Volume 2, Issue 4, April 2012 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

DWT-SVD Based Efficient Image Watermarking Algorithm to Achieve High Robustness and Perceptual Quality

Seema *
CSE Department, Amity University, Noida(UP)
seema.rana22@gmail.com

Sheetal Sharma
CSE Department, Amity University, Noida(UP)

Abstract— **In order to improve the robustness and imperceptibleness of the algorithm, a new embedding and extracting method with DWT-SVD is proposed. The approximation matrix of the third level of image in DWT domain is modified with SVD to embed the singular value of watermark to the singular value of DWT coefficient. The proposed embedding and extracting method was employed to accelerate the hybrid DWT-SVD watermarking and to avoid the leak of watermark. This hybrid technique leads to optimize both the fundamentally conflicting requirements. The experimental results show both the good robustness under numerous attacks and the high fidelity. The time needed to perform the program is greatly decreased.**

Keywords— **Digital watermarking, Digital signature, Discrete wavelet transform (DWT), Singular Value Decomposition (SVD), Hybrid DWT-SVD**

I. INTRODUCTION

In the recent few years, there is a serious problem about unauthorized and illegal access and manipulation of multimedia files over internet. Everybody can obtain copies of copyrighted multimedia openly. So we need to generate a robust method in order to protect the copy rights of media. Digital watermarking provides copyright protection of data. It is done by embedding additional information called digital signature or watermark into the digital contents such that it can be detected, extracted later to make an assertion about the multimedia data. [1, 2] For image watermarking, the algorithms can be categorized into one of the two domains: spatial domain or transform domain. [1, 2] In Spatial domain the data is embedded directly by modifying pixel values of the host image, while transform domain schemes embed data by modifying transform domain coefficients. Algorithms used for special domain are less robust for various attacks as the changes are made at least Significant Substitution (LSB) of original data. While in the transform-domain the watermark is embedded by changing the magnitude of coefficients in a transform domain with the help of discrete cosine transform, discrete wavelet transform (DWT), and singular value decomposition (SVD) techniques[3, 5]. This provide most robust algorithm for many common attacks. [7] In this paper we proposed a hybrid watermarking using DWT and SVD technique in order to achieve high robustness and transparency.

This paper is organized as follows. The section2 briefly define the DWT and SVD techniques. We demonstrate the proposed approach in Section3. Here we define embedding and extracting algorithms in DWT domain with SVD. The simulation results are illustrated in Section 4, and we also show the superiority of our scheme over the results proposed by other researchers in this section. And we conclude this paper in Section 5.

II. DWT AND SVD

A. Discrete Wavelet Transform(DWT)

DWT involves decomposition of image into frequency channel of constant bandwidth. This causes the similarity of available decomposition at every level. DWT is implemented as multistage transformation. Level wise decomposition is done in multistage transformation. At level 1: Image is decomposed into four sub bands: LL, LH, HL, and HH where LL denotes the coarse level coefficient which is the low frequency part of the image. LH, HL, and HH denote the finest scale wavelet coefficient. The LL sub band can be decomposed further to obtain higher level of decomposition. This decomposition can continues until the desired level of decomposition is achieved for the application. The watermark can also be embedded in the remaining three sub bands to maintain the quality of image as the LL sub band is more sensitive to human eye.

B. Singular Value Decomposition(SVD)

An image can be represented as a matrix of positive scalar values. Formally, SVD for any image say A of size $m \times m$ is a factorization of the form given by $A = USV^T$, Where U and V are orthogonal matrices in which columns of U are left singular vectors and columns of V are right singular vectors of image A. S is a diagonal matrix of singular values in decreasing order. The basic idea behind SVD technique of watermarking is to find SVD of image and the altering the singular value to embed the watermark. In Digital watermarking schemes, SVD is used due to its main properties: 1) A small agitation added in the image, does not cause large variation in its singular values. 2) The singular value represents intrinsic algebraic image properties. [3]

III. PROPOSED ALGORITHM USING DWT AND SVD TECHNIQUES

A. *Embedding Watermark*

- Use three level Haar DWT to decompose the image A in to four sub bands (i.e.,$LL_3, LH_3, HL_3,\ and\ HH_3$)
- Apply SVD to HL_3 sub band i.e.,
  $$A_i = U_i S_i V_i^T$$
  Where $A_i = HL_3$
- Apply SVD to the watermark i.e.,
  $$W = U_w S_w V_w^T$$
  Where $W = Watermark$
- Modify the singular value of A_i by embedding singular value of W such that
  $$S_{iw} = S_i + \alpha \times S_w$$
  Where S_{iw} is modified singular matrix of A_i
  And α denotes the scaling factor, is used to control the strength of watermark signal
- Then apply SVD to this modified singular matrix S_{iw} i.e.,
  $$S_{iw} = U\_S_{iw} S\_S_{iw} V\_S_{iw}{}^T$$
- Obtain the modified DWT coefficients, i.e.,
  $$A_{iw} = U_i \times S\_S_{iw} \times V_i^T$$
- Obtain the watermarked image A_w by applying inverse DWT using one modified and other non modified DWT coefficients.

B. *Watermark Extraction*

- Apply three level haar DWT to decompose the watermarked image A_w in to four sub bands (i.e., $LL_3, LH_3, HL_3,\ and\ HH_3$).
- Apply SVD to HL_3 sub band i.e.,
  $$A_{iw} = U_{iw} S_{iw} V_{iw}^T$$
  Where $A_{iw} = HL_3$
- Compute $S_w^* = (S_{iw} - S_i)/\alpha$, Where S_w^* singular matrix of extracted watermark(possibly distorted).
- Apply SVD to S_w^* i.e.,
  $$S_w^* = U\_S_w^* S\_S_w^* V\_S_w^*{}^T$$
- Now Compute extracted watermark W^* i.e.,
  $$W^* = U_w \times S\_S_w^* \times V_w^T$$

IV. EXPERIMENTAL RESULTS

To demonstrate the proposed approach, the gray-level image of size 512×512 (Shown in Fig.1 (a) is used as the cover image and the gray-level image of size 64×64 (Shown in Fig.1 (b) is used as the watermark. Fig. 1(c) shows the watermarked image.

The peak signal-to noise ratio (PSNR) was used as a measure of the quality of a watermarked image. To evaluate the robustness of the proposed approach, the watermarked image was tested against five kinds of attacks:

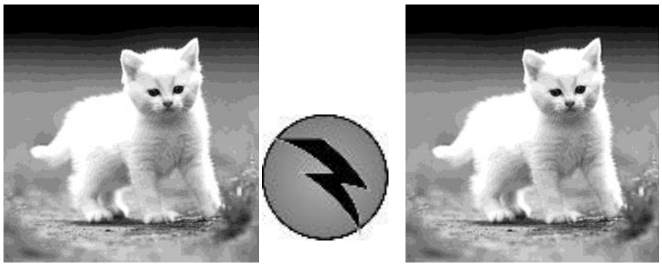

Fig.1 (a) Original Image   Fig.1 (b) Watermark   Fig.1 (c) Watermarked image (PSNR = 48.14)

1) Geometrical Attack: cropping (CR) and rotation (RO); 2) Noising Attack: Gaussian noise (GN); 3) De-noising Attack: average filtering (AF); 4) Format-Compression Attack: JPEG compression; and 5) Image-Processing Attack: histogram equalization (HE), gamma correction (GC), and Blurring Attack (BL). For the comparison of similarities between the original and extracted watermarks, the correlation coefficient was employed. In our experiments, the values of the scale factors are carried out with constant range from 0.01 to 0.09 with an interval of 0.02, and the results are illustrated in Tables I and II. It can be seen that the larger the scale factor, the robustness is maintained. In contrast, the smaller the scale factor, the image watermarked quality is better.

In order to justify our approach, we also implement the DWT-SVD based watermarking method and pure SVD-based approach [3] to compare the performance. The adjustment strategy of scale factors is like our aforementioned experiment setting, and experimental results are listed in Tables II and III.

TABLE I
CORRELATION COEFFICIENT OF EXTRACTED WATERMARKS FROM DIFFERENT ATTACKS

SF Values	CR	RO	GN	AF
0.01	0.8882	0.7141	0.9847	0.9561
0.03	0.8997	0.7142	0.9968	0.9532
0.05	0.9050	0.7143	0.9976	0.9795
0.07	0.9041	0.7143	0.9977	0.9912
0.09	0.8970	0.7144	0.9975	0.9950
SF Values	**JPEG**	**HE**	**GC**	**BU**
0.01	0.9956	0.8133	0.8388	0.8871
0.03	0.9992	0.8517	0.8631	0.8773
0.05	0.9997	0.8719	0.9877	0.8951
0.07	0.9998	0.8839	0.9489	0.9317
0.09	0.9999	0.8956	0.8420	0.9591

TABLE II
COMPARISON OF PSNR FOR C&C [7], L&T [3], AND OUR ALGORITHM

SF Value	0.01	0.03	0.05	0.07	0.09
C & C [7]	69.12	51.63	43.80	39.54	36.66
L & T [3]	60.89	48.33	42.61	38.70	35.41
Ours	62.12	52.57	48.14	45.21	43.03

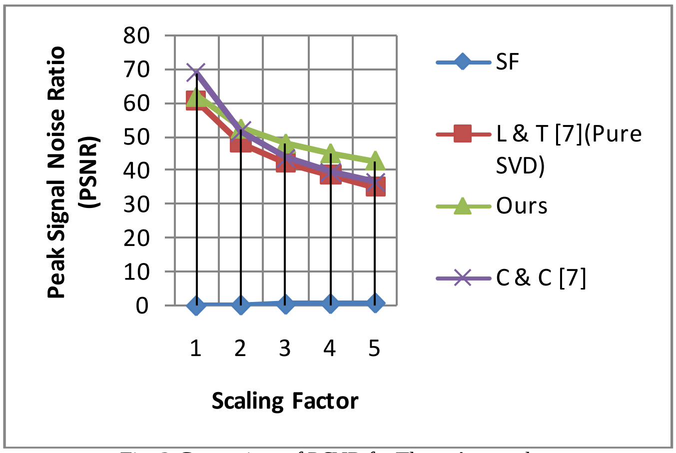

Fig. 2 Comparison of PSNR for Three Approaches

After studying the experimental results, it can be seen that the proposed scheme significantly outperforms the two compared schemes. In addition to quantitative measurement, we also need the visual perceptions of the extracted watermarks. The constructed watermarks with best-quality measurement are shown in Fig. 3(a)–(x), and we find that our scheme not only can successfully resist different kinds of attacks but can also restore watermark with high perceptual quality.

TABLE III
COMPARISON OF ROBUSTNESS FOR C&C [7], L&T [3] ALGORITHMS, AND OUR ALGORITHM

	CR		RO	
Method	**Best**	**Average**	**Best**	**Average**
C & C [7]	0.9832	0.9762	0.6086	0.4434
L & T [3]	0.9928	0.8847	0.1735	0.1119
Ours	0.9050	0.8988	0.7144	0.7143

	GN		AF	
Method	**Best**	**Average**	**Best**	**Average**
C & C [7]	0.9705	0.9762	0.8764	0.7736
L & T [3]	0.9867	0.8847	0.9866	0.9265
Ours	0.9977	0.8988	0.9950	0.9750

	JPEG		HE	
Method	**Best**	**Average**	**Best**	**Average**
C & C [7]	0.9999	0.9988	0.8809	0.6883
L & T [3]	0.9869	0.9640	0.5535	0.3395
Ours	0.6849	0.5353	0.8956	0.8633

	GC		BL	
Method	**Best**	**Average**	**Best**	**Average**
C & C [7]	0.9922	0.8866	0.6130	0.4620
L & T [3]	0.4501	0.2607	0.9120	0.6870
Ours	0.9877	0.8961	0.9591	0.9101

To compare the efficiency of our approach and other two methods, watermark extraction was performed on non-attacked watermarked images using the three methods. Experimental results are listed in Table IV. It is clearly observed that our method can be done very efficiently in comparison with other existing watermarking schemes.

Attack C & C [7] L & T [3] Ours

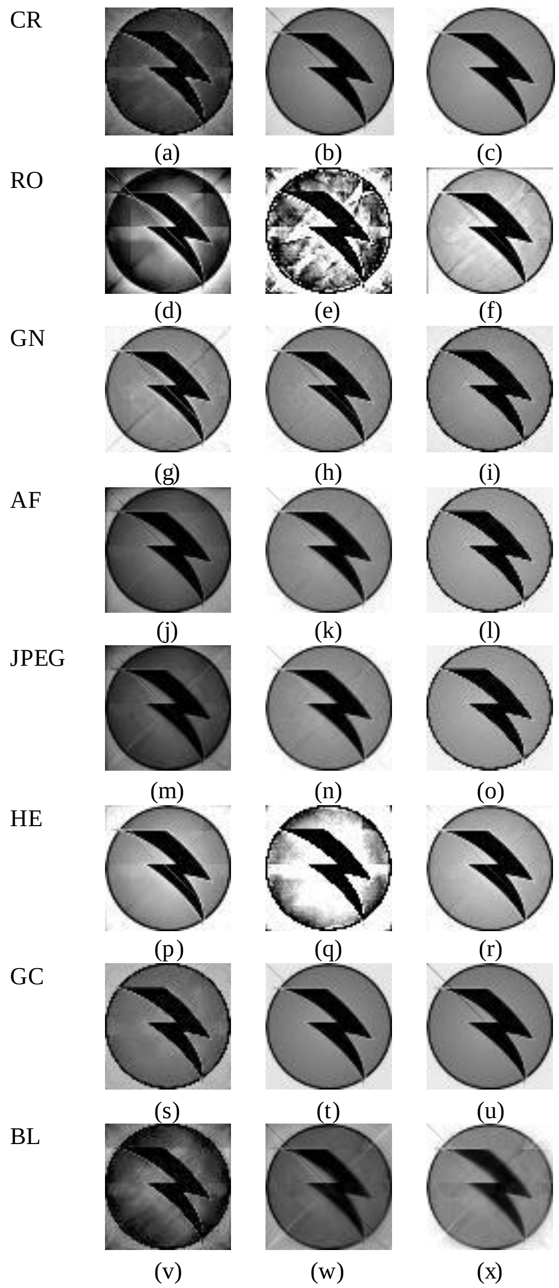

Fig. 3 Extracted watermarks obtained from C&C [7], L&T [3], and our approach in that order with different attacks: CR[(a)–(c)], RO[(d)–(f)], GN[(g)–(i)], AF[(j)–(l)], JPEG[(m)–(o)], HE[(p)–(r)], GC[(s)–(u)], and BL[(v)–(x)].

TABLE IV
COMPARISON OF EFFICIENCY FOR C&C [7], L&T [3], AND OUR ALGORITHM (UNIT: SECONDS)

	L & T [3]	**C & C [7]**	**Ours**
Watermark Embedding	11.306570	1.588811	0.643727
Watermark Extraction	10.802229	1.041107	0.341688

V. CONCLUSIONS

In our simulation, we go through the numerous tests on image with size 512 x 512. One of them is in table 1. Where we observe correlation value between original watermark and extracted watermark after applying attacks is larger if the scaling factor is high. In table 2 we compare the result of proposed algorithm with the algorithm used in C&C [7] and L&T [3]. Here the PSNR for the proposed algorithm is rising with the increasing value of scaling factors and ours is best. Whereas the table 3 show comparison between correlation value which is obtained by using C&C [7] and L&T [3] algorithm with our correlation value against different attacks. It has been observed that our value is best against all attacks except cropping attack which is lesser than other two. The above results show that when we increase the scaling factor, we get better performance especially in terms of robustness while keeping the image quality requirement at reasonable levels. The PSNR and NC values of the proposed algorithm are also better than those of C&C and L&T algorithms.

REFERENCES

[1] P.Ramana Reddy, Dr. Munaga.V.N.K.prasad, Dr D. Sreenivasa Rao, "Robust Digital Watermarking of Images using Wavelets." International Journal of Computer and Electrical Engineering, Vol. 1, No. 2, June 2009.

[2] J. Sang and M. S. Alam, "Fragility and robustness of binary-phase-only filter-based fragile/semifragile digital image watermarking," IEEE Trans. Instrum. Meas., vol. 57, no. 3, pp. 595–606, Mar. 2008.

[3] R. Liu and T. Tan, "An SVD-based watermarking scheme for protecting rightful ownership," IEEE Trans. Multimedia, vol. 4, no. 1, pp. 121–128, Mar. 2002.

[4] H.-T. Wu and Y.-M. Cheung, "Reversible watermarking by modulation and security enhancement," IEEE Trans. Instrum. Meas., vol. 59, no. 1, pp. 221–228, Jan. 2010.

[5] A. Nikolaidis and I. Pitas, "Asymptotically optimal detection for additive watermarking in the DCT and DWT domains," IEEE Trans. Image Process., vol. 12, no. 5, pp. 563–571, May 2003.

[6] V. Aslantas, L. A. Dog¢an, and S. Ozturk, "DWT-SVD based image watermarking using particle swarm optimizer," in Proc. IEEE Int. Conf. Multimedia Expo, Hannover, Germany, 2008, pp. 241–244.

[7] Chih-Chin Lai, and Cheng-Chih Tsai," Digital Image Watermarking Using Discrete Wavelet Transform and Singular Value Decomposition," IEEE Transactions on Instrumentation and Measurement., vol. 59, no. 11, pp. 3060-3063, Nov. 2010.

[8] G. Bhatnagar and B. Raman, "A new robust reference watermarking scheme based on DWT-SVD," Comput. Standards Interfaces, vol. 31, no. 5, pp. 1002–1013, Sep. 2009.

[9] E. Ganic and A. M. Eskicioglu, "Robust DWT-SVD domain image watermarking: Embedding data in all frequencies," in Proc. Workshop Multimedia Security, Magdeburg, Germany, 2004, pp. 166–174.

[10] Q. Li, C. Yuan, and Y.-Z. Zhong, "Adaptive DWT-SVD domain image watermarking using human visual model," in Proc. 9thInt. Conf. Adv. Commun. Technol., Gangwon-Do, South Korea, 2007, pp. 1947–1951.

[11] S. Mallat, "The theory for multiresolution signal decomposition: The wavelet representation," IEEE Trans. Pattern Anal. Mach. Intell., vol. 11, no. 7, pp. 654–693, Jul. 1989.

