Combining Color and Log Gabor Wavelet Based Feature Detector for Content Based Image Retrieval

R. V. Patil and K. C. Jondhale

Abstract: *Content Based Image Retrieval (CBIR) retrieves the similar type of images from repository of images based on users query. To retrieve similar images, color, texture or shape features need to be extracted from the images and stored in the feature database. The color, texture or shape features of query image are compared with the features of images in the database. This comparison is performed using color, texture or shape distance metrics. We propose here a new CBIR System, which combines color and log Gabor wavelet based feature detector for improving accuracy of CBIR System.*

Keywords: *CBIR; Phase Congruency; Euclidean Distance*

I. INTRODUCTION

CBIR or *Content Based Image Retrieval* is the retrieval similar images from the repository of images based on features such as colour, texture or shape. Traditional methods of image indexing that assign a keyword or number to an image with a categorized description have proved to be insufficient and time consuming. Such system is not CBIR. In CBIR, color, texture or shape features of each image in the database are extracted and compared to the features of the query image [6].

In typical CBIR systems (Fig. 1), features of the images in the database are extracted and stored in the feature database. To retrieve similar set of images, user inputs query image to the retrieval system. The system then extracts feature vector from query image. The similarities between the feature vectors of the query image and those of the images in the database are then calculated using distance metrics and results of the retrieval are presented to the user with the help of an indexing scheme.

CBIR involves two steps. The first step extracts color, texture or shape features. The second step discover similarities between the feature vectors of the query image and those of the images in the database.

CBIR applications are automatic face recognition systems, iris recognition system, used for crime preventions and access privileges. It is also used in a database of medical images to help diagnosis by identifying similar past cases.

II. FEATURE EXTRACTION

The color, texture and shape feature descriptors are mainly used for feature extraction.

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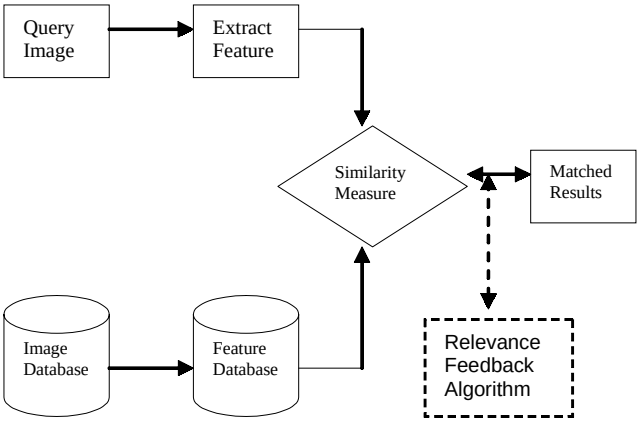

Figure 1: CBIR System

(A) Color Features

Color is significant dimension of human visual perception used to distinguish and recognize visual information. The key method of representing color information of images in CBIR systems is through color histograms.

(B) Texture Features

Texture is property of all surfaces that describes visual patterns, each having properties of homogeneity such as bricks, leaves, fabrics, flowers, etc. It provides information about the structural arrangement of the surface. In short, it is a feature that describes the physical composition of a surface.

(C) Shape Features

Shape can be defined as an outline or contour of an object. It permits an object to be distinguished from its background by its outline. Shape feature representations can be boundary-based or region based.

Boundary-based shape feature uses the outer boundary of the shape. The pixels along the object boundary are considered. Region-based shape feature uses the complete shape region by relating the considered region using its internal characteristics; i.e., the pixels in that region.

III. PHASE CONGRUENCY VIA LOG GABOR WAVELET FILTERS

Phase congruency (Phase based feature detector) is a novel feature detector [2]. It detects edge and step responses. Its

Figure 2: Original Image

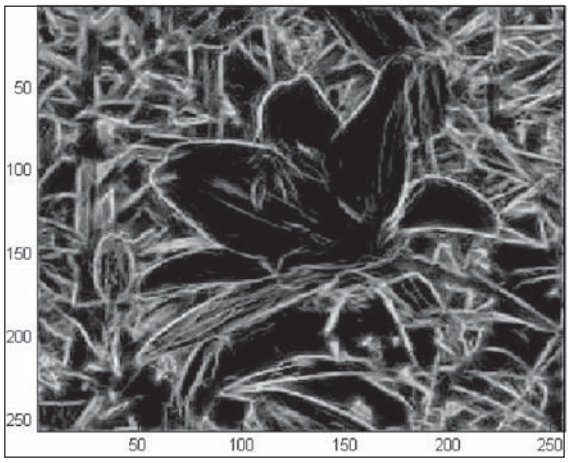

Figure 3: Corresponding Phase Congruency Image

characteristics include invariance to lighting variation within images and invariance to magnification. Local energy model, postulates that features are perceived at point in an image where Fourier components are in phase. Morrone and Owens developed this model [3]. Phase congruency values are high at edge points and at boundary of object. So Phase congruency can be used as a feature detector in CBIR systems for extracting shape information from image.

IV. PHASE CONGRUENCY VIA LOG GABOR WAVELET FILTERS

Peter Kovesi proposed a method to calculate the phase congruency via logarithmic Gabor wavelets [2]. Log Gabor wavelets are used because they can cover large frequency space while still maintaining a zero DC component in the even symmetric filter. Filters are constructed in the frequency domain using a polar co-ordinate system. The filter has two components radial component and angular component. Two components are multiplied to construct the overall filter. To calculate phase congruency image convolution is done with a set of log Gabor wavelets at different orientations and at different scales. 1-D log Gaussians in the radial direction has a transfer function of the form

$$g(w) = e^{\frac{-(\log(w/w))^2}{2(\log(k/w_0))^2}} \tag{1}$$

Where w_0 is the centre frequency of filter. To obtain constant-shape ratio filters the term k/w_0 must also be held constant for varying w_0.

The Gaussian cross-section in the angular direction is defined as

$$G(\theta) = \frac{(\theta - \theta_0)^2}{2\sigma_\theta{}^2} \tag{2}$$

Where θ_o is the orientation angle of the filter, and σ_o is the standard deviation of the Gaussian function in the angular direction. Then at each location in the image, calculate energy *E(x)* in each orientation, subtract the estimated noise effect *To* to eliminate spurious responses to noise, apply the weighting for frequency spread *Wo(x)*, and form the sum over all orientations. This sum of energies is then normalized by dividing by the sum over all orientations and scales of the amplitudes of the individual wavelet responses at that location in the image. This produces the following equation for 2-D phase congruency:

$$E_{no} = A_{no}(x)\Delta\phi_{no}(x) \tag{3}$$

$$PC(x) = \frac{\sum_o \sum_n W_o(x)\lfloor E_{no}(x) - T \rfloor}{\sum_o \sum_n A_{no}(x) + \varepsilon} \tag{4}$$

Where $A_{no}(x)$ is the amplitude of the filter pair at position *x*. o and *n* denote the index over orientation and scale respectively. The phase deviation function is defined as,

$$\Delta\phi_{no}(x) = \cos(\phi_n(x) - \overline{\phi(x)}) - \left|\sin(\phi_n(x) - \overline{\phi(x)}\right| \tag{5}$$

The Compensation of noise T is defined as

$$T = \mu_R + k\sigma_R \tag{6}$$

Where μ_R and S_R are the mean and variance of Rayleigh distribution. The Weighting function is defined as

$$s(x) = \frac{1}{N}\left(\frac{\sum_n A_n(x)}{\varepsilon + A_{\max}(x)}\right) W(x) = \frac{1}{1 + e^{g(c - s(x))}} \tag{7}$$

Where *N* is the number of scales, *Amax(x)* is the amplitude of the filter pair having maximum response at position *x*, *e* is a small constant to avoid division by zero, *c* is the cutoff value of filter response spread below which phase congruency values become penalized.

V. COLOR FEATURE EXTRACTION

One of the most important features that make possible the recognition of images by humans is color. Color is a property that depends on the reflection of light to the eye and the processing of that information in the brain. The main method of representing color information of images in CBIR systems is through color histograms. There are two types of color histograms, Global color histograms and Local color histograms. A GCH represents one whole image with a single color histogram. An LCH divides an image into fixed blocks and takes the color histogram of each of those blocks. LCHs contain more information about an image but are computationally expensive when comparing images. We used Global color histograms in extracting the color features of images. [7]

VI. FEATURE INTEGRATION AND SIMILARITY DISTANCE MEASURE

To retrieve similar set of images, First Phase congruency is used for feature extraction. Euclidean distance is calculated between the phase congruency map of query image and every image in the database. Upon completion of the Euclidean distance algorithm, we have an array of Euclidean distances, which is then sorted.

Results of Phase congruency based comparison are further used to sort images based on color similarity. We use color histograms to represent color features. To find similarity we use quadratic distance metric that helps us to overcome the problem of different color maps.

VII. EXPERIMENTAL RESULTS

To implement our system, we store 1000 images on a computer. MATLAB image processing tools are used to implement system. We have used integrated approach for CBIR. First Phase congruency is used for feature extraction. Euclidean distance measure is used to compare phase features of query image and images in database. Then we use color features to improve the accuracy of system. Experimental results are encouraging.

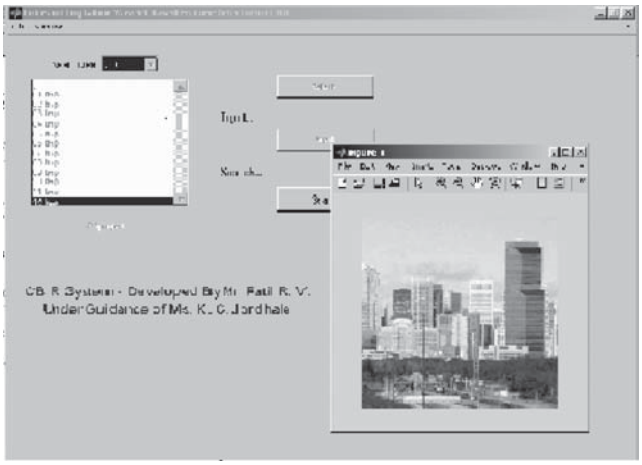

Figure 4: Query Image

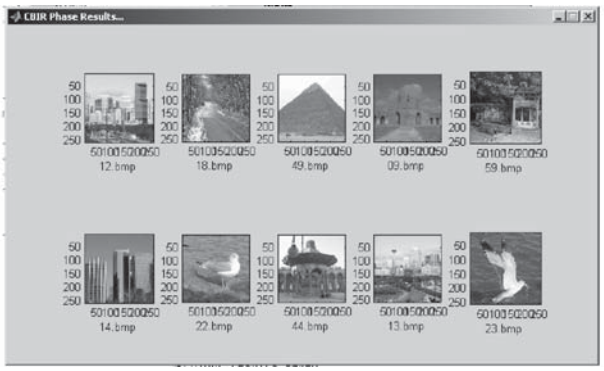

Figure 5: Phase Congruency Based CBIR System Results

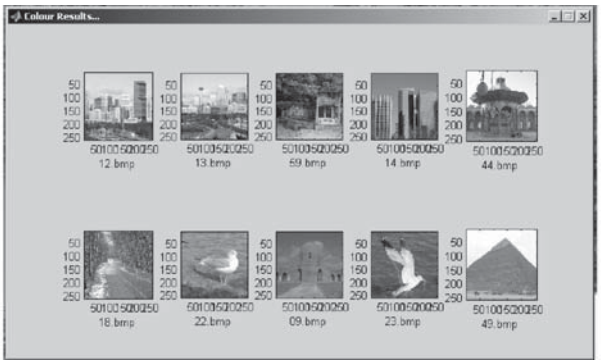

Figure 6: Phase Congruency + Colour Feature Based CBIR System Results

VIII. CONCLUSION

Phase congruency (Phase based feature detector) is low-level feature. It shows great capability in extracting shape information from image. It can be combined with color features to improve the accuracy of CBIR System

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