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Dual Image Watermarking By Using Hybrid Technique Based on DCT-DWT and SVD

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Abstract: This research presents a novel watermarking technique to embed one or more watermarks into single cover image. This algorithm makes use of the strengths of 1 level Discrete Wavelet Transform (DWT) and Singular Value Decomposition (SVD). Discrete Cosine Transform (DCT) for compression, quantization and conversion of facial image to a binary image. Take a one fingerprint image (FI) and two watermark image (WI), one is binary text image and other is facial image. The focal image is compressed using the DCT compression method. Text image is embedded into HL band and Facial image is embedded into a LH band of the cover FI. The comparative evaluation of FIs showed better outcomes with computed Peak Signal Noise Ratio (PSNR) and Mean Square Error (MSE) for WI.
Keywords: DWT, DCT, SVD, Minutiae Extraction, Compression, PSNR, MSE.

I. INTRODUCTION

The fingerprint is a kind of texture image, usually has alternately arranged ridges and valleys which forms a sinusoidal-shaped plane wave. The frequency and orientation are the most significant intrinsic properties of FI [1].

Digital contents such as pictures or videos can be copied without producing any quality corruption of the content. This leads to the digital watermark (DW) to be more important [2]. The DW of multi-media pictures and videos is normally used for ownership authentication, copyright protection (CP), classification control and usage authentication. The common characteristics of good DW are maintaining the insensitivity, secrecy robustness and insurance of the embedded watermark(EW) pictures during the communication. Moreover, the key requirement is that the quality of the picture should not be affected by a secure watermarking procedure. The watermark message should carry all possible identification information that is required for the authentication process.Watermarking techniques have been used in biometric system. In the biometric-based authentication system, Watermark is used to verify the genesis of the biometric sample. Fingerprint has become the most common biometric method due to their reliability and uniqueness [2]

II. DWT-DCT-SVD ALGORITHM

Discrete Wavelet Transform (DWT)- The main feature of wavelet transformation (WT) is to analyze the function at different levels of resolution. It is a transformation that splits the data into two components: frequency and time. The multi-resolution traits of DWT offers desirable time resolution and terrible frequency decision at high frequencies (HF) and at low frequencies (LF) right frequency decision and poor time decision. Therefore, it's miles more suitable for brief duration of HF and longer duration of LF. This property makes it efficient for image perspective. In image enhancement (IE), the LF components i.e., low intensity pixel values are analyzed more accurately. Let $M \times N$ is the size of input dark image $I(x,y)$, then

$f(u,v)=\Sigma\Sigma 2^{j}\Phi(x-u,y-v)I(x,y)dxdy$

where $f(u,v)$ is the DWT transformed data in the frequency domain and $\Phi(x-u,y-v)$ is a scaling function [3].

A. *Discrete Cosine Transform* (DCT)

A DCT expresses a finite sequence of statistics factors in terms of a sum of cosine capabilities oscillating at special frequencies. DCT are crucial to numerous programs in technological know-how and engineering, from lossy compression of audio (e.g. MP3) and pictures (e.g. JPEG) (where small HF additives may be discarded), to spectral methods for the numerical answer of partial differential equations.

This DCT turned into first time utilized in 1974 [4]. DCT is a quick set of rules just like FFT. The DCT is a way for converting a signal into primary frequency additives. It is widely used for extracting the capabilities [4].

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III. SINGULAR VALUE DECOMPOSITION (SVD)

SVD is one of the linear algebraic techniques which diagonalizes a matrix into three matrices. From the perspective of IP, a picture can be viewed as nonnegative scalar entries. The SVD of a picture A of size M x N is defined as

$A=USV^T$

Where U and V are orthogonal matrices, $U^TU=I$, $V^TV=I$, and S=diag ($\lambda_1, \lambda_2, \lambda_3, \ldots\ldots \lambda_r$). The diagonal values of S are called the singular values (SV) of A and each value represents the luminance of an A where r is the rank of A. The columns of U and V are referred to as the left and proper singular vectors of A and it preserves the geometrical propertis of the photograph. US are called the principal components of A. UV together called as the SVD Subspace of A.

The following are the some of the properties of SVD.

1) The SV of an picture have very stability, i.E. Whilst a small perturbation is introduced to a picture, huge version of its SV does not arise.

2) For an picture A, row flipped of A, Arf and column flipped of A, Acf have the equal non-zero SV.

Three) SVs constitute intrinsic houses [5].

IV. LITERATURE SURVEY

Abir Raza Baig (2015) et al present that The proposed method deals with both local (minutia or singular points; ridge termination, bifurcation, broken ridges, right ridges, core and delta) and global capabilities (ridge orientation and ridge frequency), whilst maintaining the proper ridge-valley systems and getting rid of noise on the same time. The proposed design establishes scalability, accessibility and versatility [6].

Kevin Arighi Yusharyahya (2014) et al present that attempts to evaluate the effectiveness of IE by using comparing three specific algorithms, which includes the use of power transformation in the FD, smoothing on the SD and contextual filtering using Gabor Filters. The new outcomes absolutely confirmed upgrades after enhancing poor great FI, specially while the picture is processed in the FD [7].

Shehnaz M. (2015) et al present that Fingerprint identification is very popular among the identification in biometric security systems. The identity technique comprises of IE, FE and sample type. The adjustment of gray scale values improves the intensity values of the photo. A place mask is generated which provides a strong sampling window to extract features. Multiple CS based classifier at the side of maximum probability matching is used for sample identification. Using the samples taken from FVC2002 database the performance of the proposed method is tested [8].

Waziha Kabir (2013) et al present that a novel and effective three-level scheme to beautify low-satisfactory FI. The first-level includes an orientated linear anisotropic diffusion filter with a local ridge orientation estimation that differs from conventional estimation approach. The second and the third stages consist of an oriented local ridge compensation filter and a novel angular filter, respectively [9].

Randa Atta (2012) et al. An enter image is decomposed right into a low sub-band picture and reversed L-form blocks containing the HF coefficients of the DCT Pyramid. The SV matrix of the equalised low sub-band picture is then predicted from the mixture between the singular matrix of the low sub-band picture and the singular matrix of its international HE. The qualitative and quantitative performances of the proposed method are as compared with those of traditional picture equalisation including widespread HE and local HE, as well as some state-of-the-art techniques such as SV equalisation technique [10].

Amira Bouaziz (2011) et al. Proposed Bat algorithm has proven to qualitatively and numerically enhance the FI fine through contrast manipulation on the overall stage of noise eradication and quality metrics in addition to ridge structure clarification and minutiae detection specificities [11].

V. PROPOSED WORK

This method presents a hybrid method for fingerprint enhancement and compression using DWT-SVD-DCT. Firstly, Take a one FE and two WI, one is binary text image and another is facial image. The facial image is compressed using DCT compression method. DWT is used for watermarking which divide the image into four sub bands: Low frequency and High frequency (Low Low, Low High, High Low, High High). In this approach, LH and HL bands are used for enhancement and embedding process. Apply SVD to LH and HL bands for preserving image quality. Embed cover image LH and HL band into tHL and fLH band of text image and facial image. Extract minutiae points of cover image for validation and authentication. Finally, extract the text image and facial image from watermarked image using DWT-SVD.

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A. Embedding Process

1)Input: Cover Image (CI), Text Watermark Image (WI) and Face Watermark Image

2)Output: Watermarked Image

3) Select a gray image as a cover image and two watermark images.
4) Perform 1-DWT on the CI, binary text watermark image and facial watermark image to divide into four groups:LL,LH,HL,HH and tLL,tLH,tHL,tHH, fLL,fLH,fHL,fHH.
5) Apply SVD on LH and HL band of cover image using this formula.

$$[cu, cs, cv] = svd\,(LH) \qquad (1)$$

$$[cu1, cs1, cv1] = svd\,(HL) \qquad (2)$$

Where cu, cv and $cu1, cv1$ are orthogonal matrices of LH and HL band, cs and $cs1$ are singular matrix

6) Perform SVD on the tLH and tHL coefficient of the text watermark image.

$$[tu, ts, tv] = svd\,(tLH) \qquad (3)$$

$$[tu1, ts1, tv1] = svd(tHL) \qquad (4)$$

7) DCT is implemented for compression, quantization and conversion of the grayscale facial image to a binary image. In the equation, x, is the facial image consuming N x M pixels, x (m, n) is the intensity of the pixel in column n and row m of the image, and y (j, k) is the DCT coefficient in column k and row j of the DCT matrix.

.

$$y(j,k) = \sqrt{\frac{2}{M}}\sqrt{\frac{2}{N}}\alpha_j\alpha_k \sum_{x=0}^{M-1}\sum_{y=0}^{N-1}\{x(m,n) * \cos\frac{(2m+1)j\pi}{2M}\cos\frac{(2n+1)k\pi}{2N}\} \ldots\ldots\ldots (5)$$

Where

$$\alpha_j = \begin{cases}\frac{1}{\sqrt{2}} & j = 0 \ or \ j = 1,2,\ldots\ldots,N-1 \\ 1 & \end{cases}$$

$$\alpha_k = \begin{cases}\frac{1}{\sqrt{2}} & k = 0 \ or \ k = 1,2,\ldots\ldots,N-1 \\ 1 & \end{cases}$$

8) Divide the face into 8X8 pixel block. Each block is compressed using quantization matrix 'Q_M'. The quality level range is between 1 to 100.

$$Q_{50} = \begin{bmatrix} 16 & 11 & 10 & 16 & 24 & 40 & 51 & 61 \\ 12 & 12 & 14 & 19 & 26 & 58 & 60 & 55 \\ 14 & 13 & 16 & 24 & 40 & 57 & 69 & 56 \\ 14 & 17 & 22 & 29 & 51 & 87 & 80 & 62 \\ 18 & 22 & 37 & 56 & 68 & 109 & 103 & 77 \\ 24 & 35 & 55 & 64 & 81 & 104 & 113 & 92 \\ 49 & 64 & 78 & 87 & 103 & 121 & 120 & 101 \\ 72 & 92 & 95 & 98 & 112 & 100 & 103 & 99 \end{bmatrix}$$

9) The quantized DCT coefficient is generated using rounding to the closest integer number using this equation:

$$B_{(j,k)} = round\frac{Y_{(j,k)}}{Q_{(j,k)}} \qquad (6)$$

Where The $y_{(j,k)}$ refers to the DCT coefficients in row j and column k of the input image, $Q_{(j,k)}$ is quantized matrix

10) Perform SVD on the fLH and fHL coefficient of the facial WI.

$$[fu, fs, fv] = svd\,(fLH) \qquad (7)$$

$$[fu1, fs1, fv1] = svd\,(fHL) \qquad (8)$$

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11) Modify the SV of S_{text} and S_{face} by embedding the SV of WI such that

$$S_{text} = cs1 + alpha * ts1 \quad (9)$$

$$S_{face} = cs + alpha * fs \quad (10)$$

Where alpha denotes the scaling factor is initialized to 0.01, is used to have power over the power of watermark signal

12) Embed singular matrices with orthogonal matrices for final WI as W_{LH} and W_{HL} with below formula:

$$W_{LH} = cu \times S_{face} \times cv' \quad (11)$$

$$W_{HL} = cu1 \times S_{text} \times cv1' \quad (12)$$

13) The image is reconstructed by relating inverse of DCT operation, according to Equation. 13:

$$x(m,n) = \sqrt{\frac{2}{M}}\sqrt{\frac{2}{N}}a_j a_k \sum_{x=0}^{M-1}\sum_{y=0}^{N-1}\{y(j,k) * \cos\frac{(2m+1)j\pi}{2M}\cos\frac{(2n+1)k\pi}{2N}\} \ldots\ldots\ldots(13)$$

14) Perform the one level inverse DWT (IDWT) on the DWT transformed image, to obtain the watermarked original image on four coefficients: LL, wimg_LH, wimg_HL,HH.
15) Binarize the CI then thining the image.
16) Find the ridge points of an image.
17) Find bifurcation points of an image for minutiae extraction.
18) Calculate the percentage of unaffected minutiae point.

B. Extraction Process

Input: Watermarked Image (WI)

Output: Extracted Text Image and Face Image

1) Apply one level DWT transform to split the WI W into four overlapping sub-bands (extLL,extLH,extHL,extHH).
2) Apply SVD to extLH and extHL sub band i.e.,

$$[extu, exts, extv] = svd(\text{extLH}) \quad (14)$$

$$[extu1, exts1, extv1] = svd(\text{extHL}) \quad (15)$$

3) Modify the SV of ext_{LH} and ext_{HL} by extracting the SV of WI such that

$$ext_{LH} = \frac{(exts - cs)}{alpha} \quad (16)$$

$$ext_{HL} = \frac{(exts1 - cs1)}{alpha} \quad (17)$$

4) Extract singular matrices with orthogonal matrices for final extracted WI as $ewat_{LH}$ and $ewat_{HL}$ with below formula:

$$ewat_{LH} = fu * ext_{LH} * fv' \quad (18)$$

$$ewat_{HL} = tu1 * ext_{HL} * tv1' \quad (19)$$

5) Perform the one level inverse DWT (IDWT) on the DWT transformed image, to obtain the original WI on four coefficients fLL,ewat_LH,fHL,fHH and tLL,tLH,ewat_HL,tHH.
6) Calculate Peak Signal Noise Ratio (PSNR) and Mean Square Error (MSE) value of watermarked and cover image.

$$MSE(x) = \frac{1}{N}||x - x^\wedge||^2 = \frac{1}{N}\sum_{i=1}^{N}(x - x^\wedge)^2 \quad (20)$$

Where x is cover image, x^ is watermarked image, N is the size of cover image

$$PSNR(x) = \frac{10 \, X \log((double(m).\wedge 2))}{MSE(x)} \quad (21)$$

Where m is the maximum value of the cover image

7) Calculate normalized cross-correlation between CI and WI.

$$NC = \frac{sum(sum(O\_img X\ w\_img))}{sum(sum(O\_img\ X\ w\_img))} \quad (22)$$

Where NC is normalized cross-correlation, O_img is cover image and w_img is a WI.

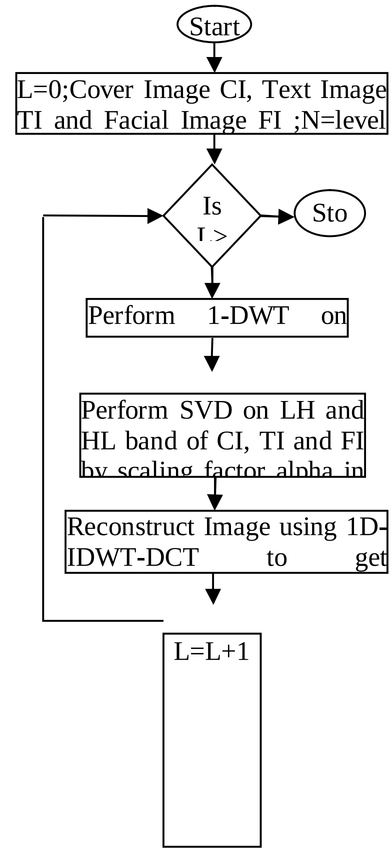

Fig1. Flow Chart of Embedding Algorithm

ig1, initialize the value of L is zero, level of decomposition is N, then perform one level DWT on both CI and WI to get low frequency and high frequency band coefficients. After that, take the low frequency band for SVD. Finally, apply inverse DWT to produce a WI after embedding process.

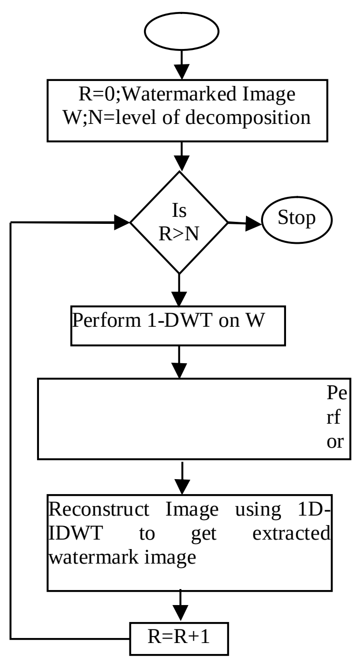

Fig2. Flow Chart of Extraction Algorithm

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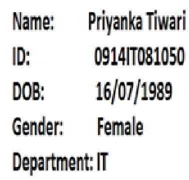
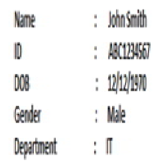
In Fig2, initialize the value of R is zero, level of decomposition is N, then perform one level DWT on WI to get LF and HF band coefficients. After that, take the low frequency band for SVD. Apply inverse DWT to produce an extracted WI after the extraction process.

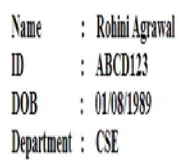
101 102 103 104

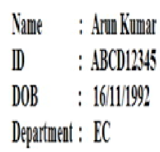
Fig3. Fingerprint Images





Text_img Text_img1





Text_img2 Text_img3

Fig4. Text Images

1011 1012 1013 1014

Fig5. Face Images

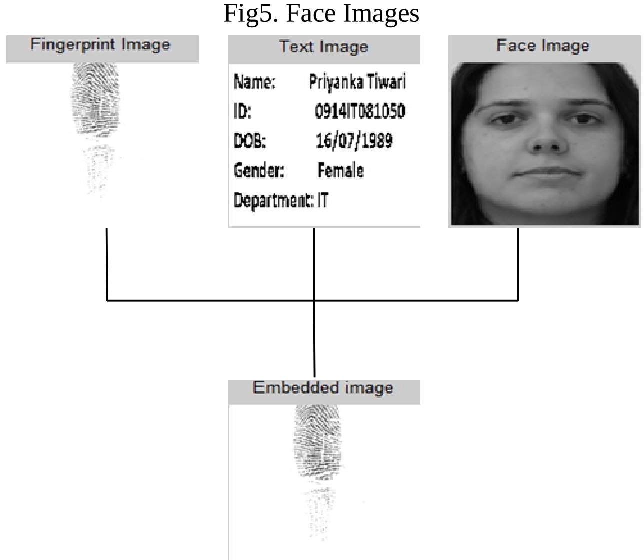


Fig6. Watermarked Image

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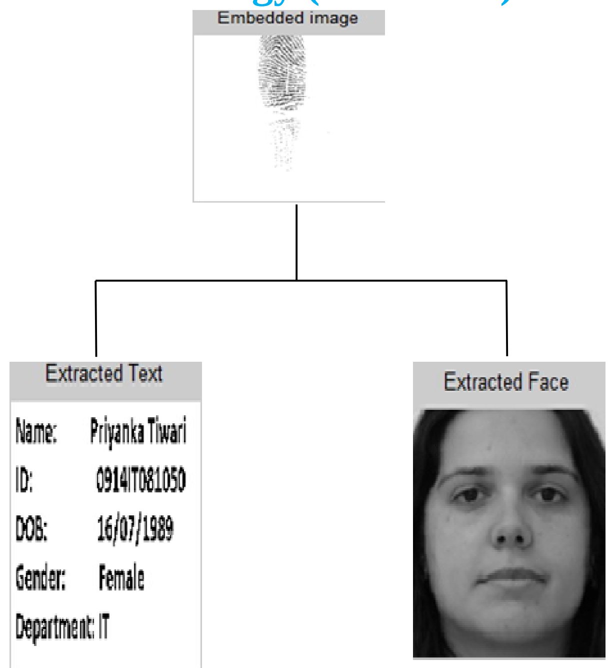

Fig7. Extracted Text and Face Image

Cover Image	Text Image	Face Image	Base PSNR	Proposed PSNR
101	Text_img	1011	29.01	86.98
102	Text_img1	1012	30.06	89.77
103	Text_img2	1013	29.20	87.77
104	Text_img3	1014	28.81	86.60

Table1. PSNR Comparison between Base and Proposed System For Watermarked Image

Cover Image	Text Image	Face Image	Base MSE	Proposed MSE
101	Text_img	1011	0.00012	0.000043
102	Text_img1	1012	0.000062	0.000023
103	Text_img2	1013	0.00011	0.000036
104	Text_img3	1014	0.00014	0.000047

Table2. MSE Comparison between Base and Proposed System for Watermarked Image

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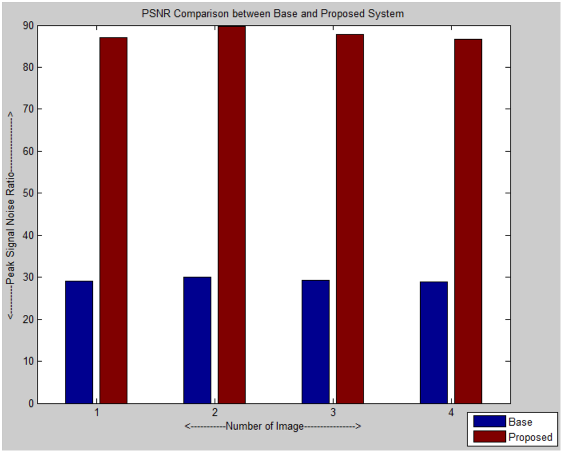
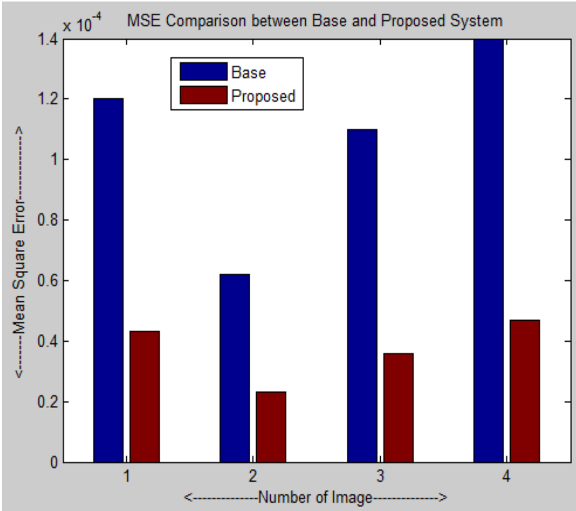
Extracted Face Image	Base PSNR	Proposed PSNR	Proposed Uncorrupted MP (%)
1011	28.09	98.44	99.81
1012	26.90	97.53	99.74
1013	26.11	96.90	99.79
1014	26.79	97.61	99.76

Table3. PSNR Comparison between Base and Proposed System for Extracted Face Image and Minutiae Extraction



Graph1. PSNR Comparison Between Base and Proposed System For Watermarked Image



Graph 2. MSE Comparison between Base and Proposed System for Watermarked Image

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VI. CONCLUSION

This method proposed a new method for fingerprint watermarking and enhancement using DWT-SVD-DCT algorithm. In this algorithm, user face and text data (Name, ID, DOB, Department) is used for authentication. The experimental result presented that embedding multiple watermark images do not affect the minutiae points. This method achieves the robustness in terms of PSNR (98db) and MSE (0.000023db). In the future, geometric attack can be applied to this algorithm for robustness and security.

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