Offline Character Recognition System Using Artificial Neural Network

Nisha Vasudeva, Hem Jyotsana Parashar and Singh Vijendra

***Abstract*—Advancement in Artificial Intelligence has lead to the developments of various "smart" devices. The biggest challenge in the field of image processing is to recognize documents both in printed and handwritten format. Character recognition is one of the most widely used biometric traits for authentication of person as well as document. Optical Character Recognition (OCR) is a type of document image analysis where scanned digital image that contains either machine printed or handwritten script input into an OCR software engine and translating it into an editable machine readable digital text format. A Neural network is designed to model the way in which the brain performs a particular task or function of interest. Each image character is comprised of 30×20 pixels. We have applied feature extraction technique for calculating the feature. Features extracted from characters are directions of pixels with respect to their neighboring pixels. These inputs are given to a back propagation neural network with hidden layer and output layer. We have used the Back propagation Neural Network for efficient recognition where the errors were corrected through back propagation and rectified neuron values were transmitted by feed-forward method in the neural network of multiple layers.**

***Index Terms*—Back propagation algorithm, character recognition, multi-layer perceptron, supervised learning.**

I. Introduction

The biometrics is most commonly defined as measurable psychological or behavioral characteristic of the individual that can be used in personal identification and verification. Character recognition device is one of such smart devices that acquire partial human intelligence with the ability to capture and recognize various characters in different languages. Character recognition (in general, pattern recognition) addresses the problem of classifying input data, represented as vectors, into categories. Character Recognition is a part of Pattern Recognition [1]. It is impossible to achieve 100% accuracy. The most basic way to recognizing the patterns using probabilistic methods in which [2] we use Bayesian Network classifiers for recognizing characters. The need for character recognition software has increased much since the outstanding growth of the Internet. Optical Character Recognition (OCR) is a very well-studied problem in the vast area of pattern recognition. Its origins can be found as early as 1870 when an image transmission system was invented which used an array of photocells to recognize patterns. Until the middle of the 20th century OCR was primarily developed as an aid to the visually handicapped. With the advent of digital computers in the 1940s, OCR was realized as a data processing approach for the first time. The first commercial OCR systems began to appear in the early 1950s and soon they were being used by the US postal service to sort mail. The accurate recognition of Latin-script, typewritten text is now considered largely a solved problem on applications where clear imaging is available such as scanning of printed documents [3, 4]. Typical accuracy rates on these exceed 99%. Total accuracy can only be achieved by human review. Optical Character Recognition (OCR) programs are capable of reading printed text. This could be text that was scanned in form a document, or hand written text that was drawn to a hand-held device, such as a Personal Digital Assistant (PDA). The character recognition software breaks the image into sub-images, each containing a single character. The sub-images are then translated from an image format into a binary format, where each 0 and 1 represents an individual pixel of the sub image. The binary data is then fed into a neural network that has been trained to make the association between the character image data and a numeric value that corresponds to the character. The output from the neural network is then translated into ASCII text and saved as a file. Recognition of characters is a very complex problem. The characters could be written in different size, orientation, thickness, format and dimension. This will give infinite variations. The capability of neural network to generalize and insensitive to the [6, 7] missing data would be very beneficial in recognizing characters. An Artificial Neural Network as the backend to solve the recognition problem. Neural Network used for training of neural network. Neural networks have been used in a variety of different areas to solve a wide range of problems. Unlike human brains that can identify and memorize the characters like letters or digits; computers treat them as binary graphics. The central objective of this paper is demonstrating the capabilities of Artificial Neural Network implementations in recognizing extended sets of image pixel data. In this paper offline recognition of character is done for this printed text document is used. It is a process by which we convert printed document or scanned page to ASCII character that a computer can recognize. A back propagation feed-forward neural network is used to recognize the characters. After training the network with back-propagation learning algorithm, high recognition accuracy can be achieved. Recognition of printed characters is itself a challenging problem since there is a variation of the same character due to change of fonts or introduction of different types of noises. Difference in font and sizes makes recognition task difficult if pre-processing, feature extraction

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and recognition are not robust.

This paper is organized as follows. Multilayer Perceptron Neural Network for Recognition is briefly described in Section 2. In section 3, Character recognition procedure is described. Section 4 training performance and accuracy of prediction is analyzed. Section 4 contains data description and result analysis. Finally, we conclude in Section 5.

II. Designing of Multilayer Neural Network For Recognition

There are two basic methods used for OCR: Matrix matching and feature extraction. Of the two ways to recognize characters, matrix matching is the simpler and more common. But still we have used Feature Extraction to make the product more robust and accurate. Feature Extraction is much more versatile than matrix matching. Here we use Matrix matching for Recognition of character. The Process of Character Recognition of the document image mainly involves six phases:

- Acquisition of Grayscale Image
- Digitization/Binarization
- Line and Boundary Detection
- Feature Extraction
- Feed Forward Artificial Neural Network based Matching.
- Recognition of Character based on matching score.

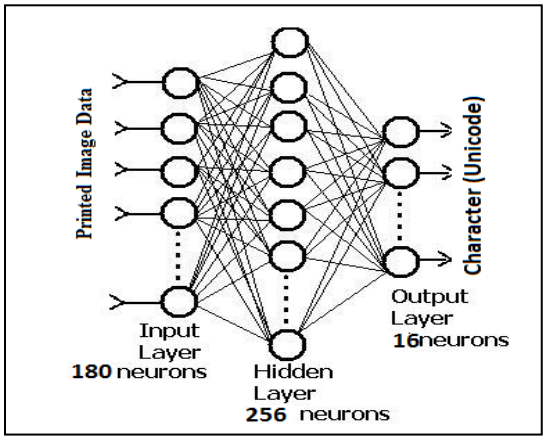

Fig. 1. Multilayer perceptron neural network

The scanned image must be [4, 5] a grayscale image or binary image, where binary image is a contrast stretched grayscale image. That grayscale image is then undergoes digitization. In digitization [12] a rectangular matrix of 0s and 1s are formed from the image. Where 0-black and 1-white and all RGB values are converted into 0s and 1s.The matrix of dots represents two dimensional arrays of bits. Digitization is also called binarization as it converts grayscale image into binary image using adaptive threshold. Line and Boundary detection is the process of identifying points in a digital image at which the character top, bottom, left and right are calculated. Feed Forward Neural Network approach is used to combine all the unique features, which are taken as inputs, one hidden layer is used to integrate and collaborate[9] similar features and if required adjust the inputs by adding or subtracting weight values, finally one output layer is used to find the overall matching score of the network.

III. Character Recognition Procedure

- Pre-processing**:-** The pre-processing stage yields a clean document in the sense that maximal shape information with maximal compression and minimal noise on normalized image is obtained.
- Segmentation: - Segmentation is an important stage because the extent one can reach in separation of words, lines or characters directly affects the recognition rate of the script.
- Feature extraction:- After segmenting the character, extraction of feature like height, width, horizontal line, vertical line, and top and bottom detection is done.
- Classification:- For classification or recognition back propagation algorithm is used.
  Output*:*-Output is saved in form of text format.

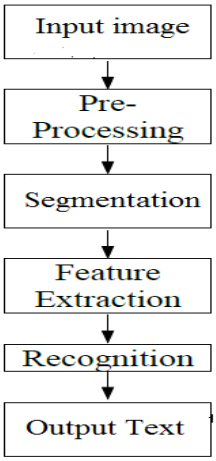

Fig. 2. Character recognition steps

IV. Training Algorithm Performance and Accuracy of Prediction

The back propagation algorithm requires a numerical representation for the characters. Learning is implemented using the back-propagation algorithm with learning rate. Gradient is calculated [10], after every iteration and compared with threshold gradient value. If gradient is greater than the threshold value then it performs next iteration. The batch steepest descent training function is trained. The weights and biases are updated in the direction of the negative gradient of the performance function. In order to determine quantitatively the model, two error measures is employed for evaluation and model comparison, being these: The model squared error (MSE) and the mean absolute error (MAE). If y_i is the actual observation for a time period t and F_t is the forecast for the same period, then the error is defined as

$$E_i = y_t - F_t \tag{1}$$

The standard statistical error measures can be defined as

$$MSE = \frac{1}{n} \sum_{i=1}^{n} e_{i=1}^{n} \tag{2}$$

And the mean absolute error as

$$\text{MSE}=\frac{1}{n}\sum_{i=1}^{n}\left|e_i\right| \quad (3)$$

where n is the *n*umber of periods of time .When the mean square error decreased gradually and became stable, and the training and testing error produced satisfactory results .the training performance curve of neural network. The accuracy of the trained network is tested against output data. The accuracy of the trained network is assessed in the following way: in first way, the predicted output value is compared with the measured values .The results are presented shows the relative accuracy of the predicted output. The overall percentage error obtained from the tested results is 4%. In the second way, the root mean square error and the mean absolute error are determined and compared. The performance index for training of ANN is given in terms of mean square error (MSE).The tolerance limit for the MSE is set to 0.001.The MSE of the training set become stable at 0.0070 when the number of iteration reaches 350. The closeness of the training and the testing errors validates the accuracy of the model.

V. Experimental Results

We create interface for proposed system for character recognition by using Microsoft Visual C # 2008 Express Editions. The MLP network that is implemented is composed of three layers input layer, output layer and hidden layer. The input layer constitutes of 180 neurons which receive printed image data from a 30x20 symbol pixel matrix. The hidden layer constitutes of 256 neurons whose [12] number is decided on the basis of optimal results on a trial and error basis. The output layer is composed of 16 neurons.

Number of characters=90, Learning rate=150, No of neurons in hidden layer=256

TABLE I: Percentage of Error for Different Epochs

No of epochs / Font Style	300	600	900
	Error		
Arial	3.44%	2.33%	1.11%
Tahoma	2.11%	1.11%	0
Times new Roman	0	0	1.11%
Bookman old style	2.11%	1.11%	0

Number of characters=90, Learning rate=150, No of epochs=900

TABLE II: Percentage of Error for Different Numbers Of Neurons

No of neurons in Hidden Layers / Font Style	64	128	256
	Error		
Arial	6.25%	2.33%	1.11%
Tahoma	1.11%	0	0
Times new Roman	2.33%	0	1.11%
Bookman old style	4.64%	2.24%	0

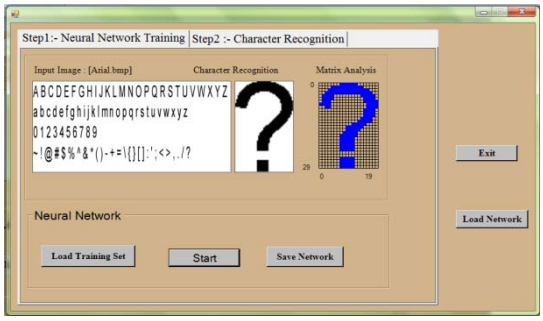

Fig. 3. Training Result

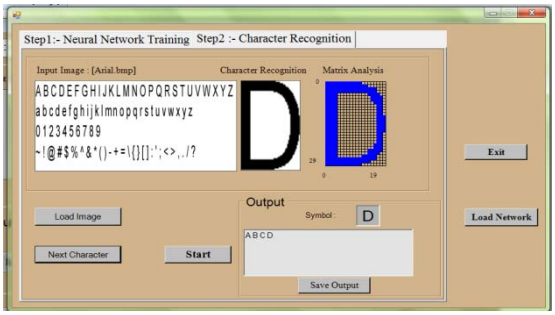

Fig. 4. Testing Result

VI. Conclusion

The important feature of this ANN training is that the learning rates are dynamically computed each epoch by an interpolation map. The ANN error function is transformed into a lower dimensional error space and the reduced error function is employed to identify the variable learning rates. As the training progresses the geometry of the ANN error function constantly changes and therefore the interpolation map always identifies variable learning rates that gradually reduce to a lower magnitude. As a result the error function also reduces to a smaller terminal function value. The result of structure analysis shows that if the number of hidden nodes increases the number of epochs taken to recognize the handwritten character is also increases. A lot of efforts have been made to get higher accuracy but still there are tremendous scopes of improving recognition accuracy.

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