Handwritten Character Recognition with Feedback Neural Network

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Abstract— The ability of a machine to interpret handwritten characters from sources like paper document, photograph, etc. to some editable computerized form is the first and foremost aim of handwritten character recognition systems. Several challenges are there to construct this kind of systems, including the tasks eg. Digitization, segmentation, normalization, feature extraction, reorganization, and reconstruction. Here, an attempt has been made to recognize individual handwritten characters by the use of artificial neurons with feedback connection. The topology of the network is formed with two layers of artificial neurons, input and output. The neurons of output layer have a feedback connection from their output line.

Keyword— Handwritten Character Recognition, Artificial Neural Network, Competitive Learning, Feedback Neural Network.

1. INTRODUCTION

Now-a-days, there is always an intension to reduce the manual work of human being through some automated system. The same is also true for the documentation and document processing in the areas of banking, education, legal, hospital, retail, mailing, and many more. The major task in this field is recognition of handwritten characters either online or offline. Though the online character recognizing is complex enough, the later is much more challenging. Also the offline character recognition is much popular for researchers, not only because of its broad application area, but for its associated difficulties.

Several approaches was taken during many years by many researchers to recognize handwritten characters efficiently. Some of them are probabilistic methods [1, 2, 3], hidden markov model [4, 5], etc. Application of artificial neural network models to achieve this task brought revolution in this field. Various different neural network models are also been applied so far, including perceptron [6, 7, 8], MLP [9], back propagation [10, 11], ART [12], Competitive learning network [13, 14, 15], etc.

In this work, a network of artificial neurons has been constructed to recognize individual handwritten characters in offline mode. The network has two layers, one is to receive input to the network and other is to produce output. Each neuron in the output layer has feedback connection, i.e. output of the neuron is again given back to the neurons for learning purpose in the output neuron.

2. THE SYSTEM

This work is an attempt towards recognizing offline individual handwritten characters. The system takes the hardcopy characters as input and produces softcopy characters in the basis of the recognition, to word editors like notepad, MS-Word, etc.

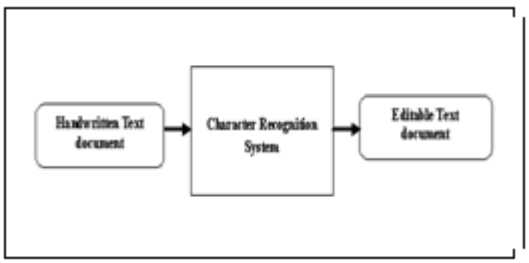

Figure 1: Handwritten Character recognition system

The system (Figure 1) performs several tasks before it employs the neural network to recognize it. The input characters for training or testing are written on a paper, and are converted into digital format by scanner, camera or some other image acquisition hardware. Those images are converted into a matrix of binary value and kept into a vector to feed them into the neural network. The recognized characters are put in a text file separately, so that the file can be edited afterwards by any word processor like MS- Word, etc. The conceptual block diagram of the system is shown in Figure 2.

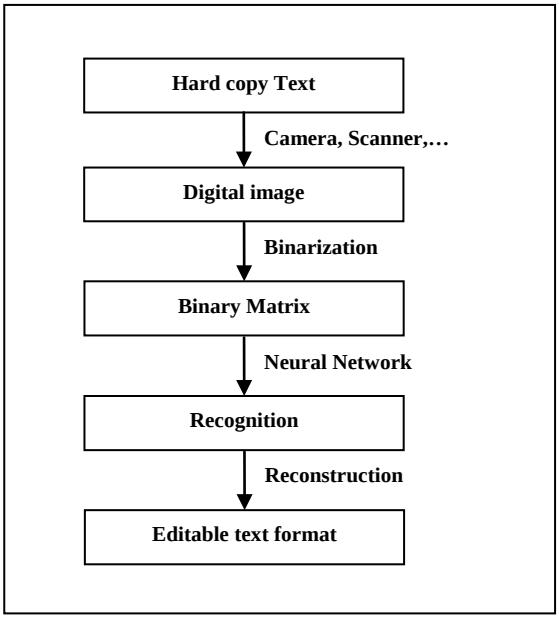

Figure 2: The conceptual block diagram of the system

3. NETWORK CONSTRUCTION

The network has two layers of neurons, input and output. The input layer contains 6400 neurons to receive input from 80x80 size binary matrix, representing a character image. Other layer, the output layer contains 26 neurons for identifying 26 capital alphabets of English language. Outputs from each of the output neuron are again fed to themselves. The input and output neurons are all connected with each other with connection lines assigned with some numerical value to represent connection strength (weights). Figure 3 depicts the mentioned network.

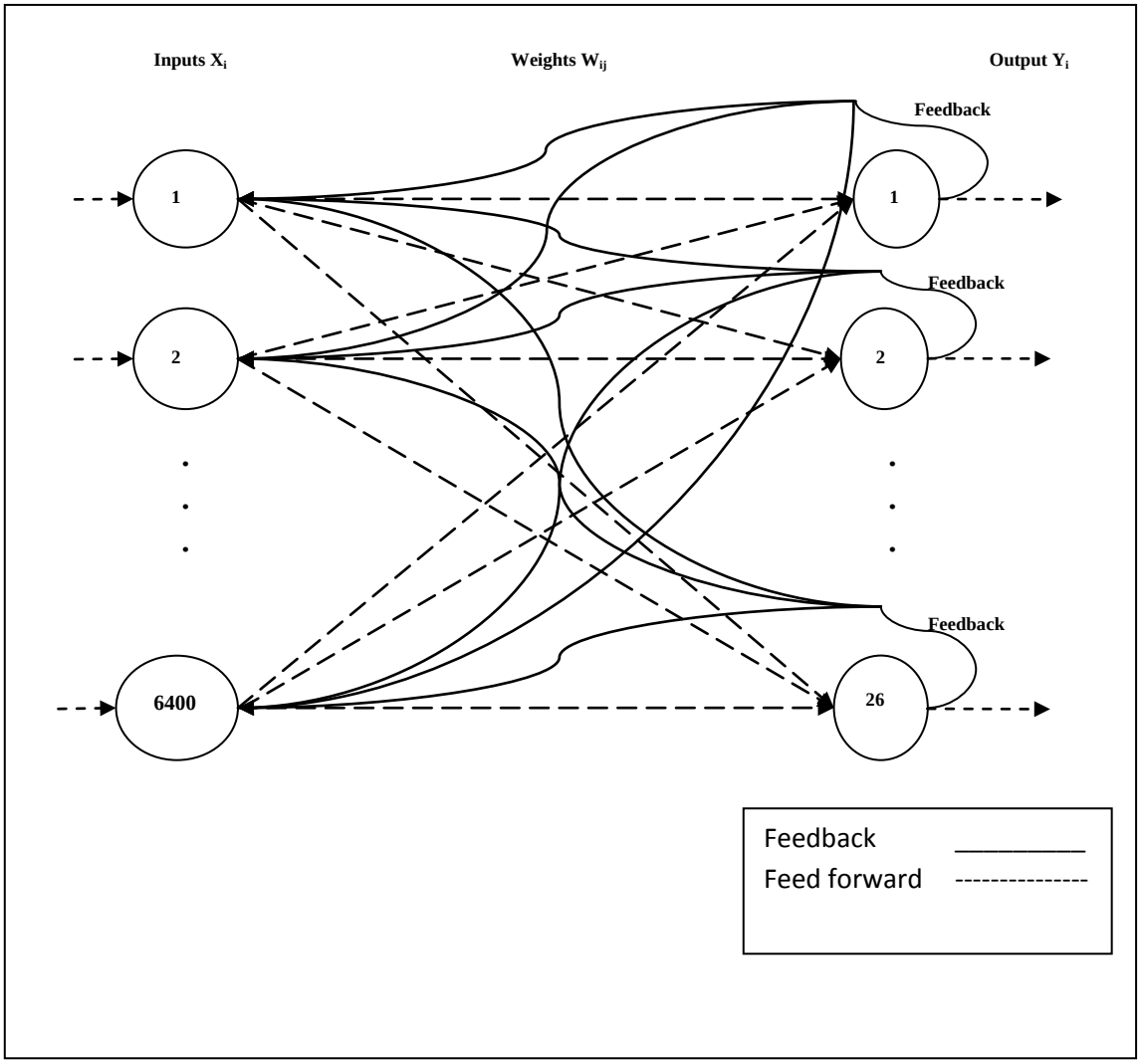

Figure 3: Neural network construction

4. TRAINING WITH THE NETWORK

To perform the recognition task the network needs to be trained first with some predefined standard character patterns. For this it uses competitive learning algorithm, which is an unsupervised form of learning method where every neuron competes with each other in the basis of their activation value. The connection weights towards the winner neuron get adjusted during training process. Initially all the connection weights are assigned with some random values during the training process these values are converged to some fixed values. The total training process is similar to am unsupervised training method.

4.1. Used Neural Network Parameters

1. Learning method = Competitive Learning
2. Layer = 2
3. Topology = Feedback
4. Number of Input neuron (X_i) = 6400
5. Number of output neuron(Y_j) = 26
6. Initial connection weight values (W_{ij}) = random
7. Value of learning constant (c) = 1

4.2. Training Algorithm

Step 1: Read input matrix in layer 1 (X_i).

Step 2: Calculate the activation value (AV_j) of each neuron in layer 2 using the following equation:

$$Av_j = \sum X_i * W_{ij}$$

Step 3: Find the neuron with maximum activation value and note it as max_index and save this index as a pair (input_id, max_index) with its corresponding input, named as input_id.

Step 4: Put the output of $Y_k = 1$ for the kth neuron with maximum activation value. Otherwise set all the output to zero i.e. $Y_j=0, j \neq k$.

Step 5: Update the connection weights for output neurons using the following formula

$$W_{ij}(new) = W_{ij}(old) + c(X_i + W_{ij}(old))Y_j$$

Step 6: Repeat the previous steps for all the inputs in the input vector.

5. Recognition with the Network

Once the training process completes, the trained network is capable of recognizing the characters for which it has been trained. Also, different variations of the character or distorted ones up to some extent are also identified by the system.

5.1. Recognition Algorithm

Step1: Take the pattern to be tested as input vector in layer 1 (X_i)

Step2: Calculate the activation value (AV_j) of each neuron in layer 2 using

$$Av_j = \sum X_i * W_{ij}$$

Step3: Find the neuron with maximum activation value.

Step4: Check the index of the neuron with maximum activation value in the saved (input_id, max_index) pair for matching.

Step5: If a match found, use the input_id to produce the recognized output.

Step6: Stop.

6. Result and Discussion

The system has been tested using Matlab software with some handwritten characters of 5 capital letters (A-E) only from English alphabet. Documents are scanned using HP office jet 6500 all in one scanner with 200 DPI resolution, black and white colour format and saved in jpeg image format. The images are kept saved in amatrix of size 80x80 pixels.

After the required training with some standard character patterns (Figure 4), the performance of the net has been tested with a number of differently handwritten characters. Some of the variations are shown in Figure 5 and the results are shown in Table 1. The feedback connection used in this network brings an extra robustness in learning process.

Figure 4: Sample characters for training

Unlike, some other system which uses perceptron, MLP, back-propagation, etc. supervised learning mechanisms to train the network; the system uses an unsupervised type of learning mechanism where the target output is not necessary to train the network.

Also, the methods mentioned above need several epochs to converge and during those epochs the connection weights are modified several times. But in the case of used feedback method number of epoch is equals to the number of training sample used. As in the output layer only one neuron have the value 1, while others are zero, the method also avoids the unnecessary weight modification via its feedback from the output neurons to the input ones.

Table 1: The testing results with the variations of representation of several characters of English alphabet.

Characters	No. of Variants	No of success	Percentage
A	10	9	90%
B	10	7	70%
C	10	8	80%
D	10	7	70%
E	10	7	70%

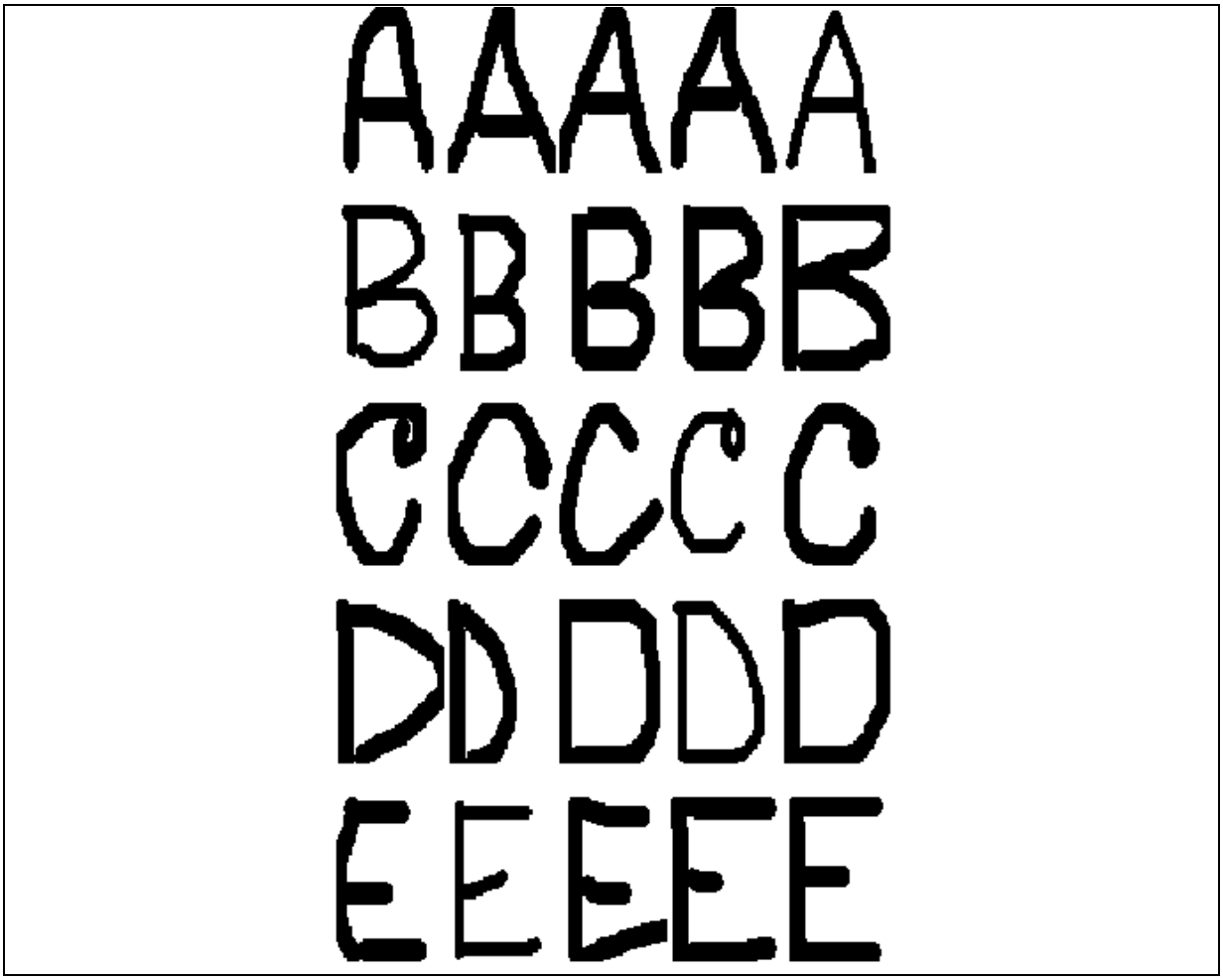

Figure 5: Sample character for testing

7. CONCLUSION

A simple handwritten character recognition system using a feedback neural network is proposed. Experimental result shows an efficient recognition. However, the proposed system is not a complete one. Some other techniques may be combined with this approach to increase the efficiency of the system. The work can be extended to recognize characters or numerals of some other languages also.

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