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Evaluation of CBIR System by Using Low Level Features of an Image

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Abstract - Content based image retrieval system refers to the process of retrieving images from large data base based upon the image content. Image content refers to image information contained in the form of colour, texture, edge, boundary and region of an image. Based upon color content of an image, there are various image retrieval techniques such as colour histogram, colour coherent vector, colour moment. The techniques based upon texture are Gray level co-occurrence matrix, transform based methods such as Gabor transform and wavelet transform. Shape based techniques include edge or boundary detection by using Hu moment invariants, Fourier descriptor, 3 D shape descriptor etc. The aim of this research work is to evaluate the performance of CBIR system with parameters precision, recall, NMRR and retrieval time by using feature extraction techniques based upon colour - histogram, texture - GLCM and region – boundary descriptors of an image. NMRR and retrieval time of different query images have been evaluated.

***Keywords**: CBIR, Histogram, GLCM, Precision, Recall, NMRR.*

I. INTRODUCTION

In today's hi tech world, images are an integral part of life. Not only professionals for their official work but many people love to click images and upload them on social media. Today most of the mobile phones are providing high resolution cameras. With the advancement in image capturing devices and internet technologies, it has now become necessary to develop efficient image database systems, browsing systems and image retrieval systems. Retrieval systems are developed under two main frameworks i.e. text based image retrieval and content based image retrieval. Text based image retrieval does not provide satisfactory results for typical images where it is cumbersome to define image by annotations. For example it would be difficult to define images of fingerprints of individuals. Also the retrieval will depend upon annotations. Text based retrieval is cumbersome and labor intensive also [1]. To overcome such problems, CBIR systems are proposed where retrieval may depend upon low level features such as color, texture or shape, middle level features such as arrangement of specific type of objects and high level features such as impressions or emotions [2]. In this research work, low level feature extraction has been performed. The figure 1 shows block diagram of a typical CBIR system. The image database consists of a large number of images. Based on the pixel values of image, features such as colour, texture shape are extracted and then stored in image database. The stored features are compared with the features of input query image. Based upon similarity value, ranking of images is done and then similar images are produced at the output. The distance measure is used to compute the similarity between query image and database images. After computing similarity, images are ranked up to some level and then produced at the output.

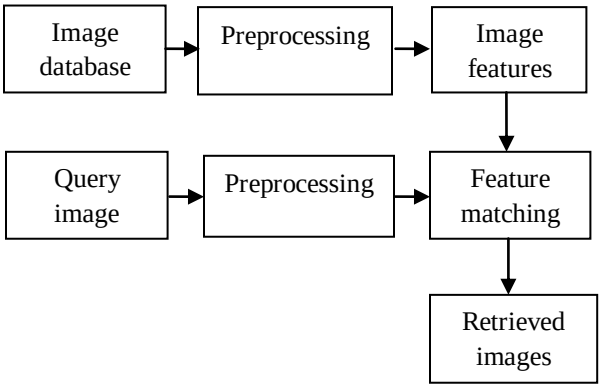

Figure 1: Bock diagram of CBIR system

II. LOW LEVEL FEATURE EXTRACTION

Evaluation of system has been done on the basis of low level features extractions of an image. For color content, histogram approach is used. For texture feature, gray level co-occurrence matrix is used. The shape information is extracted by Area, Parameter, Euler number and Orientation of image content.

A. Color Feature Extraction

Colour is the most important distinctive feature of an image. Also colour feature is insensitive to rotation, zooming of an image and provides better stability. Colour space selection plays an important role on the performance of CBIR system [3]. Generally used color space are RGB, YUV, HSV, YC_bC_r. A color histogram H for a given image is defined as a vector H = {h[1], h[2], . . . , h[N]} where color of histogram is represented by i, number of pixels in color I are defined by h[i] and number of bins are represented by N i.e. number of colors in selected model[12]. The three channel histograms are concatenated to form a feature vector. For similarity computation, histogram of query image is matched with histogram of database images.

B. Texture Feature Extraction

Texture is the physical feel of a surface. One of the statistical methods of examining texture of an image is Gray Level Co-occurrence Matrix which considers spatial relations of pixels in the image. The presence of specific pairs of pixels and their spatial relationship is used to define texture [4]. In this research, GLCM descriptors used are Energy, Contrast,

Homogeneity and Correlation. The obtained texture measures are 4×16 = 64. To reduce dimensions and computational complexity, the mean value is used by using following formula:

$$\text{Mean} = \frac{1}{N} \sum_{i=1}^{N} T_c \quad (1)$$

Where N= 16, T_c = contrast, correlation, energy, homogeneity.

C. Shape Feature Extraction

As per the taxonomy of shape extraction methods, features of an image are extracted based upon its local or global features, graph and any other parameter like view based, volumetric error based, weighted point and deformation based [5]. Graph based feature extraction technique deals with model graph, skeleton, and reeb graph. Some simple boundary descriptors such as area, perimeter, compactness, eccentricity, orientation, elongation or complex boundary based descriptors such as Fourier descriptor, grid descriptor, chain codes, statistical moments are also used for feature extraction [6]. The shape feature can also be calculated by using edge detection operators like sobel, prewitt or edge histogram [7]. In this research work, I have used area, perimeter, Euler number and orientation descriptor to calculate region feature of an image.

III. SIMILARITY CALCULATION

The similarity between query image and database image can be computed by using distance metric measures such as Euclidean distance, Chi square distance and weighted Euclidean distance [7].

$$\text{Euclidean distance, D} = \sqrt{\sum(x_i - y_i)^2} \quad (2)$$

Here, x_i is training image value and y_i is query image value. The minimum distance value indicates exact match of query image with database image.

$$\text{Chi – square distance, } D^2 = \frac{(x_i - y_i)^2}{y_i} \quad (3)$$

$$\text{Weighted Euclidean distance, D} = \sqrt{\sum W\,(x_i - y_i)^2} \quad (4)$$

Here, W indicates weight value.

In this research paper, I have used Euclidean distance formula for similarity matching. The images are sorted and ranked on the basis of similarity values. Then the images having first ten ranks are displayed to the user.

IV. SYSTEM EVALUATION

For colour feature extraction, feature vector represents frequencies of pixels that occur in quantized bins. The texture feature vector is computed by taking average of contrast, correlation, homogeneity and energy. The average values of area, orientation, euler number and perimeter is used to define shape feature vector. The evaluation of system has been done on the basis of Precision, Recall, Normalized Modified Retrieval Rank (NMRR) and Retrieval time.

$$\text{Precision} = \frac{Number\ \ of\ relevant\ \ images\ \ retrieved}{Total\ \ number\ \ of\ \ images\ \ retrieved} \quad (5)$$

$$\text{Recall} = \frac{Number\ \ of\ relevant\ \ images\ \ retrieved}{Number\ \ of\ relevant\ \ images\ \ available\ \ in\ databasee} \quad (6)$$

Generally there is an inverse relation between precision and recall because as the number of retrieved items increases, precision decreases and recall increases [8]. As the parameters precision and recall don't give any information about ranking of images. Thus NMRR has been used in this research to provide information about ranking order of retrieved images. The value of NMRR ranges from 0 to 1 [9]. The 0 value of NMRR indicates that all ground truth images are available in top rank list whereas the value 1 indicates no match [10].

$$\text{NMRR (q)} = \frac{MRR\ (q)}{K + 0.5 - 0.5 * NG(q)} \quad (7)$$

$$\text{MRR (q)} = \text{AVR (q)} - 0.5 - \frac{NG\ (q)}{2} \quad (8)$$

$$\text{AVR (q)} = \sum_{k=1}^{NG\ (q)} \frac{Rank\ \ (k)}{NG\ (q)} \quad (9)$$

Here, MRR = adjusted average rank measure, AVR = Average Rank of images in a query, NG (q) = Number of ground truth images for query q. Evidences shows that ANMRR (Averaged Normalized Modified Retrieval Rank) coincide linearly with results of subjective evaluation of retrieval accuracy of search engine [11]. In today's fast moving world, the retrieval time is considered to be one of the major deciding factors for any system to be adopted. The quick retrieval response is always desirable for any query image. Thus the retrieval time has also been considered to evaluate the performance of system.

V. EXPERIMENTAL RESULTS

The retrieval results are obtained by using GUIDE environment of Matlab. The results are computed for colour, texture, shape and combined technique. The Figure 2 shows retrieval results for input query image of apples after texture feature matching between query image and database.

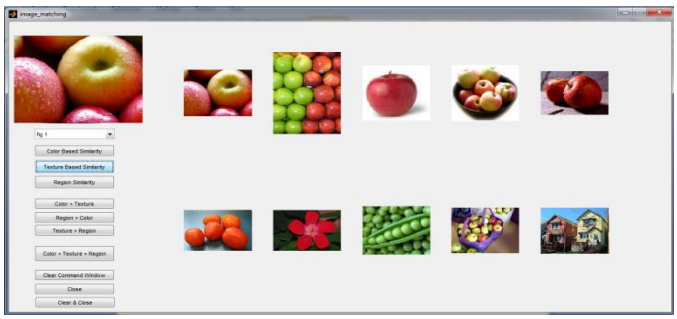

Figure 2: System outcome for texture based feature extraction

The Table I shows retrieval results of different parameters for query image of apples.

Table I: Retrieval results

Approach	Precision	Recall	NMRR	Retrieval Time (seconds)
Colour	0.4	0.6	0.31	1.12
Texture	0.5	0.83	0.33	7.82
Region	0.4	0.66	0.46	2.42
Colour + Texture	0.5	0.83	0.44	8.0
Texture + Region	0.5	0.83	0.42	9.18
Region + Colour	0.4	0.66	0.31	2.61
Colour + Texture + Region	0.4	0.66	0.4	9.22

The figure 3 shows NMRR comparison for different techniques over query image of apples.

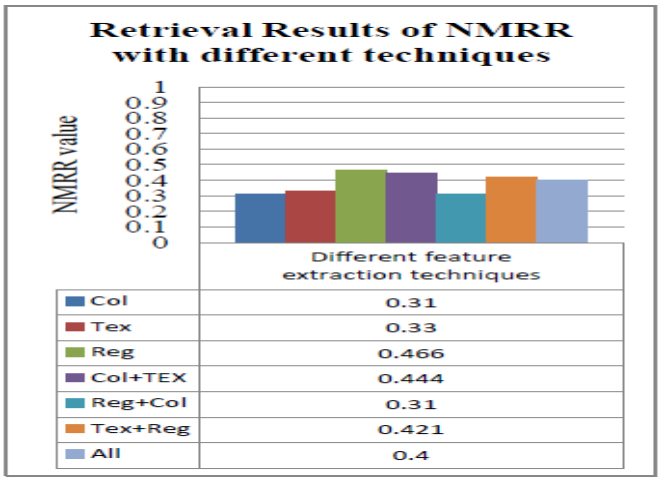

Figure 3: NMRR results for query image of apples

The colour approach and region colour approach gives minimum value of NMRR. In figure 4, NMRR results are obtained for query image of an elephant.

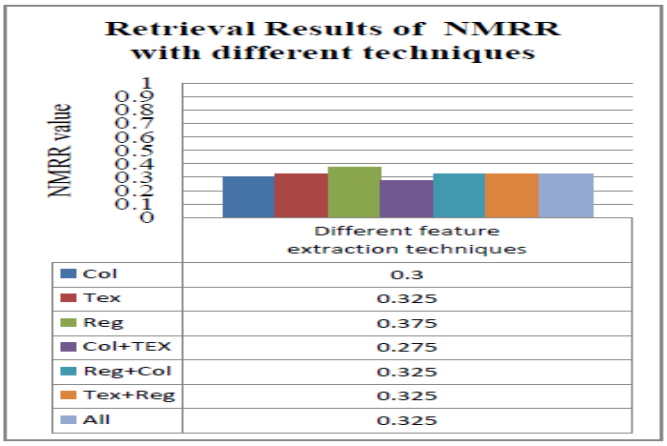

Figure 4: NMRR results for query image of Elephants

As per the results obtained, the combination of colour texture technique gives minimum value of NMRR.

The figure 5 shows comparison of retrieval time for different feature extraction techniques. As per results obtained, the texture extraction technique using GLCM takes maximum time when applied alone or in combination with other techniques whereas minimum time is taken by colour feature extraction and retrieval process.

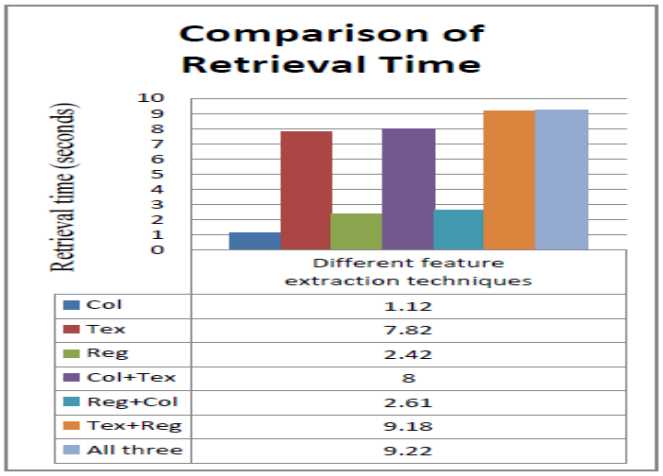

Figure 5: Comparison of retrieval time for input query image of apples

Similarly for an input query image of an elephant, the comparison of retrieval time is done for different feature extraction techniques and it was found that texture feature extraction technique takes more time to provide retrieval results.

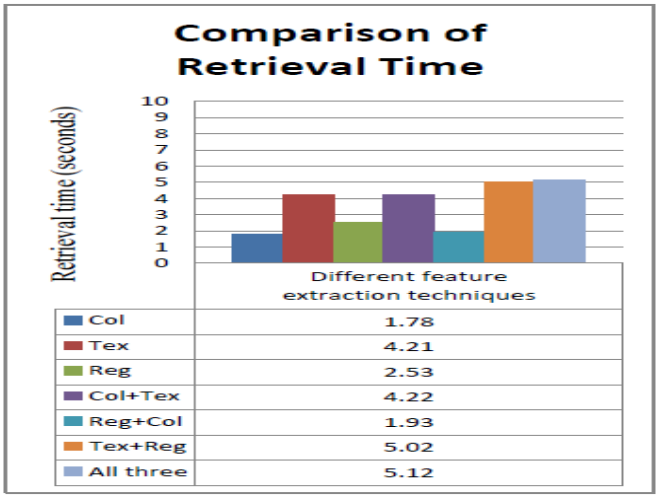

Figure 6: Comparison of retrieval time for input query image of an Elephant

VI. CONCLUSION AND FUTURE SCOPE

In this research work, the system evaluation has been done on the basis of precision, recall, NMRR and retrieval time. The

features of an image are extracted by using three different techniques and their combination. From the results, it was found that the histogram based colour feature extraction techniques is efficient, simple and fast but at the same time may give inaccurate retrieval results sometimes due to the reason that two dissimilar images may possess same histogram. The retrieval results based upon texture by using GLCM are quite good but this approach takes maximum time in providing retrieval results at the output due to the complexity involved in calculation of feature vectors. The parameters precision and recall are greatly affected by database available. Also the combined techniques will give better results as compared to individual single technique applied. The accuracy of the system may be improved by combining with some other feature extraction techniques, machine learning or by using user feedback. Some indexing method may be used to speed up the processing and retrieval of images.

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