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An Effective Algorithm depending on DWT and SVD Transforms for Watermarking Images

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Abstract

With the rapid growth of the use of internet, digital images must be protected against unapproved repetition and modification. Watermark digitalization is a potential tool for protecting copyright and preventing illegal operations. This paper introduces an efficient algorithm for digitalizing watermarked images established from combining discrete wavelet transformation (DWT) and singular value decomposition (SVD) transforms to overcome the conflict between robustness and imperceptibility. The application of DWT provides high imperceptibility whilst SVD ensures extreme sturdiness opposed to many sorts of removable and geometrical attacks. The results that were obtained experimentally revealed that the combination of DWT and SVD enhances the imperceptibility (invisibility) and sturdiness (robustness) as well as providing better results when compared with other state of arts. The suggested algorithm was tried against five types of common signal attacks. The assessment evaluation of the suggested algorithm supported the results of imperceptibility and tolerability against these attacks; consequently, the algorithm is highly effectual as well as being applicable.

KEYWORDS*: DWT, SVD, DIGITAL IMAGE WATERMARKING, COPYRIGHT PROTECTION.*

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1. Introduction

Watermark digitalization is a method of hiding secret messages and information in the multimedia such as digital pictures, documents, audios, 3D models and video clips. A digitalized watermark's main function is to act as a digital signature or a label implanted with in the original multimedia object to be extracted when proof of authentication and ownership is needed [1].

Digitalized watermark images can be usefully applied in many fields i.e. Broadcast Monitoring, Digital Fingerprinting Transaction, Tracking Copyright protection Temper, Detection Data Hiding, Content Authentication … etc. [2].

Generally, the embedding and extracting phases are usually the main phases for a watermarking system which they are complimentary to one another, the concealment of watermark data within initial image is performed during the embedding phase in which the watermark is concealed within the initial image to a watermarked image where imperceptibility is calculated to discover the degree of similarity between the initial and watermarked types. while in abstraction phase, watermark is removed from attacked watermarked image and initial watermark is compared with abstracted watermark for determining the algorithm's sturdiness, in addition to this a blind and non-blind classification can be implemented on the algorithm of the watermark ,depending whether the initial image is used in watermark abstraction phase as is the case for non-blind algorithm [3][4].

In the community of the digital watermarking field ,the researchers usually aim to design an efficient algorithm that provides high imperceptibility by hiding the watermark in such a way that it is not noticeable by the viewer. At the same time, maintain sturdiness against many types of attackers which attempt to demolish or remove the hidden watermark. The most efficient digital image watermarking algorithms combine two or more types of

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transformations such as Discrete Wavelet Transform (DWT) and Discrete Cosine Transform (DCT) [5] or DWT and Contourlet Transform (CT), [6] to change the image from the special domain to frequency domain. The purpose of applying two or more transforms is built on the reality that combination among transforms can reduce the disadvantages of each other and solves the conflict among achieving the efficient watermarking requirements.

Most previous work in spite of combination two or more transforms but either achieves robustness or imperceptibility. In this paper, we overcame the tradeoff between the preferred quality and the sturdiness of watermark. The researchers in reference [7] integrated DWT-DCT digital image watermarking algorithm and experimental results showed high imperceptibility and robustness against the Gaussian noise and cropping assaults. Reference [8] suggested a crossbreed image watermarking arrangement built on DCT-DWT-SVD. In this technique, the watermark is deeply implanted into the cover image since three transform (DCT, DWT, SVD) are taken before implanting the resistance towards the assaults. Reference [9] presented a strong new watermarking algorithm against numerous signal attacks is presented. Two watermarks were implanted in the (HL&LH) bands of the host image by using DWT & SVD. The suggested method, after simulation, revealed that it can withstand numerous attackers. While reference [10] introduced a technique based on combined CT-SVD and also applied Arnold transform to scrambling watermark pixels to ensure watermark security.

In reference [7],the authors proposed a non-blind image watermark algorithm built on applying DWT followed by CT to overcome the disadvantages when each transform is used separately. The imperceptibility evaluated measurements of the joint DWT-CT algorithm revealed a PSNR rate equal to 88.11 and the suggested algorithm improved sturdiness since it produced superior strength against Gaussian noise assault.

This paper, introduces an efficient algorithm for watermarking images built on the basis employing DWT so as to transform the image from a special to a frequency domain. The original image divided into four regions of different resolution are called HH, HL, LH and LL .The mid sub-bands are chosen for the next levels of DWT .Further, the mid sub-band are divided to equal sized blocks and SVD transform is employed to every block .after that, the singular value of every block is modified based on the value of watermark bits. The algorithm is evaluated through PSNR measurement and the effects of various types of assaults are also investigated. The DWT-SVD algorithm also compared with different related works. The results indicate that the proposed algorithm is effective and more tolerant against numerous types of signal attacks.

2. The Suggested Combined DWT& SVD watermarking Algorithm

In this work, a new watermark embedding and extraction algorithms for watermarking images built on the combination of two transforms; DWT & SVD are suggested.

1.1 Watermark Embedding based DWT&SVD Algorithm

Watermarking is performed by changing the coefficients of prudently chosen DWT sub-band, trailed by employing SVD on the chosen sub-band. The purpose of employing two transforms is built on the fact that benefits can guarantee two when transforms are pooled together and the inadequacies of the two can be counteracted. There are several methods which can be employed to implant the watermark, it was agreed to employ the frequency since a spatial domain would give us a fragile watermark that are not sturdy against signal attacks.

Figure (1) illustrates the order of the methods that were used in the algorithm that is suggested. A new algorithm method of image watermarking is presented by gushing DWT and SVD to acquire a non-blind image watermarking algorithm that offers improved invisibility (imperceptibility) and greater tolerance (sturdiness) counter to many kinds of assaults. Firstly, two levels of DWT are done on the image and mid-mid sub-bands are selected for employing SVD transform.

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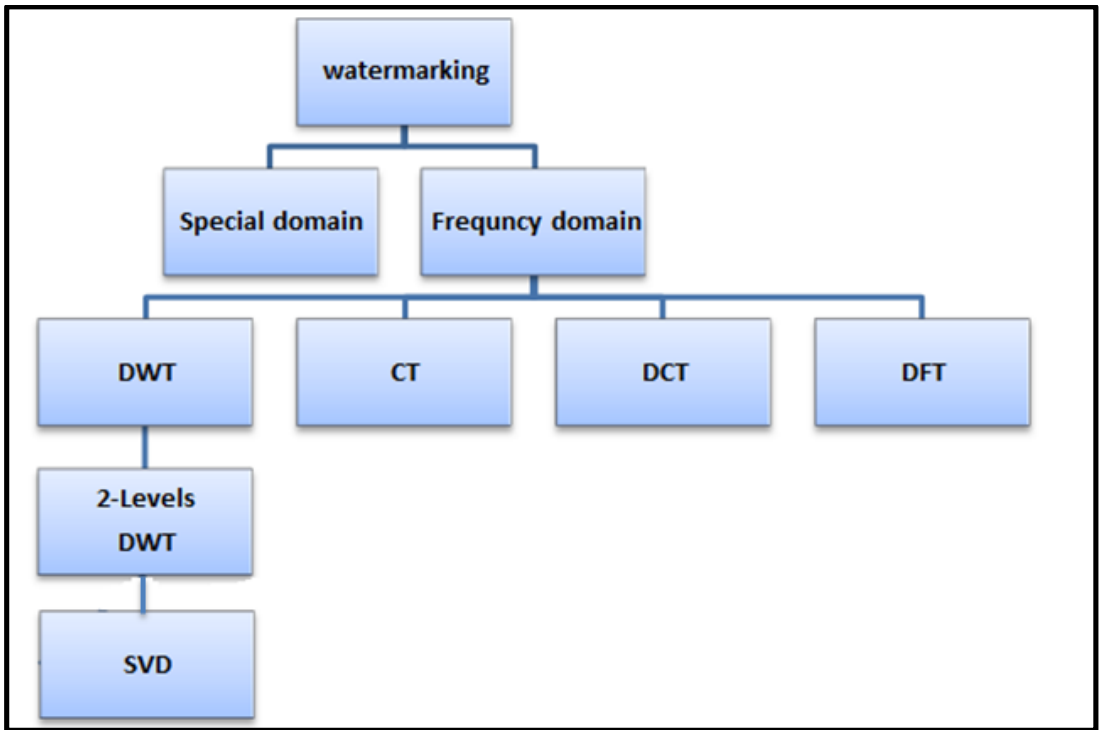

Figure (1): Watermarking Techniques

Better outcomes were obtained in imperceptibility when mid-mid sub-bands were selected. The selected sub-bands are divided into several blocks and SVD transform were applied to each one ; and lastly singular values were modified to implant the watermark. The principle aim behind combining DWT and SVD was to reduce the problems separately for each one of them. DWT offers high imperceptibility while SVD ensures high sturdily against many types of assaults. The DWT has the ability to perform good three-dimensional localization and multi-resolution properties that are close to the perceptual view of human visual system (HVS). Yet, any trivial alteration or transition in an input signal, which can lead to enormous alterations in the distribution of the wavelet factors [11]. The procedure for implanting a watermark is shown in the form of a block diagram in Figure (2) and finely described in Algorithm (1).

Algorithm (1):Watermark Embedding based DWT&SVD

Input: original image
Output: watermark image

Begin
1st step: Execute DWT to divide the initial image into sub-bands of different resolutions:LL_1, LH_1, HL_1, and HH_1.
2nd step: Select mid-mid sub-band $HL_1$to perform second levels DWT obtain four lesser LL_2, LH_2, HL_2, and HH_2 and divide HL_2 into 4×4 blocks.
3rd step: Apply SVD transform to all blocks that result from step 2:

$$A = USV^T \ldots\ldots\ldots\ldots (1)$$

4rth step: Transform the watermark image into a series made from zeros and ones.
5th step: Fix size of block as (4) and alpha values as (0.5)
6th step Determine maximum watermark size based on HL_2, and blocksize
8th step: Embed the watermark such that:
If watermark bit = zero then, modify singular value of the original image

$$HL_2 = HL_2 \times (1 + alpha) \ldots\ldots\ldots\ldots (2)$$

Else mask is filled with zeros
9th Step: Perform (IDWT) twice to obtain watermarked image.
End

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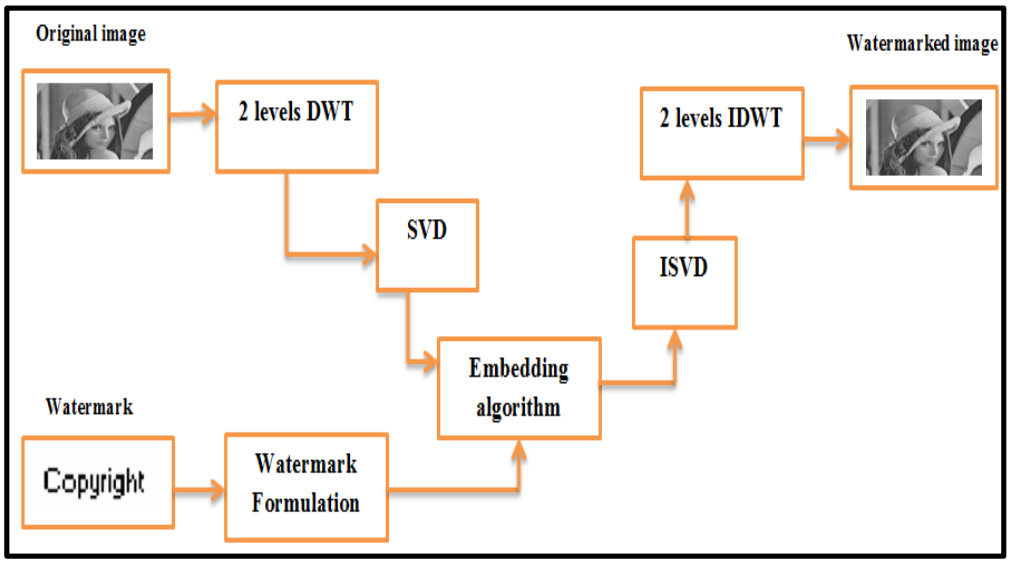

Figure (2): Block Diagram of Watermark Embedding based DWT-SVD

2.2. Watermark Extracting based DWT-SVD Algorithm

The watermark extracting algorithm based DWT-SVD is a non-blind class watermarking algorithm, and by that the extraction process is performed without existing the initial image. In Figure (3) the process for watermark extraction is illustrated as well as explained in detail in the following algorithm:

Algorithm (2):Watermark Extracting based DWT&SVD
Input: Watermarked Image **Output:** Extracted Watermark
Begin **1st step:** Decompose original image by applying two levels of DWT to obtainLL_2, LH_2, HL_2, and HH_2 and divide HL_2 to aquire 4×4 blocks. **2nd step:** Decompose watermarked image by applying two levels of DWT to obtainLL_2, LH_2, HL_2, and HH_2 and divide HL_2 into 4×4 blocks. **3rd step:** Employ SVD to the outcomes of each block from step 1 also abstract the singular value S_1 using equation 1. **4th step:** Apply SVD the outcomes from step 2 to each block to each block results from step 2 abstract also the singular values S_2 via equation 1. **5th step:** calculate difference between original image and watermarked image D=diag(HL2s1-HL2s2)'*diag(HL2s1L2s2)/(alpha*alpha)/(diag(HL2s1)'*diag(HL2s2))……..…(3) **6th step:** If the difference exceeds a threshold equal to 0.75, this means that there is a change, so abstracted watermark bit will be 0. Whereas if the dissimilarity was smaller than this threshold, here the bit will be 1. **End.**

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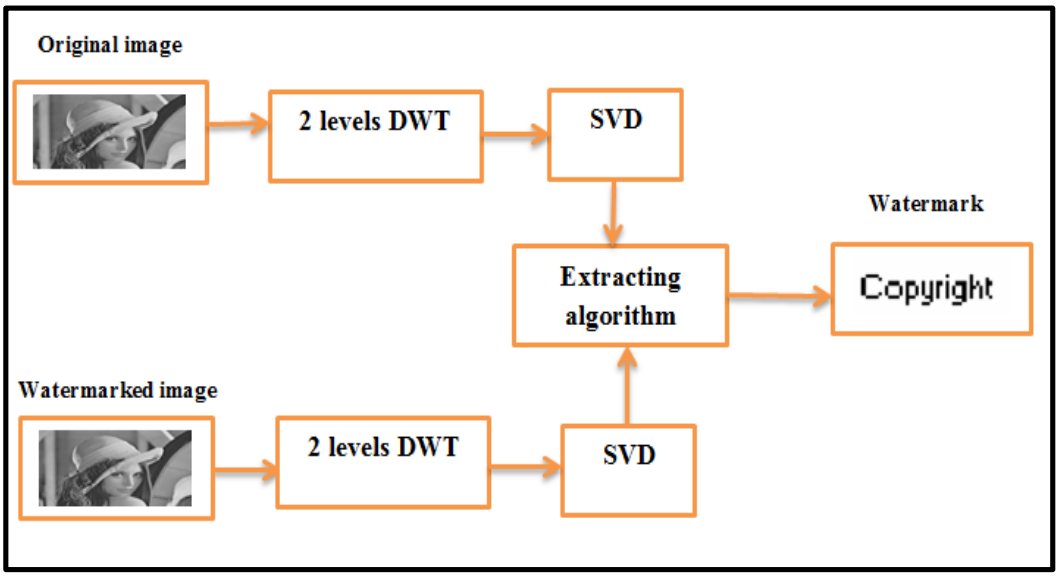

Figure (3): Block Diagram of Watermark Extracting based DWT-SVD

3. Experimental Results

The empirical data that were obtained from the implementation of the suggested method of the two properties aspects, imperceptibility and sturdiness, which are presented as follows:

3.1 Imperceptibility (Invisibility)

The hidden watermark should be completely invisible to the viewer. This means embedding watermark should not affect the initial image's perceptual quality and the viewer cannot differentiate between original and watermarked image. The Peak Signal to Noise Ratio (PSNR) is used for measuring the quality of imperceptibility for a watermarked image [8]. Images with higher PSNR metrics are considered better results. The PSNR is calculated as follows:

$$PSNR = 10 \cdot \log_{10}\left(\frac{MAX^{2}_{I}}{MSE}\right) = 20 \cdot \log_{10}\left(\frac{MAX_{I}}{\sqrt{MSE}}\right) \text{.....(6)}$$

Where I is the original image, K is the watermarked image that contain m by n pixels, , MAX_I is the image's highest pixel value and Mean Square Error (MSE) is calculated according to the following equation:

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}\left\|I(i,j) - K(i,j)\right\|^{2} \text{.....(7)}$$

3.2 Robustness

The watermark should still be detected after the image has undergone to geometrical assault and removal signal attacks like compression, cropping, dithering, rotation and noise. So the efficient watermarks should be robust against variety of such attacks. Correlation is used for determining the sturdiness of a watermark's algorithm. Correlation is a measurement of resemblance between two images. The correlation is calculated between original watermark and watermark extracted from attacked images. The correlation's value always between 1 and -1 and 0.75 or above is acceptable value[10].

$$\rho(w,\hat{w}) = \frac{\sum_{i=1}^{N} w_i \hat{w}_i}{\sqrt{\sum_{i=1}^{N} w_i^{2}}\sqrt{\sum_{i=1}^{N} \hat{w}_i^{2}}} \text{.....(8)}$$

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where N is the number of pixels in watermark image, and w and wˆ are the original and extracted watermarks respectively.

The proposed algorithm is implemented using Matlab version (2016). The Gray scale typical Lena image of size 512 x 512 is used as original image that shown in Figure (4) and sample watermark of size 50 x 20 is |shown in Figure (5).

Figure (4): Initial Image

Figure (5): Sample Watermark

When comparing the results for imperceptibility of the watermarked image after applying DWT only with the results that obtain from combined DWT-SVD a s shown in table 1, the combined DWT-SVD provides greater PSNR values, and improves the invisibility of the watermarked image

Table-1: Difference between Initial Image & Watermarked Image

Original Image	Watermarked Image			
	2-DWT Mid-Mid	2-DWT-SVD Mid-Mid	2-DWT High-High	2-DWT-SVD High-High
	 PSNR = 80.1904	 PSNR = 101.7808	 PSNR = 77.0989	 PSNR = 103.0640

The abstracted watermark's quality is also tested and improved when combined DWT-SVD especially with mid-mid sub-band and high-high sub-band of two levels DWT-SVD. Table-2 shows the extracted watermark before applying any attacks to the watermarked image.

Table-2: Difference between Original Watermark & Extracted Watermark

Original Watermark	Extracted Watermark			
	2-DWT Mid-Mid	2-DWT-SVD Mid-Mid	2-DWT High-High	2-DWT-SVD High-High
	 Correlation = 0.7361	 Correlation = 1	 Correlation = 0.7261	 Correlation = 0.9844

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The sturdiness is verified by employing many kinds of signal attacks such as: adding *Gaussian noise, JPEG compression, Rotation, Cropping, and dithering.* After the watermarked image was attacked, the watermark was extracted, and the sturdiness was tested by computing correlation between the original and extracted watermark.

- **Effect of applying a Gaussian Noise**

Figure (6): Watermarked Image (Mid-Mid) Gaussian Noise

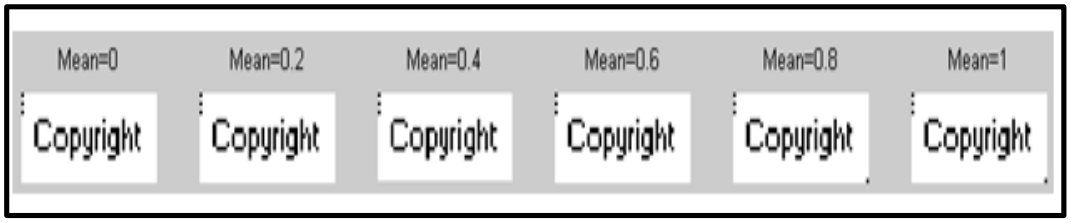

Figure (7): Extracted Watermark (Mid-Mid) Gaussian Noise

- **Effect of applying Rotation**

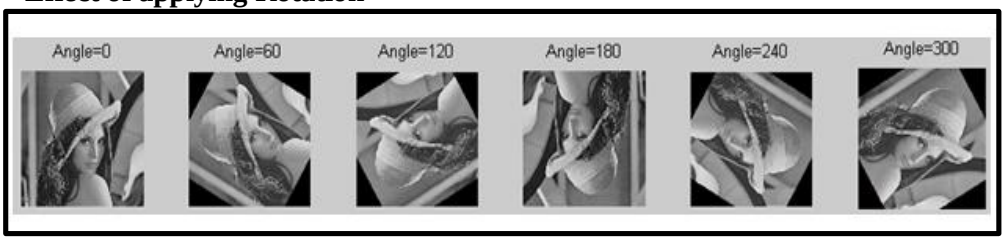

Figure (8): Watermarked Images (Mid-Mid) Rotation

Figure (9): Extracted Watermark (Mid-Mid) Rotation

- **Effect of applying Cropping**

Figure (10): Watermarked Image (Mid-Mid) Cropping

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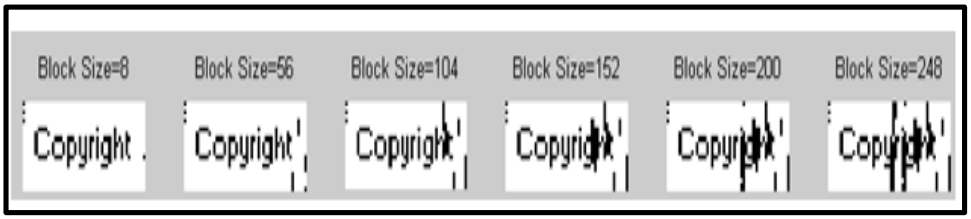

Figure (11): Extracted Watermark (Mid-Mid) Cropping

- **Effect of JPEG Compression**

Figure (12): Watermarked Image (Mid-Mid) JPEG Compression

Figure (13): Extracted Watermark (Mid-Mid) JPEG Compression

- **Effect of Dithering**

Figure (14): Watermarked Image (Mid-Mid) Dithering

Figure (15): Extracted Watermark (Mid-Mid) Dithering

The simulation results given in Table (3) and illustrated in Figure (9) and Figure (11) show the robustness of DWT-SVD o against cropping attack. The correlation values illustrated Table (4) and in Figure (7), Figure (13) and Figure (15) (11) show that the suggested algorithm is very strong against Gaussian noise and dithering assaults. The proposed algorithm also provides high robust against compression which is very useful operation that frequently used with digital images to transfer them via internet.

Table-3: Robustness Results against Geometric Attacks

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Algorithm	Correlation							
	Rotation Angle				Cropping Block Size			
	60	120	240	300	8	104	152	200
2-DWT Mid-Mid	-0.0585	0.0400	-0.0424	0.0235	0.7463	0.6808	0.6232	0.5506
2-DWT -SVD Mid-Mid	0.4275	0.2710	0.2051	0.1610	0.9947	0.8670	0.8186	0.7595

Table- 4: Robustness Results against Removal Attacks

Algorithm	Correlation								
	Gaussian Noise Mean			Compression Quality			Dithering Qe		
	0	0.4	0.8	0	40	80	5	10	15
2-DWT Mid-Mid	0.7361	0.6604	0.4450	0.4783	0.7335	0.7411	0.7411	0.7463	0.6745
2-DWT -SVD Mid-Mid	0.9842	0.9842	0.9842	0.98436	0.97928	0.97928	0.9320	0.8419	0.7595

Table (5) Gives a comparison between the empirically obtained data from the suggested algorithm with others state of arts.

Table-5: Comparison Experimental Results with Different Related Works

References	methodology	Imperceptibility	robustness
[1]	Combined DWT-DCT Digital image watermarking	PSNR=97.07	Gaussian noise and cropping Attacks
[2]	Cascading HWT-DWT Digital image watermarking	PSNR=37.52	Gaussian noise attack.
[5]	Combined DWT-CT Digital image watermarking	PSNR=88.11	Gaussian noise attack
DWT-SVD	Combined DWT-SVD Digital image watermarking	PSNR=101.78	Gaussian noise, cropping, dithering, JPEG, compression Attacks.

Comparing with other existence watermarking methods as illustrated in Table(5) , DWT-SVD based algorithm more robust and imperceptible. Thus, the proposed method keep the perceptual quality of initial image and at the same time provides a high robustness against attacks.

4. Conclusions

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In this paper, an efficient non-blind DWT-SVD watermarking algorithm for copyright protection is presents. Watermarking was performed by hiding watermark in the mid-mid sub-bands of two levels DWT of initial image followed by applying SVD on chosen sub-bands. The suggested algorithm provides high PSNR values. The sturdiness of the suggested algorithm was evaluated by applying five types of signal attacks. It achieved high resistance to compression, adding noise, cropping and dithering attacks. Comparing with other state of arts methodology, the suggested algorithm is more robust and imperceptible and enables to solve the tradeoff between imperceptibility and sturdiness.

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