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Content Based Image Retrieval using Statistical Feature and Shape Extraction

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ABSTRACT: Content based image retrieval is based on automated matching of the features of the query image with that of image database through some image similarity evaluation. This can be done by extracting a useful feature from the query image as well as database image. The features like histogram, texture and shape extraction plays very vital role in the proper image retrieval. Here we have implemented a method of image retrieval using the histogram, Statistical and Shape features. In proposed method has two phases. In the first phase, we computed statistical or texture feature from each non uniform histogram bin for each RGB color components. Then we calculated similarity between the query image and database image using Euclidean distance to retrieve first round of result which is denoted as result A. In the second phase, we use Hu moments to extract the feature from result A and again measure the similarity between the query image and resulting image and in the final result most similar images are shown. The Proposed method is tested on Wang image database containing 1000 general – purpose color image and results are shown in terms of precision and recall. The performance of the proposed method is compared with the existing systems in the literature.

KEYWORDS: Content based image retrieval, precision, recall, statistical feature, moment invariant, texture, shape.

I. INTRODUCTION

In recent years because of the explosive growth in the web and advancement in computer technology digitization, retrieving a picture from a large scale database and maintaining the intellectual property right became an important task. Thus, the content based image retrieval becomes the one of the most active research topic nowadays. For retrieving images, we use the content of the image like shape, color and texture. This structure may be known as Content Based Image Retrieval. Generally, there are two techniques which are used to retrieve picture from the image database. First one is the traditional text based matching method for retrieving the image from the database, also known as textual method which is based on searching image with the help of descriptive keyword, but this method is insufficient because sometimes we can't describe the image what we really need, so it is likewise tedious technique whereas the second technique which is called content Based Image Retrieval which is based on automated matching on their real content [1]. It matches the visual similarity between query image and database image, these visual content are called as a feature of the image.

CBIR is important field of image processing and it has various applications in multimedia, crime prevention, internet, digital libraries, and entertainment. A number of previous works have been done for CBIR based on the various feature [2]. Some works based on the single feature and some are based on the two or more features combining to get the result. In those features color feature is widely used in content based image retrieving process because it is invariant to scaling, rotation and other spatial transformation on the image feature. In generally histogram based CBIR methods are generally straightforward and quicker. Michal et al. [3] Introduced a technique is called histogram intersection, which matches model and image histogram using intersection distance metric between the histograms of an image, which allows real-time indexing into a large database of stored model. Xiang-Yang Wang et al. [4] proposed a system that firstly cluster the image, then predetermine them using fast color quantization algorithm. Then the dominant color values are obtained after that, these values are merged with the texture values and finally a robust System is presented. F. Malik et al. [5] where they used to convert grayscale image and it was further preprocessed by Laplacian filter and shows Laplacian filter give good performance for retrieval of JPEG images as compared to the median filter. In paper [6], another method was introduced which is based on shape features of image. In this method compass operator is proposed for color edge detection which detects step edges without accepting the regions on either side those have constant color. Murala S. et al. [7] proposed a combine color and texture features for CBIR, they decompose the image into sub-bands using standard wavelet and Gabor wavelet transform. M. Imran et al. [8] proposed a technique which is

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based on color histograms using HSV and First Order Statistics. In paper [9] they combine color feature and texture feature and called WBCHIR which is Wavelet Based Color Histogram Image Retrieval. S. M. Singh et al. [10] method was based on the color and texture features in which they divide the image into three equal non-overlapping regions and for every region extract the color moments as a feature vector. Ahmed Talib et al [11] introduced an adapted semantic dominant color descriptor that can be used in object-based image retrieval. The method is based on assigning a weight to each DC in the image in accordance with its belonging to the object or to the background. Naushad et al. [12] proposed simple and effective methods during the image retrieval process. It is based on the color histogram which is partitioned into several numbers of non-uniform bins and used them to computed various statistical values as a feature vector that contain most significant information of the image.
CBIR attract lots of researchers to improve the precision rate, but it's hard to define which feature is being used to retrieving the best result from the database and improve the search result precision. As the variation of search range and search object increases CBIR need to combine two or more feature together to retrieve image because sometimes single feature cannot express the whole image and by using two features it can reduce the uncorrelated image. So in this paper we combined the color and shape feature of any RGB image and compared with the image database, and presented a CBIR technique using statistical feature of colour histogram and shape feature to retrieve results. For measuring similarity between query image and database image we used Euclidean distance. The whole process is done two phases first is the statistical feature extraction and the second is the shape feature extraction. First phase of proposed algorithm can narrow the search scope and the second phase improves the results in term of precision and get the most similar results.

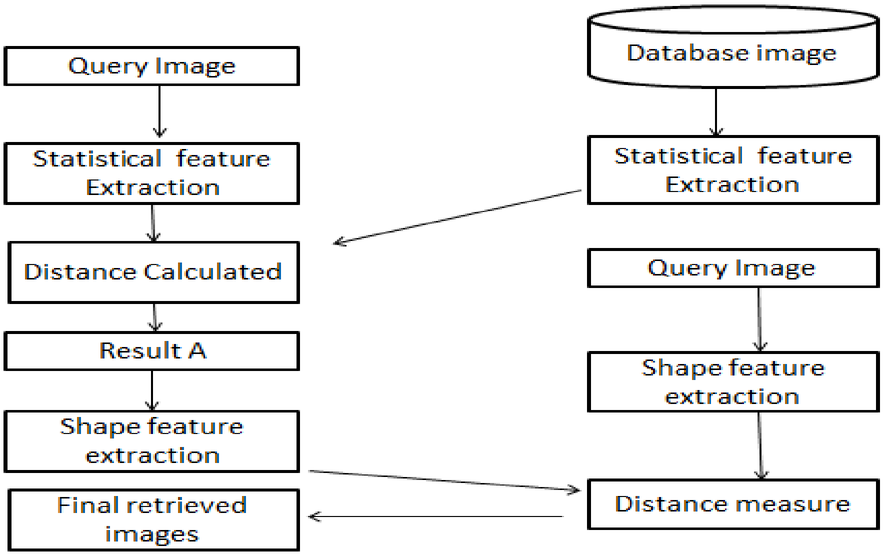

Figure1: Block diagram of proposed algorithm.

The rest of the paper is organized as follows; In Section 2 we have discussed Statistical Feature Extraction from the RGB image. In section 3 and 4 we describe the similarity measurement and shape feature extraction schema. The experiment results are depicted in section 5 and Section 6 mentions some conclusions followed by the references.

II. STATISTICAL FEATURE EXTRACTION

Texture feature gives information about the properties of intensity level distribution in the image like smoothness, uniformity, contrast and flatness thus it is considered useful for retrieving image from the database [5]. Most commonly used texture features are mean, standard deviation, kurtosis, skewness, energy etc. we can calculate these parameters directly from a color histogram. The Color histogram represents the distributions of colors in the image where X-axis denotes the intensity level r_i and Y-axis denotes the number of pixels inr_i.

Let P(r_i) is the estimated probability of r_i intensity level, which can be calculated as follows

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$$P(\mathrm{r_i}) = \frac{\text{number of pixels in } \mathrm{r_i}}{\text{total number of pixel in image}}$$

If P(r_i) is the probability of (r_i) and the total L levels, then we can compute the entire statistical texture feature in low computational cost. In this proposed method we divide The mean is measure the average value of the intensity value, if the mean is high then it means that the image is bright and if low then the image is dark. This can be calculated [5, 15] as:

$$\text{Mean} = \sum_{i=1}^{l} \mathrm{r_i}\, P(\mathrm{r_i})$$

The standard deviation shows the contrast of gray level intensities. The low value of the standard deviation indicates a low contrast and the high value shows the high contrast of the image. This can be computed [5, 12,15] as:

$$Stddev = \sqrt{\sum_{i=1}^{L} (r_i - mean)^2 P(r_i)}$$

A third order moment is skewness and it shows the skewness of the intensity values. It is the measurement of the inequality of the intensity level distribution about the mean. The positive value indicates that the large number of intensity values is on the left side of the mean and negative value indicates that the large number of intensity is on the right side of the mean and the zero value indicates that the distribution of the intensity is relatively equal on both sides of the mean [5,15]. It is defined as:

$$Skew = \frac{1}{(stdev)^3} \sum_{i=1}^{L} (r_i - mean)^3 P(r_i)$$

Fourth order moments Kurtosis is used to measure the peak of the distribution of the intensity values around the mean. The high value of the kurtosis indicates that the peak of the distribution is a sharp and low value indicates the peak of the distribution is rounded [5]. Kurtosis can be defined as:

$$Kurtosis = \frac{1}{(stdev)^4} \sum_{i=1}^{L} (r_i - mean)^4 P(r_i)$$

The energy feature measures the uniformity of the Intensity level distribution. It is the inverse of entropy. If the value is high, then the distribution is to a small number of intensity levels [5]. Energy can be defined as:

$$Energy = \sum_{i=1}^{L} P(r_i)^2$$

Following steps define the Statistical Feature extraction:

1. Take the input RGB image and decompose the image into Red, Green and Blue component and for every color component compute the probability histogram using eq. (1).
2. Maintain a non-uniform bin vector dividing the probability histogram, it is obtained such a way that $Bin_i = \sum_{i=0}^{n} P(r_i) \le \frac{1}{n}$ Where n is the number of bins, in this paper, we set total 10 numbers of bins.
3. For each color component, we computed mean, standard deviation, skewness, kurtosis and energy from each bin by using equation 2-6.

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4. Now we maintain the feature vector of the image database and combine the value of all moments in a single feature vector which is derived in step 3.

Feature database and query feature vector constructed in the same way and for every database image we compared with the query image on the basis of feature vector using distance measurement.

III. SIMILARITY MEASUREMENT

After the first phase of an algorithm as shown in figure 1 the distance is calculated between the query feature vector and database feature vector. To measure the distance or we can say to measure the similarity we use Euclidean distance because of its efficiency and effectiveness. It measures the distance between two feature vector of an image and it is defined as

$\Delta d = \sqrt{\sum_{i=1}^{n}(Q_i - D_i)^2}\ \forall_n = 1,2 \ldots n$ (7)

Where Q_i and D_i is the feature vector of the query image and database image respectively, and n is the dimensions of vectors. As the value of Δd is small it shows that the resultant image is most similar to the query Image.

IV. SHAPE FEATURE EXTRACTION

Shape feature is a stable feature because it does not change when other features change so it can easily distinguish the objects which are in the same category. Shape feature depends on two ways one is the boundary and the other one bases on the region. In the second phase of our algorithms, we extract the shape feature from result A which is obtained by the statistical feature extraction instead of using all the image database we use the small set of result doing this way we can increase the precision rate and improve the results. In this paper, we take Hu invariant moments to extracting feature vector. This method given by Ming Kuei Hu in 1962 for visual pattern recognition [13]. The main idea of moment invariant is they are insensitive under translation, rotation and scaling.
The 2-D moments of order (p+q) of an image f(x,y) of size M×N is defined as:

$m_{pq} = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} x^p y^q f(x,y)$ (8)

The corresponding central moment of order (P+q) is defined as

$\mu_{pq} = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} (x-\bar{x})^p (y-\bar{y})^q f(x,y)$ (9)

Where p = 0, 1, 2... And q = 0, 1, 2......are integers.

Where $\bar{x} = \frac{m_{10}}{m_{00}}$ and $\bar{y} = \frac{m_{01}}{m_{00}}$ (10)

Where $(\bar{x},\bar{y})$ is the center of the object. For obtaining the ability of scale invariant the normalized central moments denoted as

$\eta_{pq} = \frac{\mu_{pq}}{\mu^{\gamma}{}_{00}}$ Where $\gamma = \frac{p+q}{2} + 1$

Hu derived seven moments from the normalized second and third order of central moments: This set of moments is invariant to scale change, translation, mirroring (within a minus sign) and rotation [14]:

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$$
\begin{aligned}
M_{H1} &= \eta_{20} + \eta_{02} \\
M_{H2} &= (\eta_{20} - \eta_{02})^2 + 4\eta_{11}{}^2 \\
M_{H3} &= (\eta_{30} - 3\eta_{12})^2 + (3\eta_{21} - \eta_{03})^2 \\
M_{H4} &= (\eta_{30} + \eta_{12})^2 + (\eta_{21} + \eta_{03})^2 \\
M_{H5} &= (\eta_{30} - 3\eta_{12})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2] \\
&\quad + (3\eta_{21} - \eta_{03})(\eta_{21} + \eta_{03})[(\eta_{30} + \eta_{12})^2 + (\eta_{21} + \eta_{03})^2] \\
M_{H6} &= (\eta_{20} - \eta_{02})[(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] \\
&\quad + 4\eta_{11}(\eta_{30} + \eta_{12})(\eta_{21} + \eta_{03}) \\
M_{H7} &= (3\eta_{21} - \eta_{03})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2] \\
&\quad + (\eta_{30} - 3\eta_{12})(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2]
\end{aligned}
$$

To measure the similarity between the query images and result A image the difference is calculated between the query feature vector and result A feature vector by using the Euclidean distance. After the first phase, we take the top 20 images for the shape feature extraction and for the final result first 10 images are shown after shorting the distances. If the query shape feature vector isS_i and result A shape feature vector is A_i then Δd_f final Euclidean distance between S_i and A_i is calculated by:

$$\Delta d_f = \sqrt{\sum_{i=1}^{n} (S_i - A_i)^2}$$

Where n=number of features, i=1, 2 ...n.

V. EXPERIMENTS AND RESULTS

For an experimental result Corel database of the image which is provided by Wang et al. [16] is being used. It is freely available on the internet for the researcher. All the images are in the JPEG format with a size 256×384 and 384×256 pixels which consist of 10 categories and each category having 1000 images like people, horses, building, buses etc. There are two indicators for measuring the performance of CBIR system which are

$$Precision = \frac{Number\ of\ relevant\ images}{Total\ number\ of\ retrieved\ images}$$

$$Recall = \frac{Number\ of\ relevant\ images}{Total\ number\ of\ relevant\ images\ in\ the\ database}$$

We select 10 images randomly from each category and take the average value of precision and recall, higher value of these indicators shows the better performance of the system. The test result of precision and recall are shown in Table1.

Table 1: Precision and Recall table for top 10 retrieved images.

Category	Precision	Recall
Peoples	90	9
Beaches	82	8.2
Buildings	62	6.2
Buses	91	9.1
Dinosaurs	100	10

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Elephants	85	8.5
Flowers	90	9
Horses	98	9.8
Foods	89	8.9
Mountains	73	7.3

The results of our approach are better than previous Techniques in terms of precision as shown in Figure 3.
We have performed the simulation for the different queries of the individual class and some result for the buses, dinosaurs, flowers and mountains are shown in Figure 4.

Table 2: Comparison of proposed method with previous methods.

Category	M.Imran[8]	CMR+GTF[10]	WBCH[9]	Naushad[12]	Proposed
Peoples	85	74	65	100	90
Beaches	62	38	62	90	82
Buildings	54	36	71	50	62
Buses	45	77	92	80	91
Dinosaurs	100	95	97	100	100
Flowers	44	69	76	90	90
Horses	67	67	87	100	98
Foods	28	69	77	100	89
Mountains	21	41	49	50	73
Elephants	57	44	86	80	85
Average	**56.3**	**61**	**76.2**	**84**	**86**

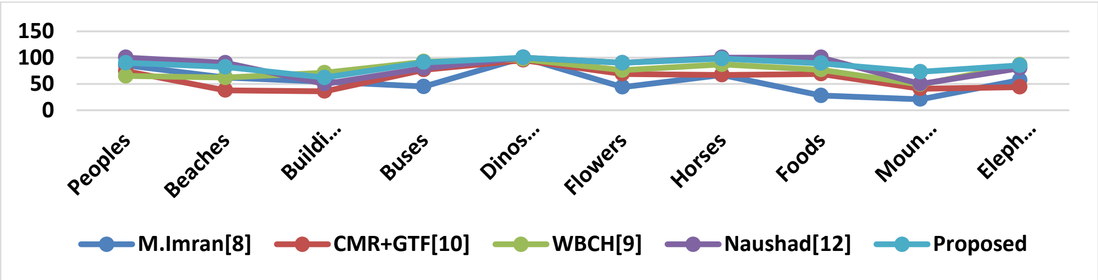

Figure 2: A comparison of average precision of our technique with other related techniques in each category.

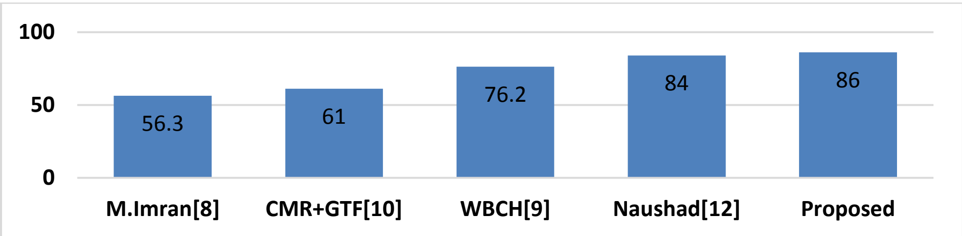

Figure 3: Average Precision of proposed method with other techniques.

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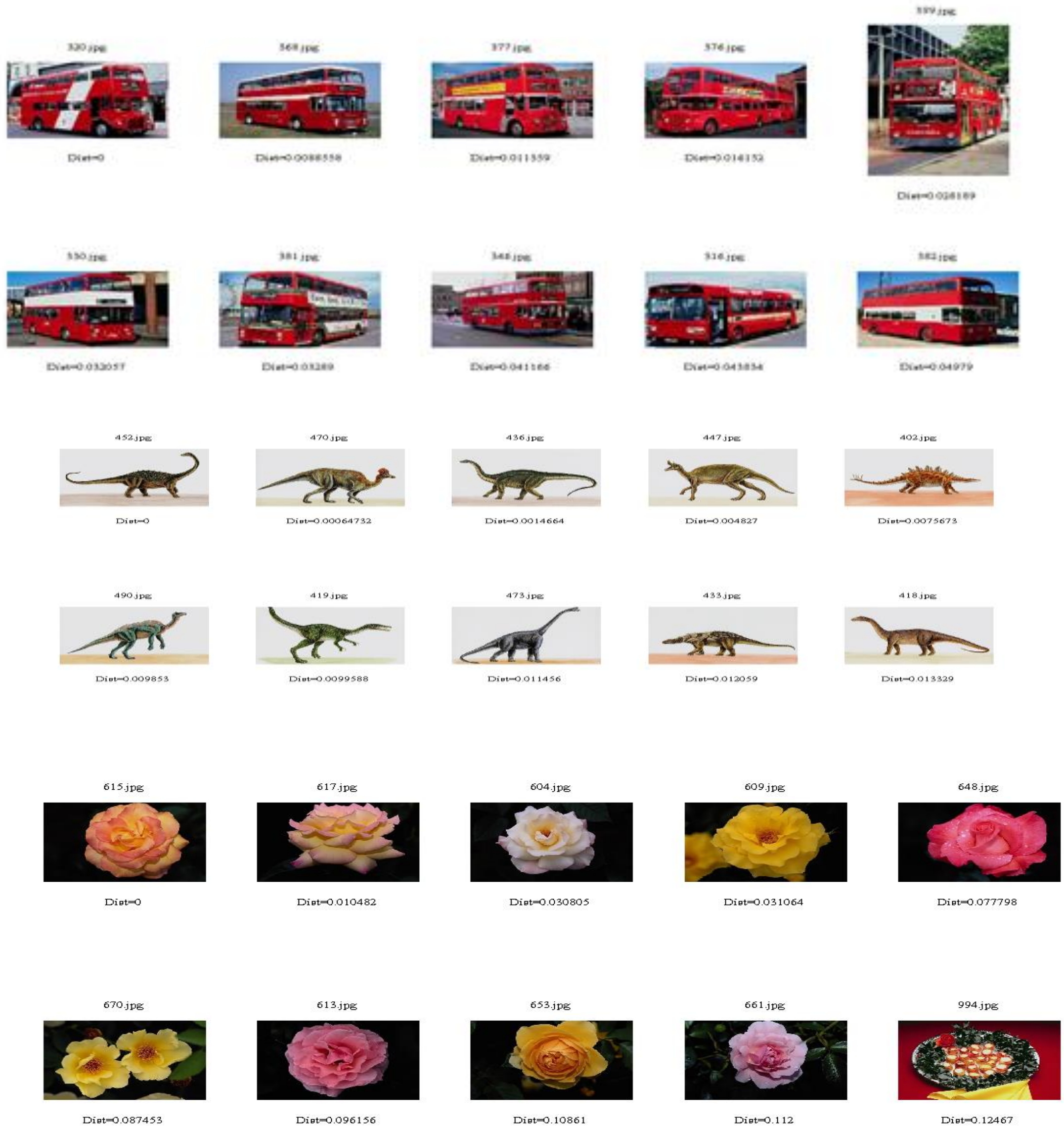

Figure 4: Query Results.

V. CONCLUSIONS

In this paper, we have proposed a method for image retrieval using the texture and shape feature of an image. In the texture feature we use the statistical feature of color histogram and for extracting shape feature we use the Hu moments and by combining both features we have improved the precision rate. The proposed technique gives good results for the buses, dinosaurs, horse, flowers and peoples whereas for other categories due to the presence of more detail features it didn't give the satisfactory results, but overall the proposed method gave 86% of precision rate and it can be used for any real time application like web search engine.

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