Handwritten Character Recognition using Wavelet Transform for Feature Extraction

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Handwritten Character Recognition using Wavelet Transform for Feature Extraction

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Abstract: - Handwritten Character Recognition is one of the important area of pattern recognition. In this paper 13 sets of handwritten characters are collected from different users; features are extracted by using multilevel 2 dimensional wavelet decomposition technique. Wavelet families used are Daubechies and Reverse Biorthogonal. Wavelet decomposition is done up to three levels i.e. level 6,7 & 8.Features obtained are then train in WEKA3.6 machine learning software for different classifiers like Multilayer perceptron, K-Nearest Neighbor, Naive Byes Results obtained for different classifiers are compared with each other. It is observed that multilayer perceptron gives accuracy of 92%for 8th level of decomposition and 98% for 6th level of decomposition. Confusion matrix shows that there is confusion between characters with similar shape like O and 0, S and 5.

Keywords: - Character recognition, DWT, multilayer perceptron, Decision tree neural network.

I.INTRODUCTION

Number of algorithms performing task of Handwritten Character recognition are developed in last few decades each having its own strengths and weakness.

One of the important applications of Handwritten Character recognition is automatic mail sorting as well as recognition of account checks. Many reports of character recognition in English have been published but still high recognition accuracy and minimum training time of handwritten English characters using neural network is an open problem. Therefore, it is important to develop an automatic handwritten character recognition system for English language.

A system capable of recognizing handwritten characters or symbols, inputted by the means of a mouse is explained by Devireddy and Apparao [1]. Rivals and Personnaz explained a novel model selection procedure for neural networks based on least squares estimation and statistical tests [2]. Pattern recognition using probabilistic methods by using Bayesian decision theory is mentioned by Liou & Yang [3].One of the method of pattern recognition is by using k-nearest neighbor algorithm which is discussed by Didaci and Giacinto [4]. Discrete wavelet transform and discrete cosine transform are used for feature extraction by Lawgali, Bouridane [5].A General view of statical pattern recognition can be found in [6].A good survey of different classification techniques is found in [7].

II. SYSTEM DESIGN

The functional blocks of Handwritten Character recognition System includes Data Collection, Registration, Preprocessing, Feature Extraction, and Classification as shown in figure 1.

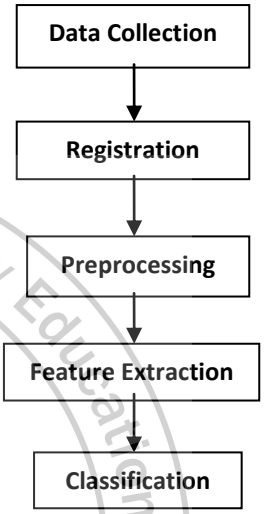

Figure1. Block Diagram of character recognition system

Data collection is done with the help of digital pen tablet which can be easily interface with PC.13 sets of samples including 26 upper case letters and 10 numerical digits are collected from 13 different users of different age groups each having different writing style. The registration process defines the framework in which our system operates so that it know what to expect as valid input. Data is then preprocessed to simplify pattern recognition problem without throwing away any important information. Multilevel 2 dimensional wavelet decomposition techniques with following two wavelet families for different levels of decomposition are used for feature extraction.

- Daubechies
- Reverse Biorthogonal

Coefficients obtained after feature extraction are then classified by using different classifiers in WEKA machine learning software

III.IMPLEMENTATION

A. Data Collection:

The first stage in any pattern recognition system is data collection. Before a pattern is made up of a set of measurement, these measurements need to be performed using some technical equipment and converted to numerical form. In the case of character recognition, such equipment includes video camera, scanners or digital board. As mansion in section II characters are generated with the help of digital notepad which will generate .jpg file. We have collected 13 sets of 36

characters from 13 different users, thus total we have 468 character samples.

B. Registration:

If captured images are in RGB scale. These images have to be converted into grayscale format before further processing. Using appropriate grayscale thresholding; binary images are to be created. So that it will be easy to convert gray images in to binary without loss of information.

C. Preprocessing:

Real world input data always, contains some amount of noise. One of the primary reasons preprocessing is to reduce noise and inconsistent data. Noisy data can obscure the underlying signal cause confusion, especially if the key input variable is noisy. Preprocessing can often reduce noise and enhance the signal.

D. Feature Extraction:

Discrete Wavelet Transform is used for Feature extraction up to 6, 7 and 8 level of decomposition. Features are extracted by using two different wavelet families which are Daubechies Reverse Biorthogonal wavelet family.
Figure 2 shows image obtained for 6th level of decomposition for both type of wavelet families

Figure 2: Reconstructed image for 6th level of wavelet decomposition for Daubechies & Reverse Biorthogonal wavelet family respectively.

Feature size for Daubechies wavelet family for 6th level of decomposition is 11x21, for 7th level of decomposition is 6x11 and for 8th level of decomposition is 3x6 and for Reverse Biorthogonal wavelet family for 6th level of decomposition is 15x25, for 7th level of decomposition is 10x15 and for 8th level of decomposition is 7x10.Feature vectors obtained are then converted in .arff file format. .arff file is attribute relation file format require for WEKA3.6 machine learning software for classification process.

E. Classification

WEKA 3.6 Machine learning software is used for classification purpose. Advantage of using WEKA is that we can select different classifiers and observe their performance. For WEKA data can be imported from a file in various formats: ARFF, CSV, C4.5, binary. MATLAB code will directly generate input file in .csv file or .arff file

Following Classifiers are used to classify features
1. Multilayer perceptron.
2. Decision Tree (J48)
3. K-nearest neighbours' classifier**. (K=1)**
4. Naive Bayes

Multilayer Perceptron model generated for 7th level of decomposition is as shown in Figure3.

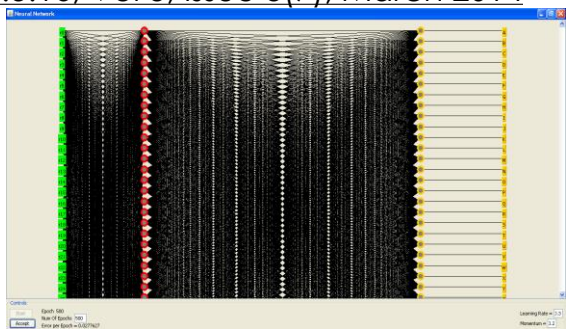

Figure. 3 .Multilayer perceptron generated for 7th level of decomposition

Classification is done by four different methods as follows

1. Use as a training set: - The classifier is evaluated on how well it predicts the class of the instances it as trained on.
2. Supplied test set: - The classifier is evaluated on how well it predicts the class of a set of instances loaded from a file.
3. Cross-validation: - The classifier is evaluated by cross-validation, using the number of folds that are entered in the Folds text field.
4. Percentage split: - The classifier is evaluated on how well it predicts a certain percentage of the data which is held out for testing. The amount of data held out depends on the value entered in the % field. [8][9].

Out of 13 sets, 10 sets are used as a training set and remaining 3 sets are used as a test set when using first 2 methods of classification. We have used 10 folds Cross-validation. When using percentage split 66% of data held out for testing.

F. User Interface to the system by GUI

In computing, a graphical user interface(GUI) is a type of user interface that allows users to interact with electronic devices using images rather than text commands. A GUI is a pictorial interface to a program. A good GUI can make program easier to use by providing them with a consistent appearance, and with intuitive controls [10].A MATLAB GUI is developed for easy interface of the user to the system; figures.4 shows GUI created in MATLAB.

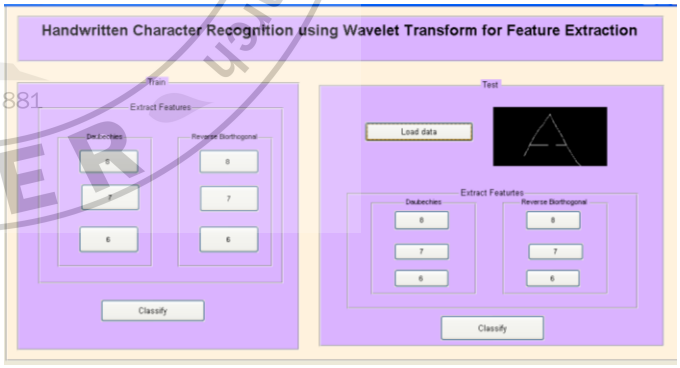

Figure 4. MATLAB GUI

IV. RESULT

Testing is done in two ways, firstly test data not included in training data (unseen data) and secondly test data included in training data(seen data). Following tables shows results for different classifiers and for different feature extraction methods.

Feature size for Daubechies wavelet family for different levels of decomposition is as follows

- For 6th level feature size is 231
- For 7th level feature size is 66
- For 8th level feature size is 18

Feature size for Reverse Biorthogonal wavelet family for different levels of decomposition is as follows

- For 6th level feature size is 375
- For 7th level feature size is 150
- For 8th level feature size is 70

Table1.Percentage of correctly classified characters for unseen and seen data when features are extracted up to 8th level of decomposition

Sr. No	Wavelet family	Daubechies		Reverse Biorthogonal	
	Classifier used	%Accuracy		%Accuracy	
		Unseen data	Seen data	Unseen data	Seen data
1	Decision Tree	34	88	37	88
2	Naive Bayes	42	59	26	54
3	KNN	56	100	56	100
4	MLP	48	92	52	98

Table2.Percentage of correctly classified characters for unseen and seen data when features are extracted up to 7th level of decomposition

Sr. No	Wavelet family	Daubechies		Reverse Biorthogonal	
	Classifier used	%Accuracy		%Accuracy	
		Unseen data	Seen data	Unseen data	Seen data
1	Decision Tree	43	89	44	91
2	Naive Bayes	50	84	46	81
3	KNN	74	100	79	100
4	MLP	61	100	68	98

Table3.Percentage of correctly classified characters for seen and unseen data when features are extracted up to 6th level of decomposition

Sr. No	Wavelet family	Daubechies		Reverse Biorthogonal	
	Classifier used	%Accuracy		%Accuracy	
		Unseen data	Seen data	Unseen data	Seen data
1	Decision Tree	37	89	87	24
2	Naive Bayes	57	97	97	60
3	KNN	55	100	100	57
4	MLP	64	98	68	98

Table 4.Percentage of correctly classified characters for Cross validation

Sr. No	Wavelet family	Daubechies			Reverse Biorthogonal		
	Decomposition level	6	7	8	6	7	8
1	Decision Tree	44	58	55	42	57	53
2	Naive Bayes	61	61	47	59	56	38
3	KNN	56	71	66	53	68	62
4	MLP	58	78	66	54	76	66

Table5.Percentage of correctly classified characters for Percentage split

Sr. No	Wavelet family	Daubechies			Reverse Biorthogonal		
	Decomposition level	6	7	8	6	7	8
1	Decision Tree	32	49	48	32	47	52
2	Naive Bayes	52	53	50	48	55	47
3	KNN	46	66	59	44	64	58
4	MLP	58	78	58	54	76	66

V. CONCLUSION

Percentage accuracy of correctly classified characters is more for seen data than unseen data. MLP and KNN classifier gives 100 % accuracy for seen data .From first three tables it is observed that Reverse Biorthogonal wavelet family gives better results than Daubechies wavelet family.

If level of decomposition of DWT is decreased then percentage accuracy will increase on the other hand time require to build model will increase with decrease in decomposition level because large feature size. Compared to other classifiers MLP will require highest time to build model. Thus there is tread off between Classification accuracy and training speed. If we want high accuracy, speed will be bit slow and if we want high speed we have to compromise with accuracy.

Table 4 and 5 shows that maximum accuracy is obtained when decomposition is done at 7th level for 10 fold cross validation and for 66% percentage split. Confusion matrix shows that there is confusion between similar shape characters like F and P, S and 5, R and K.

VI. FUTURE SCOPE

The system can be implemented for recognition of small case letters as well as Devnagari characters and cursive handwriting. In order to align recognized characters in a line MDT (Minimum distance Technique) can be used [11]. One approach to increase accuracy and reduce training time is combining multiple independent feature sets and Classifiers , where the weakness of one method is compensated by the strength of another, may improve the recognition of individual characters. Promising techniques within this area, deal with the recognition of entire words instead of individual characters.

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