Handwritten Digit Recognition Using Image Processing and Neural Networks

Faisal Tehseen Shah, Kamran Yousaf*

Abstract **__This working prototype system can detect handwritten digits from a scanned image of an input form by using Neural network technique. Hand writing recognition and Image detection through this methodology is very fast and effective as compared to old fashioned image pixel comparison methodology, which is comparably slow. In the initial phase for handwritten digit input we have designed a form which can take hand writing samples from different people. The form must have specific format so user can give multiple input in 10 rows, and hand write 0,1,2,3,4,5,6,7,8,9 in the corresponding sampling cells (rows* columns). The cell must also have width according to your requirement (e.g set it to 20*2 pixels). Once the blank forms have been manually filled by different people then scan these forms with the help of scanner. So now we have images of hand writing samples of digits. In the 2nd phase, we use image slicing technique to slice sample image of size 16*16 pixel for each digit from the scanned form [1]. Each scanned form image will make nearly 100 images of 16*16 pixels. Repeat the same step for all scanned sample forms and place all these 16*16 pixel images (sample pool) into one location. In the detection phase, a three-layered neural network is used:**

After training, the obtained weight and bias are stored for each digit sequence(signature). It is now possible to identify the meaning of any hand written digit with the help of AI engine. So now when ever any handwritten digit will be given as sample input in to the system , the output array will automatically give the digit whose corresponding match value is detected. The above process is a blueprint of human cognitive thinking process.

Index Terms—**Neural Network, Hand Written, Recognition, Neurons, Training**,

I. INTRODUCTION

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, Tumors 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.

COMSATS Institute of Information Technology, Faculty of Computer Science, Department of Computer Science Defence Road off Raiwind Road Lahore, Punjab Pakistan.; Phone: 9242 332 8481061; e-mail: fshah@ciitlahore.edu.pk
*COMSATS Institute of Information Technology, Faculty of Computer Science, Department of Computer Science Defence Road off raiwand Road Lahore ,Punjab Pakistan.

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 Defense to Map the territory for possible accurate target selection by using GIS and image processing. Even in Pakistan Sugar mills are using satellite imagery for planning their sugar can purchasing campaign and procurement planning. Imaging for medical reasons CT- Scan, MRI and Ultra Sound is now a days a common content in the patients 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 [6], by using Fourier transformation [7], using support vector machine (SVM) and using classifier [8]. 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 handwritten 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 [6] the features are basically direction features accepted by code feature, gradient feature or by Sobel and Krish operators. Fourier Transform [7] feature extraction is based on sum and difference. SVM classifier [8] 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 when ever 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 handwritten digit.

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 an 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

II. DIGITAL IMAGE PRESENTATION

We can do any symbol recognition using this methodology.. but for our project we only chose to do numerical digits 1,2,3,4,5,6,7,8,9 and 10.
Hand Written digit samples:

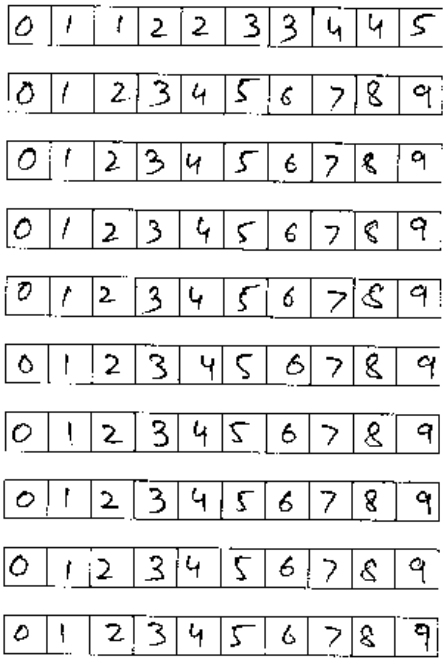

Fig. 1

Total number of rows in each form are 10 and number of column in each form are also 10. We can have 100 samples from one person as a specimen sample to analyze.

We got nearly 100 forms filled by different users
A then scanned takes hundred images.. in next step we cut these images and store each type of image in a different array so that we have 10 samples of each digit image type from on author or person. So total we have so have 100 people fill similar form in order to have a total of 10*100= 1000 samples for each digit from 1 to 10.

So we do the same treatment to each scanned form and then by doing image slicing on the scanned image of a form and made a new image which contained 10 * 100 from different people..[3] And each slice is stored (DIAGRAM Required)

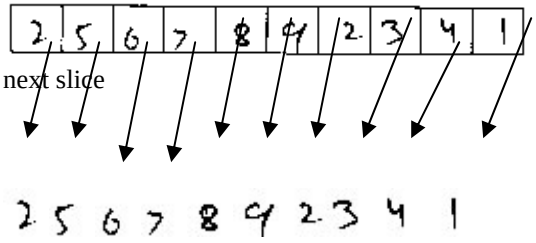

Fig. 2

We convert these image of 1000 slices of "3" into a standard resolution let say 16 *16 pixel. [2]. This will give us a standard size and resolution of the image s o that we are able to apply neural network because the identity of the image through neural network is directly proportional to the resolution of the image . in other words if we use different resolution for these images then we will not be able t compare or standardize as the input neurons will vary with the variation in resolution.

Determining the Horizontal Histogram
Vertical Histogram, Left diagonal Histogram and right Diagonal Histogram

Horizontal histogram helps to filter out the variations in the left and right
in the shift in horizontal positioning of the digit hand written in the form. (refer Fig 3 below)

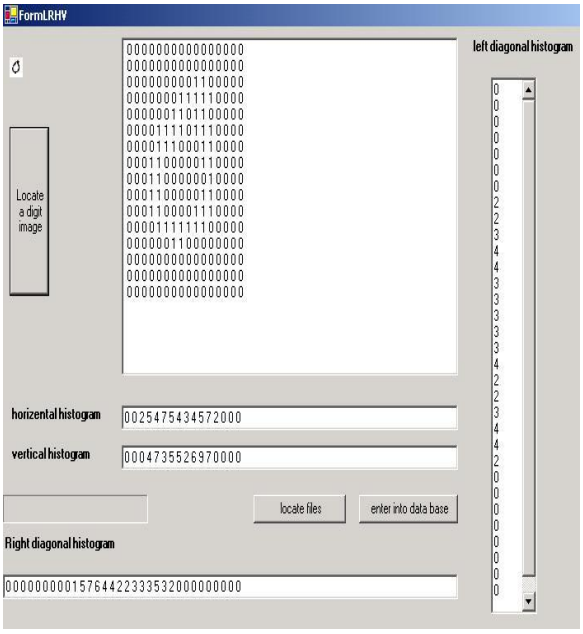

Fig. 3 AI Engine Interface

Its size is an array of 16 elements
Vertically histogram helps to filter out the variations in the y-axis where the
shift in vertical positioning of the digit hand written in the form. i.e
Its size is an array of 16 elements

Diagonal histogram helps to filter out the variations in the angular x-axis and y-axis movements of the digit hand written in the form. i.e
LDH
Its size is an array of 31 elements
/RDH
Its size is an array of 31 elements

Horizontal histogram helps to filter out the variations in
the left and right
in the shift in horizontal positioning of the digit hand written in the form. i.e

The working nature of these histograms can be ascertained through the following equations and figure. (DIAGRAM)
For example horizontal histogram can be represented through equation (1) :-
(HH+VH+LDH+RDH)= GH [4] (1)
HH (Horizontal Histogram)
VH (Vertical Histogram)
RDH (Right diagonal Histogram (Image)
LDH (Left diagonal Histogram (Image)
GH (Global Histogram)

The complete image signature of a single digit let say ('3 ') can be represented as (HH+VH+LDH+RDH)= (Global Histogram Its size is represented by an array of 94 elements

III. MAKING A DATABASE

We make a database to store each image of data for all the digits We make a table let say Digit-data which has 95 columns (a1-a94). In column 1 we store the digit ID lets say any digit from (1 to 10)So we read all the 1000 images previously sliced and stored one by one and store the global histogram In these column for digits 0 to 9

digitdata : Table

Field Name	Data Type
digitid	Text
a1	Text
a2	Text
a3	Text
a4	Text
a5	Text
a6	Text
a7	Text
a8	Text
a9	Text
a10	Text
a11	Text
a12	Text

Fig. 4 Sample Digit

At the end we obtain a huge data base of global histograms for each of the digits in the sample pool

IV. MAKING A NEURAL NETWORK

The Neural network that we use for this analysis is a 3 layer neural network where

94 input neurons in the input layer:
15 hidden neurons in the hidden layer
10 output neurons: out put layer which Correspond to digits 0-9 [4]

Input Neurons
Input required for 94 input neurons is read from the p4 elements of the global histogram.
Out put Neurons
10 output neurons suggest the corresponding detection of digits from (1 to 10)

Each neuron stores the following information fields.
Layer: Layer means to which layer does each neuron belong to whether it is input/output or hidden neurons
Index: means what is the index number of the element in the corresponding layer
Input data: What is the input data fed to the it
Output data: Which data it outputs
Expected output: what is desired output expected by us
Weights: value that facilitates the neural network required result???
Bias: is the value to facilitate calculate the desired and a already told 95 represents 94 global histograms out put ??? to ask later
Error: Expected output – output data

V. TRAINING NEURAL NETWORK

Then in order to train the neural network we make a two dimensional array of 10000 * 95(IN-PUT-ARRAY) elements where 10,000 tells that there are that many records in the database and 95 represents 94 global histograms and 1 represents. The identification of the digit. Then we also have an other array of 10000 * 10 (IDEALARRAY) elements where 10000 records and 10 is represented to identify each digit.

The 10000 records are filled I such a way that you build a 10000 by 10 and t fill out each row we follow the following procedures.
If we read the first record and the first record is zero then you put 1 in the (1,1) and put fill all other positions (1,n) by (1*0,0,0,0,0,0,0,0,0,0) by zeros. Similarly we populate this array for all 10,000 records in the data base in the same manner for remaining 9 digits.

We initialize the neural network according to the INPUTARRAY, IDEALARRAY and number of hidden neurons. As mentioned before. Input neurons of input layer will take input from the INPUTARRAY. The input neuron will only out put what the INPUTARRAY will feed as input. The hidden layer neurons output will use the following function: hidden-neuron-output= 1/ (1+exp(-input value) The setting of bias and weight were filled randomly at first to facilitate result. A random seed for bias and weight was first used in the range of Random-seed= ((=1000 to –1000)/2000)= range (+0.5 to –0.5). [4]

Then we took one sample at a time from the INPUTARRAY to propagate output and it checks the error rate according to the

firing of the neurons for the desired digit. The weight and bias are changed continuously until the error is eliminated and the desired firing sequence of neurons is achieved which equals to the required output. The Weight and Bias for each digit trained will be stored separately for stored records corresponding to each handwritten digit . Accordingly weight and Bias values will be calculated for different samples of the same digit . . So these two values for each digit will be stored in the separate text files and like this weight and bias of each digit will be maintained in a separate database. Similarly weight and bias for the output layer will also be trained and maintained. This means that for each digit we will have the text files stored in the following manner:

Digit "0" = WEIGHT and Bias hidden layer (2 files)
Digit "0" = WEIGHT and Bias output layer (2 files)
The same procedure will be used to train neural network for all the 10 digits whose data is available in the INPUTARRAY 10,000 records..

VI. RECOGNITION

SO once the neural net work has been trained for all ten digits now it is possible to identify the meaning of any hand written digit with the help of the trained neural network. So now when ever a handwritten digit will be given as sample input the system will calculate its global histogram and then feed the global histogram to the neural network. This time the neural network will take the bias and weight from the already stored text files and use that for detecting the neuron firing sequence. So in the output array it will automatically give the digit whose corresponding match value is detected. And in case none of the neurons is fired that means that it is a new digit which is not available in the trained neural network files which are also called knowledge base library.

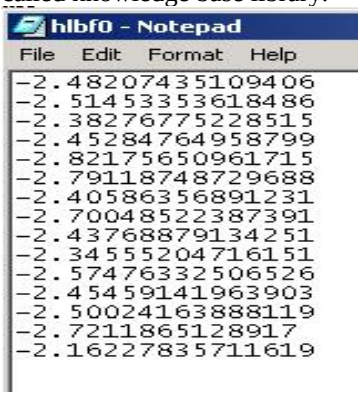

Fig. 5 Horizontal Bias
Trained data is placed in these text files

VII. CONCLUSION

Neural Networks have really created a new vision in the computer and industrial applications. Previously mat lab was used for such simulations but in such implementations one does not have full control, nor the ability to understand that what is happening behind the application. However with more understanding of neural networks, now we have more control over its applications and now we can easily implement such intelligence to identify objects into machines and computers in order to cater our needs in the industrial applications. This application developed as an in house effort by Comsats ITC Center to develop an evaluation system which can be used for grading exams, teacher evaluation and performance assessment of employees. For future work we plan to use the same technique to identify signatures for processing cheques in banking Industry and secondly to develop a face recognition system for HRM Department for student attendance system based on Computer Vision.

REFERENCES

[1] W.K. Pratt, Digital Image Processing, Wiley, 1978.

[2] Digital image processing (Rafeel C.Gonzalez,Richard E. Woods).

[3] Fundamental of Electronic Image Processing (Arthur R. Weeks, Jr.)

[4] M. Minsky, S. Papert, Perceptrons, MIT Press, Cambridge

[5] Dejm Gorgevik, Dusan Cakmakov', Vladimir Radevski"Handwritten Digit Recognition Using Statistical and Rule-Based Decision Fusion

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

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

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