A Color Based Fuzzy Algorithm for CBIR

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ABSTRACT
Volume of the information on the World Wide Web has become very huge in which digital images occupy the largest chunk of such information due to availability of good-quality digital photographic tools in affordable prices. Goal of ongoing research in the field of Image Retrieval is not only the expansion of storage capacity but also the development of effective and efficient retrieval techniques. The objective of this research is to find a solution for retrieving image information from digital image databases with better rate of recall and precision using theory of soft computing which is suitable to model a system for digital image retrieval because of the capability of this approach to capture the vague and imprecise information in digital images. In this paper a review of conventional and content-based image retrieval techniques has been given and finally a color based fuzzy algorithm for CBIR has been implemented by using Fuzzy C-Means algorithm.

KEYWORDS
CBIR, Fuzzy Logic, Color based CBIR, Soft Computing, Fuzzy Image Retrieval.

1. INTRODUCTION

Volume of the information on the World Wide Web has become very huge due to the rapidly growing hardware and software technologies and huge demand of image information worldwide. Digital images occupy the largest chunk of such valuable information available over the Internet. This is because of the availability of better quality of digital photographic tools in multimodal form and their affordable prices owing to the huge demand of information in the form of digital images related to the social media like facebook, medical imaging and health care services, criminology, security systems, defense & surveillance operations, satellite systems, online education, e-business and automatic process control etc. This is leading to requirement of the ongoing expansion of image databases thereby creating a new field of Image Data Base Management System [1, 2]. Due to tremendous growth in storage technology, speed and capacity of storage devices have increased [3] and their cost has become affordable now. So, expansion of storage capacity in today's digital systems is not a difficult task. However, the effective and efficient retrieval of digital images from such huge databases is still a challenging task [4]. A better solution for retrieving information from digital image databases is badly required. The theory of hard computing is not appropriate to design such systems due to its inherent inability to capture the fuzziness of information contained in digital images [1]. The theory of soft computing is suitable to model a system for digital image retrieval because of the capability of this approach to capture the vague and imprecise information contained in digital images. Retrieval of desired images effectively and efficiently from such a huge collection, based on their some matching features like color, texture, shape or some semantics has been an important research interest for image database, pattern matching, image processing and computer vision communities [5, 6]. In this paper, a color based fuzzy algorithm for CBIR has been implemented by using Fuzzy C-Means algorithm to measure the similarities between the query image and the relevant clustered images in the image database. This paper is an effort in the direction of faster and effective method of image information retrieval.

A background study of various image retrieval techniques has been given in section 2. A classification of image retrieval algorithms is given in section 3. The proposed algorithm has been outlined in section 4. Section 5 and 6 deal with the results and conclusion respectively.

2. BACKGROUND

Image retrieval is about selecting the relevant images from a large image database. A computer system used to retrieve relevant images through indexing, searching, retrieving and browsing from a large digital image databases is called an image retrieval system [7, 8]. Authors of [2, 9] have provided a detailed description of some commercial and non-commercial image retrieval systems.

2.1 Image Retrieval

Image retrieval is the field of study concerned with searching and retrieving digital images from a collection of image database which is being explored since the 1970s [2, 9]. B E Prasad, Amar Gupta, Hoo-Min Toong and S.E. Madnick [7] has designed the first microcomputer-based image database retrieval system at MIT, in the 1990s.

Research in image retrieval systems is evolving from keyword based, to low level features and to semantic features. Movement towards semantic features is due to the problem of the keywords which can be very subjective and time consuming while low level features cannot always describe high level concepts in the users' mind [1]. Image retrieval has been applied in the fields of digital image processing, multimedia applications, social media, digital libraries, remote sensing, astronomy, entertainment, education, defense & surveillance, criminology, terrorism, biomedicine, military, commerce, culture and Web image classification and searching [10].

An effective image retrieval system is able to operate on the collection of images to retrieve the relevant images based on the query image which conforms as closely as possible to human perception.

Two major research communities namely, database management and computer vision, study image retrieval from different perspectives, one being text-based and the other visual-based [11, 12] (See Figure 1). Text-based image retrieval techniques employ text to describe the content of the image while visual based or content-based image retrieval (CBIR) uses visual features to describe the contents of image.

2.1.1 Conventional Image Retrieval

In conventional image retrieval systems, keywords are used as descriptors to index an image; however the content of an image is much richer than what any set of keywords can express. Text-based image retrieval techniques employ text to describe the content of the image which often causes ambiguity and inadequacy in performing an image database search and query processing. This problem is due to the difficulty in specifying exact terms and phrases in describing the content of images as the content of an image is much richer than what any set of keywords can express. Since the textual annotations are based on language, variations in annotation will pose challenges to image retrieval.

2.1.2 Content Based Image Retrieval

Content based image retrieval or CBIR has become an important alternative to text based image retrieval [13]. The initiative was taken by IBM through a proposal of the query-by-image-content (QBIC) system. A CBIR system uses either low level or high level features of an image for retrieval of similar images.

The low level image features sometimes cannot describe the high level ideas or concepts in the users' mind. A computer machine can perform automatic retrieval by extracting the low level features that are represented by color, texture and shape etc. of an image with more efficiency [14, 15]. The semantic gap between the concepts in the users' mind and the low-level features offered by CBIR systems cannot be removed completely due to the fact that visual image feature descriptors extracted from an image cannot be automatically and reliably translated into high-level semantics [4].

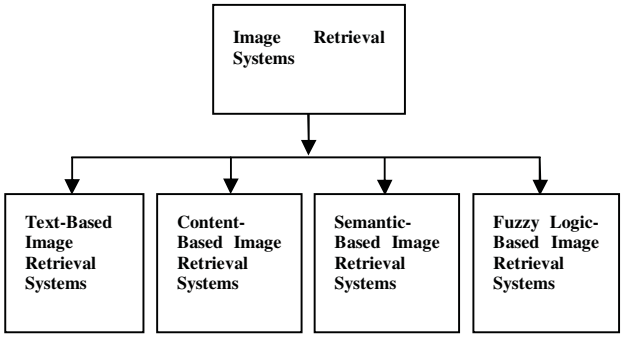

Fig. 1. Classification of Image Retrieval Systems

2.1.3 Semantic Based Image Retrieval

Neither a single feature nor a combination of multiple visual features could fully capture high level concept of images. Since the performance of image retrieval based on low level features are not satisfactory, there is a need of research for image retrieval based on semantic by trying to extract the cognitive concept of a human to map low level image features to high level concept. In addition, representing image contents with semantic terms allows users to access images through text query which is easier and preferable to users for expressing their mind compared with using images.

Clustering or segmentation of extracted low level features of images is done on the basis of similarities in characteristics of visual features. Intension is to form some regions representation and next to form objects representation in the images. The regions/objects representation will be annotated with keyword by image annotation process. This annotation process can be done either manually, semi-automatically or automatically. The image then will be represented using semantics and image retrieval can be queried based on high level concept. Semantics based contents representation has been identified as an important issue to bridge the semantic gap [16] in visual information retrieval; it is a good description and representation for image which is able to capture meaningful contents of the image. Spatial relationship among these objects/regions can be used to further increase the confidence in image understanding.

2.1.4 Fuzzy image retrieval [17, 18, 19, 20, 21, 22]

The soft computing applications in image processing can be broadly classified into the three major parts:

2.1.4.1 Soft computing techniques in image sensing

This deals with uncertainty in image sensing like wavelet based features extraction, classification, and uncertainty in rotation, scaling, shift, registration and translation of images.

2.1.4.2 Soft computing applications in image retrieval

This deals with the linguistic expression based image description framework and its applications to image retrieval.

2.1.4.3 Soft computing in applications of image analysis

This field includes the applications in the image analysis in the fields from biology, enterprise, education, governments and space sciences etc.

3. IMAGE RETRIEVAL ALGORITHMS

Image retrieval algorithms are either text-based or content-based with some variations in their approach.

3.1 Text-Based/Annotation-Based Image Retrieval (TBIR/ABIR)

Traditionally image retrieval techniques were not based on visual features but they rely on textual annotation of images which was a priori human work performed manually for every image in the image database with some related text. The image search engine would search those annotations from traditional database systems and then the corresponding images were retrieved. This techniques is also called QBT (query by text) [12, 23] because in this technique query is given in form of the text or keyword and the target are the images. When images are identified using these annotations, such retrieval is known as annotation-based image retrieval (ABIR) [12, 24].

The ABIR approach is easy to implement and understand due to popularity of commercial web search engines accustomed in retrieving the text document over the Internet. Retrieving images on text is even simpler as only the portion of the document of the image needs to be searched. Because of its low cost, text-based approach can retrieve much more relevant images over the Internet, so gives a much higher recall rate than the CBIR approach [24]. Annotation is the difficult and cumbersome task due to manual search in the large database, time consuming, costly and subjective [24]. To solve the problem of subjectivity, the contextual information in image retrieval can be distributed into two forms: 1) Enforcing interaction between the user and the system and 2) Other context is found during the data creation. In this technique images are arranged in the tree like fashion (See Figure 2). To overcome the drawbacks, content-based image retrieval systems were developed that index images by their visual contents such as color, texture and shape etc.

3.2 Content Based Image Retrieval (CBIR)

Content Based Image Retrieval (CBIR) is another technique that helps to retrieve the images from the large image databases by their visual contents present in the images on the basis of extraction of visual features of images such as color, texture and shape [25, 26, 27]. To overcome the drawbacks of text based technique, the concept of CBIR was proposed which increased the efficiency for retrieving the images. This approach is also known as the QBE (Query-By-Example) [25, 27] in which a query image is submitted to the system by the user; other techniques like clustering, segmentation/subdivision, feature extraction, indexing and ranking etc. (See Figure 3 in the previous page) are performed to retrieve the desired images.

3.2.1 Types of CBIR

Types of CBIR being explained in the following sub sections (See Figure 4):

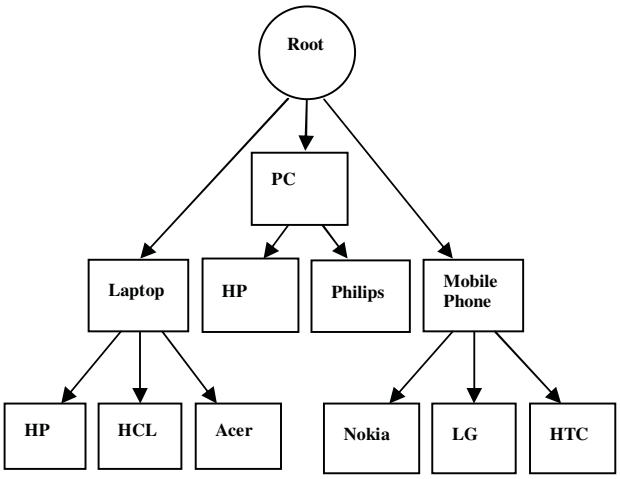

Fig.2. Tree structure of computing and communication devices

3.2.1.1 Color Based Retrieval

For CBIR, the color feature is one of the most important and comprehensive features used for retrieving images [5, 28, 29, 30, 31, 32], which plays vital role in image retrieval [33, 34, 35, 36] because of its simple representation and easy computation techniques. At the lowest level, images are represented as pixels which are used to represent points in a three dimensional color space. Some of the important color models are RGB, HSV and CMY etc.

In color based image retrieval, the user either gives a single query image or a combination of query images as input and after using the color features of the query image and those of the images in the image database the most similar images are retrieved on the basis of the similarity matching

technique [37] which is selected on the basis of some criteria.

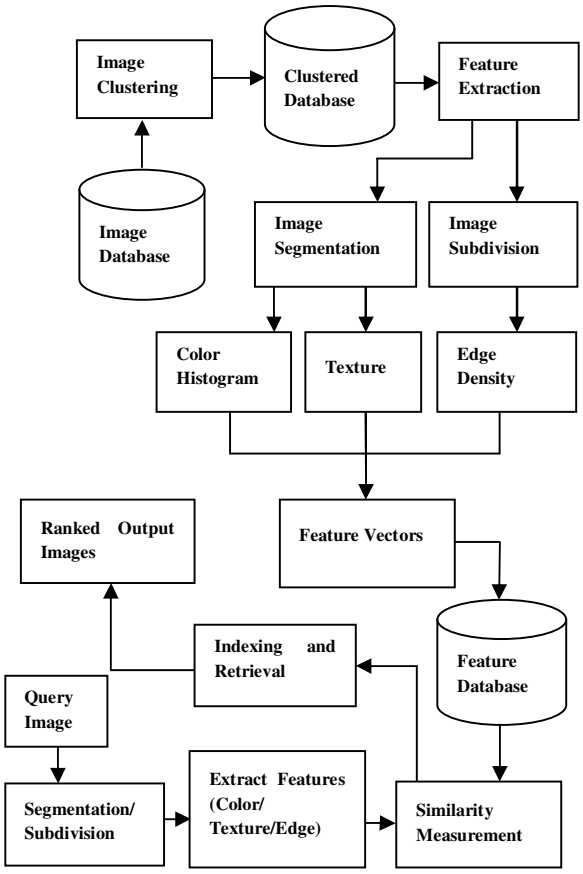

Fig. 3. Modified Architecture of CBIR System

The concept of histograms for speedy and transformation-independent retrieval of images using color feature is derived from Swain and Ballard [38], who described that the feature has got much larger information than its gray counterpart in order to identify the similarity between the images [39]. RGB and CMY color models are device-dependent and perceptually different but for display purpose of images, RGB color model is widely used [35, 40].

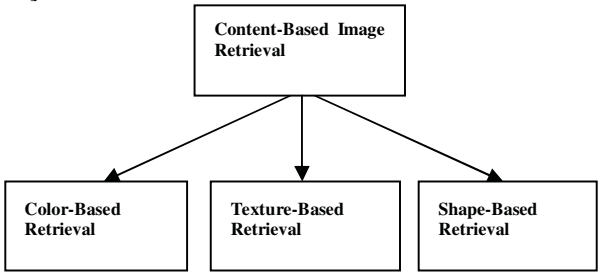

Fig. 4. Types of CBIR

3.2.1.2 Texture Based Retrieval

Texture is also an important feature of an image [41]. Extensive research has been done in the field of computer vision and pattern recognition for representation of textures available in images in order to recognize various objects in a scene. There are two basic methods of texture representation: *structural* and *statistical*. A good description of structural methods of texture representation can be found in [35, 40].

3.2.1.3 Shape Based Retrieval

Shape is another feature of images which in the form of boundary or outline of an object provides distinctive forms [35, 40] for matching those objects which are similar in shape. Shape features are used after segmentation of images into various regions of interest are performed. Researchers have found accurate segmentation a very difficult task to perform; so shape features for image retrieval are used only when the objects or regions are easily computable.

3.3 Intelligent CBIR (ICBIR)

The goal of image retrieval algorithms is to facilitate the user with the most possible relevant image from the image database. So there is an urgent need for image search engines to detect the intent of the specific user as quickly as possible [26, 27, 40]. Various tools and techniques are needed for retrieving the specific image. Various search engines for the textual/visual information are available but for the visual feature of still and moving pictures the research for better search engines is going on [26, 27]. Presently there is a need of efficient and effective image search engine which may be intelligent enough to remember user's requirements by detecting user preferences, important traits and usual habits apart from the features of information given by the query image. The ICBIR system must keep track of user's query and apply the techniques to determine color and texture desired by the user.

3.4 Clustering and Image Classification

Clustering is defined as a process of classifying data points into distinct and smaller groups or clusters according to some related characteristic features of the given data set [42]. Clustering is used in image retrieval to classify images into groups whose feature vectors are similar from the outcome of similarity metrics used for comparing the images [43]. Through clustering dissimilar images can be separated. Clustering algorithms are of the following types:

3.4.1 Hierarchical Clustering Algorithms (HCA)

HCAs use recursion to find nested clusters. They start with each data points in their own clusters and merge the most similar pair of clusters together repeatedly to form a cluster hierarchy in the former; starting with all the data points in

one cluster and recursively dividing each cluster into smaller clusters in the later.

3.4.2 Partitional Clustering Algorithms (PCA)

PCAs use partitioning of data to find all the clusters simultaneously. PCA is generally used in the field of pattern recognition to know the nature of available data.

3.4.3 Fuzzy Clustering Algorithms (FCA)

The most famous FCA is the Fuzzy C-Means algorithm [42, 44, 45], which is based on fuzzy partitioning of available data in which data points belong to some or all groups with degree of membership values ranging from 0 to 1; thereby creating probably overlapped groups. Being iterative in nature, FCM looks for cluster centers that minimize a dissimilarity (objective) function.

Steps of Fuzzy C-Means Algorithm: [44, 45]

1. Randomly initialize the membership matrix U in such a way that $\sum_{i=1}^{n} u_{ij} = 1$; j=1, 2, 3, …, n.
2. Calculate the centroid using following formula: $C_i = (\sum_{j=1}^{n} u_{ij}^{m} x_j) / (\sum_{j=1}^{n} u_{ij}^{m})$
3. Calculate dissimilarity between data points & centroids using: $J(U, c_1, c_2 \ldots, c_c) = \sum_{i=1}^{n} J_i = \sum_{i=1}^{n} \sum_{j=1}^{n} u_{ij}^{m} d_{ij}^{2}$ where, u_{ij} lies between 0 and 1; c_i is the centroid of the i^{th} cluster; d_{ij} is the Euclidian distance between i^{th} centroid and j^{th} data point; and m is a weighting exponent lying in the closed interval [1, ∞].

3.5 Similarity Measurement

To retrieve images, a query image to the retrieval system is submitted by the user. The system then changes the image into its own internal representation of feature vectors. Then the retrieval system retrieves images by calculating the similarities/distances between the feature vectors of the query image and the feature vectors of the database images.

3.6 Ranking and Indexing Techniques

An indexing scheme is used to perform image retrieval operation by an efficient way to search for the images in the database. For searching the relevant images from the image database, we need an image search engine which can find the user specified image automatically and efficiently with greater precision and speed. Ranking is used to arrange the searched images, according to some criteria for restricting the search only to a specific number of best results.

4. THE PROPOSED ALGORITHM

In Color based image retrieval systems, the following steps are generally followed:

1. Initially select a proper color model.
2. Quantize the color palette.
3. Extract all the color values from the image.
4. Measure the similarity by calculating distance function.

In color based image retrieval, the user either gives a single query image or a combination of query images as input and after using the color features of the query image and those of the images in the image database the most similar images are retrieved on the basis of the similarity matching technique which is selected on the basis of some criteria [46, 47, 48].

In our proposed system we use color as a feature for retrieving relevant images from the image database. Fuzzy C-Means algorithm is applied on the images in the image database to group the images into relevant clusters. The cluster groups may be overlapped but the inspiration is for the speed of the overall retrieval process. Color histogram can be used to represent a color image by mapping the distribution of its color onto a selected color space. In a color histogram approach color feature from color space is represented by a bar graph. These bars are known as bins and these bins are mapped to the coordinate axes [49, 50]. The color histogram is executed by using one dimensional array. The frequency of a specific color in an image is the count of pixels present in the image with that color. The frequency of a color is stored in the array [51].

The proposed algorithm is given below:

Steps of Color Based Fuzzy Algorithm:

1. Load the image database into Matlab software.
2. Distribute the images from the database into matching clusters using Fuzzy C-Means algorithm.
3. Input the query image into the system.
4. Resize the query image into a 256 × 256 block.
5. Convert color images into grayscale images.
6. Normalize grayscale images to a fixed mean.
7. Generate histograms of the query image and the images in the fuzzy clustered database.
8. Calculate similarity distance measurement between the histogram of query image and the histograms of clustered images.
9. Rank all the matching images by sorting them according to their non-decreasing order of similarity distances.

The flowchart of the proposed algorithm is given below:

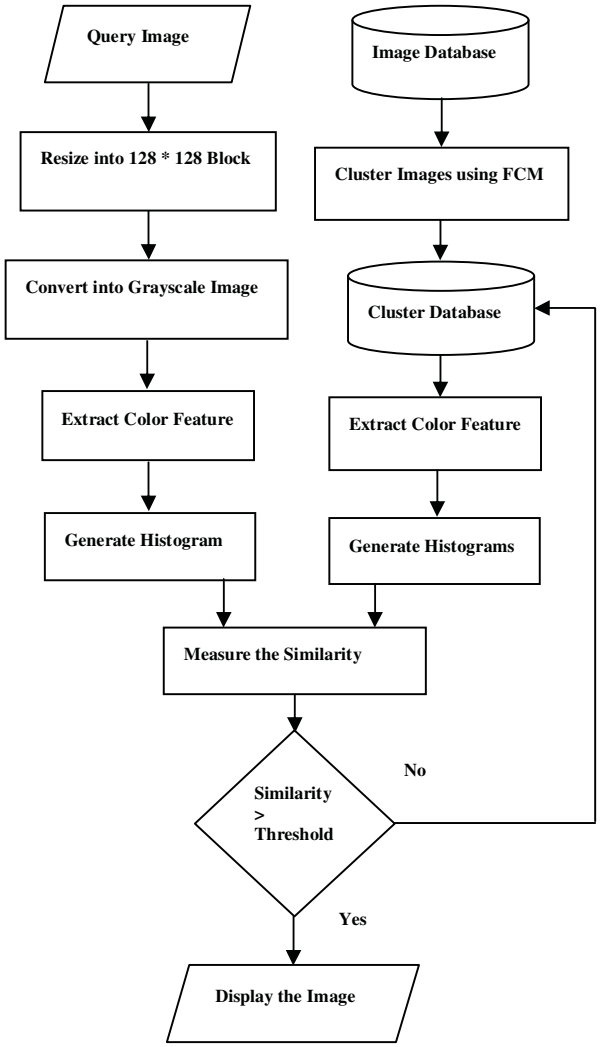

Fig. 5. Flowchart of the Algorithm

The formula for comparing histograms is given below:

$$\mathbf{d} = \sum_{j=1}^{256} (|c_1[j] - c_2[j]|)$$

Where, d = Distance between two histograms

c_1 = Histogram for the query image and

c_2 = Histogram for an image in the database.

After measuring the distances between the query image and the images in the database, the distances are sorted in non-decreasing order to make a rank of relevant images in order to display the resultant output to the system.

5. RESULTS AND DISCUSSION

A collection of medical images downloaded from the Internet [52] has been used as the image database for loading into the Matlab software. We have found the results to be very promising. One set of the result showing the Query image and the corresponding Retrieved images has been illustrated in the following Figure 6.

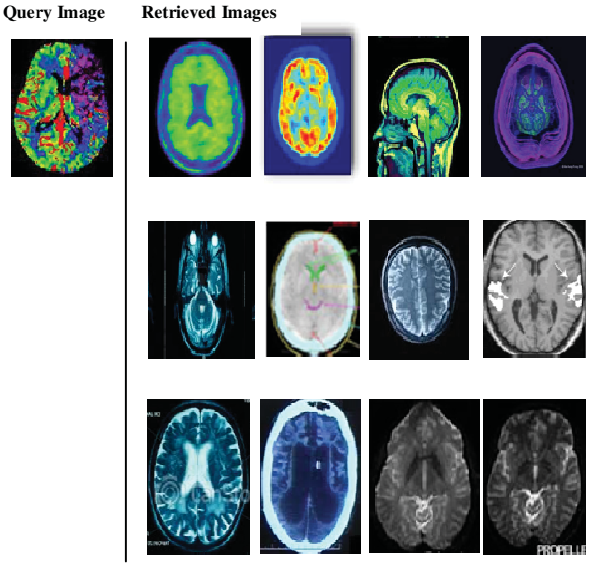

Fig. 6. Result shown on the GUI

6. CONCLUSIONS AND FUTURE WORK

In this paper, first we have reviewed the conventional and content-based image retrieval approaches and techniques used in image retrieval systems. The purpose of this research is to provide an effective and efficient algorithm for image retrieval to be based on soft computing approaches. We have proposed an image retrieval scheme using soft computing approach for which Fuzzy C-Means clustering technique has been considered. Features are extracted globally from whole of the image to keep the approach simple to implement.

As further research, firstly features can be extracted on both the whole image and segments of an image to capture the object descriptions in a better way. Secondly, some more efficient indexing and ranking techniques can be developed. Thirdly, use of relevance feedback [16] can be utilized by modifying the system into a web-based application to improve the retrieval performance. There are in fact many more future research directions including the design of an effective query processing technique.

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