selected in such a way that the network may converge properly with least generalization error. The maximum allowed epochs for the training process has been set to 100000 as shown in Fig 7. If the network could not converge within the maximum allowed epochs count, the training will stop.

The result obtained by Segmentation algorithm is as shown in TABLE I .

TABLEI. Segmentation Result

Segmented alphabets	***Alphabets***	***Percentages***
Correctly	a, d, e, f, h, k, l , m, n, r, s, t, 0, 1, 3, 6, 8, 9	100%
Incorrectly	b, c, g, i, j, o, p, q, u, v, w, x, y, z, 2, 4, 5, 7	-

In the proposed handwritten character recognition system, the neural network has been trained by each of the 26 characters image samples from the database have been involved in the learning process. Recognition rate between the various characters has been varied.

Fig8. *Hand Written Character Recognition System*

'a' is classified as 'e', 2 times and 'o', 5 times respectively.

CONCLUSION

Recognition of characters and learning of image processing techniques is done in this thesis. In this thesis we implemented Handwritten Character Recognition System using Back Propagation Neural Network. The handwritten character recognition is indeed a tough task which can be done with the methodology described here. Here the dataset taken is handwritten sentences and these are segmented

into the characters using the VNP algorithm, through which we have to extract the characters. Extracted features are fed into the back propagation neural network and tested with the stored database to recognize the characters.

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