COPYRIGHT © 2011 IJCIT, ISSN 2078-5828 (PRINT), ISSN 2218-5224 (ONLINE), VOLUME 02, ISSUE 01, MANUSCRIPT CODE: 110729

Size Independent Bangla Character Recognition System by Multilayer Feedforward Neural Network

Nazmun Nessa Moon *and* Kamal Uddin Sarker

Abstract—The Bangla 'Banjonborno' and 'Sorborno' characters have been chosen to test the recognition System. Two stages are required to implement this recognition process. They are learning stage and testing stage. In learning stage, the character to be recognized is scanned through a scanner and thus the character becomes a bitmap image. Then the boundary region of the saved image I is extracted. The feature of the scaled image is extracted and converted into an m x n matrix, which is reduced to very small matrix such as 16 X 16 using by matlab imresize scaling function. The feature matrix is then fed to the multilayer feedforward Neural Network. The Supervised learning system is considered for driving the feedforward algorithm. In testing stage, the selected features have been contained enough information within it to identify each character class uniquely. At last each unknown characters are tested through the experimental extracted features of character.

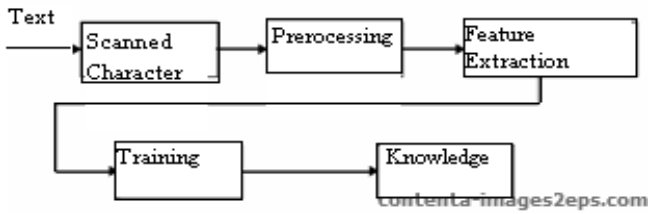
Index Terms— Adaptation method, Classifier, Feature Extraction, Generalized delta rule, Multilayer feedforward neural network.

1 Introduction

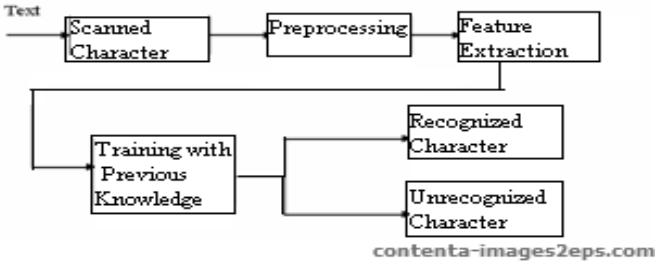
FOR a long time, the dream of computer scientist is to develop the computer as an intelligent machine as human. The human brain is so powerful that it can perform a wide variety of solving many problems from thinking, talking, remembering, feeling, and learning. This powerful device of the human has amazed and inspired many scientists to attempt modeling its operations. In this fifth generation computer, the computer scientists have come up to create intelligence in today's machines. A lot of different theories and paradigm have already been developed for this purpose. One of the most intelligence creating approaches is the character recognition. In the character recognition system, the computer is able to classify the characters as human can identify them. There are many researches and acts are performed for Indian, Chinese, Japanese and other languages. As a result, Hindi character, Konkani digits and other Japanese Kanji scripts and Portuguese characters are recognized as well as the post code detection system in this language exist as the computing accuracy increase in the computer [1][2]. To create prototype of a human brain with the human like intelligence, the scientists and technologists uses Artificial Intelligence in the machines.

2 Paradigm of the Proposed Work

In the Character Recognition System, multiple preprocessing and processing stages have been employed. The complete system can be described in two stages. One is learning stage and another is testing stage as shown in figure 1. After scanning the characters, the scanned information is processed through a set of learning phases. The pre-processing includes many features such as thinning, smoothing, and so on. The next phase is the feature extraction, and the feature is represented as 16 X 16 matrices, which are fed into neural network for training. The output of the training is saved as knowledge. Figure 1(a) presents the schematic of the training stage.



(a) Learning Stage



(b) Testing Stage

Fig. 1: Paradigm of the Character Recognition System.

During the testing stage, each of the character matrices is extracted in the same way as done in the learning stage. Then the pre-processing and processing steps take place. After the structural feature is extracted from the test data, it is then classified using the knowledge, which was saved during the testing stage as shown in figure 1(b).

- ***Nazmun Nessa Moon*** *is with the Department of Computer Science and Engineering, State University of Bangladesh, Dhanmondi, Dhaka-1205, Bangladesh. E-mail: moon_ruet@yahoo.com*
- ***Kamal Uddin Sarker*** *is with the Department of Computer Science and Engineering, Northern University Bangladesh, Dhanmondi, Dhaka-1209, Bangladesh. E-mail: ku_sarker@yahoo.com*

3 METHODOLOGICAL STEPS OF CHARACTER RECOGNITION SYSTEM

The design concepts for automatic character recognition are motivated by the ways in which character classes categorized and defined. In designing the character recognition system, the following methodological steps are followed:
1. Data Acquisition; 2. Preprocessing; 3. Feature Extraction; 4. Learning; 5. Knowledge; 6. Classifier; 7. Classified character.

The block diagram of the above phases is shown in figure 2.

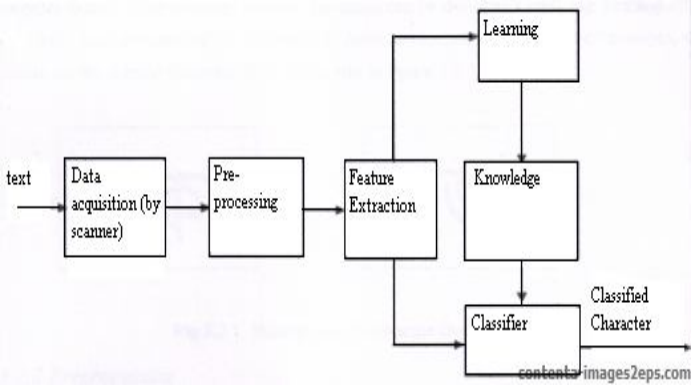


Fig. 2: Block diagram of character recognition system

In this recognition approach, the character to be recognized is scanned through a scanner and thus the character becomes as bitmap image. The image file is preprocessed and fed to the character classifier and then it may be classified by using the concept of Artificial Neural Network classifier.

3.1 Data Acquisition Process

The input data of this recognition system is printed Bangla characters to be recognized such as K, L, A. Data is acquired from the character by scanning it through the scanner as an input device. The scanned image is passed to the next stage of Character Recognition System. After scanning the text, the image can be stored as a bmp, jpg and other files with such extensions [1]. Scanning is done in monochrome mode. For example, the bitmap for the printed character K, R are shown in figure 3. Bangla letters are formed in two-dimensional space based on mostly horizontal, vertical and are stroke [3].

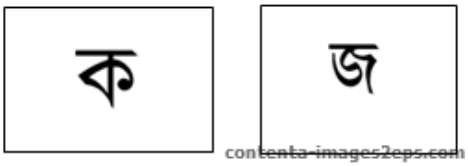


Fig. 3: Bitmap image of bangle character.

3.2 Preprocessing

Preprocessing is required for the purpose to make the raw data into usable format. By which we can achieve mire flexible input data, which is needed for to make more accurate result. Preprocessing involves the following sub-categories:

3.2.1 Gray Scale, Brightness Adjustment and Resolution Setup

After the collection of the raw data, MS-windows Photo Editor Primary filtering is used by adjusting the gray scale and brightness. Resolution was also adjusted along with filtering.

3.2.2 Filtering

The main objective of filtering is to remove the noise from the actual data. The general filtering technique is consisting of following sequences:

- To identify the actual data in the image. This will give the identification of noise automatically.
- To eliminate the noise. There are various processes of identification of actual data. In character recognition systems, continuity checking of all the parts of actual data may be a process.

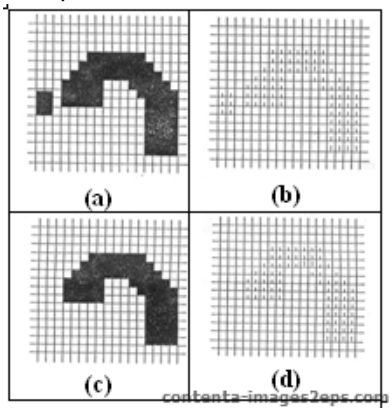


Fig. 4: A portion of bangla character, (a) Actual image with noise, (b) Corresponding matrix representation, (c) Image after filtering, (d) Corresponding matrix representation.

3.2.3 Scaling

The characters are always of different sizes. However, for the recognition purposes they are transformed to fixed size by Matlab imresize function. The scaling process transforms the character to a standard size such that it can be represented by 16×16 matrix.

3.3 Feature Extraction

Feature extraction is a subject of effective character recognition and it helps to make easy the classification task. Two approaches, namely statistical and structural approaches are applied in feature extraction. The structural approach is used to extract the feature of character recognition through the following steps:

3.3.1 Boundary Extraction of a Character

In this paper, using a Matlab imread function as shown in figure 5 has done feature extraction part. There are different sizes of characters may be available, but it has converted into in fixed size and performed following steps:

- First load bitmap image has been created its maximum size of matrix.
- Second it has been created comparatively very small than the first one and reduced size such as 16 x16 matrix.

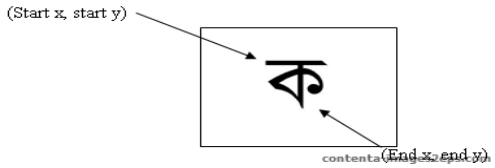


Fig.5. Start and end position of character K.

As a result, any sized character is scaled (converted) to a fixed size. The dark pixel in the bitmap image has been defined as 1 and the white pixel as 0. It is done another process simply by matrix function imresize.

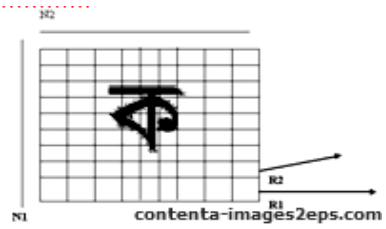


Fig.6. Conversion of R1XR2 matrix

Fig.7. Matrix with reduced image

3.4 Learning and Adaptation Methods

The input from the feature extraction of a scanned character that is a 16X16 matrix the learning element receives and processes this input, according to various strategies. This information goes into a knowledge base, which already contains some knowledge derived from previous learning situations. The connection weights of the network need not be constrained to be fixed; they can be adapted in real time to improve performance. [4]. The performance element uses this updated knowledge base to performance some task or solve some problem and to produce corresponding output. In order to evaluate how well the system has learnt, the same input is presented to an idealized system that should produce what is seemed to be the correct output. Both output are then fed into a feedback element to identify any differences and determine what additional input the learning element needs in order to produce correct output.

In this work, this computational method is done by backpropagation algorithm. [5].

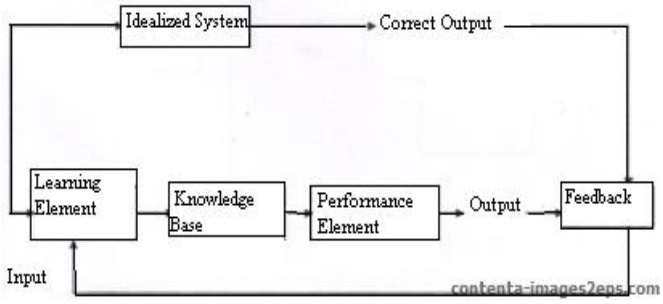


Fig. 8. Simple Learning System Model

3.5 Knowledge

In the character recognition system, the computer gains knowledge from learning the threshold vector of neurons is guessed as knowledge. First, this threshold vectors are initiated by random numbers and these are used in learning system .The threshold vectors are updated as the differences between the target and the actual outputs, are minimized. Eventually, when the target and actual outputs are come closer, the thresholds are saved for future use. This knowledge (thresholds) is used to classify the characters during the recognition process. This knowledge should be more accurate to recognize all the characters. If the knowledge is less accurate the recognition system should be failed to recognize the specified character or may be wrongly recognized.

In this paper, the differences between the target and actual outputs are referred as errors. When the error is less than or equal to 0.008, the thresholds are saved as knowledge. And this saved knowledge is used in recognition system. The target and actual output of each character is shown in appendix.

3.6 Classifier

The classifier is the tool to classify or recognition of character. In this research work, Artificial Neural Network is used as a classifier.

3.7 Classified Character

This step is the result of the Character Recognition System. To recognize a character, the character must be processed into the previous steps.

In the learning stage, each character corresponding to its outputs (Appendix) are learned If the Artificial Neural Network can successfullyclassify the character, then it is recognized, otherwise, unrecognized. The character (that is to be recognized) matrix is guessed as input in the recognition stage from a specified file. The weighted and threshold matrices also from file are used to process the character. This program searches the knowledge so that it can identify the character. If the output of the processed character is about equal to the target output with a certain acceptable tolerance (For example, the target output For the character " A "and " K " is 000000 and 001011 respectively, where the calculated output is 0.000944, 0.000953, 0.007741, 0.008750, 0.012921 and 0.993436 for " A ", and 0.001288, 0.001302 ,0.003516, 0.005586, 0.997113 and 0.995421 for " K "). Then the program shows the result that it can recognize the characters. If the calculated output is far differed from the target output out of certain tolerance then the program shows that it cannot recognize the character.

The algorithm of the recognition system is shown in Algorithm 1.

1. Input the character matrix that is to be recognized.
2. Input target output, the weighted and threshold vectors.
3. Calculate the threshold for Output units.
4. Calculate the error.
5. If (error <= a certain tolerance)
Print " the character is recognized as character
Else
Print " The character is unrecognized." end.
6. End.

Algorithm 1: The Character Recognition Technique

4 LEARNING BY BACKPROPAGATION

The learning rule for multi-layer feedforward network is called the "generalized delta rule", or the "Backpropagation rule", and was suggested in 1986 by Rumelhart, McClelland and Williams. It was a Multi-layer feedforward network with different transfer function in the artificial neuron and more powerful supervised learning rule.

In order to learn successfully we make the output of the net approach the desired output, that is, we want to continually reduce the value of this error function. This is achieved by adjusting the weights on the links between the units, and the generalized delta rule does this by calculating the value of the error function for the particular input and then backpropagation (hence the named) the error from one layer of the previous one. Each unit in the net has its weights adjusted so that it reduces the value of the error function ; for units actually on the Output, their Output and the desired output is known, so adjusting the weights is relatively simple, but for units in the middle layer, the adjustment is not so obvious.[6][7].

5 GENERALIZED DELTA RULE

The Generalized Delta Rule (GDR) is a product learning rule for feedforward multiple-layer structured neural network that uses gradient to achieve training or learning by error correction. Network weights are adjusted to minimize all error based on a measured of difference between desired and actual feedforward network output. Desired input-output behavior is given by file training set. [5].

6 TRAINING OF ERROR BACKPROPAGATION(BP)

For the purpose of character recognition, input characters are fed by backpropagation(BP) method. Error BP learning rule has been used to train these networks. In this work, the input characters are Bengali consonant and vowel character set those are represented by the input matrix X[a][i] Where a=0,1,2,3,----------,50 that represents the Bengali consonant character set (K,L,M,N, ...) and vowel character set (A,AV,B.....J) and i = 0,1,2,3, ----------,255 that represents the input pattern element (16 X 16 matrix), formed the 50X 256 input pattern matrix.

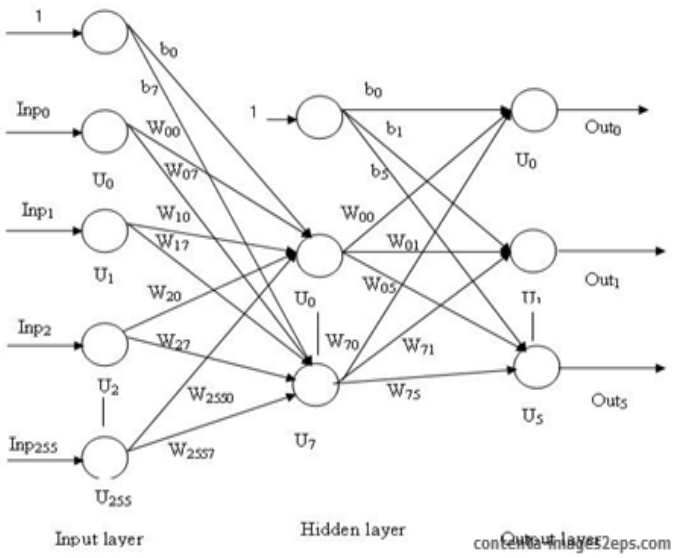


Fig. 9. The Practical Network of this system.

Here a = 0 represents "A", a = 1 represents " AV", ---------- a=38 represents " k " a = 39 represents "l" , a = 40 represents "m". On the other hand i = 0 represents the first input pattern element, i = 1 represents the second input pattern element and so on. For example, X[2][9] represents the 10-th input pattern element. The T[a][i] represents the target matrix. Where a=0,1,2,3 ,----------,50 that also represents Bengali consonant and vowel character and i=0,1,2,3,…..5 represents the target matrix element, i= 0 represents the LSB and i=5 represents the MSB.

The input layer consisted of 256 processing elements (PEs). The output layer of the network consisted of 6 PEs, representing the arbitrary target for the characters ranged from 000000 to 110001 respectively. The hidden layer consisted of variable PEs (8 to 10) . Here in this thesis work, we have used 8 PEs for hidden layer. The weight between input and hidden layers has been denoted by Wij (from the ith input PE to jth hidden PE) and hidden to output weight was denoted by Wjk (from jth hidden PE to kth output PE). The topology of this network is shown in Figure 9. The first step of the backpropagation is to initialize the weight vectors Wij, Wjk and threshold values for each PE with random numbers. The network was provided with the input characters and also the desired respective target output. The input characters – are connected to hidden units (PEs) through the weights Wij.

7 RESULT AND DISCUSSION

Experiment has been done to observe two things: the behavior of the neural network and the Character Recognition accuracy rate. The behavior of the network has been observed with respect to different parameters (hidden unit, learning rate, and spread factor) used in the proposed neur-

al network model.

A. Network Behavior Study

Before implementing the designed network in Character Recognition System, it has been tested using some sample data. For this purpose, a simple train set has been produced which represent digit 0 to 9 for a seven segment with the output patterns to classify these digits and has been given in Table-1. The network has been learnt with this pattern where the test pattern set is same as the train set. It has been seen that the network learns all the patterns in a few cycles and successfully classify them.

TABLE 1
A SIMPLE TEST PATTERN AND THEIR RESPECTIVE OUTPUT

Input	Digit	Output
0001111101	0	000000
0010100111	1	000001
0101010011	2	000010
0011101011	3	000011
0000101011	4	000100
1111101010	5	000101
0010111011	6	000110
1100100111	7	000111
1110000111	8	001000
0011111110	9	001001

B. Character Recognition Accuracy Rate

The error limit has been specified for training of the network is less than or equal to 0.008. The number of iterations for learning the specified error limit has gotten equal to 30.05000. The learning rate of the network was set to $\eta 1 = \eta 2 = 0.9$ and the spread factor was set to $k1 = k2 = 0.5$. The performance of the network has been presented in Table-2 for the character font SutonnyMJ. For this case the tolerance level is fixed at 0.05. The Character Recognition accuracy based on these features is presented in Table-3.

The percentage of success rate failure has been calculated using the following equations.

$$\text{Success rate / Efficiency} = \frac{\text{Total Success}}{\text{Total Sample}} \times 100\%$$

And

$$\text{Failure} = \frac{\text{Number of failure}}{\text{Total number of character}} \times 100\%$$

TABLE 2
PERFORMANCE OF THE ANN FOR BANGLA CHARACTER

Example 1:

Characters	No. of Sample	Recognized	Unrecognized	Success rate
অ	5	4	1	80%
আ	5	4	1	80%
ই	5	3	2	60%
ঈ	5	2	3	40%

Example 2:

So

Characters	No. of Sample	Recognized	Unrecognized	Success rate
ক	5	5	-	100%
খ	5	4	1	80%
গ	5	3	2	60%
ঘ	5	4	1	80%

CHARACTER RECOGNITION ACCURACY RATE

Sample Character	Efficiency	Failure
250	74.8%	25.2%

Discussion

In this paper, any size of character can be recognized. At first learning phase is used the character of SutonnyMJ Font. Then it appears in different font Candrabotip, MhouaCMJ, ShulikhaTE, AdarshalipiCON. For the Different font learnt by the backpropagation theory and weight adopt only for a single character. So we emphasis five type of character can be learnt by this research. Then perform recognition stage. In the recognition stage the success is above 74%. The behavior of the neural network and the Character Recognition accuracy rate has been observed. The proposed network depends on the number of hidden layer nodes. If the number of hidden layer nodes increase the number of iterations for a specified error limit would be decreased. Since the computational load of the network increases with the increasing of the hidden layer nodes, therefore the network takes more time to reach a certain error limit. The effect of learning rate on learning time is very much dependent on input patterns.

8 CONCLUSION

The goal of this paper is to simulate ANN model for Bangla Character Recognition System for any character and also emphasize any type of font can be recognition at a time. In the presented system, a single hidden layered ANN has been used as classifier. However it has realized that such ANN is not able to perform to hundred percent successes. If a multiple hidden layered ANN has been used, a more success rate would be expected. To compare the recognition

rate, the network might be trained and tested by using another network such as Hopfield, Adaptive Resonance Theory and so on. Since the generalization capacity of the network increases with the training examples, the designed work can be trained with more patterns of the character. So to improve the performance of the system, the segmentation process can be improved to deal with composite characters. [8].

APPENDIX

For learning of the neural network, the sample input characters and corresponding the target outputs are as follows:

Input	Target	Input	Target Outputs
অ	000000	ণ	010111
আ	000001	ত	011000
ই	000010	থ	011001
ঈ	000011	দ	011010
উ	000100	ধ	011011
ঊ	000101	ই	011100
ঋ	000110	ন	011101
এ	000111	প	011110
ঐ	001000	ফ	011111
ও	001001	ব	100000
ঔ	001010	ভ	100001
ক	001011	ম	100010
খ	001100	য	100011
গ	001101	র	100100
ঘ	001110	ল	100101
ঙ	001111	শ	100110
চ	010000	ষ	100111
ছ	010001	স	101000
জ	010010	হ	101001
ঝ	010011	ড়	101010
ঞ	010100	ঢ়	101011
ট	010101	ছ	101100

REFERENCES

[1] Hussain, Mohammad Zahid, Islam, Tammana and Sattar, Md.Abdus, Recognition of Printed Bangla Character by Heuris tic Method, National Conference on Computer and Information System – NCCIS'97 Dhaka, Bangladesh, Dec 9-10, 1997.

[2] Aleksander, Igro. And Morton, Helen, An Introduction to Neu ral Computing, 1980.

[3] M. R. Bashar, M. A. F. M. R. Hasan, M. F. Khan, "Bangla Off-Line Handwritten Size Independent Character Recognition Using Artificial Neural Netwroks Based on Windowing Tech nique" Proceedings of International Conference on Computer and Information Technology (ICCIT), Dhaka, Bangladesh, pp. 351-354 , 2003.

[4] N.K. Bose and P. liang Neural Network Fundamentals With Graphs, Algorithms and Applications, Published by McGraw-Hill International Edition, 1996.

[5] D.W Patterson , Introduction to Artificial Intelligence and ex pert system, prentice hall of India private limited 1992.

[6] Fu LiMain, Neural Networks in Computer- Intelligence, McGraw Hill International Edition- 1991.

[7] Neural computing: An Introduction by R Beal and T Jackson.

[8] Md. Musfique Anwar, Nasrin Sultana Shume, P. K. M. Moni-ruzzaman and Md. Al-Amin Bhuiyan, "Recognition of Printed Bangla Document from Textual Image Using Multi-Layer Perceptron (MLP) Neural Network", (IJCSIS) International Journal of Computer Science and Information Security, Vol. 8, No. 1, pp. 254-259, April, 2010.

Nazmun Nessa Moon has been serving as a lecturer with the department of Computer Science & Engineering, State University of Bangladesh (SUB). She joined at SUB in October 2010 as a Lecturer.

She served as a lecturer with the department of Computer Science & Engineering, Darul Ihsan University from September '07 to September '10. At that time, she was a course co ordinator and club-moderator of the Computer & Communication Club (C3). Currently, she continues her M.Sc Thesis work in the field of bio informatics in BUET. She has research publications in IJCIT (Vol-1, Issue-2) in the field of data mining.

Kamal Uddin Sarker has been serving as a senior lecturer with the department of Computer Science & Engineering, Northern University Bangladesh (NUB). He joined at NUB in May 2006 as a Lecturer.

He has research publications in different international journals/conferences like ISESCO, ICECE, IJCIT and University Journals in the field of Bioinformatics and Computatiuonal Biology. In addition he is a member of IEB (M-25042). He is continuing ICTP training for 18 days in the field of VLSI.