Accurate analysis on hybrid DWT and SVD based Digital Watermarking for fingerprint security

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Abstract – *Identification of persons by way of biometrics features has evolved significantly over the years. During this time, biometric recognition has received much attention due to its need for security. Among the many existing biometrics, fingerprints are considered to be one of the most practical ones. Techniques such as watermarking been used in attempt to improve security of biometric data. Watermarking is the process of embedding information into a carrier file for the protection of ownership/copyright of music, video or image files. In this paper, to overcome such duplicate things , so a new watermarking algorithm is proposed namely Discrete Wavelet Transform (DWT), Singular Value Decomposition (SVD) The algorithm converted the minutiae into binary watermark, increasing embedded information capacity. The algorithm can satisfy the transparence and robustness of the watermarking system very well and the useful information can be extracted accurately even if the fingerprint is severely regarded.*

Key Words: **Digital watermarking, Discrete Wavelet Trnasform , Singular Value Decomposition , Arnold transform, PSNR, CN (Crossing number).**

1.INTRODUCTION

Biometric systems allow for convenient identification to take place based on a person'sphysical or behavioural characteristics. In comparison with conventional token-based or knowledge based systems, they link identities directly to the owners. Moreover, these identities cannot be given up or lost easily. The uses of biometric procedures have evolved rapidly . In today's life, multimedia data transmissions over the Internet are growing rapidly. A huge problem with intellectual property laws are solved every day, because a lot of people download and redistribute the multimedia data illegally. Plenty of illegal data storages are spread all over the world.

Digital watermarking is one of the methods, that can be used for author's law protection. The basic division of watermarks is into visible and invisible watermarks. The visible watermarks are used for example in TV channels, the invisible watermarks are used to insert information for example about the author for further proof of ownership to that work.

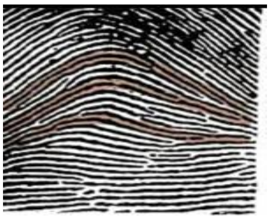
There exist two groups of invisible digital image water-marking systems. The first group, spatial watermarking, uses the spatial domain of an original image for watermark insertion, the second group frequency watermarking, uses the frequency domain for it. it. The frequency domain based watermarking systems are more resistant to a bigger group of possible attacks. In spatial domain, the watermark is embedd into specific pixels of the host fingerprint image. In transform domain, the host image is first transformed into to a frequency domain. DWT is the main transform method used in transform domain watermarking schemes which also used in JPEG and JPEG2000. Since high frequency components are affected by most of the signal processing techniques such as lossy compression, so in order to increase the robustness ,the watermark is preferred to be placed in the low frequency components. But at the same time human visual system is very sensitive to changes in low frequency range. So in dwt based watermarking technique, the dwt coefficients are modified to watermark data. A binary image or a representation of some data or message can be used as a watermark. There are procedures in existence that can help to optimize the security of biometric data,onebeing, information hiding. Information hiding techniques like watermarking can add to the security of biometric systems. Watermarking can be explained as a process of embedding information into a carrier file in order to secure copyright typically ownership. Watermarks can be either visible or non-visible to the human eye. n this study, a wavelet based watermarking algorithm is proposed to enhance the security of fingerprint images. The algorithm embeds secret data into a fingerprint image based on Discrete Wavelet Transform (DWT) and Singular Value Decomposition (SVD). The fingerprint image is first converted to the frequency domain and the SVD is applied on both the original fingerprint image and the watermark image. The singular values (SV's) of the fingerprint image are then modified with the singular values (SV's) of secret image.

1.1 FINGERPRINT PATTERNS

Fig.1.1 Thumb Impression Image representation

Fig.1.2 loops

Fig.1.3 Whorls



Fig,1.4 Arches

A fingerprint consists of three basic patterns of ridges, the arch, loop and whorl as shown in Figure . An arch can be explained as the pattern where ridges begin from one side of the finger, ascent in the centre which develops an arc, and then exits the finger from the opposite side (see Figure a). A loop can be explained as the pattern where ridges begin at one side of a finger to create a curve, and are inclined to exit in the same way they entered (same side- see Figure b). As seen above in Figure 10(c), in the whorl pattern, ridges are structured in a circular position around a central spot on the finger. In general, researchers have discovered that relatives frequently share similar fingerprint patterns, which has led to the concept that fingerprint patterns are genetic.

Arches are actually found in about 5% of fingerprint patterns encountered. The ridges run from one side to the other of the pattern, making no backward turn. Ordinarily, there is no delta in an arch pattern but where there a delta, no re-curving ridge must intervene between the core and delta, There are four types of arch patterns: plain arches, radial arches, ulnar arches and tented arches. Plain arches have an even flow of ridges from one side to the other of the pattern, no "significant up thrusts" and the ridges enter on one side of the impression, and flow out the other with a rise or wave in the center.

Loops occur in about 60-70% of fingerprint patterns encountered. One or more of the ridges enters on either side of the impression, re-curves touches or crosses the line running from the delta to the core and terminates on or in the direction of the side where the ridge or ridges entered. Each loop pattern has is onedelta and one core and has a ridge count. Radial loops are named after the radius ,bone in the forearm that joins thehand on the same side as the thumb.

Whorls are seen in about 25-35% of fingerprint patterns encountered. In a Whorl, some of the ridges make a turn through at least one circuit. Any fingerprint pattern which contains 2 or more deltas will be a whorl pattern. There are four types of whorl patterns. Plain whorls,central pocket whorls, Double loop whorls and accidental whorls

1.2FINGERPRINT MINUTIAE

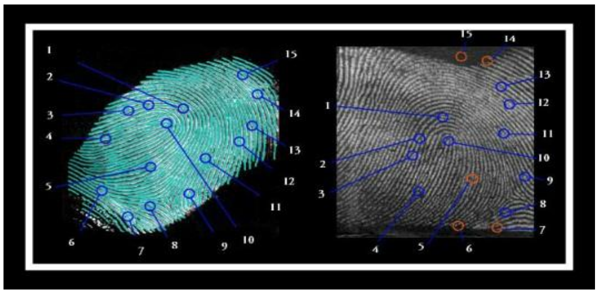


Fig 1.5

A fingerprint is formed from an impression of the pattern of ridges on a finger. Each person has its own fingerprints with the permanent uniqueness. So fingerprints have being used for identification and forensic investigation for a long time. A fingerprint is composed of many ridges and furrows. However, shown by intensive research on fingerprint recognition, fingerprints are not distinguished by their ridges and furrows, but by Minutiae, which are some abnormal points on the ridges (Fig.1 (a)). Minutiae points are most generally the locations of ending or bifurcation of ridges in a fingerprint. Every person's fingerprints are unique, and will always maintain their uniqueness explaining why they have been used for many years for authentication purposes (Barnes, 2011). Ones fingerprint consists of a pattern of ridges and valleys (located on the top of the fingertip). The top layer of skin on a finger contains the ridges while the lower skin particles contain a pattern of valleys. The distinctive types of disjunctions in ridges (minutiae) hold adequate discriminatory data to distinguish between various fingerprints. Ridge bifurcation (the area where the ridge splits) and ridge ending (the area where the ridge ends) are the most important minutiae points.

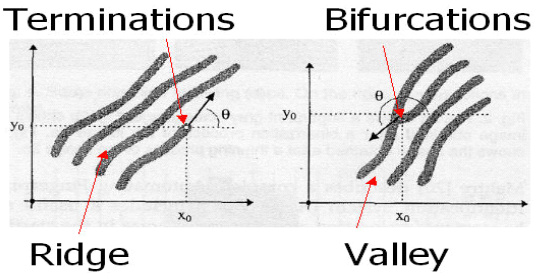


Fig 1.6 Minutiae . (Valley is also referred as Furrow, Termination is also called Ending and Bifurcation is also called Branch)

1.3 MINUTIAE POINTS

The major minutia points in a fingerprint consist of: ridge ending, bifurcation, and short ridge as shown in figure.

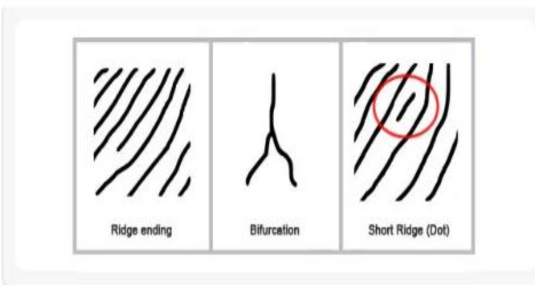


Fig 1.7 Minutiae points

1.2 Ridges-

A single rolled fingerprint may have as many as 100 or more identification points that can be used for identification purposes. These points of impression can be used as points of comparison for fingerprint identification. Depending on how prevalent the ridge characteristics, fewer or more points of comparison may be needed for positive identification.

1.3 Bifurcation-

A bifurcation is a point in a finger image from which two ridges been meet. Bifurcations have the clear appearance of branch points between curved lines. The number and locations of the bifurcations and ridge endings, known as minutiae, which are vary from finger to finger in any particular individual person, and from person to person for any particular finger (for example, the ring finger on the right hand). When a set of fingerprint images is obtained from an individual, the number of minutiae is recorded for each finger. A bifurcation is a point in a finger image from which two ridges been meet.

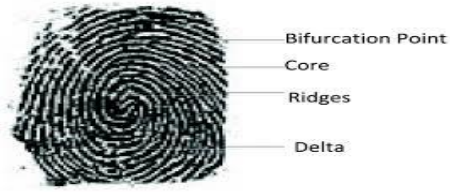


Fig 1.8 Bifurcation

2. WATERMARKING EMBEDDING

2.1 Discrete wavelet tansform (DWT)

Wavelet transform is a time-frequency domain combined analysis method. It has multi-resolution analysis features. Each level of the wavelet decomposition has four sub-images with same size. Let the LL_kstands for the approximation sub image andLH_k, HL_k ,and HH_kstand for the horizontal , vertical and diagonal direction high-frequency detail sub image respectively. Where the variable $k = 1,2,3,...(k \in N)$ is the scale or the level of the wavelet decomposition. DWT is much preferred because it provides both a simultaneous. spatial localization and a frequency spread of the watermark within the host image

The basic idea of discrete wavelet transform in image process is to multi-differentiated decompose the image into sub image of different spatial domain and independent frequencies. After wavelet decomposition, many signal processing, such as compression and filter are likely to change the high frequency wavelet coefficients. If the watermark sequence is embedded into this part, its information may be lost in the processing in sequence, which will reduce the robustness of the watermark [3]. In order to ensure the watermark has a better imperceptibility and robustness, the approximation sub-image LL_3 coefficients are chosen to embed watermark

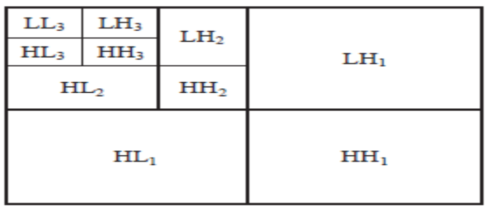


Fig 2.1 : DWT Decomposition

2.2 SINGULAR VALUE DECOMPOSITION (SVD)

If a m*n image is represented as a real matrix A , it can be decomposed as:

$$A= U S V^T$$

It is called a singular value decomposition of A . Where U is a m*m unitary matrix, S is a m*n matrix with nonnegative numbers on the diagonal and zeros on the off diagonal, and V^T denotes the conjugate transpose of V, an n*n unitary matrix. The nonnegative components of S represent the luminance pixel value of the image. Changing them slightly does not affect the image quality and they also don't change much after attacks, watermarking algorithms make use of these two properties.

2.3 ARNOLD TRANSFORM

Arnold transform is commonly known as cat face transform, it randomizes the original organization of pixels in an original image. However, if iterated enough times, the original image reappears. Arnold transform is the position shift of one to-one point. Arnold transformation on digital image of size N×N defined by Eq. 1 is a one-to-one transformation

$$\begin{bmatrix} i' \\ j' \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ 1 & 2 \end{bmatrix} \begin{bmatrix} i \\ j \end{bmatrix} \pmod{N} \quad \text{.......... (1)}$$

Where i, j ∈ {0, 1, ...,N-1}. Where (i, j) is the location coordinates of the original image pixels and (i', j') is the location co-ordinates of image pixels that after transform When all the coordinates are transformed, the image we obtain is scrambled images.

3. PROPOSED WATERMARKING ALGORITHM

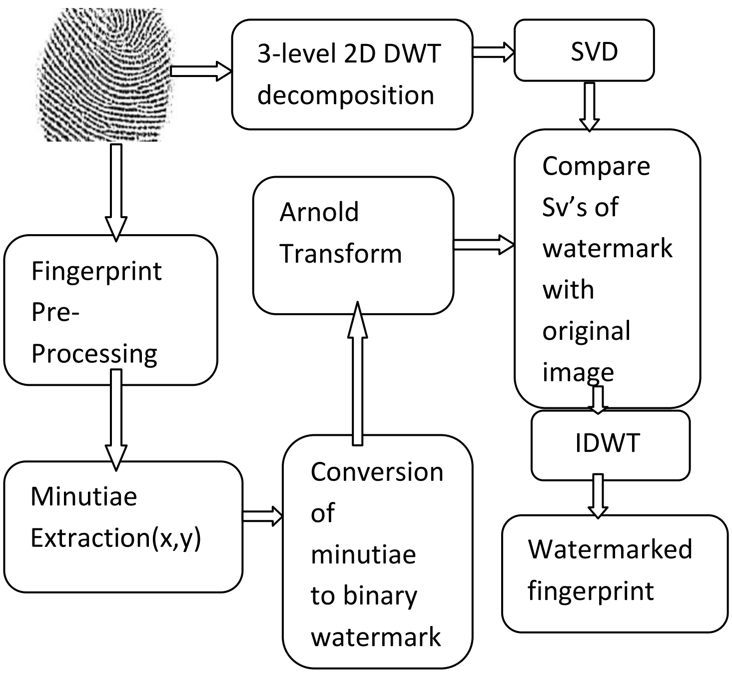


Fig.3.1 Block Diagram of Watermarking Embedding System

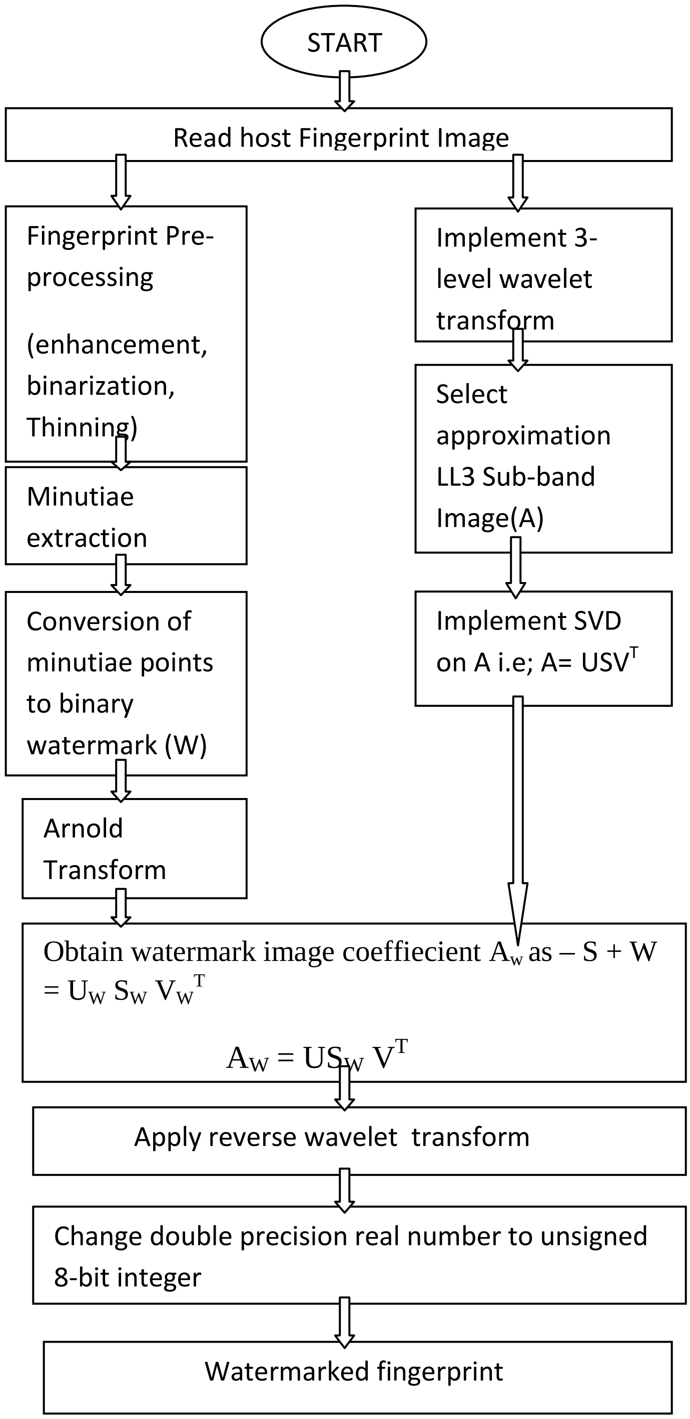


Fig..3.2 flow diagram of Watermarking (Minutiae) Embedding.

The proposed watermarking scheme has been shown in Fig. 3.The cover image is the fingerprint while the watermark is a binary image equivalent to the minutiae of the cover fingerprint. The scheme has been divided into two sections:

A. Watermark (Minutiae) Embedding

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B. Watermark (Minutiae) Extraction

3.1 Watermark (Minutiae) Embedding scheme

The steps of embedding watermarks can be described as follows:

Step1-The fingerprint image is decomposed into its 3-level two-dimensional DWT coefficients. Out of the all sub-bands, only LL_3 approximation sub-band is selected (denotes as A).

Step 2- Fingerprint Preprocessing

A real fingerprint might have discontinuities that might lead to spurious minutiae. Therefore, minutiae extraction is preceded by fingerprint preprocessing, which involves normalization, ridge orientation and frequency estimation. Finally, the ridge orientation and frequency estimation values are used for filtering the fingerprint using Gabor wavelet. Gabor filtering enhances the ridges oriented in the direction of the local orientation, and decreases anything oriented differently. Hence, the filter increases the contrast between the foreground ridges and the background, whilst effectively reducing noise. The filtered output is then binarized and thinned to one-pixel width.

Step 3-Minutiae Extraction

Minutiae points such as end points and bifurcation points are identified by calculating Crossing number (CN). CNvalue isdefined as half the sum of the differences between pairs of adjacent pixels in the eight neighborhoods.

$CN=0.5 P_i - P_{i+1}$ |, $P_1 = P_9$

where Pi is the pixel value in the neighborhood of a pixel P. If crossing Number is 1, 2 and 3 or greater than 3 then minutiae points are classified as Termination, Normal ridge and Bifurcation respectively. it is shown as

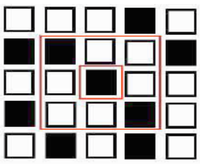

Fig.a Crossing number=2 Normal ridge pixel

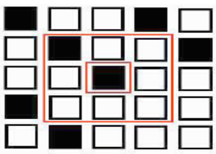

Fig.b Crossing number=1 Termination

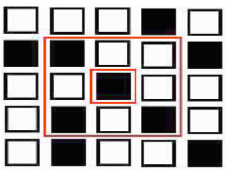

Fig.c Crossing number=3 Bifurcation points

Step 4- Perform Arnold transform for watermark image W. which is shown in the following figure-

Fig. 3.3 Arnold transform watermark

Step 5- We obtain the watermarked image coefficients matrix A_W through the following three steps:

1. $A = USV^T$
2. $S + \alpha W = U_W S_W V_W^T$
3. $A_W = US_W V^T$

Step 6-Apply reverse wavelet transform for original image, and then changing the double-precision real number to unsigned 8-bit integer. Thus, obtain the watermarked image in which watermark are embedded.

3.2 Watermark (Minutiae) Extraction scheme

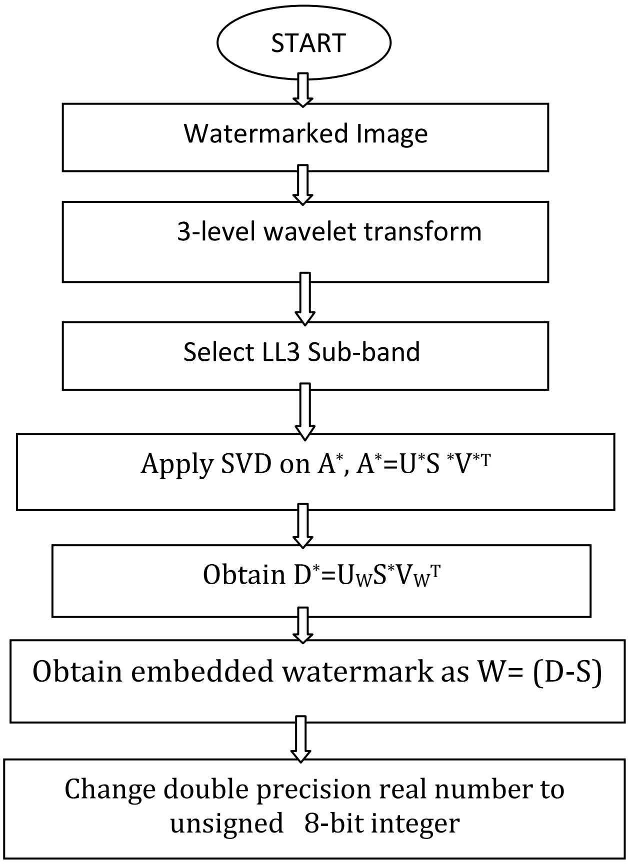

Fig. 3.4 Flow diagram of Watermark (Minutiae) Extraction

We can extract the watermark by the reverse
Calculation of watermark extraction:

Step 1-Perform a 3-level wavelet transform using haar wavelet for watermarked image, and obtain low-frequency wavelet coefficient LL_3 (denotes as A*).
Step 2-Apply SVD to the **A***, such that **$A^* = U^* S_1^* V^{T*}$, and obtain U *,S_1* and V^T*.**
Step 3: Now by using values of U w, V_W and S_1 *, obtain D* according $D^* = U_W S_1 {}^*V^T$, in the end we canobtain the watermark which is embedded according to
$W^* = (D^* - S) / \alpha$.
Step 4-Finally changing the double-precision real number to unsigned 8-bit integer for watermark image, and perform inverse Arnold transform for watermark image.
Step 5- Minutiae points are then regenerated by stacking bit planes and converting them back to decimal system.

4. CONCLUSION

In this paper, we proposed a watermarking algorithm for fingerprint images based on hybrid DWT and SVD domain. The purpose of the proposed watermarking scheme is to extract minutiae from even tampered fingerprint. Applying the Arnold transform to the watermark makes the results even better.

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