WAVELET BASED FINGERPRINT IMAGE RETRIEVAL
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ABSTRACT
The image retrieval problem encountered when searching and retrieving images that is relevant to a user’s request from a database. To solve this problem, Text based image retrieval and Content based image retrieval in an image database. In Text based image retrieval, images are indexed using keywords, subject headings or classification codes, which in turn are used as retrieval keys during search and retrieval. In Content based image retrieval, input goes in the form of an image. In these images, different features are extracted and then the other images from database are retrieved accordingly.

CBIR is currently used in various fields such as architectural and engineering design, crime prevention, medical diagnosis, military, biometric etc. Biometric distinguishes the people by their physical or behavioral qualities. Fingerprints are viewed as a standout amongst the most solid for human distinguishement because of their uniqueness and ingenuity.

I have proposed a system to retrieve fingerprint images on the basis of their textural features, by using different wavelets. From the input fingerprint image, first of all fingerprint image is decomposed up to three levels using DWT and then its textural features are extracted. Feature vectors are obtained by computing Mean, Standard Deviation and Energy. Similarly, it is done for Query fingerprint image. Then these features are matched for similarity using Chi-Square and then resultant images are displayed. The database fingerprint images are taken from different types of scanners, with different technologies, size and resolution. It is assumed that one kind of scanner will generate similar fingerprint images of same resolution, size and format. So similarity is measured if the system retrieves images from the same scanner from which the Query image is taken. Different parameters are calculated such as—Specification, Sensitivity, Positive Predictive Value, Negative Predictive Value, Recognition Rate and Accuracy. Based on these parameters, the results show that Haar and Daubechies (db10) Wavelets achieves best retrieval effectiveness.

Keywords—Content based Image retrieval, Wavelets, Feature extraction, Texture Image Retrieval

I. INTRODUCTION
CBIR contrasts from established information retrieval in that image databases are basically unstructured, since digitized images comprise simply of varieties of pixel intensities, with no inalienable importance. One of the key issues with any sort of image preparing is the need to separate helpful information from the crude information, (for example, perceiving the vicinity of specific shapes or textures) before any sort of thinking about the image's substance is conceivable. Image databases hence vary on a very basic level from content databases, where the crude material (words put away as ASCII character strings) has as of now been legitimately organized. There is no likeness level 1 retrieval in a content database. CBIR draws a large number of its strategies from the field of image preparing and PC vision, and is viewed by some as a subset of that field. It varies from these fields chiefly through its accentuation on the retrieval of images...
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with craved components from a gathering of noteworthy size. Image handling covers a much more extensive field, including image upgrade, pressure, transmission, and elucidation. While there are hazy areas, (for example, object recognition by highlight examination), the refinement between standard image investigation and CBIR is typically genuinely obvious. An illustration may make this reasonable. Numerous police drives now utilize programmed face recognition frameworks. Such frameworks may be utilized as a part of one of two ways. Firstly, the image before the camera may be contrasted and a solitary singular's database record to check his or her character. For this situation, just two images are coordinated; a procedure couple of onlookers would call CBIR. Also, the whole database may be looked to locate the most firmly coordinating images. This is a genuine example of CBIR. Research and development issues in CBIR cover a range of topics, many shared with mainstream image processing and information retrieval. Some of the most important are:

- understanding image users’ needs and information-seeking behavior identification of suitable ways of describing image content
- extracting such features from raw images
- providing compact storage for large image databases
- matching query and stored images in a way that reflects human similarity judgments
- efficiently accessing stored images by content
- providing usable human interfaces to CBIR systems

Biometrics has developed as an issue and inciting examination field. Indeed, a few biometric applications have been received in non-military personnel, business, and measurable territories. The ubiquity of fingerprint-based distinction has prompted the formation of expansive scale databases. While the extensive size of these accumulations bargains the retrieval speed, the noise and the mutilation that can be found in fingerprint pictures might lessen the general recovery exactness. Accordingly, both retrieval accuracy and speed assume an imperative part in the fingerprint distinction process.

II. RELATED WORK

The expanded need of content based image retrieval technique can be found in various diverse areas like Data mining, Education, Medical Imaging, Crime Prevention, Weather Forecasting, Remote Sensing and Management of earth Resources. In CBIR, the visual features of Color, Texture and Shape are extricated. Every feature is spoken to utilizing feature descriptors. For recovering the images, the feature descriptors of the question are contrasted with those of the images in the database. In Biometrics systems, images make use of patterns which are also represented by feature vectors. The candidate patterns are then retrieved from the database by comparing the distance of their feature vectors. This work presents the content based image retrieval of fingerprint images by extracting texture feature by using different type of wavelets. Various Journals, Conference proceedings, e-books etc have been considered to carry out literature survey, which forms the basis of the research. A list of some of the most relevant research work is presented in this section.

2.1. Content Based Image Retrieval

The literature survey for Content Based Image Retrieval is as follows:
Choras [1] discussed about image feature extraction techniques and their applications for CBIR and Biometrics System. The feature descriptors of query were compared with the feature descriptors of images in the database for the retrieval. The feature vectors of biometrics system images (such as fingerprint, iris, hand etc) could also be represented. The distance between the feature vectors were computed and the retrieval was made by comparing the distance between the feature vectors. They proposed an approach for mapping image content onto low-level features.

An algorithm for texture feature extraction using wavelet decomposed coefficients of an image and its complement was proposed by Hiremath et al. [6]. Four different approaches were used for the same. In first method, texture features were extracted from each channel of the RGB color space. In second method, texture features were extracted for the luminance channel V and color features for the chromaticity channels H and S. In third method, texture features are extracted from the luminance channel Y and color features from the chromaticity channels C_b and C_r. Fourth method, uses gray scale texture features computed for a color image. They concluded that Haar wavelets are more effective in texture classification as compared to other wavelets.

Baaziz et al. [8] highlighted the current progress relevant to texture based image retrieval and spatial frequency image representation. They gave an overview of statistical methodologies and techniques employed for texture feature extraction using DWT, Gabor wavelets, dual tree complex wavelets and contourlets. They provide a general picture of the trends in this emerging field of research. Further they developed a vision for future in-depth explorations and suggested design choices for texture retrieval applications.

Singha et al. [9] displayed the substance based picture recovery, utilizing features like textures and color, called WBCHIR (Wavelet Based Color Histogram Image Retrieval). These features were extracted through wavelet transformation and shading histogram and the blend of these features was powerful to scaling and translation of items in a picture.

Parameshwari et al. [12] presented the content based image retrieval, using texture and color features. The different features were extracted and the effectiveness of content based image retrieval could be increased. The proposed system had confirmed a faster retrieval method on a COREL image data base and CASIA image database containing 1000 color images and medical images respectively. The performance of this proposed method was evaluated using color image and medical image database and measured using average precision, average recall. The experimental result showed this proposed method had accomplished the highest retrieval rate.

Rajam et al. [13] covered approaches used for extracting low level features. Various distance measures for measuring the similarity of images were discussed. In addition to these, various data sets used in CBIR and the performance measures, were also addressed.

An algorithm was proposed by Mistry et al. [15] on the basis of extraction and matching of color and texture. This algorithm was based on the computations of energy levels and Euclidean
distance between the energy of query image and database image. DWT was used to characterize color image retrieval. These features were invariant to scale, translation and rotation. The features used could describe different properties of an image. The proposed system integrated these features to retrieve accurate images.

2.2. Wavelets:
The literature survey for Wavelets is as follows:

A comparison of different wavelets based on texture features for content based search and retrieval was made by Ma et al. [2]. They included orthogonal and bi-orthogonal wavelet transforms, tree-structured decompositions and the Gabor wavelet transforms. The orthogonal and bi-orthogonal wavelet transforms were discussed. The conventional orthogonal and bi-orthogonal wavelet transforms have many advantages such as lower feature dimensionality and lower image processing complexity. These transforms were efficient for browsing for large image database applications. In their experiments, best performance was achieved by Gabor features.

Wavelets allow analysis of images at various levels of resolution. Kociolek et al. [3] deals with using DWT derived features used for digital image texture analysis. These derived features were tested in images from standard Brodatz catalogue. The features are derived by Discrete Wavelet Transform.

Arivazhagan et al. [4] proposed a technique of feature extraction for characterization and segmentation of texture at multiple scales based on block by block comparison of wavelet co-occurrence features. The usage of co-occurrence features computed for DWT images for texture segmentation was exhibited. The features were considered same when the windows or sub-images were from the same texture and different if they were from different textures. According to them, the proposed method yielded better results than the texture spectrum method.

A wavelet based texture feature extraction method from images was proposed by Vadivel et al. [5] for CBIR applications. They used high frequency components of Daubechies’ wavelet transform as texture features. The images were decomposed up to three levels. 9 features were obtained from these levels. Any image can be specified as a Query image for retrieval. The distance was computed and the images were retrieved on the bases of distance metric.

Zegarra et al. [7] proposed different types of wavelets for representing and describing the textural information presented in the fingerprint image. They made use of eight different data sets and applied different wavelets with different similarity measures and evaluated the retrieval results. According to them, Gabor wavelets with Chord similarity measure achieve the best retrieval effectiveness.

The fundamentals of DWT were listed along with the Matlab implementation by Mistry et al. [10]. Image was filtered by low pass and high pass filters. Image was decomposed into multilevel which includes: Approximation details (LL), Horizontal details (HL), Vertical details (LH), Diagonal details (HH). When they applied frequency on an image, there were high variations between two adjacent pixels. And when they applied low frequency on an image, there were smooth variations between the adjacent pixels.

Malakooti et al. [11] have introduced a new image recognition method based on discrete wavelet transform and singular value decomposition that is capable of retrieving most of the images similar to the target image. DWT was used to transfer the target image from the spatial domain
into frequency domain in which it was divided into LL, LH, HL, HH sub-bands. SVD was used to extract its singular values as the reliable and robust features for the recognition. To create feature vector, they used Mean and Variance of low level frequency. Once feature vector was computed then Euclidean Distance was calculated to retrieve images which were similar to the target image on the bases of minimum error criteria. If a distance measure comes out to be zero, then the retrieved image would be exactly as input image.

Chadhary et al. [14] discusses that a wavelet is a wave-like oscillation with amplitude starts from zero, increases, and then decreases again to zero. Properties of wavelets and its types were also discussed. Further families of wavelets were listed. Haar wavelet, Symlets, Daubechies wavelet, Coiflets, Biorthogonal wavelets and Meyer wavelets were represented along with their advantages and disadvantages.

III. PROPOSED SYSTEM

The Fingerprint images are similar to each other if we distinguish them on the bases of the content of the image such as Color, Texture and Shape. Color feature and Shape feature cannot distinguish the fingerprint images on content bases. So, we consider the Texture feature to distinguish the fingerprint images. The fingerprint images are taken for different types of scanners which make use of different type of technologies. It is assumed that one type of scanner may produce same type of texture in all the images. The quality of different scanners also differs. The content of the fingerprint images from same type of scanners is considered to be similar. The proposed system extracts the texture features for both Query fingerprint image and Database images. After measuring the similarity, the similar fingerprint images are retrieved.

The proposed system is divided into two sub systems namely: Enlistment Subsystem and Query Subsystem.

ENLISTMENT SUBSYSTEM:

In this subsystem, first of all the fingerprint images in the database are loaded (Bolt 1). Once the fingerprint images from database are loaded into the system, they are decomposed into sub-images by using discrete wavelet transform (Module A). These images are decomposed up to three levels. The original fingerprint images are decomposed in order to extract the details of the images. The more the image is decomposed into its sub-images, the more exact the details will be. The original fingerprint image is decomposed into four sub-bands: LL, LH, HL and HH. LL sub-band consists of approximation details. LH sub-band consists of horizontal details. HL consists of vertical details and HH sub-band consists of diagonal details. In wavelet decomposition, only LL sub-band contains useful information. So, we decomposed the LL sub-band again into four sub-bands. Again the LL sub-band is decomposed into four sub-bands. Thereby, we decomposed the fingerprint image up to three levels. This decomposition is done by using different types of discrete wavelet transformations. In the proposed system, we make use of 25 types of wavelets.

After decomposing the fingerprint image, the features are extracted from the decomposed fingerprint image (Module B, Bolt 2). The texture features are extracted by computing the Mean, Standard Deviation and Energy of the decomposed fingerprint image. The features are extracted from all the images in the database.
Once all the features are computed, they form a feature vector. This feature vector is stored in the descriptor library (Bolt 3) for further use. All the fingerprint images are then stored in the database (Bolt 4).

- **QUERY SUBSYSTEM:**
  In this subsystem, first of all the Query fingerprint images is loaded (Bolt 1). Once the Query fingerprint image is loaded into the system, it is decomposed into sub-images by using discrete wavelet transform (Module A). This image is decomposed up to three levels. The original Query fingerprint image is decomposed in order to extract the details of the images. The more the image is decomposed into its sub-images, the more exact the details will be. The original Query fingerprint image is decomposed into four sub-bands: LL, LH, HL and HH. LL sub-band consists of approximation details. LH sub-band consists of horizontal details. HL consists of vertical details and HH sub-band consists of diagonal details. In wavelet decomposition, only LL sub-band contains useful information. So, we decomposed the LL sub-band again into four sub-bands. Again the LL sub-band is decomposed into four sub-bands. Thereby, we decomposed the Query fingerprint image up to three levels. This decomposition is done by using different types of discrete wavelet transformations. In the proposed system, we make use of 25 types of wavelets.

After decomposing the Query fingerprint image, the features are extracted from the decomposed Query fingerprint image (Module B, Bolt 2). The texture features are extracted by computing the Mean, Standard Deviation and Energy of the decomposed Query fingerprint image.

Once all the features are computed, they form a feature vector. This feature vector is stored in the descriptor library (Bolt 3). After forming the feature vector, the similarity is computed between the Query fingerprint image and the Database fingerprint images (Module C). The similarity is measured by “Chi-Square”. This distance is measured between the Query fingerprint image and the entire Database fingerprint images. The resultant is stored in ascending order.

In order to retrieve the similar fingerprint images to the Query fingerprint image, the images with minimum Chi-Square value are considered. Eight fingerprint images are retrieved from the databases which have minimum Chi-Square value.
IV. METHODOLOGY

To obtain the stated objectives the following methodology is used.

1. To reduce the redundancy in the input fingerprint image and decrease the number of elements in the feature vector we applied three-level DWT on the input image. The input fingerprint image is transformed into four bands of frequency: LL, LH, HL and HH. We have selected the LL subband because it contains the most useful features of the input image while the other three bands of frequencies only contain the details and can be ignored. The LL subband is a coarse approximation of the image and removes all high frequency information. The LH subband removes high frequency information along the rows and emphasizes high frequency information along the columns. The result is an image in which vertical edges are emphasized. The HL subband emphasizes horizontal edges, and the HH subband emphasizes diagonal edges. To compute the DWT of the image at the next scale the process is applied again to the LL subband.

2. The texture features of input fingerprint image are extracted by calculating the Energy, Mean and Standard Deviation on the pixels of the image.

3. After extracting features from the image, put the extracted features into a matrix for further computation.

4. Similarity matching of the query fingerprint image and the database fingerprint images is calculated by CHI_SQUARE. First of all, Chi-Square is calculated on all the images in the database and on the Query image. Then the results are stored in ascending order in an array. Top eight images with minimum Chi-Square are retrieved and displayed.

V. DATABASE

Our experiments are based on four types of databases, the Bologna FVC-2000 [16], FVC-2002 [17] and FVC-2004 [18] databases which consist of four different datasets, referred to as DB1, DB2, DB3, and DB4. Further, each of these datasets contains 8 fingerprint samples of 100 different fingers. Thus, each data set has 880 fingerprints. By considering that each data set was collected through different fingerprint technologies, in order to cover the advances in fingerprint sensing techniques, the size of the fingerprint images, as well as the resolution, varies among them. Data sets DB1, DB2, and DB3 were collected by different scanners technologies, whereas the data set DB4 was collected by using software for generating synthetic fingerprints. Table 1 summarizes the different fingerprint technologies used to generate the databases. These databases were not acquired in real environments and, according to a formal protocol; the data are characterized by the presence of distortions (rotations, translations, low quality images) with in fingerprints of the same individual’s finger. All these aspects make these datasets very useful for testing our system in extreme conditions.
VI. EXPERIMENTS AND RESULTS

A series of experiments were conducted to test the retrieval accuracy of our fingerprint image retrieval system, using different wavelet-based feature extraction algorithms and Chi-Square similarity measure. The retrieval experiments were considered independently in each of the four datasets of the three databases. A simulated query is one of the 880 images in the data sets. Thus, a total number of 880 different fingerprint queries were performed per data set. The
relevant retrieved images for each query are defined as the remaining fingerprints from the same type of scanner, and the distances between the images are stored in increasing order. Once the fingerprint images are retrieved, six different parameters [19] are calculated which are as follows:

1. Specification
2. Sensitivity
3. Positive Predictive Rate
4. Negative Predictive Rate
5. Recognition Rate
6. Accuracy

All these parameters are computed all the retrieved images and for all the graphs are framed. Some of them are shown as follows:
Based on the results above, it is found that:

1. The retrieval time is minimum consumed by Haar Wavelet, Symlet (sym3) Wavelet and Reverse Bior (rbio1.1) Wavelet.

2. The maximum positive predictive value is given by Haar Wavelet, Daubechies (db2) Wavelet, Symlet (sym2) Wavelet, Daubechies (db4) Wavelet and Daubechies (db6) Wavelet.

3. The minimum negative predictive value is predicted by Daubechies (db10) Wavelet.

4. The Recognition Rate is maximal obtained by Daubechies family (db2, db10).

5. The maximum Accuracy is obtained by Haar Wavelet, Daubechies (db10) Wavelet, Symlet (sym2) Wavelet.

From the above results, Haar Wavelet and Daubechies (db10) Wavelet achieves the best retrieval effectiveness.

VII. CONCLUSION AND FUTURE SCOPE

The following conclusions are drawn on the basis of experimental observations and analysis:

1. Investigation of texture based fingerprint image retrieval is to reduce the search space for identification is done.

2. I have proposed an approach to characterize fingerprint images by using different types of wavelet transforms.

3. The retrieval effectiveness was compared by analyzing the results in terms of Specifications, Sensitivity, Positive Predictive Value, Negative Predictive Value, Recognition Rate and Accuracy.

4. For all the experiments, the best results were found with Haar Wavelet and Daubechies (db10) Wavelet.

In future, the present work may be extended on the following:

1. The databases used in our experiments do not reflect real acquisition conditions such as abnormal distortions, including noise, significant rotations and translations [ ]. So, the future
work includes more realistic fingerprint image databases with which the retrieval
effectiveness of image descriptors can be improved.
2. Our experiments make use of Chi-Square for similarity matching. Further, we can make use of
different types of similarity measures to improve the effectiveness of the system.
3. Currently, the image is decomposed up to level 3. The image can further decomposed into
more levels to extract more detailed features.

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Yashika Birdi and Er. Jagroop Kaur


