HAND-WRITTEN ENGLISH NUMERAL RECOGNITION SYSTEM USING NEURAL NETWORK

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CERTIFICATE

This is to certify that the work in the project entitled HAND-WRITTEN ENGLISH NUMERAL RECOGNITION SYSTEM USING NEURAL NETWORK by Akash choudhary is a record of his work carried out under my supervision and guidance in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Computer Science and Engineering.

Prof. Ratnakar Dash
CSE Department of NIT Rourkela

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Akash choudhary

ABSTRACT

This thesis aims at implementing an algorithm for recognition of hand-written English numeral. Handwriting recognition has been one of the active and challenging research areas in the field of image processing and pattern recognition. In this thesis the digits are classified into two groups, one group comprises of blobs with/without stems and the other digits with stems only. The blobs are identified based on a new concept called morphological region filling technique. This eliminates the issue of finding the size of blobs and their structuring elements.

This method completely eliminates the complex process of recognition of horizontal or vertical lines. This extracted feature will then classified with the help of neural network train tool. It is a faster English numeral recognition algorithm it uses part of the character instead of complete image.

Contents

Chapter 1

Introduction

In OCR, input device scan the characterson the page one by one and then compares with them characters stored in the computer's memory.With OCR function character recognition can be accomplished by just registering character and specifying the area. Both alphanumeric characters and user defined characters can be identified.

Some practical application of OCR

- Reading aid from the blind.
- Automatic text entry into the computer for desktop publication, library cataloging.
- Document data compression.

Advantages

A printed page is in the machine-readable text form, we can do all kinds of things we couldn't do before. we can search through it by keyword (handy if there's a huge amount of it, edit it with a word processor, incorporate it into a web page, compress it into a ZIP file and store it in much less space, send it by email—and all kinds of other neat things.

1.1 Character recognition classified into:

- Template based
- Feature based approach

1.1.1 Template based

The first approach is the machine learning approach and is the most commonly and widely used approach for the recognition process. This method requires having a large database of test images on which the system is trained to give specific output. The training process takes much time and it depends on the varieties of the sample images taken for the training purpose. This method takes much time to evaluate but the accuracy of recognition is very high.

Early OCR system employed only template approach. But they become ineffective in the presence of noise, change of handwriting.

1.1.2 Feature based

Feature based approach determines important properties (features) from the test patterns and employs them in a more sophisticated classification model.

Feature based character recognition constitutes

- Pre-processing
- Segmentation
- Feature extraction
- Classification

1.2 Steps in OCR system

1. Pre-processing.
2. Segmentation.
3. Feature Extraction.
4. Classification.

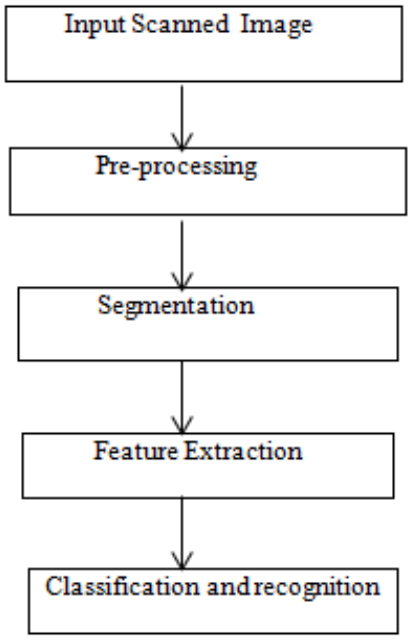

Figure 1:Flow chart of typical OCR system

1.2.1 Pre-processing

It commonly involves low frequency background noise, normalizing the intensity of the individual particle image, removing reflection and masking portions of images. Image pre-processing the technique of enhancing data images prior to computational processing. In preprocessing input image are converted into gray scale Then Gray scale image are converted into binary image using some threshold value then removal of noise having less than 30 pixels.

1.2.2 Segmentation

Segmentation partitions an image into distinct regions containing each pixels with comparable traits. To be compelling and useful for image analysis and translation, the regions should strongly relate to depicted objects or features of interest. Significant segmentation is the first step from low-level image processing transforming a greyscale or colour image into one or more other images to high-level image regarding in terms of features, objects, and scenes. The achievement of image analysis depends on reliability of segmentation.

Segmentation techniques are either *contextual* or *non-contextual*. The latter take no account of spatial relationships between features in an image and group pixels together on the basis of some global attribute, e.g. grey level or colour. Contextual techniques additionally exploit these relationships, e.g. group together pixels with similar grey levels and close spatial locations.Thresholding is the simplest non-contextual segmentation technique. Image segmentation is typically used to locate objects and boundaries in images. Script segmentation is done by executing the following operations: Line segmentation, Word segmentation and character segmentation.

1.2.3 Feature extraction

Feature extraction a type of dimensionality reduction that efficiently represents interesting parts of an image as a compact feature vector. This approach is useful when image sizes are large and a reduced feature representation is required to quickly complete tasks such as image matching and retrieval. In this process feature at different level is extracted from the image.

1.2.4 Classification

I have used neural network for the purpose of classification and recognition. Classification uses the feature extracted from the previous step to identify the characters.

1.3 Objective of the Project

The objective of the project is to implement an OCR system for English numerals .The input to the system would be a pure English graphic image and output would be a recognized English numeral.

Chapter 2

Literature Review

A few high accuracy algorithms have as of late been proposed for recognition of handwritten numerals. In an interesting paper **Lam and Suen [**14**]** describe a recognition system that comprises of a consecutive combination of a quick structural classifier and a strong relaxation algorithm. The arrangement is based on the design of a set of primitives derived from the image of the numeral. Although very low error rates are realized, the method is relatively slow, owing to a far reaching preprocessing of the numeral image prior to feature extraction and the unpredictability of the relaxation algorithm.

Srihari et al.[15] proposed a recognition system that uses three algorithms:

(1)A template matching algorithm: An input character is size-normalized to anl6x16gridandcompared by a Hamming distance to a set of size-normalized prototypes. The N classes or the N' prototypes that most closely match an input character are then determined. Up to 18,000 prototypes have been used at one time with this technique. Experiments have shown that performance steadily improves as more prototype data is added. This is because the large number of variations in hand printed text are better represented as some of the more obscure prototypes are added to the training data.

(2)A mixed statistical and structural classifier utilizing features derived from the contours: It partitions a character with a 5x5 grid and determine the presence or absence of a horizontal or vertical stroke, a hole, across point, an endpoint, or a small or large concavity in each grid cell. These 175 features are supplemented with five more that describe global features of the character. This feature vector of 180 component is then input to a Bayesian classifier that determines the top Classes that most closely match the input character.

(3)A structural classifier utilizing features such as size and stroke placement: This method calculates the curvature at every point along the inner and outer contours of a binary image. Eight types of features are defined based on the amount of Curvature present at any point.

The features are similar. Three features are used for concave curvature, and five for convex curvature. Each feature is also associated with its direction and location. The feature string extracted from an unknown character is matched against a rule base to achieve recognition. The results inferred from the three algorithms are joined in a logical manner to arrive at the definite choice on the identity of the test numeral. The final accuracies were appeared for altogether higher than those accomplished with the individual algorithms.

Kimuraand his co-workers had developed a statistical classification technique [16, 17] that uses the histogram of the direction vector determined from the contours of the character. Despite the fact that the method was produced for recognition of Chinese characters, the method could without much of a stretch have been adjusted for numeral recognition.

Shridhar et ai. [18, 19] had reported a high speed accuracy structural recognition algorithm that uses features derived primarily from the left and right profiles of the numeral images. High speed and good correctness's were accounted for; then again, this calculation as well as the factual classifier did not accommodate the dismissal of awful specimens. In this paper the authors further develop the statistical classification technique of Kimura et al. and the profile analysis technique of Shridhar and Badreldinto realize a fast, very low error rate recognition algorithm. This algorithm allows the user to adjust the error rate.

Chapter 3

Applied Methodology

3.1 Morphological extraction method

Mathematical Morphology is initially created from set theory. In this process we can totally eliminates the fuzzy process of recognition of vertical line or horizontal lines. We have utilized primitive morphological operations for preprocessing of picture.

As English language consist of 10 digit and each digit is different from the other digits by some characteristic feature. Recognition of this numerals appears simple but the problems arises due to similarities between different numerals and discrepancies between the same numeral and can be tackled by analyzing the similar and dissimilar features after that decisions should be made accordingly. In this paper, divided the ten digits into two groups. Group 1 which consists of digits with blobs with or without stems. Like **[0, 4, 6, 8,and 9].**And Group 2 consists of digits with only stems, like **[1, 2, 3, 4, 5, and 7].**

Now the group 1 is again divided into two subgroups i.e. the digits with only two blobs i.e. 8and another with a single blob with or without stems **[0, 4, 6, 8, and 9].**These blobs are identified by region filling method. For this purpose, blobs are initially filled by using morphological region filling method as described below.

An input image is resized to size 45x36. Size of the image is taken as randomly. After that the input image is converted to binary. Now morphological-dilation process is operated on that binary image. If A and B are sets in Z2, the dilation of A by B is denoted for some a εA and bεB as

$A \oplus B = \{c\varepsilon\ Z2 \mid c = a + b\}$……. (1)

In dilation process the image is expanded to fill all the holes that should be present inside foreground.

Numerals cab be detected by 2 features:

- blobs
- stems

Blobs are the boundary line surrounded by the number .We can easily identified with the help of boundary finding method considering the property as hole. In this method the input will be a

binary image and returns the exterior boundaries of the image. The boundary β(A) of a set A is characterized as

β(A) = A - (A Θ B) …….. (2)

These boundaries that are not related to blobs .It has been seen that there are exactly two boundaries that are not coating the blobs. Consequently this procedure gives the number of blobs present in the image. Now image is to be filled using morphological region filling method.

Start with a point R inside the boundary, and fill the complete region with 1's.And rest are labeled 0.Procedure to fill the entire region with 1's:

$$X_k = (X_{k-1} \oplus B) \cap A^c, \quad k = 1, 2, 3 \ldots\ldots\ldots \quad (3)$$

Initially *Xo* = R, and B is 3x3 symmetric structuring element. The algorithm terminates at iteration step k if$X_k = X_{k-1}$.The set union of Xk and A contains the filled set and its boundary.

Then true image is subtracted from the filled image.

We can identify object using connected component approach. Say Z be a connected component contained in a set A and assume that a point R of Z is known. Now

$$X_k = (X_{k-1} \oplus B) \cap A, \quad k = 1, 2, 3 \ldots \quad (4)$$

Where *Xo* = R, and B is 3x3 symmetric structuring element. If$X_k = X_{k-1}$, the algorithm has converged and we let Z = Xk.

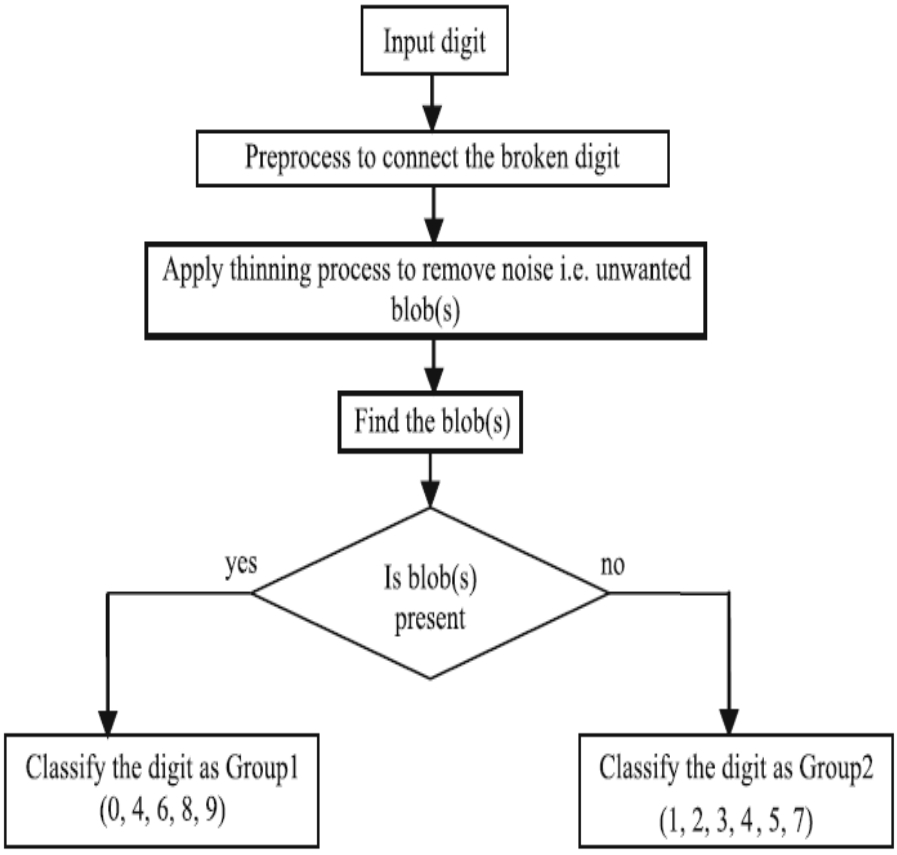

Figure 2: Decision tree for English numeral

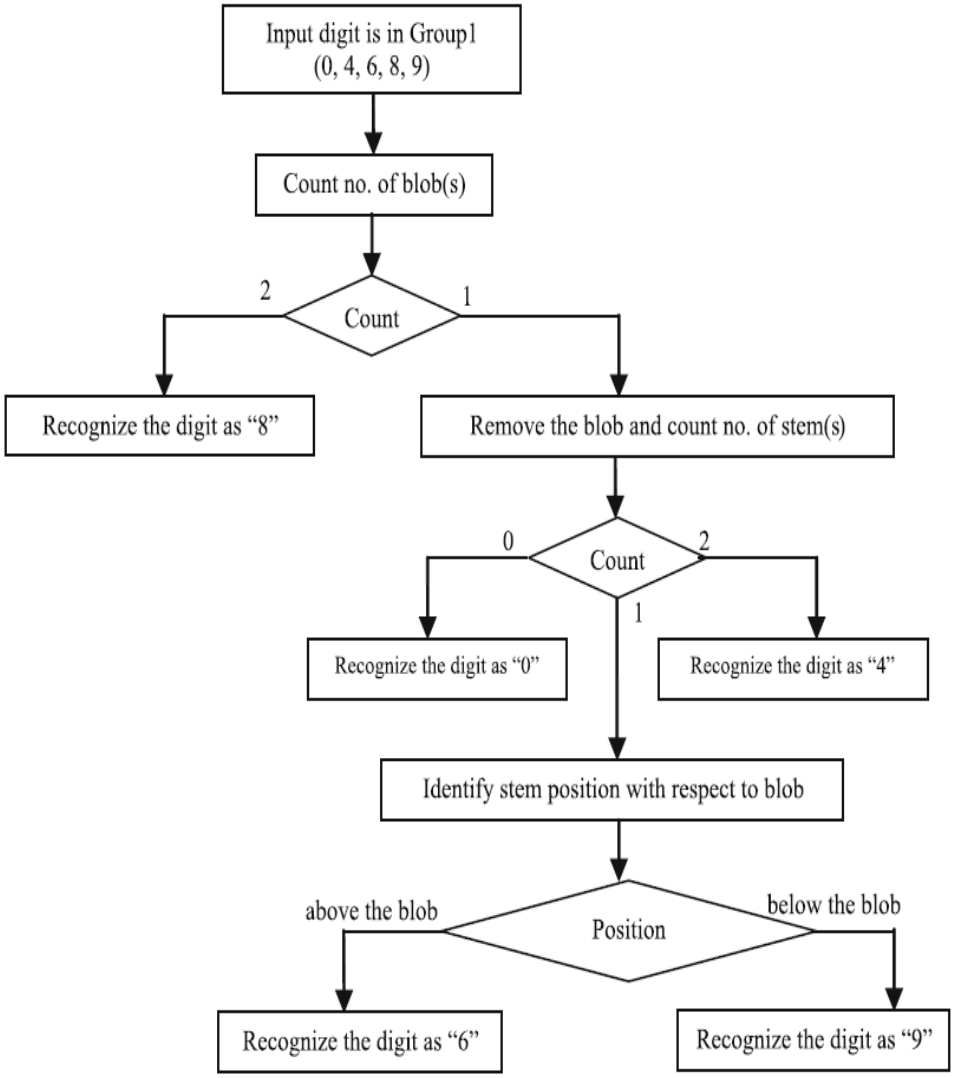

Figure 3: Decision tree for group 1 digit

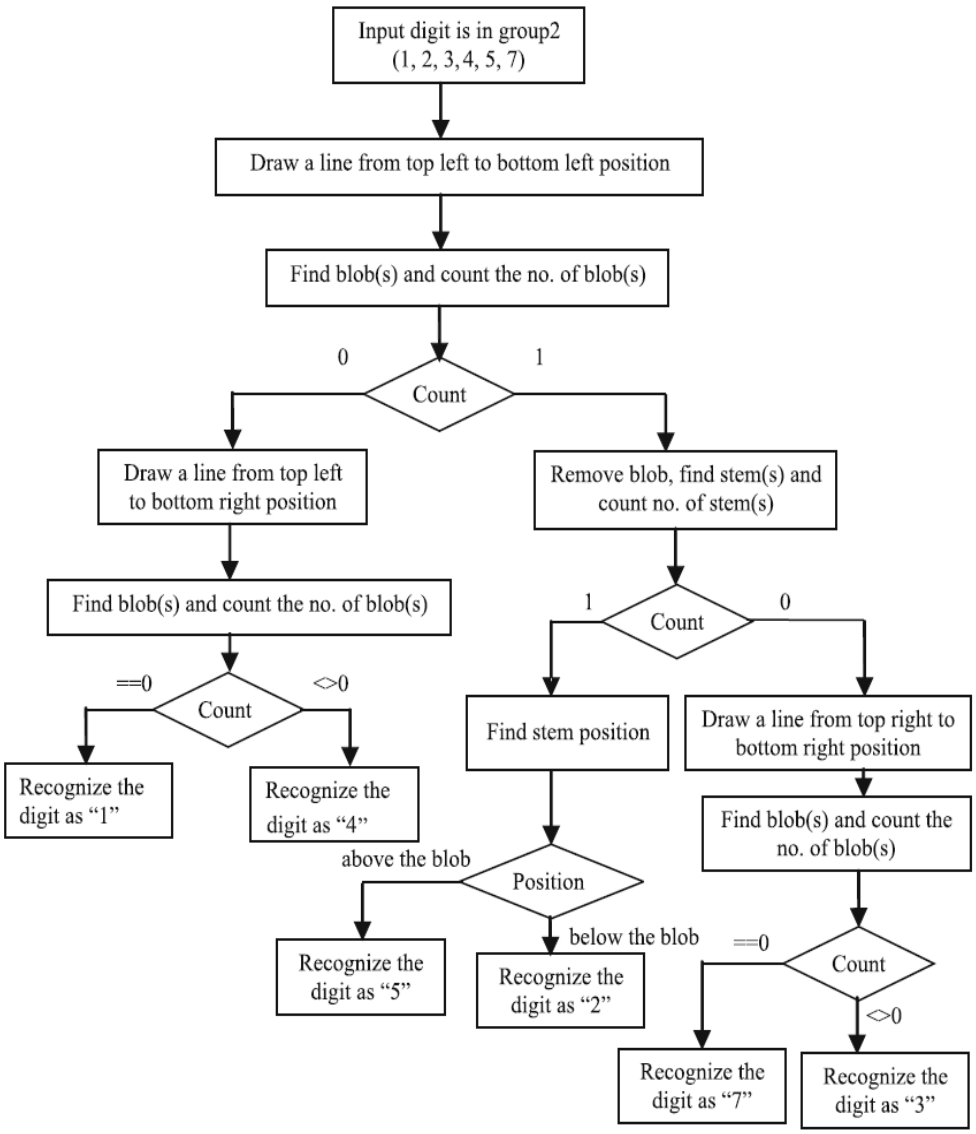

Figure 4: Decision tree for group 2 digits

By equation (4) a connected component blob is identified and later it is filled by a Region filling algorithm with background intensity. To check if there is any further blob a scan line approach is used to identify any fore ground pixel is in the image zone. Of course the above Process of equation (4) is repeated to identify whether it is a connected component or not. The methodology ends when all the joined segments are distinguished.

The process of recognizing these digits are given in detail in the flowchart in figures 2, 3 and 4. To conquer the disadvantage caused due to breaks in the handwritten digits at first, dilation technique is applied. To overcome the noise created by extra blobs in the form of additional single or more dots, thinning or skeletonization is connected as a fundamental step.

3.2 Implementation and results

The experiment were formed with the help of MATLAB.

3.2.1 Neural network overview

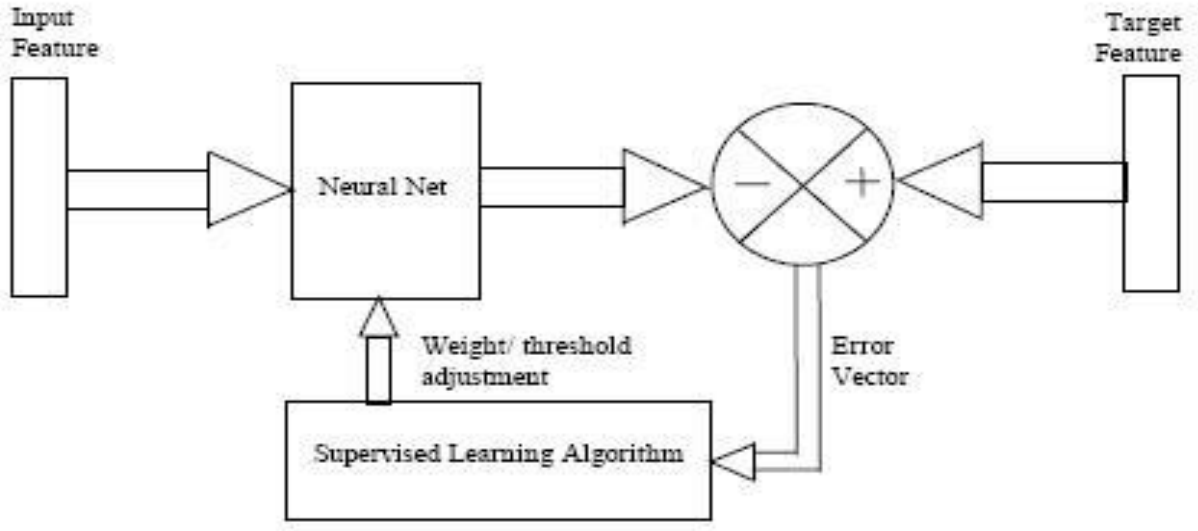

Figure 5: Neural Network Overview

So, basically neural network are composed of simple elements (neurons) operating in parallel. They can be trained by adjusting the value of the connection (weights) between elements in training the network are adjusted or trained so that a particular input lead to a specific target output.

3.2.2 Training

The matlab neural network toolbox used for the construction of neural network which uses nntraintool for the training of neural networks.

The entire feature set is divided into:

- **Training 70%**
- **Testing 15%**
- **Validation 15%**
-

While testing set is used to have a complete independent test of whether network is generalizing or not. Validation is used to see of the training process is not over fitting the network.

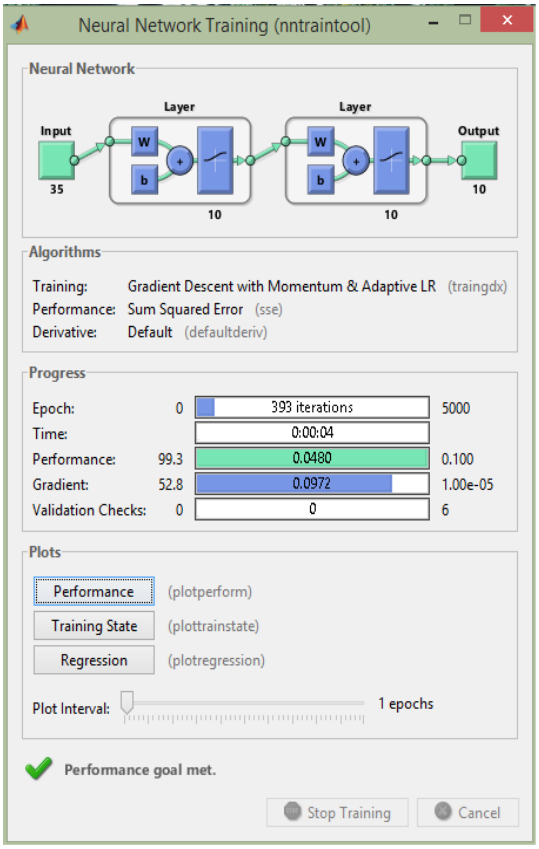

Figure6:Neural network training

3.2.3 Result

I have taken the snapshots of GUI interface

GUI interface consist of 6 action buttons

1. Load image
2. Select
3. Crop
4. Pre-Processing
5. Feature extraction
6. Recognize

Load Image

First we have to load the handwritten English graphic numeric image

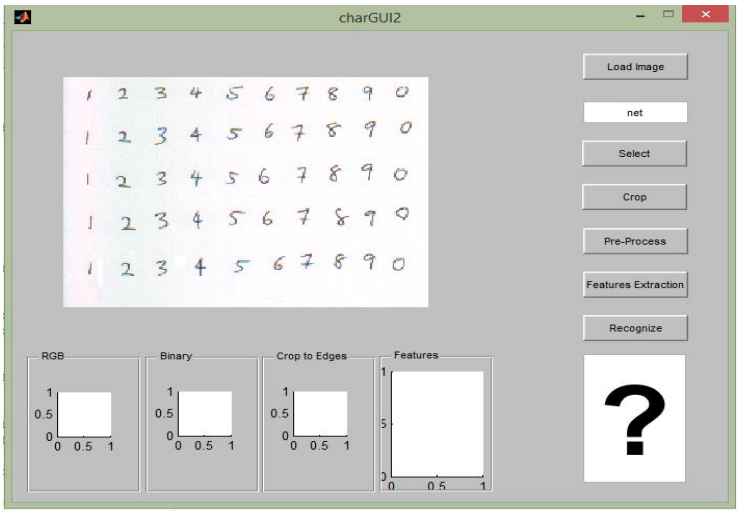

Figure 7: GUI interface of loading an image

Select

In this we have to select a random number that should be recognize.

Here I have selected number 5

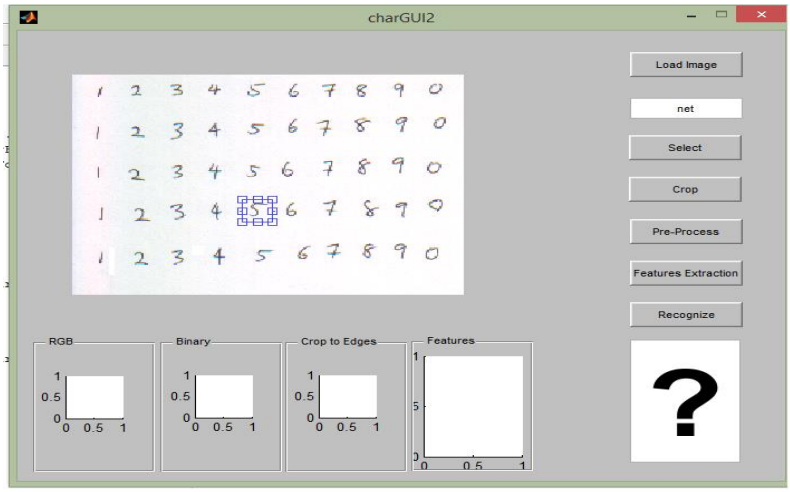

Figure 8: GUI interface of selecting an imag

Crop

Now the selected image is cropped i.e. 5

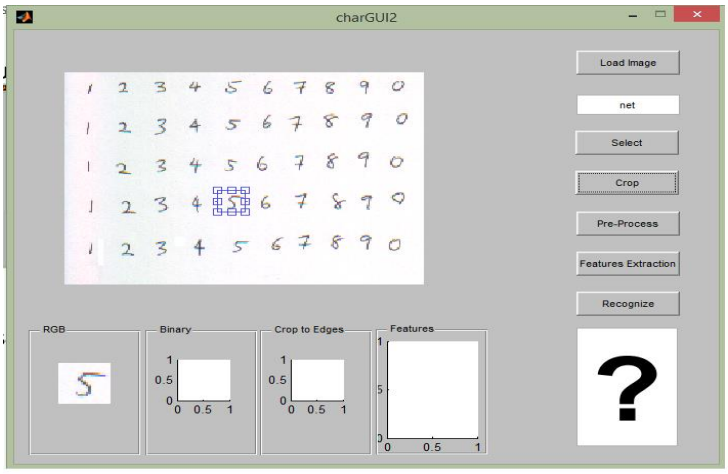

Figure 8: GUI interface of cropping an image

Pre-processing

In pre-processing step the cropped image, which is in RGB is converted into binary by removing noise.

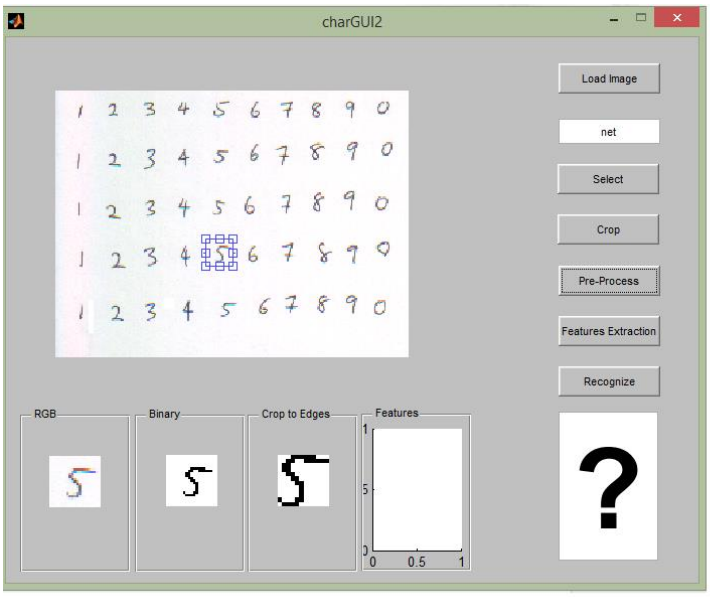

Figure 9: GUI interface of pre-processing an imag**e.**

Feature extraction

In feature of the selected image is extracted i.e. 5

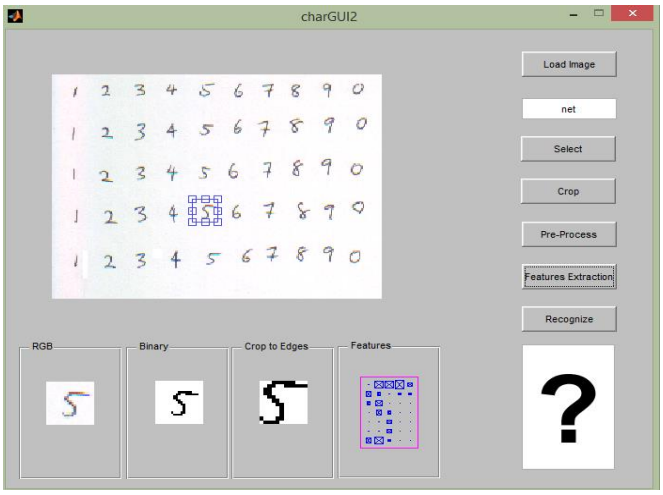

Figure 10: GUI interface of feature extraction an imag**e.**

Recognition

And finally the extracted feature of a selected image is recognize with the database.

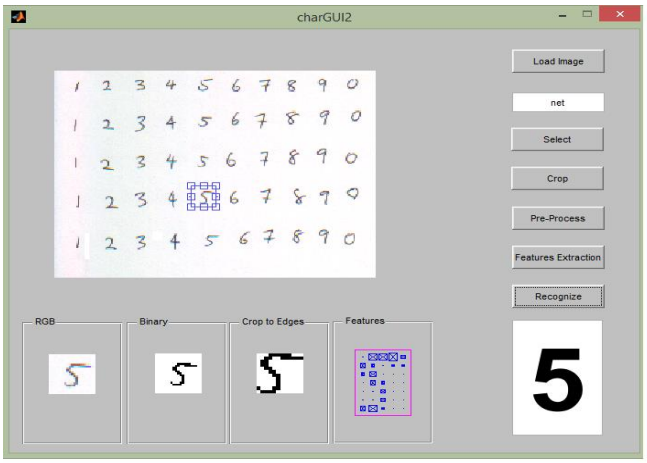

Figure 11: GUI interface of recognize image

Chapter 4

Conclusion

This algorithm evolved a new technique of recognition of digits by distinguishing proof of blobs and stems. Most of the digits are recognized by identification of blobs and to possible extent stems are extended to blobs by specific rules. The average success rates of recognition of all digits are above 90%.

The method fails in detecting the broken digits with large gap and deficient digits i.e. digits with additional stems or strokes.

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