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An Approach of Image Retrieval Using Content Based Retrieval System

[$]Parulpreet singh
[$]*Lect,Dept of CSE, Baddi university, India*

[#] Kulvinder Singh Mann
[#] *Associate prof.,Dept of IT, Gne college, Ludhiana India*

Abstract: ***The digital image is used to identify and recognize a person, object, location and various things. To find specific digital images from large database of images has become an area of wide interest nowadays. CBIR (Content based image retrieval) means that searching, browsing and retrieval the image using the actual contents of the image like visual features of an image such as color, shape, texture and spatial layout rather than the metadata such as keywords, tags and descriptions associated with the image. To improve existing CBIR performance, it is very important to find effective and efficient image decomposition, feature extraction and image matching mechanisms. This research aims to improve the performance of CBIR using wavelet decomposition by haar wavelet. After that features are extracted using f-norm theory. K-mean clustering is used to form the cluster of images and similarity matching is done using f-norm theory. The use of progressive retrieval strategy is to provide balance between computational complexity and retrieval accuracy. In this paper we compared the retrieval performance of proposed content based image retrieval system with the exiting technique of wavelet histogram. The proposed research produces better results than wavelet histogram.***

Keywords: f-norm, haar wavelet, image decomposition, progressive retrieval strategy, feature extraction.

I. Introduction

CBIR (Content based image retrieval) means that searching, browsing and retrieval the image using the actual contents of the image like visual features of an image such as color, shape, texture and spatial layout rather than the metadata such as keywords, tags and descriptions associated with the image. Content based image retrieval is also known as query by image content (QBIC) and content-based visual information retrieval (CBVIR). Content based image retrieval is desirable because most webs based image search engines rely purely on metadata and this produces a lot of garbage in the results. Also having human manually enter keywords for images in a large database can be inefficient, expensive and may not capture every keyword that describes the image. Thus a system that can filter images on their content would provide better indexing and return more accurate results [1].

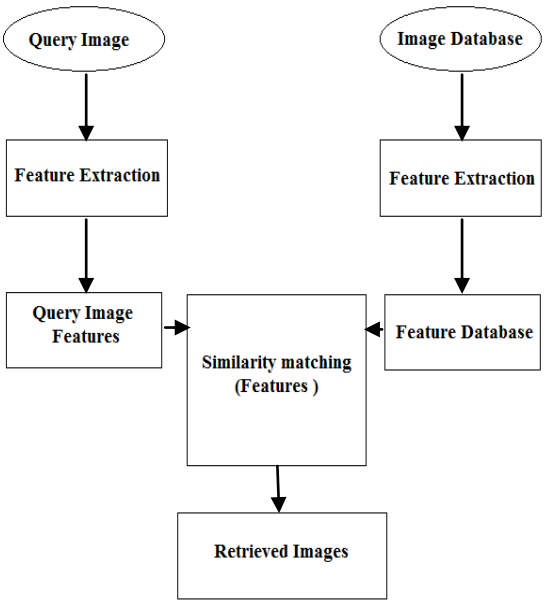


Figure 1.1: Architecture of a CBIR system

Content based image retrieval systems have received a lot of attention from the academic and commercial development community in recent years. In such a system user can pose the queries such as "retrieve images similar to given image", "retrieve images of buses" from a large database.

Figure 1.1 shows the architecture of a typical CBIR system. For each image present in the image database, its features are extracted and the obtained feature vector is stored in the feature database. When a query image comes in, its feature space will be compared with those in the feature database one by one and the similar images with the smallest feature distance will be retrieved.

II. CBIR IN SIMPLE IMAGES

Content based image retrieval (CBIR) aims at developing techniques that support effective searching and browsing of large image digital libraries on the basis of automatically derived image features. [2] World Wide Web (WWW) has enabled users to access data in a variant of media formats. [4] The number of digital images on the WWW is estimated to be more than hundreds of millions. [3] This creates development of novel techniques for efficient storage and as well as for image retrieval. CBIR systems in simple image are developed to retrieve the simple image from a large collection of images in an effective and efficient manner by development of better techniques and tools.

A picture of beautiful valley of himachal Pradesh or the facial expression of an actor in an image is beyond words. Pictures have to be seen and searched as pictures. Therefore, content based image retrieval systems are developing in the field of simple image databases where the number of images is very high. Features are derived directly from the images and they are extracted and analyzed by means of computer processing. CBIR allowing to automatically extracting targets according to objective visual contents of image itself (e.g. color texture) has become increasingly attractive, in multimedia systems.[6] CBIR for simple images focus on producing systems which retrieve a image from a large collection of images in an effective and efficient way.

III. PROPOSED SYSTEM

The proposed content based image retrieval system is based on decomposition of database images using haar wavelet in the offline as well as in online for query image. With f-norm theory the extraction of image features takes place. A feature vector matrix is formed. After that k-mean clustering is applied on the database images. A feature vector matrix is formed and is clustered using k-mean clustering. The feature vector matrix is stored in index file according to its cluster.

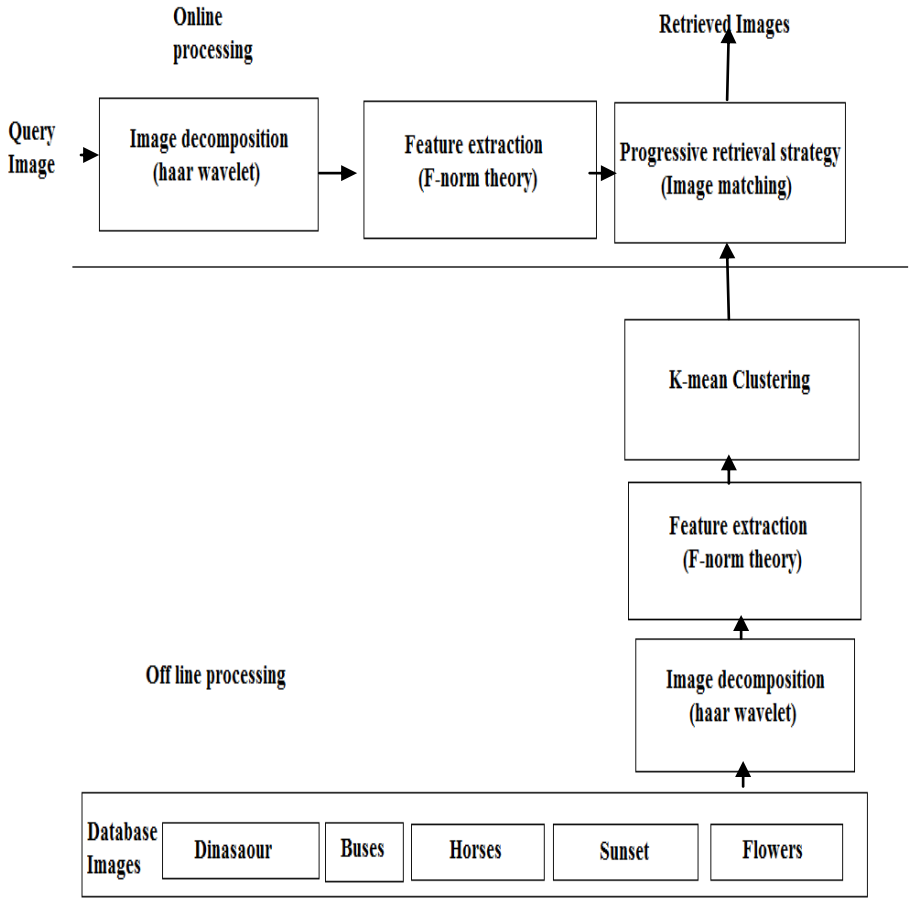


Figure 1.2: Structure of proposed CBIR system

The highly efficient image matching takes place using f-norm theory. After applying the f-norm formula that the complete matrix is compared using f-norm matching. The use of progressive retrieval strategy is to provide balance between computational complexity and retrieval accuracy. During the image retrieval process decomposition, feature extraction and clustering are performed on query image and further the matching of the similarity takes place.

IV. HAAR WAVELET

First the decomposition of image using haar wavelets takes place. If a data set R_0, R_1 ….R_{N-1} contains N elements, there will be N/2 averages and N/2 wavelet coefficient values. The averages are stored in the upper half of the N element array and the coefficients are stored in the lower half as shown in the Figure 3.3.[1] The averages become the input for the next step in the wavelet calculation, where for iteration i+1, $N_{i+1} = N_i/2$. The recursive iterations continue until a single average and a single coefficient are calculated. [7] This replaces the original data set of N elements with an average, followed by a set of coefficients whose size is an increasing power of two (Ex: 2^0, 2^1, 2^2 ... N/2).

The haar equations to calculate an average a_i and a wavelet coefficient c_i from an odd and even element in the data set are:

$$a_i = \frac{R_i + R_{i+1}}{2} \qquad c_i = \frac{R_i - R_{i+1}}{2}$$

V. FEATURE EXTRACTION

Proposed CBIR system is based on direct wavelet decomposition of image in RGB color space and utilizes the "query by example" method. With approaches mentioned above, database images are decomposed offline into multi-level coefficients from -1 to -J levels, with which, we can generate color feature database and perform similarity match between images. After decomposition, each resulting sub image is in fact a coefficient matrix, where, by special processing, large coefficients with more energy can be distributed in the up-left area, therefore, with f-norm theory, we can well decrease the dimension of image feature and perform highly efficient image matching.

a) Feature vector

Suppose A is a square matrix and A_i is its i^{th} order sub matrix where

$$\mathbf{A} = \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \cdots & \cdots & \cdots \\ a_{n1} & \cdots & a_{nn} \end{bmatrix}, \ \mathbf{A_i} = \begin{bmatrix} a_{11} & \cdots & a_{1i} \\ \cdots & \cdots & \cdots \\ a_{i1} & \cdots & a_{ii} \end{bmatrix} (i = 1 \sim n)$$

The F-norm of Ai is given as:

$$\|Ai\|F = (\sum_{k=1}^{i} \sum_{l=1}^{i} |akl|^{2)1/2}$$

Let $\Delta A_i = \| A_i\|_F - \|A_{i-1}\|_F$ and $\|A_0\|_F = 0$, we can define the feature vector of A as:
$V_{AF} = \{\Delta A_1, \Delta A_2 \ldots \Delta A_n\}$

VI. K-MEAN CLUSTERING

K-mean clustering is used to form the cluster. This method initially takes the number of components of the population equal to the final required number of clusters. [2] In this step itself the final required number of clusters is chosen such that the points are mutually farthest apart. [5] Next, it examines each component in the population and assigns it to one of the clusters depending on the minimum distance. The centroid position is recalculated every time a component is added to the cluster and this continues until all the components are grouped into the final required number of clusters. The K-means algorithm is very simple and can be easily implemented in solving many practical problems.

K-means clustering is a method of cluster analysis which aims to partition n observations into k clusters in which each observation belongs to the cluster with the nearest mean. Given a set of observations (x_1, x_2, …, x_n), where each observation is a d-dimensional real vector, k-means clustering aims to partition the n observations into k sets ($k \leq n$) $S = \{S_1, S_2, \ldots, S_k\}$ so as to minimize the within-cluster sum of squares.

$$\arg\min_{\mathbf{S}} \sum_{i=1}^{k} \sum_{\mathbf{x}_j \in S_i} \|\mathbf{x}_j - \boldsymbol{\mu}_i\|^2$$

where μi is the mean of points in S_i.

VII. SIMILARITY MATCHING

Define the Similarity α_i of ΔA_i and ΔBi as:

$$\alpha_i = \begin{cases} \min(\Delta A_i, \Delta B_i) / \max(\Delta A_i, \Delta B_i) & --- \Delta A_i \neq 0 \text{ or } \Delta B_i \neq 0 \\ 1 & ---------- \Delta A_i = 0 \text{ or } \Delta B_i = 0 \end{cases}$$

And we can thus give the similarity α of the matrices A and B as:

$$\alpha = \sum_{i=1}^{n} C_i \, \alpha_i$$

Where,

$$c_i = \frac{2i-1}{n^2} \; (i = 1, 2, \ldots, n), \sum_{i=1}^{n} c_i = 1$$

.

Obviously, the similarity $0 \leq \alpha \leq 1$.

VIII. PROGRESSIVE STRATEGY

The progressive retrieval strategy is used in order to balance between computational complexity and retrieval accuracy.

1. Rough filtering: Starting from the maximal decomposition level –J, with the resulting LL coefficients, we calculate standard variances vectors of the query image and the database image as (σ_r^q, σ_g^q, σ_b^q) and (σ_r^d, σ_g^d, σ_b^d) respectively, after which, we can roughly filter database images as

$$F = (\beta\sigma_r^q < \sigma_r^d < \sigma_r^q/\beta) \&\& (\beta\sigma_g^q < \sigma_g^d < \sigma_g^q/\beta) \&\& (\beta\sigma_b^q < \sigma_b^d < \sigma_b^q/\beta)$$

Where, the filtering constant $\beta \in (0, 1)$ is used to adjust the sifted database images. If F is false, then database image can be identified as far apart from Query image and therefore is discarded; else, database image be kept for further match.

2. More precise filtering: with the obtained LL coefficients, which best reflect the general feature of image. The similarity criteria to determine more precise images. If a exceeds a given threshold, it means that mismatch occurs and it should be discard.

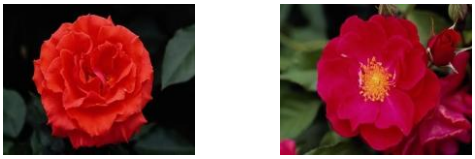
3. Iteration: J=J-1, and iterate step 1~ 4 till J = 0. Finally, retrieval results are fed back to users in the order of their similarity values.

IX. RESULTS

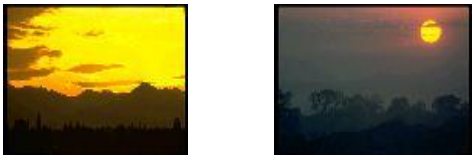
A database of 500 images of five typical groups of color images is taken to perform the experiment. Mostly all the images in database are of size 384x256 before decomposition. In the database five typical groups of color images are stored namely:

- Buses

- Flowers



- Sunset



- Horses

Dinosaurs

Figure 1.3: Sample database images

There are five different groups of images. The five groups are sunset, flowers, horse, buses and dinosaurs. For the given query image there are retrieved images with number at the foot of each image indicates its similarity(α) to the example image. α values indicate the similarity between the query image and the images in the database .For similar images, α value is 1.Greater the α value greater is the similarity between the query image and the database image. Retrieved images are sorted according to their alpha values (degree of similarity). The rough filtering constant is taken as 0.6 and precise filtering threshold is taken as 0.7.

Query image

Retrieved images

1.00 0.73 0.70

0.80 0.74

Query image

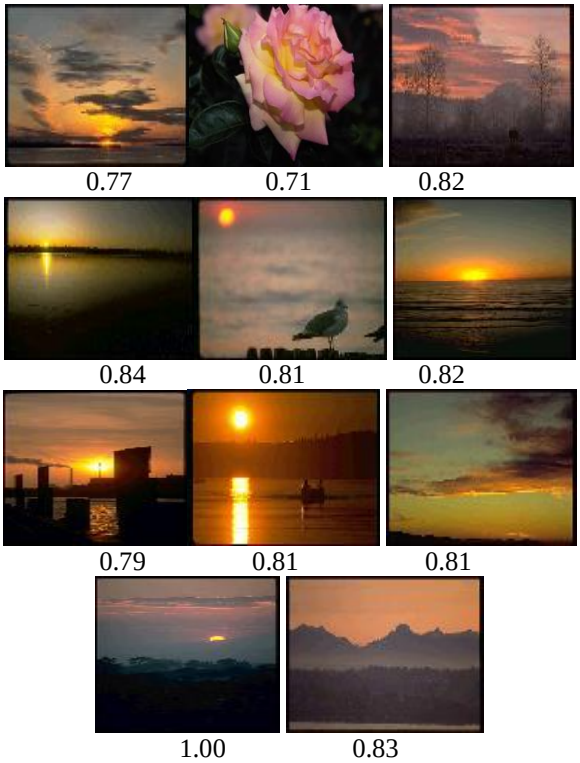
Retrieved images

0.74 1.00 0.79

0.84 0.73

Query image

Retrieved images



Query image

Retrieved images

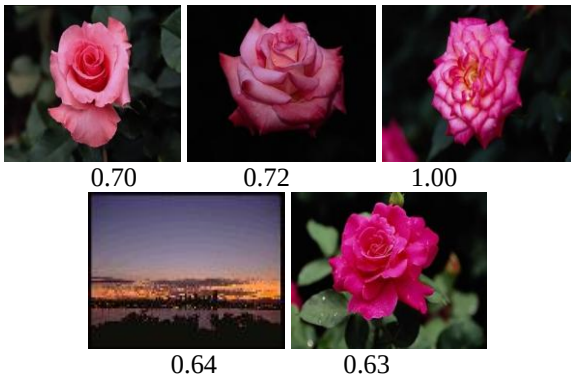


Figure 1.4: Resulting images of query image

$$\text{Recall rate} = \frac{\text{Number of relevant items retrived}}{\text{Total number of relevant items in collection}}$$

The proposed system is compared with wavelet histogram on two performance measuring indices. The indices are recall rate and retrieval speed.

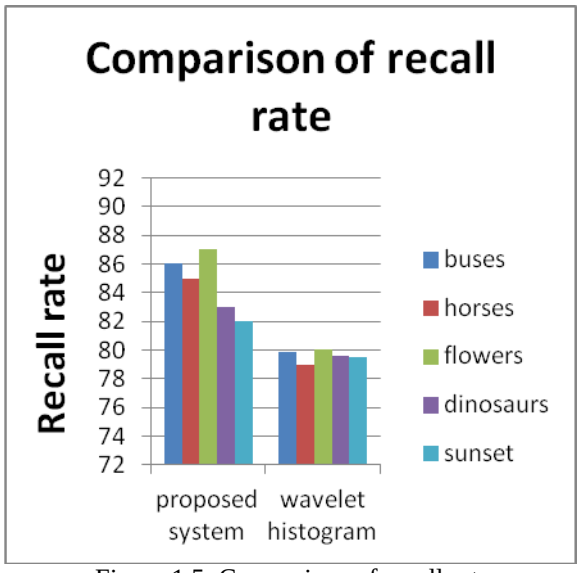


Figure 1.5: Comparison of recall rate

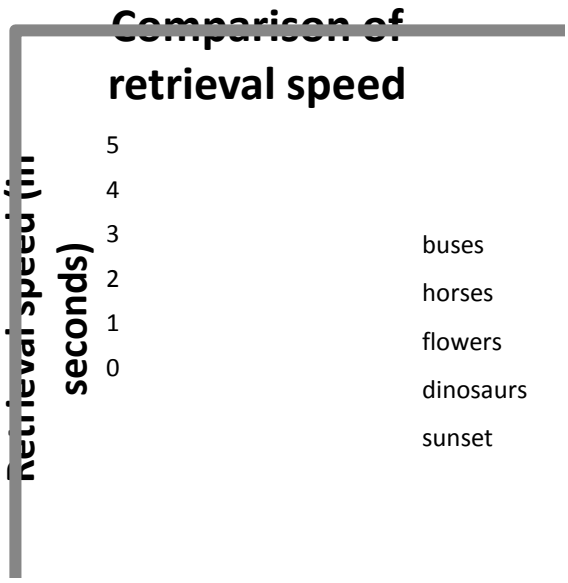


Figure 1.6: Comparison of retrieval speed

Table 4.1: Recall rate and retrieval speed of proposed approach

Categories of Proposed system	Recall rate	Retrieval speed
Buses	86	1.95
Horses	85	2.09
Flowers	87	2.4
Dinosaurs	83	2.01
Sunset	82	2.2

X. CONCLUSION

The proposed content based image retrieval approach uses haar wavelet for wavelet decomposition of images. After that features are extracted using f-norm theory. K- mean clustering is used to form the cluster of images and similarity matching is done using f-norm theory. We focus on recall rate and retrieval speed the two retrieval indices. We compared the retrieval performance of proposed content based image retrieval system with the exiting technique of wavelet histogram. In addition the progressive retrieval strategy helps to achieve flexible compromise among retrieval indices. The results are validated by using a set of test images including 5 groups of images. We conclude from the results that the proposed system achieve high retrieval performance.

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