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Dual Image Signature Method using DWT and SVD in YCbCr Colour Space

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***Abstract:** The digital data can be easily modified and copied, so it is not secure, so owner authentication is required to prevent this unauthorised access of digital data. Image signature (water mark) is required to embed with digital data. The Discrete Wavelet Transform (DWT) supports image signature algorithms possess dual resolution attaining imperceptibility. The Singular Value Decomposition (SVD) supports to achieving the robustness in order to add the signature information to the singular values of the diagonal matrix.. In this work implementing dual image signature method using DWT and SVD in YCbCr colour space. The cover image is embedded with dual images to achieve better security from unauthorized persons. The proposed method improves the robustness and imperceptibility of the cover image.*

***Keywords:** DWT, SVD, Imperceptibility, Robustness*

I. INTRODUCTION

These days, the data is accessible in digital form. It is informal to make a duplicate or change the data. So, it needs a technique to avoid duplication of data. Image signature or watermarking method is one of the widespread ways out to this problem. In watermarking method, an information signal is hiding another image. The information image has called cover image and the other image has called watermark image. There are numerous applications using image signature method like ownership, fingerprinting, copy control, authentication. Wavelet transform decomposes a signal into asset of basic functions these basis functions are called wavelets.

A. Discrete Wavelet Transform (DWT)

Wavelet transforms are centred on small wavelets with partial duration. The scaled version wavelets allow examining the signal in different scale. The filter bank contains high and low pass filter at decomposition phase.

When the signal passes over these filters, it splits into 2 bands. The low pass filter extracts the coarse data of the signal and also provides an average of operation. The high pass filter extracts the detail data of the signal and also provides a difference operation. The filtering operation output is reduced by 2.

A 2D transform is able by performing 2 separate 1D transforms. 1st, the image is filtered along the row and reduced by 2. It is then filtering the sub image along the column and reduced by 2.

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This splitting the image into 4 bands, namely, LH, LL, HL and HH respectively as shown in figure 1. Further level decomposition can be completed by splitting LL band once again.

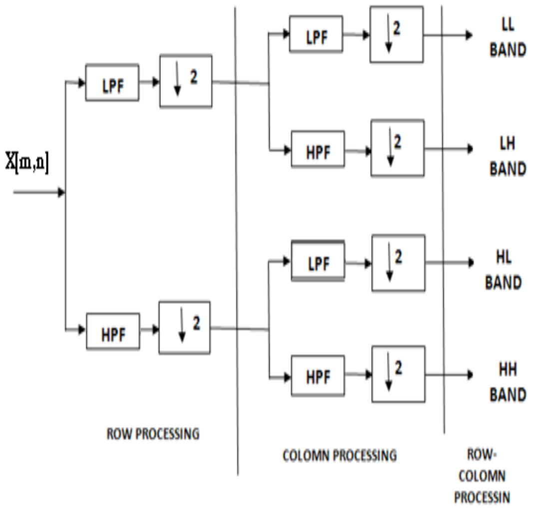


Figure 1: Level Decomposition using DWT

B. SVD

An image can be seen as a matrix with non negative scalar entries from the perspective of image processing. The SVD is a well known linear algebraic technique for factorizing a given matrix. The SVD is familiarly related to the family theory of diagonalizing a symmetric matrix. P is an N × N square matrix with rank r, r ≤ N. The SVD of P is represented as

$$P = USV^T = \begin{bmatrix} U_{1,1} & \cdots & U_{1,N} \\ U_{2,1} & \cdots & U_{2,N} \\ \vdots & \ddots & \vdots \\ U_{N,1} & \cdots & U_{N,N} \end{bmatrix} \begin{bmatrix} S_1 & 0 & \cdots & 0 \\ 0 & S_2 & \cdots & 0 \\ \vdots & 0 & \cdots & \vdots \\ 0 & 0 & \cdots & S_N \end{bmatrix} \begin{bmatrix} V_{1,1} & \cdots & V_{1,N} \\ V_{2,1} & \cdots & V_{2,N} \\ \vdots & \ddots & \vdots \\ V_{N,1} & \cdots & V_{N,N} \end{bmatrix}$$

U and V= N×N orthogonal matrices
S =N×N singular, diagonal matrix

II. LITERATURE SURVEY

Watermark inserting can be done using spatial or frequency domain techniques. Several transforms i.e. FrFT, DFT, DHT, DCT, SVD and DWT are used to implant the watermark into the particular transform coefficients of the cover image. In this work implementing dual image signature method using DWT and SVD methods. The proposed watermark embedding improves the imperceptibility and robustness of the cover image.

III. PROPOSED ALGORITHM

A. Dual Watermark Embedding

The block diagram of dual watermark embedding is shown in figure 2. Embedding is the process of inserting a watermark image into a cover image.

- **Watermark Embedding Algorithm**
- Read the RGB cover image of size N*N*3.
- Convert the RGB color space into YC_bC_r color space.
- Read the Y channel of the cover image, because the watermark is embedded to Y channel.

Embedding of watermark1 image with Y channel cover image.

- Apply 1st level DWT to the Y channel cover image, which is decomposed into four sub bands, namely LL, LH, HL and HH.
- Apply 1st level DWT to the LL band, which is decomposed into 4 sub bands, namely LL_1, LH_1, HL_1 and HH_1.
- Apply SVD to LH_1 band.
- Read the gray watermark1 image
- Apply DWT to the gray watermark1 image, which is decomposed into 4 sub bands, namely LL, *LH, HL and HH.*
- Read the watermark1image of LH (say Wm), which is equal to the size of $LH_1$of Y channel cover image.
- Apply SVD to Wm.
- Embedding the watermark1image with Y channel cover image by changing the singular values of LH_1 using Wm, which results Y channel cover image with watermarked1image.
- **Embedding of watermark2 image with Y channel cover image with watermarked1image**.
- Apply inverse SVD and 2 level inverse DWT to Y channel cover image with watermarked1 image (say 1st watermarked image).
- Apply 1st level DWT to the 1st watermarked image, which is decomposed into 4 sub bands, namely LL_2, LH_2, HL_2 and HH_2.
- Apply 1st level DWT to the LL_2 band, which is decomposed into four sub bands, namely LL_{21}, LH_{22}, HL_{22} and HH_{22}.
- Apply SVD to LH_{22} band.
- Read the gray watermark2 image
- Apply DWT to the gray watermark2 image, which is decomposed into four sub bands, namely LL, LH, HL and HH.

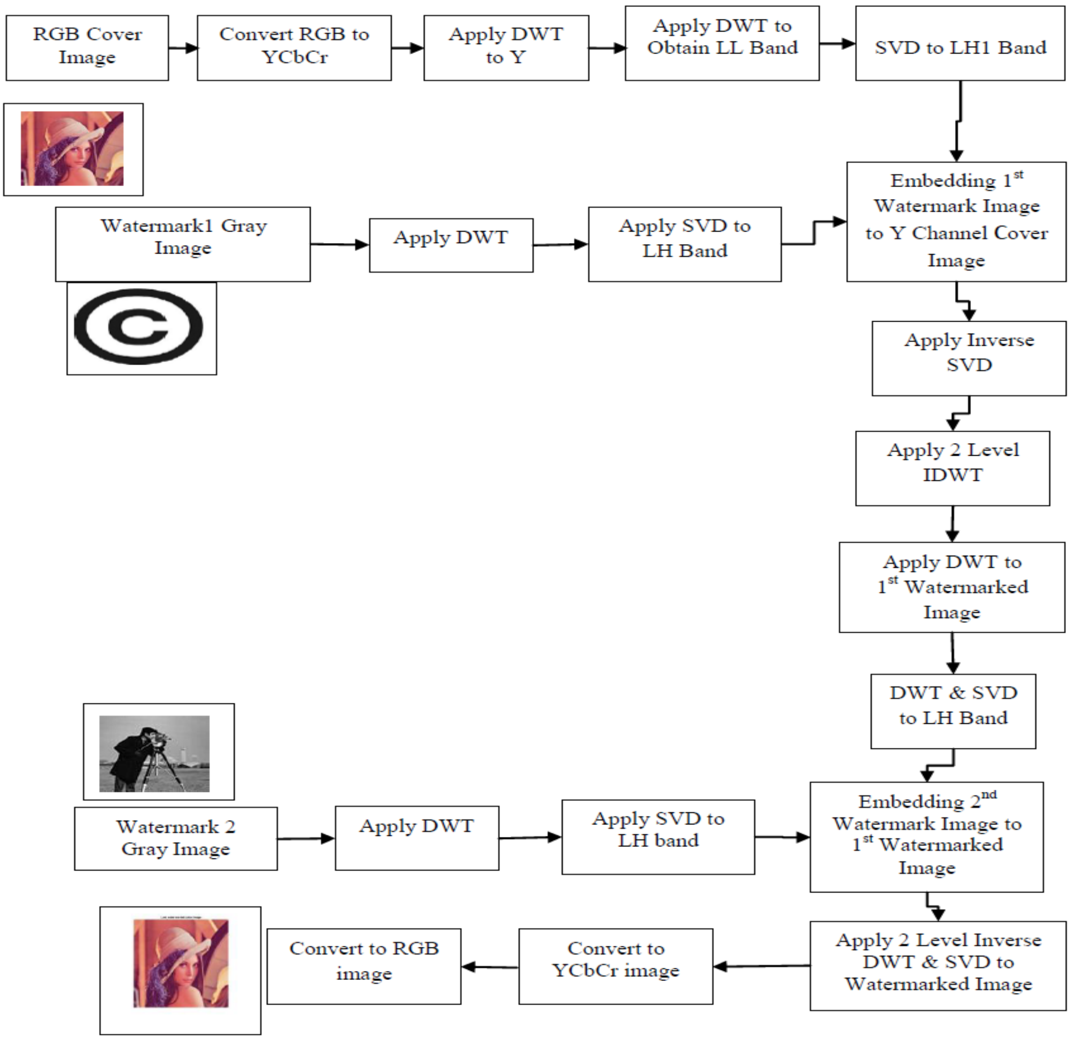


Figure 2: Block Diagram of Dual Watermark Embedding

- Read the watermark2 image of LH (say Xm), which is equal to the size of LH_{22} of 1st watermarked image.
- Apply SVD to Xm.
- Embedding the watermark2 image with 1st watermarked image by changing the singular values of LH_{22} using Xm, which results Y channel cover image with watermarked1image and watermarked1image.
- After embedding two watermark images, the Y channel is concatenated with $C_{b,}C_r$ components.
- Convert YC_bC_r image into RGB color space, which is dual watermarked RGB cover image.

B. Dual Watermark Decryption

Dual watermark decryption is exactly the inverse of watermark image embedding.

- Read the dual watermarked cover (RGB) image of size N*N*3.
- Convert the RGB color space into YCbCr color space.
- The algorithm is implemented on Y channel, because watermarks are embedded in Y channel.
- Apply 2-level DWT to the Y channel, which is divided into 4 sub bands, namely LL, LH, HL and HH.
- Extracting watermark1 in LH_1 using SVD singular values.
- 1st watermarked gray image is obtained by applying ISVD followed by IDWT
- Similarly 2nd watermarked gray image is obtained by applying ISVD followed by IDWT to the above image.

The RGB cover is converted in to YCbCr then divided in to 3 planes Y, Cb, Cr. DWT is applied to Y plane to the LL part. Again apply DWT to LL part to obtain LH part. SVD is applied to LH part. Now DWT is applied to waterark1 and SVD is applied on LH part. The singular values of water mark1 are replaced in the Y plane cover image. The resultant image is called the watermarked 1 image. Then apply the ISVD on watermarked 1 image. Again apply 2 levels IDWT on watermarked 1 image.
Similarly for dual watermark embedding, DWT is applied to watermarked 1 image to the LL part. Again apply DWT to LL part to obtain LH part. SVD is applied to LH part. Now DWT is applied to waterark2 and SVD is applied on LH part. The singular values of water mark2 are replaced in the watermarked 1 image. The resultant image is called the dual watermarked image. Then apply the ISVD on dual watermarked image. Again apply 2 levels IDWT on dual watermarked image. Then convert dual watermarked image in YCbCr and again convert to RGB image.

IV. RESULTS

MATLAB is used to explore the performance of the proposed watermarking algorithm. The colour image of size 512×512 is used as the cover image. Two gray scale images are used as the first and second watermark images respectively. The size of the watermark images are 256×256. RGB colour image as the cover image, 1st watermark, and 2nd watermark images are shown in figure 3.

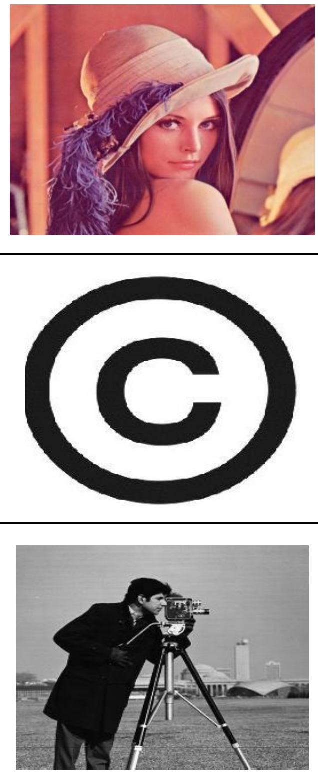


Figure 3: RGB Colour Image as the Cover Image, 1st Watermark, and 2nd Watermark Images

The imperceptibility of the watermark image is calculated by Peak Signal to Noise Ratio (PSNR). Higher value of PSNR means the quality of watermarked image is more, which resembles the original image.

$$PSNR = 10\log_{10}\left(\frac{MAX^2}{MSE}\right)$$

The likeness between the original & the extracted watermark image or the robustness of the watermark image is evaluated by the Normalized Cross Correlation Coefficient (NCC). Mean Square Error (MSE) is used to measure the dissimilarity between cover and watermarked images.

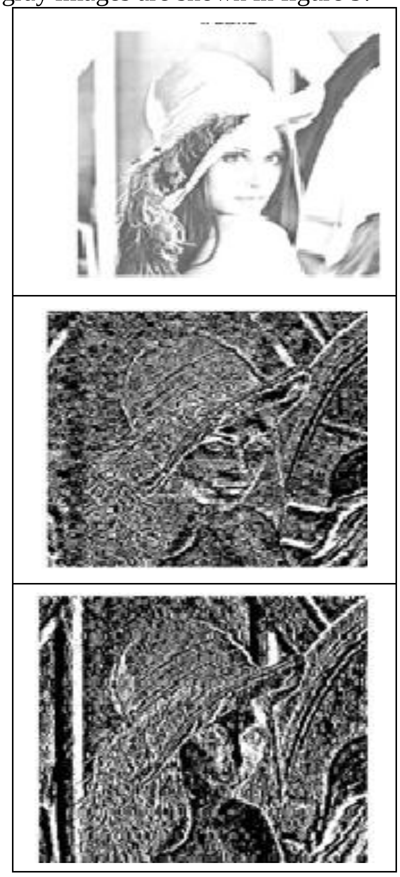
$$NCC = \left[\frac{\sum_{i=0}^{M-1}\sum_{j=0}^{-1N}[W(i,j) \quad W^1 \quad (i,j)]}{\sum_{i=0}^{M\ -1}\sum_{j=0}^{N-1}[W(i,j)]^2}\right]$$

$$MSE = \frac{1}{MN}\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}[x(i,j) - y(i,j)]^2$$

In PSNR and MSE equations x (i, j) and y (i, j) represent the pixel value of the cover image and the watermark image respectively. In this work YCbCr colour space is used, in which Y is intensity component is also called as gray component of the colour image. Y, Cb, and Cr components of the YCbCr image is shown in figure 4.

Figure 4: Y, Cb, and Cr components of YCbCr Cover Image

The four sub bands LL, LH, HL, and HH are shown in figure 5 respectively. The first and dual watermarked images in Y channel are shown in figures 6 and 7 respectively. The dual watermarked image in RGB colour space is shown in figures 8. The first and second extracted watermark gray images are shown in figure 9.



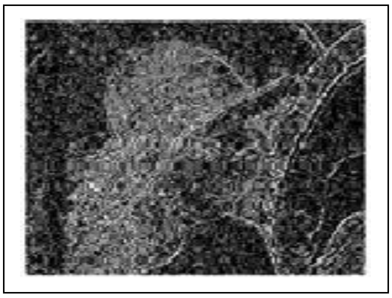


Figure 5: LL, LH, HL, and HH Sub Bands of Ycomponent is separated by using DWT

Figure 6: First Watermarked Image in Y Channel

Figure 7: Dual Watermarked Image in Y Channel

Figure 8: Dual Watermarked Image in RGB Colour Space

The PSNR value of the dual water mark colour image (i.e. embedded watermark 1 & 2 with cover image) is given in the table 1. NCC1 and NCC2 values of the watermarks 1 and 2 extracting from the dual watermark colour image, also the NCC1 and NCC2 values of the watermarks 1 and 2 extracting from the dual watermark colour image with attacks are given in the table 2. The NCC values of the extracted watermark 2 from the dual watermarked colour image with different attacks are compared to [5] are shown in table 3.

Figure 9: First and Second Extracted Watermark Gray Images

Table 1: PSNR Value of the Dual Water Mark Colour Image

			
Cover Image	Watermark-1 Image	Watermark-2 Image	Dual Watermark Colour Image
The PSNR of the Dual Watermark Colour Image is 49.87 dB			

Table 2: NCC1 and NCC2 Values of Extracted Watermark 1 & 2 from the Dual Watermarked Colour Image and With Different Attacks

		NCC-1	**NCC-2**
			
	Dual Watermark Colour Image	Extracted Watermark-1 Image	Extracted Watermark-2 Image
With Out Attacks		0.9793	0.9997
With JPEG Quality Factor Q = 70		0.9947	0.9907
With JPEG Quality Factor Q = 50		0.9947	0.9907
With JPEG Quality Factor Q = 10		0.9806	0.9985
Rotation With 45^{o} 		0.9223	0.9862
Rotation with 5^{o} 		0.9301	0.9815
Gaussian Noise With σ =50		0.9699	0.9995
Gaussian Noise With σ =20		0.9248	0.9949
Cropping Top Left 		0.9747	0.9913
Cropping Bottom Right 		0.9492	0.9852
Median Filter with 13 x 13		0.9487	0.9889

Table 3: Comparision of the NCC Values of Extracted Watermark 2 from the Dual Watermarked Colour Image with Different Attacks to [5]

	NCC Values of Existing Work	**NCC Values of Dual Watermark Colour Image**
		

With JPEG Quality Factor Q	0.9572	0.9907
With JPEG Quality Factor Q	0.9451	0.9907
With JPEG Quality Factor Q	0.8910	0.9985
Rotation With 45^o 	0.9762	0.9862
Rotation with 5^o 	0.9841	0.9815
Gaussian Noise With	0.9928	0.9995
Gaussian Noise With	0.9924	0.9949
Cropping Top Left 	0.9096	0.9913
Cropping Bottom Right 	0.9868	0.9852
Median Filter with	0.9837	0.9889

V. CONCLUSION

In this paper a dual image signature implemented using DWT and SVD method. The eminence of the watermarked image is good in terms of imperceptibility. The PSNR value for dual image signature is 49.87 dB. Most of the attacks are provided good NCC values as in existing method [5]. But the proposed method had well robust against all the attacks except for rotation and median filtering attacks, when compared with the existing method [5].

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