RESEARCHERID
THOMSON REUTERS

[Alexendre, 4(5): May 2017] ISSN 2348 – 8034
DOI- 10.5281/zenodo.581047 Impact Factor- 4.022

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

NON-BLIND IMAGE WATERMARKING SCHEME USING BI-DIMENSIONAL EMPIRICAL MODE DECOMPOSITION, DWT, DCT AND FUZZY SET

Noura Alexendre[*1], Ntsama Eloundou Pascal[2], Bitjoka Laurent [3]

[*1,2]University of Ngaoundere, Department of Physics Faculty of Science, Energy, Signal, Imagery and Automatic Control Laboratory, Cameroon

[*3] University of Ngaoundere, Ensai ,Energy, Signal, Imagery and Automatic Control Laboratory, Cameroon

ABSTRACT

The traffic of digital images has increased rapidly in the wide networks. The protection of this kind of data becomes important for many reasons such as confidentiality, authenticity and security. Nowadays, the most important engine to provide authenticity is watermarking. In this paper we present a method of invisible and robust hybrid watermarking to guarantee the authenticity and the confidentiality of images. This method or algorithm combines Discrete Wavelet Transform (DWT), Discrete Cosine Transform (DCT) and Bi-dimensional Empirical Mode Decomposition (BEMD) .In fact we propose to apply the BEMD to the original image then we take the First Intrinsic Mode Function (IMFs) decomposition of the image, we apply the Discrete Wavelet Transform (DWT) level 2, then we apply the Discrete Cosine Transform (DCT), to obtained news coefficients. It is here that we proceed with the integration of the mark coefficients after use of fuzzy set, DWT and DCT transforms. The method is not blind because it makes use of the original image for extracting the mark. The method is robust to certain usual attacks such as, filtering, adding noise and rotation. Results tested on different pictures by some attacks, are Satisfactory in terms of imperceptibility and robustness with measures of peak signal-to-noise ratio (PSNR).

Keywords: *Watermarking, DWT, BEMD, DCT.*

1. INTRODUCTION

The sharing of digital data has boomed growing in recent years because of the Internet. Transmitted digital information includes images, videos and texts. This increases the risk of transmission loss, hacking, fraud and forgery. To guard these risks every time the images are posted online, it seems reasonable and important to the protection and copyright of their owners. Watermarking techniques can ensure the security aspect of the images transmitted on the Internet. Watermarking is a technique or science that involves inserting a mark indelibly image can retrieve it. Watermarking algorithms is classified into two categories: the space domain and the frequency domain. The first method is to directly modify the values of the host image pixels to insert the pixels of the mark include as examples the techniques of Least Significant Bit (LSB) [1] and Patchwork [2] .These technologies are very complex and often less robust to attacks. As to frequency domain transforms are often used prior to the insertion of the mark. The commonly used frequency-domain transforms are: Discrete Cosine Transform (DCT) [3], the Discrete Fourier Transform (DFT), and the Discrete Wavelet Transform (DWT) [3], Wavelet Packet Transform (WPT) [4], Contourlet Transform (CT) among others. Empirical Mode Decomposition (EMD) is another technique for digital image watermarking. It is based on direct extraction of the image energy associated with various intrinsic time scales [5]. The technique adaptively decomposes non stationary images into a set of intrinsic oscillatory modes. The mean trend the coarsest component-of the image is highly robust under noise attack and JPEG compression [6]. In this paper, it will be shown that the BEMD is an efficient some attacks issue [6-7]. It is proposed a non blind, hybrid algorithm in which the mark is inserted in first Intrinsic Mode Function. Initially, the BEMD algorithm is applied to the host image to get different Intrinsic Mode Functions (IMFs) and residue images (R), as well as, the mean trend. The first IMFs is then decomposed into sub-bands using the DWT. The DCT is then applied to the frequency band and the same watermark data is embedded by modifying the DCT values after applying Fuzzy set and DWT. This paper is organized as follows: Section II briefly reviews materials and methodology use for the algorithm. The proposed watermarking algorithm is also introduced in section II. The experimental results and discussion in section III. The conclusion, in section IV, closes the paper.

2. METHOD & MATERIAL

2.1.Material

2.1.1. Wavelet Transform and Discrete Cosinus Transform (DCT)

The Discrete Wavelet Transform (DWT) decomposes input image into four components namely LL, HL, LH and HH where the first letter corresponds to applying either a low pass frequency operation or high pass frequency operation to the rows, and the second letter refers to the filter applied to the columns.The lowest resolution level LL consists of the approximation part of the original image. The remaining three resolution levels consist of the detail parts and give the vertical high (LH), horizontal high (HL) and high (HH) frequencies [8].

2.1.2 Discrete Cosine Transform (DCT)

DCT is a transform representing a signal in the form of a series of coefficients obtained from a sum of cosine functions oscillating at different frequencies and at different amplitudes [9]. Like the other transforms, DCT is applied to remove the correlation among the elements of the signal. The DCT for image A with M x N size is given by:

$$DCT_{pq} = \alpha_p \alpha_q \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} A_{m,n} \cos(\frac{\pi(2m+1)p}{2M}) \cos(\frac{\pi(2n+1)q}{2N}) \quad (1)$$

Where $0 \leq p \leq M-1$, and $0 \leq q \leq N-1$

$$\alpha_q = \frac{1}{\sqrt{N}} \text{ if } q=0 \text{ and } \alpha_q = \sqrt{\frac{2}{N}} \text{ if } 1 \leq q \leq N-1 \quad (2)$$

The corresponding inverse transformation (Whether 2D-IDCT) is defined as

$$A_{m,n} = \sum_{m=1}^{N-1} \sum_{n=1}^{N-1} \alpha_P \alpha_q DCT_{pq} (\cos(\frac{\pi(2m+1)p}{2M}) \cos(\frac{\pi(2n+1)q}{2N}) \quad (3)$$

Ability in compressing energy of the signal in few coefficients is one of the criteria for comparing performance of the transforms. DCT is among the best in term of the compressing capability and therefore, when quantizing, the transform is allowed to ignore the coefficients with low amplitudes without losing the accuracy during reconstructing the signal from its coefficients.

2.1.3.Bi-Empirical Mode Decomposition (BEMD)

The use of EMD has many applications. Initially it has been proposed to study the ocean waves by Huang's. It can be use in image processing name Bi-dimensional Empirical Mode Decomposition (BEMD) because of the 2D dimension of image [7]. The main idea of EMD is decompose the original signal into a numbers of IMFs and residue. The original signal is obtained by summing the IMFs and residues.

$$S_i(t) = \sum_{l=1}^{n} C_l + r_d \quad (4)$$

Where $S_i(t)$=signal n=number of IMFs C_l=IMF rd=residues

To get IMFs of original EMD signal some properties need to be satisfied.

The number of extrema and the number of zero crossing must different at most by one, get only one maximum or minimum between two zeros thirdly any point of the local mean of the signal must be zero. To find the IMFs,the sifting process is use ,this process sifting is an algorithm created by Huang et.al.

The BEMD has some similarity with one dimensional EMD in terms of detection of extremas and interpolation. The sifting process to obtained BIMFs component is obtained using a bi-dimensional sifting and some steps as follows:

Step1: Detect local extrema(e_{max} ,e_{min}).

Step2: Building the 2D 'envelop' with a B-spline function.

Step3: Make averaging of two envelopes to determine the local mean (e_{lk}).

$$e_{l,k} = \frac{e_{max} + e_{min}}{2} \quad (5)$$

Step4: Subtracting envelops to the BIMFs.

$$h_{l,k}(m,n) = inp_{l,k}(m,n) - e_{l;k}(m,n) \quad (6)$$

Step5: Calculing a sifting stop condition: $e_{l,k}(m,n) \prec \beta$ after obtaining the process criteria.
Step6: Subtraction of the BIMFs from the (residual) image.

$$f(m,n) = \sum_{i=l}^{N} \inf_j(m,n) + r(m,n) \quad (7)$$

The 3 BIMFs are calculated by repeating the sifting process. In our scheme we use the first BIMFs to insert the mark [2].

2.1.4.Fuzzy domain

Fuzzy set theory is a useful theory; it is use in computer vision and image processing applications. Fuzzy image processing has tree mains stages: fuzzification, modification of membership function values and defuzzification. Fuzzy image enhancement is based into membership function. Fuzzy sets are sets whose elements have varying degrees of membership (This idea is in contrast with classical or crisp set, because membership value of a crisp set member is always 1) [10].. Let X be a space of points, with a generic element of X denoted by x. Thus X =$_{\beta A}$ {x}. A fuzzy set Ã in X is defined by a membership function μ_A (x) which map each point in X in the interval [0,1], with the values of (x) at x representing the "degree of membership" of x in Ã. Thus large value of the membership function represents the high degree of the membership. Example of membership functions are Gaussian, Sigmoid, Trapezoidal and many others [10].

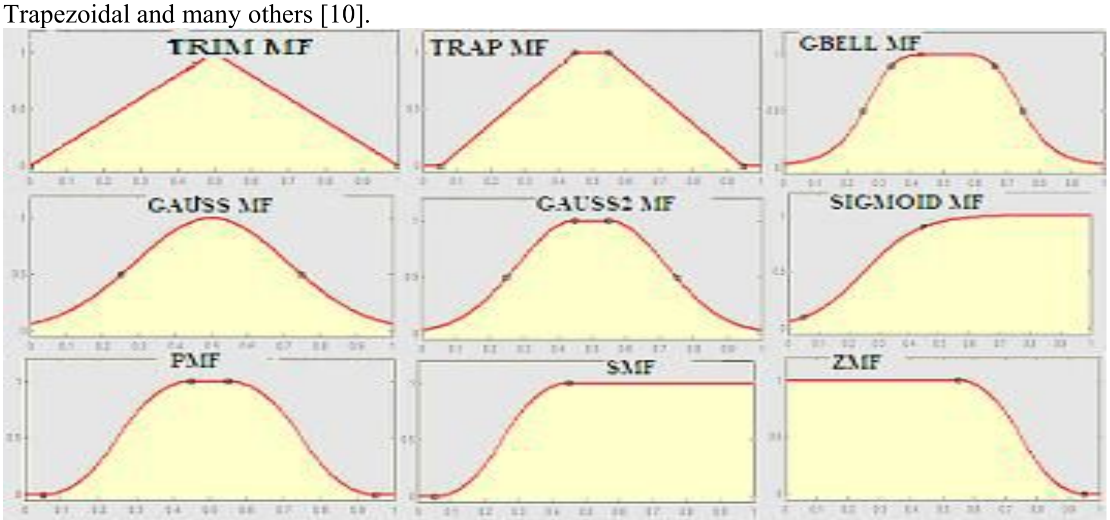


Figure 1: Membership function[10].

The image enhancement algorithm we developed contain following steps:
1. Take an input image and set membership function for each gray level as:

$$\beta(i,j) = e^{-\left(\frac{(Max - (\frac{X(i,j)}{V})}{2}\right)} \quad (8)$$

here Max, X(i,j),V are respectively max gray level, any gray level,variance between gray values.

[Alexendre, 4(5): May 2017] ISSN 2348 – 8034
DOI- 10.5281/zenodo.581047 Impact Factor- 4.022

2. Get new membership values by putting:

$$K(i,j)=2*(\beta(i,j))^2 \quad \text{if} \quad \beta(i,j)\le 0.5 \tag{9}$$

$$K(i,j)=1-(1-2*(\beta(i,j)))^2 \quad \text{if} \quad 0.5\le \beta(i,j)\le 1 \tag{10}$$

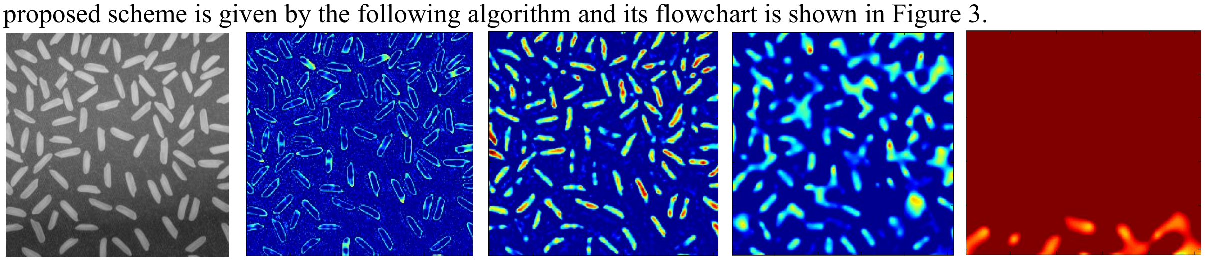
3. Finaly we get enhanced image by setting with the following method:

$$L(i,j)=Max-V\sqrt{-2\log(\beta(i,j))} \tag{11}$$

2.2-Methodology

2.2.1.Proposed Algorithm

In our work, the watermark is inserted in first obtained decomposition from BEMD of the image. Because it is highly robust against common attacks [5], the DWT is applied on it and the obtained sub bands are used to embed the watermark in the image by means of DCT tool. The image of the same size of the cover watermark. The proposed scheme is given by the following algorithm and its flowchart is shown in Figure 3.



(a) (b) (c) (d) (e)

Figure 2: Rice image with applying BEMD, a) original image b)First IMF c)Second IMF d)Third IMF e)Residue

2.2.2. Watermark Embedding

In the following section the explain of our embedding method is give. Firstly we apply BEMD to host or original image to obtained four images 3BIMFs and residue image. Then two level DWT is applied on first IMFs image, four sub-bands are obtained at this steps. The DCT transform is applied in each sub-band; it is in those news sub-bands that the insertion takes place after obtained also four sub-bands of watermark by DCT, DWT and FUZZY enhancement applications. To obtained the watermarked image, the inverse IDWT is applied to 4 news sub-bands to get new first BIMFs image which is sum with the two IMFs and residue image to achieve watermarked image, as

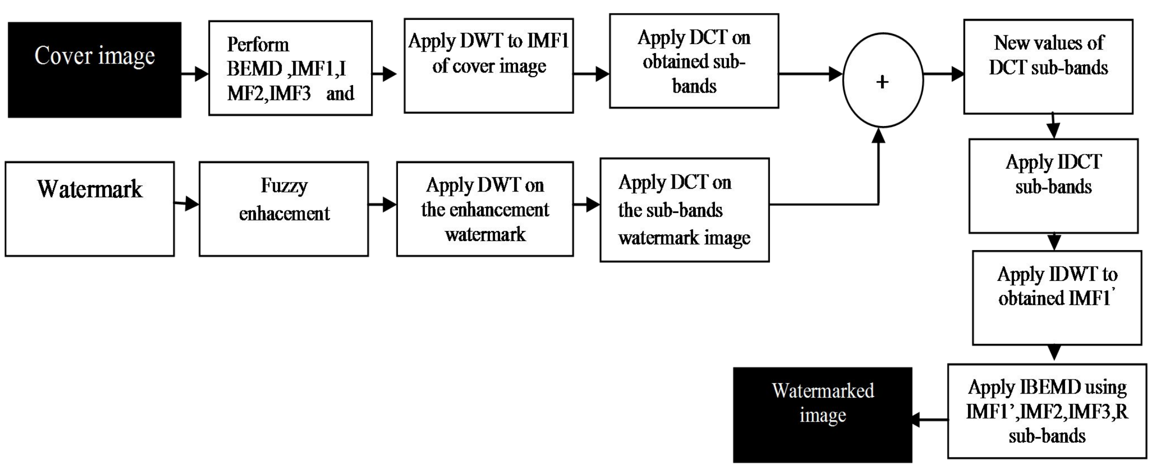


Figure 3: Watermarking embedding

ISSN 2348 – 8034
Impact Factor- 4.022

.
II.2.3. Watermark Extraction

The extraction algorithm need the cover and original images, it is non-blind algorithm. On the first BIMFs of watermarked image, two level DWT is applied to generate 4 sub-bands,The DCT is applied to have news 4 sub-bands ,the comparison of sub-bands of watermarked image and original image is done do obtained the sub-bands,we apply IDWT and defuzzyfication enhancement to get watermark(fig 5).

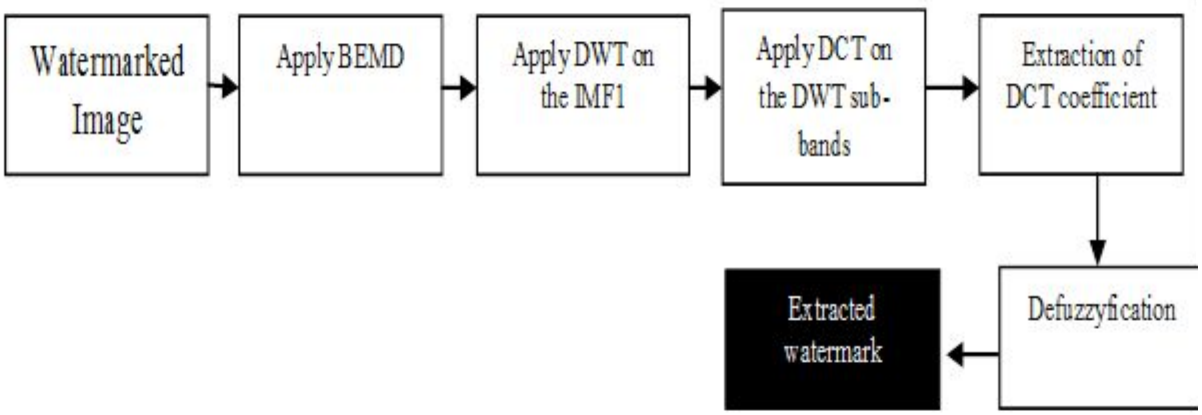


Figure 4: Watermark extraction

3. RESULT & DISCUSSION

In our work we used 'Rice',’Barbara’,’Lena’ and ‘Peppers’ as tests images, precision made they are gray images. The invisibility of the brand is verified. It is no perceptible difference between the original image and the marked image.In what follows we will present the results of tests and some performances of the developed method (using DWT) .These performance is presented in terms of quality and vis-à-vis robustness attacks such as filtering and rotation. These performances are estimated through parameters which are the MSE (Mean Error Signal) and PSNR (peak signal-to-noise ratio). The main parameter and commonly used for image quality is PSNR, it is expressed in decibels, it compares the similarity between the original image and the watermarked image. Typically an image with PSNR over 30 dB is considered good quality. The PSNR formula is:

$$PSNR_{db} = 10\log_{10}\left(\frac{\max^2}{MSE_r}\right) \qquad (12)$$

Where MSEr is Mean Squared Error between original and distorted images, which is defined in equation (11).

$$MSE_r = \sum_{i=0,j=0}^{M-1,N-1} \frac{\left[O_{im}(i,j) - W_{im}(i,j)\right]^2}{M \times N} \qquad \textbf{(13)}$$

$O_{im}(i,j)$ is original image and $W_{im}(i,j)$ is watermarked image.

Generally speaking, the evaluation of a watermark algorithm contains two parts: robustness and concealing. The comparability of the distilled watermark(W_{di}) with the original watermark (W_{or}) is quantitatively analyzed by using Normalized Cross-Correlation (NCC) [9]. The Normalized Cross-Correlation (NCC) is defined as:

ISSN 2348 – 8034
Impact Factor- 4.022

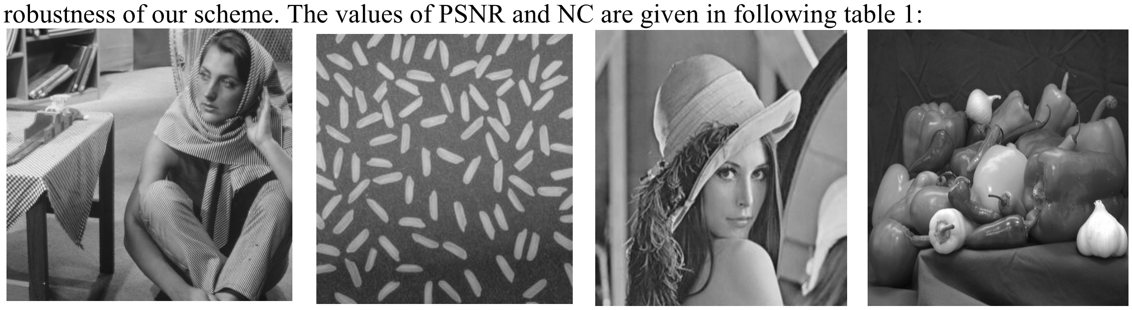
$$NCC = \frac{\sum_{k=0}^{k-1}\sum_{l=0}^{l-1} W_{or}(k,l)W_{di}(k,l)}{\sum_{k=0}^{k-1}\sum_{l=0}^{l-1} W_{or}(k,l)^2} \quad (14)$$

The performance of our algorithm is measured using PSNR,the obtained results without any attacks are presented as follow.

Figure 5: Proposed method on rice image, a)Original image, b)Watermarck,c) Watermarked image,d) Extracted watermark

3.1 Tests of robustness against some attacks

To approve the results obtained using BEMD and the effect of using DWT and Fuzzy set .We use different grayscale images as:"Lena", "Barbara", "rice" and "Peppers" these images are same size 512x512, to verify the robustness of our scheme. The values of PSNR and NC are given in following table 1:



a)Barbara b)Rice c)Lena d)Peppers

Figure 6: Some images use

Table1: Result of PSNR and NC without attack

Types images	*PSNR of watermarked image*	*Normalized Correlation(NC)*
Barbara	43	0.899
Rice	38	0.932
Lena	40	0.983
Peppers	39	0.921

 ISSN 2348 – 8034
Impact Factor- 4.022

The obtained results of PSNR for the tests images are superior to 30,and the results of Normalized Correlation (NC) in some cases superior to 0.9 as tell in literature, it denotes the character of robustness of our method.

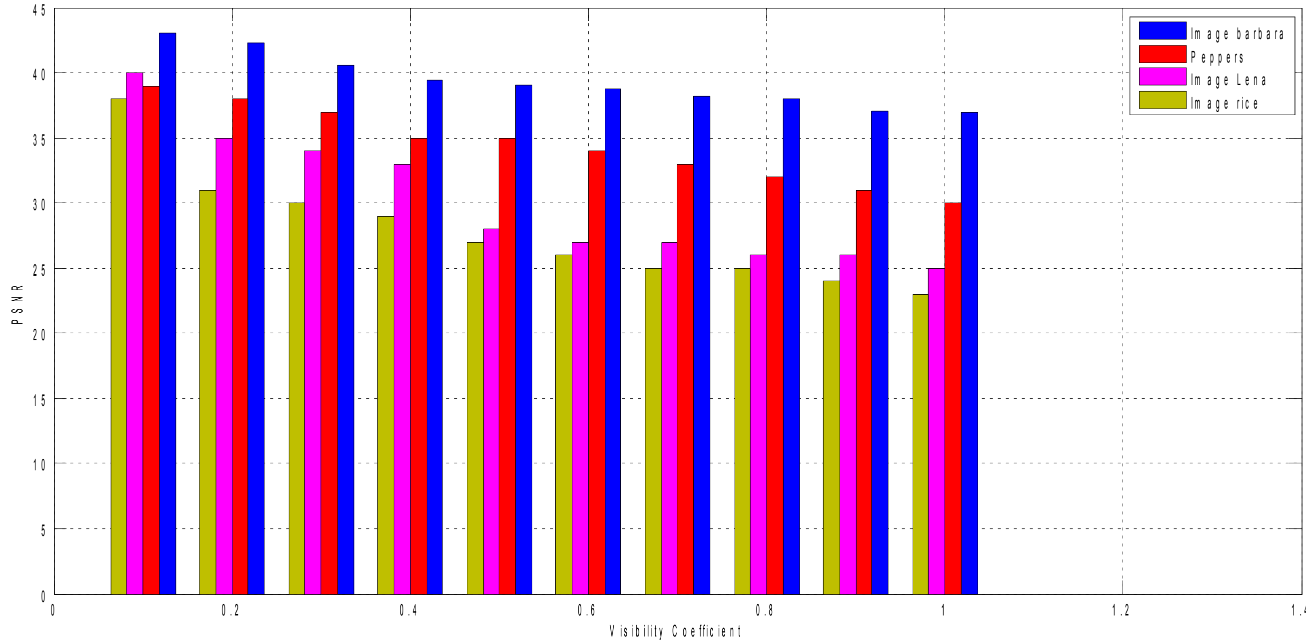


Figure 7 :results of PSNR fonction of visibility coefficient

The above figure shows the Psnr of the four images use for the experimental test.In the four cases the PSNR are some parts superor to 30,it prouve the robustness of our algoritm based to BEMD.

Table2: Result of PSNR and NCC under different attacks

Attack Type	Rice		Peppers		Barbara		Lena	
	PSNR	NCC	PSNR	NCC	PSNR	NCC	PSNR	NCC
No attack	38.234	0.932	39.771	0.921	43.776	0.876	40.110	0.883
Salt-Pepper (density 0.01)	23.678	0.511	27.156	0.602	24.445	0.547	23.543	0.621
Gaussian Noise (0.01)	20.213	0.304	17.334	0.412	18.342	0.628	21.894	0.533
Median Filtering 3x3	19.067	0.401	18.521	0.578	12.891	0.477	15.216	0.323
Rotation (20°)	18.902	0.514	22.433	0.304	16.423	0.356	11.509	0.490
Shifting Translation [10 10]	14.098	0.443	21.221	0.367	13.662	0.510	19.257	0.714
Compression	17.467	0.323	13.082	0.534	16.535	0.324	14.134	0.532

Simulation results suggest that this watermark algorithm can be robust against many common different types of attacks as show above.

4. CONCLUSION

In this work a watermarking scheme is presented. The scheme is based to BEMD, DWT,Fuzzy Set and DCT. The mark is inserted in DWT coefficients of original image after using BEMD and DCT. The scheme is a non blind method. The mark is extracted on various images and under Gaussian, filtering, salt α peppers and rotation attacks. The PSNR and NC results obtained, show that our watermarking scheme is robust.

5. ACKNOWLEDGEMENTS

The authors tank the anonymous referees for their valuable suggestions which let to the improvement of this work.

REFERENCES

1. *A. Yen JC, "Watermark Embedded in Electronic Letters",Xi"an:XiDian University Press, 2000, pp. 80-81.*
2. *Nikolaidis, "Copyright Protection of Images using Robust Digital Signatures", ICIP, Conf, pp. 2168-2171, 1999.*
3. *M.Sathik1 and S.S.Sujatha "An Improved Invisible Watermarking Technique for Image Authentication", International Journal of Advanced Science and Technology Vol. 24, November, 2010.*
4. *W. Song1 and X. Sun "A New Watermarking Frame Based on the Genetic Algorithms and Wavelet Packet Decomposition", Journal of Information Hiding and Multimedia Signal Processing. Volume **6**, Number **3**, May 2015.*
5. *Norden H., Zheng S., Steven L., Manli W., Hsing S., and Henry. L., "The Empirical Mode Decomposition and the Hilbert Spectrum for Non-Linear and Non-Stationary Series Analysis," in Proceedings of the Royal Society of London, series A , London, UK, vol. 454, pp. 903-995, 1998.*
6. *Lee Y., Nah J., and Kim J., "Digital Image Watermarking using Bidimensional Empirical Mode Decomposition in Wavelet Domain," in Proceedings of the 11th IEEE International Symposium on Multimedi, California, USA, pp.583-588, 2009.*
7. *S.Amira-Biad,T.Bouden et al. "A Bi-dimensional Empirical Mode Decomposition Based Watermarking Scheme,"The International Arab Journal of InformationTechnology,vol 12.No.1,January 2015.*
8. *A. Chowdhury, Z. K. Hasneen, „„Color Image Watermarking Technique by Featuring Joint DWTDCT Domain in YIQ Color Space"", International Journal of Research in Computer Engineering and Electronics, ISSN 2319-376X , Vol3, Issue4, July-August 2014.*
9. *M. Jiansheng, L. Sukang,and T.Xiaomei,A Digital Watermarking Algorithm Based On DCT and DWT,ISBN 978-952-5726-00-8 (Print), 978-952-5726-01-5. Proceedings of the 2009 International Symposium on Web Information Systems and Applications, Nanchang, China, May 22-24, 2009, pp.104-107.*
10. *T.Mahashwari and A.Asthana, „"image enhancement using fuzzy technique"", international journal of research review in engineering science & technology (ISSN 2278–6643) volume-2, issue-2, june-2013.*
11. *A.Sherstinsky and Rosalind W. Picard, "Restoration and Enhancement of Fingerprint Images usingM-Lattice – A Novel Non-linear Dynamical System", IEEE Pattern Recognition, Vol.2,p.p 195-200,1994 .*