

# Handwritten Characters Recognition Using Fuzzy Logic

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**Abstract**—In the present world of technologies Handwritten Character Recognition is one of the burning and challenging topics. It is the science that tries to make the machines as intelligent as humans in order to recognise the characters and classify them into the desired categories using the approach that is simple and reliable. This paper includes the introduction part, the steps involved in character recognition and the related algorithms for classification. And, further in this paper a method has been proposed to predict the personality of a person from feature that is extracted from their handwriting using soft computing techniques basically on Fuzzy Logic. In this paper the technique that is used for identifying Handwritten Character Recognition is Active Character Detection Algorithm. This technique is implemented using Fuzzy Logic and Neural Network. Thus, the performance of Handwriting Recognition behaviour depends on how will the different personal writing styles and its variations are modelled using Fuzzy Rules. The system is most likely to show high recognition accuracy for most characters.

**Keywords:** Feature extraction, Classification, Active Character Detection, Neural Network, Fuzzy Logic.

## 1. INTRODUCTION

The term “Handwriting” is coined to mean as a surface consisting of artificial graphics marks conveying some message through the mark’s conventional relation to a language (Plamondon and Srihari, 2000). Handwriting is a skill that is personal to every individual. Handwriting Recognition is the method of producing the symbolic form from the information that is stored in the handwriting data. The data in the Handwriting is being captured and stored in the digital format either by writing with special pen on an electronic surface or by scanning the characters that is written on paper.

Character Recognition is being categorised based upon the following two important aspects:

- 1) On the basis in which data is being acquired.
  - a) **Online Character Recognition:** It is also called as the intelligent character recognition. It recognizes the direction of the movements while writing characters. This method is widely used in cell phones, touch screen and touch pads etc.

- b) **Offline Character Recognition:** It is also called as optical character recognition. In this method either the printed text or handwritten text is converted into the digital format of the text. While writing the character it doesn’t involve the advantage of recognising the direction of movement.
    - 2) On the basis of the text type.
      - a) Machine Printed
      - b) Handwritten
- This paper focus only on the Offline handwritten recognition system that is being developed in past some years.

## STEPS INVOLVED IN HANDWRITTEN CHARACTER RECOGNITION SYSTEM

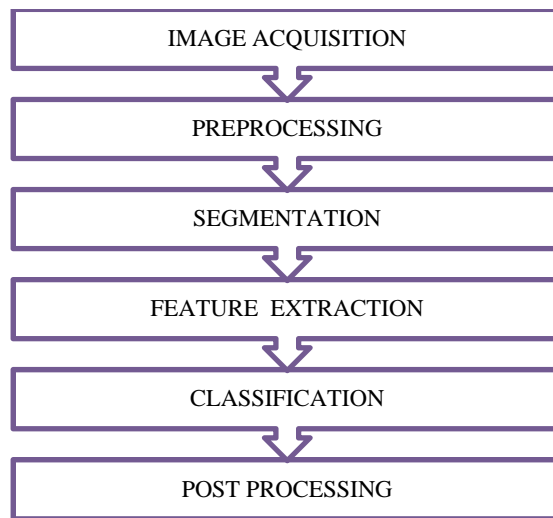


Fig. 1

### 1. Image Acquisition

Digitising and storing the image is termed as the image acquisition. Image acquisition is the preliminary step in

Handwriting character recognition. In recognition system scanned image is used as an input image. All the images are saved in the same format.

## 2) Pre processing

Pre processing of image involves the following steps:

- a) **Filtering:** Using this structural feature is extracted easily and the noise is removed.
  - b) **Thinning:** It is a process that is done iteratively in order to delete the outer pixels along the edge of the pattern until only a skeleton of pixel pattern is left.
  - c) **Search Vertices:** We extract a line junction in this step and the end of lines called as the vertices. At junction point numbers of branches of a vertex meet each other.
- 3) **Segmentation:** Segmentation means split to pieces. It is an important process as it affects the Recognition rate. In this method using a labelling process we assign a number to each character. The labelling gives the information about the number of characters in the image.

There is basically two types of Segmentation: External and Internal. In Internal Segmentation the sequence of characters in an image is partitioned into sub-images that is of individual characters. While, External segmentation involves the isolation of various writing units like words, sentences or paragraphs. Sometimes, the two adjacent characters components may overlap or touch then this situation creates problem in segmentation task. So it is an important stage.

- 4) **Feature Extraction** The input data is transformed into the set of features are called as feature vector, this process is known as feature extraction. It is basically used for the dimensionality reduction. When in an algorithm input data is too complex to be processed and is redundant than the input data is transformed into feature vector. Feature Extraction is a two-fold process as : It tells that not all data points are relevant for recognition and the network sizes becomes tractable computationally in case of neural network by reducing the data input space. So the feature extraction selects and prepares data that is to be used by the classifier for the recognition process. In feature extraction handwriting text is represented by a set of different features.

## 5) Classification

The classification step involves the decision making part in the recognition system for this it uses the feature that is extracted in the feature extraction step.

Various classification algorithms are as follows

- a) **K nearest neighbour:** It is based on example based learning. In recognition the k-nearest neighbour (KNN) is a method that classifies objects in the feature space based on the closest training examples. It is the simplest machine learning algorithm in which object is classified using the majority votes from the neighbours and then object is assigned to the class that is most common among KNN. Neighbours in this case are taken from the set of objects for which correct classification is known.
- b) **Naive Bayes Classifier:** It is based on the statistical and probabilistic classifier that is using the Bayesian

Theorem. It predicts the probability of same that is given and belongs to a particular class. It is the best type of the classifier, the above assumption is known as the “class conditional independence”. The Naive Bayes classifies using supervised learning approach for training. And the training in this case is fast and easy. Also, testing is simple and straight forward. Naive Bayes classifier uses the principle of maximum likelihood approach. For calculation of conditional probabilities the normal distribution is used. Parameters used in this case are mean and variance that is used in classification requires small amount of training. The classifier functionality is explain below with an example as: A fruit is recognised as an orange if it is round in shape, orange in color and 6” in diameter.

- c) **Support vector machine:** A N-dimensional hyper plane uses for the classification in support vector machine (SVM) which optimally categorised the data into two categories. It is a supervised learning method in which input data set is analysed and then learns from it and then use it in classification. SVM training algorithm constructs a model which assign new examples into one class or the other. It uses a hyper plane that is optimal which separates non linear data also. So, it is an efficient method.
- d) **Decision Tree:** A tree like structure is used to model all decision and all its possible consequences. It is a simple but a very powerful form of multiple variables analysis. The decision tree splits the set of data into branch like segments. An inverted decision tree is formed the segments that start with root node at the top. Every node that starts from the root includes the field name also known as object of analysis. The decision rule is obtained from a method that exhibit the relationship between the object that is analysed and fields which is one or more and acts as the input field that create the branches. The target field value is estimated using the value of the input field which is also known as the outcome. Once relationship is obtained then decision rules is derived that described the relationship between target and inputs. And then this decision rule is used to predict the unseen observation values.
- 6) **Post Processing** It is the final stage in the handwriting character recognition system. Recognised character is printed in the structured text format.

## 2. TECHNIQUE FOR IDENTIFYING HANDWRITTEN CHARACTER RECOGNITION

### 2.1 Active character detection algorithm (ACR)

It uses an active heuristic function which is same as that used by search algorithm that adaptively determines the feature itself as well as the length of feature vector which is used to classify the character. The central idea is that we will use a small set of features which can be computed from the image. The same features is computed from different sub images that

result in original image. Sub images in this method are defined by Quad tree rule. The character image that is bounding in the box is divided into four rectangular regions. The centre of mass of the contour is firstly computed. The four regions is determined by the vertical and the horizontal line that passes through the centre of mass.

### 3. SOFT COMPUTING TECHNIQUES INVOLVED IN HANDWRITING RECOGNITION

Soft computing is the best technique for the handwriting recognition. Soft computing is a branch of computer science that deals with intelligent and wiser machines. Intelligence involves not only coming to the answer but also provide the power to derive the answer. The soft computing (SC) applications provide two advantages:

- a) To solve non linear computation of problem in which mathematical model are not available.
- b) Also introduces the human knowledge like recognition, learning, understanding etc.

The SC techniques leads to system that have high Machine Intelligence Quotient(MIQ).The feature that is important for SC is acquisition of information from uncertain or inaccurate data.SC is a combination of techniques which involves various fields that come under different categories in computational intelligence.SC involves three branches the overview of these branches is explained below section

#### 1) Artificial Neural Network

In these artificial neurons is interconnected. Artificial neuron acts as a computational model that is inspired by the neurons of the human brain. The neurons in Artificial Neural Network (ANN) consist of Inputs, Weights, Activation Function and Output. The Input (also called as synapses) is multiplied by weight (strength of each signal) and result of the multiplication is computed at the Summation junction. And, the result of Summation junction is then passed into another function called Activation function which gives Output.ANN gives optimal solution using Fuzzy Matching .Also, acts as a classifier in character recognition. It uses the supervised learning in which we perform learning initially using the training data then it classifies the data on the basis of the knowledge it learns. The nodes in human brain are adaptable. It gains knowledge through the change in weight assigned in the connection.ANN is classified on the basis of:

- a) Architecture or Interconnection between neurons
- b) Activation Function
- c) Learning

It is a grateful degradation system because whatever it learns is distributed over the whole network.ANN has the ability to recover from distortions easily and has the capability to learn by example. The ANN used in areas like Air Traffic Control, Staff Scheduling, Weather Prediction and Handwriting Recognition etc.

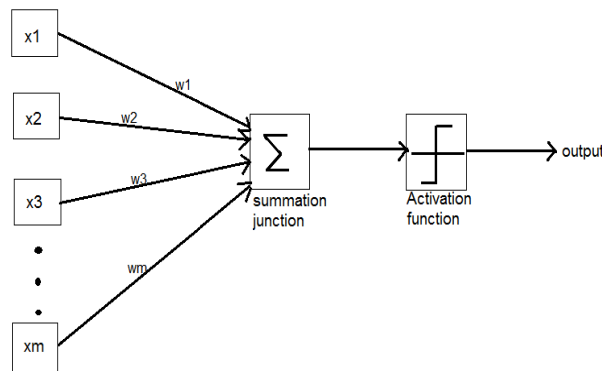


Fig. 2

#### 2) Fuzzy Logic

Fuzzy Logic (FL) works on imprecise, vague and ambiguous data input to give a definite conclusion. A Fuzzy Expert System (FES) is used instead of Boolean Logic. FES involves membership function and rules. The rules in FES are like:

**If service is excellent or food is Delicious then tip= generous**

Here service and food are input variables; Tip an output variable excellent, delicious and generous are fuzzy variables defined by membership function on service, food and tip respectively. The set of rules in FES is called as the knowledge base. There is the antecedent part which deals about to what degree the rule is to be applied also called as the rules premise, whereas the conclusion part assign membership function to output variable also called as rules consequent.

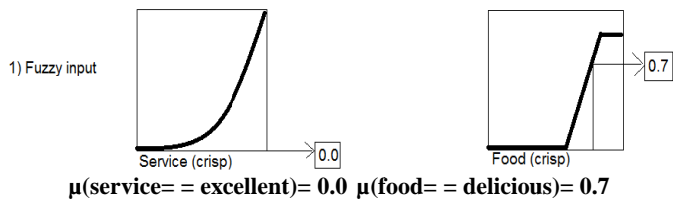
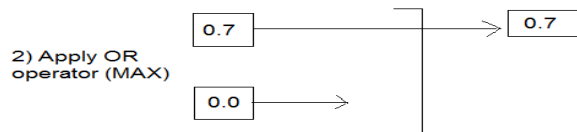


Fig. 3



**If (0.0 or 0.7) then tip= generous**  
**MAX (0.0, 0.7) = 0.7**

Fig. 4



**If (0.7) then tip= generous**

Fig. 5

### Benefits of Using Fuzzy Logic

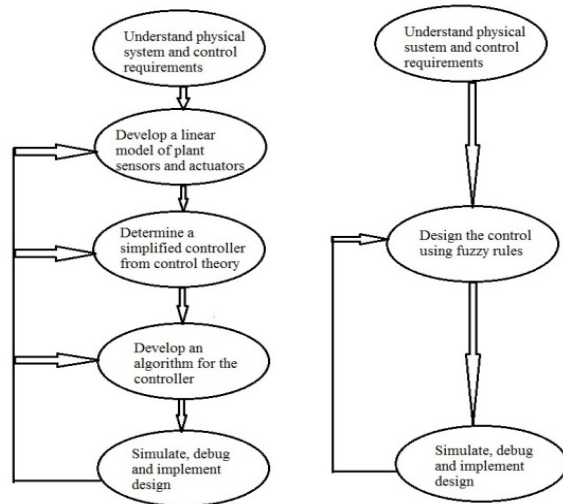


Fig. 6

### 4. CONCLUSION

This research paper provides a useful method that is used in handwriting recognition for constructing intelligent handwriting recognition system. Due to low computational requirement fuzzy logic is an efficient method for character recognition. As fuzzy system are robust; if some rules are removed then also the system works properly. The tedious task with the fuzzy logic is the building of rule-base that describes the character that is to be recognized. The problem is that different people writes the same character in different ways. So, the hybrid approach like NeuroFuzzy is used because it uses the concept of neural network and fuzzy logic system both.

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