

# Digital Watermarking using DWT-SVD Algorithm

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## **Abstract**

In recent years, technology is not the rocket science but it cut both ways in terms of fast transmission and manipulation. Manipulation of data raises online data vulnerability and copyright issues. Digital watermarking comes out as one of the best solutions to deal with these issues. In this paper, various watermarking techniques reported in literature are reviewed. A simple digital watermarking algorithm based on discrete wavelet transform and singular value decomposition has been proposed in this paper. This proposed method helps to understand basic concept of digital watermarking. Experimental results demonstrate the effectiveness of the proposed method. One of the major advantages of the proposed scheme is the robustness of the technique on wide set of attacks.

## I. INTRODUCTION

The proliferation of digital media over the internet has been raised in last few years. The enhancing usage of digitization has given a great lead to copyright issues. To tackle with copyright issues, digital watermarking comes out as suitable solution. Digital watermarking is process of inserting watermark information into host image. Watermark is the copyright information which protects digital data from the illegal replication and distribution. Watermark can be inserted into digital data by various methods as reported in literature. These methods mainly classified into two categories called transform domain and spatial domain. In spatial domain, watermark is inserted inside the digital content by modifying pixel values. Least significant bit is one of the spatial domain has been presented in history. At transform domain, digital data is represented in terms of frequencies. Digital watermarking at transform domain has been performed by different method as reported in literature. Every method in transform domain has own advantages and disadvantages. DCT, DWT, DFT, FFT comes as an example of various transform used at transform domain. Transform domain coefficients are modified by the watermark for inserting watermark. Third watermarking techniques used is spread spectrum. Spread spectrum basically to spread the watermark energy over visually important frequency bands, so that the energy in any one band is small and undetectable.

In this paper, transform domain method is employed. This paper combines discrete wavelet transform and singular value decomposition. The Adoption of above technique increases robustness of watermarking method. Discrete Wavelet Transform is a transform that is used in numerical as well as functional analysis. In this transform, the wavelets are sampled with the discrete values. The main advantage of this transform over Fourier Transform is that it captures both frequency and location information. In Discrete Wavelet Transform, signal energy concentrates to specific wavelet coefficients. This characteristic is useful for compressing images.

The DWT technique decomposes the original image into four sub bands that comes under independent frequency and spatial domain. These sub bands are LL, LH, HL and HH as shown below in Figure 1.

<b>LL</b>	<b>LH</b>
<b>HL</b>	<b>HH</b>

**Figure 1:** Sub bands of discrete wavelet transform

In linear algebra, the singular value decomposition (SVD) is a factorization of a real or complex matrix. An image can be represented in the form of a matrix of scalar values. SVD decomposes an image represented by a matrix  $A$  of size  $M.N$  into a product of three matrices  $A=USV^T$  where  $U$  and  $V^T$  are  $M.N$  and  $N.N$  orthogonal matrices, respectively. Here,  $S$  is an  $N.N$  diagonal matrix. The elements of  $S$  are only nonzero on the diagonal and are called the singular values of  $A$ . When the rank of  $A$  is  $r$ ,  $S = \text{diag}(\gamma_1, \gamma_2, \dots, \gamma_n)$  satisfies  $\gamma_1 > \gamma_2 > \gamma_3 > \dots > \gamma_r = \gamma_n = 0$ . Let  $A$  be a matrix whose elements are pixel values of an image. The image can be written as:

Embedding in the low frequency components decreases the image distortions after the embedding process and more sensitive to modifications in histogram such as contrast/brightness adjustment, gamma correction, histogram equalization and more. Whereas watermarking in middle and high frequencies are more robust to noise adding and non-linear deformations. Embedding multiple watermarks in both the low and high frequency bands of DWT will increase its robustness overall.

$$A = \sum_{i=0} \alpha_i u_i v_i$$

SVD is used because of the following properties:

1. Little disturbance added to the image does not cause high variation to the singular values of the image.
2. The singular value of the image represents the essential algebraic image properties.

The organization of this paper is as follows. Section II provides a short review on digital watermarking based on discrete wavelet transform and singular value decomposition.. Section III illustrates discrete proposed embedding and decoding method. Section IV provides experimental results for proposed scheme. Finally, section IV concludes this paper.

## II. LITERATURE SURVEY

Watermarking is a technique which is widely used and continuously developed by the use of various methods and implementations. Vast research work had already been done in this field that helped us to set a path for this work and contribute in the field of watermarking.

Chun-Ling Yang et al[1] proposes a discrete wavelet transform based structural similarity (DWT-SSIM) method for image quality assessment. SSIM is an image quality assessment method. Since it is proposed in pixel domain, much computation is done when it is used in DWT domain. DWT is used since it is a very popular technique. The implementation is easy and the technique produces good results. Vidyasagar M et al[2] reported a detailed survey of existing and newly proposed stenographic and

watermarking techniques for images only. In this, watermarking methods are classified based on different domains in which watermark information is embedded.

Guan Jinyu et al[3] reported digital watermarking method with discrete wavelet transform for gray scale images. Proposed method has good watermark invisibility which is evaluated under various attacks. Raval Mehul S. et al[4] proposed Discrete Wavelet Transform Based Multiple Watermarking Scheme where watermarks are embedded into low frequency components. By embedding both watermarks into low frequency components of image, one could achieve extremely high robustness properties.

Xiangui Kang et al[5] proposed a DWT-DFT Composite Watermarking Scheme which resists affine transform and JPEG compression attacks.

Watermark is based on spread spectrum and embedded into LL band of discrete wavelet transform with a training sequence. A template is also inserted into middle frequency components of DFT. Robustness of watermarking method is improved by using new embedding strategy, watermark structure, 2-D interleaving, and synchronization technique. On the other hand, Ali Al-Haj et al[6] and Saied Amirgholipour Kasmani et al[7] proposed watermarking scheme that combines both DWT and DCT transform. Combination of both transform provides improved results in terms of robustness and imperceptibility against signal processing attacks [6]. In [7], firstly, 3<sup>rd</sup> level DWT is performed on host and after that DCT transformation is applied on each selected DWT sub band. Watermark bits are embedded in the coefficients of the corresponding DCT middle frequencies. PN sequence is used as watermark bits. At extraction, watermarked image is pre-processed by Laplassian of Gaussian filters. Correlation between mid-band coefficients and PN- sequences is calculated to determine watermarked bits.

Preeti Sharma et al[8] and Poonam et al[9] both presented the technique DWT-SVD to solve the copyright issues. While in [8] hybrid transformation has been done since the modifications in the singular values makes them vulnerable to various attacks, [9] uses genetic based algorithm and 3<sup>rd</sup> level DWT watermarking technique. Singular values of the watermark are embedded to 3<sup>rd</sup> level DWT approximation matrix of host image. The Genetic Algorithm is used to optimize the scaling factor for optimized embedding of the watermark before testing them against various attacks. Shaoquan Wu et al[10] proposed Efficiently Self-Synchronized Audio Watermarking in which hidden informative data and synchronization codes were embedded into the low frequency coefficients in DWT. The embedded data have self-synchronization ability. Thus, the robustness of hidden data and efficiency of synchronization code searching both are increased. The performance is analyzed with the calculation of

SNR and BER. There were further more researches and Xiang-Gen Xia et al[11], Daxing Zhang et al[12] and Qiang Wang et al[13] proposed three different ways to

implement DWT in embedding of the watermark onto the cover image. In [11], a multi-resolution watermark is used by adding pseudo-random codes to the coefficients at high and middle frequency bands of DWT. Proposed method is robust against common image distortions. Depending upon noise level of image, watermark information is retrieved by computation load.

While in [12] a Contour-based Semi-fragile Image Watermarking Algorithm is developed and implemented by dividing the Y subdivision of original image in 4x4 blocks and applying first a 2-level DWT before applying Canny Edge Detector to give a filtered contour image. Arnold transform is performed on watermark image in order to destroy space relativity. Watermark embedding is perceived by changing the relationship of selected middle DWT coefficients in accordance with corresponding watermark bit. On the other hand, in [13] a new method called Chaos is implemented in the Wavelet Transformation. The watermark is embedded onto the singular values of the host image's DWT subbands. Furthermore, an Efficient Hardware Implementation of Image Watermarking Using DWT and AES Algorithm is proposed with the addition of cipher key. DWT is first applied for the following, image decomposition, image quantization and determination of appropriate sub bands to precede encryption. It also helps in reducing the execution time. After the implementation of DWT to the image, analysis of the Advanced Encryption Standard is done and using a cipher key in AES further enhances the encryption performance [14].

A Robust watermarking scheme for digital images has been presented in literature. This scheme is based on nonnegative matrix factorization (NMF) and DWT. Gaussian pseudo-random code sequence is used as watermark. Watermark is inserted into factorized decomposition coefficients using NMF [15]. Jong Ryul Kim et al[16] proposed a Robust Wavelet-Based Digital Watermarking Using Level-Adaptive Thresholding. In this, coefficients of all subbands are utilized by using a level-adaptive thresholding scheme and the watermark is embedded to the selected coefficients with the help of different scale factors that depends on the level of decomposition. For the detection of watermark, vector projection method is used. Some of the other watermarking schemes proposed on the DWT technique were in combination with Particle Swarm Optimizer[17] and Neural Networks[18]. While in [17], PSO is used to optimize the modifications while embedding the watermark without losing the

transparency. The process involves the computation of the detection response, parameter estimation and threshold selection. Also they switched to approximate host signal parameter estimates in order to better the runtime performance. To make the watermark robust and less vulnerable to different types of attacks, it is necessary to find the maximum amount of interested watermark before the watermark becomes visible. So in [18], Neural Networks were used to implement an automated system for creating maximum-strength watermarks. Roland Kwitt et al[19] proposed a Lightweight Detection of Additive Watermarking in the DWT-Domain. They took a closer look at the computational requirements of watermark detectors. They showed that by switching to approximate host signal parameter estimates or even fixed parameter settings we achieve a remarkable improvement in runtime performance without sacrificing detection performance. Guohui Li et al[20] proposed a Sorted Neighborhood Approach for Detecting Duplicated Regions in Image Forgeries. This technique is based on both DWT and SVD. SVD is used on fixed-size blocks of low-frequency component. The SV vectors are then lexicographically sorted and duplicated image blocks will be close in the sorted list, and therefore will be compared during the detection steps. These researches helped in the selection of techniques to be studied and implemented for this research work.

### **III. PROPOSED SCHEME**

#### **i) Watermarking Embedding procedure:**

The procedure for embedding the watermark that we are following in this project is given as follows:

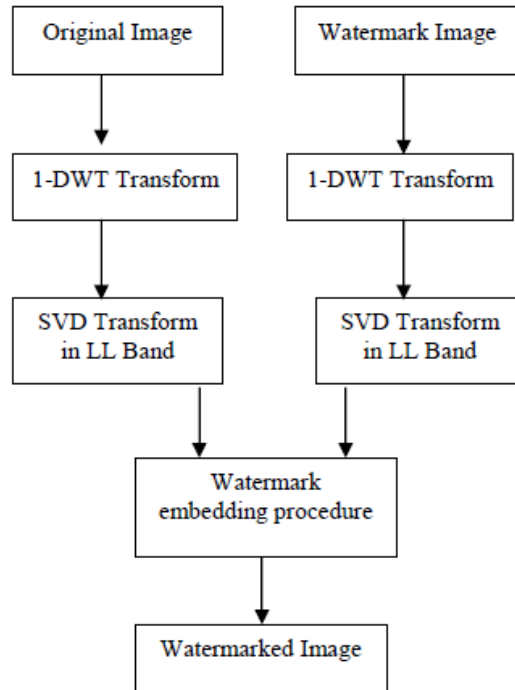
- a. Select the host and the watermark image.
- b. Apply DWT transform on both original and the watermark image.
- c. Apply SVD on the LL sub band of both original and the watermark image.
- d. Apply the watermarking algorithm on the two images and generate the resulting watermarked image.

#### **Watermark extraction procedure:**

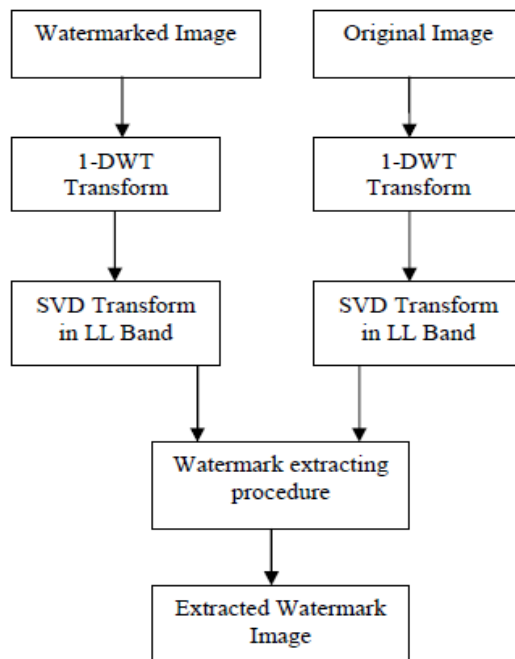
The watermark extraction process that we are going to use in our project is given as follows:

- a) Select the host and the watermarked image.
- b) Apply DWT transform on both original and the watermarked image.
- c) Apply SVD on the LL sub band of both original and the watermarked image.

- d) Apply the extraction algorithm on the two images and generate the resulting watermarked image.



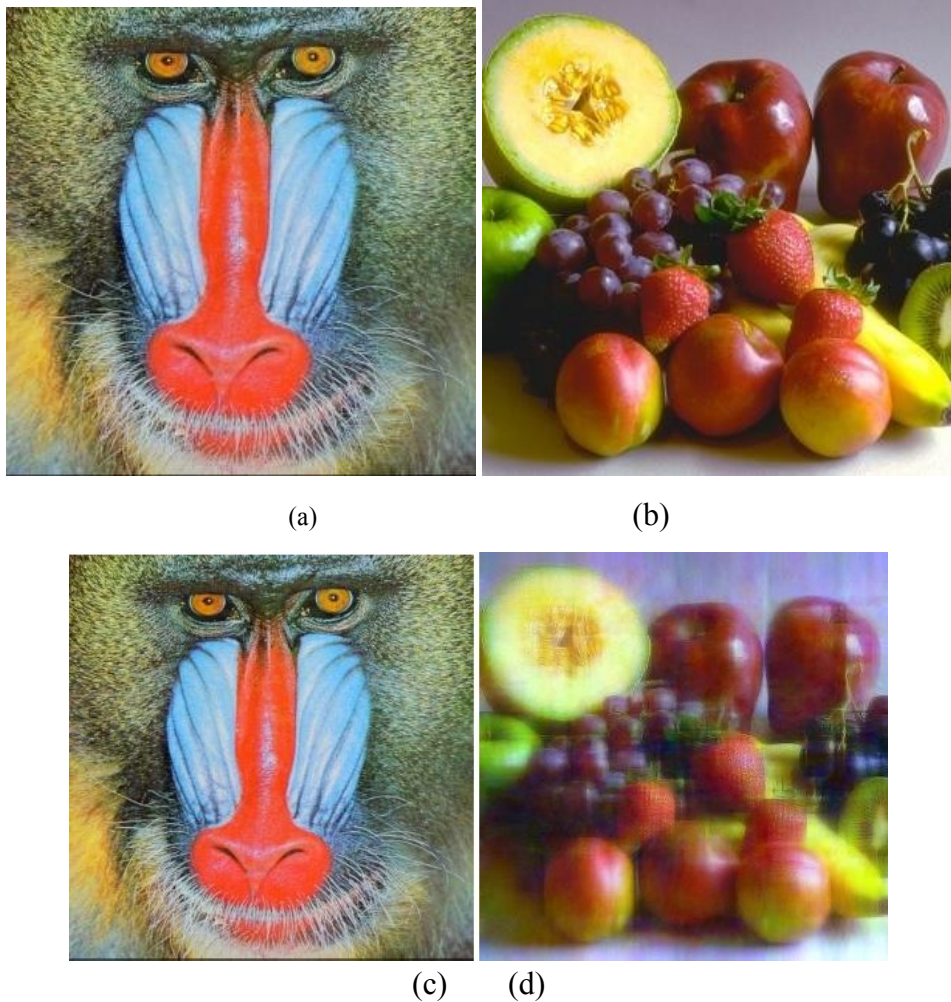
**Figure 2:** The Watermarking embedding procedure



**Figure 3:** The Watermarking extraction procedure

#### IV. EXPERIMENTAL RESULTS:

On implementing the above watermarking algorithm, the following are the results from which we can compare and evaluate the quality of the embedding and extracting methods.



**Figure 4:** (a) - Host Image; (b) – Watermark;  
(c) – Watermarked Image; (d) – Extracted Watermark

**Table 1:** Evaluation Parameters

Parameters		Baboon	Lena	Peppers
Embedding	PSNR	44.0242	35.6922	35.8694
	MSE	2.5742	17.5330	16.8321
Extraction	PSNR	20.46	21.0853	14.3917
	MSE	584.8243	506.4715	2.3655e+03



After inserting numerous attacks on the watermarked images, the performance of the watermarking implemented is affected as follows:

Attacks	Parameters	Baboon	Lena	Peppers
Salt & Pepper	PSNR	22.2438	22.0785	21.5663
	MSE	387.880	402.929	453.3717

**Table 2:** Evaluation Parameters after Attacks

		5	5	
Gaussian Noise	PSNR	20.0336	19.9657	20.2351
	MSE	645.236 1	655.409 7	615.9893
Rotation	PSNR	13.9030	15.4941	14.7914
	MSE	2.6472e +03	1.8351e +03	2.1574e+ 03
Crop	PSNR	11.3863	11.7306	9.0046
	MSE	4.7256e +03	4.3653e +03	8.1775e+ 03
Translation	PSNR	16.3417	20.7853	21.6185
	MSE	1.5098e +03	542.685 5	447.9510

## V. CONCLUSION

In this paper, different watermarking techniques were studied and basic watermarking technique known as DWT-SVD is proposed. The implemented algorithm works only for the RGB images. Proposed method has been tested under different attacks and the performance was observed under those attacks. Some of the important findings inferred from the papers are as follows:

- Division of image into various bands.
- There are various filters used for watermarking like haar, sym4, db5, bior etc. The use of different wavelet filters for the different scenarios.
- Combining Singular Value Decomposition with DWT in digital watermarking.
- How to find out the structural similarity (SSIM) between two images. It is a novel image quality assessment method, and attracts a lot of attentions for its good performance and simple calculation.

- e) The process of applying genetic algorithm in combination with DWT and finding out the most optimum place for inserting the watermark in the host image. Improvements can be further done by the application of Fuzzy Logic or Neural Network methods that will further optimize and enhance the performance and results.

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