International Journal of Enhanced Research in Science, Technology & Engineering
ISSN: 2319-7463, Vol. 4 Issue 9, September-2015

Offline handwritten and printed Urdu digits recognition using Daubechies Wavelet

Ratan Borse[1], Imtiyaz Ansari[2]

[1]Department of Electronic Science, M. S. G. College Malegaon Camp, Maharashtra, India
[2]Department of Computer Science, M. S. G. College Malegaon Camp, Maharashtra, India

ABSTRACT

This paper presents an optical character recognition system for Urdu Language Digits (Handwritten and Printed). A lot of work has been done in recognition of characters and numerals of various languages like Devanagari, English, Chinese, and Arabic etc. But in case of Urdu Digits very less work has been reported. Different Daubechies Wavelet transforms are used in this work for feature extraction. Total 4000 samples of digits- Handwritten and Printed have been used. The back propagation neural network has been used for classification. An average recognition accuracy of Handwritten Digit is 92.07% and for Printed Digit is 99.95% been achieved.

Keywords: Daubechies Wavelet Transforms, Feature Extraction, Handwritten Digits, Printed Digits, Zonal Densities.

1. INTRODUCTION

To recognize handwriting digit is not a difficult task for human, but for a computer, it could be very difficult. The problem is how to program a computer to do that kind of task. With conventional approach, it is very difficult to formulate the solution, but the intelligent approach has been developed for this kind of job. Handwritten digit recognition and pattern analysis is one of the active research topics in digital image processing. The technology is leaping into so much advancement that image recognition will become part and parcel of our daily lives. Applications such as Ultra sound, MRI use image processing to detect broken bones, tissues, Tumours and various kind of diseases and are used for various other industrial applications Contemporary it is used for detecting airport luggage scanning and for detecting the quality of food grains to detect fungi and other micro diseases.. So now in modern era image processing is used for security reasons through thumb print recognition, eye retina detection and then for crime detection it is also used for face recognition.
Satellite imagery is used to detect crop growing patterns, their cultivated area, advance warning to farmers in Australia is given for pesticide and disease. One of the state of the art applications is the cruise missile guidance system developed by US Defence to Map the territory for possible accurate target selection by using GIS and image processing. Imaging for medical reasons CT- Scan, MRI and Ultra Sound is now a days a common content in the patient's medical history, detection of fungi is good topic to research. Researchers have put lot of effort in image processing. Different approaches have been used for handwritten recognition, feature extraction [1], by using Fourier transformation [2], using support vector machine (SVM) and using classifier [3]. On the contrary in this research hand written digit recognition is done through giving a cognitive thinking process to a machine by developing a neural network based AI engine, which recognizes any digit. The same technique can be further used in any application for signature verification or hand writing recognition or other bio metric applications. In the approach of feature extraction [1] the features are basically direction features accepted by code feature, gradient feature or by Sobel and Krish operators. Fourier Transform [2] feature extraction is based on sum and difference. SVM classifier [3] used rule based reasoning for digit recognition. The cited methodologies make use of mathematical formulas or complex mathematical or statistical formula to process image and it is repeated during each transaction of image processing.

The idea of using Neural network based AI engine is unique and simple to use. It only requires one time training of the neural network where as in cited methodologies whenever there is an image to process all steps are repeated again and again for image pre-processing which uses important cycle time and takes longer time intervals to recognize each digit.[12] AI Engine based approach is customizable, and adaptable to be used for any generic image recognition application. i.e. signature recognition, face recognition or thumb print recognition . Image Processing does not end over here but now it has added and other dimension of neural network or one may call machine vision which has giving an ability to machines of digit recognition similar to that of human cognitive thinking process. Neural Signatures through neural network training give a cognitive power to machines / computers to think like human brain and identify images with the help of image neuron in the same way as human cognitive or thinking process works for signal processing.

Neural imaging has not only given precision to Identification of different images but it has also greatly enhanced the speed of Image Recognition. Previously large amounts of memory and processor time was used for Image processing but now Memory size or image size have been taken out of this equation and Image processing has become efficient due to implementation of neural networks to computers to identify images through neural imaging or neural signature.[8,9]

2. LITERATURE REVIEW

S. A. Husain, AsmaSajjad, Fareeha Anwar, [13] presented a method for recognition of online Cursive Urdu hand written Nastaliq Script. The system was currently trained for 250 ligatures. The Recognition rate of base ligatures was 93% and of the secondary strokes was 98%. Sabri A. Mahmoud and Sameh M. Awaida [14] had presented a system for automatic independent writer off-line handwritten Arabic (Indian) numeral recognition, based on a quasi-multi resolution approach to feature extraction using SVM. The database had 44 writers with 48 samples of each digit samples. The recognition results of SVM were compared to those of the HMM classifier. The achieved average recognition rates were 99.83% and 99.00% using, respectively, the SVM and HMM classifiers. Yuval Netzer, Tao Wang, Adam Coates, Alessandro Bissacco, Bo Wu, Andrew Y. Ng.[15] had presented the problem of recognizing digits in a real application using unsupervised feature learning methods: reading house numbers from street level photos. To this end, we introduce a new benchmark dataset for research use containing over 600,000 labeled digits cropped from Street View images.

Mohamed Abaynarh, Hakim Elfadili, Khalid Zenkouar, and LahbibZenkouar [16] had used Legendre moments features for recognizing Amazighe characters. The system showed good performance (97%) on a database of 7524 handwritten Amazighe characters. Mohamed Abaynarh, Hakim Elfadili and LahbibZenkouar had [17] presented unconstrained handwritten Amazighe character recognition based upon orthogonal moments and neural networks classifier. The result shows that if the number of hidden nodes increases the number of epochs (iterations) taken to recognize the handwritten character is also increases. The proposed system extracts moments features from character images and accuracy achieved is 97.46%. Mostofa Kamal Nasir and Mohammad Shorif Uddin [18] developed a method that was based on preprocessing, kmeans clustering, Bayesian theorem and SVM. Number of sample digits was 300.Success rate achieved was 99.33%. Ban N. Dhanoon and Huda H. Ali [19] proposed a method for handwritten numerals recognition. The method was simply depends on determining number of terminal points and its positions for each digit in its different shapes, that represent the main feature for recognition. The proposed method was based on structural primitives such as curve, line, point type etc. in a manner similar to that in which human beings describe characters geometrically.

Anilkumar N. Holambe [20] developed a system for extracting feature of handwritten and ISM printed characters of devanagri script. Sobel and Robert operator were used for extracting Gradient feature of the devanagari script .In this System computing gradient used was 8,12,16,32 directions and getting different feature vectors. Vikas J Dongre [21] has given a review of various techniques used for feature extraction and classification of Devnagari character recognition. The various feature extraction techniques like Fourier transforms, wavelets, zoning, projections etc has been discussed. Raju G. [22] has proposed an OCR system for Malayalam characters. The proposed feature extraction method has used different wavelet filters and MLP network has been used as classifier. An average recognition rate of 81.3% has been achieved. M Abdul Rahiman, M S Rajasree [23] has also proposed a Malayalam OCR system. The proposed system has used Daubechies wavelet (db4) for feature extraction and neural networks for recognition. The system has been given an accuracy of 92%.

G S Lehal and Chandan Singh [24] has given an OCR system for printed Gurmukhi script. The feature extraction has been done using the structural features and binary classifier trees and nearest neighbour classifier has been used. It has been found that an accuracy of 96.6% has been obtained. Syed. Afaq Husain and Syed. Hassan [25] had presented a paper for the off-line recognition of cursive Urdu Text. The methodology had been developed for the Noori Nastaliq Script. Word (Ligature) based dentification had been adopted instead of character based identification. A multi-tier holistic approach had been utilized to recognize ligatures from a pre-defined ligature set. The system was currently trained for a small number of ligatures. Abdurazzag Ali ABURAS and Salem M. A. REHIEL [26] were proposed a new structure of off line OCR system which uses the wavelet image compression 40x40 bitmap image as input this produces a decomposition vector for each character. These vectors can uniquely represent the corresponding characters. Haar Wavelet transform used. The wavelet of level three of details was applied since higher level of details did not give better results. Average accuracy achieved was average 80%.

3. RESEARCH METHODLOGY

A. Digital Image representation

The ten Urdu language digits with their English digits equivalence are shown in Fig.1. Recognition of Handwritten and Printed Urdu digits is a complicated task due to the cursive and unconstrained shape variations, different writing style and different kinds of noise that break the strokes primitives in the character or change their topology. The digit writing stroke, length, width, orientation and other geometrical features of a digit changed while writing the same digit. Fig. 2

represents Printed Urdu Digits and Fig. 3 shows variation in handwriting of same writer are shown with respect to every attempt.

English Digit	Urdu Digit	English Digit	Urdu Digit
0	۰	5	۵
1	۱	6	۶
2	۲	7	۷
3	۳	8	۸
4	۴	9	۹

Figure 1: English and Urdu Digits with their Equivalence

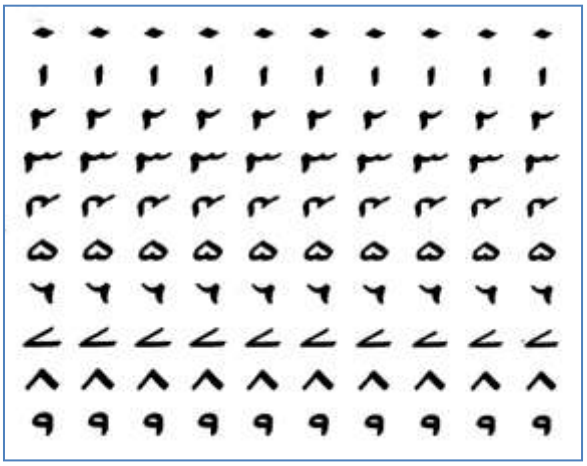

Figure 2: Printed Urdu Digit Samples

Figure 3: Handwritten Urdu Digit Samples

B. Database Construction

The handwritten Urdu Digit samples are taken from different writers. There are total 2150 handwritten digit samples which have been used in the proposed recognition system. 2000 samples have been used for training of neural network and 150 samples have been used for testing. These samples are taken by scanning the handwritten digits at 400 dpi. One Person's Digit sample is shown in fig. 3.

For printed digits, 10 different font with 2 style (Normal and Bold) each digit (0 - 9) is printed on paper and scanned at 400 dpi resulting a database of size 2000 samples as 10 different fonts x 20 (style) x 10 (ten digits) = 2000 printed digit samples of Urdu language.
These samples are used for training the purpose and 150 samples are used for testing purpose. There are total 2150 samples which have been used in the proposed recognition system.

C. Training and Testing the Neural Network

There are two steps in building a classifier: training and testing see Fig. 4.

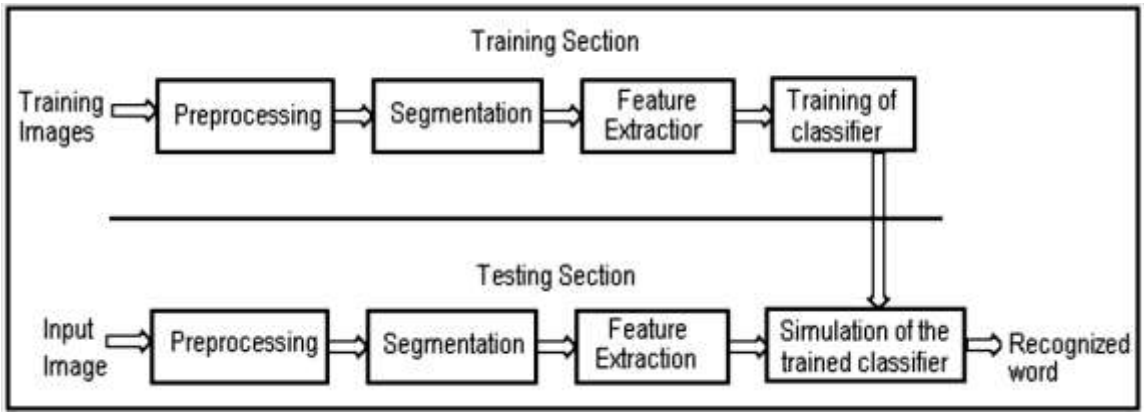

Figure 4: steps for building the Neural Network

These steps can be broken down further into sub-steps.

1. Training
a) Pre-processing - Processes the data so it is in a suitable form.
b) Segmentation - dividing image to segments
c) Feature extraction - Reduce the amount of data by extracting relevant information, usually results in a vector of scalar values. (We also need to NORMALIZE the features for distance measurements!)
d) Model Estimation/ Training Classifiers- from the finite set of feature vectors, need to estimate a model (usually statistical) for each class of the training data.

2. Testing
a) Pre-processing
b) Segmentation
c) Feature extraction - (both same as above)
d) Simulation/Classification of trained Classifier - Compare feature vectors to the various models and find the closest match. One can use a distance measure.

In the pre-processing stage the Recognition system has given a raw scanned colour image then following operations has been performed on it:
1. Conversion of color image in to grey image.
2. Median filtering is performed to the image to remove noise[4].
3. The image then converted in to the binary image using thresholding.
4. The binary character image is normalized to 64*64.

Wavelets are localized basis functions which are translated and dilated versions of some fixed mother wavelet. The decomposition of the image into different frequency bands is obtained by successive low-pass and high pass filtering of the signal and down-sampling the coefficients after each filtering. In this work Daubechies (db1, db2, . . . db10) discrete wavelet transforms are used [5, 6].

The feature extraction is done by using the following algorithm:

For each pre-processed image following steps have been repeated:
a. Number of black pixels along each row of the binarized image has been counted to form a 32 sized vector.
b. The 1D wavelet transform on row count vector (two levels) has been applied.
c. Then the approximation (low frequency or average) coefficients have been directly taken as feature values.
d. Number of black pixels along each column has been counted to form a 64 sized vector.

e. The 1D wavelet transform on column count vector (three levels) has been applied.
f. Then the approximation coefficients have been directly taken as next feature values.
g. Divide each 64*64 image in to 16 zones of size 8*16.
h. Then find the mean zonal densities of these 16 zones. Out of 16 low level image with lesser texture image is ignored and 15 images are considered for next step.
i. Take these as the next 15 values of feature vector.
j. Take aspect ratio as the last feature element of the feature vector.

Above explained steps are repeated with different wavelet filters viz. db1, db2, ….., db10. After the feature extraction has been done, the feature vectors lengths are summarized in the Table 1:

Table 1: Length of Feature Vectors

Wavelet Filter	length of feature vector
db1	64
db2	66
db3	68
db4	70
db5	72
db6	74
db7	76
db8	78
db9	80
db10	82

The back propagation neural network has been used for classification of the Urdu digits. Back Propagation Neural Network (BPNN), is a Multilayer Neural Network which is based upon back propagation algorithm for training. [7,8]This neural network is based upon extended gradient-descent based Delta learning rule, commonly known as Back Propagation rule.

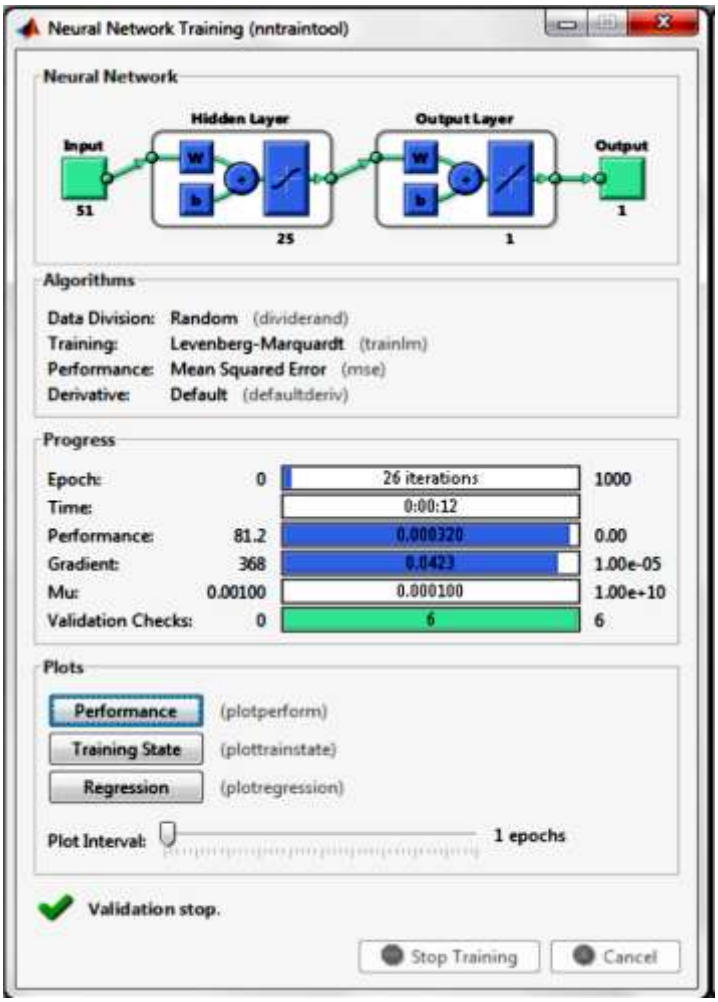

Figure 4: Back Propagation Neural Network Training screen

In this network, error signal between desired output and actual output is being propagated in backward direction from output to hidden layer and then to input layer in order to train the network. In this network input nodes equal to number of feature vector elements, 25 hidden layer with 51 input nodes and 1 output nodes are used see figure 4.The performance analysis of training, testing and validation of digit in 26 Epochs is represented in figure 9. The testing input is fed into the input layer, and the feed forward back propagation network will generate results based on its knowledge from trained network.

4. RESULTS

In this work, various Daubechies Wavelet Transforms e.g. db1 to db10 have been used to extract the wavelet coefficients. Then a feature vector has been obtained by combining the wavelet coefficients, zonal densities and aspect ratio which is given as input to the BPN network. The outcomes for Handwritten Urdu Digit recognition are summarized in Table 2. The values of average recognition accuracy using different Daubechies wavelets are 92.07% and average recognition time is 1.42. The outcomes for Printed Urdu Digits are summarized in Table 3. The values of average recognition accuracy using different Daubechies wavelets are 92.07% and average recognition time is 0.94773.

Table 2: Comparisons of Recognition Accuracy using different Daubechies Wavelets

Wavelet Filter	Handwritten Digits		Printed Digits	
	%Recognition Rate	Recognitio Time (in sec)	%Recognition Rate	Recognitio Time (in sec)
db1	82.2%	1.0247	99.9%	0.8928
db2	95.4%	1.1015	99.95%	0.9534
db3	92.85%	2.0003	99.95%	0.8918
db4	91.55%	1.4659	99.95%	1.2088
db5	76.15%	1.501	100%	1.0226
db6	95.8%	1.1163	99.85%	0.8974
db7	98%	1.4792	99.95%	0.9117
db8	98%	1.5082	100%	0.8922
db9	95.55%	1.5725	100%	0.8968
db10	95.25%	1.4754	100%	0.9098
Average	92.07%	1.4245	99.95%	0.94773

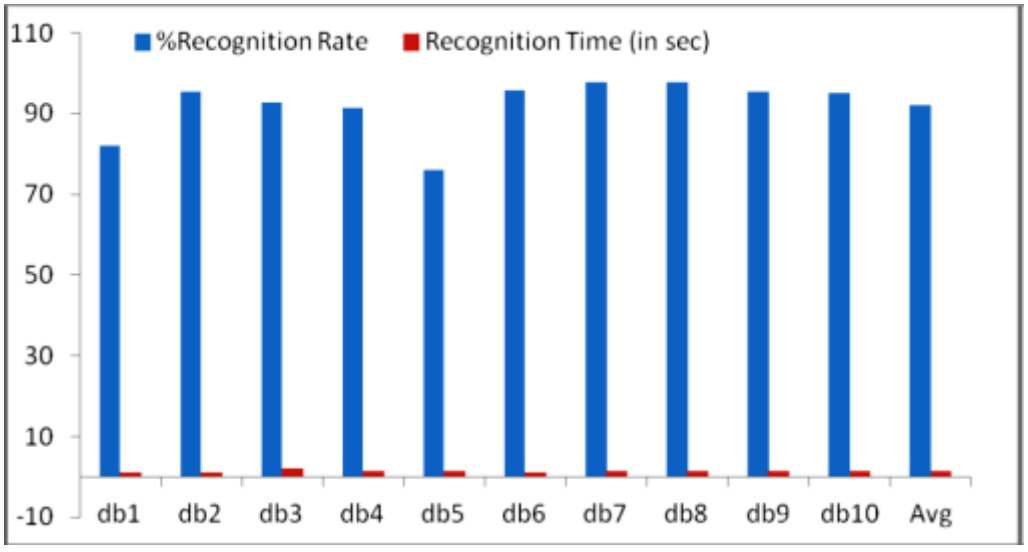

Figure 5: Recognition rate and recognition time using different Daubechies wavelets for Handwritten Digits

5. CONCLUSION

It has been found for Handwritten Digits, db7 and db8 wavelets have given the highest recognition accuracy. The db1 wavelet has the least recognition time 1.02 seconds. It has been observed in this work that certain digits have confused with other digits during recognition process. It has been found that for numeral 6 recognition accuracy is least. The confusion matrix for each Urdu Digit using db7 is shown below:

Table 3: The Confusion Matrix for each Urdu Digit using db7

Urdu Digit	Recognition as per Urdu Digit									
	0	1	2	3	4	5	6	7	8	9
0	99	1	0	0	0	0	0	0	0	0
1	0	97	2	0.5	0.5	0	0	0	0	0
2	0	0.5	98	1.5	0	0	0	0	0	0
3	0	0	1	98	1	0	0	0	0	0
4	0	0	0	0.5	99.5	0	0	0	0	0
5	0	0	0	0	0.5	98.5	0	0.5	0	0.5
6	0	0	0	0	0	2.5	96.5	0.5	0.5	0
7	0	0	0	0	0	0.5	0.5	99	0	0
8	0	0	0	0	0	0	0.5	1	98.5	0
9	0	0	0	0	0	0	0.5	1	1	95

In this recognition system an average recognition rate for Handwritten Urdu Digit is 92.07% and for Printed Urdu Digit is 99.95% has been obtained. It has been found for Printed Digits db5, db8,db9 and db10 wavelets have given the highest recognition accuracy. The db1 wavelet has the least recognition time 0.8928 seconds. . It has been observed in this work that certain digits have confused with other digits during recognition process. The confusion matrix for each Urdu Digit using db5 wavelet is shown below:

Table 4: The Confusion Matrix For Each Urdu Digit Using DB5

Urdu Digit	Recognition as per Urdu Digit									
	0	1	2	3	4	5	6	7	8	9
0	100	0	0	0	0	0	0	0	0	0
1	0	100	0	0	0	0	0	0	0	0
2	0	0	100	0	0	0	0	0	0	0
3	0	0	0	100	0	0	0	0	0	0
4	0	0	0	0	100	0	0	0	0	0
5	0	0	0	0	0	100	0	0	0	0
6	0	0	0	0	0	0	100	0	0	0
7	0	0	0	0	0	0.5	0	100	0	0
8	0	0	0	0	0	0	0	0	100	0
9	0	0	0	0	0	0	0	0	0	100

As the size and quality of database is major factor influencing OCR systems, so relatively large database can be used in the future work. This will help to enhance the recognition accuracy. By adding some more features can also be helpful to enhance the recognition accuracy

4. ACKNOWLEDGMENT

The authors gratefully acknowledge the Management, M.G. Vidyamandir Nasik, and Principal, M. S. G. College Malegaon Camp for their support in this work.

REFERENCES

[1] Cheng-Lin Liu, Kazuki Nakashima, Hiroshi Sako, Hiromichi Fujisawa, Handwritten Digit Recognition Using State-of-the-Art Techniques IEEE 2002

[2] Gang Liu, Di Wu, Hong-Gang Zhang, Jun Guo , A new Feature Extraction Method Based on Fourier Transform in Handwriting Digits Recognition, IEEE 2002

[3] Dejan Gorgevik, Dusan Cakmakov", Vladimir Radevski', Handwritten digit recognition by combining support vector machines using rule based ITI 2001.

[4] Abdurazzag Ali ABURAS and Salem M. A. REHIEL, "Off-line Omni-style Handwriting Arabic Character Recognition System Based on Wavelet Compression", ARISER Vol. 3 No. 4 , 123-135, 2007.
[5] J.T. Tou and R.C. Gonzalez, Pattern Recognition Principles, Addison-Wesley Publishing Company,Inc., Reading, Massachusetts, 1974.
[6] Lim, Jae S., Two-Dimensional Signal and Image Processing, Englewood Cliffs, NJ, Prentice Hall, 1990,pp. 469-476.
[7] Daubechies, I., Ten lectures on wavelets, CBMS-NSF conference series in applied mathematics. SIAM Ed. 1992.
[8] Mallat, S., "A theory for multiresolution signal decomposition: the wavelet representation," IEEE Pattern Anal. and Machine Intell., vol. 11, no. 7, pp. 674–693, 1989.
[9] Yuval Netzer, Tao Wang, Adam Coates, Alessandro Bissacco, Bo Wu, Andrew Y. Ng, "Reading Digits in Natural Images with Unsupervised Feature Learning", research.google.com/pubs/archive/37648.pdf.
[10] Mohamed Abaynarh, Hakim Elfadili, Khalid Zenkouar, and LahbibZenkouar, "Neural Network Classifiers for Off-line Optical Handwritten Amazighe Character Recognition", IJCSNS International Journal of Computer Science and Network Security, VOL.12 No.6, June 2012.
[11] Mohamed Abaynarh, Hakim Elfadili and LahbibZenkouar , " Handwritten Characters ClassificationUsing Neural Networks and Moments Features", International Journal of Modern Engineering Research (IJMER) Vol.2, Issue.5, pp-3572-3577 ISSN: 2249-6645, Sep-Oct. 2012.
[12] J.T. Tou and R.C. Gonzalez, Pattern Recognition Principles, (Addison-Wesley Publishing Company, Inc., Reading, Massachusetts), 1974.
[13] S. A. Husain, AsmaSajjad, Fareeha Anwar, "Online Urdu Character Recognition System", MVA 2007 IAPR Conference on Machine Vision Applications, Tokyo, JAPAN, May 16-18, 2007,
[14] Sabri A. Mahmoud and Sameh M. Awaida, " RECOGNITION OF OFF-LINE HANDWRITTEN RABIC(INDIAN) NUMERALS USING MULTI-SCALE FEATURES AND SUPPORT VECTOR MACHINES VS. HIDDEN MARKOV MODELS", The Arabian Journal for Science and Engineering, Volume 34, Number 2B, October 2009.
[15] Yuval Netzer, Tao Wang, Adam Coates, Alessandro Bissacco, Bo Wu, Andrew Y. Ng, "Reading Digits in Natural Images with Unsupervised Feature Learning", research.google.com/pubs/archive/37648.pdf
[16] Mohamed Abaynarh, Hakim Elfadili, Khalid Zenkouar, and LahbibZenkouar, "Neural Network Classifiers for Off-line Optical Handwritten Amazighe Character Recognition", IJCSNS International Journal of Computer Science and Network Security, VOL.12 No.6, June 2012.
[17] Mohamed Abaynarh, Hakim Elfadili and LahbibZenkouar , " Handwritten Characters Classification Using Neural Networks and Moments Features", International Journal of Modern Engineering Research (IJMER) Vol.2, Issue.5, pp-3572-3577 ISSN: 2249-6645, Sep-Oct. 2012.
[18] Mostofa Kamal Nasir1 and Mohammad ShorifUddin, "Hand Written Bangla Numerals Recognition for Automated Postal System", IOSR Journal of Computer Engineering (IOSR-JCE)), PP 43-48 , e-ISSN: 2278-0661, p- ISSN: 2278-8727Volume 8, Issue 6, Jan. - Feb. 2013.
[19] Ban N. Dhanoon and Huda H. Ali, "Handwritten Hindi Numerals Recognition", International Journal of Innovation and Applied Studies, ISSN 2028-9324 Vol. 3 No. 1, pp. 310-317, , May 2013.
[20] Anilkumar N. Holambe, "Printed and Handwritten Character & Number Recognition of Devanagari Script using Gradient Features", International Journal of Computer Applications (0975 – 8887), Volume 2 – No.9, June 2010.
[21] Vikas J Dungre, A Review of Research on Devnagari Character Recognition, International Journal of Computer Applications, Vol. 12, No.2, November 2010
[22] Raju G., ―Wavelet Transform and Projection Profiles in Handwritten Character Recognition – A Performance Analysis‖, IEEE, pp. 309-314, 2008.
[23] M Abdul Rahiman, M S Rajasree, ―OCR for Malayalam Script Using Neural Networks ‖, IEEE, 2009.
[24] G S Lehal and Chandan Singh, "A Gurmukhi Script Recognition System", Proceedings of the International Conference on Pattern Recognition (ICPR'00), 2000.
[25] Syed. Afaq Husain and Syed.Hassan Amin, "A Multi-tier Holistic approach for Urdu Nastaliq Recognition", IEEE INMIC, Karachi, Dec. 2002.
[26] Abdurazzag Ali ABURAS and Salem M. A. REHIEL, "Off-line Omni-style Handwriting Arabic Character Recognition System Based on Wavelet Compression ", ARISER Vol. 3 No. 4 , 123-135, 2007.