International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 4 (2018) pp. 1900-1907

A Robust Watermarking Scheme Based on DWT and DCT Using Image Gradient

Salah Mokhnache[1] *,Tewfik Bekkouche[2], Djamel Chikouche[3]

[1,3]Department of Electronics, Faculty of Technology University of Msila, Algeria.

[2]Department of Electronics, Faculty of Technology University of Bordj Bou Arraridj, Algeria.

[1]ORCID: 0000-0003-2955-3357

Abstract

In this paper we propose a combined watermarking scheme of images based on discrete Transforms. The Discrete Wavelet Transform DWT allows the decomposition of the image after multi - resolution analysis in sub bands by means of successive sub-samplings of the image to let a refined isolation of the low-frequency components in order to form a less sensitive insertion space. In the other hand, the Discrete Cosine Transform DCT is characterized by a separation effect of the high frequencies , from the low frequencies and the average frequencies, giving thus the possibility of using a range of frequencies including coefficients with a high degree of energy. For the selection of the places suitable for insertion of the watermark and to ensure a compromise between the invisibility and the robustness one uses the softness of the image which is evaluated according to the degree of variation of the spatial values of the image. In this approach we use the gradient of the image as a measuring tool because it presents a spatial derivative which gives a topological map of the image. This step is important for locating the regions where the disturbances are intense and also makes it possible to evaluate the average softness of the image. The proposed approach provides good robustness against various attacks

Keywords: Watermarking, DWT, DCT, Image Gradient.

INTRODUCTION

The traffic of digital images is increasing rapidly on communication networks. Nevertheless, this progress is accompanied by the birth of various problems linked to security and authentication, which justified the fact that data protection has become an intellectual property. To remedy this problem of security, protection and authentication of multimedia documents [1],[2],[3] currently the most common way to address the problem of privacy and copyright is watermarking of digital images. Watermarking is a digital technology that is used to prove copyrights ownership and ensure authenticity for multimedia products .It is realized by putting secret information in the image that is insensible for the human visual system. It is only effective if it is resistant to various treatments of the image compression, adding noise, contrast change, and it manages to survive several intentional attacks. This secret information embedded within the image is called watermark. In recent years, a lot of papers dealing with digital watermarking technology appeared in literature, some of them are seen in [1],[2],[3],[4],[5] An effective watermarking algorithm should satisfy a set of requirements, including invisibility, robustness, imperceptibility and compatibility of the watermark with the original image. All these requirements must be satisfied without affecting the quality of the original image [6],[7]

Watermarking has been used by several methods. These methods are due to the diversity of the choice of insertion domain used, it can be either a spatial domain or a transformed one according to the application to which the watermarking is dedicated. In a transformed domain watermarking uses as a domain of insertion a space resulting from a transformation and it should be noted that it is a transform in the frequency domain such as DCT, DFT, and a transformation in Multi-resolution domain for the DWT. These transforms have the major advantage of being the transformation space used by the compression standards (DCT used by$JPEG$, DWT by $JPEG2000$ and DFT by$MPEG$). Discrete transforms have long been used in the digital signal and image processing they have significant applications on watermarking , there are several transforms that brings an image into frequency domain such as Discrete Cosine Transformation (DCT) [8],[9] Discrete Wavelet transform (DWT) [10],[11] Singular Value Decomposition(SVD) [12] Discrete/Fast Fourier Transform (DFT/FFT) [13] ,and Hadamard transform [14],[15].Attempts to use hybrid digital watermarking algorithms have an enormous advantage and propose watermarking schemes with more robustness against attacks and in order to increase the watermark's imperceptibility and integration rate, We can cite the work of Nasrin M et al [16] Who proposed a hybrid scheme using the Integer Wavelet Transform (IWT) and Singular Value Decomposition (SVD), as well as the work of S. K. Amirgholipour et al[17] Where they propose a combined scheme using DCT and DWT. Among these algorithms, we mention other works using the combined methods using discrete transforms A. Al-Haj [18] and C-C. Lai et al [19]

To increase the robustness, another combinations are used like Combining watermarking and encryption algorithm are also used [20]. The proposed approach is a combined scheme using DCT and DWT by the exploitation of the image gradient [21] because an image gradient is a directional change in the intensity or color in an image. Image gradients may be used to extract information from images.It provides two pieces of information. The magnitude of the gradient tells us how quickly the image is changing, while the direction of the gradient tells us the direction in which the image is changing most rapidly.

METHODOLOGY

In this paper a robust hybrid watermarking developed based on DWT and DCT using image gradient.

Discrete Cosine Transform

The DCT (Discrete Cosine Transform) is the most used transformation in video compression domain and digital image processing. It is used in standards compression (JPEG) the Joint Photography Expert Group. DCT technique transform a signal or image from spatial domain into a spectral representation with an inherent ability to exhibit excellent energy compaction ,it is a linear transformation that conserves energy whose coefficients are real and can be interpreted as spatial frequencies. It is characterized by a separation effect of the high frequencies , from the low frequencies and the average frequencies, giving thus the possibility of using a range of frequencies including coefficients with a high degree of energy. The DCT is generally performed not on the whole image but on blocks of size $(8*8)$ pixels. If x and y denote the spatial dimensions of the image, u and v denote dimensions in the frequency domain of the image, N is the number of samples $I(x,y)$ the input image is decomposed into non-overlapping blocks and then each block is transformed into corresponding DCT coefficients giving the transformed image $F(u,v)$ according to the following equation:

$$F(u,v)=\frac{2}{N}c(u).c(v)\sum_{x=0}^{N-1}\sum_{y=0}^{N-1}I\,(x,y)$$
$$cos\left[\frac{\pi}{N}u\left(x+\frac{1}{2}\right)\right].cos\left[\frac{\pi}{N}v\left(y+\frac{1}{2}\right)\right] \qquad (1)$$

The inverse transform is given by:

$$I(x,y)=\frac{2}{N}\sum_{x=0}^{N-1}\sum_{y=0}^{N-1}c(u).c(v).F(u,v).$$
$$cos\left[\frac{\pi}{N}u(x+\frac{1}{2})\right].cos\left[\frac{\pi}{N}v(y+\frac{1}{2})\right] \qquad (2)$$

Where

$$c(u)=c(v)=\begin{cases}\sqrt{\frac{1}{N}} & for\ u,v=0\\ \sqrt{\frac{2}{N}} & otherwise\end{cases}$$

The DCT has good frequency localization, a compaction of the energy which surpasses that obtained with the discrete Fourier transform (DFT). And it is easy to implement and it has, in particular, the advantage of generating a real transformed signal.

Discrete Wavelet Transform

The Discrete Wavelet Transforms are generally orthogonal and allow the reconstruction of the initial signal by the Inverted Wavelet Transform[22] [23] DWT decomposes an image into four sub bands, namely an LL approximation sub band and three detail sub bands LH, HH, and HL Corresponding respectively to the vertical, diagonal and horizontal details. This decomposition is carried out using two filters, a high pass filter and a low pass filter .The letter H corresponds to the high-pass filter and the letter L to the low-pass filter applied separately on the rows and the columns. So for images, applying DWT corresponds to processing the image by two filters. The filters divide the input image into four non-overlapping multi-resolution sub bands. The sub-band LL represents the coarse-scale DWT coefficients while the sub-bands LH, HL and HH represent the fine-scale of DWT coefficients. To obtain the next coarser scale of wavelet coefficients, the sub-band LL is further processed until some final scale N is reached. When N is reached we will have $3N+1$ sub-bands consisting of the multi-resolution sub-bands LL_N and LH_N, HL_N and HH_N [24] Figure 1 shows the successive decomposition by the discrete wavelet transform of an image up to three resolution levels with the corresponding sub bands

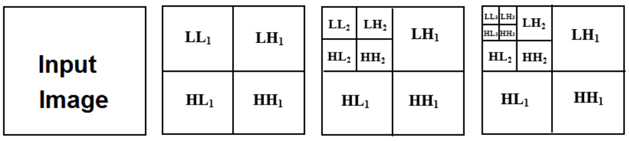


Figure 1. Successive Decomposition by DWT

Due to its excellent spatio-frequency localization properties, the discrete wavelet transform is very suitable to locate the areas in the host image where a watermark can be embedded effectively. Those proprieties allow the watermark to be embedded without being perceived by the human eye. The compromise adopted by many DWT-based watermarking algorithm, is to embed the watermark in the middle frequency sub bands LH and HL where acceptable performance of imperceptibility and robustness could be achieved.

Image Smoothness

The image smoothness is evaluated according to the degree of sudden variations of spatial values of the image, it is reflected by the percentage of high frequency participation in image energy. In order to study this disturbance, we must find an efficient means of measurement and also we must fix a scale of measurement, which allows us to compare the different levels of softness. In this paper, we used the image gradient as a measuring tool because the gradient is a spatial derivative that gives a topological map of the image, which is important for locating regions where the disturbances are intense and also allows to evaluate the average softness of the image. We know that an image may be defined as a two-dimensional function, $\boldsymbol{f(x,y)}$, where x and y are spatial (plane) coordinates, and the amplitude of $\boldsymbol{f}$ at any pair of coordinates(x,y) is called the intensity or gray level of the image at that point. For a function $\boldsymbol{f(x,y)}$, the gradient of $\boldsymbol{f}$ at coordinates $(\boldsymbol{x},\boldsymbol{y})$ is defined as the two-dimensional column vector :

$$\nabla f = \begin{bmatrix} G_x \\ G_Y \end{bmatrix} = \begin{bmatrix} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial y} \end{bmatrix} \quad (3)$$

The magnitude of this vector is given by

$$\nabla f = mag(\nabla f) = \left[G_x^2 + G_y^2\right]^{1/2} = \left[\left(\frac{\partial f}{\partial x}\right)^2 + \left(\frac{\partial f}{\partial y}\right)^2\right]^{\frac{1}{2}} (4)$$

The components of the gradient vector itself are linear operators, but the magnitude of this vector obviously is not because of the squaring and square root operations. The computational burden of implementing Eq. (4) over an entire image is not trivial, and it is common practice to approximate the magnitude of the gradient by using absolute values instead of squares and square roots [21]:

$$\nabla f = |G_x| + |G_y| \quad (5)$$

The direction of the gradient vector also is an important quantity. Let $\alpha(x,y)$ represent the direction angle of vector ∇f at (x,y).Then ,from vector analysis

$$\alpha(x,y) = tan^{-1}\left(\frac{G_y}{G_x}\right) \quad (6)$$

Computation of the gradient of an image is based on obtaining the partial derivatives $\frac{\partial f}{\partial x}$ and $\frac{\partial f}{\partial y}$ at every pixel location. The high value of the gradient makes it possible to locate the zones of the high frequencies which clearly show the perturbed regions of the image, unlike the low frequencies they are located by the values where the gradient assumes relatively low values which show the smooth regions of the image. As we have just described that the gradient serves as an effective measuring tool for determining the degree of softness of the image. The interest of our approach is to fix a scale of measurement which allows us to classify the images according to their sweetness and of course, to better adapt the parameters of our algorithm to the characteristics of the image. For this purpose, the average of the gradient of the image is calculated in order to determine the degree of softness of the image, next the average of the gradient of each block is calculated to determine the degree of local softness. And depending on the ratio between the two averages, a decision can be made on the most appropriate place for insertion.

Proposed Algorithm

In this section we present the algorithm used in our approach for insertion and extraction of the watermark. This algorithm treats the non-blind watermarking, which requires the presence of the original image for the extraction of the watermark.

Watermark Embedding Process

The embedding phase will involve the following steps:

- Let 'I' be the cover image and 'W' be the watermark image.
- Apply a two level DWT to the cover image (Haar wavelet)
- Then apply DCT to the second level DWT of LH_2 and HL_2 coefficients.
- Calculation of the local average gradient of each 8x8 block of part LH_2 and HL_2.
- Calculation of the total average gradient of the parts LH_2 and HL_2
- Thresholding and selection of smooth, moderately smooth and high perturbations for LH_2 and HL_2.
- Division of the watermark into two parts, one part will be inlaid in LH_2 and the other part in HL_2.
- Reconstitution of LH_2 and HL_2 by performing the inverse DCT ($iDCT$).
- Reconstruction of the approximation part (LL_1) by performing a two level inverse DWT ($iDWT$).
- Saving the keys of Inlay places LH_2, HL_2 and the watermarked image.
- And finally, inverse DWT ($iDWT$) to produce watermarked image.

What shows the efficiency of our approach are the keys of the incrustations in parts LH_2 and HL_2 after the thresholding following the gradient calculation and the choice of places where the image presents disturbances. This requires knowledge of the insertion keys to be able to extract the watermark.

Watermark Extraction Process

- Reading keys from LH_2, HL_2.
- Apply the two-level DWT to the watermarked image and cover image.
- Perform the DCT of the LH_2, HL_2 parts of the cover image and watermarked image.
- Extraction of the two parts of the watermark encrusted in LH_2 and HL_2 of the watermarked image.
- Finally, apply the inverse $DCT(iDCT)$ to find the inserted watermark

EXPERIMENTAL RESULTS

To evaluate the performance of the proposed scheme a number of experiments are performed on the MATLAB platform on two images of size 512 × 512, namely Clown, and Baboon images and 32 × 32 logo taken as watermark(as shown in Fig. 2).

proposed watermarking scheme based on DWT and DCT using image gradient is verified against various experiments in terms of imperceptibility, robustness ,attack by adding noise ,JPEG Compression ,filtering and geometric transformation.

Imperceptibility Measurement:

Peak signal-to-noise-ratio (PSNR) has been employed to measure the imperceptibility. The PSNR value is utilized to find a similarity between a host image and a watermarked image. In an effective invisible watermarking algorithm watermark should be imperceptible/invisible from HVS (human visual system) . High PSNR indicate a lower variation between the host image and watermarked image.

The PSNR can be defined as follows:

$$(\mathrm{PSNR})_{\mathrm{dB}} = 10\log_{10}\left\{\mathrm{MxN}\frac{\max I^2(i,j)}{\sum_{i,j}[I(i,j) - I_w(i,j)]^2}\right\}$$

Where $I(i,j)$represents a pixel, whose coordinates are $(i;\ j)$ in the original, undistorted image, and $I_w(i;\ j)$ represents a pixel, whose coordinates$(i;\ j)$, in the watermarked image.

Robustness Measurement: Normalized Cross-Correlation (NC) and Bit Rate Error (BER)

In order to measure the "degree of reliability" of the detected watermark, which amounts in fact to a "distance calculation" between the inserted and the detected watermark, it was decided to measure the normalized cross correlation (NC) and bit rate error (BER) values between the original watermark and extracted watermark without attack or after applying different types of intended attack are compared to establish the robustness property. The BER and NC can be calculated as follows:

$$\mathrm{NCC} = \frac{\sum_{i-1}^{m}\sum_{j-1}^{n} W(i,j) \times W'(i,j)}{\sqrt{\sum_{i-1}^{m}\sum_{j-1}^{n} W(i,j)^2}\sqrt{\sum_{i-1}^{m}\sum_{j-1}^{n} W'(i,j)^2}}$$

$$\mathrm{BER} = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n} w(i,j) \otimes w'(i,j)}{(m \times n)}$$

Where,

$W(i,j)$ represent the pixel intensity value at coordinate (i, j) of original watermark, $W'(i,j)$ represent the pixel intensity value at coordinates (i, j) of extracting watermark and $\otimes$ denotes the XOR gate

Figure 3 shows the watermarked images and Figure 4 shows the extracted watermarks without any attacks.

Figure 2 host images (a) Image *clown* (b) image *Baboon*

Figure 3 Watermarked images (e) and (f)

Figure 4 Extracted Watermarks (g) and (h)

From these figures, it can be seen that it is difficult to differentiate between the original images and their watermarked ones .The imperceptibility of the watermarked image was excellent with a Peak Signal to Noise ratio of 43 dB for Clown image and 42 dB for Baboon image , knowing that the minimum acceptable value of PSNR for optimized imperceptibility is 38 dB so we can confirm that the invisibility constraint is verified because the insertion of the watermark is performed in the mid-frequency coefficients of the DCT of the sub bands (LH and HL). To evaluate the performance of our method and to estimate the similarity between the inlaid watermark and the extracted watermark, we use the Normalized Cross-Correlation (NC) and Bit Rate Error (BER) . In the literature, a Normalized Cross-Correlation (NC) value which is equal or above 0.75 denotes an acceptable extracted watermark and for BER the value close to zero means that the watermark has no error in the extracted mark. The results obtained by measuring NC and BER between the original watermark image and the extracted one are very satisfactory (Table 1)

Table 1. Imperceptibility and robustness measurement without attack

Image		Logo	
	PSNR	NCC	BER
Clown	43	1	0,0008
Baboon	42	1	0,0006

International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 4 (2018) pp. 1900-1907

Robustness tests against attacks

Selected attacks such as JPEG attacks, filtering (Median filter), adding noise and geometric transformations (Cropping) are the most common and have been used with various parameters to properly test the robustness of our proposed method

Noise addition attack

The results shown in **Figure 5** and **Figure 6** indicate that for a Gaussian noise of a variance 0.003, the recovery of the watermark is average, and for a variance of 0.001 recovery is good with very few detection errors. Concerning the addition of the Salt & Pepper noise, the recovery of the watermark is very good for a density of 0.01, 0.02 and acceptable for a density of 0.05.

Gaussian noise attacks (Variance =0.001)

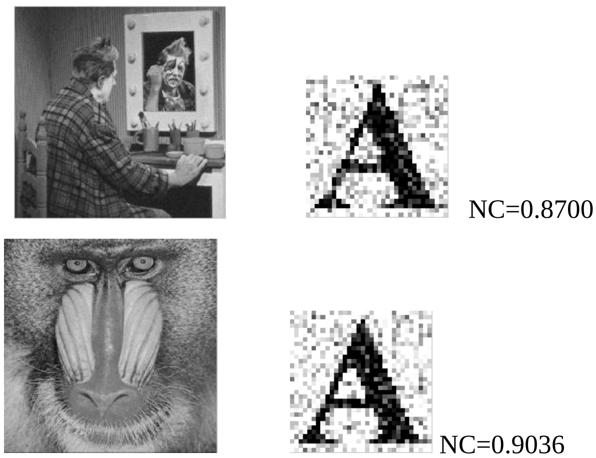


Figure 5 Evaluation of the Normalized Cross-Correlation values against Gaussian Noise attack (Variance=0.001)

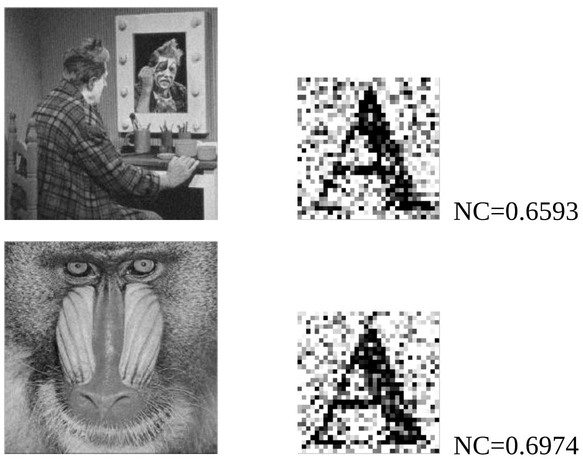


Figure 6. Evaluation of the Normalized Cross-Correlation values against Gaussian Noise attack (Variance=0.003)

Salt & Pepper noise

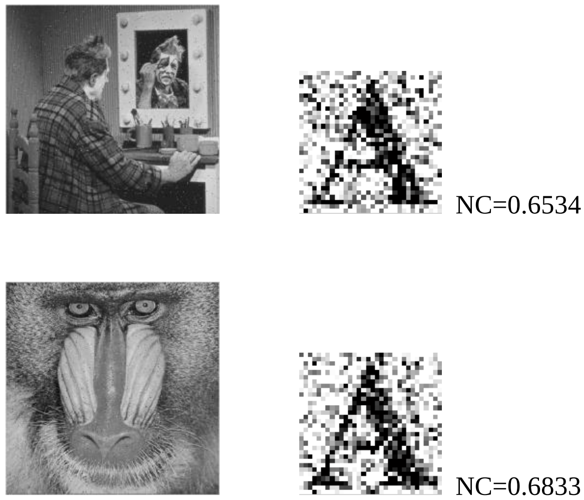


Figure 7. Evaluation of the Normalized Cross-Correlation values against Salt & Pepper noise attack.(density=0.01)

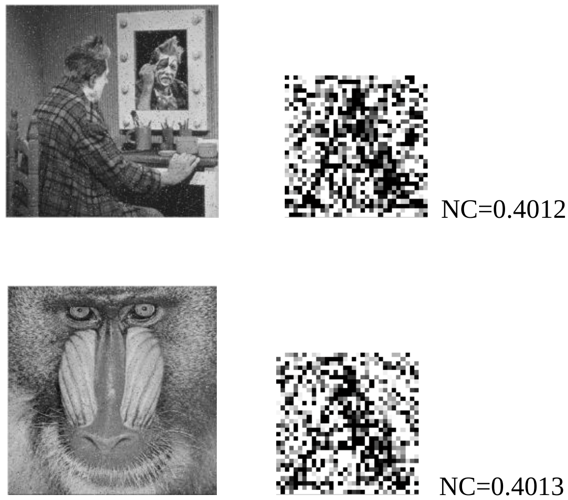


Figure 8. Evaluation of the Normalized Cross-Correlation values against Salt & Pepper noise attack.(density=0.03)

JPEG Compression attacks

The experiments carried out on the test images have shown the performances of this algorithm and to appreciate its robustness The Third attack is JPEG compression, the . Figure 9 shows the Normalized cross correlation standard is almost 1 (NC=1).

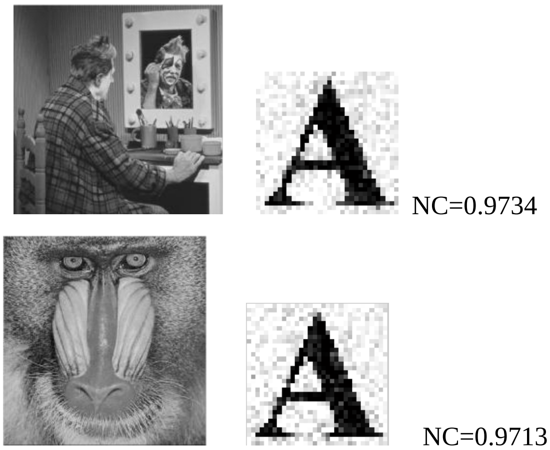


Figure 9. Evaluation of the Normalized Cross-Correlation values against JPEG attack.(Q =60%)

Filtering (Median filter) attacks

The watermarked image is filtered by the Median filter. It can be deduced that the extracted watermark in the case of the Median filter is acceptable. Since the normalized correlation (NC) is greater than 50% for Clown and less than 50% for Baboon, shows Figure10.

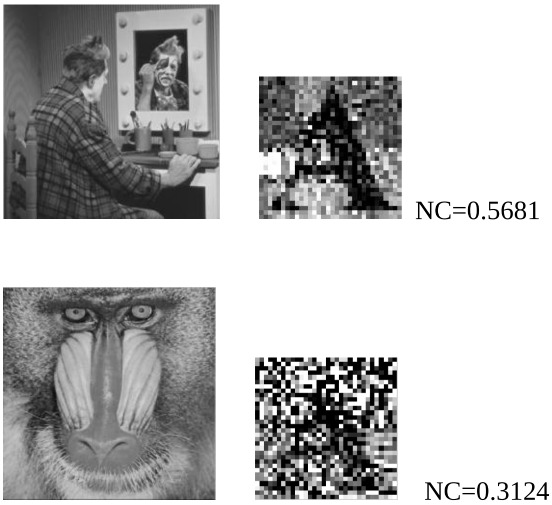
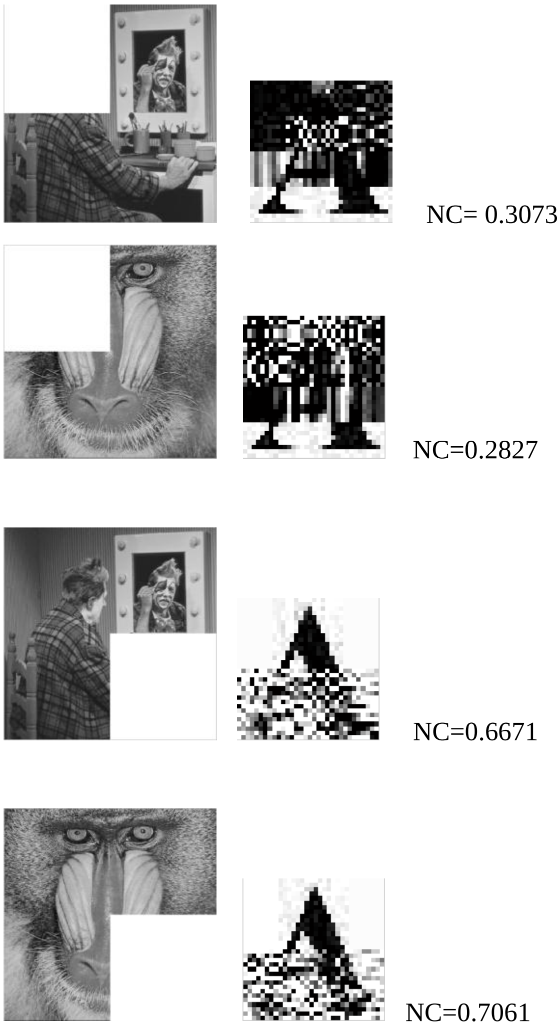


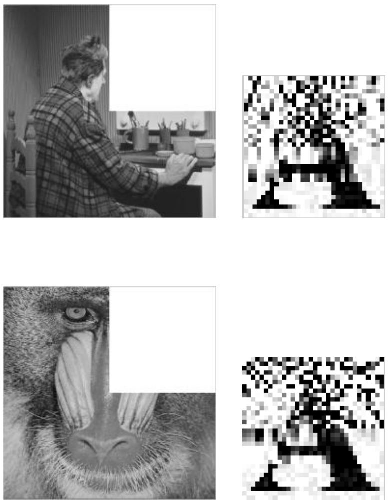
Figure 10. Evaluation of the Normalized Cross-Correlation values Median filter(3-3) attack.

Geometric Transformation (Cropping)

The watermark was recovered perfectly following a 1/4 sampling of the watermarked image in different places as shows Figure 11



robustness against cropping is very reliable as we can see, the mark was recovered perfectly but less good for the top left side block .



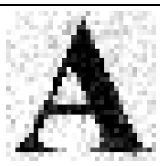
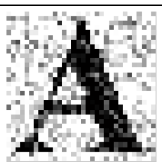
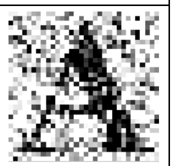
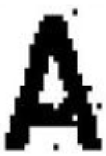
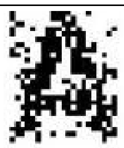
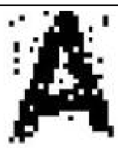
NC=0.5738

NC=0.6049

Figure 11. Evaluation of the Normalized Cross-Correlation values against Croping.

Compared to previous work, the proposed approach yields satisfactory results that many algorithms, either for imperceptibility or, robustness the table 2 shows a comparison of our approach with Patel one (D. Patel et al, 2011) where We highlight the effectiveness of our approach

Table 2. Comparison of Normalized Cross- Correlation NC and extracted watermark with the results published in reference (D. Patel et al, 2011) after different attacks

Our Method	JPEG 60%	Gaussian noise	Salt & Pepper noise
N C	0.97	0.87	0.65
			
D. Patel Method	JPEG 60%	Gaussian Noise	Salt & Pepper noise
N C	0.96	0.54	0.77
			

Also, we have compared the proposed method scheme with the reference (E.Li et al 2006) . The results are shown in Table 3. We can see that as to the proposed method performed good imperceptibility and more robustness against various attacks.

Table 3. Comparison of our method and the method proposed in reference (E.Li et al 2006) .

Different Attacks	Normalized Correlation (N C)	
	(E.Li et al 2006) PSNR=40.6dB	Our Method PSNR=43dB
Cropping 1/4	0.61	0.66
Median filter	0.35	0.56
JPEG	0.78	0.97
Gaussian Noise	/	0.87

CONCLUSION

The results of proposed approach by the combination of two transforms .The discrete wavelet transform DWT and the discrete cosine transform DCT by using image gradient as a measuring tool which gives a topological map of the image was very efficient for locating the regions where the disturbances are intense which allowed a good inlay and ensures a robustness for our watermarking. The results were exhibited in a way which allows a direct judgment, either subjective or objective, and to evaluate the quality of the watermarked image and extracted watermark by the evaluation metrics, the PSNR for the inlay and NC normalized correlation for the extraction watermark. One can conclude either for imperceptibility or the robustness. This system using a hybrid algorithm has a greater robustness against various attacks.

REFERENCES

[1] Lu, C.S., and Liao, H.Y., 2001, "Multipurpose Watermarking for image authentification and protection", IEEE Transactions on image processing Vol 10, pp.1579-1592.

[2] Y.Wang, J.F.Dohorty, and R.Evan Dyck. , 2002, "A wavelet based watermarking algorithm for ownership verification of digital images"IEEE Transactions on image processing,Vol.11, ,pp.77-88 .

[3] Y.Govindarajan and S.Dakshinamurthi , 2009, "Novel reversible watermarking scheme for authentication of military images" Int. J. Signal and Imaging Systems Engineering, Vol. 2.

[4] I. Cox, J. Kilian, F. Leighton, and T. Shamoon , 1997, "Secure spread spectrum watermarking for multimedia," *IEEE Trans. Image Processing*, vol. 6, pp. 1673–1687.

[5] M.Kutter and S.Winkler, 2002, "A vision based masking model for spread spectrum image watermarking". IEEE *Trans. Image Processing*, vol. 11.

[6] H.T. Wu and Y. M. Cheung, 2010, "Reversible watermarking by modulation and security

enhancement" *IEEE Trans. Instrum. Meas.*, vol. 59, no. 1, pp. 221–228.

[7] D.Kannan and M.Gobi, 2015, "An extensive research on robust digital image watermarking techniques", *International Journal of Signal and Imaging Systems Engineering*, Vol. 8, Nos. 1/2, pp.89–104.

[8] Barni, F. Bartolini and A. Piva , 1998, "A DCT domain system for robust image watermarking" IEEE Transactions on Signal Processing. 66, pp 357-372.

[9] W.C.Chu, 2003, "DCT based image watermarking using sub sampling. IEEE Trans Multimedia 5, 34-38.

[10] K. J. Giri,M. A. Peer, and P.Nagabhushan, 2014, "A Channel Wise Color Image Watermarking Scheme Based on Discrete Wavelet Transformation" in Proceeding of IEEE International Conference on Computing For Sustainable Global Environment transaction,pp758-762.

[11] E. Li, H. Liang, and X. Niu, 2006 "Blind Image watermarking scheme based on wavelet tree quantization robust to geometric attacks" *Proc. IEEE. WCICA*, pp 10256–10260.

[12] D.Vaishnavi and T.S.Subashini, 2014, "Robust and Invisible Image Watermarking in RGB Color space using SVD" International Conference on Information and Communication Technologies.

[13] E.Ganic ,SD.Dexter,and AM.Eskicioglu, 2005, "Embedding multiple watermarks in the DFTdomain using low and high frequency bands". In: Proc. security steganography and watermarking of multimedia contents. pp 175–84.

[14] W.Pratt, J.Kane and Andrews HC, , 1969, "Hadamard Transform image coding". In:Proceedings of the IEEE. VOL. 57, NO. 1.

[15] Ho.AT, J.Shen and SH.Tan , 2003, "Robust digital image -in -image watermarking algorithm using the fast Hadamard transform" .International symposium on optical science and technology. International society for optics and photonic.

[16] Nasrin M.Makbol and Bee EeKhoo , 2014, "A new robust and secure digital image watermarking scheme based on the integer wavelet transform and singular value decomposition" Digital Signal Processing.Volume33,pp 134–147.

[17] S. K. Amirgholipour and A. R. Naghsh-Nilchi , ,2009, "Robust Digital Image Watermarking Based on Joint DWT-DCT "International Journal of Digital Content Technology and its Applications. Vol. 3, pp.42-54.

[18] Ali Al-Haj , 2007, "Combined DWT-DCT Digital Image Watermarking," Journal of Computer Science 3 (9): 740-746.

[19] C.C Lai and C.C Tsai , 2010, " Digital image watermarking using discrete wavelet transform and singular value decomposition". IEEE Trans Instrum Measure;59:3060–3.

[20] S. Ajili and M.A. Hajjaji, *2016,* "Combining watermarking and encryption algorithm for medical image safe transfer: method based on DCT" *Int. J. Signal and Imaging Systems Engineering, Vol. 9, Nos. 4/5.*

[21] R.C.Gonzalez, and E. Richard . Woods, 2002, "*Digital image Processing*" (New Jersey : Prentice Hall).

[22] Yuping. Hu, Wei .Qun .Liu, Ying. Deng,Wenhua. He and Jinggou Dai, 2004, "Readable watermarking algorithm based on wavelet tree quantization." Communications, Circuits and Systems, ICCCAS 2004. International Conference on , Volume:1, , pp.579 – 583.

[23] J. Zan, M.O. Ahmad, and M.N.S. Swamy, 2004, "Object-based image watermarking technique using wavelets." Electrical and Computer Engineering. Canadian Conference on, Volume: 2, , pp.1143 – 1146 ..

[24] P.S. Murty and P. Rajesh Kumar, 2010, "A Robust Digital Image Watermarking Scheme Using Hybrid DWT-DCT-SVD Technique" IJCSNS International Journal of Computer Science and Network Security, VOL.10 No.10.

[25] D. Patel and S. Patnaik , 2011, "Robust Image Watermarking Based on Average and Significant Difference" Proceedings of the World Congress on Engineering and Computer Science , San Francisco, USA.