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Analysis of Image Retrieval Using Linear Transformation Techniques

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Abstract- Every of us will have a large set of stored images such as scanned copies, multimedia files. Image retrieval is a process of finding similar images to that of query image or to find out to which database the query image belongs. Here we are using two linear transformation techniques Gabor-Walsh Wavelet pyramid technique and Curvelet transform 7method Feature vectors of each of the database images are extracted by applying these techniques, then by calculating Euclidian distance we find that to which database the query image belongs. The comparative analysis is done based on the FAR, FRR & TSR parameters.

Index Terms- CBIR (content based image retrieval)FAR (False Acceptance Rate), FRR (False Rejection Rate), GWWP (Gabor Walsh & Wavelet Pyramid), TSR (True Success Rate).

I. Introduction

With the growing technology throughout the society, the digitized images, visual objects multimedia files are also increasing. These huge amounts of images require novel methods to search and access the images. Advances in medical and other technologies have provided extensive storage, image generation, and transmission abilities. Because of increase in the usage of these digital images in various fields, researchers are focusing on new methods by which images can be easily, quickly and precisely retrieved and accessed from large databases. Technology is improving with the age and the usage of digital images is increasing in various fields like science, geography, engineering, architecture, advertising, design, publishing, and medicine. Hence the retrieval mechanism and processing of the desired image from the database has become important. Since many years researchers are working on different image retrieval processes. The two basic methods which are used for image retrieval are Text based image retrieval and Content based image retrieval [6].

Content Based image retrieval is a process in which the similar images are retrieved from huge databases. Various visual features like shape, color, texture, and spatial layout which are extracted using different techniques are used to prepare different databases. With increase in the volume of databases, researchers are trying to find faster method of retrieving similar images. Hence the research focus has been shifted from low-level feature extraction algorithms to the high level visual feature extraction mechanism. To develop better content based image retrieval system, it is important to work on various processes involved in retrieval like feature extraction, image segmentation, image decomposition and similarity matching techniques[6]. Sometimes it is very difficult and time consuming to give a proper name to an image, and sometimes a lot of information is needed to properly describe an image. It means people manually need to number the images and this is very time consuming and inefficient. To avoid this traditional manual work, a CBIR system performs retrieval based on feature vectors extracted from each of the database image and the query image. Most CBIR systems work in the same way. These feature vectors are then stored. The feature vector of query image is matched against each of the database feature vectors and then the similar images are retrieved.

Content based image retrieval system is an emerging field in image retrieval from a large database. Even though this area has been explored for decades, there is still a very huge scope for achieving the accuracy of human visual perception in distinguishing images. The CBIR system can be improved by working more on the indexing, retrieval design and feature extraction mechanism and to reduce the time better clustering approach with image decomposition and feature extraction can be used. To achieve more accurate and fast result better methods of image decomposition can be applied.

Linear transformation is the process of mapping between two modules that preserves the operation of addition and scalar multiplication. The linear transformation techniques are the fundamental of image processing field. Here we have used two of the linear transformation techniques GWWP and Curvelet transform to perform image retrieval process.

II. Literature Survey

The basic fundamentals of content based image retrieval (CBIR) are divided into three parts, multidimensional indexing, feature extraction and retrieval systems design [1]. The proper grouping of the generated large amount of images by both military and civilian is needed, so as efficient browsing, searching and retrieval takes place. The two major approach of image retrieval, text based image retrieval and visual based image retrieval. The text based image retrieval is a very popular framework of image retrieval. There are two major difficulties. The first trouble is when there is huge set of image collection is present then large number of workers are required to manually number each image. The other trouble is resulted from the rich content present in the images and the subjectivity of human visual perception. That is, for the same image content different people may recognize it differently. The perception subjectivity and annotation impreciseness may cause unrecoverable mismatches in later retrieval processes. To overcome these difficulties, content-based image retrieval was established. Instead of being numbering annotated by text- based key words;

images would be indexed by their own visual content, such as texture color. The fundamental architecture of a CBIR system is shown in Figure1. the feature vectors of all database images are extracted and saved in the feature matrix. Then the test image is entered and it feature vector is extracted; then it is matched with all the database features using similarity measures. The similar images are retrieved.

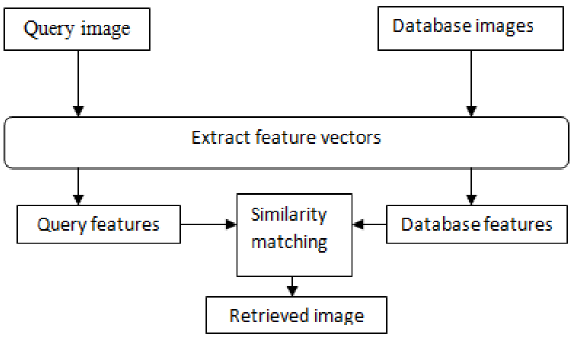

Fig 1: Image retrieval process

To make the content-based image retrieval truly scalable to large size image collections, efficient multidimensional indexing techniques need to be explored. Main challenge in such an exploration for image retrieval is high dimensionality. The best way to index is to reduce the dimensionality and then indexing the images. Clustering is a powerful tool in performing dimension reduction. The clustering technique is used in various disciplines such as pattern recognition, speech analysis and information retrieval. Normally it is used to cluster similar objects (patterns, signals, and documents) together to perform recognition or grouping. This type of clustering is called row-wise clustering. However, clustering can also be used column-wise to reduce the dimensionality of the feature space. But blind dimension reduction can be dangerous, since information can be lost if the reduction is below the embedded dimension. To avoid blind dimension reduction, a post-verification stage is needed. The Figure 2 shows the process of indexing of images. When a query is posed in the high level phrase, the data is retrieved from the database. Image indexing is done to improve the retrieval mechanism. The indexing helps retrieving the images when a query is posed by the user.

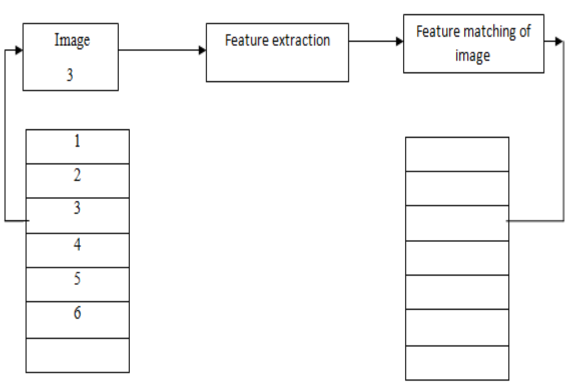

Fig 2: Indexing process

III. Brief Explanation of Proposed Methods

1) Gabor Walsh and Wavelet transform

Gabor filters are the bandpass filters which are used for feature extraction and stereo disparity estimation in image processing. Multiplication of Gaussian envelope function and complex oscillation gives impulse response of these filters. Gabor showed that these elementary functions minimize the space (time)-uncertainty product. By extending these functions to two dimensions it is possible to create filters which are selective for orientation. Under certain conditions the phase of the response of Gabor filters is approximately linear. This property is exploited by stereo approaches which use the phase-difference of the left and right filter responses to estimate the disparity in the stereo images. It was shown by several researchers that the profile of simple-cell receptive fields in the mammalian cortex can by described by oriented two-dimensional Gabor functions. Because of the multiplication-convolution property (Convolution theorem), the Fourier transform of a Gabor filter's impulse response is the convolution of the Fourier transform of the harmonic function and the Fourier transform of the Gaussian function. The filter has a real and an imaginary component representing orthogonal directions. The two components may be formed into a complex number or used individually.

Complex

$$g(x, y; \lambda, \theta, \psi, \sigma, \gamma) = \exp\left(-\frac{x'^2+\gamma^2 y'^2}{2\sigma^2}\right) \exp\left(i\left(2\pi\frac{x'}{\lambda}+\psi\right)\right)$$

Real

$$g(x, y; \lambda, \theta, \psi, \sigma, \gamma) = \exp\left(-\frac{x'^2+\gamma^2 y'^2}{2\sigma^2}\right) \cos\left(\left(2\pi\frac{x'}{\lambda}+\psi\right)\right)$$

Imaginary

$$g(x, y; \lambda, \theta, \psi, \sigma, \gamma) = \exp\left(-\frac{x'^2+\gamma^2 y'^2}{2\sigma^2}\right) \sin\left(\left(2\pi\frac{x'}{\lambda}+\psi\right)\right)$$

Where $x' = x\cos\theta + y\sin\theta$ & $y' = -x\sin\theta + y\cos\theta$

In this equation, λ represents the wavelength of the sinusoidal factor, θ represents the orientation of the normal to the parallel stripes of a Gabor function, ψ is the phase offset, σ is the sigma/standard deviation of the Gaussian envelope and γ is the spatial aspect ratio, and specifies the ellipticity of the support of the Gabor function.

The size of the feature vector plays an important role in the retrieval of images. The Walsh matrix is a set of m number of rows and can be denoted by W_k for 0,1,…….,m-1.The Walsh matrix can have number of properties. Walsh transform matrix row is the row of the Hadamard matrix specified by the Walsh code index, which must be an integer in the range [0,..., m-1]. For the Walsh code index equal to an integer j, the respective Hadamard output code has exactly j zero crossings, for j = 0, 1,..., m-1.

The combination of Gabor-Walsh and the wavelet (Haar wavelet) helps us to extract features more efficiently and matching of query image with database will be more accurate than other available methods. This technique is implemented in this project.

2) Curvelet transform

Actually the ridgelet transform is the core spirit of the curvelet transform. In 1999, an anisotropic geometric wavelet transform, named ridgelet transform, was proposed by Candes and Donoho. The ridgelet transform is optimal at representing straight-line singularities. Unfortunately, global straight-line singularities are rarely observed in real applications. To analyze local line or curve singularities, a natural idea is to consider a partition of the image, and then to apply the ridgelet transform to the obtained sub-images. This block ridgelet-based transform, which is named curvelet transform, was first proposed by Candes and Donoho in 2000. Apart from the blocking effect, however, the application of this so-called first generation curvelet transform is limited because the geometry of ridgelets is itself unclear, as they are not ture ridge functions in digital images. Later, a considerably simpler second-generation curvelet transform based on frequency partition technique was proposed. The second-generation curvelet transform has been shown to be a very efficient tool for many different applications in image processing. The overview of the curvelet transform is shown below for four step.

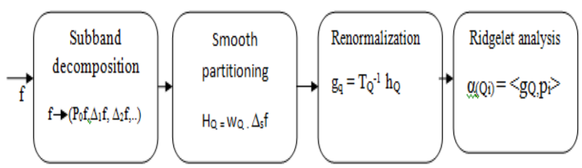

Fig 3: Curvelet transform

The Curvelet transform is a multiscale directional transform that allows an almost optimal nonadaptive sparse representation of the object with edges. The brief explanation of each steps is discussed below:

Subband decomposition step divide the image into several resolution layers. Each layer contains details of different frequencies. The object f is filter into subbands.

$$Q_{(s,k_1,k_2)} = \left[\frac{k_1}{2^s}, \frac{k_1+1}{2^s}\right] \times \left[\frac{k_2}{2^s}, \frac{k_2+1}{2^s}\right] \in \mathbf{Q}_s$$

Smooth Partitioning define a collection of smooth window $\mathbf{w_Q(x_1, x_2)}$ localized around dyadic squares.

In Renormalization for a dyadic square Q, let $T_Q f(x_1, x_2) = 2^s f(2^s x_1 - k_1, 2^s x_2 - k_2)$ denote the operator which transports and renormalizes f so that the part of the input supported near Q becomes the part of the output supported near [0,1]×[0,1]. In this stage of the procedure, each 'square' resulting in the previous stage is renormalized to unit scale: $g_Q = T_Q^{-1} h_Q$ The ridgelet element has a formula in the frequency domain:

$$\hat{\rho}_\lambda(\xi) = \frac{1}{2}|\xi|^{-\frac{1}{2}}\left(\hat{\psi}_{j,k}(|\xi|)\cdot\omega_{i,l}(\theta) + \hat{\psi}_{j,k}(-|\xi|)\cdot\omega_{i,l}(\theta+\pi)\right)$$

where,

- $\omega_{i,l}$: periodic wavelets for $[-\pi, \pi)$.
- i : the angular scale , $l \in [0, 2^{i-1}-1]$: the angular location.
- $\psi_{j,k}$: Meyer wavelets for $\Re$.
- j : the ridgelet scale , k : the ridgelet location.

Each normalized square is analyzed in the ridgelet system:

- The ridge fragment has an aspect ratio of $2^{-2s}\times 2^{-s}$.
- After the renormalization, it has localized frequency in band $|\xi| \in [2^s, 2^{s+1}]$.
- A ridge fragment needs only a very few ridgelet coefficients to represent it.

The above steps are applied in sequence to get the curvelet transform of each data base images and also the test image. All the feature vectors are then saved and the Euclidian distance is measured between test and the database images and the least distance will indicate to which class it belongs to. Based upon this False Acceptance Rate and False Rejection Rate and TSR (True Success Rate) is calculated.

FRR= (True claims rejected/total true claims) X 100%

FAR= (Imposter claims accepted/total imposter claims) X 100%

TSR= (correct match / total images in database) X 100%

IV. Algorithm

i. Create a database of 2 set of images.
ii. Extract each image from first set of images in the database for the operation.
iii. Apply walsh transform for the extracted image and then apply gabor function and apply Haar transform for the first method. [for second method apply Curvelet transform steps at this stage]
iv. Extract each image from second set of images in the database for the operation and repeat the steps 3,4 and 5.
v. Obtain the query image for test.
vi. Repeat the steps 3, 4 and 5 on the obtained query image.
vii. Find the Euclidian distance between the query image and images in the database for both sets.
viii. The image set database which is having minimum Euclidian distance with the query image is the original database for the query image.

V. Results

1) FAR & FRR for GWWP method

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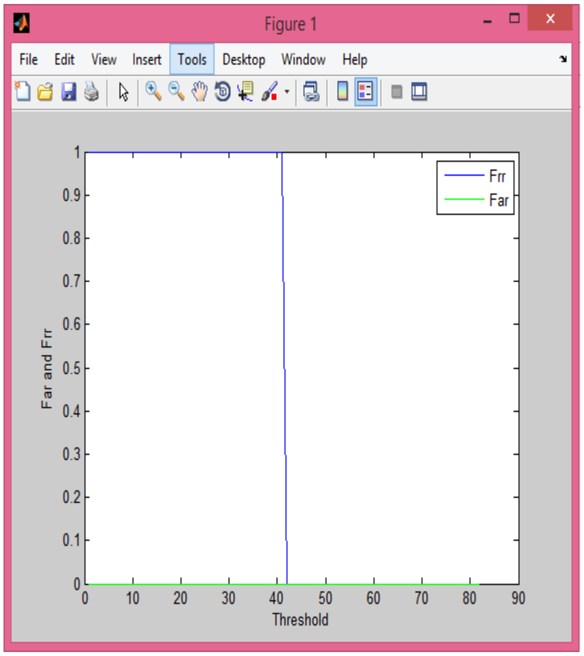

Fig 4: Graph of FAR & FRR values of GWWP

2) FAR & FRR for Curvelet transform

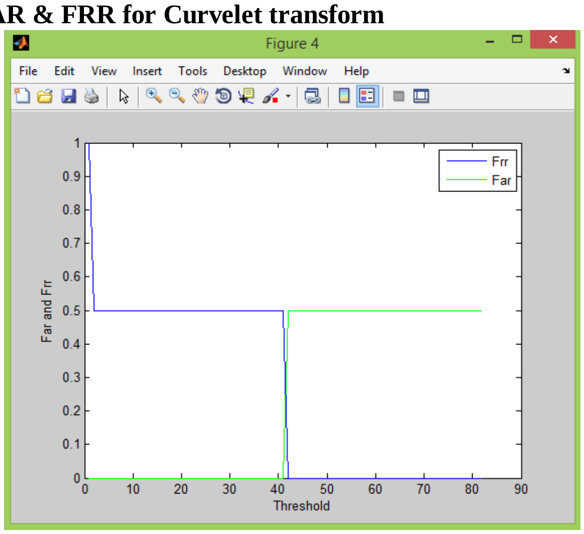

Fig 5: Graph of FAR & FRR values of Curvelet transform

3) Table for FAR, FRR & TSR values

i) Using GWWP method

Table I: FAR, FRR & TSR values of GWWP transform

Threshold	**FAR**	**FRR**	**TSR (%)**
1.0000	1.0000	0	11.8098
2.0000	1.0000	0	25.9003
3.0000	1.0000	0	58.8094
4.0000	1.0000	0	84.2387
5.0000	1.0000	0	89.0481
6.0000	1.0000	0	95.2800
7.0000	0.5844	0.0007	95.2800
8.0000	0.5773	0.0078	95.2800
9.0000	0.4941	0.0136	95.2800
10.0000	0.4175	0.0149	95.2800
11.0000	0.2935	0.0170	95.2800
12.0000	0	1.0000	95.2800
13.0000	0	1.0000	95.2800
14.0000	0	1.0000	95.2800
15.0000	0	1.0000	95.2800
16.0000	0	1.0000	95.2800
17.0000	0	1.0000	95.2800
18.0000	0	1.0000	95.2800
19.0000	0	1.0000	95.2800
20.0000	0	1.0000	95.2800

ii) Using Curvelet transform

Table II: FAR, FRR & TSR values of curvelet transform

Threshold	FAR	FRR	TSR (%)
1.0000	1.0000	0	12.8098
2.0000	1.0000	0	26.9003
3.0000	1.0000	0	59.8094
4.0000	1.0000	0	86.2387
5.0000	1.0000	0	90.0481
6.0000	1.0000	0	97.2800
7.0000	0.5785	0.0034	97.2800
8.0000	0.5553	0.0131	97.2800
9.0000	0.4899	0.0141	98.2800
10.0000	0.3272	0.0152	98.2800
11.0000	0.1452	0.0187	98.2800
12.0000	0	1.0000	98.2800
13.0000	0	1.0000	98.2800
14.0000	0	1.0000	98.2800
15.0000	0	1.0000	98.2800
16.0000	0	1.0000	98.2800
17.0000	0	1.0000	98.2800
18.0000	0	1.0000	98.2800
19.0000	0	1.0000	98.2800
20.0000	0	1.0000	98.2800

VI. CONCLUSION

The time taken to execute GWWG code in MATALB is 207.733sec and for Curvelet it is 2098.29566sec. The Curvelet takes a lot of time for execution but if we save the feature vectors extracted during the first execution; we can get the results within few seconds in the next run of the program. As we can see the values of FAR, FRR & TSR of each of the methods in the above tables; we can make out that there is no huge difference in FAR

& FRR values. But by looking at the TSR values we can see that for Curvelet True success rate (TSR) value is greater than GWWP. Curvelet TSR value is 98% which is 3% greater than that of GWWP. Hence we can say that Curvelet is better technique to map the image successfully. Curvelet is very good in detecting the smallest of the small curves in the image. Hence it is better to go for curvelet transform.

The application of these methods can be found in forensic sciences, military applications where the database of culprits are maintained and to match the evidences to these databases; we can use these methods effectively. The application is also found in textile industry, medical diagnosis, art collection and many more.

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