Recognition of Handwritten Text: Artificial Neural Network Approach

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Abstract— Due to its wide application area and inherent complexity, handwritten character recognition grabs great interest of various researchers since long. The task is much more challenging when it comes in the form of handwritten text document. This work is an approach towards recognition of handwritten texts through competitive neural network. One way of segmenting texts into individual character is also revealed here. Text inputs are converted into binary matrices and are segmented into small pieces to find out probable individual characters from the text. Identified character matrices are normalized into standard sizes, and recognized using an artificial neural network and finally displayed them into an appropriate text editor with some font.

Keywords— Handwritten Character Recognition, Handwritten Text Recognition, Artificial Neural Network, Competitive Learning, Segmentation.

1. Introduction

With the rapid evolution of computerization process, it has become necessary to search for such systems which can make documentation and related works automatic. Till now the systems need to perform lots of manual process like writing, typing etc., to enter some text into a system. Hence, there is much scope to introduce systems, which can perform these kinds of task easily and automatically. Segmentation of handwritten texts and recognizing them using Artificial Neural Network is a move towards this kind of system. Further, every individual has their own writing style. Even the writings from the same person generally differ from one another. Though same alphabet or numeral may be same for a particular printed font but in case of handwritings, they always differ. Most of the human being, with previous knowledge of the used language, can easily understand those characters; even they are distorted very badly. In case of machines, it may be possible to avoid such situations.

A number of research works are going on in this topic with a variety of different approaches, including probabilistic methods [1, 2, and 3], hidden Markov model [4, 5]. Among several other alternatives, use of artificial neural network [6, 7, 8, 9, 10, and 11] is being popular day by day. For building efficient recognition of individual characters, it is most important to find out an appropriate feature by which they can be classified properly. In one such kind of method, image of handwritten English characters are segmented row wise and every row is classified using perceptron networks to find the particular match [12]. In some other works they are segmented column wise [13] and blokwise [14]. Extraction of a mask vector from the existing image matrix and use of it as an important feature for classification is also applied [15].

Recognition of handwritten text documents appears much more difficult when the task of segmentation of the text considered. Number of works have been attempted to accomplish

segmentation task for long time and for different languages [17, 18, 19, 20].

The proposed work is an approach towards recognition of handwritten texts through neural network. The system is capable of recognizing handwritten text and converts them into an equivalent text document, which can be edited using word processors. The handwritten text document is segmented into individual characters and ultimately fed into a network of artificial neurons. This network was previously trained by competitive learning method, with standard characters of English alphabets. The identified characters are displayed through a word processor by means of proper font.

2. Handwritten Character recognition system

A handwritten recognition system takes input as text document, written on a paper and gives output as computerized text document which can be edited through some word processor like notepad, word pad, Ms-Word etc (Figure 1).

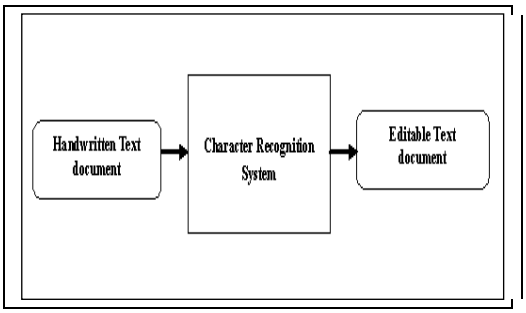

Figure 1: Handwritten character recognition system

3. Competitive Neural Network

Competitive learning [21, 22] is one of the popular unsupervised mechanisms to train a network of processing units to achieve some pattern recognition task. Basically, a competitive learning network checks the activation value of each unit and declares a winner unit that possesses the maximum activation value. The weight vector of the winner is adjusted to bring its component closer to the input vector components. Output for every winning unit is set to 1 while others are set to zero.

A vector input $X = \{x_i, i=1, 2, 3\ldots..n\}$, passed into the layer of every unit U_j, $j=1, 2, 3\ldots..m$, with the synaptic weights W_{ij}, which represents the connection strength between i^{th} element of input vector to the j^{th} unit. Activation value of each unit has been calculated by summing up the weighted inputs, i.e.

$$\text{Activation Value } (U_j) = \sum x_i W_{ij}$$

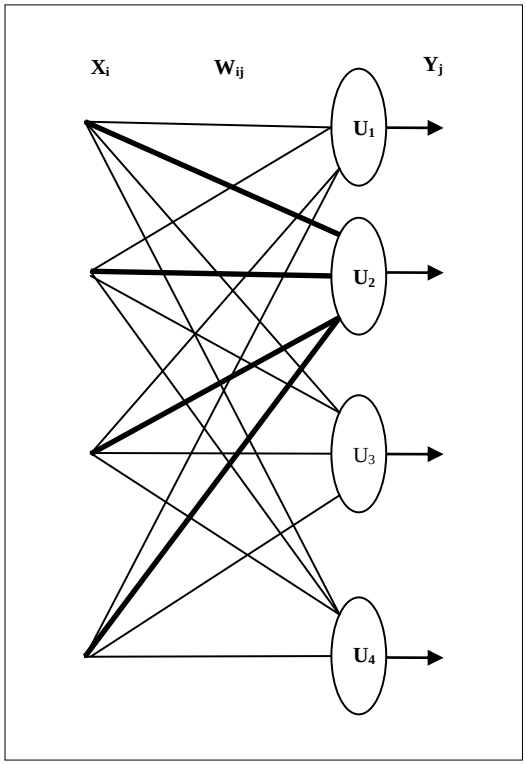

Figure 2: Competitive learning network

In the neural network (Figure 2), U_2 is the winner with maximum activation value and the weights are adjusted according to the relation:

$$W_{i2}(new) = W_{i2}(old) + c(x_i - W_{i2})$$

Where, ‘c’ is a small positive learning constant.

Initially, the weight vector contains some random values and during the training process those values are updated for several times. The whole process is performed for all the input set for several iterations (epochs). Finally a trained network is obtained that will be able to identify the patterns for which it was trained.

4. The System

The proposed system performs recognition of handwritten texts by segmenting them into individual characters. Also, the segmented individual characters are normalized and preprocessed. The total system has been illustrated using a conceptual block diagram as shown in Figure 3.

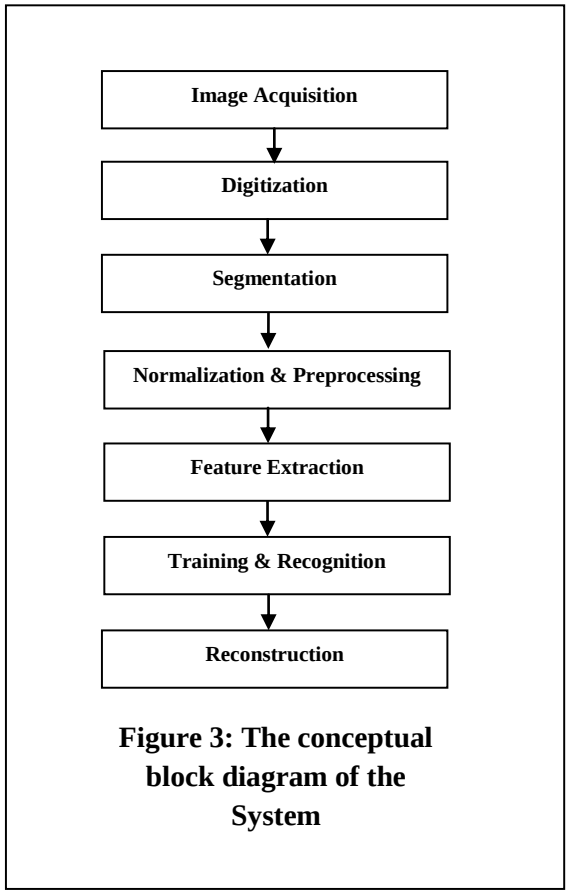

Figure 3: The conceptual block diagram of the System

4.1. Image Acquisition

The basic input of the system is hard copy text document, written on a paper. In order to process this handwritten text, a scanner, camera or any other image acquisition tool is used to convert it into digital format.

4.2. Digitization

The digitized text image file is nothing but a matrix containing binary values. The size of the matrix is same as the pixel size of the document image. All blank spaces are represented with 0, where as written portions are with 1. As for example, character **A** is represented in three different matrices of sizes 5x5, 10x10, and 20X20 as shown in Figure 4.

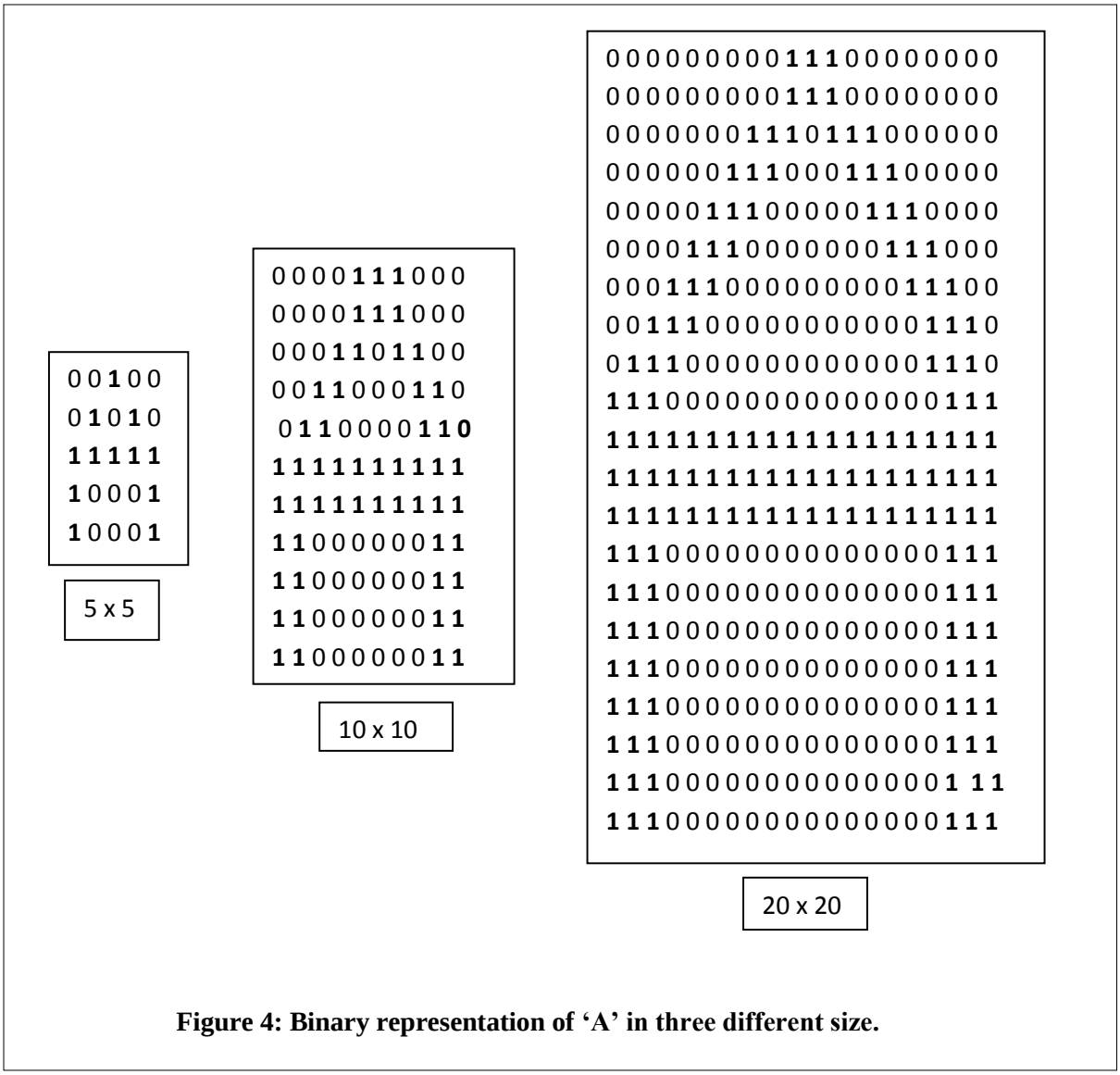

Figure 4: Binary representation of 'A' in three different size.

4.3. Segmentation

The next work is to separate the individual characters from the original text forming words and lines. This is known as segmentation, meaning dividing the whole text image into individual characters. The process includes line segmentation, word segmentation, and character segmentation. The text document needs to be separated first line wise, then word wise and lastly, character wise. In this system, a method has been given to separate individual upper case English characters from a document as shown in Figure 5.

In order to segment lines from the entered text document, the binary representation of the document image is scanned row wise. The process starts from left corner of the binary matrix and each element of the matrix is scanned row wise. A counter is used to count the number of 1s in each row. If the row, contains elements that represent some portion of a text line it must have sufficient 1s in their elements. So, the counter can reflect the existence of portions

of some text in a row. If the counter does not shows significant 1s in the row, the system assumes that the row is empty, i.e. it does not contain any portion of the text document. Those empty rows between other nonempty row separates each line of the text document.

Steps for Line Segmentation

1. Input the text document image form
2. Convert it to binary image matrix
3. Scan every element of binary image matrix row wise
   i. If number of 1s in the row > some predefined value, say V_1,

      Then, add the row in a separate matrix (a matrix which will contain a line only- a line-matrix)

      Until a row with V_1 > number of 1s in the row is found

   ii. If number of 1s in the row < V_1,
4. Go for finding next row using step 3.
5. End.

Once the lines are found, the system checks the line-matrices column wise for counting 1s in each column in order to find individual characters of the line. A counter same as used in line segmentation is also used here for counting the 1s. A significant count in this counter represents an existence of some portion of any character in respective column. In the same way, a column is found empty by insufficient counts in respective column. The empty / insufficient counted columns separate each character from the line matrix.

Steps for Character Segmentation

1. Input binary line- matrix detected by line segmentation algorithm
2. Scan every element of binary image matrix column wise
   i. If number of 1s in the column > some predefined value, say V_2,

      Then, add the column in a separate matrix (a matrix which will contain a character only (character-matrix)

      Until a column with V_2 > number of 1s in the column is found.

   ii. Add the columns in another separate matrix (space-matrix) in which number of 1s < V2 until a column with V2 < number of 1s in the column is found [for inter character and inter word spaces].

   iii. Discard the space-matrix (inter character], whose size is smaller than some predefined size value.
3. Go for finding next character and word space using step 2.
4. End

4.4. Normalization and Preprocessing

Segmentation of given text document produces different individual character matrices of different sizes. Now, it is required to convert the character matrices to be of same size, so that the proposed system properly identifies them. This task is achieved in this phase and all the patterns are made of 80x80 size. The smaller ones are filled with some padding bits whereas larger ones are reduced by deducting some unnecessary bits from it to achieve normalization.

Steps for Normalization

1. Input binary character-matrix identified by character segmentation Count the elements in each row.
2. Count the elements in each row
    a. If number of element is greater than 80, then delete extra elements from last.
    b. Else, add some extra zero to the end of the row so that its number of element becomes 80.
3. Perform the same tasks as in step 2 for each column of the matrix.
4. End

4.5. Feature Extraction

In this phase, the important features, by which a given character can be separated from another, are done. In this work, the character-matrix itself is presented as a total feature for training and recognition purpose.

4.6. Recognition

The artificial neural network trained by competitive learning technique is used to serve the recognition task (Figure 2). The network has two layers of neurons. The first layer contains 6400 input neurons for receiving 80x80 matrix input to the network and the second layer, the output layer, contains 26 output neurons to indicate output for 26 English capital alphabets. The network is trained with standard character patterns (Figure 5) before it performs recognition task.

4.7. Reconstruction

After completion of recognition process, the system indicates any of the 26 English capital letters as output, for every character input text. Depending on this indication the system puts the identified character in a text file separately with the appropriate spaces, so that the file can be edited afterwards by any word processor.

5. Result and discussion

The system has been tested using Matlab tools with real time handwritten texts; each of them contains 10 capital letters (A-J) only from English alphabet. Using HP Office-jet 6500 all in one scanner, documents are scanned, with 200 dpi resolution b/w, to prepare image file in jpeg format. The neural network was trained with standard character patterns (Figure 5). The text document, to be tested, also contains some noise in it as shown in Figure 6. The system is significantly capable to discard those noises.

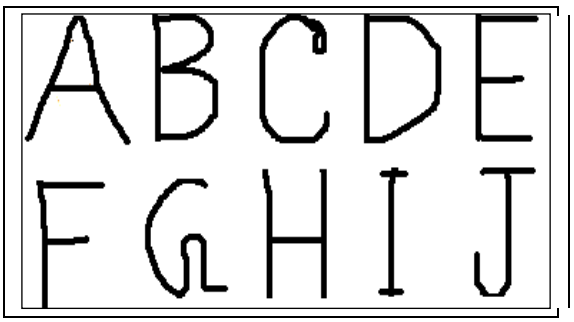

Figure 5: Character Images for Training

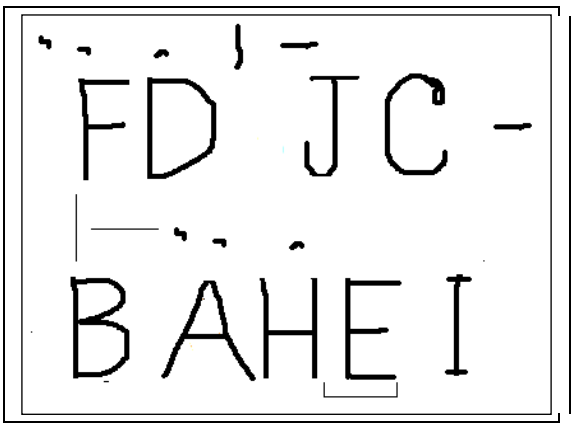

Figure 6: Sample Text Document for Testing

Encouraging overall result has been obtained by testing the system with variety of text images (Table1).

Table 1: Test results

Characters	No. of Variants	No of success	Percentage
A	10	8	80%
B	10	6	60%
C	10	7	70%
D	10	7	70%
E	10	8	80%
F	10	9	90%
G	10	7	70%
H	10	8	80%
I	10	9	90%
J	10	7	70%

6. Conclusion

The system reveals a way of segmenting a text into individual characters and then recognizes those using an unsupervised artificial neural network. Results with the work are up to the mark as compared to other relative systems in this field.

Though the system is an efficient one, still lots of improvement, like inclusion of some feature extraction technique, modified neural network classifier, etc. can be incorporated to enhance the efficiency of the system.

Further, presence of joined lower case letters which is obvious in any handwritten text is not considered here for simplicity of the system.

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