

Design Approach for Content-Based Image Retrieval Using Gabor-Zernike Features

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ABSTRACT

Features from an image is known as Content-based Image Retrieval. Color, Texture and Shape are the major features of an image and play a vital role in the representation of an image..In this paper, a novel method is proposed to extract the region of interest(ROI) from an image,prior to extraction of salient features of an image.The image is subjected to normalization so that the noise components due t

The process of extraction of different o Gaussian or other types of noises which are present in the image are eliminated and the successful extraction of various features of an image can be accomplished. Gabor Filters are used to extract the texture feature from an image whereas Zernike Moments can be used to extract the shape feature.The combination of Gabor feature and Zernike feature can be combined to extract Gabor-Zernike Features from an image.

Keywords: CBIR, GABOR Filter, ZERNIKE Moments, feature extraction, texture, shape.

INTRODUCTION

Digital images are increasing very quickly because of developing techniques of multimedia and information, communications network. The information contained in an image is one of the prime components of human progress in various domain.Many techniques are suggested by different scientists in order to retrieve the information or data contained in the image. The semantic relevance of the query image and the retrieved images is one of the prime factor in the design of an CBIR system.The visual content eg. Color, texture and shape is one of the key feature in the design of an content-based Image Retrieval system.The objective of this paper is to study the use of texture and shape as an image feature for retrieval of an image.

Texture contains important information about the structural arrangement of surfaces and their relationship to the surrounding environment. Many techniques like multiresolution filtering and color correlogram has been proposed by many scientists in the literature.The systems Walrus[2] and WIndsurf [3] both uses region features extracted from wavelet transform while Walrus uses Birsch segmentation to obtain regions. Windsurf uses K-means. In this paper, an image is filtered with a set of Gabor Filters of different preferred orientations and special frequencies and the features obtained from a feature vector is used for image retrieval.

Shape is one of the fundamental visual features in the Content-based Image Retrieval (CBIR)paradigm. Numerous shape descriptors have been proposed to describe the shape as an important aspect in the field of content-based image retrieval.There are two main categories of shape descriptors:

CONTOUR BASED SHAPE DESCRIPTORS

Region based Shape descriptors

Contour based shape descriptors use the boundary information ignoring the shape interior content while the region based shape descriptors exploit interior pixels of the shape.For CBIR purpose,a shape descriptor should be affine invariant, robust, compact and easy to derive and match.In this paper,complex ZernikeMoments of sufficiently higher order is used to extract the shape feature from an image.To combine both texrure and shape information into consideration for the purpose of retrieval of image, a set of Gabor Filters is used to extract texture feature whereas Zernike Moments are used to extract shape features.

Extraction of Features

The extraction of different features is one of the major stages in designing a reliable image retrieval system. The features of an image can be broadly classified into global shape features like texture, shape histogram, color histogram, moments etc.

Extraction of Texture:

Texture, a global shape feature could be used to associate related shapes. The successful combination of Gabor Filters and Zernike Moments is to produce a set of features suitable for texture and shape.

Gabor Filters (GF):

The extraction of texture of an image is accomplished by using a set of Gabor Filters. GABOR Filters are a group of wavelets capturing energy at a specific frequency and a specific direction. The expansion of a signal using this basis provides a localized frequency description, therefore, capturing local features/energy of the signal. Texture features can thus be extracted from this group of energy distributions.

A 2D Gabor function $g(x,y)$ and its Fourier transform $G(u,v)$ are defined as follows;

$$G(x,y) = (1/2\pi\sigma_x\sigma_y) \exp[-1/2(x^2/\sigma_x^2 + y^2/\sigma_y^2) + 2\pi jWx] \quad \text{Eq.(1)}$$

$$G(u,v) = \exp\{-1/2[(u-W)^2/\sigma_u^2 + v^2/\sigma_v^2]\} \quad \text{Eq.(2)}$$

Where $\sigma_u = 1/2\pi\sigma_x$ and $\sigma_v = 1/2\pi\sigma_y$

A set of self-similar functions can be generated from dilation and rotation of the Gabor function $g(x,y)$

$$G_{mn}(x,y) = a^{-m} G(x',y') \quad \text{Eq.(3)}$$

Where $a > 1$:

$x' = a^{-m}(x \cos \theta + y \sin \theta)$ and $y' = a^{-m}(-x \sin \theta + y \cos \theta)$;

$\theta = n\pi/N$; m and n specify the scale and orientation of wavelet respectively with $m=0,1,\dots,M-1$ and $n=0,1,\dots,N-1$

M is the number of scales and N is the number of orientations.

For a given image $I(x,y)$, the discrete GABOR wavelet transform is given by a convolution $W_{mn} = \sum I(x_1,y_1) g_{mn}^*(x-x_1, y-y_1) \dots \dots 4$ where $*$ indicates complex conjugate.

Texture feature representation

Applying GF with different orientation and different scale on an image $I(x,y)$ with size $P \times Q$, we obtain a set of magnitudes

$$E(m,n) = \sum \sum |W_{mn}(x,y)| \quad \text{Eq.(4)}$$

The standard deviation σ_{mn} of the magnitude of the transformed coefficients is:

$$\sigma_{mn} = \sqrt{\sum \sum (|W_{mn}(x,y)|) / P \times Q} \quad \text{Eq.(5)}$$

Where $\mu_{mn} = E(m,n) / P \times Q$, is the mean of the magnitude .

The Gabor feature vector is given by:

$$F = [\sigma_{00}, \sigma_{01}, \dots, \sigma_{(M-1)(N-1)}] \quad \text{Eq.(6)}$$

This feature vector is normalized to [0,1] range by z-score normalization..

$F_{Gabor} = (f - \mu) / \sigma$; where μ is the mean and σ is the standard deviation of f .

The similarity between two features indexed with Gabor feature vectors is the Euclidean distance between the two Gabor feature vectors. Shape feature extractors describe the general topological and statistical gray level distribution. Zernike Moments are one of the most popular shape descriptors.

Zernike Moments:

ZERNIKE Moments have many desirable properties such as rotation invariance, robustness to noise, expression efficiency .The complex ZM are derived from Zernike polynomials which are a set of complex orthogonal polynomials defined over the interior of a unit circle $x^2 + y^2 = 1$.

$$V_{mn}(x,y) = V_{mn}(\rho,\theta) = R_{mn}(\rho) \exp(jm\theta) \quad \text{Eq.(7)}$$

$$R_{mn}(\rho) = \sum (-1)^s \frac{(n-s)!}{s!(n-|m|/2-s)!(n-|m|/2-s)!} \rho^{n-2s} \quad \text{Eq.(8)}$$

Where n is a non-negative integer, m is an integer such that $n-|m|$ is even and $|m| < n$, and $\theta = \tan^{-1}(y/x)$.

The projection of the image function onto a basis set, gives the Zernike Moments of order n with repetition m as :

$$A_{mn} = (n+1) / \pi \sum \sum f(x,y) V_{mn}(x,y), x^2 + y^2 < 1 \quad \text{Eq.(9)}$$

It has been shown that the ZM on a rotated image have the same magnitudes. So, $|A_{mn}|$ can be used as a rotation invariant feature of the image function. $|A_{mn}|$ is a special case of Radial Zernike Moments.

2.2.2 Shape feature representation:

ZM is not scale invariant or translation invariant. The normalization of an image is done by using the Cartesian moments before calculation of ZERNIKE Moments in order to achieve the scale invariance and translation invariance. ZM is rotation invariant. Therefore we use $|A_{mn}|$ as a feature set for image retrieval. The ZM feature vector with moment order n and repetition m is given by:

$$f = [|A_{00}|, |A_{01}|, \dots, |A_{(n-1)(m-1)}|]$$

This feature vector is normalized to $[0,1]$ range by z-score normalization .

$F_{Zernike} = \frac{f - \mu}{\sigma}$, where μ is the mean and σ is the standard deviation of f .

The similarity between two shapes indexed with ZM descriptors is the Euclidean distance between the two ZM normalized feature vectors.

Gabor-Zernike feature for extraction of both texture and shape:

The Gabor-Zernike feature vector is obtained by combining both the Gabor feature and Zernike feature vectors as follows:

Normalize the Gabor feature and Zernike feature respectively by the process of z-score normalization.

The Gabor-Zernike feature is given by:

$$F_{\text{Gabor-Zernike}} = \{F_{\text{gabor}}\} \cup \{f_{\text{Zernike}}\}$$

RETRIEVAL EXPERIMENTS

A set of experiments have been carried out to test the capacity of both Gabor Filters and Zernike Moments in order to retrieve texture and shape in our database.

Parameter Selection:

A collection of images of the JPEG category was done in order to create the image database used in our experiments. Ten images of four different classes of images each were chosen in order to extract the texture feature and shape feature respectively with the help of Gabor Filters and Zernike Moments respectively. The number of scales (n) and the number of orientations (m) play a vital role in the process of extraction of various image features. Three scales and eight orientations are used to capture the edge and texture features of an image. Using the above parameters, we get a 9-dimensional texture feature for each image.

Moment order (n) and repetition (m) are the important parameters in calculating the shape feature from an image. With higher order, ZM carries more fine details of an image but becomes more susceptible to noise. In our experiments, moment order (n_0) of sufficiently higher order is used to extract shape feature from an image. Thus, we get a 4-dimensional shape feature for each image.

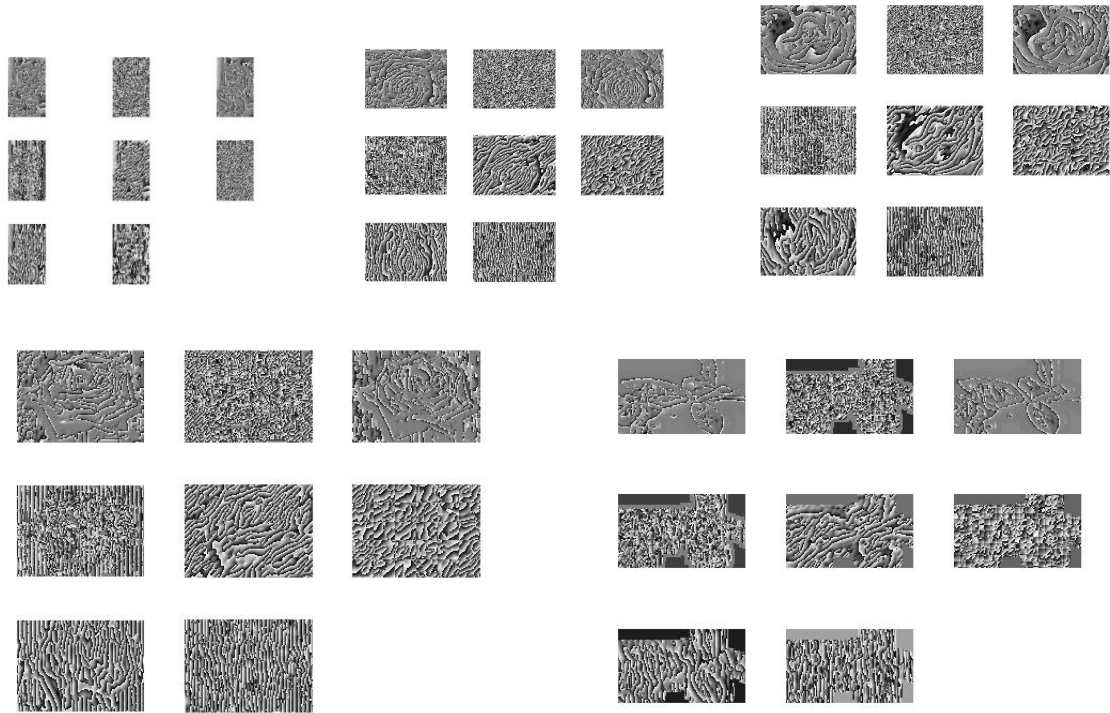
Retrieval Rate

In our experiments, all images in the database were converted from RGB to grayscale and were resized to 128×128 pixels. After performing some of the pre-processing steps like contrast and illumination equalization, histogram equalization, the images are rotated, translated, scaled and cropped to the desired size after balancing the computational complexity of an image. Each image in the database is chosen as a query image and compared with other images in the database. The retrieval rate for the query image is measured by counting the number of images from the same category which are found in the top m matches. Some samples of images in our database are given as below:

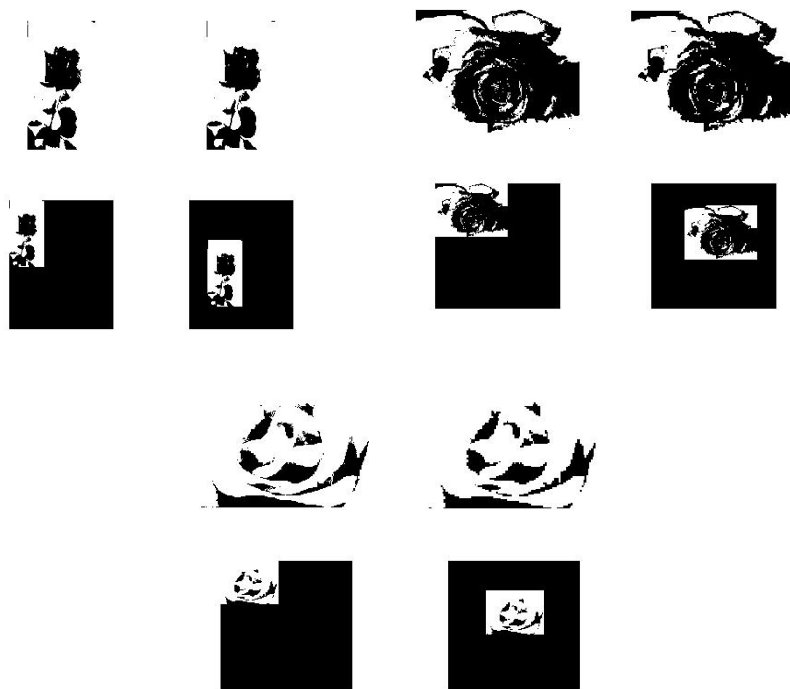


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In order to extract the texture feature from each image, a set of Gabor Filters was applied to each image in the database and texture feature was successfully extracted from each image. A Gabor Filter with eight orientations and three scales were used to capture the edge and texture feature from every image. The results obtained after applying a set of Gabor Filters to an image are as given below:



In order to extract the shape feature from an image, the image was subjected to Zernike Moments of sufficiently higher order and shape feature was successfully extracted from each image. The images were converted from JPEG format to Bitmap image format, before calculating the Zernike Moments. The results obtained after applying ZM are as given below:





CONCLUSION

In this paper, different features of an image such as texture and shape were successfully extracted with the help of Gabor Filters and Zernike Moments respectively in order to define the process of image retrieval. In order to extract the Gabor-Zernike features from an image, the image will be subjected to normalization with the help of z-score normalization and the combined features i.e. the Gabor feature and the Zernike feature will be extracted and the query image will be compared with all images in the database in order to perform the process of CBIR.

ACKNOWLEDGEMENT

I am very much thankful to Prof.S.K.Tadse, Assistant Professor of GHRCE, Nagpur giving me a valuable guidance for this project.

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