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Improved Query by Image Retrieval using Multi-feature Algorithms

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Abstract— Query by Image Retrieval uses image content features to search and retrieve digital images from a large database. Visual feature extraction methods are commonly employed techniques for searching purpose. However, their usefulness is limited by computational time, inefficient indexing and retrieval performance. In this paper, we present a simple and efficient image retrieval model based on the semantic features that uses histograms and Gabor wavelet techniques for extracting the features of the image. The proposed method is tested through simulation in comparison with the existing approaches and the results are encouraging.

Index Terms— Image Retrieval, Gabor Wavelet, Precision and Recall, Edges, Image Database, Image Processing, Image indexing.

1 Introduction

IMAGE retrieval is a searching technique which retrieves desired images from a large scale image collections based on user queries. In conventional image databases, image retrieval is based on metadata. Many techniques have been developed for metadata-based domain, but its perception objectivity and annotation impreciseness may cause unrecoverable mismatches in later retrieval processes [3][4]. Currently, Query by image retrieval has become a prominent research area in the field of information science, which retrieves images from databases based on visual content [2]. Many advanced techniques evolved in Query by image retrieval (QBIR) systems due to the vast usage of visual data, which envisages the need for fast and effective retrieval mechanisms. But the visual fact differs in the way in which querying and retrieval is done.

In every QBIR system, a feature vector is extracted from each image in the database system and is compared to the query image feature vector [1]. The vital differences between the query image and image database are extracted by the retrieval algorithms to index and order the similar images. The general block diagram of QBIR system is

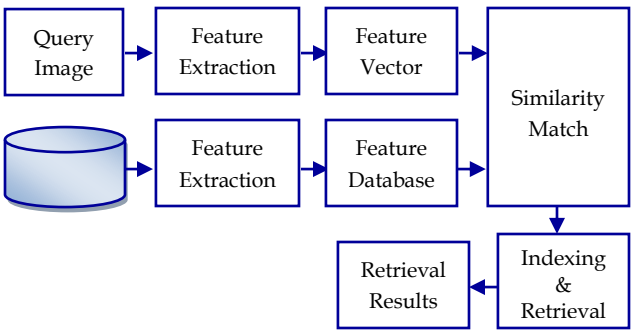

Fig 1: General QBIR system

Query by image Retrieval is extremely useful in a plethora of applications such as historical research, advertising, fashion, graphic design, crime prevention, medical diagnosis, geographical information and remote sensing systems. One of the main tasks of QBIR systems is similarity comparison; extracting feature signatures of every image based on its pixel values and defining rules for comparing images. The components of the signature give an improved correlation between image representation and semantics. An image is compared to other images by calculating the difference between their corresponding features.

1.1 Relevance of Work

The incomplete annotations issue degrades the retrieval performance of Text based image retrieval [6]. Query by Image Retrieval (QBIR) has therefore evolved into a necessity [6]. To fully exploit the potential of images, we need the ability to search for them based on the contents of the images themselves. But QBIR system also faces many challenging problems because of the large size of the database, the difficulty of understanding the images, both by people and computers, the difficulty of formulating a query and the issue of evaluating results properly.

In our method, we explore an alternative strategy for searching an image database [7] in which the query is expressed in terms of an image and its multiple features are extracted using different image feature extraction algorithms. These features are analyzed with the features of image database and the most similar images are retrieved using an efficient index based sorting algorithm

2. Literature Review

Previous content based approaches have applied many local and global features to represent the image content. In [1], color moment primitives and Gabor filter are used for color and texture feature extractions. In their work, an image is divided into blocks, and each block's color moments are extracted. These moments are clustered into different classes by using a clustering algorithm, and a color feature vector is calculated from the query image and the images in the image database. The Canberra distance measure is used to compute the dis-

tance between the features to find out the most similar images.
The average precision is 62.25.

Xue and Wanjun [8] proposed a model in which color histograms and color moments feature extraction methods are integrated. They stated that the index sorting was better than other approaches [1].

Z.C. Huang, P.P.K. Chan, W.W.Y. Ng and D.S. Yeung's work proposes a model based on color and texture features [9]. They used color moments of the Hue, Saturation and Value (HSV) of the image and texture features are extracted by using Gabor descriptors. They normalized the features and calculated the similarity by using Euclidean distance. They reported that the proposed method had higher retrieval accuracy than the previous conventional approaches [1].

3. PROPOSED METHOD

In our method, a multi-feature image retrieval method is proposed by combining the features Color histogram, edge, edge directions, edge histogram and texture features. In this model, the query image and all images in the database were resized to 128 x 128 pixels. After performing some pre-processing steps like noise removal, its above features are extracted and are stored as small signature files. Similar images should have similar signatures. These signatures are compared with the query image's signature. During the similarity measure, the distances between the different features are measured. Appropriate weights are applied to normalize the distance coefficients [1]. These normalized coefficients are sorted and indexed based on the distance values obtained.

3.1 Feature Extraction

Image content may include both visual and semantic content. Visual content can be very general and domain specific. A feature is defined as an interesting part of an image. The most important low level image processing operations are feature detection and feature extraction. Feature detection examines every pixel of the image and finds a relevant piece of information for solving the computational task related to a certain application. The extraction of visual features such as color, texture, shape, spatial relationship etc. is one of the major operations in designing a reliable and efficient image retrieval system.

3.1.1 Color Histogram

Color feature is the most commonly used visual feature in image retrieval because it's easier to extract than other image features. A proper color space and an effective color descriptor have to be determined to extract the color features from the image content. A color space is a multidimensional space in which the different dimensions represent the different components of color [1].

In image retrieval, the color histogram is used to represent the distribution of colors in an image, through a set of bins. A color histogram is a type of bar graph, where the height of each bar represents an amount of a particular color of the color space being used in the image. That is, it denotes the joint probability of the intensities of the three color channels such as Red, Green and Blue. In this paper, we chose the HSV color space to represent the image histogram. The main advantage of color histogram is easy to compute and effective in characterizing both the global and local distribution of colors in an image.

3.1.2 Edges and Edge directions

Edges in the image are considered as an important cue to represent the content of an image. An edge in an image corresponds to an intensity discontinuity in the scene. There are many ways to perform edge detection. In this paper, the color space is changed to YCbCr and a Sobel edge detector is used to find the approximate absolute gradient magnitude at each point in an input grayscale image. The Sobel edge detector operator performs a two dimensional spatial gradient measurement on an image and uses a pair of 3x3 convolution masks, one estimating the gradient in the x-direction (Gx) and the other estimating the gradient in the y-direction (Gy). The convolution masks matrix is

$$Gx = \begin{pmatrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{pmatrix}$$

$$Gy = \begin{pmatrix} 1 & 2 & -1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{pmatrix}$$

The gradient magnitude is given by

$$|G| = \sqrt{Gx^2 + Gy^2} \quad (1)$$

An approximated magnitude can be calculated by

$$|G| = |Gx| + |Gy| \quad (2)$$

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The angle of orientation of the edge relative to the pixel grid is given by

$$\theta = \arctan(Gy|Gx) \quad (3)$$

Here, edge directions are calculated to represent the shape of the objects.

3.1.2 Edge Histogram

To achieve a high retrieval performance we may need edge distribution information for the whole image space and some horizontal and vertical semi-global edge distributions also. So Edge histograms are used to represent the global feature composition of an image.

3.1.4 Texture extraction by using Gabor

Image Texture contains important information about the structural arrangement of the image surface and describes the relationship of the surface to the surrounding environment. Gabor wavelet is widely used to extract texture information and edge direction from images and is efficient for similarity measurement in image retrieval.

3.1.5 Histogram Intersection Distance Method

Here the Histogram intersection distance method is used to compute the distance between different features. Swain and Ballard proposed histogram intersection for color images and is defined as,

$$dist_{ID} = \frac{\sum_{i=1}^{i=n} min[Q[i], D[i]]}{|D[i]|} \quad (4)$$

This equation is extended by Smith and Chang as

$$dist_{ID} = \frac{\sum_{i=1}^{i=n} min[Q[i], D[i]]}{min[|Q[i]|, D[i]]} \quad (5)$$

Here $|Q|$ and $|D|$ Represents the histogram magnitude of the query image and a representative image in the database.

Multiple features are combined and appropriate weights, 0.90 for color and 0.20 for texture features are added to normalize the distances. The weighted sum of normalized distances is sorted in ascending order and they are ranked based on the lowest distance from the query image to the image in the database. The weighted sum, $WS(dist_{ID})$, of the distances can be calculated by using the following formulae:

$$WS(dist_{ID}) = \sum_{i=1}^{i=n} (dist_{ID} * weight) \quad (6)$$

The image that has the lowest distance is displayed because it represents the most similar image compared with the query image.
The block diagram of the proposed system is

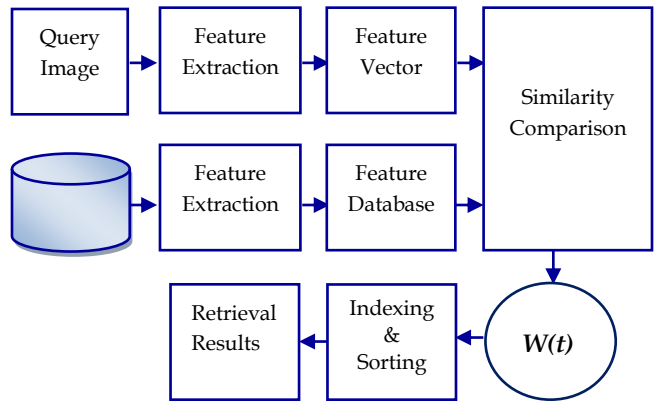

Fig 2: Block diagram of Proposed Query by image Retrieval

3.1.6 Proposed algorithm

Algorithm 1: Image Retrieval

Input: QF is the Query Image Feature Signature, DF is the Image Database Feature Signatures, N is the Total No. of images

Output: Images similar to Query Image

```
k ← 1
foreach i in DF do
    DB ← LoadImage(i)
    dist(1, i) ← HistIntersection(QF,DB)
    Score(k, i) ← Sort_Ascending(dist)
    k ← k + 1
end
for i ← 1 to N do
    im ← LoadImage(Score(i))
    Display(im)
end
```

3.1.7 Performance Evaluation

In information retrieval, precision and recall are the basic measures used in evaluating search strategies. Precision is the ratio of the number of relevant images retrieved to the total number irrelevant and relevant images retrieved. Recall is the ratio of the number of relevant images retrieved to the total number of relevant images in the database. Precision and recall are usually expressed as.

$$\text{Precision} = \frac{\text{Number of relevant images retrieved}}{\text{Total number of images retrieved}} \quad (7)$$

$$= \frac{\mathbf{A}}{\mathbf{A}+\mathbf{B}} \qquad (8)$$

$$\textbf{Recall} = \frac{\textbf{Number of relevant images retrieved}}{\textbf{Total number of relevant images}} \qquad (9)$$

$$= \frac{\mathbf{A}}{\mathbf{A}+\mathbf{C}} \qquad (10)$$

Here, **A** represents the number of relevant images that are retrieved; **B** represents the number of irrelevant images, and **C** represents the number of relevant images that are not retrieved. The number of relevant images retrieved is the number of resulted images that are similar to the query image. The total number of images retrieved is the number images that are returned by the searching algorithm.

The average precision of the images belongs to a particular class can be computed as

$$\textbf{Avg. Precision} = \sum_{i=1..N} \textbf{Precision}_i \,/\, \textbf{No. Classes} \qquad (11)$$

4. EXPERIMENTS AND RESULTS

The proposed method has been implemented by MATLAB 7.8 [10] and tested on the WANG database [11][12] of 800 Corel images in JPEG format of size 384 x 256 and 256 x 384 as shown in Figure 4. The image class comprises 100 images in each of eight categories. After the retrieval, the retrieved image is considered a match, if and only if it is in the same category as the query image.

Fig 3: Sample Query image of Class 5

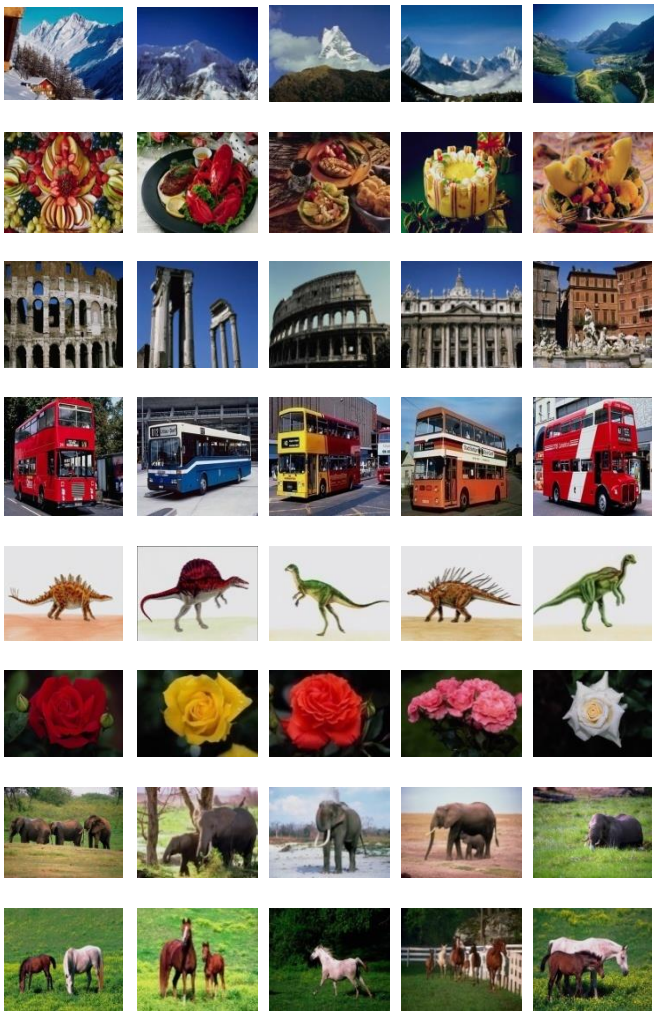

Fig 4: Sample WANG Image Database

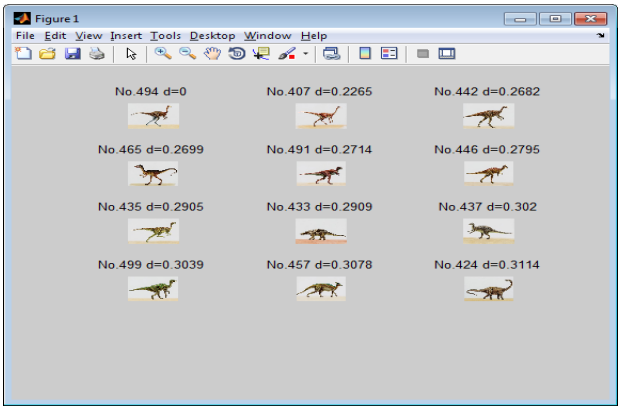

Fig 5: Sample Result of Dinosaurs Search

The effective system has the highest recall and precision rates. The average precision of the Gabor texture feature based system(GTF) is 46.5; Color moment whole (CMW) is 54.13; Color moment overlapping of horizontal region (CMR) is 59.63; Color moment whole image and Gabor texture feature(CMW+GTF) is 58.75; Color moment overlapping of horizontal region and Gabor texture feature(CMR+GTF) is 62.25. In our method, the average precision is 66.0 and is more efficient than other systems.

Table 1: Precision of retrieval for top 100 images

.Image Class	Average Retrieval of					
	GTF	CMW	CMR	CMW + GTF	CMR + GTF	IQBIR
Building	0.37	0.75	0.75	0.74	0.74	0.56
Buses	0.35	0.67	0.78	0.60	0.77	0.70
Dinosaurs	0.99	0.74	0.83	0.96	0.95	1.00
Elephants	0.39	0.60	0.45	0.58	0.44	0.48
Flowers	0.75	0.42	0.61	0.71	0.69	0.68
Horses	0.27	0.55	0.70	0.47	0.67	0.65
Food	0.44	0.67	0.62	0.72	0.69	0.71
Mountains	0.20	0.43	0.43	0.36	0.41	0.50

Table 2: Average Precision of above methods

GTF	CMW	CMR	CMW + GTF	CMR + GTF	IQBIR
46.5	54.13	59.63	58.75	62.25	66.0

5. CONCLUSION

In our system, Multi-feature comparison was carried out. The results show that a combination of multiple features gives a better retrieval rate compared to the performance of individual features.

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