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Comparison of Content Based Image Retrieval Systems Based on Various Techniques

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Abstract – **Nowadays people are interested in using digital images. So the size of the image database is increasing rapidly. Lot of interest is paid to find images in the database. There is a great need for developing an efficient technique for retrieving the images. In order to find an image, image has to be represented with certain features. Color and texture are two important visual features of an image. This paper proposes that the color feature can be extracted using HSV color space and the texture features can be extracted using grey level cooccurance matrix (GLCM) and Discrete wavelet transformation. In this paper, we have compared different content based image retrieval techniques to achieve good efficiency in the image retrieval.**

This comparison has done in between content based image retrieval using HSV color space and GLCM, GLCM and wavelet and the combination of HSV, GLCM and Wavelet. After obtaining all the experimental results, a comparative study was done. From the result, we have found that the CBIR system that uses the combination of all the three techniques gave a better performance as compared to other two methods with an accuracy of 83.95%.

Keywords – **CBIR, HSV, Wavelet Transformation, GLCM.**

I. Introduction

The content based image retrieval system is also known as query by image content. The term contents refer to color, texture, shape or any other information that can be derived from the image itself. Content Based Image Retrieval (CBIR) was proposed to retrieve images based on visual features (contents) of images in substitute for the traditional text based image retrieval, since the linguistic description of image by small number of key words is very limited in comparison to the image contents [2, 9]. The visual contents called as features, are numeric descriptors capturing specific visual characteristics. Text based image retrieval consumes more time when the database is very large[16]. To get around these problems, content based image retrieval system is proposed.

In an image, two features are present, local features and global features. From the literature we came to know that the local features play an important role in finding the similarity of images than global features[15]. So, in this paper, we present a technique for image retrieval based on local features like color and texture. Because these Low level visual features of the images such as color and texture are especially useful to represent and to compare images automatically. Color is a low level feature that gives the visual similarity. This color feature is extracted using HSV Color space [1]. Texture is also an important visual feature that refers to describe repeated patters, surface properties of an object and their relationship to the surrounding environment. Many objects in an image can be distinguished solely by their textures without any other information [3]. In our techniques, texture features are extracted using gray-level cooccurrence matrix (GLCM) and discrete wavelet transformation.

II. Features Extraction

A. Color extraction

The color feature is extracted from an image by using color space. The most common color space used to extract color from an image is HSV. The HSV color space has three components: hue, saturation and value. It is used to select various different colors needed for a particular picture. It gives the color according to human perception [1, 5, 13]. In HSV, hue represents color. In this model, hue is an angle from 0 degrees to 360 degrees.

Table-2.1: Hue color ranges

Angle	Color
0-60	Red
60-120	Yellow
120-180	Green
180-240	Cyan
240-300	Blue
300-360	Magenta

Saturation indicates the range of grey in the color space. Its value ranges from 0 to 1. When the saturation is ’0,’ the color is grey and when the saturation is ’1,’ the color is a primary color. A faded color is due to a lower saturation level, which means the color contains more grey. Value is the brightness of the color and varies with color saturation. Its value is calculated from 0 to 1. When the value is ’0′ the color space will be totally black. With the increase in the value, the color space brightness up and shows various colors.

2.A (1) Non-interval quantization

Because of a large range of each component, if characteristics are directly calculated for retrieval, then computation will be very difficult to ensure rapid retrieval. It is essential to quantify HSV space component to reduce computations and improve its efficiency. At the same time, because the human eye can distinguish only limited colors, there is no need to calculate all segments. H,S,V components are quantized with unequal intervals according to the human color perception.

Based on the color model of substantial analysis, we divide color into eight parts[13]. Saturation and intensity are divided into three parts separately in accordance with the human eyes to distinguish. In accordance with the different colors and subjective color perception quantification, quantified hue (H), saturation(S) and value (V) are showed below. In accordance with the quantization level above, the H,S,V three-dimensional feature vector

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for different values of with different weight to form one-dimensional feature vector named[6].

$$G = Q_S Q_V H + Q_V S + V \quad (1)$$

Where *QS* is quantified series of S, *QV* is quantified series of V.

Here we set *QS* =*QV* =3, then

$$G = 9H + 3S + V \quad (2)$$

$$H = \begin{cases} 0 & \text{if } h \in [316, 20] \\ 1 & \text{if } h \in [21, 40] \\ 2 & \text{if } h \in [41, 75] \\ 3 & \text{if } h \in [76,155] \\ 4 & \text{if } h \in [156,190] \\ 5 & \text{if } h \in [191,270] \\ 6 & \text{if } h \in [271,295] \\ 7 & \text{if } h \in [296,315] \end{cases} \qquad S = \begin{cases} 0 & \text{if } s \in [0, 0.2) \\ 1 & \text{If } s \in [0.2, 0.7) \\ 2 & \text{if } s \in [0.7, 1) \end{cases} \qquad v = \begin{cases} 0 & \text{if } v \in [0, 0.2) \\ 1 & \text{if } v \in [0.2, 0.7) \\ 2 & \text{if } v \in [0.7, 1) \end{cases}$$

In this way, three-component vector of HSV form one-dimensional vector, which quantize the whole color space for the 72 kinds of main colors [3, 7].So we can handle 72 bins of one-dimensional histogram. This quantification can be effective in reducing the images by the effects of light intensity, but also reducing the computational time and complexity.

B. Extraction of texture feature using GLCM

GLCM is created in four directions with the distance between pixels as one. Texture features are extracted from the statistics of this matrix.[3, 5, 13] The main advantage of GLCM is its Rotation invariance characteristic. Four GLCM texture features are commonly used which are given below: GLCM is composed of the probability value, it is defined by $P(i, j | d, \theta)$ which expresses the probability of the couple pixels at θ direction and *d* interval. When θ and *d* is determined, $P(i, j| d, \theta)$ is showed by $P_{i,j}$. Distinctly GLCM is a symmetry matrix; its level is determined by the image gray-level. Elements in the matrix are computed by the equation showed as follow:

$$P(i, j| d, \theta) = \frac{p(i,j|d,\theta)}{\sum\sum p(i,j|d,\theta)} \quad (3)$$

GLCM expresses the texture feature according the correlation of the couple pixels gray-level at different positions. It quantificationally describes the texture feature.[2, 15] In this paper, texture feature include four properties energy, contrast, entropy, homogeneity.

I. Energy

$$E=\sum\sum p(x, y)^2 \quad (4)$$

It is a gray-scale image texture measure of homogeneity changing, reflecting the distribution of image grayscale uniformity of weight and texture.

II. Contrast

$$I=\sum\sum(x-y)^2 p(x, y) \quad (5)$$

Contrast is the main diagonal near the moment of inertia, which measure the value of the matrix is distributed and images of local changes in number, reflecting the image clarity and texture of shadow depth. Contrast is large means texture is deeper.

III. Entropy

$$S = -\sum\sum p(x, y)\log p(x, y) \quad (6)$$

Entropy measures image texture randomness, when the space co-occurrence matrix for all values is equal, it achieved the minimum value; on the other hand, if the value of co-occurrence matrix is very uneven, its value is greater.

Therefore, the maximum entropy implied by the image gray distribution is random.

IV. Homogeneity

$$H = \frac{\sum\sum 1\, p(x,y)}{1+(x-y)^2} \quad (7)$$

It measures local changes in image texture number. Its value in large is illustrated that image texture between the different regions of the lack of change and partial very evenly. Here $p(x, y)$ is the gray-level value at the coordinate (x, y).

B. Extraction of texture features using wavelet transformation

Texture is a difficult concept to represent. It can be represented as a statistical measure or as wavelets. Here texture was represented using wavelet coefficients. This was a certain alteration of the method proposed in for texture feature [4, 10]. Mathematically, wavelet transform is a convolution operation, which can equivalent to passing the pixel values of an image through a low pass filter and a high pass filter.

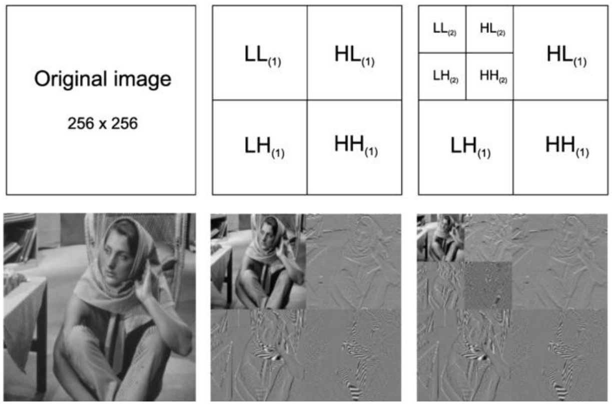

Fig.2.1. wavelet transform

In this paper two dimensional wavelet method is implemented for image retrieval where it leads to a decomposition of approximation coefficients in the first level and the details in three orientations (horizontal, vertical and diagonal) [4, 11, 12]. The high level frequency components contain information about edges and high level imaged details, that's why all high level coefficients were taken for matching. Each image was decomposed into four sub bands.

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III. Architecture for the Content Based Image Retrieval

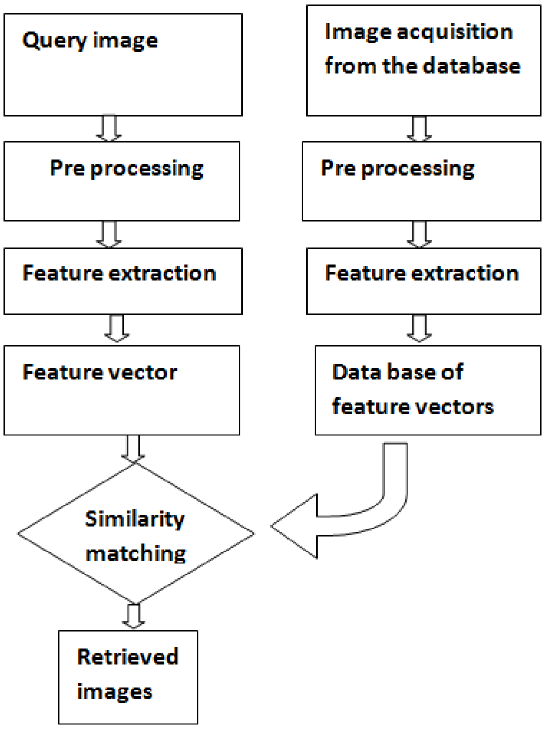

Fig.3.1. Architecture for the Content Based Image Retrieval

IV. Similarity Measure

Content based image retrieval determines visual similarities between query image and images in database. In the three different techniques in this paper, Euclidean distance is used to measure the similarity between the query images and the images in the database[8]. The images with the minimum distance are displayed

Euclidian Distance= $\sum\sqrt{(Ai - Bi)^2}$ (8)

Where A is the query image feature and B is the feature of the database image

V. Proposed Methods

In this paper, three combinations of techniques were proposed. Out of which first combination uses both HSV Color Space and GLCM, second combination uses GLCM and Wavelet transformation and the third combination uses all the three techniques

5.1. Image retrieval using HSV and GLCM

The proposed method is based on HSV and GLCM. In this method color of the query image is extracted using HSV and the texture features are extracted using Grey Level Cooccurance Matrix.

This technique is efficient in color dominating images when compared to the other images.

Implementation of image retrieval using HSV and GLCM

Step1: Choose a query image from the data base.

Step2: Convert the query image from RGB to HSV color space and extract the HSV(Hue, Saturation, Value) features.

Step3: Quantize the HSV values and a feature vector is constructed.

Step4: From the query image obtain four statistic features (Energy, Contrast, Entropy and inverse difference) from GLCM.

Step5: Construct a combined feature vector for color and texture.

Step6: Extract the same features vectors of the images in the database as the query image.

Step7: Find the distances between feature vector of query image and the feature vectors of target images using normalized Euclidean distance.

Step8: sort the Euclidean distances.

Step9: retrieve first 15 most similar images with minimum distance

5.2 Image Retrieval Using GLCM and Wavelet Transform

This method is based on GLCM and Wavelet Transformation. GLCM is used to extract the texture features of the image. The four GLCM features are extracted using GLCM technique. Wavelet Transformation is mainly used to extract the texture features of the image.[11] Along with the texture features, wavelet transformation gives analyses the image frequency and edges.

Implementation of image retrieval using GLCM and Wavelet Transformation

Step1: Choose a query image from the data base.

Step2: Convert the query image from RGB to grey and extract the GLCM features (energy, contrast, entropy, homogeneity).

Step3: Extract the wavelet features from the image by using wavelet transformation.

Step4: Extract the same features of the images in the database as the query image.

Step5: Find the distances between features of the query image and the features of target images using normalized Euclidean distance.

Step6: Sort the Euclidean distances.

Step7: Retrieve first 15 most similar images with the minimum distance.

5.3 Image Retrieval using HSV, GLCM and Wavelet

This method uses HSV Color Space, GLCM and Wavelet transformation.HSV color space is used to extract the color features of the image , GLCM is used to extract the four features (Energy contrast, entropy, homogeneity) and wavelet transformation is used to extract the texture features and to detect the edges. All these features are extracted to the images in the database, similarity is measured and the images with the required images are retrieved

Implementation of image retrieval using HSV and GLCM and Wavelet Transformation

Step1: Choose a query image from the data base.

Step2: Convert the query image from RGB to HSV color space and extract the HSV(Hue, Saturation, Value) features.

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Step3: Quantize the HSV values and a feature vector is constructed
Step4: From the query image obtain four statistic features (Energy, Contrast, Entropy and inverse difference) from GLCM.
Step5: Construct a combined feature vector for color and texture.
Step6: Convert the RGB image to grey image and extract the wavelet features.
Step7: Extract the same features vectors of the images in the database as the query image.
Step8: Find the distances between feature vector of query image and the feature vectors of target images using normalized Euclidean distance.
Step9: Sort the Euclidean distances.
Step10: Retrieve first 15 most similar images with minimum distance.

VI. Result and Discussion

For the proposed methods, a database with eight hundred images is used. The images in the database are classified into different categories namely cars, mountains, flowers, horse and flags etc., each category consists of twenty similar images. The query image is selected from the database and the images are retrieved using the three techniques. The results from the three techniques are analyzed. Out of these images, the results of flowers, cars and mountains are shown below; the top middle of the window shows the query image.

Fig. 6.1. (a) Result for HSV color and GLCM based method.

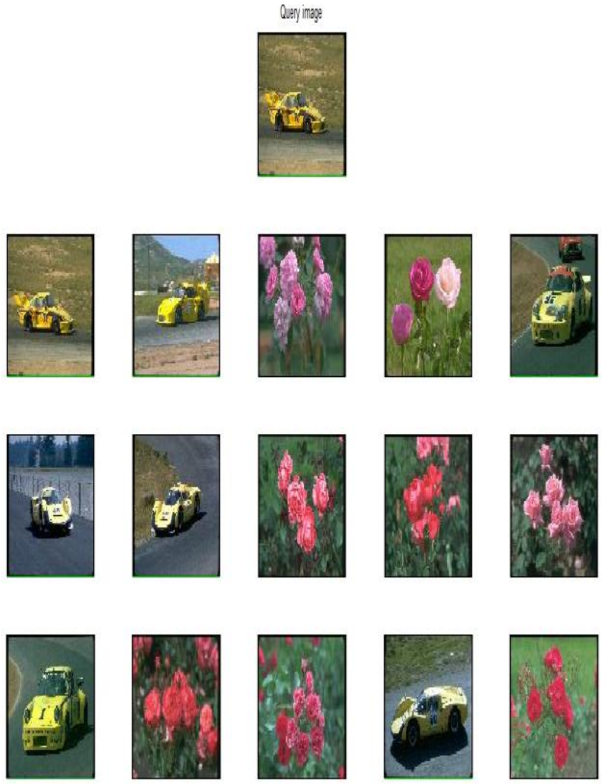

Fig.6.1. (b) Result for HSV color and GLCM based method

Fig.6.1. (c) Result for HSV color and GLCM based method

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Fig.6.2. (a) Result for GLCM and Wavelet based method

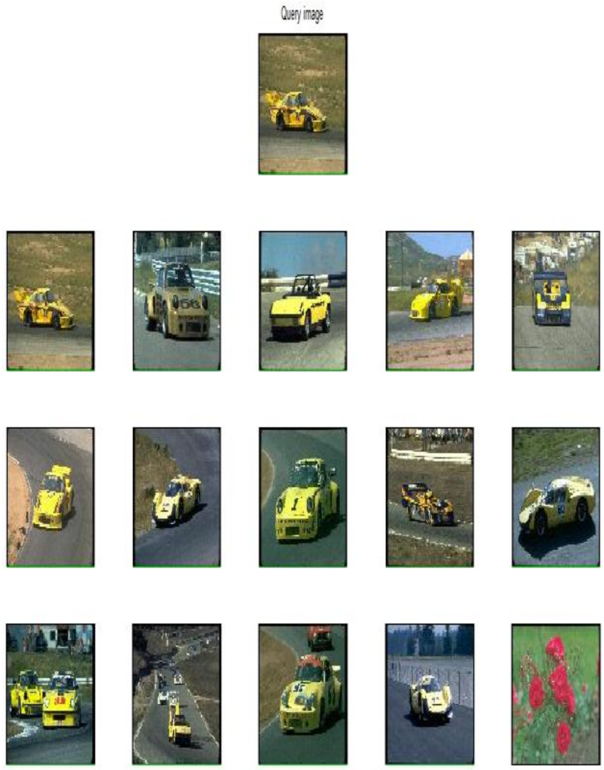

Fig.6.2. (b) Result for GLCM and Wavelet based method

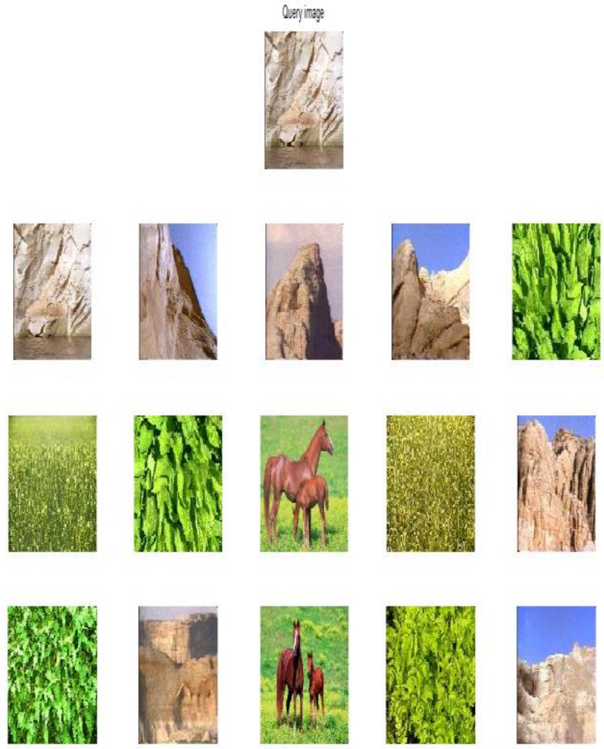

Fig6.2.(c).Result for GLCM and Wavelet based method

Fig.6.3. (a) Result for HSV- GLCM and Wavelet based method

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Fig.6.3. (b) Result for HSV GLCM and Wavelet based method

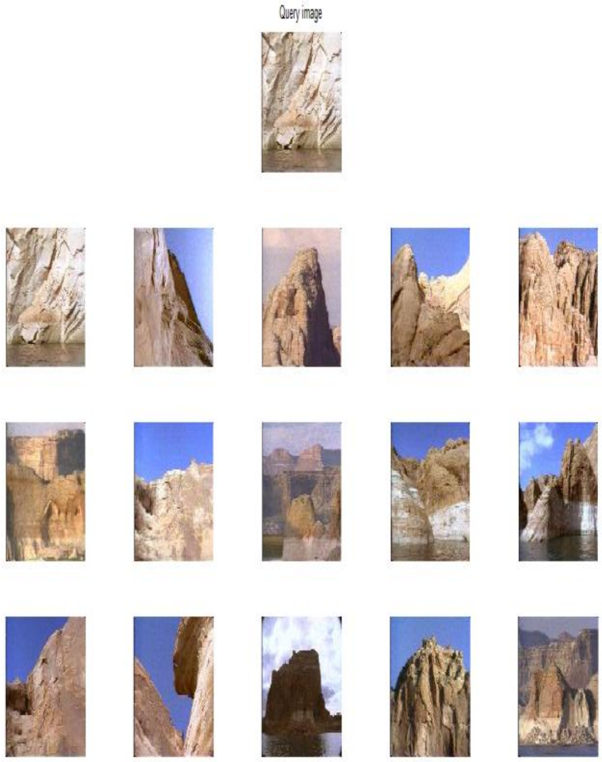

Fig.6.3. (c) Result for HSV, GLCM and Wavelet based method

Table 6.1-Precision and Recall of various methods

Images	HSV-GLCM			GLCM-Wavelet			HSV-GLCM-Wavelet		
	Images Retrieved	Precision	Recall	Images Retrieved	Precision	Recall	Images Retrieved	Precision	Recall
Dinosaur	15	1	0.75	15	1	0.75	15	1	0.75
Flowers	13	0.86	0.65	14	0.93	0.7	15	1	0.75
Bushes	13	0.86	0.65	10	0.66	0.5	15	1	0.75
Cars	7	0.46	0.35	14	0.93	0.7	14	0.93	0.7
Horse	15	1	0.75	11	0.73	0.55	15	1	0.75
Bear	11	0.73	0.55	14	0.93	0.7	14	0.93	0.7
Ship	15	1	0.75	10	0.66	0.5	15	1	0.75
Flag	15	1	0.75	15	1	0.75	15	1	0.75
Mountain	2	0.133	0.1	7	0.46	0.35	15	1	0.75
Trees	9	0.6	0.45	11	0.73	0.55	11	0.73	0.55

6.1. Performance evaluation

The performance of an image retrieval system is evaluated in terms of its accuracy. Accuracy is the average of precision and the recall values. Precision and Recall values are calculated by using the below formulae. The efficiency of an image retrieval system is maximum when its accuracy is high.

$$\text{Precision} = \frac{number\ \ of\ similar\ \ images\ retrieved}{total\ \ number\ \ of\ images\ \ retrieved} \quad (9)$$

$$\text{Recall} = \frac{Number\ \ of\ similar\ \ images\ \ Retrieved}{total\ \ Number\ \ of similar\ \ images\ \ in\ the\ database} \quad (10)$$

$$\text{Accuracy} = \frac{Precision\ +Recall}{2} \times 100 \quad (11)$$

From the result, we can say that the efficiency of the system with the combination of HSV color space, GLCM, and the Wavelet transformation gives the maximum efficiency with an accuracy of 83.95%., where the combination of GLCM gives 70.4% of accuracy and the combination of HSV Color Space and GLCM gives an accuracy of 66.97%.

Table 6.2: Accuracy of various methods

Images	Accuracy		
	HSV-GLCM	GLCM-Wavelet	HSV-GLCM-Wavelet
Dinosaur	87.5	87.5	87.5
Flowers	75.5	81.5	87.5
Bushes	75.5	58.0	87.5
Cars	40.5	81.5	81.5
Horse	87.5	64.0	87.5

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Bear	64.0	87.5	81.5
Ship	87.5	58.0	87.5
Flag	87.5	87.5	87.5
Mountain	11.65	40.5	87.5
Trees	52.5	64.0	81.5

VII. Conclusion and Future Scope

The main objective of this research is to investigate and evaluate an effective and robust approach for texture representation and to use it in image retrieval. For this purpose, we have investigated the texture analysis using several approaches. Throughout the contrast, the characteristics of the main methods, i.e., discrete wavelet, and GLCM were discussed. The combination of HSV, GLCM and Wavelet has absorbed the advantages of the color feature and wavelet while overcomes the disadvantages of both these methods. From experimental results, the combination of all the features is found to be promising. Finally, we compared the CBIR based on combination of color, GLCM and wavelet performance with that of the existing color and texture based methods and wavelet based methods. This research has found that combination of the three techniques outperformed the individual techniques in both accuracy and efficiency. From all the experimental results, HSV color space and GLCM based search gives an average retrieval accuracy of 66.97%, GLCM and Wavelet based search gives an average retrieval accuracy of 70.4% , Finally the combination of HSV Color Space, GLCM and Wavelet search gives an average retrieval accuracy of 83.95%. Performance of combination based search is better than the GLCM, wavelet and color based search because the combination extracts all the features information more accurately than individual techniques. Therefore, we find the combination of HSV Color Space, GLCM and Wavelet texture descriptor as a powerful means to perform CBIR

The content based image retrieval can be further developed to obtain 100% efficiency by using various techniques and by extracting high level features like edges, shapes, curves etc.,[10].

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