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An Efficient Method for Image Retrieval Using Curvelet, Wavelet-PCA and Colour Histogram

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Abstract: Nowadays, image retrieving from large database has become a wide area of interest due to the recent development in internet and medical field. In this study an attempt has been made to improve the accuracy of content based image retrieval. In the methods, retrieving process is based on extracting any of the low level features of image such as texture, colour and shape and it is used as a query to retrieve image. In our proposed system, the efficiency of the retrieving process is increased by obtaining all the features like texture, shape, and colour using three different algorithms. Here the texture feature of an image is extracted by using Discrete curvelet transform, discrete wavelet transform with PCA is used to extract shape feature of an image and colour feature is extracted by using Color Histogram. Finally the output of all the above methods is combined and it is given as a query to retrieve images from the database. Experiment results demonstrate that our proposed method is more robust and more efficient than previous algorithm.
Keywords: CBIR, Discrete Curvelet transform, DWT with PCA, Color histogram.

I. INTRODUCTION

Over the past few decades Internet and other image capturing devices becomes the main source of providing a huge number of multimedia images. So it is needed to create an efficient and effective retrieval system to retrieve these images. Image retrieval system is used for searching and retrieving digital images for large database. There are two methods of image retrieval text based and content based image retrieval. In text based image retrieval user use keyword or descriptor as a query and the images which is relevant to the keyword is retrieved from the database. Since different users understands image in different point of view. The descriptor used to describe the image is inconsistent. For example, an image consisting of trees and mountains can be labeled as either ‘trees’ or ‘mountains’ or ‘nature’ by different people. to overcome the drawback in content based image retrieval (CBIR) [1.2] the image is represented by the contents of the images like color, texture and shape. Several algorithms have been proposed to increase the efficiency of retrieving process in CBIR. In our proposed method we are using curvelet transform to extract texture feature of the image, shape by using discrete wavelet transform and Principal component analysis (PCA) and color by using Color histogram. Since we are extracting all the low level feature of the image such as texture, shape, and color to represent the image the efficiency of the proposed algorithm is increased significantly and it is shown experimentally.

The remaining parts of this paper are organized as follows. Section II describes curvelet transform and texture feature extraction. Section III briefly describes about wavelet haar

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transform and principle component analysis used in shape feature extraction of the image . Section IV describes color histogram algorithm for color feature extraction. Section V explains about Euclidian distance to compare query image and database images. Section VI tells about the performance metrics used for image retrieval process. Section VII discuss about the image databases, performance and result analysis, followed by conclusion in Section VIII.

II. CURVELET TEXTURE FEATURE EXTRACTION

Curvelet transform provides more detailed information of the image in the spectral domain using more orientation information at each scale. Therefore, curvelet transform is employed to extract texture feature. The curvelet transform is nothing but the extended form of two-dimensional ridgelet transform. Given an image f(x,y) its continuous ridgelet transform at scale a, translation b and orientation θ is defined as,

$$RT_f(a,b,\theta) = \iint \Psi_{a,b,\theta}(x,y) f(x,y) dxdy \qquad (1)$$

where, a > 0 and 2D ridgelet function, is $\Psi_{a,b,\theta}(x,y)$obtained from a univariate function, Ψ_x which has vanishing mean and sufficient decay. The ridgelet, $\Psi_{a,b,\theta}(x,y)$ is given as,

$$\Psi_{a,b,\theta}(x,y) = a^{\frac{1}{2}}\Psi(x\cos\theta + y\sin\theta - b)/a \qquad (2)$$

A ridgelet is a wavelet type function and is constant along the lines: xcosθ+ysinθ =const. It is seen that, the ridgelet has line parameters (b,θ). This means ridgelet can have different orientation and scales to create the curvelets that covers complete spectrum. So, in case of curvelet, there contains no loss of frequency information Fig.1 shows frequency spectrum coverage of curvelet transform.

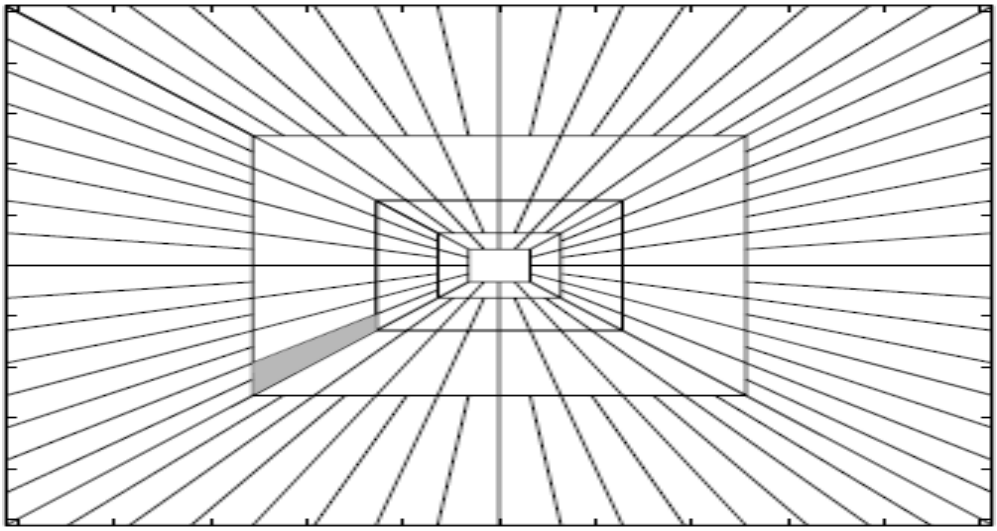

Fig.1-Frequency spectrum coverage of curvelet transform

A.Curvelet Computation

To obtain curvelet coefficient, fourier samples of image 2D image is given as a input in the form of Cartesian array f[m,n] such that 0≤m<M,0≤n<N and generates a number of curvelet coefficients indexed by a scale j , an orientation l and two spatial location parameters (k1 ,k2) as output. To obtain the curvelet texture descriptor, statistical operations are applied to these coefficients. Discrete curvelet coefficients can be defined by [3] suman thesis:

$$C^D(j,l,k_1,k_2) = \sum_{\substack{0\le m<M \\ 0\le n<N}} f(m,n)\, \varphi^D_{j,l,k_1,k_2}[m,n] \qquad (3)$$

Where, $\varphi^D_{j,l,k_1,k_2}[m,n]$ is a digital curvelet transform.

To extract features, using curvelet transform Fast Fourier transformation is applied to the query image and the curvelet. Then the inverse fast fourier transform is applied to the above

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product to get the set of curvelet coefficient.

Each image is decomposed into 4 or 5 levels of scales using curvelet transform. For 4 and 5 levels of decompositions, a total of 26(= 1 +8 +16 +1) and 42(= 1 +8 +16 +16 +1) sub bands of curvelet coefficients are generated. We are interested in homogenous texture because it bears discriminative information for image to image matching. Thus, we calculate mean and standard deviation of the magnitude of the transformed coefficients. The curvelet coefficients of Lena image is shown in fig2. Detail description of such feature extraction process is explained in Sumana et al.[4].

Fig.2 – Log coefficient of Lena Image

III. SHAPE FEATURE EXTRACTION USING WAVELET PCA

More than one feature of the image is needed to increase the efficiency of the retrieving process. In our method shape feature of the image is extracted by applying discrete wavelet transform and Principle component analysis.

A. Discrete Wavelet Transform

Discrete Wavelet Transform (DWT) [5] is the most widely used to transform an image from the spatial domain to frequency domain. By applying DWT the image is decomposed into four bands LL,LH,HL,HH as shown in fig.3.

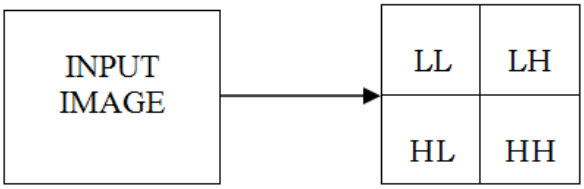

Fig-3 Flow chart of DWT Sub band coding

The sub band LL is the low frequency component, it is the approximate sub image of the original image contains most of the energy, the sub band HL is the component of the low frequency in horizontal direction and the high frequency in vertical direction, it provides the horizontal edge of the original image, the sub band LH is the component of the high frequency in horizontal direction and the low frequency in vertical direction, it manifests the vertical edge of the original image; the sub image HH is the high frequency component, it manifests the oblique edge of the original image. The coefficients of the image obtained from DWT transformation possess some useful characteristics for image retrieval. Usually a two-dimensional discrete wavelet transform can be accomplished in two steps horizontal and vertical operations. In this work, Haar discrete wavelet transform, was used to obtain the image of frequency domain. Figure-4 shows the row and column operations.

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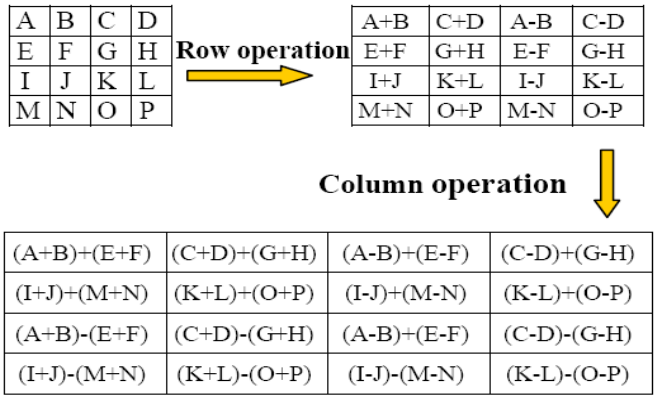

Fig.4 Row and column operation of 2D Haar transform

B. Principle Component Analysis

Principal component analysis is a technique used to represent and retrieve images on the basis of content. Principal component analysis reduces the dimensionality of the search to a basis set of prototype images, that best describes the images[9,10]. Here each image is described by its projection on the basis set; a match to a query image is determined by comparing its projection vector on the basis set with that of the images in the database. Eigen images are computed for a training set of images. These eigen images are ordered and it has the information about the amount of variations among the images.

$$\overrightarrow{u_i}=\sum_{k=1}^{N} v_{ik}\,(\overrightarrow{x_k}-m)$$

Where, $\overrightarrow{u_i}$ represents the Eigen image for training set of images, i=1, 2….N. 'm' is the average image of N training set images. v_{ik} Eigen vectors k=1, 2….N. These Eigen images can be thought of as a set of features that together characterize the variation among the images. The space spanned by the Eigen images is called eigenspace.

$$\overrightarrow{x_k}=\sum_p w_p u_p$$

Each image in the set can then be approximated with a linear combination of these eigenimages. The coefficients wp are the feature description for the image xk, each of which is assigned to a different class k. A new query image, qi, is projected similarly onto the eigen space and the coefficients wq are computed. The class that best describes the query image is determined by a similarity measure defined in terms of the euclidean distance of the coefficients wq and wp (where p = 1, 2 … k for k classes in the training set). The training set image whose coefficients are closest (in the euclidean sense) to that of the query image is selected as the match image. If the minimum euclidean distance exceeds a preset threshold, the query image is assigned to a new class.

IV COLOUR FEATURE EXTRACTION USING COLOUR HISTOGRAM

Colour histogram[8,15] is one of the most widely used method to the colour feature of the image. Since colour is an important feature when the database contains colour images. The algorithm utilized for colour feature extraction is explained here:

Step 1: Select a query image from the database and extract RGB format pixel information.

Step 2: For the query image create 48 bin normalized histograms.

Step 3: Read image from the database and extract RGB format pixel information.

Step 4: Create 48 bin normalized histograms for each of the RGB components of each image

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in the database. Thus, each image have 3 histograms associated with it.

Step 5: By comparing calculate Euclidean distance between the query image histograms and each image in the database.

Step 6: Sort images of the database in the ascending order of Euclidean distance to query image and return the result as an output

V. EUCLIDEAN DISTANCE

Euclidean distance [2] is the technique used to find the similarity between the query image and the images the database based on the features. Then the database images has been sorted out in an ascending order according to Euclidean distance E. The Euclidean distance can be expressed as follows.

$$E(Q, D) = (\sum_{i=1}^{2n} (Q_i - D_i)^2)^{1/2}$$

Where,
$Q = \{Q_1, Q_2, \ldots . Q_{2n}\}$ feature vector of query image.
$D = \{D_1, D_2, \ldots . D_{2n}\}$ feature vector of target image in database.

VI PERFORMANCE EVALUATION

Precision-Recall is the most widely used measurement method to evaluate the accuracy of the retrieval process. Precision P is defined as the ratio of of the number of retrieved relevant images to the total number of retrieved images

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

Recall is defined by R and is defined as the ratio of the number of retrieved relevant images to the total number of relevant images in the whole database.

$$\text{Recall}(R) = \frac{\text{Number of relevant images retrieved}}{\text{Total no of relevant images in the database}}$$

VII EXPERIMENTAL RESULTS AND DISCUSSION

The proposed method is applied to a Corel stock photo database contains 100 images of six different types of group. Each group contains 20 images, in JPEG format of size 384 × 256 and 256 × 386 (i) African people, (ii) buses, (iii) dinosaurs, (vi) elephants, (v) flowers, (vi) horses. The main objective of our proposed method is to create a efficient image retrieval system by extracting low level feature of the image such as texture, shape and color by using technique such as Curvelet transform, discrete wavelet with principle component analysis and color histogram. The efficiency of the proposed method is analyzed by performing image retrieval on six different categories of images in the coral database. The performance of the

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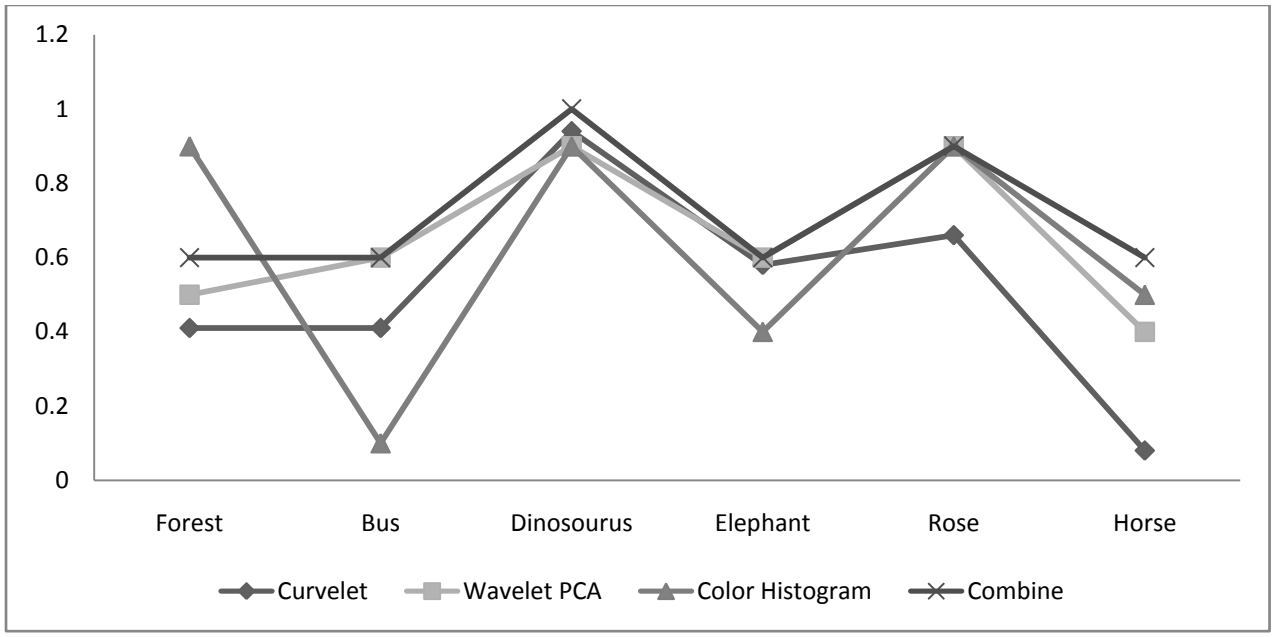
image retrieval process is evaluated using metrics such as precision and recall as mentioned in the previous section.

A. Comparison Table:

Category	Cuvelet	DWT-PCA	Color Histogram	Proposed Method
African People	0.41	0.50	0.90	0.60
Buses	0.41	0.60	0.10	0.60
Dinosaur	0.94	0.90	0.90	1
Elephant	0.58	0.60	0.40	0.60
Flowers	0.66	0.90	0.90	0.90
Horses	0.08	0.40	0.5	0.60
Average Precision/Recall	0.51	0.65	0.61	0.71

C. Precision Graph of all methods:



VIII. CONCLUSION

From the analysis it is shown that the precision of the image retrieval is not only depends on algorithm such as curvelet transform, Wavelet with PCA and colour histogram. it also depends on the types of the images .comparison table shows that the average precision is increased slightly compare to individual methods. In future this method can be applied to larger database and it can also applied for retrieving medical images in medical field. However the improvement needs to be done to decrease the computation time of the image retrieving process.

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