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Wavelets based Fingerprint recognition

(Gabor filter multispectral analysis and shape context feature extraction)

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***Abstract*— In this paper we introduced a wavelet based feature extraction technique where we apply a Gabor filter after wavelet decomposition to remove non-dc components. Further this technique is compared with a unique shape context based fingerprint matching technique. Our observation proves that accuracy is 91%.**

Keyword: wave, wavelet, pattern, unique, filter

I. INTRODUCTION

Among all biometric indicators, finger prints have one of the highest levels of reliability and have been extensively used by forensic experts in criminal investigations. A fingerprint image is a pattern of ridges and valleys, with ridges as dark lines while valleys as light areas between the ridges. Ridges and valleys generally run parallel to each other, and their patterns can be analyzed on a global and local level. The ridge structure in a fingerprint can be viewed as an oriented texture patterns having a dominant spatial frequency and orientation in local neighbourhood. The frequency is due to inter ridge spacing and orientation is due to the flow pattern exhibited by ridges. So a finger print can be viewed as an oriented texture pattern. Jain et al. showed that for sufficiently complex oriented texture such as finger prints, invariant texture representations can be extracted by combining both global and local discriminating information in the texture. So this oriented texture pattern can be used for the recognition of fingerprints.

Study shows that use of texture analysis using wavelet transform can increase the recognition rates. Texture is a specific kind of pattern. The texture analysis is one of the most important techniques used in the analysis and classification of images where repetition or quasirepetition of fundamental elements occurs. A great number of approaches to texture analysis have been investigated over the past three decades. Three principal approaches are used in texture analysis, namely, statistical, spectral and structural. But the disadvantage of the texture analysis schemes is that the image is analyzed at one single scale. Using wavelet a multi-scale representation of texture can be achieved by which we can extract the local information about the texture from the image which is utilized to increase the recognition rates. The previous work showed that introducing MR (multi resolution) techniques into the classification of biological images greatly improves the classification accuracy. MR tools are used because of (a) they provide space-frequency localized information in sub bands. (b) They are fast and efficient to compute.

II. WAVELET TRANSFORM

Before going to wavelet transform we must know about the wavelets. A wavelet is a waveform of effectively limited duration that has an average value of zero. In mathematical term wavelets are mathematical functions that cut up data into different frequency components, and then study each component with a resolution matched to its scale. Fig.1 shows the comparison of wavelets with sine waves, which are the basis of Fourier analysis. Sinusoids do not have limited duration they extend from minus to plus infinity. Where sinusoids are smooth and predictable, wavelets tend to be irregular and asymmetric. Fourier analysis consists of breaking up a signal into sine waves of various frequencies. Similarly, wavelet analysis is the breaking up of a signal into shifted and scaled versions of the original (or mother) wavelet.

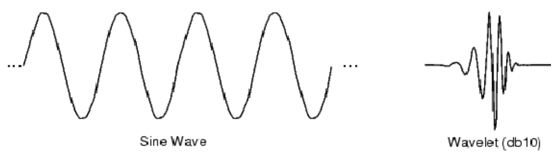

Fig. 1 Comparison of sine wave and wavelet

Fig.1 shows that signals with sharp changes might be better analyzed with an irregular wavelet than with a smooth sinusoid. It also makes sense that local features can be described better with wavelets that have local extent. So wavelet has advantages over traditional Fourier methods in analyzing physical situations where the signal contains discontinuities and sharp spikes. Wavelets were developed independently in the fields of mathematics, quantum physics and electrical engineering. There are many kinds of wavelets one can choose between smooth wavelets, compactly supported wavelets, wavelets with simple mathematical expressions, wavelets with simple associated filters etc. some single wavelet families are shown in Fig 2.

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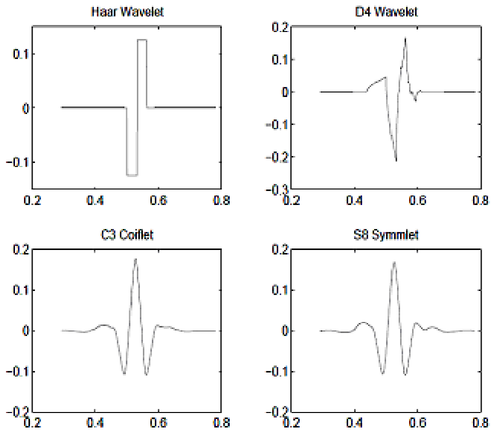

Fig. 2 Some single wavelet families.

Wavelet Transform is used to split the signal into a bunch of signals and represents the same signal, but all corresponding to different frequency bands. The principle advantage is they provide what frequency bands exists at what time intervals. Wavelet transform of any function f at frequency a & time b is computed by correlating f with wavelet atom as

$$Wf(a,b) = \frac{1}{\sqrt{a}} \int_{-\infty}^{\infty} f(t)\psi\left(t - b/2\right)dt \qquad (1)$$

It provides time-frequency localization. Wavelet transform is always defined in terms of a ‘mother’ wavelet ψ and a scaling function φ , along ith their dilated and translated versions. Applying wavelet transform on 1D signal, it can correctly detect the singularity in a signal. For images, the 2D scaling function φ(x, y) and mother wavelet ψ(x, y) is defined as tensor products of the following 1-D wavelets ψ (x) , ψ (y) and scaling functions φ(x),φ(y) .

Scaling function
$$\phi(x, y) = \phi(x) \times \phi(y)$$

Vertical wavelets
$$\psi^{y}(x, y) = \phi(x) \times \psi(y)$$

Horizontal wavelets
$$\psi^{x}(x, y) = \psi(x) \times \phi(y)$$

Diagonal wavelets
$$\psi^{d}(x, y) = \psi(x) \times \psi(y)$$

The use of wavelet transform on image shows that the transform can analyze singularities easily that are horizontal, vertical or diagonal. So we can use the directional resolving power of wavelet in the fingerprint recognition to track the variation in orientation of fingerprint ridges. Wavelet transform is used in many applications some examples are: Analysis & detection of singularities, For detection of shapes of objects, Invariant representation of patterns, Handwritten & printed character recognition, Texture analysis & classification, Image indexing & retrieval, Classification & clustering, Document analysis. Wavelets have been mostly implemented from fields of data compression and signal processing to more mathematically pure field of solving partial differential equations. Wavelets provides time-scale map of any signal it can provide extraction of features that vary in time. Above features makes wavelet an ideal tool for analyzing signals of a transient or non-stationary nature. Hence the use of wavelet in fingerprint recognition system increases performance of system.

III. PATTERN RECOGNITION

Pattern recognition is a branch of science that develop "classifiers" that can recognize unknown instances of objects. To recognize an object means to classify it, or to assign it to one of a set of possible classes or labels. This class assignment of objects is based on an analysis of the values of one or more features of the object. Pattern recognition techniques are used in a wide variety of commercial applications. Common examples include character recognition, such as the scanning of a printed page of text into a word processor; natural language recognition, such as using voice commands to relay a set of possible responses to a computer system over the phone; analysis of fingerprint, face, or eye images in order to verify a person's identity; analysis of images taken from airplanes or satellites, perhaps in order to detect and track oil. Humans have a powerful ability to classify objects based on sensory input. Although humans have the ability to read patterns, there are at least two potential advantages to using computer systems for pattern recognition. Even if a person with minimal training could perform a certain task, he or she might not be able to handle the volume of work in a timely fashion, or without becoming bored and error-prone. In other cases, such as recognizing signs of cancer in x-ray images, the task requires specialized training, and there simply may not be as many human experts as needed. Pattern recognition technology has many important uses beyond those already mentioned. For example, pattern recognition techniques might be used to spot credit card fraud, or to detect attempts to break into computer systems. Pattern recognition techniques can also be used in the area of robotics to help robots interpret visual input and move from one place to another. In summary, it should be clear that pattern recognition technology lies at the core of many applications that involve "intelligent" decisions made by computer.

IV. PROPOSED METHOD OF FINGERPRINT RECOGNITION:

This section shows the proposed method which consists of two main modules as shown in Fig. 3 which represents the methodology of the implementation. The whole fingerprint identification system includes enrollment module and identification module. Enrollment module involves the storage of fingerprint images into database, while the identification module processes the input fingerprint image, compares it with the fingerprint images from database and matches it to the correct fingerprint image from database. Both of the enrollment module and identification module have feature

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extraction process. In this process, after finding the core point of the fingerprint image, Region of interest (ROI) is extracted around this core point so as to make the system translation invariant. Then, apply multilevel wavelet decomposition on the extracted ROI. At each level, the wavelet transform decompose the given image into three directional components, i.e. horizontal, diagonal and vertical detail sub bands in the direction of 0, 45 and 135 respectively apart from the approximation (or) smooth sub band.

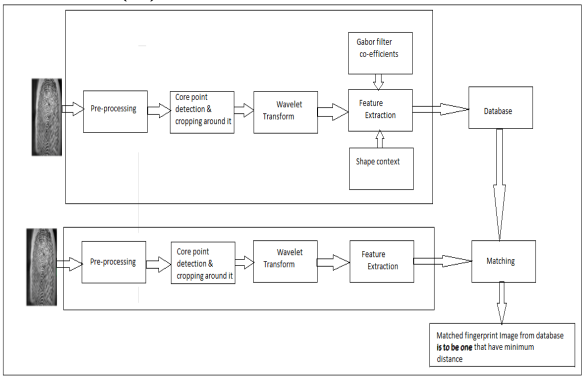

Fig.3: Block diagram

A Gabor filter is applied after wavelet decomposition to remove non-dc components. Fig.4 shows the result of multispectral Gabor filter based fingerprint recognition.

Fig.4. Result of multispectral Gabor filter based fingerprint recognition.

Further this technique is compared with a unique shape context based fingerprint matching technique. Shapes are easy to extract and shape models are considered efficient.

All these texture features contains the characteristics of the fingerprint image and it can represent the fingerprint image. This texture feature is compared and matched with the texture feature of images from database. The matched fingerprint image from database is the one that have minimum distance value. For the matching of database template and test template features different distance metrics can be used like Euclidean distance, Canberra distance, and Manhattan Distance metrics.

We conduct experiments on accuracy on publically available fingerprint databases. The following results are obtained using MATLAB.

After p-reprocessing and decomposing of fingerprint images using wavelets, feature extraction is done. Then, fingerprint recognition is carried out. To know the performance of the system, 8 trials are carried out. In each trial step value is assigned in increasing order from 1 to 8. In first trial step value is set to 1. Step value 1 implies 1 impression of each person in database. For this trial Accuracy, FAR (*False Accept Rate (FAR):* It is the probability that system incorrectly matches with images stored with input image database.) and average error is being calculated. Thus, this procedure is repeated till step value = 8. The values of each parameter in each trial is noted and tabulated as shown in below tables. Then, graphs of each parameter v/s step value are drawn separately as shown in the following fig 5, fig 6 and fig 7, respectively.

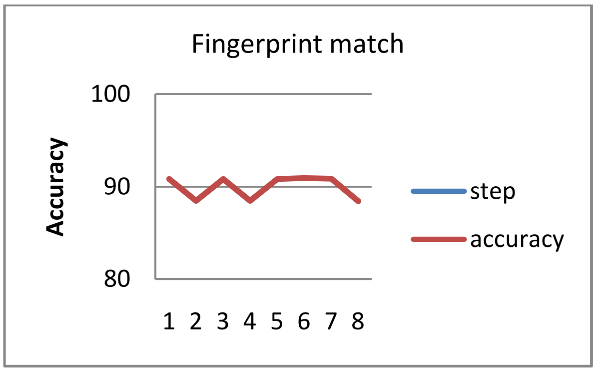

Fig.5. Accuracy v/s Step value

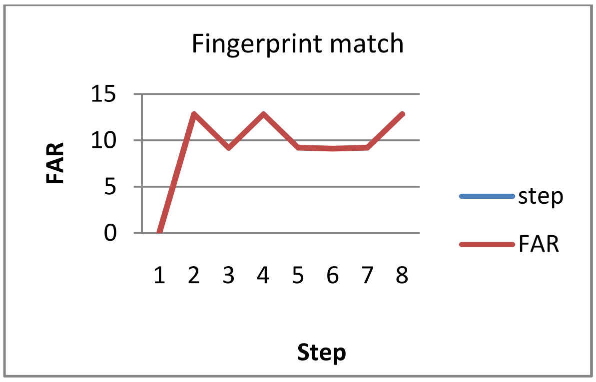

Fig.6. FAR v/s Step value

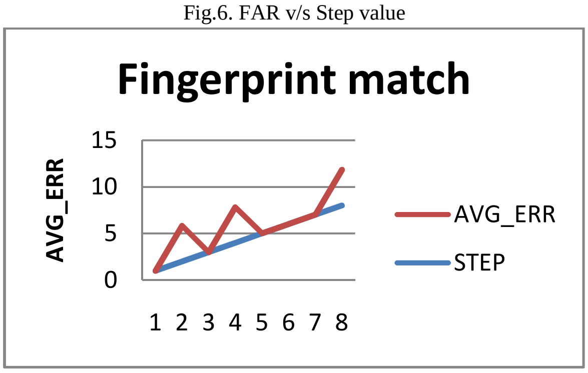

Fig.7. Avg_err v/s Step value

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CONCLUSION

In this paper we analysed the performance of two fingerprint techniques wiz, multispectral Gabor filter based fingerprint recognition and shape context based fingerprint recognition.First, some instances of persons in the database are used for training. Training is the process of applying pre-processing filters on the fingerprint followed by feature extraction. The extracted features are stored in a database. The system is tested by classifying the images of known classes by first, extracting their features followed by comparing the database features. As the actual classes are known, the result of classification is compared with known result to obtain accuracy. Numbers of features are changed to check the change in accuracy. The accuracy was 34.38% of the first technique and that of the second was 91%.

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