International Journal of advanced studies in Computer Science and Engineering
IJASCSE Volume 3, Issue 4, 2014

A NEW ROBUST IMAGE WATERMARKING SCHEME BASED ON DWT WITH SVD

S.Shanmugaprabha
PG Scholar, Dept of Computer Science & Engineering
VMKV Engineering College, Salem
India

N.Malmurugan
Director
Sri Ranganathar Institute of Engineering & Technology
Coimbatore, India

Abstract— **Image watermarking plays important role in applications like Copyright protection and Authentication. Robust watermarking is key research area in these applications in order to be resistant to most types of attacks. In addition to Robustness, high imperceptibility, security, and large capacity are other essential requirements in any watermarking scheme. This paper presents a new image watermarking scheme based on the Discrete Wavelet Transform (DWT) and the Singular Value Decomposition (SVD). The gray scale image watermark was embedded directly in the singular values of the DWT sub-bands of the host image. The scheme achieved a large capacity due to the redundancy in the DWT domain and at the same time preserved high imperceptibility due to SVD properties. Embedding the watermarking pixel's values without any modification inside the wavelet coefficient of the host image overcomes the security issue. Furthermore, the experimental results of the proposed scheme showed a high level of robustness against the image processing attacks.**

Keywords- ***Image watermarking, Discrete Wavelet Transform Singular Value Decomposition, Robustness, Imperceptibility***

I. INTRODUCTION

Watermarking (data hiding) is the process of embedding data into a multimedia element such as image, audio or video for security purposes or copyright protection. This embedded data can later be extracted from, or detected in the multimedia. A watermarking algorithm consists of an embedding algorithm, and an extraction, or detection algorithm. The type of information needed by the detector is an important criterion in classification of watermarking schemes:

- Non-blind schemes require both the original image and the secret key(s) for watermark embedding.
- Semi-blind schemes require the secret key(s) and the watermark itself.
- Blind schemes require only the secret key(s) [5].

Watermarking can be performed in the spatial or transform domain. Spatial domain methods are less complex but are not as robust as transform domain methods against various attacks [1]. One of the most common techniques in transform domain watermarking is to modify the coefficients obtained from singular value decomposition (SVD) of the cover image. The SVD based watermarking algorithm was first presented by Liu et al [4]. In this algorithm, the authors after applying singular value decomposition to the cover image modify these coefficients by adding the watermark. They apply SVD transform again on the resultant matrix for finding the modified singular values. These singular values were combined with the known component to get the watermarked image. In another similar work, Chandra et al. [3], embed singular values of the watermark in the singular values of entire host image. The most important drawback of SVD-based algorithms is quality degradation of the watermarked image. In addition, the extracted watermark is not robust enough against common attacks in SVD- based algorithms. Thus researchers, usually combine SVD with other algorithms such as DCT and DWT.

In [2], authors combined DWT with SVD technique. In that paper, after decomposing the host image into four sub-bands, SVD is applied to each sub-band and singular values of the watermark is embedded into the sub-bands. In [6], DWT is combined with SVD technique to hide singular values of watermark in high frequency band (HH) of an image. When DWT is combined with SVD technique, the watermarking algorithm outperforms the conventional DWT algorithm with respect to robustness against Gaussian noise, compression and cropping attacks [7]. In our work, SVD is embedded in LL band of the cover image and found that the results are better than earlier one. The paper is organized as follows. In sections 2 DWT and SVD transforms are explained respectively. In section 3, the proposed embedding and extraction algorithms are introduced. Experimental results are presented in section 4 and finally the conclusion is given in section 5.

II. DWT AND SVD

A. DWT

Wavelets are special functions which, in a form analogous to sines and cosines in Fourier analysis, are used as basal functions for representing signals [7]. For 2-D images, applying DWT corresponds to processing the image by 2-D filters in each dimension. The filters divide the input image into four non-overlapping multi-resolution sub-bands LL1, LH1, HL1 and HH1. The sub-band LL1 represents the coarse-scale DWT coefficients while the sub-bands LH1, HL1 and HH1 represent the fine-scale of DWT coefficients. To obtain the next coarser scale of wavelet coefficients, the sub-band LL1 is further processed until some final scale N is reached. When N is reached we will have 3N+1 sub-bands consisting of the multi-resolution sub-bands LLN and LHx, HLx and HHx where x ranges from 1 until N. This is illustrated in Fig 1

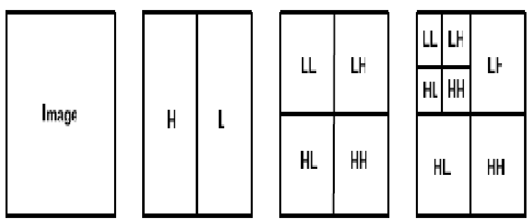


Figure 1 Two dimensional wavelet transformation of an image.

Due to its excellent spatio-frequency localization properties, the DWT is very suitable to identify the areas in the host image where a watermark can be embedded effectively. In particular, this property allows the exploitation of the masking effect of the human visual system such that if a DWT coefficient is modified, only the region corresponding to that coefficient will be modified. In general most of the image energy is concentrated at the lower frequency sub-bands LLx and therefore embedding watermarks in these sub-bands may degrade the image significantly. Embedding in the low frequency sub-bands, however, could increase robustness significantly. On the other hand, the high frequency sub-bands HHx include the edges and textures of the image and the human eye is not generally sensitive to changes in such sub-bands. This allows the watermark to be embedded without being perceived by the human eye. The compromise adopted by many DWT-based watermarking algorithm, is to embed the watermark in the middle frequency sub-bands LHx and HLx where acceptable performance of imperceptibility and robustness could be achieved

B. *SVD*

The singular value decomposition of a matrix is a factorization of the matrix into a product of three matrices. Given an m×n matrix A, where m ≥ n, the SVD of A is defined as [8]

$$A = U \Sigma V^T$$

where U is an m×n column-orthogonal matrix whose columns are referred to as left singular vectors; Σ =diag (σ1, σ2, . . . , σn) is an n×n diagonal matrix whose diagonal elements are nonnegative singular values arranged in descending order; V is an n×n orthogonal matrix whose columns are referred to as right singular vectors.

If rank (A) = r then

$$\Sigma \text{ satisfies } \sigma_1 \geq \sigma_2 \geq \cdots \geq \sigma_r \geq \sigma_{r+1} = \sigma_{r+2} = \cdots \sigma_n = 0$$

SVD efficiently represents intrinsic algebraic properties of an image, where singular values correspond to brightness of the image and singular vectors reflect geometry characteristics of the image. Since slight variations of singular values of an image may not affect the visual perception, watermark embedding through slight variations of singular values in the segmented image has been introduced as a choice for robust watermarking [9].

III. PROPOSED DWT-SVD BASED WATERMARKING

A. *Watermark Embedding*

The proposed watermark embedding algorithm is shown in Figure 2.

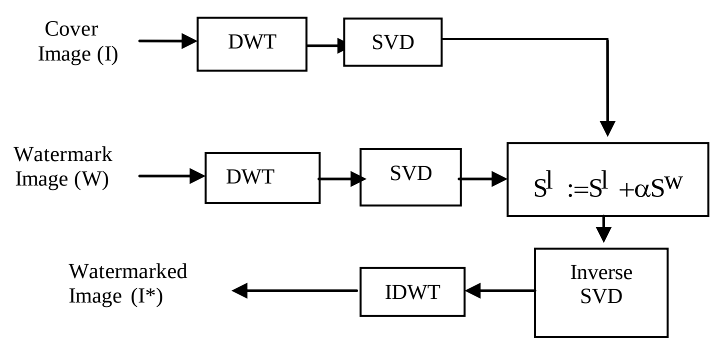


Figure 2 Block Diagram of the proposed watermark embedding algorithm

The steps of watermark embedding algorithm are as follows:

1. *Apply DWT to the cover image to decompose it into LL, HL, LH, and HH subbands.*
2. *Apply SVD to the low frequency subband LL of the cover image:*

$$I^l = U^l S^l V^l$$

3. *Apply DWT to the visual watermark.*
4. *Apply SVD to the low frequency subband of watermark:*

$$W = U^{W} S^{W} V^{W}$$

5. *Modify the singular values of the cover image with the singular values of watermark image* $S^{*l} := S^{l} + \alpha S^{W}$

   where α *is scaling factor,* S^{l} *and* S^{W} *are the diagonal matrices of singular values of the cover and watermark images, respectively.*
6. *Apply inverse SVD on the transformed cover image with modified singular values* $I^{*l} = U^{l} S^{*l} V^{l}$
7. *Apply inverse DWT using the modified coefficients of the low frequency bands to obtain the watermarked image.*

Flow chart for the above Algorithm

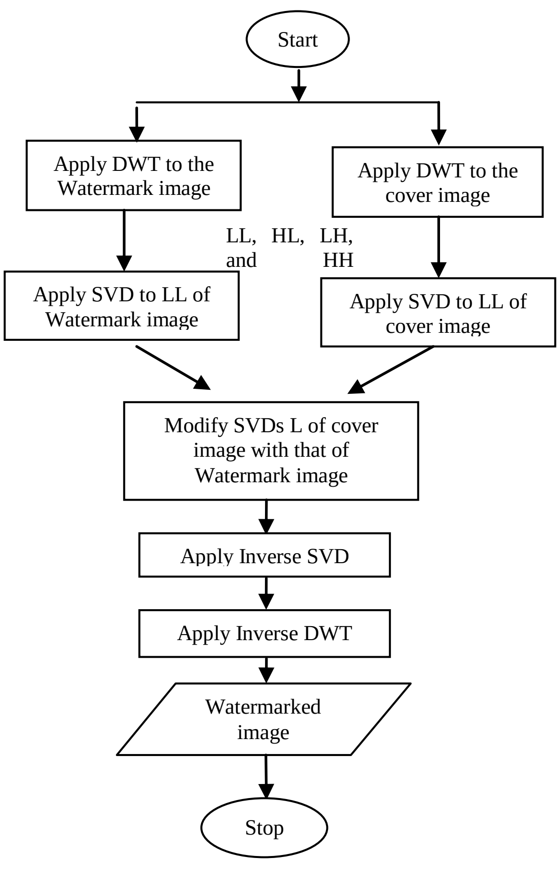


Figure 3 Flow cart for Watermark Embedding

B. *Watermark Extraction*

The proposed watermark extracting algorithm is shown in Figure 4.

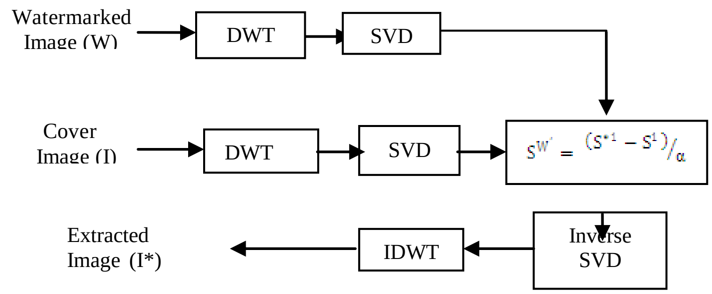


Figure 4 Block Diagram of the proposed watermark extracting algorithm

The steps of watermark extracting algorithm are as follows and the flow chart will as same as sown for watermark embedding:

1. *Using DWT, decompose the watermarked image* I^{*} *into 4 subbands: HH, HL, LH and LL.*
2. *Apply SVD to low frequency subband LL:* $I^{*1} = U^{*1} S^{*1} V^{*1}$
3. *Extract the singular values from low frequency subband of watermarked and cover image:* $S^{W'} = (S^{*1} - S^{1})/\alpha$ *where* S^{1} *contains the singular of the cover image*
4. *Apply inverse SVD to obtain low frequency coefficients of the transformed watermark image.*
5. *Apply inverse DWT using the coefficients of the low frequency sub-band to obtain the watermark image.*

IV. RESULTS AND DISCUSSION

In this study, we used gray scale Lena image as our host image of size 512x512, and the Cameraman for watermark image with same size. In our experiments, we used the scaling factor $\alpha = 0.25$. Fig. 5 shows cover image, watermark, watermarked image and the extracted watermark. When watermarks are extracted, similarity of the watermarked and cover image can be defined by the PSNR (Peak Signal to Noise Ratio) criterion:

$$PSNR = 10\log_{10}\left(\frac{255^2}{MSE}\right)$$

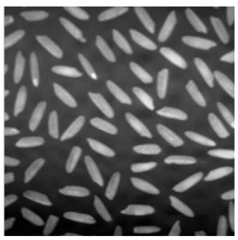
where MSE (Mean Square Error) is defined as:

$$MSE = \left(\frac{1}{MxN}\right)\sum_{x=1}^{M}\sum_{y=1}^{N}\left(p(x,y) - p'(x,y)\right)^2$$

where m and n are the dimensions of the images X and Y. PSNR is measured in dB.

(a) Cover image

(b)Watermark image

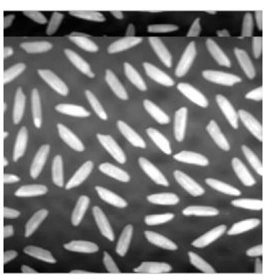


(c)Watermarked image

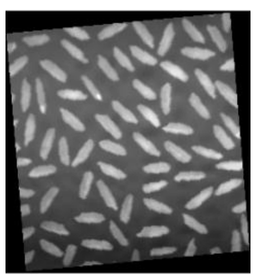
(d)extracted image

Figure 5 (a) Cover image (b) watermark image(c) watermarked image (d) extracted watermark

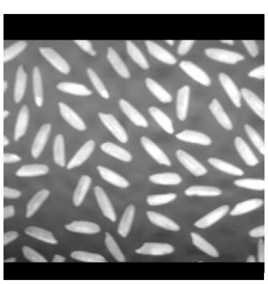
Larger values of PSNR indicate better watermark concealment. We compared the watermarked image with the original one and PSNR was obtained as 37.52 db.



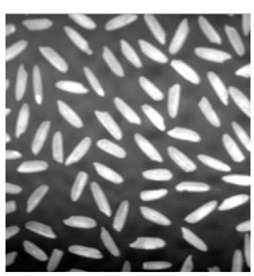
Shift 2%



Rotate 50^0

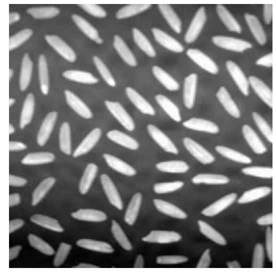


Cut

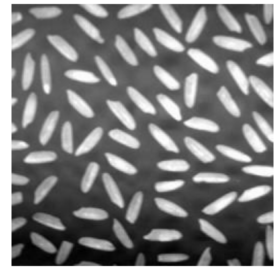


Median filter $^{(7\times7)}$

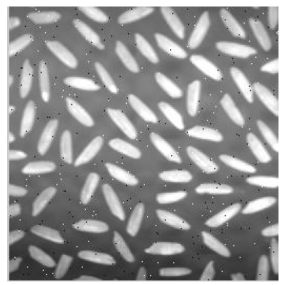
To investigate the robustness of the algorithm, the watermarked image was attacked by applying processing shift, rotation, cropping, median filtering, JPEG compression, Gaussian noise, salt & pepper noise, speckle noise and histogram equalization. The results of these attacks are shown in Figure 6.



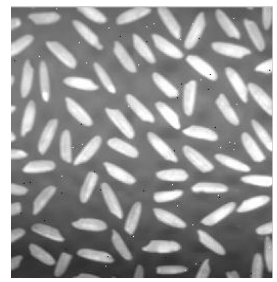
Gaussian Noise (var 0.001)



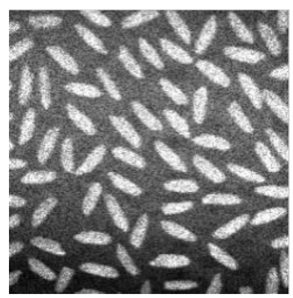
Gaussian Noise (var 0.005)



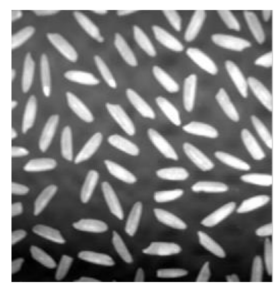
Salt & Pepper Noise Density .001



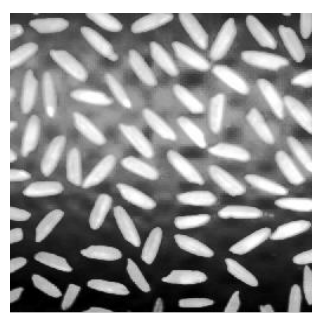
Salt & PepprNoise Density .005



Speckle noise (var0.04)



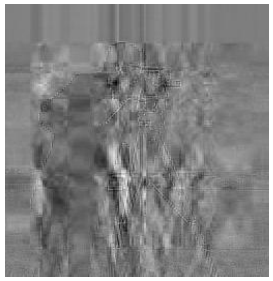
JPEG Compression 50%



Histogram equalization

(a)

Shift



Rotate 50º

Cut median

median filter$^{(7\times7)}$

Gaussian Noise (var 0.001)

Gaussian Noise (var 0.005)

Salt & Pepper Noise Density .001

Salt & Pepper Noise Density .005

Also the comparison results of our method with DWT-SVD are summarized in Table 4.1. The numbers in Table 1 indicate the PSNR and MSE between extracted watermarks and original ones. As can be seen from Table 1, our method DWT-SVD is doing better for all attacks compared to DWT.

Speckle noise (var 0.04)

JPEG Compression 50%

Histogram equalization

(b)

Figure 6 (a) Watermarked image under different attacks, (b) extracted watermarks

TABLE 1 THE RESULTS OF OUR METHOD DWT- SVD

METHOD	DWT		DWT- SVD	
	MSE	PSNR in dB	MSE	PSNR in dB
No Attack	5.712	37.303	3.7242	42.4205
speckle Noise (0.04)	54.765	30.542	49.7646	31.1616
speckle Noise (0.06)	58.871	30.476	54.315	30.7816
speckle Noise (0.08)	60.297	30.173	56.5078	30.6097
shifting from 10 row	5.712	37.303	3.7242	42.4205
shifting from 25 row	13.463	36.984	11.7454	37.4321
shifting from 50 row	15.712	35.273	13.7242	37.0205
salt & pepper (density 0.005)	14.345	36.078	12.2398	37.2531
salt & pepper (density 0.001)	6.212	40.832	4.2147	41.8832
Median filter [3 * 3]	5.712	37.303	3.7242	42.4205
Median filter [5 * 5]	5.712	37.303	3.7242	42.4205
Median filter [7 * 7]	5.712	37.303	3.7242	42.4205
Histogram equalization	58.098	27.765	54.3064	30.7823
Gaussian noise (var 0.005)	5.697	37.534	3.7203	42.4251
Gaussian noise (var 0.001)	5.705	37.481	3.7132	42.4333
Cut	7.810	39.12	6.72	39.8571
JPEG compression(SPIHT)	5.123	37.895	3.3657	42.86

V. CONCLUSION

We presented a new watermarking method based on DWT-SVD to embed a watermark image which can be as large as the cover image. Modifying singular values of the cover image in DWT domain provides high robustness against common attacks. High PSNR and correlation coefficient of watermarked image is another beneficial point of the algorithm as the result of DWT implementation. The results demonstrated that the proposed method is more robust to various attacks compared to DWT based methods by 5 dB maximum and 1.5 dB minimum for various attacks. DWT is shift invariant, and its redundancy introduces an over complete frame expansion. It is known that frame expansion increases robustness with respect to additive noise. Thus, DWT based signal processing tends to be more robust than DWT based techniques. Another advantage of this method is the possibility to embed a large watermark in the cover image. This work can be further extended with variation in DWT like RDWT.

REFERENCES

[1] D. Kundur, D. Hatzinakos, Towards robust logo watermarking using multiresolution image fusion, IEEE Transcations on Multimedia 6 (2004) 185–197.

[2] Q. Li, C. Yuan, Y.Z. Zong, Adaptive DWT-SVD domain image watermarking using human visual model, ICACT-2007, 2001, pp. 1947–1951.

[3] D.S. Chandra, Digital image watermarking using singular value decomposition, Proceedings of the 45th Midwest Symposiumon Circuits and Systems (MWSCAS'02), vol. 3, 2002, pp. 264–267.

[4] Liu, R. and Tan, T. (2002) An SVD-based watermarking scheme for protecting rightful ownership, IEEE Transactions on Multimedia, Vol.4, No.1, Pp. 121-128.

[5] A. Sverdlov, S. Dexter, A.M. Eskicioglu, "Robust DCT-SVD Domain Image Watermarking For Copyright Protection: Embedding Data In All Frequencies", Proceedings of the 13th European Signal Processing Conference (EUSIPCO2005), Antalya, Turkey, September 2005.

[6] L. Liang, S. Qi, "A new SVD-DWT composite watermarking", Proceedings of IEEE International Conference on Signal Processing (ICSP) , 2006.

[7] V. Santhi, A. Thangavelu, "DWT-SVD Combined Full Band Robust Watermarking Technique for Color Images in YUV Color Space", International Journal of Computer Theory and Engineering, vol. 1, no. 4, pp. 424-429.

[8] C.C. Chang, C.C. Lin, Y.S. Hu, "An SVD oriented watermark embedding scheme with high qualities for the restored images", International Journal of Innovative Computing, Information and Control (ICIC), vol. 3, no. 3, pp. 609-620.

[9] P. B. Paul, and X. Ma, "Image Adaptive Watermarking Using Wavelet Domain Singular Value Decomposition", IEEE Transactions on Circuits and Systems for Video Technology, vol.15, no.1, pp.96-102.