A Comparative Analysis of Watermarked and Watermark Images Using DCT and SVD Based Multiple Image Watermarking

Tarun Rathi[1(✉)], Rudra P. Maheshwari[2], Manoj Tripathy[3], Rahul Saraswat[4], and X. Felix Joseph[5]

[1] Department of Electrical and Computer Engineering, Maddawalabu University, Bale Robe, Ethiopia
rathi.tarun@gmail.com

[2] Raj Kumar Goel Institute of Technology, Ghaziabad, India
rpmaheshwari@hotmail.com

[3] Department of Electrical Engineering, Indian Institute of Technology Roorkee, Roorkee, India
tripathy.manoj@gmail.com

[4] Department of Electronics and Communication Engineering, Anand Engineering College, Agra, India
rahulsaraswat.ece@gmail.com

[5] Department of Electrical and Computer Engineering, Bule Hora University, Hagere Mariam, Ethiopia
felixjoseph75@gmail.com

Abstract. In many applications of digital watermarking, watermarked image of good quality is required. But there is a trade-off between a number of embedded watermark images and quality of watermarked image. This aspect is quite important in the case of multiple digital images watermarking. In this case, multiple images singular value decomposition based watermarking algorithm performs much better than other transform based methods. This paper presents robust multiple digital images watermarking using singular value decomposition (SVD) method. The results are compared with Discrete Cosine Transform (DCT) based multiple images watermarking method. In the case of multiple images DCT watermarking or in other transform based method more coefficients are varied according to the watermark images, which degrade the quality of watermarked image. In the case of SVD image watermarking method only singular values are being varied either in single or multiple images watermarking. This helps in preserving the quality of watermarked image.

Keywords: Singular value decomposition (SVD) · Discrete cosine transform (DCT) · Peak signal to noise ratio (PSNR) · Normalized correlation (NC) · Accuracy rate (AR) · Multiple image watermarking

F. A. Zimale et al. (Eds.): ICAST 2018, LNICST 274, pp. 574–581, 2019.
https://doi.org/10.1007/978-3-030-15357-1_46

1 Introduction

To prevent the illegal copying and tracking of the digital contents and for several other important applications, digital image watermarking is being introduced. This hides the information within the digital document like image, audio, video, [1].

Watermarking methods can be classified in two categories spatial domain and transform domain [2]. In spatial domain changing the pixels of the host image directly embeds the watermark. Due to this, extracting watermark in a noisy channel is very rare in the spatial domain, [3]. So, transform based algorithms like discrete Fourier transform (DFT), discrete cosine transform (DCT), discrete wavelet transform (DWT), are introduced which are more robust than spatial domain but in the case of geometric attacks or noisier channel these algorithms do not perform well, [4]. We have used singular value decomposition (SVD) algorithm for better result.

The multiple images watermarking method is a trade-off between the numbers of embedded watermark images and quality of watermarked image. In the case of transform domain watermarking, quality of watermarked image degrades more due to more changed coefficients. So this paper proposes a method of SVD based multiple images watermarking. In SVD based watermarking the watermarked image does not degrade as much as in other transform based watermarking method because only singular diagonal values are being varied. SVD is having stability, flip and transpose property etc. [5]. This makes SVD based multiple images watermarking robust and secured.

2 Evaluation Parameters

Peak signal to noise ratio represents the quality of the watermark image. Mean square error (MSE) is to be calculated to compute the PSNR between extracted and original watermark image. PSNR and mean square error (MSE) can be expressed as follow:

$$PSNR = 10 * \log\left(\frac{255^2}{MSE}\right) \tag{1}$$

$$MSE = \frac{1}{M * N} \sum\nolimits_{i=1}^{N} \sum\nolimits_{i=2}^{M} [I(i,j) - I^*(i,j)]^2 \tag{2}$$

Where $I(i,j)$ and $I^*(i,j)$ are the pixel values of original images and watermarked images respectively. Image matrix size is denoted by $M * N$.

Robustness is the feature of the watermark image to preserve information even after the different noise and malicious attacks [6]. This is measured as normalized correlation (NC) used for similarity measurement between the original watermark and extracted watermark. Normalized correlation (NC) can be expressed as follow.

$$NC = \frac{\sum_i w_i w_i^{*^2}}{\sum_i w_i^2} \tag{3}$$

Here w_i is the original watermark and w_i^* is the extracted watermark. Bigger the NC value means better similarity between two images.

Accuracy rate (AR) is also used to compare original image and processed image. AR increases in proportion to the image quality and it is defined by the following formula.

$$AR = \left(\frac{No.\,of\,pixels\,in\,processed\,image}{No.\,of\,pixels\,in\,original\,image}\right) * 100\%. \tag{4}$$

3 DCT Based Multiple Images Watermarking

DCT is a very useful method for image processing which converts the image into different frequency coefficients. In blind multiple images DCT watermarking; the host image is segmented into multiple blocks of the same size. Then each block is transformed using DCT. The message bits are embedded as a coefficient modification. In the case of more watermarking images, more coefficients are varied. Here four coefficients are modified for two watermark image (see Fig. 1). High-frequency coefficients are more sensitive to image processing attacks and low-frequency coefficients are having visual effect so middle-frequency coefficients are selected for embedding the watermark message. These selected coefficients work as a secret key without knowing that one can not extract the watermark. After modification in coefficients, the inverse DCT is applied to produce the watermarked image. At extraction part, watermarked image is segmented in blocks and DCT is applied to every block. From known coefficients message bits are recovered and reshaped into watermark image.

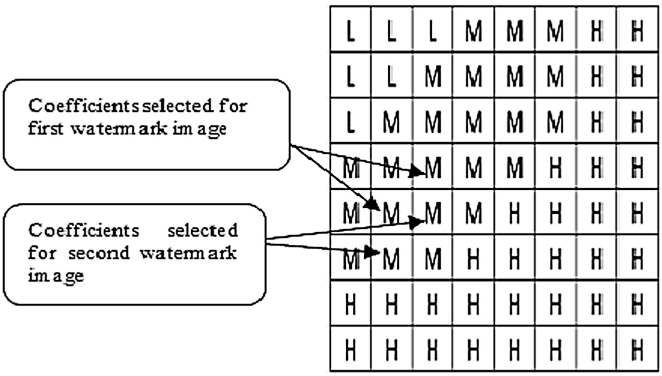

Fig. 1. Coefficients of a DCT block of the host image.

4 SVD Based Multiple Images Watermarking

SVD is very useful for image processing. This is a numerical technique to analyze the image matrix, which converts the image into three different metrics, [7]. The SVD of image I_m can be described as

$$I_m = HSV^T \tag{5}$$

$$I_m = [h_1\, h_2 \ldots h_N] \begin{bmatrix} s_1 & \cdots & \\ \vdots & \ddots & \vdots \\ & \cdots & s_N \end{bmatrix} \begin{bmatrix} v_1 \\ \vdots \\ v_N \end{bmatrix}^T \tag{6}$$

In Eq. (5), I_m is the image matrix, H and V are two $M * N$ and $N * N$ unitary orthogonal matrices, and S is a $N * N$ diagonal matrix, [8]. Where, H represents the horizontal detail component of the image and V represents the vertical detail component of image I. Both H and V are orthogonal matrices and S is a singular matrix, which consists of singular values. Singular values in S-matrix are arranged diagonally and in decreasing order [9]. One of the important properties of SVD is that a little change in the singular values does not affect the quality watermark image. Due to the property of SVD, SVD algorithm produces more robust and secure watermark, [10].

A host image is divided into blocks, and then SVD is applied for each block. Two watermark images are embedded in the form of singular values modification, [11]. For this different random sequence for a different bit of every watermark image is added to singular values with a gain factor. After modifying singular values we take the inverse of the SVD process to produce watermarked image. At extraction part, SVD is applied to watermarked image. From the correlation between stored singular values and modified singular values message bits are recovered and reshaped into watermark image, [12].

5 Experimental Results

5.1 DCT Based Multiple Image Watermarking

For single and multiple images watermarking, different values of accuracy rate (*AR*), *PSNR* and normalized correlation (*NC*) with respect to gain factor K are used (see Table 1 in Appendix). This K is the difference between two coefficients in transformed matrix. This shows that for the same value of K, *PSNR* of the watermarked image in single image watermarking is more than the *PSNR* of watermarked image in multiple images watermarking because more coefficients are varied in multiple images watermarking. While *PSNR* of watermark images depends on the selected coefficients in which watermark bits are being embedded. DCT algorithm based watermarking is applied on images with a constant gain factor (k_1) of 20 (see Fig. 4 in Appendix). *PSNR* Variations with respect to gain factor K in DCT based algorithm for single and multiple images watermarking are compared (see Fig. 2). The watermarked image-1 of single image DCT watermarking method is having higher PSNR value than the watermarked image-2 of multiple images DCT watermarking method (see Fig. 2).

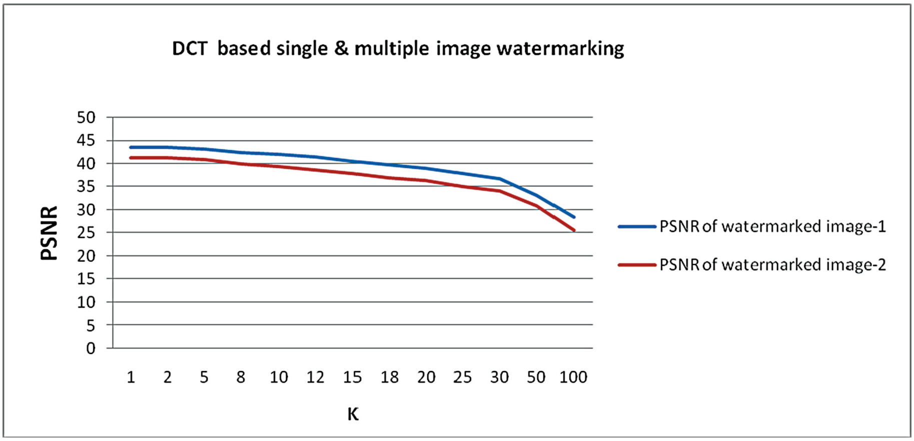

Fig. 2. PSNR variation in DCT single image and multiple image watermarking. (K = Gain factor for DCT based watermarking)

5.2 SVD Based Multiple Image Watermarking

SVD based single and multiple images watermarking is applied with different values of *AR*, *PSNR* and normalized correlation with respect to gain factor *alpha* (see Table 2 in Appendix). For the same value of *alpha*, *PSNR* of the watermarked image in single image watermarking is slightly more than the *PSNR* of watermarked image in multiple

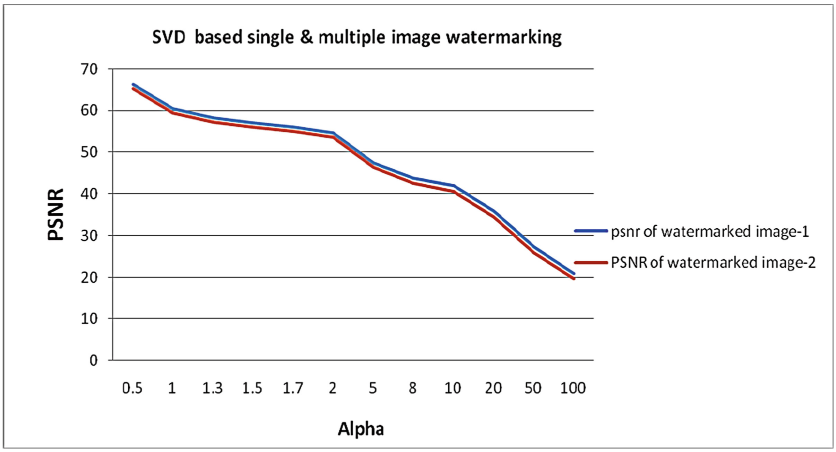

Fig. 3. PSNR variation in SVD single image and multiple image watermarking. (Alpha = Gain factor for SVD based watermarking).

images watermarking unlike in DCT based method because only singular values are varied in multiple images watermarking (see Table 2 in Appendix).

SVD based multiple images watermarking with gain factor *alpha* as 20 is applied to the same image (see Fig. 5 in Appendix). *PSNR* Variations of watermarked images with respect of gain factor *alpha* are compared for image-1 and image-2 (see Fig. 3).

The watermarked image-1 of single image SVD watermarking method is having slightly higher PSNR value than the watermarked image-2 of multiple images SVD watermarking method (see Fig. 3).

6 Conclusions

In this paper, two multiple images digital image watermarking algorithm is implemented using MATLAB which is based on DCT and SVD. Experiment results conclude that SVD based multiple images watermarking algorithm has better watermarked image compared to DCT based multiple images watermarking algorithm.

Two watermarks are extracted in each method and we can see the difference that in DCT based multiple image watermarking two watermarks are having different psnr depending on the different coefficient which we are selected while there is slight change in the psnr of two watermarks in SVD based multiple images watermarking.

Appendix

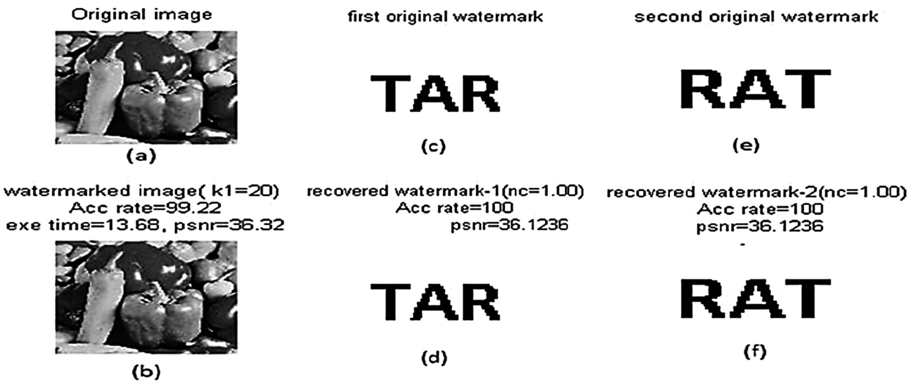

Fig. 4. DCT multiple image watermarking, (a) Host image, (b) Watermarked image, (c) First watermark, (d) First recovered Watermark, (e) Second watermark, (f) Second recovered watermark. ($k1$ = Gain factor for DCT based multiple image watermarking, nc = normalized correlation).

Table 1. DCT single image and multiple image watermarking

Gain factor	DCT single image watermarking					DCT multiple images watermarking							
	Watermarked image		Watermark			Watermarked image		Watermark-1			Watermark-2		
K/K1	AR	PSNR	NC	AR	PSNR	AR	PSNR	NC	AR	PSNR	NC	AR	PSNR
1	100	43.4	0.7	81.2	5.2	100	41.2	0.7	82.8	5.2	0.59	70.3	3.8
2	100	43.3	0.71	81.2	5.3	100	41.2	0.7	79.6	5.2	0.59	70.3	3.8
5	100	43.0	0.79	82.8	6.8	100	40.7	0.8	82.8	7.0	0.61	78.1	4.0
8	99.8	42.3	0.95	95.3	13.5	99.8	40	0.94	95.3	12.5	0.67	76.5	4.7
10	99.4	41.8	0.99	98.4	21.0	99.4	39.3	0.99	100	20.4	0.74	90.6	5.7
12	99.2	41.3	1	100	36.1	99.2	38.6	1	100	36.1	0.83	95.9	7.6
15	98.8	40.4	1	100	36.1	99.2	37.7	1	100	36.1	0.93	96.8	11.9
18	98.8	39.6	1	100	36.1	99.2	36.8	1	100	36.1	1	100	31.3
20	98.8	39	1	100	36.1	98.9	36.3	1	100	36.12	1	100	36.1

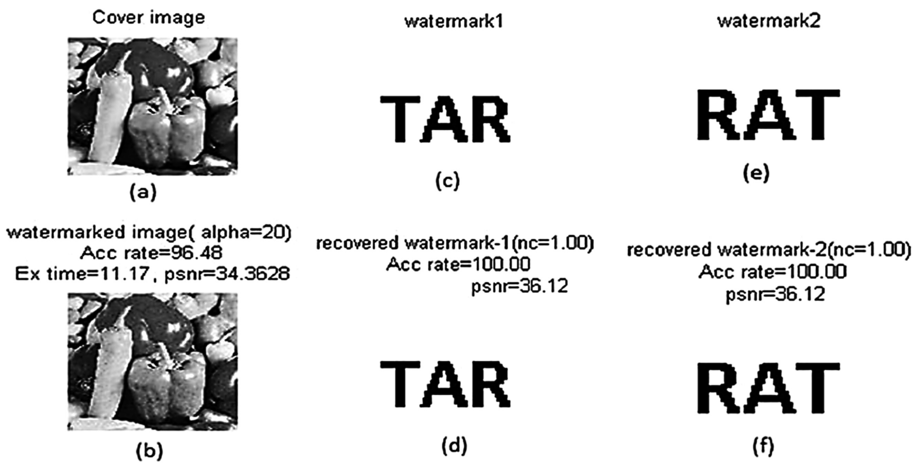

Fig. 5. SVD multiple image watermarking, (a) Host image, (b) Watermarked image, (c) First watermark, (d) First recovered watermark, (e) Second watermark, (f) Second recovered watermark. (alpha = Gain factor for SVD based multiple image watermarking, nc = normalized correlation).

Table 2. SVD single image and multiple images watermarking

Gain factor (alpha)	SVD single image watermarking					SVD multiple images watermarking								
	Watermarked image		Watermark			Watermarked image		Watermark-1			Watermark-2		
	AR	PSNR	NC	AR	PSNR	AR	PSNR	NC	AR	PSNR	NC	AR	PSNR
1	100	60.3	0.04	7.8	0.73	100	59.2	0.05	4.69	0.76	0.07	12.5	0.96
1.3	100	58.2	0.66	71.8	5.1	100	57.0	0.72	79.6	6.03	0.75	75	6.73
1.5	100	57.0	0.97	96.8	15.1	100	55.9	0.98	100	16.7	0.98	96.8	18.7
1.7	100	56.0	1	100	33.1	100	54.8	1	100	36.1	1	100	36.1
2	100	54.6	1	100	36.1	100	53.5	1	100	36.1	1	100	36.1
5	99.4	47.4	1	100	36.1	99.2	46.3	1	100	36.1	1	100	36.1
8	99.2	43.7	1	100	36.1	99.2	42.4	1	100	36.1	1	100	36.1
10	99.0	41.9	1	100	36.1	98.8	40.5	1	100	36.1	1	100	36.1

References

1. Potdar, V.M., Han, S., Chang, E:. A survey of digital image watermarking techniques. In: Proceedings of the IEEE International Conference on Industrial Informatics, pp. 709–716 (2005)
2. Lu, Z.M., Zheng, H.Y., Huang, J.W.: A digital watermarking scheme based on DCT and SVD. In: Proceeding of IIHMSP 2007 Conference, Kaohsiung, pp. 241–244 (2007)
3. Rykaczewski, R.: Comments on "An SVD-based watermarking scheme for protecting rightful ownership". IEEE Trans. Multimedia **9**(2), 421–423 (2007)
4. Wang, N., Wang, Y., Li, X.: A novel robust watermarking algorithm based on DWT and DCT. In: International Conference on Computational Intelligence and Security, vol. 1, pp. 437–441 (2009)
5. Rafigh, M., Moghaddam, M.E.: A robust evolutionary based digital image watermarking technique in DCT domain. In: Proceedings of IEEE 7th International Conference on Computer Graphics, Imaging and Visualization, pp. 105–109 (2010)
6. Lai, C.-C., Tsai, C.-C.: Digital image watermarking using discrete wavelet transform and singular value decomposition. IEEE Trans. Instrum. Measur. **59**, 3060–3063 (2010)
7. Run, R.S., Horng, S.J., Lai, J.L., Kao, T.W., Chen, R.J.: An improved SVD-based watermarking technique for copyright protection. Int. J. Expert Syst. Appl. **39**(1), 673–689 (2012)
8. Parashar, P., Singh, R.K.: A survey : digital image watermarking techniques. In: 3rd IEEE International Conference on Industrial Informatics Techniques, pp. 111–124 (2014)
9. Chinchmalatpure, P., Ramteke, K., Dahiwale, P.: Fingerprint authentication by hybrid DWT and SVD based watermarking. In: IEEE International Conference on Innovations in Information, Embedded and Communication Systems, ICIIECS, pp. 0–3 (2015)
10. Rao, R.S.P., Kumar, P.R.: An efficient genetic algorithm based gray scale digital image watermarking for improving the robustness and imperceptibility. In: International Conference on Electrical, Electronics, and Optimization Techniques (ICEEOT), pp. 4568–4571 (2016)
11. Gupta, P., Parmar, G.: Image watermarking using IWT-SVD and its comparative analysis with DWT-SVD. In: 2017 International Conference on Computer, Communications and Electronics, COMPTELIX, pp. 527–531 (2017)
12. Ansari, I.A.: On the security of "block -based SVD image watermarking in spatial and transform domains". In: International Conference on Digital Arts, Media and Technology (ICDAMT), pp. 44–48 (2018)