Fuzzy Based Handwritten Character Recognition System

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ABSTRACT

Character recognition is the mechanical or electronic translation of scanned images of handwritten, typewritten or printed text into machine-encoded text [1]. This paper presents a fuzzy approach to recognize characters. Fuzzy sets and fuzzy logic are used as bases for representation of fuzzy character and for recognition. This paper describes a fuzzy-based algorithm which first segments the character and then using fuzzy system gives the possible characters that match the given input and then using defuzzication system finally recognizes the character.

Keywords- Defuzzification, fuzzy logic, fuzzy set, Handwritten character recognition, OCR.

1. INTRODUCTION

Character recognition is considered as one of the important technology for today's world and it is used in many fields such as artificial intelligence, computer vision, pattern matching etc. There are two types of character recognition systems [2].

1. Optical character recognition: - It is also considered as offline character recognition. In this type of character recognition either handwritten, type written or printed text is converted into digital format. It does not have the advantage of recognizing direction of the movements while writing the character.

2. Intelligent character recognition: - It is also considered as online character recognition. It recognizes character on the basis of the direction of the motion while writing character [3]. This method is generally available on touchpads, touchscreen cellphones etc.

Some of most commonly used methods available to implement optical character recognition are,

1. Neural networks.
2. Fuzzy logic.

Neural networks: - Neural networks are more commonly used in artificial intelligence termed as artificial neural networks. These are composed of artificial neurons or nodes which are interconnected. These interconnected neurons can be used for many artificial intelligence problem without necessarily creating a model of a real biological system.

Fuzzy logic: - Fuzzy logic is a many valued logic. It deals with reasoning that is approximate rather than fixed and exact [3,4]. In traditional two valued logic, we can have only two values true and false. But if the value is partially true then traditional two value logic is not appropriate to work with. This problem is solved by fuzzy logic. In fuzzy logic value ranges between completely true to completely false.

Thus, reasoning with fuzzy logic is similar to human reasoning that allows for approximate value and inferences as well as incomplete or ambiguous data. Fuzzy logic deals with the 'degree of truth' that can be basically defined as to which extent the given data is true.
For example, if there is a glass of water 30% filled with water, and a statement is made that glass is full. Then degree of truth for this statement will be 0.3, indicating that statement is 30% correct and 70% wrong.

Basic syntax for the rules in fuzzy logic is [4]:

IF variable IS property THEN action

This paper presents an approach for implementing optical character recognition using 'FUZZY LOGIC'.

2. Handwritten Character Recognition Using Fuzzy Logic

2.1 Sentence segmentation

Firstly, the input is taken in form of scanned images of the handwritten documents. These images consist of number of sentences. Firstly, those sentences need to be divided into characters to recognize each character independently. This segmentation can be done using any algorithm. Thus the sentences are divided into characters.

2.2 Character segmentation

Now, the output of the 1st step will be individual characters. Each of this character is analyzed to get recognized. We have a database of the characteristics features of the characters. Character recognition process need to match the features of characters with characteristic features in database. For this, the character further needs to be divided into number of cells. For example consider the English alphabets. They are segmented into **4** x **4** matrix cells. Character 'K' is shown as an example in Fig. 1.

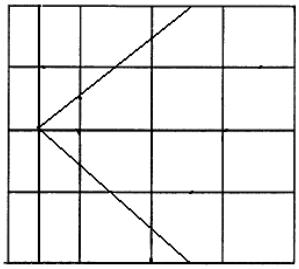

Fig.(1)

2.3 Character analysis

In this step, each cell is analyzed for characteristic features and the output is stored accordingly. Some of the characteristic features are as shown in Fig 2.

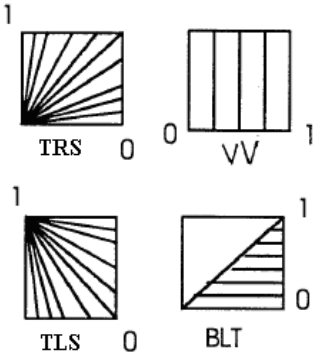

Fig.(2)

Each cells of the characters are compared with the characteristic feature on the basis of membership function [3] and the result is the category name under which it has membership associated with them. This will form part of the pattern extractor. The membership values may be classified into 'Low', 'Medium', and 'High' with membership values overlapping between them as shown in Fig 3.

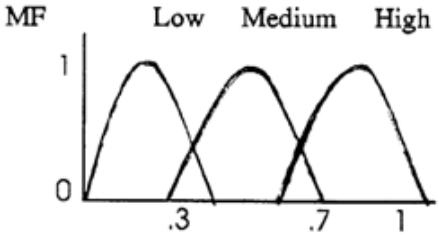

Fig.(3)

Here, The Character analyser and Character Recognition System which constitute the fuzzy processor consist of a number of IF..... THEN.... ELSE rules. These rules may be applied to the output from the pattern extractor which will be in the form of a fuzzy matrix of all the cells constituting a particular character.

All the cells of the character together forms the universal set as follows.

X = { X11, X12, X13, X14, X21, X22, X23, X24, X31, X32, X33, X34, X41, X42, X43, X44}

Now for each character of the alphabet we will have one fuzzy set for itself defined as $\overline{A}, \overline{B}, \ldots\ldots\ldots\ldots, \overline{Z}$.

So the fuzzy set, **S = {** Xij, μ(Xij), Ck }

Where S = $\overline{A}, \overline{B}, \ldots\ldots\ldots\ldots, \overline{Z}$

Xij = cells from universal set.

μ(Xij) = Membership value of Xij in category Ck.

Ck = Feature category name.

Some of the rules that form part of the fuzzy **process** for character 'K' is given below:

IF **X11** is MEDIUM OR MEDIUM-HIGH OR HIGH in VV
THEN **X11** is 0.4 in VV.
IF **X12** is LOW **OR** LOW-MEDIUM OR MEDIUM in BRS
THEN **X12** is **0.2 in** BRS.

On the basis of the values obtained above by applying fuzzy rule we get the complete fuzzy set for the character 'K' as follows.

$\overline{k}$ ={(X11,0.4,VV),(X12,0.2,BRS),(X13,0.8,BRS), (X21,0.4,VVTRS),(X22,0.8,BRS),(X31,0.4,VV TLS),(X32,0.8,BLS),(X41,0.4,VV),(X42,0.2,B LS), (X43,0.8,BLS) }

Using these standard fuzzy set different variations of letter as shown in the following figure can also be detected.

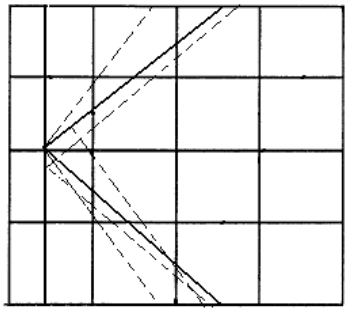

Fig.(4)

Fuzzy set for other characters can also be obtained in similar manner.

3.DEFUZZICATION

As a result of applying the previous steps, we obtain a fuzzy set of each character. This fuzzy set is then compared to the fuzzy set of the characters in the database. The database contains the default fuzzy set of all the characters. When the fuzzy set is compared, we obtain a fuzzy set from the comparing process that describes, for each fuzzy set of characters present in the database, how much the character's fuzzy set obtained from the previous steps matches with the default set [4]. In other words, for every possible default set, we get a grade of membership that describes to what extent the obtained fuzzy set matches with the default set.

Once this is obtained, using a fuzzy system as a controller, we want to transform this fuzzy information into a single value that will actually recognize the character. This transformation from a fuzzy set to a crisp number is called a defuzzification. Defuzzification is the process of producing a quantifiable result in fuzzy logic, given fuzzy sets and corresponding membership degrees. Different approaches are available for defuzzification. They are as follows

- Centre of gravity method (COG)
- Centre of singleton method (COS)
- Maximum methods
- Margin properties of the centroid methods

In our system, we are going to apply the maximum method for defuzzification. This class of method determines the final value by selecting the membership function with the maximum value. Like in our project, when we once obtain the values i.e. the extent to which it matches with different characters, then the defuzzification system gives the final result as the character whose value is maximum. Thus, if a character 'K' gives output as 0.3 in 'R',0.6 in 'K' and 0.1 in 'B', then the maximum value is given as output by the defuzzification system and thus character 'K' is recognized successfully.

4. RESULTS

There are 3 steps for implementing this system which are as explained in the section 2 and 3. We have implemented the character segmentation part and the results are as follows:-

Fig(5) shows the original image(handwritten word).

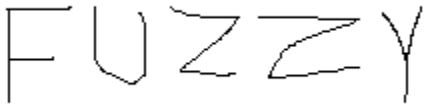

Fig.(5)

The sentence segmentation is then done. In this step, each character is separately identified from a word in a sentence and shown in a red colored box. The image is then divided and each character is considered as a separate image. Then each image is divided into 4*4 matrix cells by using padding and zooming. Segmented images are shown in Fig(6) to Fig(10).

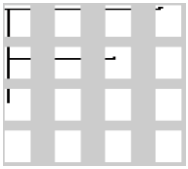

Fig.(6)

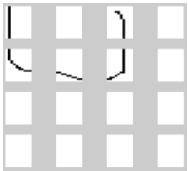

Fig.(7)

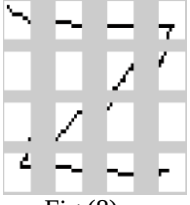

Fig.(8)

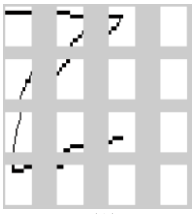

Fig.(9)

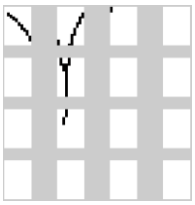

Fig.(10)

CONCLUSION

In this paper, a fuzzy recognition system of off-line handwritten characters has been designed. The system has basically 3 steps. We have implemented the first step of the 3 steps in handwritten recognition. The variability in human handwriting was interpreted as source of fuzziness in these characters. Fuzzy sets have been used to model this fuzziness using a small characteristic features. This has led to a simple, but powerful recognition system. The success of the fuzzy rule-based system that is used in recognizing the characters would be quite heavily depended on the accuracy of the features extracted and the way the rules are structured. Hence a novel characteristic that makes our system more accurate is that the system divides each character in number of cells and then the features of each cell are extracted by comparing then with characteristic features in the database. No training is needed by this system for recognition. The system is likely to show high recognition accuracy for most characters.

FUTURE SCOPE

The system given in this paper is mainly used for recognition of off-line handwritten characters. The work can be extended for recognizing online handwritten characters by combining system with optical character recognition system. Also this system works accurately only for separated characters & not for connected characters. Hence connected characters cannot be recognized. A good segmentation algorithm to segment connected characters can be used to avoid this limitation.

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