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DWT-SVD based Multiple Watermarking Techniques

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Abstract: *Multiple watermarks is to convey multiple sets of information designed to suit differing objectives and is used to increase robustness and security with many different methods in which the embedded information is not easily lost. DWT-SVD based successive and segmented watermarking technique is proposed. The successive and segmented of multiple watermarking techniques makes the watermarks much more robust. The successive and segmented watermarking achieves more imperceptibility and robustness.*

Keywords: *successive watermarking, segmented watermarking, discrete wavelet transform, singular vale decomposition.*

I. Introduction

Applications, in digital communication include electronic advertising, real time image, audio, and video delivery, digital repositories and libraries, and web publishing. Jacobson Roberta Beach, a popular Journalist has criticized the misuse of work by writers in websites article 'Copyright and Wrongs' [1]. An important issue that arises in these applications is the protection of the rights of all the participants. It has been recognized, for quite some time, that the current copyright laws are inadequate to deal with the digital data. This has led to an interest towards developing new copy deterrence and protection mechanisms. One such effort that has been attracting interest is based on digital watermarking techniques.

A multiple watermarking technique which combined the wavelets based on texture properties to watermark authentication and copyright information inside a cover image is proposed in [2]. The experimental results proved that their algorithm was efficient in terms of quality and the results also proved that storing watermarks using texture properties had also provided high robustness.

The inspiration behind the present work is the motivation of the work done by Mintzer et al. [3] discussed "If one watermark is good, or more better?". In this converse, the multiple watermarks are employed to convey multiple sets of information into image. Hence, it has been decided to investigate the multiple watermarking for the purpose of copyright protection, medical safeties and secured communications.

Andreas Mascher-Kampfer et al. [4] focused on a comparison of blind and non-blind algorithms in successive watermarking technique. In their scheme, the imperceptibility of watermarked image is found to have low PSNR values. This motivated the researcher to implement the discrete wavelet transform (DWT) based successive watermarking technique using different embedding methods.

Sheppard et al. [5] described three multiple watermarking techniques theoretically and the author explained a weakening of detection performance in composite watermarking technique using the Fourier and discrete cosine transform watermarking strategies. The above said studies motivated to implement the practical application of the same. This also prompted the researcher to undertake a different methodology in multiple watermarking techniques using the DWT and singular value transformation (SVD) with optimization.

Yuancheng Li et al. [6] proposed a novel multiple watermarking algorithm using bandelet transform of different frequency subbands. To improve the performance of their algorithm, the investigator to employ the work on the multiple watermarking algorithm using daubechies wavelet transform of different frequency subbands. Jagadeesh et al. [7] presented a genetic algorithm approach for SVD based digital image watermarking. In their work, the robustness of extracted watermark was found to be low. This inspired the researcher to implement the work on DWT and SVD based multiple watermarking techniques using genetic algorithm.

Comparison of multiple-watermarking techniques based on DWT and SVD using Genetic algorithm for medical images is proposed in [8]. The research elaborates the three main categories of multiple watermarking techniques such as successive, segmented and composite watermarking. The optimization is to maximize the performance of peak signal to noise ratio and normalized correlation in multiple watermarking techniques using genetic algorithms. Intern Glen E. wheeler et al. [9] discussed the segmented watermarking technique in which the original image is divided into square blocks with each block having a watermark independently. Their segmented watermarking technique has not investigated against the attacks. This prompted the investigator to work on the same line but with a difference in varying the embedding methods and also it is proposed with optimization technique.

A new color image watermarking for copyright protection is proposed in [10]. It was based on embedding multiple watermark bits into the blue component of a color image in DWT domain. The experimental results demonstrate that their proposed method successfully makes the watermark perceptually invisible and robust to some geometric and common image processing attacks. This paper is organized as follows; the proposed work is explained in section 2. The experimental results and discussion are presented in section 3. Finally, concluding remarks are given in section 4.

II. Proposed Work

The proposed work focuses on successive and segmented watermarking technique. The proposed methodology are discussed as follows,

A. Successive Watermarking Technique

In successive watermarking technique, the watermarks are embedded one after the other. In case the digital information (Image) is sold, the information about original owner and the information about recipient are embedded. If re-selling is possible, every time the sold digital information along with the information of the new recipient can be embedded using successive watermarking technique. In this case, we can trace back the way the origin of the digital information and to reconstruct the entire trading chain.

B. Segmented Watermarking Technique

In the segmented watermarking technique, the original image is segmented into several parts and each watermark is embedded into the specific share. Without the knowledge of any one of the partner, the watermark cannot be recovered.

C. Discrete Wavelet Transform

The heart of wavelet analysis is a multi resolution analysis (MRA). Multi resolution analysis is the decomposition of an image into different sub images of different size resolution levels. MRA is designed at high frequencies, to provide poor frequency resolution and good time resolution. MRA is designed at low frequencies, poor time, frequency resolution and good frequency resolution.

The main advantages of wavelets are that they offer localization in frequency domain and able to separate the fine details in a Signal. This can be used to isolate the fine and coarse details in a signal. A wavelet transform can be used to decompose a signal into component wavelets.

D. Singular Value Decomposition

The SVD is a powerful matrix decomposition tool which has also been used in a variety of applications. From the viewpoint of linear algebra, a discrete image can be represented as a 2D matrix with nonnegative scalar entries

E. Watermarking Embedding and Extraction Method

The DWT-SVD based watermark embedding and extracting process can be described as follows

(1) Sucessive Watermark Embedding

1. The original image (I) is Input Original image
2. Apply DWT to the input image. By applying DWT the image is decomposed in to four sub bands HH, HL, LH and LL.
3. Apply SVD to the LL band.
4. The watermark image are embedded in the original image using additive embedding method
5. Apply Inverse SVD and apply Inverse DWT.
6. Finally the watermarked image1 will be obtained
7. Similarly, the second watermark is embedded into watermarked image1 to get the watermarked image 2

(2) Sucessive Watermark Extraction

1. Input watermarked image 2 and watermarked image 1.
2. Apply DWT to the watermarked images. By applying DWT both the images are decomposed in to four sub bands HH, HL, LH and LL.
3. Apply SVD to the LL band.
4. The second watermark image is extracted from the watermarked image2 and the watermarked image2 using additive extraction method
5. Apply Inverse SVD.
6. Finally the second watermark image will be obtained.

7. The first watermark is extracted from the watermarked image1 and original image by repeating the above steps.

(3) Segmented Watermark Embedding

1. The original image (I) is partitioned into two sub images such as odd sub image (Iodd) and even sub image (Ieven). The odd sub and even sub images are Input Original image
2. Apply DWT to the input images. By applying DWT the images are decomposed in to four sub bands HH, HL, LH and LL.
3. Apply SVD to the LL band.
4. The watermark images are embedded in the odd sub and even sub image using additive embedding method
5. Apply Inverse SVD and apply Inverse DWT.
6. Finally the odd and even watermarked images will be obtained
7. The two sub images are combined to get a final watermarked image

(4) Segmented Watermark Extraction

1. Input odd and even watermarked images.
2. Apply DWT to the odd and even watermarked images. By applying DWT both the images are decomposed in to four sub bands HH, HL, LH and LL.
3. Apply SVD to the LL band.
4. The watermark images are extracted from the odd and even watermarked images and the odd and even original images using additive extraction method
5. Apply Inverse SVD.
6. Finally the watermark images will be obtained.

III. Results And Discussion

In this paper, a robust multiple successive and segmented watermarking technique is proposed based on wavelet domain for Color images. Fig.1(a - h) shows the original images of size 512×512 and the image watermarks of size 48×48 as shown in Fig.1(i) and Fig.1(j).

A. Evaluation of Results

The quality of the system is evaluated using the quality metrics. The quality metrics calculated in our proposed work are PSNR and NC.

(1) PSNR (Peak Signal to Noise Ratio)

PSNR is the logarithmic value of ratio between signal and noise. It is expressed in decibels. The PSNR is used to measure quality of watermarked image as follows:

$$PSNR(dB) = 10\log_{10}\frac{255^2}{MSE} \tag{1}$$

where,

MSE = Mean square error

(2) NC (Normalized cross Correlation)

Normalized Correlation (NC) is used to measure the quality of the watermark after recovery. The NC between the embedded watermark W (i, j) and the extracted watermark W' (i, j) is given by

$$NC = \frac{\sum_{i=1}^{H}\sum_{j=1}^{L} W(i,j)\times W'(i,j)}{\sum_{i=1}^{H}\sum_{j=1}^{L}[W(i,j)]^2} \tag{2}$$

Table 1 shows the scaling factor, PSNR and NC values on successive watermarking technique. Table 2 shows the scaling factor, PSNR and NC values on segmented watermarking technique.

Images	PSNR values	NC 1 Values	NC 2 values
(a)	37.9634	1	1
(b)	38.0820	0.9999	0.9898
(c)	38.7064	1	1
(d)	38.0398	0.9923	1
(e)	38.0489	1	1
(f)	37.0826	0.9894	1
(g)	37.6591	1	0.9952
(h)	37.9974	0.9943	1

Table 1: PSNR and NC values on successive watermarking

Images	PSNR values	NC 1 Values	NC 2 values
(a)	39.9373	1	1
(b)	39.9581	1	0.9498
(c)	40.1757	1	1
(d)	40.0338	0.9239	1
(e)	40.0432	0.9912	1
(f)	38.9581	1	0.9012
(g)	39.6411	1	1
(h)	39.9893	0.9219	1

Table 2: PSNR and NC values on segmented watermarking

(a) (b) (c) (d) (e)

(f) (g) (h) (i) (j)

Fig. 1. Set of Original images and Its Watermark Images

(a) (b) (c) (d) (e)

(f) (g) (h) (i) (j)

Fig. 2. Set of Watermarked images and Its Extracted Watermark Images

IV. Conclusion

Multiple image watermarking work is done by using DWT-SVD. The low frequency of image in DWT domain is modified with SVD in order to embed the singular value of watermark to the singular value of DWT coefficient. In the proposed approach, the original image is segmented into two sub images, and then the two watermarks are embedded in the singular values of each sub image separately. In the extraction process the watermarks are extracted from the singular values of the watermarked sub images. The sucessive and segmentation of multiple watermarking processes makes the watermarks much more robust

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