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Image Retrieval Model Based on Color and Shape Features Utilizing 2D Wavelet Transform

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Abstract—The need for automatic feature extraction and comparison has become one of the most important research topics in image based retrieval. That due to the rapid increases in images databases and the difficulties of indexing images based on textual description. CBIR (content based image retrieval) utilizes automatic feature extraction based on color, texture, and shape using image analysis and processing techniques. In this paper a novel two-leveled CBIR system is proposed. In the first level, spatial domain is considered with color features extraction and comparison. While, in the second level a hybrid feature based approach is deployed. In which edge detection and enhancement, morphological operator (Dilate), and 2D-DWT (wavelet transform) are used. WANG database of 1000 images form 10 categories is used to test the proposed system. Moreover, extensive comparisons with the most related systems are conducted and the result are better than the other compared systems.

Keywords- CBIR; Edge Detection; Color Moments; Morphological Dilate and 2D-DWT.

I. INTRODUCTION

Retrieving images based on manual annotated has many drawbacks because of the subjective nature related to the meaning of images and the huge size of image databases. CBIR (content-based image retrieval), overcomes these drawbacks through utilizing image processing techniques to extract content features of images automatically [1].

Edge detection is defined as the process of discovering sharp discontinuities in an image [2]. Identifying boundaries of objects within image is made through the changes in pixel intensity (discontinuities). Edge detection methods simply working by convolving the image with a 2-D filter, these filters (operators) should be sensitive to noticeable gradients [3]. There are many traditional edge detection operators like Canny, Sobel, Prewitt, Laplacian and Roberts [4]. In [5] Morphological filters were utilized in edge detection.

Wavelet transform is considered as one of the most important technique in image processing and retrieval. In [6] they apply wavelet transform to image de-noising, and the result was encouraging. In [7] they utilize wavelet transform in image compression. In [8] a new CBIR approach based on color and texture was proposed. In [9] they characterize query images based on wavelet basis in order to enhance retrieval accuracy. Moreover, the proposed system was flexible in choosing the best wavelet filter suited image query based on regression. In [10] they propose a new approach to designate the content of the image based on edge histogram and wavelet transform. Furthermore, utilizes DWT (discrete wavelet transform) and EHD (edge histogram descriptor) enhances the performance of image retrieval system based on shape and texture. In [11] researchers propose a CBIR system wherein wavelet transform and color coherence vector are used to extract image feature. The proposed system consists of three major steps, wavelet coefficients calculation, quantization, and computing of coherence vector of the wavelet coefficients. They tested the proposed system on a database of 500 images and the results showed high level of efficiency.

In this paper, a two leveled content based image retrieval is proposed. In the first level, color based features were used to retrieve the first set of image from the image database based on image query. Filtration based on color features in this level reduces the number of candidate images to be considered in the second level (retrieval based on shape). Shape-based retrieval utilizes edge detection and enhancement, morphological Dilate to solidify objects within an image, and 2D wavelet transform coefficients extraction and comparing. QBE (query by example), is adopted in this research. In which, feature vector of query image and image databases are

extracted, compared, sorted based on similarity measure, and retrieved. The paper is organized as follows: proposed model is presented in section 2. The similarity measures are described in section 3. The experimental results are discussed in section 4. The conclusion is drawn in section 5.

II. PROPOSED MODEL

2.1 Color Based Retrieval

Color based CBIR systems are widely used. Unfortunately, a lot of concern is given to the global color features extraction and comparison with less concern on spatial characteristics of images. It is impractical to compare the color of images using pixel by pixel comparison. Accordingly, global features based on color moments is the most dominant approach to compare images based on color. In this research, spatial characteristics of images based on color and color moments are combined by slicing images to six sub-image each and calculate the color moments of each sub and compare it with the equivalent sub in the query image. The following Fig. 1, shows the proposed color-based image retrieval level.

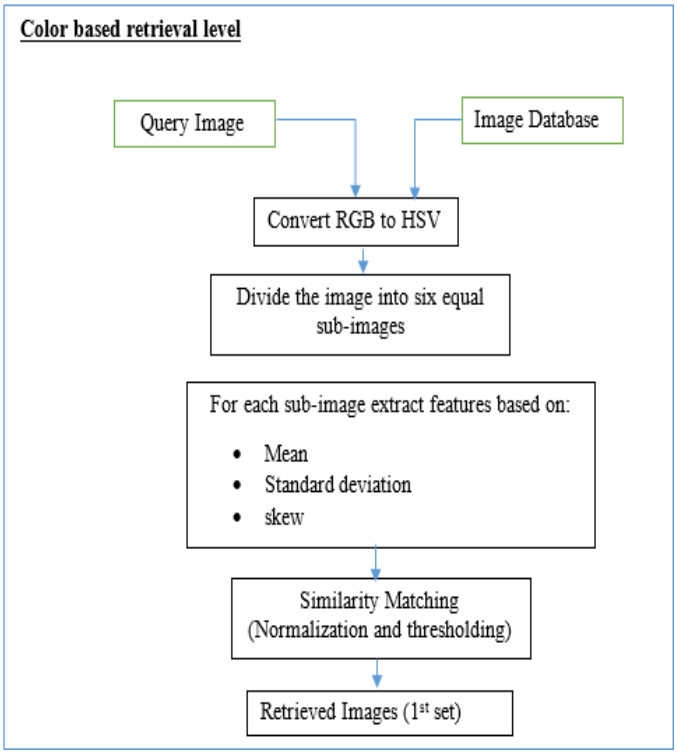

Figure 1. Proposed color retrieval model

Color moments is widely used to extract features based on probability distribution of color. First, second, and third order moments can be calculated as follows:

a) Mean:

$$\mu = \sum_{i=1}^{N} \frac{1}{N} P_{ij} \tag{1}$$

b) Standard deviation

$$\sigma_i = \sqrt{\left(\frac{1}{N} \sum_{j=1}^{N} \left(P_{ij} - \mu_i \right)^2 \right)} \tag{2}$$

c) Skewness

$$S_i = \sqrt[3]{\left(\frac{1}{N} \sum_{j=1}^{N} \left(P_{ij} - \mu_i \right)^3 \right)} \tag{3}$$

Where, N = Number of pixels in the Image

P_{ij}= j-th pixel value of the image at the i-th color channel

2.2 Shape Based Retrieval

Fig. 2, shows the proposed shape-based image retrieval level.

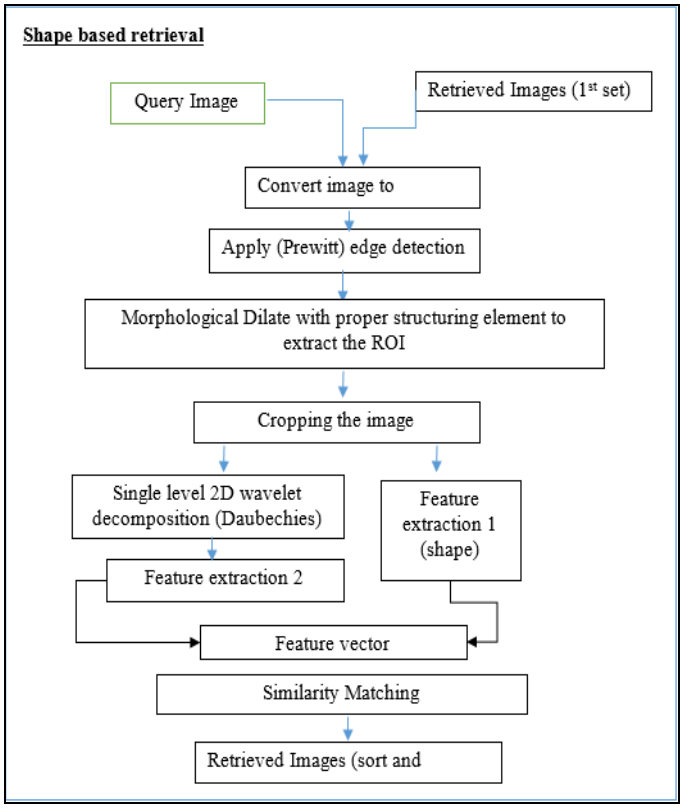

Figure 2. Shape based retrieval model

2.2.1 ROI (Region of Interest)

Extracting shape features is not as simple as it with color features. Especially, if there are many overlapped shapes within the same image. Objects within an images need to be manipulated using efficient shape discrimination filters like; edge detection, morphological operators, and segmentation techniques. Consequently, shape based similarity and retrieval relies on the suitable discriminator, image manipulation, and the correct feature extracted from image query and image databases to be an acceptable CBIR system based on shape.

ROI is identified in this research through applying "Prewitt" edge detector, followed by morphological dilate with proper structuring element, and finally cropping image to eliminate the unwanted pixels. There are many edge detectors accessible to researchers, such as Roberts, Sobel and Prewitt operators [12]. Testing of the different operators shows that using Prewitt may yield to better results as compared with other operators. In this research Prewitt operator is adapted. Fig. 3, shows sample image and proposed filtration process.

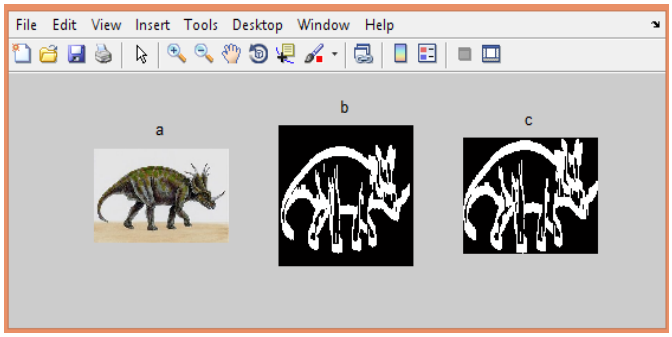

Figure 3. a) Original Image b) Edge detection followed by Dilate c) Cropping unwanted pixels in (b)

2.2.2 *Mathematical Morphology and Feature extraction 1 (shape)*

Mathematical morphology introduced by Matheron to analyze geometric structure and it was extended to image analysis by Serra [9]. Morphological **dilate** on binary images may yield to solidify objects within images. As stated in [13], the key morphological operations are Dilate and erosion. Suppose that I(x, y) represent gray scale image and B(s, t) is the structuring element, then dilation of I(x, y) by B(s, t) is defined as:

$$(I \oplus B)(x,y) = \max\{I(x-s, y-t) + B(s,t)\} \quad (4)$$

Erosion of gray scale image I(x, y) by B(s, t) is specified by:

$$(I \Theta B)(x,y) = \min\{I(x+s, y+t) - B(s,t)\} \quad (5)$$

Two of the most significant region based features are considered (Area and Centroid):

- Area (A) : The actual number of pixels in the region
- Centroid C(x, y) : represents the horizontal and vertical center of mass of the region as shown in the following formulas:

$$C_x = \frac{1}{6*A}\sum_{i=0}^{n-1}(x_i + x_{i+1})(x_i y_{i+1} - x_{i+1} y_i) \quad (6)$$

$$C_y = \frac{1}{6*A}\sum_{i=0}^{n-1}(y_i + y_{i+1})(x_i y_{i+1} - x_{i+1} y_i) \quad (7)$$

2.2.3 *2D Discrete Wavelet Transform (2D-DWT)*

Wavelet transform is a depiction of signals or image in terms of basis functions that are attained by dilating and translation a basic wavelet function [14]. In 2D wavelet there are a scailing function and three wavelets. The scailing function may stated as follows [2] :

$$\varphi(x, y) = \varphi(x)\varphi(y) \quad (7)$$

And "directionally sensetive" wavelets:

$$\psi^H(x,y) = \psi(x)\varphi(y) \quad (8)$$

$$\psi^V(x,y) = \varphi(x)\psi(y) \quad (9)$$

$$\psi^D(x,y) = \psi(x)\psi(y) \quad (10)$$

Discrete wavelet transform of image *I(x, y)* of size, M x N is:

$$W_\varphi(j_0, m, n) = \frac{1}{\sqrt{MN}}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)\varphi_{j_0,m,n}(x,y) \quad (11)$$

$$W_\varphi^i(j, m, n) = \frac{1}{\sqrt{MN}}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)\psi_{j,m,n}^i(x,y) \quad (12)$$

where i= {H,V,D}

2D-DWT is used in this research. One level of decomposition is applied using (Dubechies), the major feature extraction steps are:

a) Decompose image using one level 2D-DWT to obtain the approximation and detailed coefficients.
b) For each coefficient extract the following features:
   - *Mean.*
   - *Variance.*
   - *Mean of energy*
   - *Maximum amplitude*

The following Fig. 4, visulaize the process of edge detection, morphological dilate, cropped edge detection, and cropped 2D-wavelet approximation subband for two images.

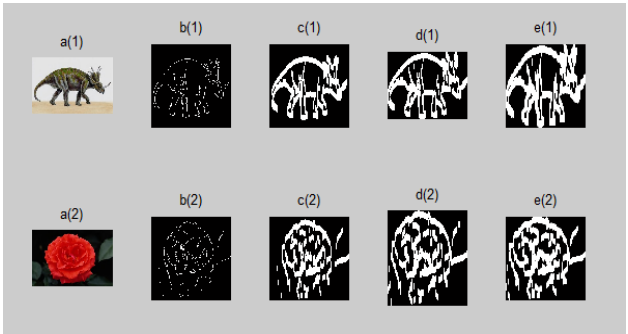

Figure 4. a (1) First original image , b(1) Edge detected image, c(1) Dilated image d(1) cropped dilated image, e(1) Cropped 2D- wavelet approximation sub band. a (2) Second original image , b(2) Edge detected image, c(2) Dilated image d(2) cropped dilated image, e(2) Cropped 2D- wavelet approximation sub band.

By testing different images, it was noticeable that the Approximation sub band gives slightly better detail than original edge detector operator.

III. SIMILARITY MEASURES

Many distance measure are available to calculate the similarity or dissimilarity between feature vectors like; Euclidian distance, City block distance, and Minkowski distance. The difference can be measured by distance measure in the n-dimensional space "the bigger the distance between two vectors, the greater the difference" [15].

Given two vectors V_1 and V_2, where $V_1 = [a_1 a_2 a_3 .. a_n]$ and $V_2 = [b_1 b_2 b_3 .. b_n]$. The distance between $V_1$and V_2can be calculated, based on Euclidean distance function as follows:

$$D_e = \sqrt{\sum_{i=1}^{n} (a_i - b_i)^2} \quad (13)$$

City block distance is calculated as:

$$D_{city} = \sum_{i=1}^{n} \left| a_i - b_i \right| \quad (14)$$

Minkowski distance is defined as:

$$D_M = \left[\sum_{i=1}^{n} \left(\left| a_i - b_i \right| \right) \right]^{\frac{1}{P}} \quad (15)$$

In [16], they tested many of distance measures and the comparison shows that Euclidean distance gives slightly better results as compared to other distance measures. Therefore, Euclidean distance is adopted in this research.

IV. EXPERIMENTAL RESULTS

For the purpose of evaluation and comparison of the proposed approach with some other related approaches a general purpose WANG database [17] containing 1000 Corel images of 10 categories in JPEG format is used. These categories are (Buses, Elephants, Flowers, Horses, Dinosaurs, Buildings, Food, Mountains, Beaches, and Africa) each with 100 images. To evaluate the performance of any retrieval system, precision and recall are considered as the most common evaluation measures to be used.

The definition of precision and recall in [18] is adopted to measure the similarity.

$$\text{Precision} = \frac{\text{Relevent Hits}}{\text{All Hits}} \quad (16)$$

$$\text{Recall} = \frac{\text{Relevent Hits}}{\text{Expected Hits}} \quad (17)$$

In this research, 10 images randomly selected as test images. From each category one random image is selected as query image. These test images are shown in Fig. 5.

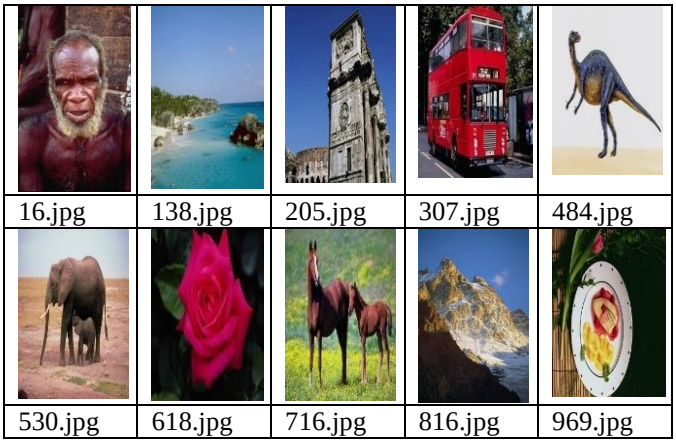

Figure 5. Test Images

The average recall and precision of the proposed approach is calculated based on the number of retrieved images N_r= [9, 19, 29, and 39]. Number of images retrieved is controlled via the threshold value chosen using color-based retrieval Level.

Fig. 6 shows sample of retrieved images, with N_r= 9, the image query is shown at the left top corner of the retrieved set.

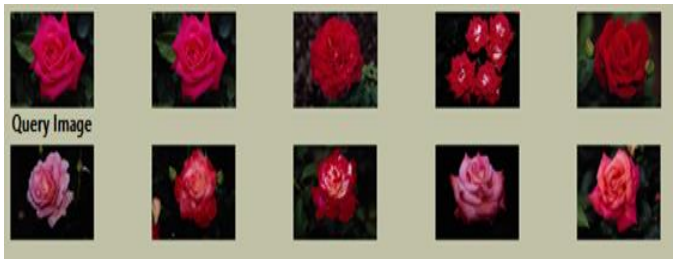

Figure 6. Retrieved results (Flowers, N_r = 9)

Fig. 7 shows sample of retrieved images, with N_r= 19, the image query is shown at the left top corner of the retrieved set.

Figure 7. Retrieved results (Dinosaurs, N_r= 19)

The following Table 1 shows the experimental results of the proposed approach (1st Level).

TABLE 1 AVERAGE PRECISION AND RECALL

CLASS	Average precision	Average Recall
Elephants	0.54	0.65
Beaches	0.75	0.40
Dinosaurs	0.90	0.87
Buildings	0.60	0.56
Horses	0.70	0.45
Flowers	0.87	0.75
Food	0.63	0.56
Mountains	0.50	0.41
Africa	0.56	0.47
Buses	0.85	0.69
Overall Average	0.69	0.58

In Givekiet. al. [19]. They tested different color models using wavelet transform with no consideration to shape-based retrieval. The HSV-wavelet average precision obtained using the same set of image database was (0.64) and average recall (0.55). Consequently, the proposed approach provides better results. The following Table 2 shows the experimental results of the proposed approach (2nd Level).

TABLE 2 AVERAGE PRECISION AND RECALL

CLASS	Average precision	Average Recall
Elephants	0.82	0.55
Beaches	0.75	0.48
Dinosaurs	0.99	0.75
Buildings	0.78	0.50
Horses	0.93	0.45
Flowers	0.94	0.65
Food	0.71	0.50
Mountains	0.69	0.45
Africa	0.67	0.48
Buses	0.98	0.70
Overall Average	0.83	0.55

Table 2, shows that the filtration process deployed in the 1st Level, enhances the average precision noticeably. At the same time negatively affects the average recall. This was expectable since the number of the candidate images were decreased as compare with the 1st Level. It is all about compromising, since the precision is more important in most cases we may accept some slight lost in average recall. It is obvious that the best results obtained is related to the class of (Dinosaurs), that because in this class objects were in contrast with the background. Consequently, it is preferable that when it comes to shape based retrieval some pre-processing to isolate objects from background is adopted in order to enhance the performance of the CBIR system.

In Dileshwar P. [20], they proposed CBIR system based on color edge detection and Haar wavelet transform. They tested the following images (shown in Fig.8) using different number of retrieved images Nr (10, 20, 30, and 40). In this research, the same query images were used and tested with N_r (40), since at this number of retrieved images, the proposed approach in [20] achieves the best precision results. Table 3, shows the comparison between proposed approach in this paper and proposed approach in [20].

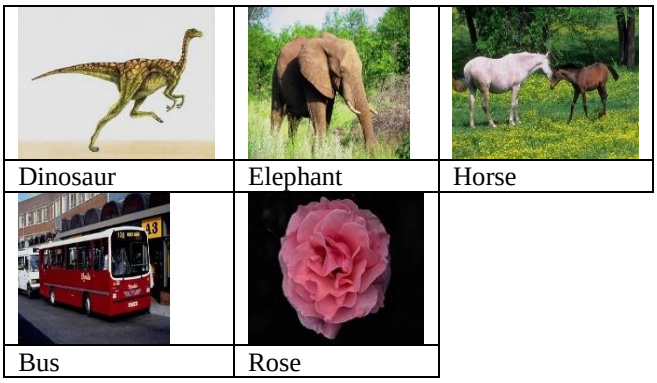

Figure 8. Query Images

TABLE 3 PRECISION COMPARISON

Image class	Precision (%) Dileshwar P. [20] Approach	Precision (%) Proposed Approach
Dinosaur	95	99
Elephant	95	93
Horse	97	94
Bus	82.5	98
Rose	57	91
Average Precision	85.3	95

Table 3, shows that the average precision (accuracy) of the proposed approach outperforms the proposed approach in [20]. Fig.9, shows sample of retrieved images for the query (Bus).

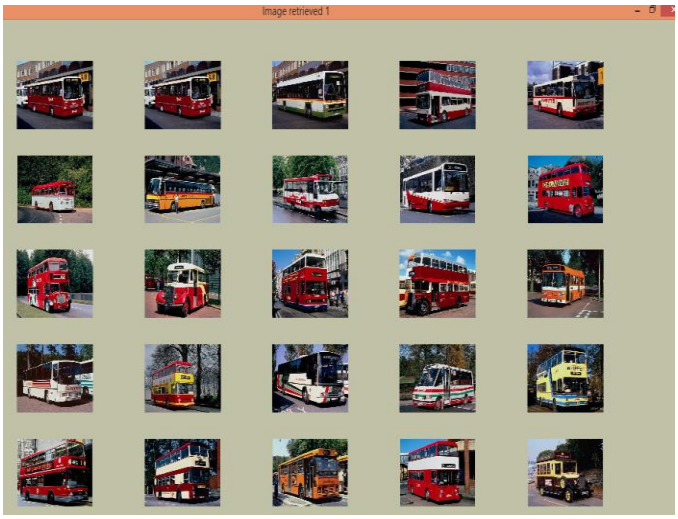

Figure 9. Sample of revived images of the proposed system for the query (Bus)

V. CONCLUSION AND FUTURE WORKS

A new approach for content based image retrieval utilizing wavelet transform combined with edge detection and enhancement and morphological operators is proposed. The proposed model relies on filtration of image database based on QBE (Query by example) and the strategy of two Leveled filtration process is deployed.

In the first Level, color features related to each sub-image is calculated in order to localize the color features instead of globalize them. In the second Level of retrieval, ROI is identified and features extracted based on shape are combined with features extracted using 2D-DWT in one feature vector representing the image query and images database. After that, similarity matching and retrieval is done using Euclidean distance measure. Wang Database with 1000 image is used to test the proposed approach and the experimental results showed the superiority of the proposed approach as compared with most relevant CBIR approach.

As a future work, the need to an effective methods to isolate objects from background need to be explored further in order to enhance the accuracy of retrieval.

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