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Wavelet based finger print identification for effective biometric security

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ABSTRACT

Fingerprint identification is one the most important biometric technologies since the unchangeable fingerprints during human life span, and the uniqueness of each individual's fingerprint. This paper is an attempt to design and implement a biometric security system in human fingerprint using the concept of wavelet analysis, and a new scheme for human fingerprint recognition using wavelet packet decomposition is presented. Each human fingerprint is described by a subset of band filtered images containing wavelet coefficients. These coefficients characterize the human fingerprint texture and a set of simple statistical measures allows us to form efficient and meaningful feature vectors. Then, a useful and reliable Bayes classifier is employed in order to classify the human fingerprint feature vectors into person classes.

Introduction

Biometric gives an alternative and higher security compared to password or Pin identifications. Nowadays, Various Biometric systems are employed for security purpose like faces recognition, iris recognition and fingerprint recognition. Among all the biometric techniques, fingerprint-based recognition is the most common method which has been successfully used in numerous applications. Everyone is known to have unique, immutable fingerprints. In order to allow queries at a higher semantic level, some particular pictorial objects have to be detected and exploited for indexing.

This paper focuses on human fingerprint detection and recognition, given that such data are of great interest for user's queries. In recent years, considerable progress has been made on the problem of human finger print recognition.

In this paper, we proposed a method for human fingerprint based on a wavelet packet decomposition of the human fingerprint images. Each human fingerprint image has described by a subset of band filtered images containing wavelet co-efficient.

From these wavelet coefficients which characterize the human fingerprint texture, we form compact and meaningful feature vectors, using simple statistical measures. Then, we show how an efficient and reliable Bayes' classifier can be used in order to classify the human fingerprint feature vectors into person classes.

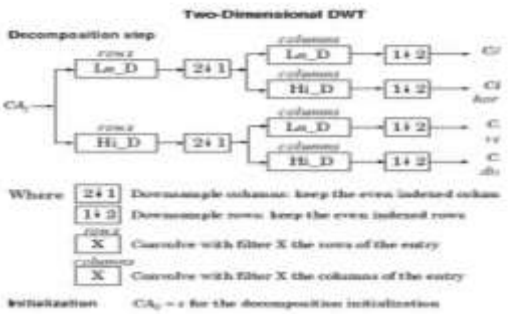

Fig.1. the filter structure of DWT

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Wavelet based Approach

In the last decade, wavelets have become very popular, and new concentration is rising on this topic. The main reason is that an absolute framework has been recently built in particular for what concerns the construction of wavelet bases and efficient algorithms for its computation. We based our attitude on wavelet decomposition of fingerprint images for the reasons that we explain hereafter. The main characteristic of wavelets (if compared to other transformations) is the opportunity to provide a multi resolution analysis of the image for the use of coefficient matrices. Wavelets provide spatial and frequency decomposition of an image at the same time. Computational complexities of wavelets are linear with the number (N) of computed coefficients (E(N)) while other transformations, also in their fast implementation, lead to $N \log_2 N$ complexity. Thus, wavelets are adapted also for dedicated hardware design (Discrete wavelet Transform).

Wavelet packet decomposition

The continues wavelet transform of a 1D signal $f(x)$ is defined as $(W_a f)(b) = \int f(x)\psi_{a,b}(x)dx$................(1)

where $\psi_{a,b}(x) = \frac{1}{\sqrt{a}}\psi\left(\frac{x-b}{a}\right)$. The mother wavelet has to comply with the admissibility criterion to make sure that it is a localized zero-mean function. Equation(1) can be discredited by limiting 'a' and 'b' to a discrete lattice $(a = 2^n, b \in z)$. Normally, some more constraints are focused on to ensure that the transform is non-redundant Complete and constitutes a multi resolution representation of the original signal. This leads to a well organized real space implantation of the transform using quadrature mirror filters. The extension to the 2D case is usually performed by applying a sub band filter bank to the image. Normally, a low pass filter and a band pass filter are used. The convolution with the low pass filter results in a so called Approximation image and the convolution with the band pass filter in a specific direction results in so called Details image. In classical wavelet decomposition, the image is split into an Approximation and Detail images. The Approximation is then dividing itself into a second level approximation and details. The filter structure is shown in fig (1). For N-level decomposition, then signal is decomposed in the following way

$$A_n = \left[H_x * \left[H_y * A_{n-1}\right]_{\downarrow 2,1}\right]_{\downarrow 1,2}$$
$$D_{n1} = \left[H_x * \left[G_y * A_{n-1}\right]_{\downarrow 2,1}\right]_{\downarrow 1,2}$$
$$D_{n2} = \left[G_x * \left[H_y * A_{n-1}\right]_{\downarrow 2,1}\right]_{\downarrow 1,2}$$
$$D_{n3} = \left[G_x * \left[G_y * A_{n-1}\right]_{\downarrow 2,1}\right]_{\downarrow 1,2}$$

where * denotes the convolution operator , $\downarrow 2{,}1 \downarrow (1{,}2)$ sub-sampling along the rows (columns) and $A_0 = I(x, y)$ is the original image. A_0 is obtained by low pass filtering and is the approximation image at scale n. the details images are obtained by band pass filtering in a specific direction and thus contain directional detail information at scale n. the original image is thus represented by a set of sub images at several scales; the wavelet packet decomposition that offers a richer signal analysis (discontinuity in higher derivatives, self similarity and etc.). In that case, the details in addition to the approximations can be split. This results in a wavelet decomposition tree. Usually, an entropy based criterion is used to select the deepest level of the tree, while keeping the meaningful information. In this paper, level-2 of decomposition is selected according to the size of human fingerprint images. The tree structure for level-2 is shown in fig (2). As a result the 16 resulting coefficient matrices derived and used for recognition system which are displayed in fig (3). For each coefficient matrix, a set of statistical features are computed.

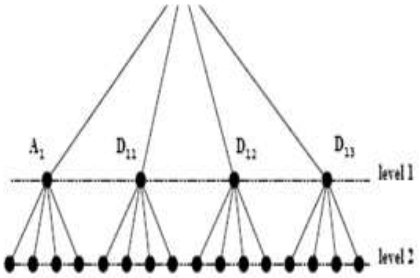

Fig.2. Decomposition Tree of Level-2

Before proceeding with wavelet packet analysis and feature extraction, then, a rectangular area containing the fingerprint is obtained by using wavelet image extension method. After this step of preprocessing, the wavelet packet decomposition is performed on the whole image but the wavelet coefficients will be considered only in the human fingerprint bounding box. There is no need to perform a deeper decomposition because, after the second level, the sizes of imaeges are becoming too small and no more valuable information is obtained. At the second level of decomposition, we obtain on image of Approximation (low resolution) and 15 images of detail images. Therefore, the human fingerprint is described by 16 wavelet coefficient matrices, which represent quite a huge amount of information. It is recognized that, as the complexity of a dimensions of the pattern space, it is important to take decision only on the most essential, so called discriminatory information, which is conveyed by the extracted features. Thus, Due to the need of discriminatory information, this is conveyed by the extracted features. Thus, we are faced with the need of dimensionality reduction. Each of the 16 coefficient matrices contains information about the texture of the human fingerprint.

Bayes classification

When solving a pattern recognition problem, the ultimate objective is to design a recognition system which will classify unknown patterns with the lowest possible probability of misrecognition. The Bayes classifier gives the minimized total average loss. The Bayes classifier used Bayes theorem for classification. The a prior estimate of probability of certain class is converted to the measurement conditioned probability of the state via, $p\left(\frac{w_i}{x}\right) = \frac{p\left(\frac{x}{w_i}\right) p(w_i)}{p(x)}$ where $p(x)$ is the Density function and $p\left(\frac{x}{w_i}\right)$ is the class conditioned probability density functions for feature vector. $p(w_i)$ is a prior class probability .i.e. something is known about the a prior likelihood of the occurrence of class w_i. The observations / feature vector, x is classified by choosing the state of nature, w_i, for which $p\left(\frac{w_i}{x}\right)$ is largest. The quality $p(x)$ is common to all class conditional probabilities. Therefore it represents a scaling factor that may be eliminated. Bayes classifier generally is based on the assumption of an analysis for the various density functions.

Experimental Results

To verity the classifier performance for this approach, collections of 25 fingerprint images are taken. The given image has been decomposed with the help of wavelet decomposition in db-2 method and Shannon entropy also accompanied to extract the texture vector matrix. These decomposed 16 matrixes are verified with the known matrixes. To classify the coefficient we have proposed Bayes classifies which given efficient classification.

The wavelet coefficients for the decomposing images, 16 of single input image, are stored in matrix form. The Bayes classifier generates a posterior probability or measurement conditioned probability of a state of nature with the help of Bayes Rule. Bayes rule generates 25 posterior probability values for a single decomposed image.

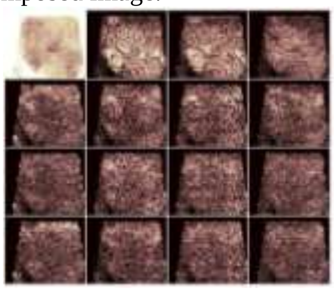

Fig.3. Decomposed fingerprint Image

In this same way, the posterior probability values for the remaining 15 decomposed images are obtained. These values are stored in 25 x 16 resultant matrixes. In the matrix row gives image class and the column gives the decomposed image.

Then, the resultant matrix is analysed in column wise to convert it into Boolean matrix. i.e. it has only 1’s and 0’s. The procedure to convert the resultant matrix into Boolean Matrix is in column wise the largest value is assigned to 1. The other position in that column is filled with zero values.

To generate the result the Boolean matrix is analysed in row wise. The given input image is classified into the class which has large number of 1's in the Boolean matrix. From the results, classification is achieved with very minimum error.

Conclusion

This experiment shows that good recognition rates of approximately 96% is obtained. Thus, the wavelet transform proved to provide an excellent image decomposition and texture description. In addition to this, very fast implementations of wavelet decomposition are available in hardware form. However, detecting features are by itself a different and time consuming process so this will be needed for recognition. Therefore, this will focus on fast and efficient algorithm for feature detection.

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