Orientation-Wavelet Features with Spectral Coding for Pattern Recognition

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Abstract: *In the area of pattern recognition feature descriptors are important parameters to describe image property. In the approach towards feature description, wavelet based feature extraction are dominantly been used to extract texture features. In the approach towards feature extraction based on wavelet transformation, the detail coefficients are taken as the base coefficients and a texture features from these spectral bands are taken for recognition. However in these spectral bands coefficients reveals a directional variation in each plane. In these coefficients large amount of coefficients are not much informative and show similar representation. These coefficients can be extracted and removed so as to minimize computation overhead. To achieve this objective in this paper, a orientation based wavelet transformation approach is proposed to achieve a dimensional reduction in wavelet feature extraction.*

Keywords: Wavelet features, orientation filters, pattern recognition, retrieval accuracy.

1. Introduction

Pattern recognition has evolved as a base need for various applications ranging from general image retrieval to high end applications such as medical image processing, astronomical image processing, distant learning, etc. The system accuracy of such retrieval system is evaluated using the recall rate for estimation. It is in great demand for the estimation accuracy for the automated learning systems. The retrieval accuracy of the system is dependent on the features used in retreivation. Various descriptive features are used for the retrieval of image information from the data base. The most effectively and commonly used feature information's are the textural features and color features used as descriptive information. Various methods were observed in past for the effective retrieval of image information from the given data base. In An automatic recognition requires that the input information be matched with a large number of database information**.** Due to large volume of data information in a database, the memory consumption is observed to be very high. This limits the current system to be used for real time applications where speed of retrieval is mainly required. Hence an effective method should be developed to utilize the memory effectively by representing the image Data in a feature format revealing the most. The images are represented in various formats to represent in which shape, color, and textures are of prime importance. Where representing the data in more features format improves retrieval accuracy, more the representative coefficient the system takes that much time to process in retrieval. The texture information's reveals the content variation in the image and are mostly used feature. To retrieve texture features, wavelet transformations are mostly used due to their capability of representing the multi-resolution information. Wavelet-based coding provides substantial accuracy in representation by the hierarchical decomposition of image into resolution bands. Over the past few years, a variety of powerful and sophisticated wavelet-based schemes [3],[4] for image representation, have been developed and implemented.. to have better representability of image the filters used in

wavelet transforms should have the property of orthogonality, symmetry, short support and higher approximation order. Due to implementation constraints, these scalar wavelets do not satisfy all these properties simultaneously [5],[6]. In addition the distribution of orientation of the wavelet coefficients are more informative and hence need to be coded for finding orientation features. In this paper an approach to extract orientation description based on gabor transformation and orientation field is proposed.

2. Pattern recognition system

Problems with conventional methods of image indexing have led to the rise of interest in techniques for retrieving images on the basis of automatically-derived features such as color, texture and shape – a technology now generally referred to as Content-Based Image Retrieval (CBIR). The problems of image retrieval are becoming widely recognized and the search for solutions is an increasingly active area for research and development. As more digitized images are collected, the number of multimedia computers increases, and networks became more predominant, large on-line databases (collections) of images and video become more popular. Those available resources have created a need for retrieving specific images from the image databases. So developing a user-friendly image retrieval system is more important in current scenario. A lot of research has been carried out on

Content based image retrieval (CBIR) in the past decade. The goal of CBIR systems is to return images that are similar to a query image. Such system characterizes images using low-level perceptual features like color, shape and texture. The overall similarity of a query image with data base images. Due to rapid increase in tremendous amount of digital image collections, various techniques for storing, browsing, retrieving images have been investigate in recent years. The traditional approach to image retrieval is to annotate image by text and then use text based data base

management system to perform image retrieval. There are several drawback of using key words to achieve visual information. The keywords become inadequate for large database and it is difficult to phrase each of the images. To overcome difficulties encountered by a text based image retrieval system, content-based image retrieval (CBIR). In CBIR, the system can discriminate and retrieve images on their visual content such as colors, shape, textures, or the rotation among the objects. There are various existing content-based image retrieval system.

A) QBIC: The QBIC system has developed methods to query large on line libraries using image and video content as the basis of the query. in other words, system allows users to search through data base's consisting of very large numbers of images using sketches, layout or structural description, texture, color and sample images. QBIC techniques serve as data base filters and reduce the search complexity for the user. This technique limit the content feature to those parameters that can be easily extracted, such as color distribution, texture, global shape of an image and layout. System offers a user virtually unlimited set of unanticipated queries thus allowing for general purpose application rather than catering to particular application. Color based and texture based queries are allowed only for the individual objects and layout based queries are allowed only for entire image.

B) Photo-Book: It provides set of tools for browsing and searching image sequences. The features used for querying can be based on both text annotation and image content. The key idea behind the system is semantics preserving image compression, which reduces image to a small set of the perceptually significant coefficients. these feature described the shape and texture of the images in the data base photo book uses multiple image features based for querying general purpose image data bases. These features can be used in any combination with textural features to improve the efficiency and accuracy of the result.

C) Virage: Similar to QBIC supports visual queries based on the arbitrary combination of the color, texture and object boundary information. The user can adjust weights associated with the automatic features according to their own emphasis.
In all these approaches feature extraction plays an important role. The color and shape descriptor are yet developed via R,G,B plane coding or via shape tracing approach. However, in the process of texture feature descriptor, wavelet based coding has emerged in recent past. Due to the nature of multi resolution coding this coding, finds its application now in various real time Retrieval system.

3. Wavelet feature extraction

The recognition approach suggested is provided with the frequency spectrum information, for the estimation of resolution features description of the give image in pattern recognition. For the evaluation of the spectral information in this work db4 wavelet transformation approach is used. Wavelet transformation basically decomposes the given image into it's fundamental resolution and from the extracted spectral coefficient the resolution mean variation could be

predicted and treated as feature information for recognition. In this paper a db4 Wavelet transformation is applied on the image data for extraction of features for training the data and testing for recognition. The DWT architecture developed split the image spectrum in two (equal) parts, a low pass and a high-pass part. The high-pass part contains the smallest details that are interested in and could stop here. However, the low-pass part still contains some details and therefore it can be split again. And again, until a satisfactory number of bands are have created. In this way an iterated filter bank can be created.
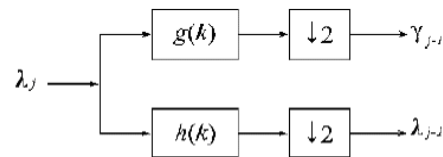

Figure 1: Implementation of one stage iterated filter banks

Usually the number of bands is limited by for instance the amount of data or computation power available. The process of splitting the spectrum is shown in figure 1. The advantage of this scheme is to design only two filters whereas the disadvantage is; only image spectrum coverage is fixed. Wavelet transform is capable of providing the time and frequency information simultaneously. Hence it gives a time-frequency representation of the signal. When one is interested in knowing what spectral component exists at any given instant of time, to know the particular spectral component at that instant. In these cases it may be very beneficial to know the time intervals these particular spectral components occur. Wavelets (small waves) are functions defined over a finite interval and having an average value of zero. The basic idea of the wavelet transform is to represent any arbitrary function f(t) as a superposition of a set of such wavelets or basis functions. These basis functions are obtained from a single wave, by dilations or contractions (scaling) and translations (shifts). wavelet has two functions "wavelet "and "scaling function". They are such that there are half the frequencies between them. They act like a low pass filter and a high pass filter. Figure 2-6 shows a typical decomposition scheme. The decomposition of the signal into different frequency bands is simply obtained by successive high pass and low pass filtering of the time domain signal. This filter pair is called the analysis filter pair. First, the low pass filter is applied for each row of data, thereby getting the low frequency components of the row. But since the low pass filter is a half band filter, the output data contains frequencies only in the first half of the original frequency range. By Shannon's Sampling Theorem, they can be sub-sampled by two, so that the output data now contains only half the original number of samples. Now, the high 8 pass filter is applied for the same row of data, and similarly the high pass

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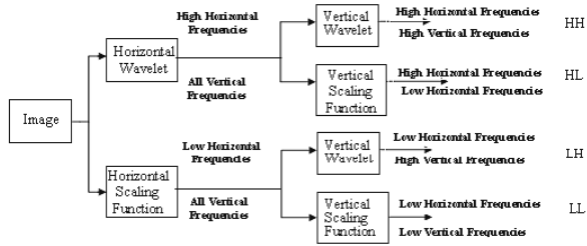
144

components are separated.

Figure 2: Pyramidal Decomposition of an image

This is a non-uniform band splitting method that decomposes the lower frequency part into narrower bands and the high-pass output at each level is left without any further decomposition. This procedure is done for all rows. Next, the filtering is done for each column of the intermediate data. The resulting two-dimensional array of coefficients contains four bands of data, each labeled as LL (low-low), HL (high-low), LH (low-high) and HH (high-high). These resolution features are averaged over the mean to process the query image for recognition. For a given query image

(a)   (b)

Figure 3: (a) Original Image, (b) multi scaled image using db4 wavelet coefficient

A K-level 2D-Discrete Wavelet Transform (DWT) is applied. The Daubechies-4 wavelet bases were used due to their orthonormal properties, which are important for the preservation of the textural structure along the different scales of the transform. This transform results in a new representation of the original window, which consists of $B=3_{K+1}$ sub-windows, corresponding to different wavelet bands. Each band is denoted as $B_j(k)$, where k is the current level of the transform and $j = 0, 1, 2, 3$ for $k = K$, or $j = 1, 2, 3$ for $k < K$. $B_0(k)$ corresponds to the low frequency band. These bands have various textural features which have a effect of orientation over different direction. Hence rather to considering the wavelets bands features, in this orientation filters are used for feature extraction.

4. Gabor orientation Feature

Gabor filters have been presented in several works on image processing [7], [8], [9]; however, most of these works are related to segmentation and analysis of texture. Rolston and Rangayyan [10], [11] proposed methods for directional decomposition and analysis of linear components in images using multiresolution Gabor filters. Multiresolution analysis by using Gabor filters has natural and desirable properties for analysis of directional information in images; most of these properties are based upon biological vision studies as described previously. Other multiresolution techniques have also been used with success in addressing related topics such as texture analysis and segmentation and image enhancement. Chang and Kuo [12], for instance, developed a new method for texture classification which uses a tree-

structured wavelet transform for decomposing an image. In their work, image decomposition is performed by taking into account the energy of each sub image instead of decomposing sub signals in the low-frequency channels. If the energy of a sub image is higher than a certain fixed threshold value, then the decomposition procedure is applied again; else, the decomposition is stopped in that region. Different tree structures are used which are highly depends upon the value of the threshold. A 2-D Gabor function is a Gaussian modulated by a complex sinusoid. It can be specified by the frequency of the sinusoid and the standard deviations and of the Gaussian envelope.

$$\psi(x,y) = \frac{1}{2\pi\sigma_x\sigma_y} \exp\left[-\frac{1}{2}\left(\frac{x^2}{\sigma_x^2} + \frac{y^2}{\sigma_y^2}\right) + 2\pi jWx\right]$$

Gabor wavelet represents a bank of Gabor filters normalized to have dc responses equal to zero and designed in order to have low redundancy in the representation. are obtained by dilation and rotation of $\psi(x,y)$ as in (1) by using the generating function

$$\psi_{m,n}(x,y) = a^{-m}\psi(x',y'), \quad a > 1, \quad m,n = \text{integers}$$
$$x' = a^{-m}[(x - x_0)\cos\theta + (y - y_0)\sin\theta]$$
$$y' = a^{-m}[-(x - x_0)\sin\theta + (y - y_0)\cos\theta]$$

Where (x_0, y_0) center of the filter in the spatial domain; $\theta = n\pi/K$ total number of orientations desired; and scale and orientation, respectively. The scale factor in (2) is meant to ensure that the energy is independent. Gabor wavelets in the frequency domain is defined as,

$$\Psi(u,v) = \frac{1}{2\pi\sigma_u\sigma_v} \exp\left\{-\frac{1}{2}\left[\frac{(u-W)^2}{\sigma_u^2} + \frac{v^2}{\sigma_v^2}\right]\right\}$$

The design strategy used is to project the filters so as to ensure that the half-peak magnitude supports of the filter responses in the frequency spectrum for the high varying regions than low varying regions in each spectral band. Each spectral band obtained from the wavelet process is applied with the gabor filter, and by doing this, it is ensured that the filters will capture the maximum information with minimum redundancy in each direction. The obtained output for the gabor filter at different orientation reveals the orientation in one particular direction. Taking these orientations as feature vectors a recognition system is evaluated.

5. Experimental results

The proposed system is tested for different test sample at different orientations, and it is observed to have classification rate in the range of 80-100%. Multiple instance of same class are recognized with 80% accuracy, because multiple instance of same class have close resemblance to each other. The accuracy of the developed system is defined by,

Percentage of accuracy = (No. Of correctly recognized samples/Total No of samples in the test suite)*100.

Eight orientation features were used obtained from the gabor transformation of the wavelet sub bands and the results of the classification process obtained is as illustrated below.
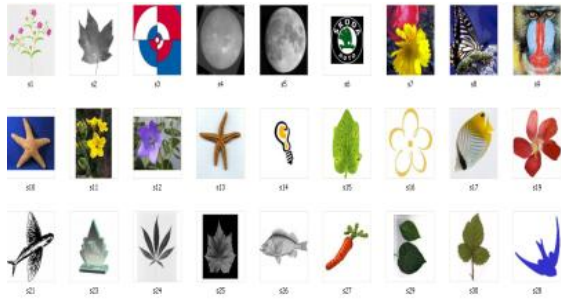
Figure 4: A randomly collected database images for testing

A sample query passed with a orientation of 90^0 orientation, and the result is shown in fig 5.

Figure 5: query sample at 90^0 orientation

Classified samples for the given sample query is as shown below in fig 6,

Figure 6: Top 5 classified observations obtained from the database for the given query sample at 90^0 orientation.

Figure 7: query sample at $+33^0$ orientation

Classified samples for the passed query sample is as shown below in fig 8.

Figure 8: Top 5 classified observations obtained from the database for the given query sample at $+33^0$orientation.

Figure 9: query sample at -33^0 orientation

Classified samples for the passed query sample is as shown below in fig 10,

Figure 10: Top 5 classified observations obtained from the database for the given query sample at -33^0 orientation.

Figure 11: query sample at -270^0 orientation

Classified samples for the passed query sample is as shown below in fig 12,

Figure 12: Top 5 classified observations obtained from the database for the given query sample at -270^0 orientation.

Table 1: Classification result of the developed test system

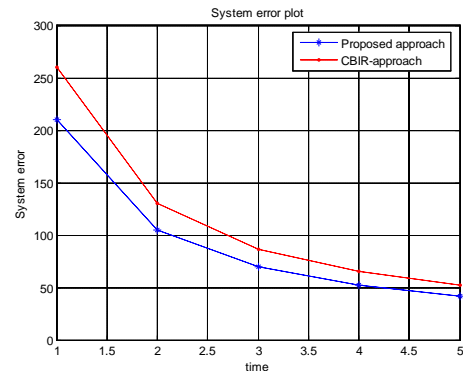| Training samples	percentage accuracy (%)	Remark
150	100	Available test set in DB
150	66	With DWT spectral features
150	80	With DWT + Gabor orientation features

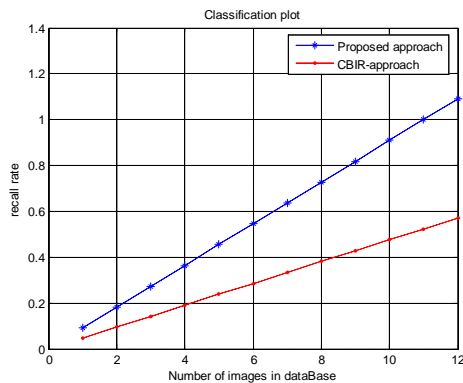**Figure 13:** Classification error with number of processing recursion

Figure 14: System recall rate obtained for the developed approach

6. Conclusion

In this paper a orientation based feature descriptor for pattern recognition system is developed. In the proposed approach the developed system is processed with wavelet sub band and the orientation features for each sub band is considered. This approach extracts the feature based on the nature of information of orientation feature variation in DWT sub band coefficients. The approach achieves about 20% of retrieval accuracy improvement in comparison to DWT based retrieval system.

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