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IMAGE RETRIEVAL USING COLOR-SIZE MOMENTS AND WAVELET FEATURES

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ABSTRACT

The rapid growth of digital imaging techniques and versatility among the images has motivated the development of Content Based Image Retrieval (CBIR). CBIR is the application of computer vision techniques which uses the visual contents to retrieve relevant images from large databases according to user's interests. The visual contents (color, texture, shape etc) serve as the features for the images. Features are measurements of extreme interest analysed from an image. This paper proposes a novel combined Color-Size and texture features for CBIR system. A new type of visual feature named Color-Size feature which integrates the information of both color and size of the image in terms of number of segments is proposed. To implement the system, initially the images are segmented using Watershed segmentation approach. Different images would yield different number of segments that has to be taken into account for the extraction of features. From the segmented image the Color-Size features are extracted using Color-Size Moments. Gabor filter and Haar wavelet are employed to extract texture features. Then the combination of color-size and texture features is formed. The feature extraction process is accomplished for both the query image and images stored in database. Finally, the relevant images are retrieved for the given user's query image.

Keywords: *Computer vision, Content Based Image Retrieval, Color-Size Moments, Visual features, Watershed approach*

1. INTRODUCTION

Images have always been an inevitable part of human communication and it roots millennia ago. Images make the communication process more interesting, illustrative, enchanting, understandable and transparent in human's life from time to time. With the rapid development of digital imaging techniques and internet, lot of images are available to public. Consequently, there is a dramatic high demand for efficient image retrieval methods. Image retrieval has become one of the most popular topics in the field of pattern recognition and artificial intelligence.

Retrieval of required-query-similar images from large repository of digital images is a challenging need of today. The image retrieval techniques based on visual image content have been in-focus for more than a decade. Generally, the most common two categories of image retrieval methods are text based and content based. Textual annotation of images is speculative and time consuming. It cannot capture the visual contents of images. The amount of labor required to annotate every single image, as well as the difference in human perception when reporting the images which lead to inaccuracies during the retrieval process. It is often introspective and context-sensitive. Hence there is a need for better system. Problems with text-based access to images have shifted focus of the researchers to content based image retrieval.

Since the needs and necessities of image users vary, a system that satisfies all the criteria of users has to be imposed. CBIR is an exact solution. It is a technique which utilizes visual contents of an image to search and retrieve similar images relating to the query image from huge image databases in accordance with user's interests. It has received intensive attention in the literature of image information retrieval since this area was started years ago, and consequently a broad range of techniques has been proposed. After a decade of intensive research, this technology is now beginning to move out of the laboratory to the marketplace, in the form of commercial products like QBIC and Virage. Active research in CBIR is geared towards the development of methodologies for analyzing and interpreting image databases. In CBIR system, it is common to group the image

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features in three main classes: color, texture and shape.

IBM [1] has introduced several versions of the QBIC system which is widely used for image retrieval purposes. Using the system, users are able to search the image by identifying certain characteristics of the image. Latest versions of QBIC use regional segmentation function to segment the image into different regions.

Another system known as SIMPlicity [2] is used to segment the image into regions/blocks and extracts features from each block that uses K-means algorithm for clustering and uses six features. Three of them are colour features extracted from LUV colour model and other three represent energy features that are used for wavelet transform. The values that are assigned to regions are used for distance function. The system accommodates all the regions equally.

In the VisualSEEK, the system uses both content based and text-based queries. The system uses color and texture visual features. The color feature is denoted by color set, texture feature is based on wavelet transform, and spatial relationship between image regions[3].

The MIRROR [4] system investigates the MPEG7 visual descriptors [5] and the Img(Rummager)[6] system extracts several features in real time.

A CBIR scheme [7] has shown the comparative analysis of various feature extraction techniques such as Average RGB, Co-occurrence, Local color histogram, Global color histogram and Geometric moments. An improvement has been stated in image retrieval by introducing the idea of Query modification through image cropping.

An image retrieval application [8] has performed a simple color-based search using color, texture and shape features. This paper has incorporated fuzzy histogram for color, Tamura features for texture and Moment invariants for shape features.

In the paper [9], Color coherence vector is used as color descriptor. The speed of shape based retrieval is enhanced by considering approximate shape rather than exact shape.

2. ARCHITECTURAL DESIGN OF PROPOSED METHOD

It is proposed to extract statistical color and structural texture features from the images. *Figure 1* presents the architecture for the proposed system and the following steps are used.

- Image Pre-processing
- Segmentation
- Feature Extraction
- Similarity analysis

The rest of the paper is organised as follows. Section 3 presents about the proposed system. Section 4 displays the experimental results and Section 5 provides the conclusion of the proposed system.

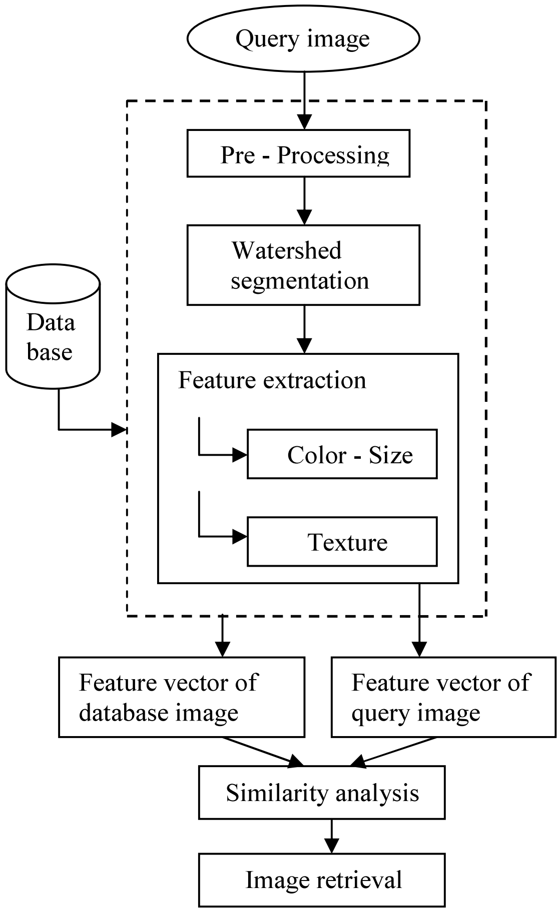

Figure 1 Architectural design of proposed work

3. PROPOSED SYSTEM

3.1 Image Pre-processing

Image noise is the random variation of brightness or color information in images produced by the sensor and circuitry of a scanner or digital camera. The query image undergoes noise filtering and hence it is performed to remove the distortions that would make the image much suitable for further processing. The noise is filtered using Median filter which serves the best for filtering the noise in the proposed system.

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Median filter is a non linear digital filtering technique[10], often used to remove salt and pepper noise. It is widely used in digital image processing under certain conditions. Because it preserves edges whilst removing noise. Here, the neighboring pixels are ranked according to brightness and the median value becomes the new value for the central noisy pixel. It does not shift boundaries, as it can happen with conventional smoothing filters.

To remove the noise using median filter:

Step1: Consider each pixel in the input image

Step2: Sort the neighboring pixels numerically

Step3: Replace the original value of the pixel with the median value from the list

Step4: If window has odd number of entries, then the middle value is taken as the median

Step5: If window has an even number of entries, the average of the two middle pixel values is used as the median.

3.2 Segmentation

Image segmentation is the most important field of image analysis which refers to the process of dividing a digital image into multiple segments[11]. Each of the pixels in the segments is similar in accordance with some characteristic or computed property, such as color, intensity, or texture.

Watershed Segmentation is used in the proposed system which is a widely used method for image segmentation in the field of mathematical morphology. It yields more stable results than other segmentation approaches based on detection of discontinuities, thresholding, and region processing. Here, the image is considered as a topographic relief, the numerical value of each pixel determining the corresponding point elevation. A rain drop hitting any point will travel along the greatest gradient towards the nearest local minima, or in some points two or more local minima. The set of all pixels leading to the same local *minimum* is called a *catchment basin.* The set of all the different catchment basins constitutes a non intersecting partition of the image, i.e. *segmentation* of the image.

4. FEATURE EXTRACTION

Features are measurements of extreme interest analyzed from an image. A feature is a characteristic which can capture a certain visual property of an image either globally for the entire image or locally for certain regions or objects. Many features like color, shape, texture etc are in existence. It is compulsory to extract these features from image for analyzing the similarity among different images as well as for retrieving relevant images. Feature extraction is the process of mapping the image pixels into the feature space where it is stored as feature vectors.

5. PROPOSED COLOR - SIZE FEATURE EXTRACTION

One of the important features that make possible the recognition of images by human is color. Color is a property which is used for providing discrimination among various objects and hence adopted as the most dominant feature in CBIR (ex: QBIC). Usually colors are defined in three dimensional color spaces [8]. These could be **RGB** (Red, Green, and Blue), **HSV** (Hue, Saturation, and Value) or **HSB** (Hue, Saturation, and Brightness). RGB color space is adopted in the proposed system. In this paper, size of an image is considered as novel idea. The ***Size*** feature denotes the size of the image in terms of number of segments. Various images would yield varying number of segments that has to be taken into account for feature extraction.

5.1 Color Moments

Color moments are measures that can be used to differentiate images based on features of color. These are scaling and rotation invariant. Since color moments encode both shape and color information they are good features to use under changing lighting conditions. Three color moments namely Mean, Standard deviation and Skewness [12] are used as features in image retrieval applications as most of the color distribution information is contained in the low-order moments. In this proposed work, Color moments are computed for RGB color model.

5.1.1 Mean:

The first color moment can be interpreted as the average color in the image, and it is calculated by using the following formula,

$$E_i = \sum_{j=1}^{N} \frac{1}{N} p_{ij} \tag{1}$$

where N is the number of pixels in the image and P_{ij} is the value of the j-th pixel of the image at the i-th color channel.

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5.1.2 Standard Deviation:

The second color moment is the Standard Deviation, computed by taking the square root of the variance of the color distribution.

$$\sigma_i = \sqrt{\left(\frac{1}{N} \sum_{j=1}^{N} (p_{ij} - E_i)^2\right)} \quad (2)$$

where E_i is the mean value, or first color moment, for the i-th color channel of the image.

5.1.3 Skewness:

The third color moment is the skewness that measures the asymmetric nature of color distribution , and thus it gives information about the shape of the color distribution. Skewness can be computed with the following formula:

$$s_i = \sqrt[3]{\left(\frac{1}{N} \sum_{j=1}^{N} (p_{ij} - E_i)^3\right)} \quad (3)$$

In this paper, three color moments are calculated for each R, G, B channel, totally nine values are extracted and the average of these nine values is denoted as the tenth feature value.

5.2 The Size feature

It denotes the count of segments in the watershed segmented image. In this paper, the size component is embedded over the histogram with the effort of increasing the accuracy rate in retrieval process. Therefore Color-Size component integrates eleven feature values where nine components representing the color moments with mean as tenth value and the final single component denoting the number of segments. Thus, both color and size factors are incorporated together for the effectiveness of presenting more similar and relevant images during the retrieval process.

6. EXTRACTION OF TEXTURE FEATURE

Textures are visual patterns which is one of the main features utilized in image processing. It describes the distinctive physical composition of a surface and contains information about structural arrangement of surface (clouds, leaves, bricks etc). Since an image is composed of pixels; texture can be defined as the entity consisting of mutually related pixels and group of pixels. This group of pixels is called as texture primitives or texture elements referred as *texels*. The methods of characterizing texture fall into two major categories: *Statistical* and *Structural* [13][14]. The former qualifies texture by the statistical distribution of the image density and latter describes texture by identifying structural primitives and their placement rules. Gabor filter and Haar wavelet both belong to Structural category [13] are used to extract the texture features in the proposed system.

6.1 Gabor Filter

Gabor filter provides useful means for analyzing the texture information of an image. Gabor wavelet is widely adopted to extract texture from the images for retrieval and has been shown as very efficient. Basically Gabor filters are a group of wavelets, with each wavelet capturing energy at a specific frequency and specific orientation. The scale and orientation tuneable property of Gabor filter makes it especially useful for texture analysis.To extract the Gabor texture feature of an image *I*, *I* is first filtered with a bank of scale and orientation Gabor filters, and then the mean and standard deviation values are computed.

When an image undergoes processing by Gabor filter, the output is the convolution of the image *I(x, y)* with the Gabor function *g(x, y)* which is given by,

$$r(x, y) = I(x, y) * g(x, y) \quad (4)$$

where * represents the 2D convolution. After applying Gabor filters on the image by scale and orientation, we are able to obtain an array of magnitudes.

$$E(m,n) = \sum_x \sum_y |G_{mn}(x,y)|$$
$$m = 0,1,\ldots,M-1;\ n = 0,1,\ldots,N-1 \quad (5)$$

The magnitudes represent the energy content at different orientation and scale of image. The filter is applied with 4 scales and 3 orientations. In the proposed work, 4 scales and 3 orientations at 0^o, 45^o and 90^o are implemented to extract texture features. The following mean μ_{mn} and standard deviation σ_{mn} of the magnitude of the transformed coefficients are used to represent the texture feature of the region,

$$\sigma_{mn} = \sqrt{\sum_x \sum_y (|G_{mn}(X,Y)| - \mu_{mn})^2 / P \times Q} \quad (6)$$

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where m represents the scale and n represents the orientation. The feature vector that represents the texture features are created using mean μ_{mn} and standard deviation σ_{mn} as feature components. And these components are saved into two feature vectors having 12 values each and then these two vectors are combined in order to make the single feature vector that will be treated as an image texture descriptor. In this proposed system, twenty four feature values comprising mean and standard deviation of twelve values each.

6.2 Haar Wavelet

Haar transforms provide a multi-resolution approach for texture analysis and classification. Decomposition of images with wavelet transform yields multi-resolution from detailed image to approximation images in each level.

A data set X_0, X1….X_{n-1} contains N elements; there will be N/2 averages and N/2 wavelet coefficient values. The averages are stored in the first half of the N element array, and the coefficients are stored in the second half of the N element array. The averages become the input for the next step in the wavelet calculation.

If images of size N x M are taken then it is decomposed up to K^{th} level where K= 1, 2, 3 etc. The quadrants (sub-images) within the image indicated as LL1, HL1, LH1, and HH1 represent detailed images for approximation, horizontal, vertical, and diagonal orientation, respectively in the first level. The sub-image LL1 corresponds to an approximation image, when it is further decomposed, it results the two-level wavelet decomposition. Therefore in the proposed work, single level decomposition is applied such that it is sufficient to extract feature values for analyzing texture. Then four feature values referred to the average for approximation, horizontal vertical and diagonal are extracted. *Figure* 2 shows the Haar decomposition.

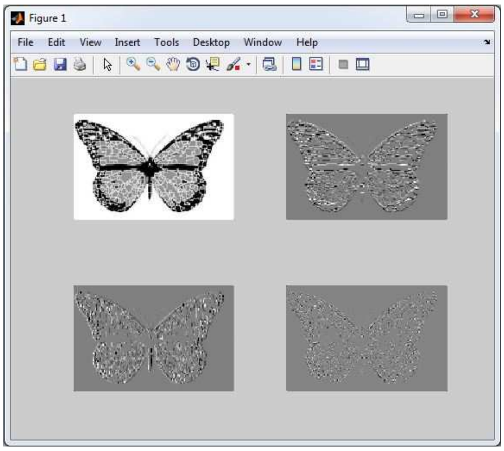

Figure 2 Haar decomposition

7. SIMILARITY ANALYSIS

Similarity between two images is measured numerically that reflects the strength of connections between them. Similarity is crucial in obtaining relevant results. To obtain relevant results, various researchers use different methods to measure similarity. For example, some researchers used fuzzy measures, histogram intersection and Euclidean distance. In this proposed system, Canberra distance is used to calculate the similarity between two feature vectors as follows:

$$\delta d = \sum_{i=1}^{n} \frac{(|Qi - Di|)}{|Qi| + |Di|} \tag{7}$$

8. EXPERIMENTAL RESULTS

The simulations are taken place using MATLAB. The number of search results may vary depending on the number of similar images in the database. The development of powerful processing with faster and cheaper memories contribute heavily to CBIR growth. In order to assess the performance of the proposed method, Caltech101 datasets are utilized. In our experiment, 900 images from CalTech101 database are selected such as are Butterflies, Pigeon, Emu, Buddha, Fish, Rooster, Water lily, Sunflower, Kangaroo and Leopard under ten categories. The images are in the size of 300 x 200 pixels. The sample GUI is presented in figure 3.

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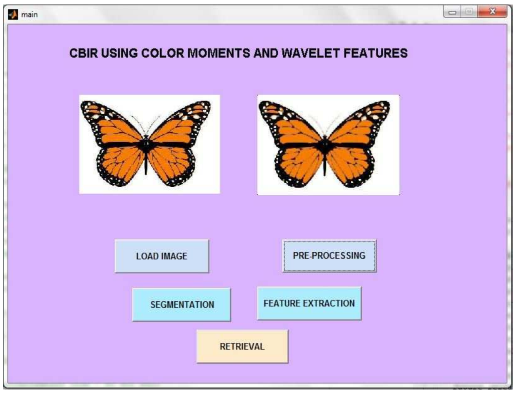

Figure 3 GUI for proposed work

8.1 Performance measures:

The performance of a CBIR system can be measured in terms of its precision and recall. Precision measures the retrieval accuracy; it is the ratio between the number of relevant images retrieved and the total number of images retrieved. Recall measures the ability to retrieve all relevant images in the database. It is the ratio between the number of relevant images retrieved and all of the relevant images in the database[15]. They are defined as follows:

$$\text{Precision (P)} = \frac{\text{No. of relevant images retrieved}}{\text{Total number of images retrieved}}$$

$$\text{Recall (R)} = \frac{\text{No. of relevant images retrieved}}{\text{No. of relevant images in database}}$$

The Table.1 shows the results of average precision and average recall for color-size features and the Table.2 shows the results of average precision and average recall for Texture features. The Table.3 shows the results of average precision and average recall for combined features.

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Table 1 Average Precision And Recall For Color-Size Feature

Category	Precision	Recall
Butterflies	0.92	0.76
Pigeon	0.88	0.77
Emu	0.84	0.73
Buddha	0.83	0.65
Fish	0.70	0.68
Rooster	0.61	0.73
Water lily	0.60	0.75
Sunflower	0.58	0.78
Kangaroo	0.66	0.81
Leopard	0.64	0.79

Table 2 Average Precision And Recall For Texture Feature

	HAAR wavelet		Gabor filter	
Category	Precision	Recall	Precision	Recall
Butterflies	0.78	0.87	0.65	0.75
Pigeon	0.74	0.75	0.72	0.68
Emu	0.69	0.63	0.48	0.59
Buddha	0.63	0.69	0.41	0.73
Fish	0.58	0.63	0.53	0.65
Rooster	0.61	0.67	0.66	0.68
Water lily	0.66	0.71	0.69	0.71
Sunflower	0.58	0.72	0.44	0.73
Kangaroo	0.54	0.74	0.57	0.69
Leopard	0.53	0.69	0.47	0.71

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Table 3 Average Precision And Recall For Combined Features

	Average Precision		Average Recall	
Category	CSM+ Haar	CSM+ Gabor	CSM +Haar	CSM+ Gabor
Butterflies	**0. 83**	**0.78**	**0.77**	**0. 68**
Pigeon	**0. 81**	**0.77**	**0.73**	**0.70**
Emu	**0.77**	**0.76**	**0.71**	**0.69**
Buddha	**0.73**	**0.70**	**0.69**	**0.71**
Fish	**0.71**	**0.69**	**0.70**	**0.73**
Rooster	**0.72**	**0.70**	**0. 67**	**0.75**
Water lily	**0.73**	**0.68**	**0.68**	**0.72**
Sunflower	**0.67**	**0.61**	**0.72**	**0.74**
Kangaroo	**0. 63**	**0. 58**	**0.70**	**0. 63**
Leopard	**0.61**	**0. 68**	**0.73**	**0. 67**

To evaluate the most efficient image retrieval, precision and recall scores are combined into a single measure of performance, known as the F-score. Higher values of the F-score are obtained when both precision and recall are higher. The formula for calculating the F-score is:

$$\text{F-score} = 2 * \frac{P * R}{P + R} \quad (8)$$

Accuracy for proposed system is calculated as follows:

$$\text{Accuracy} = (P + R) / 2 \quad (9)$$

In *Figure* 4, the chart depicts the F-score measure of combination of color-size moments with Haar wavelet and also the combination of color-size moments with Gabor filter.

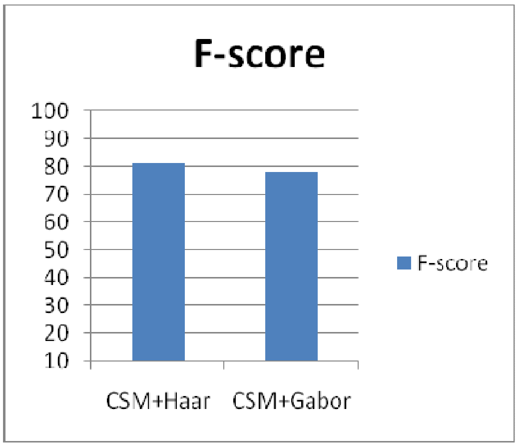

Figure 4 F-Score For Combined Features

In *Figure* 5, the chart depicts the accuracy measure of combination of color-size moments with Haar wavelet and also the combination of color-size moments with Gabor filter.

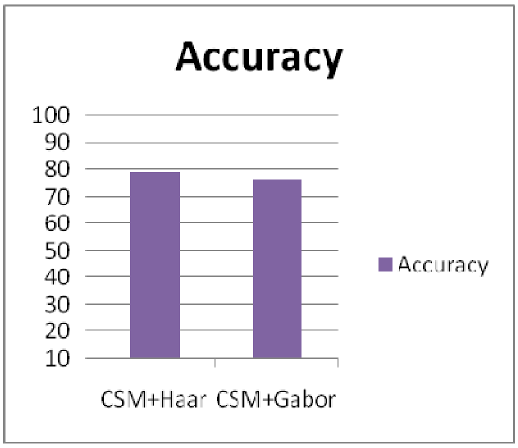

Figure 5 Accuracy For Combined Features

The retrieval results for two classes (Butterfly, Pigeon) are presented in figures 6 and 7.

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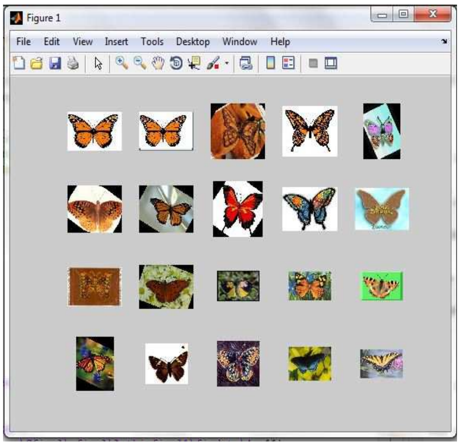

Figure 6 Image Retrieval For Butterfly Class

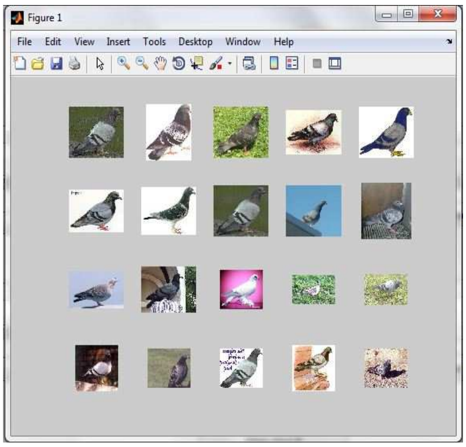

Figure 7 Image Retrieval For Pigeon Class

9. CONCLUSION

A design of feature extraction has been proposed for developing CBIR. Initially the query image is pre-processed and segmented. Watershed segmentation approach is most suited for the proposed system since the aim is not to generate perfect segments, rather to make useful segments only. It ensures closed region boundaries. From the segmented image the Color-Size Moments (CSM) and Texture (Gabor and Haar) features are extracted. The feature values are incorporated together for the purpose of storing it as a single feature vector. The feature vector of query image is compared against the images stored in the database. The images with nearest vector distance are retrieved as the similar results. The Precision and Recall values are analysed for individual as well as combined techniques. F-score and Accuracy of proposed system are also found. Based on the test results the combined features yield better performance than individual feature. Moreover, it is found that the combination of Color-Size Moments and Haar wavelet performs well in accordance with F-score and Accuracy rate.

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