Gabor Wavelet Transform And Co-occurrence Matrix Based Texture Features For CBIR

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Abstract —**For any given image, texture analysis done by using Gabor wavelet transform and co-occurrence matrix method. Textural features are extracted with the help of content-based image retrieval system. The Objective project research is to examine how the most similar texture images can be retrieved automatically for the given query image. So by categorizing images into one of the classes the search can be restricted to only a particular class to which the query image belongs to. Textural retrieval will be done on different images. Results are compared from both the methods Gabor wavelet transform and co-occurrence matrix method using different images.**

Keywords: Texture feature extraction, multiscale, sub-image matching, content-based retrieval, wavelet transform.

1. Introduction

Content-based image retrieval [CBIR], a technique which uses visual contents to Search images from large scale image databases according to user's interests, has been an active and fast advancing research area since the 1990s. During the past decade, remarkable progress has been made in both theoretical research and system development. However, there remain many challenging research problems that continue to attract researchers from multiple disciplines.

Text-based image retrieval uses traditional database techniques to manage images. According to text descriptions, images can be organized by topical or semantic hierarchies to facilitate easy navigation and browsing based on standard Boolean queries. Content-based image retrieval uses the visual contents of an image such as color, shape, texture, and spatial layout to represent and index the image.

1.1 Formulation of the problem and methodology

1.2.1 Formulation of the problem

1 To examine how the most similar texture images can be retrieved automatically for the given query image.
2 The retrieval is based on the features extracted from the gray level occurrence matrix, which is well known method for analyzing texture images.

1.2.2 The methodology that will be used here using Gabor wavelet transform is:

1. The decomposition of the image into a mathematically represented signal using wavelet transforms functions.
2. The analysis of the wavelet transforms to retrieve image information; texture in recognizable format.
3. Remove redundancy.
4. Matching the recognized features with those stored in the database.
5. Creating graphical user interface for the system.

1.2.3 The methodology that will be used here using Co-occurrence matrix method is:

1. First find co-occurrence matrix from a given image.
2. There are 14 statistical measures are given by Haralick. These are the measures of texture can be extracted from the matrix into a feature vector. Out of them 4 are considered here: - Energy, Entropy, Contrast, and Homogeneity. These values are calculated
3. Feature vector is stored.
4. Matching is done with the stored database similar images with query image are shown.

2. DESCRIPTION

2.1 Theoretical Issues

Texture is a very general notion that can be attributed to almost everything in nature. For a human, the texture relates mostly to a specific, spatially repetitive (micro) structure of surfaces formed by repeating a particular element or several elements in different relative spatial positions .Generally, the repetition involves local variations of scale, orientation, or other geometric and optical features v of the elements. The texture features describe local arrangements of images signals in the spatial domain or the domain of Fourier or other spectral transforms. Image textures defined as images of natural textured surfaces and artificially created visual patterns which approach, within certain limits, these natural objects.

Haralick has proposed 14 statistical features to be extracted. In this paper 4 relevant features are used.

1. Energy
2. Entropy
3. Contrast
4. Homogeneity

CBIR has two major parts:

Feature extraction: - where set of features is generated to represent the content of each image in database.

Similarity measurement:-where a distance between query image and each image in database is computed.

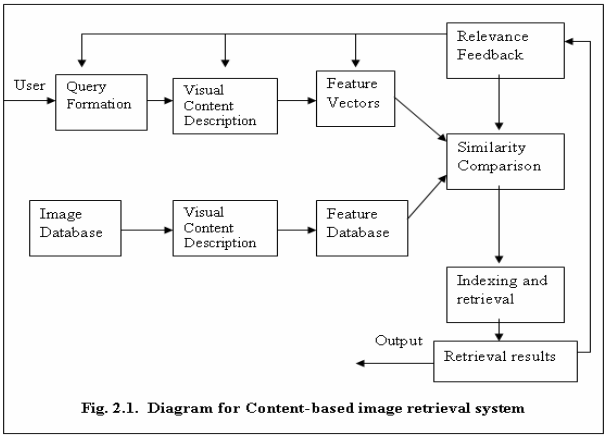


Fig. 2.1. Diagram for Content-based image retrieval system

One great example of how CBIR has worked is its use in medical databases. Before images of medical cases where retrieved by looking through massive medical catalogues. With CBIR retrieving the correct images fro a specific case takes seconds. An image of a lung covered with tumors can be input as a query and then by taking features such as the color and shape of the tumor and the organ that it is infecting many images can be retrieved in seconds of previous cases that are identical. Figure 2.1 is showing the conceptual framework for CBIR.

Actually texture analysis includes

- Texture classification,
- Texture segmentation, and
- Texture synthesis.

Texture Classification deals with the recognition of image regions using texture properties. Each region in an image is assigned a texture class.

Texture segmentation deals with detecting the texture boundaries in an image to obtain a boundary map.

The goal of texture synthesis is to extract three-dimensional information from texture properties. An original approach to texture-based classification regions, for image indexing and retrieval, is presented. Texture is a description of the spatial arrangement of color or intensities in an image or a selected region of an image.

The method of texture analysis chosen for feature extraction is critical to the success of the texture classification. Metric used in the comparing the feature vector is also critical. Many methods have been proposed to extract texture features .Here we are going to discuss the Gabor Wavelet transform and Co-occurrence matrix method.

2.1 Design Considerations:

2.1.1Using Gabor wavelet transforms

Basically Gabor filters are a group of wavelets, with each wavelet capturing energy at specific frequency and a specific direction.

Expanding a signal using this basis provides a localized frequency description, therefore capturing local features/energy of the signal .texture features can then be extracted from, this group of energy distributions. The scale (frequency) and orientation tunable property of Gabor filter makes it especially useful for textural analysis. A two dimensional Gabor function and its Fourier transform can be written as:

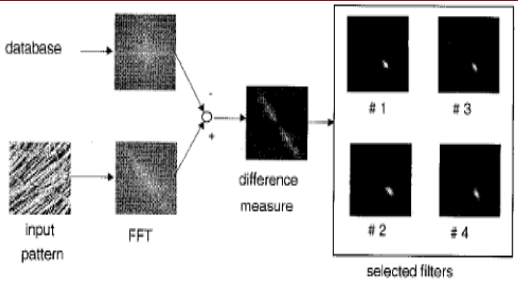


Fig 2.2 Filter selection strategy

$$g(x,y) = \left(\frac{1}{2\pi\sigma_x\sigma_y}\right)\exp\left[-\frac{1}{2}\left(\frac{x^2}{\sigma_x^2}+\frac{y^2}{\sigma_y^2}\right)+2\pi jWx\right] \quad (2.1)$$

$$G(u,v) = \exp\left\{-\frac{1}{2}\left[\frac{(u-W)^2}{\sigma_u^2}+\frac{v^2}{\sigma_v^2}\right]\right\} \quad (2.2)$$

Where $\sigma_u = ½\,\pi\,\sigma_x$ and $\sigma v = ½\,\pi\,\sigma_y$.

Gabor functions complete but nonorthogonal basis set. Expanding a signal using this basis provides a localized frequency description. A class of self-similar functions, referred to as Gabor wavelets is considered. Let $g(x,y)$ be mother Gabor wavelet, then this self-similar filter dictionary can be obtained by appropriate dilations and rotations of $g(x,y)$ through the generating function

For this method first scale and orientation values are considered. And maximum and minimum frequency is decided.

$$D(m,n) = \sum_x \sum_y |g_{mn}(x,y)| \quad (2.3)$$

$$m = 0,1,\ldots M-1; n = 0,1,\ldots N-1$$

These magnitudes represent the energy content at different scale and orientation of the image.

$$\text{Mean } \mu_{mn} = \frac{D(m,n)}{P\times Q} \quad (2.4)$$

$$\text{Variance } \sigma_{mn} = \frac{\sqrt{\sum_x \sum_y (G_{mn}(x,y) - \mu_{mn})^2}}{P\times Q} \quad (2.5)$$

After that different filters are selected. Here input pattern has string orientation preference which distinguishes the pattern from much of the database images. Filter selection strategy where different number of filter are used can be given as

$$\text{Feature vector f} = (\mu_{00}, \sigma_{00} \ldots\ldots\ldots \mu_{mn}, \sigma_{mn}) \quad (2.6)$$

Where the subscript represents the scale(0,…3) and orientation (0,….5). The feature vector dimension is [Scale * Orientation * 2] 48.

One query image is taken. And it is compared with all other images stored in the database. Euclidean distance is calculated between query image and image stored in Image database. All distances are sorted in increasing order. Depending upon all classes images are distributed each class will have 16 images. Finally Retrieval accuracy is calculated.

2.1.2 Using co-occurrence matrix method

Co-occurrence matrix is also called statistical approach. This method isconsidering the distribution of gray levels and their interrelationship. The pixel values are used to construct numerical structures which are associated to the texture pattern of an image. This pattern is based mainly on the inter-relationship between one pixel and its neighbors. In this matrix, the indexes of rows and columns represent the given range of the image gray levels, the value P(i ,j) stored at the position (i ,j) is the frequency that gray levels i and j occurs with, at a given distance and at a given direction.

There are 14 statistical measures are given by Haralick. These are the measures of texture can be extracted from the matrix into a feature vector. Out of them 4 are considered here: - Energy, Entropy, Contrast, and Homogeneity.

Formulae for measures of texture are given in Table 2.1.

Table 2.1

Features extracted from gray level co-occurrence matrix

Energy	$\sum_{i,j} p(i,j)^2$
Entropy	$-p(i,j)^* \log_{10} p(i,j)$
Contrast	$\sum_{i,j} \lvert i-j \rvert^2 p(i,j)$
Homogeneity	$\sum_{i,j} \frac{p(i,j)}{1+\lvert i-j \rvert}$

2.3.3 Combination of Gabor wavelet transforms and co-occurrence matrix Method

In this Feature vectors calculated by Gabor wavelet transform and the feature vectors calculated by co-occurrence matrix method are stored. Then the combination of both feature data is taken. Euclidean distance is calculated between query image and image stored in image database. Distance is sorted in increasing order. Retrieval accuracy is calculated by using both methods. And one query image is given and images which are matched with this query image are found out.

At last we have to calculate Retrieval accuracy.

3. TEXTURE IMAGE DATABASE

The texture database used in the project consists of 116 different textures classes. Each of the 512 X 512 images is divided into sixteen 128 X 128 no overlapping sub images, thus creating a database of 1856 texture images. A query pattern in the following is any one of 1856 patterns in the database. This pattern is then processed to compute the feature vector. The distance d(i,j), where I is the query pattern and j is a pattern from the database, is computed. The distances are then sorted in increasing order and the closest sets of patterns are then retrieved. In the ideal case all the top 15 retrievals are from the same large database. The performance is measured in the terms of the average retrieval rate which is defined as the average percentage number of patterns belonging to same image as the query pattern in the top 15 matches. I have taken the database of 40 classes. The images for different classes are shown in figure 4.1

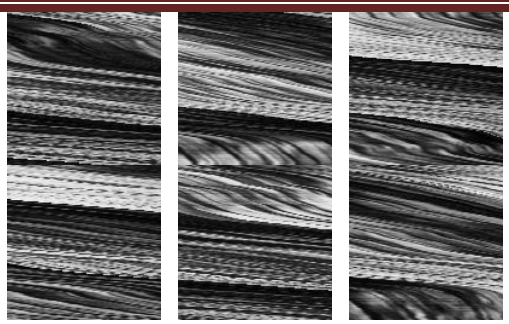


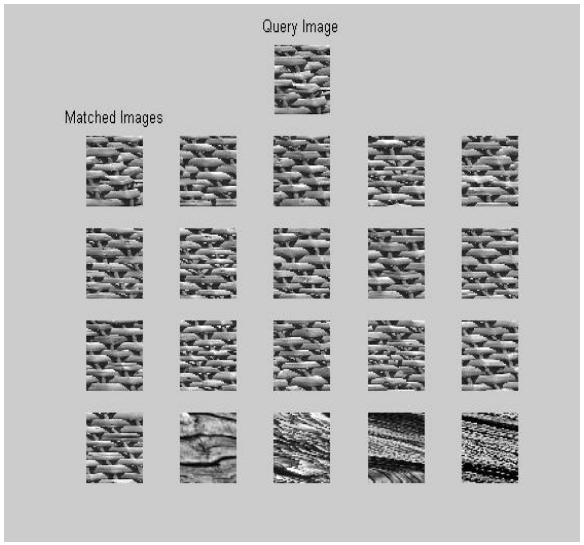
Fig.4.1 Image Database for class 1

4. RESULTS AND DISSCUSSION

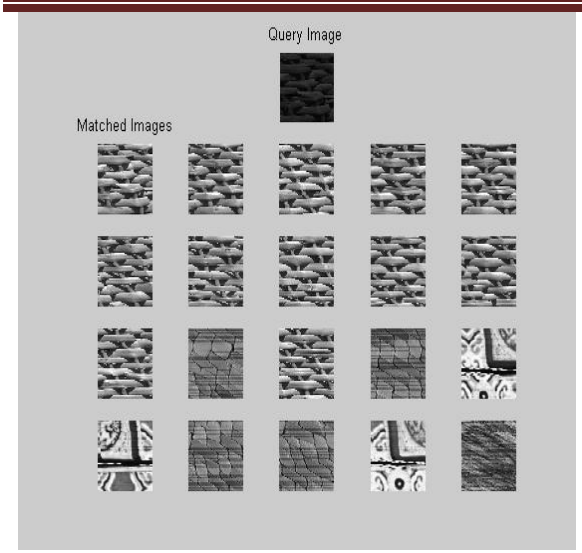
Results obtained are discussed by applying, Gabor wavelet transform method, Co-occurrence matrix method and combination of these both methods. We have considered the first 20 matched images with the query image. The results can have any number of matched images by using threshold values.

4.1 Results of the query image and matched images.

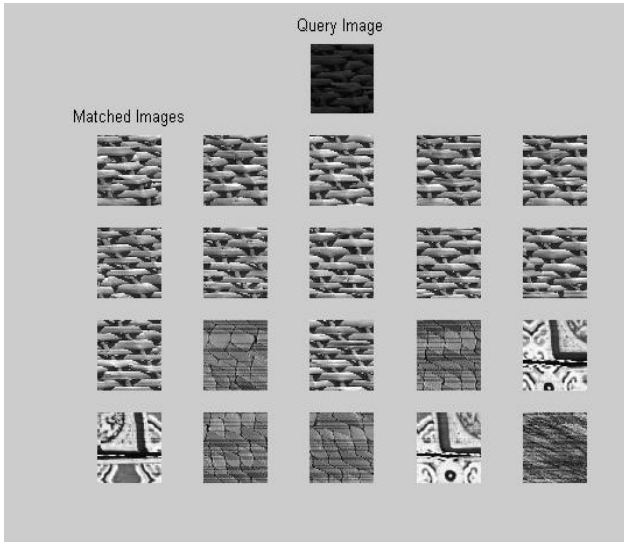
The Query image no. is 220. And the matched results are shown in figure 4.1(a),(b),and (c) by using all three methods. By Gabor wavelet transform we are getting best results. The total matched images are 16. By co-occurrence matrix method and combination of both methods the matched images are 11.



4.1 (a) By Gabor wavelet transforms method



4.1 (b) Co-occurrence matrix method



4.1 (c) By combination of both methods

4.2 Class-wise Retrieval accuracy.

Class-wise retrieval accuracy given by Gabor wavelet transforms method, Co-occurrence matrix method and combination of both methods is as shown in Table 4.1

Table 4.1

Class	Retrieval Accuracy		
	Gabor wavelet transforms method	**co-occurrence matrix method**	**combination of both methods**
C1	61.719	66.406	66.406
C2	47.656	67.578	67.578
C3	43.359	23.047	23.047
C4	48.047	23.828	23.828
C5	93.359	74.609	74.609
C6	48.438	76.563	76.563
C7	60.938	38.281	38.281
C8	76.563	69.922	69.922
C9	85.156	90.625	90.625
C10	54.688	28.906	28.906

4.3 Comparison of three methods:

Here we have compare all methods with respect to calculate feature extraction time, feature vector length, mean retrieval accuracy.

Table 4.2

	Gabor Wavelet Transform method	**Co-occurrence matrix method**	**Combination of both methods**
Feature Extraction Time	0.08sec	0.05 sec	0.09 sec
feature Vector Length	Z=1 X 48	Z=1 X 16	Z=1 X 64
Mean retrieval accuracy	70.1660	58.5254	58.5254

4.4 Conclusion and future work

- This project is intended to retrieve images by using Gabor wavelet transform method and co-occurrence matrix method. Also results are calculated by using combination of both methods.
- It has been observed that results obtained by Gabor wavelet transform are better than co-occurrence matrix method.
- The results have been obtained using Euclidean distance for matching purpose .The same can be calculated by other means also.

- Instead of taking first 20 images as the matched images we can put some threshold and see the exact matched images.

5. REFERENCES

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