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Fuzzy Logic based Image Processing

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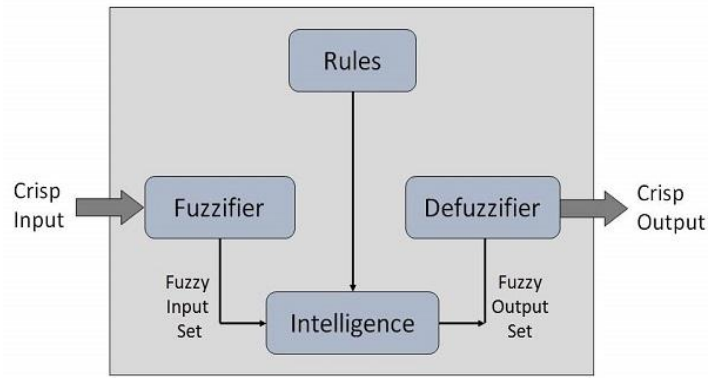
Abstract: Images have been playing very important role in human life since beginning of human civilization. Applications of images are found ranging from basic but very effective exchange of ideas and information to some advanced technologies in the industry, society, medical and military field. Image data has become an important field of research with rapid and huge growth of visual information in the number of large-scale and online image repositories[2]. "Fuzzy set theory and fuzzy logic provide powerful tools to represent and process human knowledge in form of fuzzy if-then rules. Many difficulties in image processing arise because the data, tasks, and results are uncertain[3]. This uncertainty, however, is not always due to the randomness but to the inherent ambiguity and vagueness of image data. Beside randomness-which can be managed by probability theory-other kinds of imperfection in image processing include grayness ambiguity, geometrical fuzziness, and vague knowledge of image features. This paper imports fuzzy logic concept into image retrieval to simulate these properties of human's thoughts. Fuzzy method emphasis on adopting the fuzzy language variables to describe the similarity degree of image features, not the features themselves. In this way, we can simulate the nonlinear property of human's judgments of the image similarity as well as making use of the fuzzy inference to instruct the weights assignment among various image features.

Keywords: Content Based Image Retrieval; Fuzzy Logic; Color Feature, Fuzzy Color Histogram; Fuzzy Colored Image.

INTRODUCTION

CBIR is a set of techniques for retrieving semantically relevant images from an image database based on automatically derived image features generally, in CBIR systems, the visual features (color, texture, and shape) are represented at low level. Classical mathematic method adopts the rigid logic to measure the similarity of images, and therefore cannot deal with the uncertainty and imprecision exist in the humans thoughts. To overcome this problem, we introduce a new system of visual features extraction and matching using Fuzzy Logic (FL) which is a powerful tool that deals with reasoning algorithms used to emulate human thinking and decision making in machines. Fuzzy Logic - Classical Set Theory:-A set is an unordered collection of different elements. It can be written explicitly by listing its elements using the set bracket. If the order of the elements is changed or any element of a set is repeated, it does not make any changes in the set.



II. FUZZY APPROACHES

Membership functions allow you to quantify linguistic term and represent a fuzzy set graphically. A membership function for a fuzzy *set A* on the universe of discourse X is defined as $\mu A: X \rightarrow [0,1]$.Here, each element of *X* is mapped to a value between 0 and 1. It is called membership value or degree of membership. It quantifies the degree of membership of the element in *X* to the fuzzy set *A*.x axis represents the universe of discourse. y axis represents the degrees of membership in the [0, 1] interval[1]. There can be multiple membership functions applicable to fuzzily a numerical value. Simple membership functions are used as use of complex functions does not add more precision in the output All membership functions for LP, MP, S, MN, and LN are shown as below −

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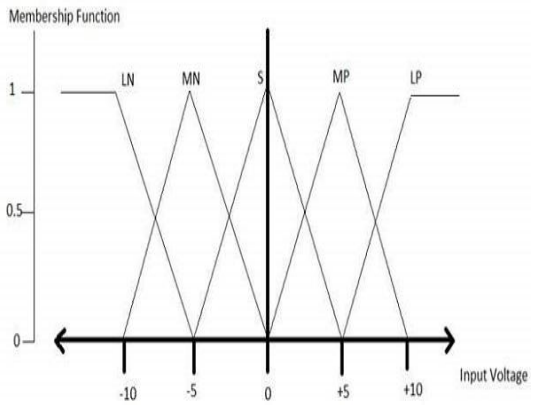

III. FUZZY REASONING

Fuzzy reasoning, approximate reasoning, is an inference procedure whose outcome is conclusion for a set of fuzzy if-then rules. The steps of fuzzy reasoning can be given as follows:"Input variables are compared with the membership function on the premise part to obtain the membership values of each linguistic label (fuzzification).The membership values on the premise part are combined through specific fuzzy set operations such as: min, max, or multiplication to get firing strength (weight) of each rule. The qualified consequent (either fuzzy or crisp) is generated depends on the firing strength. The qualified consequents are aggregated to produce crisp output according to the defined methods such as: cancroids of area, bisector of area, mean of maximum, smallest of maximum and largest of maximum (deffuzification).

Rules of fuzzy reasoning:
Rules

- If x is A1 and y is B1
  Then z is C1
- If x is A2 and y is B2
  Then z is C2

IV. FUZZY LOGIC IN PATTERN IMAGE PROCESSING

Fuzzy image processing (FIP) is the collection of all approaches that understand, represent and process the images, their segments and features as fuzzy sets. The representation and processing depend on the selected fuzzy technique and on the problem to be solved.

Fuzzy image processing has three main stages:
1. Image Fuzzification
2. Modification of membership values
3. Image Defuzzification

The most important reasons for FIP are as follows:
1. Fuzzy techniques are powerful tools for knowledge representation and processing
2. Fuzzy techniques can manage the vagueness and ambiguity efficiently

In many image-processing applications, expert knowledge is used to overcome the difficulties (e.g. object recognition, scene analysis). Fuzzy set theory and fuzzy logic offer us powerful tools to represent and process human knowledge in form of fuzzy if-then rules. On the other side, many difficulties in image processing arise because the data/tasks/results are uncertain. This uncertainty, however, is not always due to the randomness but to the ambiguity and vagueness. Beside randomness which can be managed by probability theory can distinguish between three other kinds of imperfection in the image processing

• Grayness ambiguity
• Geometrical fuzziness
• Vague (complex/ill-defined) knowledge

These problems are fuzzy in the nature. The question whether a pixel should become darker or brighter than it already

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is, the question where is the boundary between two image segments, and the question what is a tree in a scene analysis problem, all of these and other similar questions are examples for situations that a fuzzy approach can be the more suitable way to manage the imperfection

Fuzzy Logic Edge detection for Image segmentation
Edge detection techniques transform images to edge images benefiting from the changes of Grey tones in the images. Edges are the sign of lack of continuity, and ending. As a result of this transformation, edge image is obtained without encountering any changes in physical qualities of the main image. Objects consist of numerous parts of different color levels. In an image with different Grey levels, despite an obvious change in the Edge detection.
There are different possibilities for development of fuzzy logic based edge detections. One method is to define a membership function indicating the degree of edginess in each neighborhood. This approach can only be regarded as a true fuzzy approach if fuzzy concepts are additionally used to modify the membership values. The membership function is determined heuristically. It is fast but the performance is limited.

V. PATTERN RECOGNITION BASED ON FUZZY CLUSTERING

clustering can be considered the most important unsupervised learning problem; so, as every other problem of this kind, it deals with finding a structure in a collection of unlabeled data. Clustering is defined as "the process of organizing objects into groups whose members are similar in some way". A Cluster is therefore a collection of objects which are "similar" between them and are "dissimilar" to the objects belonging to other clusters. Various approaches are used for clustering like Fuzzy C means Algorithm, Log-Based Clustering, Hierarchical Clustering, Retrieval Dictionary Based Clustering, Fuzzy K Means clustering method, Fuzzy edge detection

VI.FUZZY INFERENCE SYSTEM

Fuzzy inference system is a method that interprets the values in the input vectors and based on used defined rules ,assigns values to the output vector. Using a GUI editors and viewers in the fuzzy logic toolbox , we can build the rules set, define membership functions and analyze the behavior of a fuzzy inference system. The editors and viewers are used to edit and view the membership functions and rules for fuzzy inference system[5]. The steps of fuzzy reasoning (inference operations upon fuzzy IF–THEN rules) performed by FISs are:

1.Compare the input variables with the membership functions on the antecedent part to obtain the membership values of each linguistic label.(this step is often called fuzzification.)
2. Combine (usually multiplication) the membership values on the premise part to get firing strength(degree of fulfillment) of each rule.
3. Generate the qualified consequents (either fuzzy or crisp) or each rule depending on the firing strength.
4. Aggregate the qualified consequents to produce a crisp output. (This step's called defuzzification.)

VII.FUZZY INFERENCE METHODS

The most important two types of fuzzy inference method are Mamdani and Sugeno fuzzy inference methods ,Mamdani fuzzy inference is the most commonly seen inference method. This method was introduced by Mamdani and Assilian.Another well -known inference method is the so -called Sugeno or Takagi –Sugeno – Kang method of fuzzy inference process .This method was introduced by Sugeno [4].This method is also called as TS method. The main difference between the two methods lies in the consequent of fuzzy rules.

VII. CHALLENGES IN FUZZY LOGIC

One of the main advantages of a fuzzy logic based approach that it allows the developers to focus on the decision logic of the algorithm. Also, the architecture of a fuzzy logic approach requires that an algorithm for a specific problem is built on a bottom up design, where all sub steps of the decision algorithm are described and composed to reach the final solution. This comes at a price unfortunately. In this section the author describes some of the issues faced in fuzzy logic based projects and a general overview of the issues with the use of fuzzy logic.
There is a risk involved when designing a project and deciding to use fuzzy logic. This includes the previously mentioned phase of designing of the fuzzy logic solution for a specific algorithm[4]. Modeling a domain specific problem in pseudo code is easier then achieving the same in a fuzzy logic description. It is highly unlikely that the domain expert has knowledge is/or an expert in fuzzy logic as well. It also introduces further difficulties in the maintenance of the algorithm implementation.

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VIII. CONCLUSION

Fuzzy image processing is a powerful tool form preparation of expert knowledge edge and the combination of inaccurate information from different sources[2]. The intended fuzzy rules are an attractive result to improve the quality of edges as much as possible. The main advantage of fuzzy logic is membership function can be used to classify edges. For example to order them from primary to irrelevant and to choose with which class of edges we want to operate with, or use in some more complex image processing[3]. fuzzy image processing technique, is time complexity because we need to iterate several times through the image. There are many possible fields of use for this approach, especially when we are dealing with sensitive and uncertain data. It could be used in molecular biology or in Medical laboratories for sample extractions, image improvement, image segmentation, noise removal, pattern recognition and as preprocessing method for more complex image processing algorithms.

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