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Off-Line Hand Written Character Recognition Using Radial Basis Function

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----------**ABSTRACT**----------

Handwriting has continued to persist as a means of communication and recording information in day-to-day life even with the introduction of new technologies. Given its ubiquity in human transactions, machine recognition of handwriting has practical significance, as in reading handwritten notes in a personal Digital Assistant (PDA), in postal addresses on envelopes, in amounts in bank checks, in handwritten fields, in forms etc. To solve the problem of writer identification with intermediate classes (writers) and objects (characters) , it is a good way to extract the features with clear physical meanings. The extracted features are in variant under translation scaling and stroke width.The off-line (which pertains to scanned images) is considered. Algorithms of preprocessing, character and word recognition, and performance with practical system are indicated. The recognition rate of Radial Basis Function (RBF) is found to be better compared to that of Back Propagation Network (BPN). The recognition rate in the proposed system lies between 90% to 100%.

Keywords: Neural Network, writer identification, back propagation and Radial Basis Function (RBF)

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1. INTRODUCTION

The identification of a person on the basis of scanned images of handwriting is a useful biometric modality with application in forensic and historic document analysis and constitutes an exemplary study area within the research field of behavioral biometrics. Writer recognition is the task of determining the author of sample handwriting from a set of writers and verifying the writer from the sample [1].

Research into writer identification has been focused on two streams, off-line and on-line writer identification [2]. Generally it is believed that text-independent writer identification is more difficult than text-dependent writer identification. Text-independent Offline writer recognition is more challenging than online writer recognition.

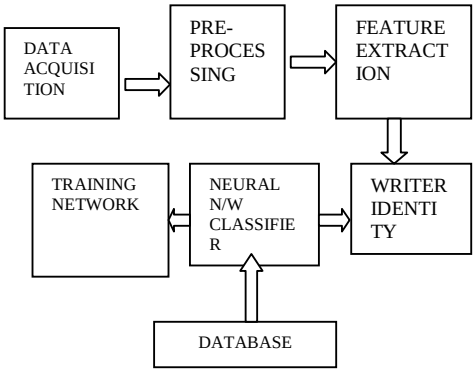
In the present system, we have extracted character level features from the scanned images of the characters written by different writers. For recognition purpose Back Propagation Neural Network (BPN) and Radial Basis Function (RBF) Networks are used.

2. LITERATURE SURVEY

Writer identification and verification methods fall into two broad categories: text-dependent versus text-independent methods [3]. The text-dependent methods are very similar to signature verification techniques and use the comparison between individual characters or words of known semantic (ASCII) content. These methods therefore require prior localization and segmentation of the relevant information, which is usually performed interactively by a human user. The text-independent methods for writer identification and verification use statistical features extracted from the entire image of a text block. A minimal amount of handwriting (e.g., a paragraph containing a few text lines) is necessary in order to derive stable features insensitive to the text content of the samples. Our approach falls in this latter category. From the application point of view, the notable advantage is that human intervention is minimized.

Volume: 02, Issue: 04, Pages: 792-795 (2011)

3. OVERVIEW OF THE SYSTEM



The major objective of the system under developed, is that it should be equally applicable to all languages. The features collected are text independent. Most of the features used are geometric features. We have used neural network for writer identification and verification [4]. In the following sections, we would explain in detail, each of the blocks in the above system.

Feature Extraction

Writer identity based on handwriting images requires three main processing steps.

1) Feature extraction

2) feature matching/feature combination

3) Writer identification and verification.

The following table gives an overview of the features used.

Feature	***Explanation***	***Computed From***
Aspect ratio	Ratio of width to height	Original Segmented image for each character
End Points	End points position, number, angle joining, distance between them	Thinned character
Junction	Junction position, number, angle joining, distance between them	Thinned character
Loop	The loop length, position, area, slant angle of loop,average radius of the loop, angle and distance between loop center and centroid of the character	Edge image
Contour direction	Directional PDF	Edge image
Moment feature vector	Features are extracted from the second and third order moments	Original Segmented image for each character

The features have been chosen so, that more accuracy is obtained, for less amount of training.

4. BACK PROPAGATION NEURAL NETWORKS

The training of a network by back propagation involves three stages [6]. The feed forward of the input training pattern, the calculation and back propagation of the associated error, and the adjustment of the weights. After training, application of the net involves only the computations of the feed forward phase. Even if training is slow, a trained net can produce its output very rapidly. Numerous variations of back propagation have been developed to improve the speed of the training process.

4.1 RADIAL BASIS FUNCTION NETWORKS

Radial basis functions are embedded into a two-layer feed-forward neural network. Such a network is characterized by a set of inputs and a set of outputs. In between the inputs and outputs there is a layer of processing units called hidden units. Each of them implements a radial basis function. The way in which the network is used for data modeling is different when approximating time-series and in pattern classification. In the first case, the network inputs represent data samples at certain past time-laps, while the network has only one output representing a signal value. In a pattern classification application the inputs represent feature entries, while each output corresponds to a class as shown in Fig.

An RBF network contains the following:

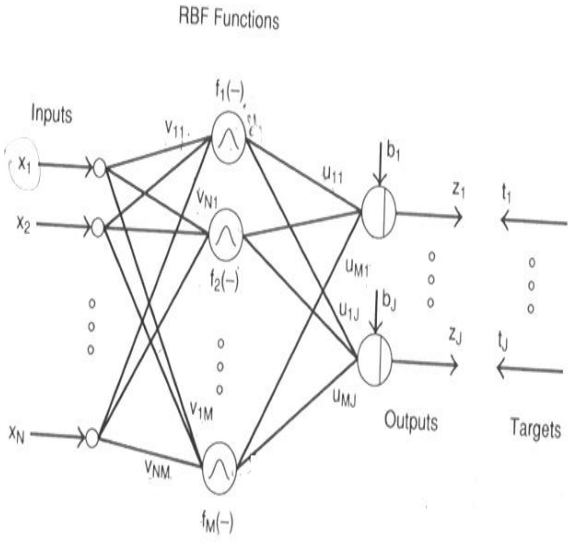
I. An input layer of branching nodes, one for each feature component, just as does in MLP.

II. A hidden layer of neurodes where each neurode has a special type of activation function centered on the center vector of a cluster or subcluster in the feature space so that the function has non negligible response for input vectors close to its center.

III. An output layer of neurodes that sum outputs from the hidden neurodes, that is , the output layer neurodes use a linear activation function.

Volume: 02, Issue: 04, Pages: 792-795 (2011)

Schematic diagram of RBF Network



5. IMPLEMENTATION AND RESULTS

5.1 IMPLEMENTATION

The features extracted from the writing sample are then used to train the neural network. The features used in our program vary with the character being used to train the network, so instead of defining a specific length for the features, we keep a threshold for each of the feature and construct a feature vector with some redundant values.
The maximum length of feature vector for each feature is given below:

Aspect Ratio—1

Max. Number of features from end-points—14

Max number of features from t-junctions—14

Max number of features from hole—25

Number of features from moments —3

Length of angle histogram—10

It is to be noted that though we extracted 7 features from moments[7], only 3 of them are used; as the remaining don't give the required inter writer variability. The unused values in the feature vector are initialized to zero.

Combining all of the features given above, a feature vector of length 76 is constructed and given as input to each to the neural network. The input to the neural network should in the range of (-1, 1). So the features extracted are scaled down before giving them to the neural network.
The values of the features extracted for 3 different writers, for the character 'A' are given below:

The neural network creates as many output neurons as there are writers, and the output of the neural network is such that the corresponding neuron is activated for the writer, in that order.

	Writer1	Writer2	Writer3
Target	1.000000	0.000000	0.000000
Vector	0.000000	1.000000	0.000000
	0.000000	0.000000	1.000000

It is to be noted that here have taken output target as 0.5 instead of 1 (which is normally taken) as our algorithm requires the values to be within the range of (-1, 1). For testing the network, a test image from same writer's database is taken and given as input to the system. The output of the neural network is a continuous range of value. For writer identification, minimum distance classification is used.

Character	Back Propagation Network (BPN)				Radial Basis Function Network(RBN)			
	Writer1	Writer2	Writer3	Time taken to train system for 3 writers	Writer1	Writer2	Writer3	Time taken to train system for 3 writers
A	75	86	80	1012	83	90	89	480
J	79	82	87	1910	84	86	96	985
S	74	70	80	2140	90	80	95	1543
Average	86.33	80.66	82.33	2120.66	94	92	93.33	1054.33

Combining all the features given above, a feature vector of length 76 is constructed and given as input to each neural network. The input to neural network should be in the range of (-1, 1). So the features extracted are normalized before giving them to neural network.
Time taken for training Neural Network: The table below gives time taken by each of the network to train for 3 writers. The times are given in terms of ticks of the processor clock.

Time taken for RBF to train for 3 writers	1054.33
Time taken for Back Propagation Network to train for 3 writers	2120.66

6. CONCLUSION

In this Paper, we have presented a writer identification and recognition system that utilizes Radial Basis Function (RBF) in the Off-line mode. Our approach is text independent and uses text lines as basic entities, from which features are extracted. For each writer we train a recognizer and present unknown input text line to each recognition system. While testing the system it has been observed that accuracy for RBF is more than 90%. In our future work we plan to test the system on a larger database including a larger number of writers.

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