Efficient Content Based Image Retrieval using Novel Soft Computing Techniques

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***Abstract*— Retrieval of images based on low level visual features such as color, texture and shape have proven to have its own set of limitations under different conditions. As the number and size of image databases grows, accurate and efficient content-based image retrieval systems become increasingly important in business and in the everyday lives of people around the world. In this paper we describe a novel framework for performing content-based image retrieval using soft computing techniques such as Artificial Neural Network and Fuzzy Logic. Given a user specified query image, the system first extracts image features by using wavelet decomposition. These features can be used for training of Multilayer Feed Forward Back-propagation algorithm and these features will be also used as an input to the Fuzzy Inference System. The experimental results reveal that the performance of image retrieval can be surprisingly enhanced.**

***Keywords*— CBIR, Soft Computing, Artificial Neural Network Fuzzy Inference System**

I. INTRODUCTION

In the early 1990s, as a result of advances in the Internet and new digital image sensor technologies, the volume of digital images produced by scientific, educational, medical, industrial, and other applications available to users increased dramatically. The difficulties faced by text-based retrieval became more and more severe.

The efficient management of the rapidly expanding visual information became an urgent problem. This need formed the driving force behind the emergence of content-based image retrieval techniques. In 1992, the National Science Foundation of the United States organized a workshop on visual information management systems to identify new directions in image database management systems. It was widely recognized that a more efficient and intuitive way to represent and index visual information would be based on properties that are inherent in the images themselves. Researchers from the communities of computer vision, database management, human-computer interface, and information retrieval were attracted to this field. Since then, research on content-based image retrieval has developed rapidly. Retrieval of *required-query-similar* images from abundantly available / accessible digital images is a challenging need of today. The image retrieval techniques based on visual image content has been in-focus for more than a decade.

The fundamental difference between content-based and text-based retrieval systems is that the human interaction is an indispensable part of the latter system. Humans tend to use high-level features (concepts), such as keywords, text descriptors, to interpret images and measure their similarity. While the features automatically extracted using computer vision techniques are mostly low-level features (color, texture, shape, spatial layout, etc.). In general, there is no direct link between the high-level concepts and the low-level features.

1.1 Image Retrieval Systems

The term content-based image retrieval (CBIR) appears to have been first used in the literature by Kato [1992] to describe his experiments in the automatic retrieval of images from a database by colour and shape [1]. The typical CBIR system performs two major tasks. The first one is feature extraction, where a set of features is extracted to describe the content of each image in the database. The second task is the similarity measurement between the query image and each image in the database, using the feature extraction.

The feature extraction values for a given image are stored in a descriptor that can be used for retrieving similar images. Image descriptors are descriptions of the visual features of the contents in images that produce such descriptions. They describe elementary characteristics, such as color, texture, shape or motion, among others. The key to a successful retrieval system is choosing the right

features to accurately represent the images and the size of the feature vector. The features are either global, for the entire image, or local, for a small group of pixels. According to the methods used in CBIR, features can be classified into low-level and high-level features [2]. Color features are the most widely used low-level features for image retrieval because it is one of the most straightforward features utilized by humans for visual recognition. However, image retrieval using color features often gives disappointing results because, in many cases, images with similar colours do not have similar content.

1.2 Soft computing Techniques

Soft computing is a type computing which deals with imprecision, uncertainty, partial truth, approximation and vague data. Soft computing became a formal Computer science are of study in early 1990s. Earlier computational approaches could model and precisely analyze only relatively simple systems. More complex systems arising in biology, medicine, the humanities, management sciences, and similar fields often remained intractable to conventional mathematical and analytical methods. Components of Soft Computing include:

- Artificial Neural Networks (ANN)
- Fuzzy Logics (FL)
- Evolutionary Computations (EC)

a) Artificial Neural Network

Neural networks were earlier thought to be unsuitable for deduction because of their inherent black-box nature. This is, however, its strength as well. No information in symbolic form is needed to train the neural network for subsequent classification and/or deduction beyond its domain of training. There has also been active research aimed at extracting the embedded knowledge in trained networks in the form of symbolic rules. This serves to identify the attributes that are needed in performing classification.

b) Fuzzy Logic

The ability to model imprecise and qualitative knowledge and handle uncertainty are distinguished characteristics of fuzzy sets. Fuzzy logic is capable of addressing approximate or vague notions that are inherent in many content based image retrieval tasks.

Fuzzy Membership Function and Linguistic Variables

The special structure of fuzzy numbers makes calculations very time-consuming and sophisticated. Generally for facilitating calculations and practical usage, particular fuzzy numbers are used. In this paper, the experts' opinions are described by linguistic variables which have been expressed in trapezoidal fuzzy numbers.

In order to determine the relevancy of ontology elements to related specific domain (concept's membership degree to main domain and relation's membership degree to concepts), seven linguistic variables have been used as: "not relevant", "very low relevant", "low relevant", "medium relevant", "high relevant", "very high relevant", and "fully relevant". Figure 1 presents these linguistic variables and their corresponding trapezoidal fuzzy numbers.

1.3 Fuzzification the "Modification Process Ontology"

Software maintenance happens in a relatively disorganized way and naturally leads to the deterioration of software systems' structure. Lacking a complete knowledge of all the implementation details, apply modifications that will result in a loss of structure, which in turn makes the systems more difficult to understand fully and, therefore, to maintain [30]. To break this vicious circle, we aim at developing a knowledge management approach for software maintenance domain. This approach will be modelled as fuzzy ontology.

c) Evolutionary Computing

Evolutionary computation uses iterative progress, such as growth or development in a population. This population is then selected in a guided random search using parallel processing to achieve the desired end. Such processes are often inspired by biological mechanisms of evolution. Evolutionary computing techniques mostly involve metaheuristic optimization algorithms. Broadly speaking, the field includes : Evolutionary algorithms such as Gene expression programming, Genetic algorithm, Genetic programming, Evolutionary programming, Evolution strategy, Differential evolution, Differential search algorithm, Eagle strategy and Swarm intelligence which includes, Ant colony optimization, Particle swarm optimization, Bees algorithm and Cuckoo search.

II. RELATED WORK

An accurate and rapid model for content based image retrieval process depending on a new matching strategy is presented in [1] use soft computing techniques. The proposed model is composed of four major phases namely: features extraction, dimensionality reduction, ANN classifier and matching strategy. As for the feature extraction phase, it extracts a color and texture features, respectively, called color co-occurrence matrix and difference between pixels of scan pattern. The artificial neural network in the proposed model serves as a classifier so that the selected features of query image are the input and its output is one of the multi classes that have the largest similarity to the query image. In addition, the proposed model presents an effective feature matching

strategy that depends on the idea of the minimum area between two vectors to compute the similarity value between a query image and the images in the determined class.

Relevance feedback methods in Content Based Image Retrieval iteratively use relevance information from the user to search the space for other relevant samples [2]. As several regions of interest may be scattered through the space, an effective search algorithm should balance the exploration of the space to find new potential regions of interest and the exploitation of areas around samples which are known relevant. However, many algorithms concentrate the search on areas which are close to the images that the user has marked as relevant, according to a distance function in the multidimensional feature space. this novel hybrid approach that uses a scattered search algorithm based on NSGA II only at the first iteration of the relevance feedback process. This system gives good precision and recall.

An efficient content-based image retrieval system based on fuzzy relevance feedback is developed [3]. Conventional content based image retrieval systems that use relevance feedback, want user to mark retrieved images as relevant or irrelevant, while this determination is difficult for images which are rich in semantic. As a result, this system integrates the log information of user feedback using a soft feedback model to construct fuzzy transaction repository. The semantic similarity between the query image and each database image can then be computed using the current feedback and the semantic values in the FTR. Furthermore, the SVM is applied to the session-term feedback in order to learn the visual similarity.

Samy Sadek, Ayoub Al-Hamadi, Bernd Michaelis, and Usama Sayed presented Image Retrieval using Cubic Splines Neural Networks [4]. They have discussed a new architecture for a CBIR system; the Splines Neural Network-based Image Retrieval (SNNIR) system. SNNIR makes use of a rapid and precise network model that employs a cubic-splines activation function. By using the cubic-splines network, the proposed system could determine nonlinear relationship between images features so that more accurate similarity comparison between images can be supported.

Katarzyna Agnieszka Olkiewicz and Urszula Markowska-Kaczmar proposed Emotion-based Image Retrieval using Artificial Neural Network Approach[5]. They have presented the approach for content based image retrieval systems which takes into account its emotional content. The goal of their research was to examine possibilities of use of an artificial neural network for labelling images with emotional keywords based on visual features only and examine an influence of used emotion filter on process of similar images retrieval.

Kim-Hui Yap and Kui Wu proposed Fuzzy relevance feedback in content-based image retrieval systems using radial basis function network[6]. They have presented a new framework called fuzzy relevance feedback in interactive content-based image retrieval systems based on soft-decision. An efficient learning approach is proposed using a fuzzy radial basis function network. Conventional binary labelling schemes require a crisp decision to be made on the relevance of the retrieved images. However, user interpretation varies with respect to different information needs and perceptual subjectivity. In addition, users tend to learn from the retrieval results to further refine their information priority. Therefore, fuzzy relevance feedback is introduced to integrate the users fuzzy interpretation of visual content into the notion of relevance feedback. Based on the users' feedbacks, an FRBFN is constructed, and the underlying parameters and network structure are optimized using a gradient-descent training strategy.

Wang Xiaoling and Xie Kanglin presented Application of the Fuzzy Logic in Content-based Image Retrieval [7]. They introduced the fuzzy logic into image retrieval to deal with the vagueness and ambiguity of human judgment of image similarity. Their retrieval system has the following properties: firstly adopting the fuzzy language variables to describe the similarity degree of image features, not the features themselves; secondly making use of the fuzzy inference to instruct the weights assignment among various image features; thirdly expressing the subjectivity of human perceptions by fuzzy rules impliedly; lastly they proposed an improvement on the traditional histogram called the Average Area Histogra to represent color features. Experimentally we realized a fuzzy logic-based image retrieval system with good retrieval performance.

An automatic content based image retrieval system annotate and retrieve images by assuming regions in an image can be described using a vocabulary of blobs. Blobs are generated from image features using clustering. Features are locally extracted on regions to capture Color, Texture and Shape information. Regions are processed by an efficient segmentation algorithm. Images are structured into a region adjacency graph to consider spatial relationships between regions.

III. PROPOSED WORK

In this paper, we describe a novel framework for performing content-based image retrieval using soft computing techniques such as Artificial Neural Network and Fuzzy Logic. Given a user specified query image, the

system first extracts image features by using wavelet decomposition. These features can be used for training of Multilayer Feed Forward Back-propagation algorithm and these features will be also used as an input to the Fuzzy Inference System (FIS). The proposed framework is shown in Figure 2

A. *Preprocessing*

The database images and query image may have different dimensions and color representation, moreover the images may contain some degree of noise or they may be blurred. To improve the complexity of CBIR algorithm it is required to process the images prior to apply to CBIR algorithm. The preprocessing involves filtering, normalization, resizing of images.

B. *Extracting image features by using Wavlet transform*

Wavelet Transform is very useful tool for decomposition of images into different energy levels. This technique will be used for low level features extraction of database images and query image. Discrete Wavelet Transform (DWT) is used in this work.

C. *Training of Artificial Neural Network*

The low level features extracted by using Wavelet Transform are used as input to the ANN. Feed Forward Back Propagation Neural Network Architecture is proposed. It consists of input layer, one hidden layer and output layer. '*tansig*' transfer function is used for input and hidden layer whereas '*purelin*' transfer function is used for output layer. The system is trained for features of 1000 database images.

D. *Defining Fuzzy Inference System*

The high level semantic features which are linguistic variables will be mapped onto fuzzy variables. The membership functions are defined for inputs and output. Fuzzy Inference Rules are also defined, then the FIS is simulated for test image.

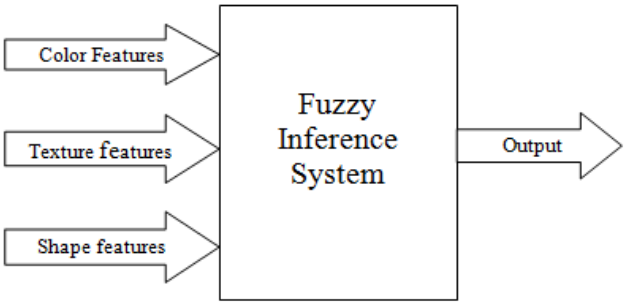


Fig.1. Fuzzy Inference system

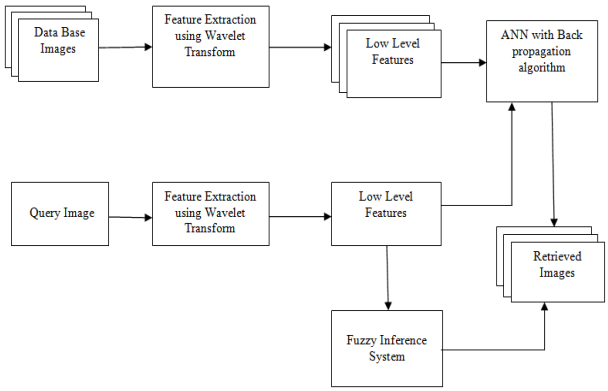


Fig.1. Framework for CBIR using fuzzy inference system

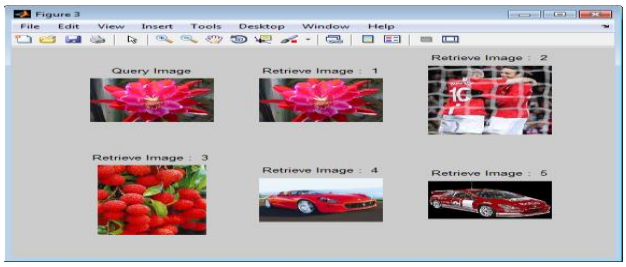
VI. RESULTS

Possible outcomes

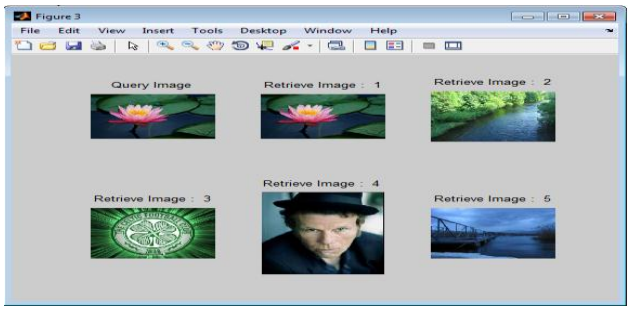
- Input → Query Image
- Output → The set of images from the image database with matching features with Query image

The Experiment is carried out by taking some query/test images as follows

Fig.3. Query/Test images



(a)



(b)

Fig.4. (a) & (b) Image retrieval resultsThe authors have carried out experiments on test images by using ANN and Fuzzy Logic approach and the precision and recall are given below.

Table I : Precision Values (%)

Category	ANN	Fuzzy Logic
Food	46	48
Buildings	61	63
Beach	87	90
Elephants	85	90
Buses	63	67
Flowers	85	88
Mountains and Glaciers	40	50
Average	66.71	70.85

Table II : Recall Values (%)

Category	ANN	Fuzzy Logic
Food	10	10
Buildings	11	11
Beach	19	21
Elephants	18	20
Buses	11	12
Flowers	17	17
Mountains and Glaciers	9	10
Average	13.57	14.42

VII. CONCLUSION

The dramatic rise in the sizes of images databases has stirred the development of effective and efficient retrieval systems. In this paper, the authors have proposed a novel framework for performing content-based image retrieval using soft computing techniques such as Artificial Neural Network and Fuzzy Logic. The comparative results are presented. It is found that the soft computing approach for content based image retrieval can improve the retrieval accuracy and efficiency.

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