



Robustness Watermarking Authentication Using Hybridisation DWT-DCT and DWT-SVD

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ABSTRACT

The watermarking is a method of concealing digital information in multimedia data, namely the host image. Discrete wavelet transform (DWT) when joined with discrete cosine transform (DCT) and SVD deliver powerful digital watermarking image. There are different types of intrusions that either plunder the actual ownership or demolish the appearance. In this paper, the DWT-DCT, DWT-SVD approach has been proposed to ensure security by concealing the watermark inside the actual image and validate the proprietor's image. Using DWT-DCT and low-bit percentage, the watermark image was inserted and abstracted. The DWT-SVD hybrid produced very good results.

Keywords: Digital image, Discrete cosine transform (DCT), Discrete wavelet transform (DWT), Singular value decomposition (SVD), Watermarking

INTRODUCTION

Ensuring digital information security is important particularly in the context of digital images. This is due to the fact that digital images can be easily accessed via the communicating media which means that

the image is downloadable by anyone who could claim its ownership. Hence, validating the image is not only considered as dynamic but also an important research area (Mishra, Agarwal, Sharma, & Bedi, 2014). In an approach known as watermarking, three types of algorithms are used: embedding algorithm, attack and extracting algorithm. The embedding algorithm comprises a mechanism of fastening the digital data with the watermark that can be a text or an image. In this mechanism, the host image as well as the watermark are considered together while the watermark image is embedded inside the host image, therefore, safeguarding the host

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image. Hence, the inserted image can demolish the features of actual data. Nevertheless, the abstraction algorithm is a mechanism of abstracting the watermark from the watermarked image different from the host image. Hence, the watermark image with respect to its performance is evaluated following the different characteristic specifications, for instance, normalised correlation (NC), peak-signal-to-noise-ratio (PSNR), mean square error.

An advantageous watermarking pattern should be powerful and imperceptible. The imperceptibility feature shows the non-cognitive distinctness between the watermarked and the actual report which is not noticeable to the human eye. Also, the watermark should not intervene with the media that is being safeguarded. The notion of agility means the individual should not demolish the watermark and nor should he or she make the report not valuable. The watermarks also should be powerful and strong enough to signal execution and intrusions. Powerful watermarking is invulnerable against intrusions for instance, noise, cropping, filtering etc. These intrusions aim to erase or demolish the watermark part which lead to deteriorating the viewable feature of the watermarked image considerably. In this manner, it is utilised to safeguard and ascertain authorship. Breakable watermarking on the other hand guarantees image authentication instead of validating the real ownership. An unauthentic amendment will either destroy or change the watermark. Semi delicate watermarking integrates the characteristics of both delicate and powerful watermarking so as to discover un-authentic handling while still being powerful and resistant against authentic handling. The most vital operation for watermarking is preserving electronic information regarding ownership authorisation. Electronic watermarking supports the verification of the ownership authorisation of the presented image. For frequency realm watermarking, values of precise densities are altered from their actual two distinct arrangements (Kumar, Saini & Kumar, 2012).

Typically, in electronic image watermarking, an individual value of the scaling determinant is utilised to introduce the watermark in the complete host image. The local allocation of the actual image is not acknowledged during the introduction process. Nevertheless, this kind of introduction can lead to unwanted naked relics inside watermarked image (Cox, Kilian, Leighton & Shamoon, 1997; Li, Yuan, & Zhong, 2007). These distortions are recorded mainly in sleek domains because the latter are susceptible to sounds. To reduce these distortions, the scaling determinant should be reduced in the plain domains, thereby influencing the powerfulness of the introduced process. In other domains, enhancing the scaling determinant above a definite margin can cause naked disruptions inside the marked image. Choosing a scaling determinant has become an important point of agreement between imperceptibility and powerfulness (Cox et al., 1997). The induced individual scaling determinant may not be suitable for disturbing all the coefficients of cover image as various illusory factors may display additional or smaller strength to alteration. Digital watermarking mechanism come under spatial and frequency category depending upon the class in which they are used for introducing the watermark. Spatial category watermark alters the pixels of one or two unplanned chosen subsets of images (Waleed, Jun, Abbas, Hameed, & Hatem, 2014). This kind of mechanism proves powerless across average image processing and intrusions such as sound, filtering, compression which may be demolished with less effort by disruption (Waleed et al., 2014).

The deformities caused by damaged image compression, signal processing function and other intrusions are the average difficulties faced during utilisation and allocation of watermarked image. Therefore, a powerful watermarked image is needed to form support across image deformities of enduring intrusions (Zhang, Wang, Qian, & Feng, 2011). Frequency category is also recognised as transform category, for instance Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT), Discrete Fourier Transform (DFT) and also Singular Valued Decomposition (SVD) are some of the ordinary categories being introduced (Shensa, 1992 ; Waleed et al. 2014). These categories can be joined together to enhance the efficiency of the frequency category and the powerfulness under the intrusions. Still, ordinary research on image watermarking has restricted its analysis to the utilisation of accepted mathematical creations, for example DCT, DWT and some other composite variants, for example DWT-DWT and DWT-DCT. In this paper, we highlight the efficiency of hybrid watermarking mechanism for the two joint methods: DWT-DCT, DWT-DWT and DWT-SVD.

Discrete Wavelet Transform (DWT) comprises a mechanism that is utilised in uncontrolled watermarking mechanism and collateral for transforming the region watermarking. Owing to its potential against vulnerable intrusions, wavelet based watermarking has become a well-known domain (Karniawan & Purnama, 2011). The DWT partitions the signal in two dimensions: high frequency and low frequency (Terzija, 2006). A signal is made to pass in between the high pass filter and then access low pass filter to examine the low frequency filter. Outcome from the high and low pass filters deliver DWT coefficients that are employed on the modified real image, acknowledged as Inverse Discrete Wavelet Transform (IDWT) (Terzija, 2006). Typically, the introduction of watermark inside the image is gained by contemplating the DWT coefficients of the disintegrated image with the coefficients that have the sufficient area suitable enough for the introduction of the watermark. Dharwadkar and Amberker (2010) suggested against the intrusion categories to ignore image deformities created by intrusions and the utilisation of sub-band coefficients to modify it via channel sound. Further, values of correlation coefficient are not enhanced amid the actual watermarking and extorted watermarked (Gupta & Shrivastava, 2010).

The DCT is a recognised function of mutation that alters a signal from the spatial to the frequency realm and so far, it has been utilised in the JPEG class for the abstraction of image due to its efficiency. It alters actual data into the actual spectrum ignoring the difficulties of repetition. The well-known block dependent DCT alters the segments into un-stretched blocks and employs the DCT to every individual block.

The DCT and DWT alterations, so far, have been commonly employed in profuse digital signal processing functions. Meanwhile, discrete cosine transform comprises a mechanism for altering a signal into basic frequency categories (Dharwadkar & Amberker, 2010). An image is highlighted as an average of sinusoids of different densities and weights. Here, 'x' is employed as an input image while coefficients of DCT for the altered output image 'y' are computed based on the following equation 1. Based on the equation, 'x' denotes an input image of $N \times N$

M pixels and $x(m, n)$ is the strength of the pixel in row m and column n of the image while $y(u, v)$ signifies the DCT coefficient in row u and column v of the DCT matrix.

$$y(u, v) = \sqrt{\frac{2}{M}} \sqrt{\frac{2}{N}} \alpha_u \alpha_v \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} x(m, n) \cos \frac{(2m+1)u\pi}{2M} \cos \frac{(2n+1)v\pi}{2N} \quad (1)$$

Where,

$$\alpha_u = \begin{cases} \frac{1}{\sqrt{2}} & u = 0 \\ 1 & u = 1, 2, \dots, N-1 \end{cases} \quad \alpha_v = \begin{cases} \frac{1}{\sqrt{2}} & v = 0 \\ 1 & v = 1, 2, \dots, N-1 \end{cases}$$

The reorganisation of the image is performed by employing opposite DCT application following the given equation.

The SVD is a matrix decomposition that is both useful and powerful. This is in accordance to a theory of linear algebra of diagonalisation of rectangular matrix. As a multimedia tool, it is highly valuable especially with respect to data analysis and images transformation in terms of reduction of dimension. The SVD can be used for $N \times M$ matrix A . At the same time, it can be subdivided into the outcome of three matrices: an orthogonal matrix U , a diagonal matrix S and the transpose of an orthogonal matrix V . In this approach, both entropy and edge entropy are employed for the DWT-SVD owing to the fact that entropy is the underpinning conception of information theory (Ali, Ahn, Pant, & Siarry, 2015). For grey scale images, such states match up to the grey levels adoptable by the individual pixel.

$$Entropy = \sum_{i=1}^l - p_i \log 2p_i \quad (2)$$

where l signifies the number of grey levels and p_i signifies the probability linked with grey level to action class (i). Therefore, image-wise, the entropy is regarded as a global measure. Note that compared with the conventional entropy, an exponential of entropy function has better capacity in securing two-dimensional spatial correlation of image (Ali et al., 2015). This is termed edge entropy and the edge information of the image being employed.

$$E = \sum_{i=0}^{l-1} P_i \exp^{1-P_i} \quad (3)$$

A hybrid DWT-DCT and DWT-SVD approach is used for watermarking domain for the utilisation of the mother wavelet, the legibility and the imperceptibility of the abstracted/introduced watermark and the image feature indicator for each wavelet family. The host image is disintegrated into four sub-bands and the sub-band LH2/HL2 is selected which employs DWT to every single sub-band and introduces individual watermark value in these sub-bands. The DWT-SVD is used to improve the quality of the watermarking. As such, their fusion is a very attractive technique of watermarking. Kumar, Saini and Kumar (2012) show the introduction mechanism in the horizontal (HL) delivers efficient outcome than the vertical sub-band (LH). In another study (Shefali, Deshpande, & Tamhankar, 2008), the researchers employed orthogonal

two-fold realm of DCT and DWT alteration and utilised the image characteristics to organise the watermark but the clipping and circulation create maximum disintegration. Furthermore, Kumar, Saini, and Kumar (2012) utilised a tremendous frequency to the introduced watermark image dependent on DCT-DWT. The outcome delivered efficient capacity for some ordinary image processing applications.

MATERIALS AND METHODS

The grey scale watermark image with the dimensions 50x20 are hidden inside a grey scale cover image. Here, the dimensions are of 512x512 with the watermark image; the message comprises the wavelet. Meanwhile, Haar level 2 is condensed prior to its introduction within the cover image bits. The watermark image is the altered wavelet Haar level 2. The altered wavelet’s distinct coefficients are counted into 3 bits each where there are actually 8 bits. At the same time, the grey scale watermark image may be concealed inside the points of the original cover image. The introduced action is performed by concealing a piece of a sector and here, the concealing of every section of the grey scale watermark image inside the cover image sector is performed (Mohamed, & El-Mohandes, 2012).

The flowchart showed the complete methodology adopted by this study is shown in Figure 1. The left side displays the watermark infusion while the right side represents watermark abstraction after employing the intrusion adjacent to the image that is watermarked.

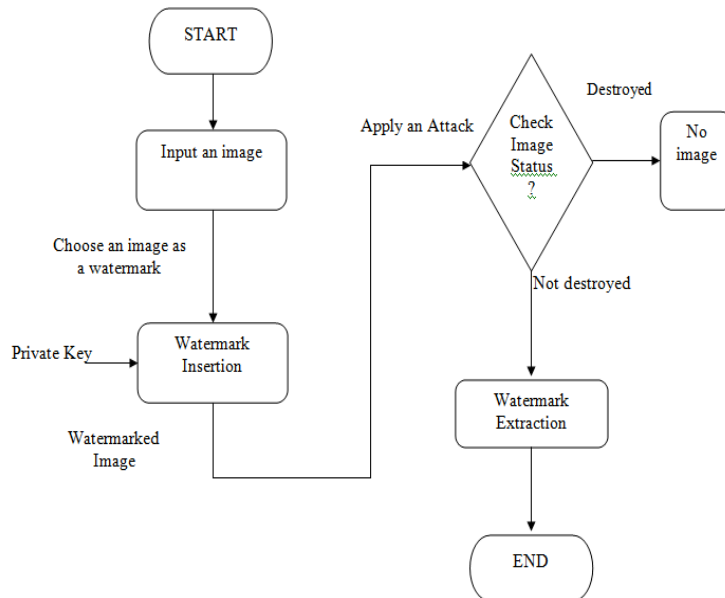


Figure 1. Methodology flowcharts

These steps explain the embedding watermarking inside the digital image using DWT-DCT. The proposed algorithm for the introduction of watermark is shown in Figure 1 with the following steps:

- Step 1: DWT is utilised to partition the grey scale cover image into four orthogonal multi-determined sub-bands: LL1, HL1, LH1 and HH1. LH1 is selected for the later step. DWT isolates an image into under determined matching image (LL) and horizontal (HL), vertical (LH) and diagonal (HH) categories.
- Step 2: DWT is once again utilised to partition the sub-band LH1 and acquire minor four sub-bands at lower stage and then LH2 sub-band will be selected. It is important to observe that the other sub-band might lead to different outcome.
- Step 3: LH2 is partitioned into 4x4 regions.
- Step 4: Based on DWT-DCT algorithm, DCT is utilised at each region in the appointed sub-band.
- Step 5: Watermark is constructed into units and zeros.
- Step 6: Pair of distinct un-correlated series are produced. The initial series introduces the watermark bit 0 (PN_0) and the other series have been utilized to introduce the watermark bit 1 (PN_1). Total components in every paired pseudorandom series must be identical to the total mid band components of the DCT altered partitions.
- Step 7: Pair produced un-correlated pseudorandom series, PN_0 and PN_1, are joined with the support of progressed determinant k, in the DCT altered 4x4 regions that have been the applicants from the DWT sub-bands of the grey scale cover image. Introduction mechanism is observed in the centre of the DCT coefficients. If it is considered that D is the matrix in the centre of DCT coefficients, then the concealed action can be displayed as:

If watermark bit is 0, then,

$$D' = D + k * PN_0 \quad \text{where k denotes a key} \quad (4)$$

Else,

If watermark bit is 1, then,

$$D' = D + k * PN_1 \quad (5)$$

- Step 8: By employing converse DCT and DWT, the watermarked image is re-organised.

For the embedding watermarking by using DWT-SVD there are steps to explain the embedding operations:

Step 1: Watermark W is decomposed utilising SVD

$$W = U_W * S_W * V_W^T \quad (6)$$

Step 2: Use DWT (Haar) and decompose cover image into four sub-bands: LL, HL, LH and HH. DWT is once again utilised to partition the sub-band LH1 and acquire minor four sub-bands at lower stage and by selecting LH2 sub-band.

Step 3: Replace the SVD of the LH2 sub-band with the SVD of the watermark, and the end uses inverse DWT for generating the watermarked cover image.

The ownership is identifiable via the actual image. This occurs when certain power demands the abstraction of the watermark image and searches the real owner of the image. Here, the wavelet transforms the mechanism, for instance DWT and DWT-DCT. The mechanism is useful for abstracting the watermark as:

Step 1: The assaulted image is further disintegrated into four orthogonal multi determinant sub-bands namely LL1, HL1, LH1 and HH1 via the use of DWT.

Step 2: After employing DWT one more time to LH1 so as to collect the limited four sub-bands and select the sub-band LH2.

Step 3: LH2 is further partitioned into regions of 4x4.

Step 4: The DCT alteration is executed in every region in the sub-band LH2 and abstracting the centred band coefficients of each region.

Step 5: Un-identical paired uncorrelated pseudorandom series are produced one more time. Total number of components in every paired pseudorandom series must be match the number of mid-band components of the DCT altered DWT sub-bands. Reproducing the paired pseudorandom series, PN_0 and PN_1 are utilised using the same source as in the introduction of the watermark mechanism.

Step 6: For every region in sub-band LH2, the correlation in the middle of the coefficients of centred-band and the pair produced pseudorandom series, PN_1 and PN_0, is determined. If the correlation with the PN_0 appears advanced in comparison to the correlation with PN_1, then the abstracted watermark bit is regarded as 0 else 1.

Step 7: Retrieving the watermark by utilising the abstracted bits, and calculating the strength of the algorithm via the correlation evaluation amid the actual watermark and the abstracted one.

For the SVD-DWT extraction, below are the steps:

Step 1: IDWT (Haar) enables the decomposition of the watermarked image into four sub-bands again and by selecting LH2 sub-band.

Step 2: Use the SVD on the LH2 sub-band, and extract the watermark from LH2 sub-band.

Step 3: Construct the watermark via the use of SVD of original watermark

$$W_E = U_W * S_H * V_W T \tag{7}$$

RESULTS AND DISCUSSION

The proposed algorithm has been employed on 512x512 cover image. After that it was employed on a 50x20 grey scale image alongside the ‘copyright’ watermark written inside. The algorithm appears to be powerful against intrusions such as Gaussian noise, circulation, abridgement which are not very often utilised in real life but are classic and typical. Some of the intrusions such as Gaussian noise are synchronized attacks while others such as cropping are biased numerical intrusions. Still some others entail watermark elimination which aids in the measurement of the correlation between the actual grey scale watermark and the abstracted grey scale watermark derived from the invaded grey scale cover image.

Applying the operation, PSNR can be measured as:

$$PSNR = 10 \cdot \log_{10} \left(\frac{MAX^2}{MSE} \right) \tag{8}$$

$$NR = 20 \cdot \log_{10} \left(\frac{MAX, pixelvalue}{\sqrt{MSE}} \right)$$

where: the Mean Square Error (MSE) represents the aggregate squared error amid the altered and the actual image. Meanwhile, PSNR represents the peak error measure while MAX denotes the highest pixel’s value. Then, correlation ρ can be acquired as:

$$P(w, \hat{w}) = \frac{\sum_{i=1}^N w_i \hat{w}_i}{\sqrt{\sum_{i=1}^N w_i^2} \sqrt{\sum_{i=1}^N \hat{w}_i^2}} \tag{9}$$

where ρ represents the introduced watermark w and abstracted watermark \hat{w} in terms of correlation while N denotes the watermark image’s measure. Applying the DWT- DCT transform, the algorithm documented a superior PSNR value as opposed to using only DWT. Further, the capability of an algorithm to store the cover image of non-fuzzy is acknowledged as the algorithm’s imperceptibility gauged by the utilisation of peak signal to noise ratio (PSNR). The actual image, watermark and the original image plus watermark using DWT-DCT are shown in Figure 2 while Figure 3 displays the actual image, watermark and the original image plus watermark using DWT-SVD. When the results are compared between the hybrid DWT-DCT and DWT-SVD for calculating the PSNR, the DWT-SVD has better and robust watermark image. This study used grey scale image data set for images (see Figures 2 and 3)

to explain the embedding watermarking inside the host digital image before calculating the PSNR and Correlation. The DWT-SVD generates the best result and robust watermark when compared with DWT-DCT.

After frequent repetitions, the algorithm displays efficient strength across this type of intrusion. Attack factor signifies the extent to which the attack occurs and also indicates the extent to which the attack affects the watermark image. Correlation signifies the correlation of the watermark initially in the very beginning when the outbreak is launched and afterwards thus, indicating the strength of the algorithm. Correlation operation measures the correlation value in comparison with the threshold value. Utilising the threshold value, the image is regarded as watermarked if the correlation value transcends threshold value.



















Original image	Watermark	Original image + watermark	Original image	Watermark	Original image + watermark
					
The (PSNR) = 30.513 correlation = 0.73			The (PSNR) = 30.506 correlation = 0.67		
Original image	Watermark	Original image + watermark	Original image	Watermark	Original image + watermark
					
The (PSNR) = 30.515 correlation = 1			The (PSNR) = 30.513 correlation = 0.739		

Figure 2. The imperceptibility images for original image + watermark by using DWT-DCT

Original image	Watermark	Original image + watermark	Original image	Watermark	Original image + watermark
					
The (PSNR) = 52.218 correlation = 0.968			The (PSNR) = 44.20 correlation = 0.833		







Original image	Watermark	Original image + watermark	Original image	Watermark	Original image + watermark
					
The (PSNR) = 47.44 correlation = 0.911			The (PSNR) = 55.22 correlation = 0.984		

Figure 3. The imperceptibility images for original image + watermark by using DWT-SVD

The DWT-DCT algorithm breaks down the frequencies into high and low frequency and considers the medium image frequency. It (DWT-DCT) fulfils the criterion where frequency transform is used on a large scale in image compression. Table 1 and 2 displays the outcome for powerful analysis of DWT-DCT algorithm to counter Gaussian sound intrusion. Delivered outcome displays better advancement correlation of abstracted and introduced watermarks in comparison with DWT. Tables 3 and 4 display the result for the hybrid DWT-SVD and the result was better compared with hybrid DWT-DCT. However, the types of attacks are applied and the results are shown to prove the robustness of watermarking. The quality of the extracted watermark is established by the correlation value computation.

Table 1
Types of attack by using DWT-DCT









Type of attacks	Attack factor	Correlation (Leena)	Correlation (Papper)	Correlation (Man)	Extracted watermark using DWT-DCT	Type of attacks	Attack factor	Correlation (Leena)	Correlation (Papeer)	Correlation (Man)	Extracted watermark using DWT-DCT
Gaussian Filter	1	0.73	0.73	1		Gaussian Noise	0.1	0.73	0.7	0.1	
	2	0.71	0.707	0.99			0.3	0.65	0.69	0.92	
	3	0.709	0.70	0.98			0.5	0.64	0.45	0.57	
	5	0.706	0.69	0.58			0.7	0.35	0.40	0.41	

Table 2
Types of attack by using DWT-DCT









Type of attacks	Attack factor	Correlation (Leena)	Correlation (Papper)	Correlation (Man)	Extracted watermark using DWT-DCT	Type of attacks	Attack factor	Correlation (Leena)	Correlation (Papeer)	Correlation (Man)	Extracted watermark using DWT-DCT
Rotation	35	-0.014	0.026	0.045		Median Filter	1	0.73	0.73	0.98	
	60	-0.02	0.011	0.036			2	0.29	0.26	0.52	
	90	-0.02	0.006	-0.09			3	0.22	0.21	0.49	
	180	-0.02	-0.024	-0.03			5	0.016	0.070	0.17	

Table 3
Type of attack by using DWT-SVD

















Type of attacks	Attack factor	Correlation (Leena)	Correlation (Papper)	Correlation (Man)	Extracted watermark using DWT-SVD	Type of attacks	Attack factor	Correlation (Leena)	Correlation (Papeer)	Correlation (Man)	Extracted watermark using DWT-SVD
Gaussian Filter	1	0.968	0.98	0.911		Gaussian Noise	0.1	0.96	0.97	0.90	
	2	0.90	0.95	0.80			0.3	0.87	0.96	0.92	
	3	0.85	0.923	0.719			0.5	0.20	0.90	-0.08	
	5	0.80	0.920	0.712			0.7	0.008	0.61	-0.04	

Table 4
Type of attack by using ZDWT-SVD

Type of attacks	Attack factor	Correlation (Leena)	Correlation (Papper)	Correlation (Man)	Extracted watermark using DWT-SVD	Type of attacks	Attack factor	Correlation (Leena)	Correlation (Papeer)	Correlation (Man)	Extracted watermark using DWT-SVD
Rotation	35	0.005	0.026	0.01		Median Filter	1	0.96	0.98	0.91	
	60	0.001	0.011	0.017			2	0.41	0.40	0.52	
	90	-0.07	0.006	0.02			3	0.07	0.20	-0.04	
	180	0.01	-0.024	-0.03			5	0.006	0.014	-0.01	

CONCLUSION

Utilising DWT-DCT and DWT-SVD, powerful digital image watermark technique was employed with the huge capability of watermark information of actual image. The constructed algorithm is associated with the watermark and DWT-DCT and DWT-SVD are used to maintain ownership privilege by concealing ownership image in another image and safeguard it. The introduction and abstraction by utilisation of DWT-DCT is more efficient than utilisation of DWT alone because DWT-DCT breaks down borderline densities. Medium densities of images are considered and DWT-DCT incorporates the reality that the altered frequency is utilised on a large scale in image compression. Watermark image can be abstracted when employing various types of intrusions. Hence, the application of the wavelet classification and execution of Haar transform are effective in sightless and invisible watermark. Assessment of the proposed algorithm, correlation values of the introduced and the abstracted watermark show the efficiency of digital wavelet transform adjacent to dithering. In comparison, correlation values of circulation intrusion display distinct deterioration which is not caused by the algorithm's weakness. Instead, it is caused by modifying attitude of the watermark values of the embedded and extracted watermark which clearly proves the superior performance of DWT-SVD compared with that of DWT-DCT. Meanwhile, the correlation value of the rotation attack demonstrates high level of degradation which is caused by the shift of watermark values caused by value position change and not by the algorithm's lack of capability. However, it is hoped that future research would relocate the values prior to the extraction process, and apply algorithms for optimising the digital image watermarking of nature inspired algorithms such as Bat algorithm and Harmony search that have not been applied yet.

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