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HANDWRITTEN CHARACTER RECOGNITION SYSTEM USING ARTIFICIAL NEURAL NETWORKS

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ABSTRACT

In this paper, a Handwritten Character Recognition system is designed using Multilayer Feedforward Articial Neural Networks. Backpropagation Learning algorithm is prefered for training of neural network. Training set occures of various Latin characters collected from different people. The characters are presented directly to the network and correctly sized in pre-processing. Recognition percentage of the system is higher than acceptable level. Input datas, network parametres and training period effect the result.

Keywords: **:** *Character Recognition, Artificial Neural Networks, Backpropagation, Supervised Learning.*

1. ARTIFICIAL NEURAL NETWORKS (ANN)

A neural network is a computing paradigm that is loosely modeled after cortical structures of the brain. It consists of interconnected processing elements called neurons that work together to produce an output function. The output of a neural network relies on the cooperation of the individual neurons within the network to operate. Processing of information by neural networks is often done in parallel rather than in series. Neural network is sometimes used to refer to a branch of computational science that uses neural networks as models to either simulate or analyze complex phenomena and/or study the principles of operation of neural networks analytically.

The optical character recognition is one of the earliest applications of Artificial Neural Networks. Classical methods in pattern recognition do not as such suffice for the recognition of visual characters[1]. Because the 'same' characters differ in sizes, shapes and styles from person to person or time to time with the same person. And shapes of characters may be more noisy in different handwritings. ANN confirms adaptive learning by using previous samples and gains generalization capability. A neural system is able to work with noisy, unknown and indefinite data.

2. PRE-PROCESSING AND NEURAL NETWORK DESIGN

Taking precedence, the image acquisition of different handwritten characters is realized. We collected characters from approximately five hundreds distinct people. Each character was

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scanned properly. Hence they are are called images.
The character images need to be digitized to store on computer . The process of digitization involves scanning, adjusting the image, and uploading. A digital image is a picture represented electronically as bits or bytes. In this study digitized images are converted to binary (0 and 1) format.

Using pre-processor is inevitable in such systems. To represent an image with digits, grey scales of the image is used. Image frame consists 256 x 256 pixels and it has numbers between 0-256 that symbolize grey level of each point. Input image is converted to a binary matrix in image digitization [2]. The numbers between 0-256 turn 0 or 1 according to grey level. This expresses black-white image. White pixels are marked with 0 and blacks with 1.

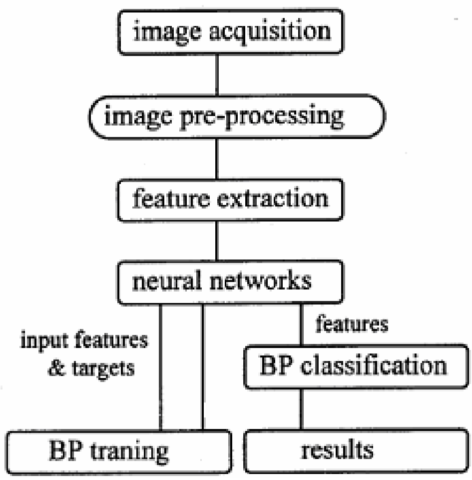

Figure 1 . *System Block Diagram*

The next step is image normalization. Then the images are trained with backpropagation learning algorithm until system error is acceptable. Thus the diagram of recognition system is developed as seen in Figure 1.

2.1. Feature Extraction

Feature extraction is the process of getting information about an object or a group of object in order to facilitate classification. The character from the scanned image is normalized from various sizes into 25 x 25 pixels as in Figure 2.

Normalization has the capability of extracting all of the invariant features from an image using only a small amount of information about the image.

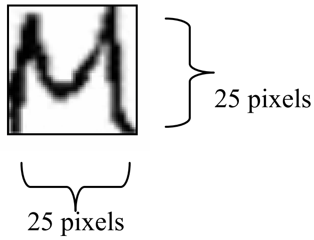

Figure 2. *A 25 x 25 'M' character*

Normalization is sometimes called contrast stretching[3]. Owing to normalization handwritten characters in different sizes are recognized. And system becomes size independent. So recognition performance rises although distinction in handwritings. In this system, characters are normalized to 25 x 25 matrices.

2.2. Neural Network Architecture

In multilayer perceptrons it is not possible to decide how many layers and neurons are optimum for any problem. Numbers of hidden layers and neurons in network are effective on system performance [4]. The most commonly used networks consist of an input layer, a single hidden layer and an output layer.

In our network system the input layer size is set by the type of pattern. Our training characters are on a 25 x 25 = 625 grid. Hence 625 pixels require 625 inputs in input layer (Figure 3). It means input layer consists of 625 neurons.

The number of hidden layer neurons needs to be experimented with for the best results. We reach this result after heuristic search in network to rise performance. Neuron number of hidden layer is 35.

Output layer has 26 neurons. Because there are 26 characters in Latin alphabet. Each output layer neuron set represents a character. Only first neuron target value is '1' and others are '0' for character 'A' . Only second neuron target value is '1' and others are '0' for character 'B'. And for character 'Z' only last neuron value is '1'.

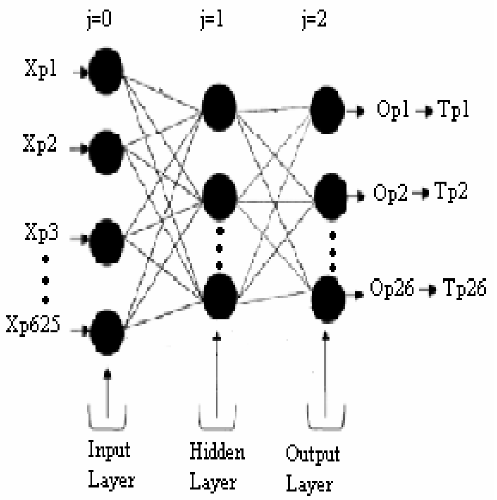

Figure 3. *Neural Network Architecture*

3. LEARNING MECHANISM

The network was trained with Backpropagation Learning algorithm[5]. Backpropagation network learns by examples. We give the algorithm examples of what we want the network to do and it changes the network's weights so that, when training is finished, it gives the required output for a particular input.

3.1. Backpropagation Algorithm

First the inputs are applied to the network and worked out the output. The initial weights are random numbers. The p th sample input vector of pattern $X_p = (X_{p1}, X_{p2}, \ldots, X_{pN0})$ and corresponding output target $T_p = (T_{p1}, T_{p}, \ldots, T_{pNM})$ is presented. The input values to the first layer are passed.

$$Y_{0i} = X_{pi} \quad (1)$$

For every neuron i from input to output layer, the output from the neuron is found:

$$Y_{ji} = f\left(\sum_{k=1}^{Nj-1} Y_{(j-1)k} W_{jik}\right) \quad (2)$$

Here f(x) is sigmoid activation function.

$$f(x) = \frac{1}{1+\exp(-x)} \quad (3)$$

For the output layer, the error value is:

$$\delta_{Mi} = Y_{Mi}(1 - Y_{Mi})(T_{pi} - Y_{Mi}) \quad (4)$$

And for hidden layers:

$$\delta_{ji} = Y_{ji}(1 - Y_{ji})\sum_{k=1}^{N_{j+1}} \delta_{(j+1)k} W_{(j+1)ki} \quad (5)$$

Weight change is:

$$\Delta W_{jik} = \beta \delta_{ji} Y_{(j-1)k} \quad (6)$$

β is a constant learning rate.

3.2. Training of Network

Backpropagation algorithm runs with a large data set about 1000 input characters. To train the network we begin to apply the first letter and change all the weights in the network. Next apply the second letter and do the same, then the third and so on (Figure 4) [6]. Once all 26 letters are done, we return to the first one again and repeat the process until the error becomes small.

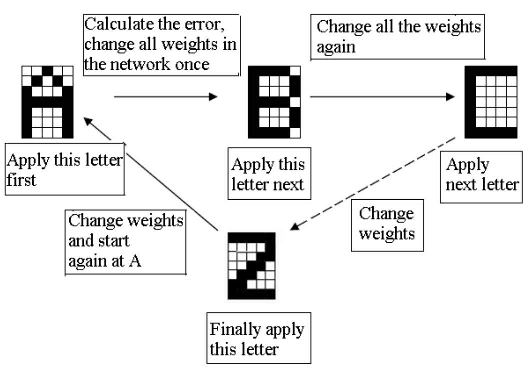

Figure 4 . *Running of the algorithm*

We stop training once the network can recognise all the letters successfully, so the error fall to a lower value first. This ensures that the letters are all being well recognised. We evaluate the total error of the network by adding up all the errors for each individual neuron and then for each pattern in turn to give a total error as shown in Figure 5.

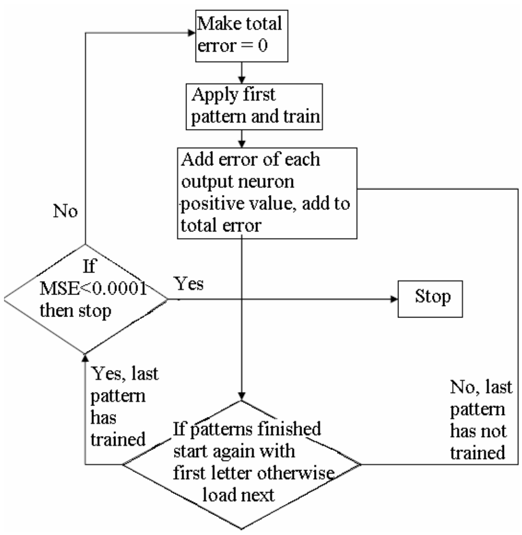

Figure 5 . *Training network and flow chart*

System has been trained until MSE (Mean Square Error) falls to 0,0001. Approximately after 120.000 iterations error reaches to an acceptable value (Figure 6). MSE decrease after epochs is shown in Table 1. MSE is defined below. P represents pattern number.

$$MSE = \frac{1}{2P}\sum_{p=1}^{P}\sum_{j=1}^{N_M}\left(T_j - O_j\right)^2 \qquad (7)$$

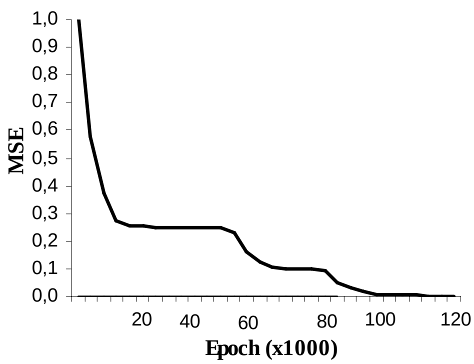

Figure 6.: *MSE- Epoch graphic*

Table 1.: *MSE decrease after epochs*

Epoch	MSE
4.000	1,0200
20.000	0,2524
40.000	0,2504
52.000	0,2283
60.000	0,1255
80.000	0,0913
100.000	0,007
120.000	0,00013

4. SIMULATION RESULTS

As the system error is small enough system training has stopped. In neural network system initial weights are between [-0,5] and [+0,5]. Learning parameter is chosen 0,2. For it has seen that system performance is higher with these values. About 500 handwritten characters have been used to test the recognition system. The target output layer neuron sets are shown in Table 2. Handwritten characters are classified acording to this table. At the end of the test step recognition performance of system is measured %83. Some characters are misclassified as shown in Figure 7.

Table 2.: *Output layer target neuron values*

Output Layer Neuron Values	Chr
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	A
0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	B
0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	C
0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	D
0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	E
0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	F
0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	G
0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	H
0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	I
0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	J
0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	K
0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0	L
....	.
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1	Z

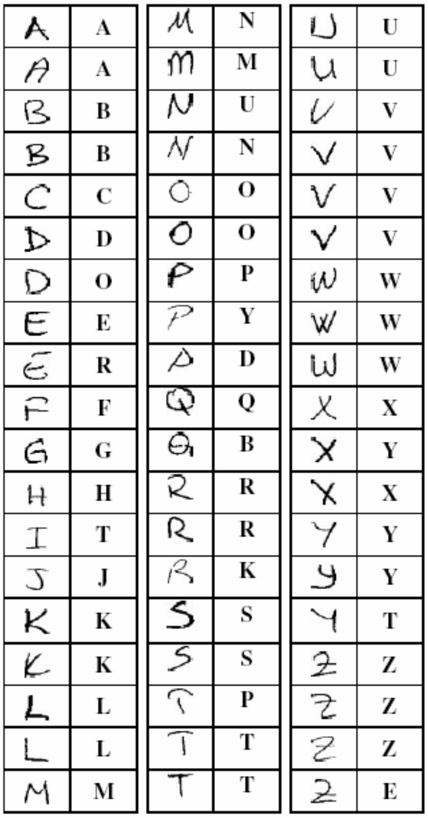

Figure 7 . *Classification of handwritten characters*

5. CONCLUSION

Artificial neural networks offer several advantages in character recognition despite the computational complexity involved. Because neural network systems can work with noisy and defected data. The experiment results show recognition rate is %83 for noisy data. The highest rates are achieved on restricted tasks, such as the %99 rate achieved on machine-printed characters. Because the characters are mostly same with each other. Because of training set images and test set images are similar, system can correctly and easily classify them. But in our system all of the characters have been written by people. Hence handwritten character shapes and sizes are different from person to person. This causes misclassification of characters and decrease the recognition rate. We can increase the rate by changing network topology and collecting datas with less noise.

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