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# A Review of Robust Watermarking Scheme based on RDWT-SVD

Physics

**KEYWORDS:** Digital Image Watermarking, Redundant Discrete Wavelet Transform, Singular Value Decomposition.

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## ABSTRACT

In this review paper, a new method for non-blind image watermarking that is robust against affine transformation and ordinary image manipulation is explained. This method presents a watermarking technique based on redundant discrete wavelet transform (RDWT) and Singular Value Decomposition (SVD). After applying RDWT to both cover and watermark images, we apply SVD to the LL sub-bands of them. We then modify singular values of the cover image using singular values of the visual watermark. The advantage of the reviewed technique is its robustness against most common attacks. Analysis and experimental results show higher performance of the reviewed method in comparison with the DWT-SVD method.

**I. INTRODUCTION**

In the internet age, multimedia (image, text, audio and video) data is requirement of the user and companies for their personal and social purposes. All multimedia files are transferred and kept on internet for accessing those files from anywhere. These multimedia files should be secured and authenticated by particular user or company, otherwise anyone can thieve data and sell to other company. So hiding the data or encrypting the data is necessary for the copyright purposes such that no unintended person can access its originality or authentication. There are many ways for hiding the information such as steganography, cryptography and watermarking etc. But in digital world, watermarking is most commonly used for copyright protection of digital information data. Digital watermarking is the pattern of bits inserted into the multimedia files or hiding the digital information into the carrier signal that identifies the file's copyright information. AttackA watermarking life cycle phase consists of an embedding algorithm, an attack and an extraction or detection algorithm which is shown in Fig. 1. Watermarking can be performed in the spatial or transforming domain. Spatial domain methods are less complex but are not as robust as transform domain methods against various attacks [1, 2]. So, transform domain is mainly used for the watermarking process.


**Fig. 1. Watermarking life cycle phase**

**I. SVD & DWT**

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. In SVD first algorithm [3], 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. Discrete cosine transform (DCT)/Discrete wavelet transform (DWT) is also used for the digital watermarking process.

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 [4, 5]. But DWT has one drawback that is because of the down-sampling of its bands, it does not provide shift invariance. This causes a major change in the wavelet coefficients of the image even for minor shifts in the input image. The shift variance of DWT causes inaccurate extraction of the cover and watermark image [6]. So, to overcome these drawbacks, redundant discrete wavelet transform (RDWT) is developed. The un-decimated discrete wavelet transform or sometimes called RDWT is used for watermarking process because it generated less distorted image when extracted. In RDWT, we modifies the filters at each level by up-sampling. It means RDWT contains the coefficients of DWT of shifted signal. Here, Fig. 2 shows the 1D DWT and RDWT with their inverse procedure.

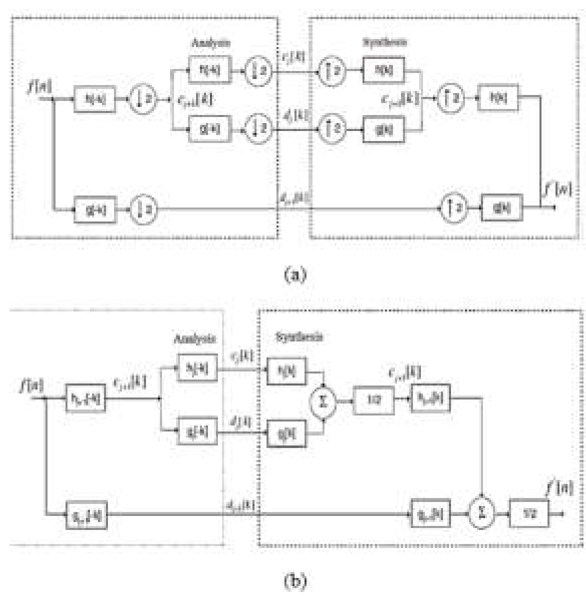

**Fig. 2 (a) 1D DWT analysis and synthesis (b) RDWT analysis and synthesis filter banks**

**I. RDWT-SVD BASED WATERMARKING**

When we combined RDWT with SVD process, then we can take advantages of both process in watermark embedding and extraction. Embedding and extraction process steps are described below [1].

**A. Watermark Embedding**

The watermark embedding algorithm of review paper is shown in Fig. 3. The steps of watermark embedding algorithm are as follows:

1. Apply RDWT to the cover image to decompose it into LL, HL, LH, and HH sub-bands.
2. Apply SVD to the low frequency sub-band LL of the cover image: I1

= U1 S1 V1
3. Apply RDWT to the visual watermark.
4. Apply SVD to the low frequency sub-band of watermark: W = UW SW VW
5. Modify the singular values of the cover image with the singular values of watermark image:

$S^*1 := S1 + \alpha SW$

where $\alpha$ is scaling factor, S1 and SW 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*1 = U1 S*1 V1
7. Apply inverse RDWT using the modified coefficients of the low frequency bands to obtain the watermarked image.

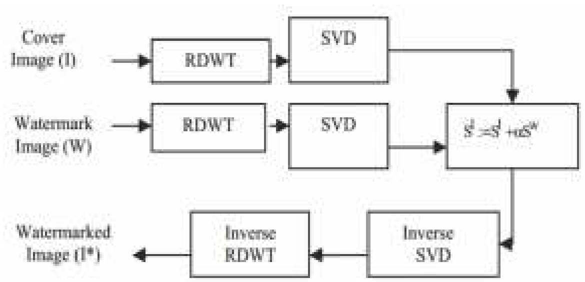


**Fig. 3. Block Diagram of the watermark embedding algorithm**

B. Watermark extraction
The watermark extracting algorithm of review paper is shown in Fig. 4.

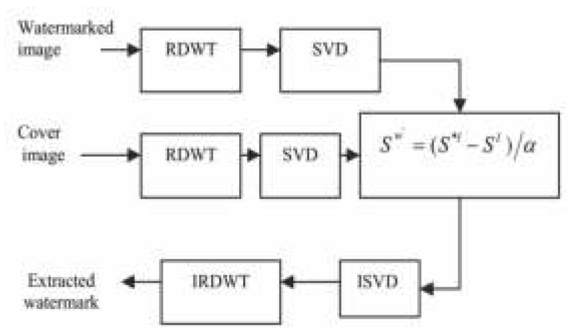


**Fig. 4. Block Diagram of the watermark extracting algorithm**

The following steps describe the watermarking extraction algorithm:

1. Using RDWT, decompose the watermarked image I* into 4 sub-bands: HH, HL, LH and LL.
2. Apply SVD to low frequency sub-band LL: I*1 = U*1 S*1 V*1
3. Extract the singular values from low frequency sub-band of watermarked and cover image:

Sw' = (S*1 – S1)/$\alpha$ where S1 contains the singulars of the cover image.
4. Apply inverse SVD to obtain low frequency coefficients of the transformed watermark image.
5. Apply inverse RDWT using the coefficients of the low frequency sub-band to obtain the watermark image.

IV. EXPERIMENTAL RESULTS
In this review paper, we used gray scale Lena image (512x512) as a cover image and cameraman image as a watermark image of same size which is shown in Fig. 5. Here, scaling factor $\alpha$ has 1.25 value.

**(a)**

**(b)**

**Fig. 5. (a) Cover image (Lena – 512x512) (b) Watermark image (Cameraman – 512x512)**

When watermarks are extracted, similarity of the watermarked and cover image can be defined by the PSNR (Peak Signal to Noise Ratio) criterion:

$$PSNR = 10 * \log_{10}\left[\frac{\max((X(i,j))^2}{MSE}\right]$$

And MSE (Mean Square Error) is defined as:

$$MSE = \frac{1}{m*n}\sum_{i=1}^{m}\sum_{j=1}^{n}[X(i,j) - Y(i,j)]^2$$

where m and n are the dimensions of the images X and Y. PSNR is measured in db. Larger values of PSNR indicate better watermark

concealment.
We compared the watermarked image with the original one and PSNR was obtained as 34.1235 dB and MSE 0.0004 dB. 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 standard correlation coefficient is obtained by equation (3).

$$\text{correlation} = \frac{\sum(x-\bar{x})(y-\bar{y})}{\sqrt{\sum(x-\bar{x})^2}\sqrt{\sum(y-\bar{y})^2}}$$

**I. CONCLUSION**

We reviewed a new watermarking method based on RDWT-SVD to embed a watermark image which can be as large as the cover image. Modifying singular values of the cover image in RDWT 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 RDWT implementation. These results demonstrated that the proposed method is more robust to various attacks compared to DWT based methods. RDWT 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, RDWT 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.

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