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Studying The Noise Effect on Data Hiding Based on Contourlet Coefficients

Dr. khalil I. Alsaif* Nagham salim AL-lella**

Abstract

The noise have so many effects on secret message embedded on cover image, which cause a high distortion it could reach not to retrieve or difficult to recognize in case of image.

In this research a study of noise effect on the image watermark when it embedded on the image contourlet coefficients (contourlet transformation was used as a recent transform for image), so the watermark was embedded in the coefficients which has the low energy to make less effect on the layout as much as possible in addition to give wide area.

Different type of noise were added (**Gaussain, Salt&Pepper and Speckle Noise**) on the practical application shows a clear effect for **Gaussain Noise** and low effect for **Speckle Noise** in addition to high security robustness plus difficulty to attacked by hackers.

Keywords:- Digital Image Transformation, Countourlet, Watermarking.

دراسة تأثير الضوضاء على اخفاء البيانات باعتماد معاملات التحويلات الكنتورية

الخلاصة

للضوضاء تأثيرات كثيرة على الرسائل السرية المطمورة ضمن غلاف صوري مما يؤدي الى تشويش كبير يصل الى عدم امكانية الاسترجاع في بعض الاحيان او صعوبة التمييز في الحالات الصورية.

*Assist Prof /dept. Computer science / Computer Sciences and Mathematics College / Mosul University

**researcher /dept. Physics / Science College / Mosul University

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في هذا البحث تم دراسة تأثير الضوضاء على العلامة المائية الصورية عندما يتم طمره في داخل معاملات التحويلات الصورية وقد اعُتمدت التحويلات الكنتورية (احدى التحويلات الحديثة للصور) حيث ضُمنت العلامة المائية داخل المعاملات التي تمتلك طاقة منخفضة لأجل جعل التأثير على الشكل الخارجي اقل ما يمكن اضافة الى اعطاء مجال واسع.

أُضيفت انواع مختلفة من الضوضاء (Gaussain, Salt&Pepper and Speckle Noise) واظهر التطبيق العملي وجود تاثير واضح لضوضاء نوع Gaussain Noise واقل تاثير للضوضاء من نوع Speckle Noise ،اضافة الى قوة عالية في مستوى السرية وصعوبة الاختراق من قبل المتطفلين.

1- Introduction

Information, the most sought after commodity of electronic epoch, proves itself as a icon of power. Especially if the information is confidential and is of critical utility, the power it wields becomes immense. In order to prevent misuse of this enormous power by unauthorized people, security systems have to be implemented to guard the powerbase. Security of the data conventionally is relied on the encryption techniques. But, with growing number of established and successful attacks like cryptanalysis or worst case brute force attacks on encryption based systems, this is high time some improved security system has to be developed. The concept of data hiding was firstly proposed by Simmons in 1983[1].

Data hiding is a process to hide secret messages in a cover media to make them undetectable. The main goal of data hiding is to enhance communication security by embedding secret messages into an inconspicuous carrier and thereby transmit them to the receiver[2].

Data hiding techniques suggested a classification of the information hiding techniques as can be seen in Fig.(1)[3].

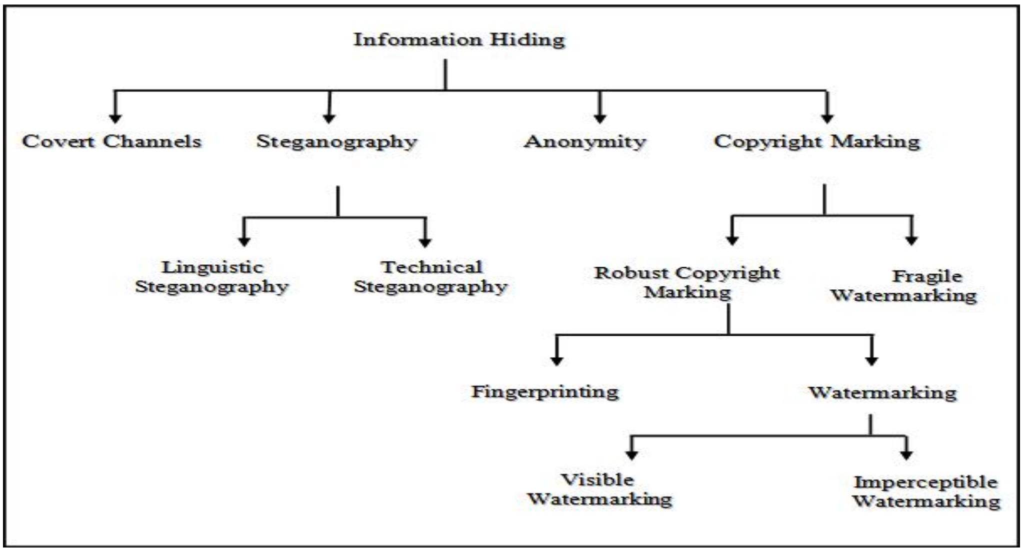


Fig.(1). A classification of information hiding techniques

Steganography it is the art of hiding information in ways that prevents the detection of hidden messages, the most important characteristic is the robustness against possible attacks. In fact, there are many copyright marks that are not hidden, such as a company logo, and whose main purpose is to differentiate one product, or service, against others and thus give a unique identity. Covert channels can be regarded as one of the main sub-disciplines of data hiding, is used for information transmission, but that is not designed nor intended for communications[3],In general, the techniques of data hiding have to satisfy the following requirements:

Imperceptibility: it is an important quality of image steganography that could prevent the attackers from detecting the secrets existing in the stego-image. **Hiding capacity:** the cover image should incapacitate significant number of secret bits[1].

2- RELATED WORKS

Yuning Hua, present his research Discrete wavelet transform (DWT) and discrete cosine transform (DCT) algorithm combined is used in fragile watermark embedding to achieve the color image content integrity protection[4].

Mahalingam Ramkuma,in his research apply data hiding scheme in image which based on the magnitude of DFT coefficients[5].

Naoya Sasaki. *et.al.*, try to applied audio watermarking based on association analysis which is one of the typical analysis methods of data mining[6].

Sergey Anfinogenov, *et. al.*, describe a new method of digital watermarking based on the embedding of the local maxima into the Fourier transform area of the image. Simulation results are presented, which confirm that the proposed method is resistant, to cyclic shifts, row and column removal, cropping, addition of noise, rotation and JPEG transforms[7]

Hoda Rezaee Kaviani, *et.al.*, In this paper a Contourlet based image watermarking algorithm is proposed which embeds a watermark in the singular values of the Contourlet transform of an image, watermarking is done in three scales of Contourlet transform[8].

Ahmed Salama, *et.al.*, propose a digital image watermarking technique in the wavelet domain approach. It embeds the watermark in the components of the third band of the DWT of an image[9].

Suhad Hajjara, *et.al.*, In his paper, method for digital image watermarking presented using the biorthogonal wavelet transform. The method is based on decomposing an image using the Discrete Wavelet Transform (DWT), and then embedding a watermark into significant coefficients of the transform[10].

3- AIM OF THE RESEARCH

In this research a different types of noise were added to an image which hold an in usable watermark, the study which type has the most effect on the retrieved cover image and the secret massage by measuring some factors.

4- DIGITAL WATERMARKING

Is one of the best solutions to prevent illegal copying, modifying and redistributing multimedia data, its a technique to embed copyright or other information into the underlying data.

4.1 Types of Watermarking:

According to the type of documents to be watermarked, the watermarking techniques can be divided into four types:

a) Image Watermarking.
b) Video Watermarking.
c) Audio Watermarking.
d) Text Watermarking.

According to Human Perception, the watermarking techniques can be divided into three types:

a) Visible Watermark: is a translucent overlaid into an image and is visible to the viewer.
b) Invisible Watermark: is used as evidence of ownership and to detect misappropriated images.
c) Dual Watermark: is the combination of visible and invisible watermark. An invisible watermark is used as a backup for the visible watermark.

According to Working Domain, the watermarking techniques can be divided into two types:

a) Spatial Domain Watermarking Techniques
b) Frequency Domain Watermarking Techniques

In spatial domain techniques, the watermark embedding is done on image pixels while in frequency domain watermarking techniques the embedding is done after taking image transforms. Generally frequency domain methods are more robust than spatial domain techniques. According to the watermarking extraction process, techniques can be divided into three types:

a) Non-blind: schemes require original image and secret key for watermark detection.

b) Semi-blind: schemes require secret key and watermark bit sequence for extraction.

c) Blind: schemes need only secret keys for extraction[11].

4.2 Characteristics of Watermarking:

There are many characteristics that watermarking holds, some of them are as follows:

a) Invisibility: an embedded watermark is not visible.

b) Robustness: piracy attack or image processing should not affect the embedded watermark.

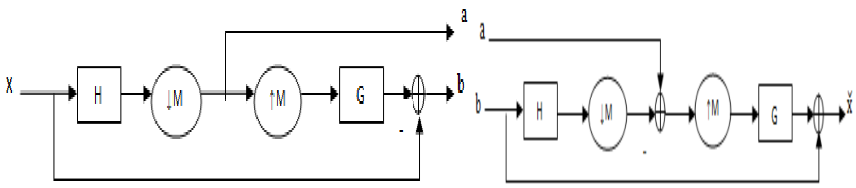
c) Readability: A watermark should convey as much information as possible. A watermark should be statistically undetectable. Moreover, retrieval of the digital watermark can be used to identify the ownership and copyright unambiguously.

d) Security: A watermark should be secret and must be undetectable by an unauthorized user in general. A watermark should only be accessible by authorized parties[12].

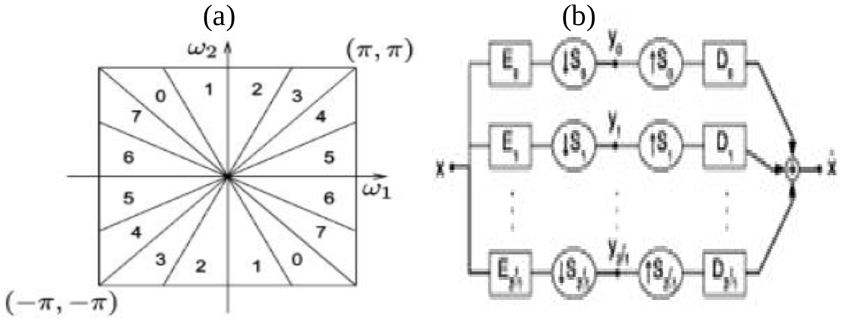
5- CONTOURLET TRANSFORM

A new nonseparable two-dimensional signal transform, called the Contourlet Transform (CT) has recently been proposed as an alternative to an improvement on separable wavelet for representation of natural images. This transform scales to capture the intrinsic geometrical structure in visual information through a multiresolution, multidimensional decomposition, An efficient representation of visual information is one of the important tasks in image processing applications such as denoising. Efficiency of a representation refers to the ability to capture significant information of an object of interest using a small description. these images contain intrinsic geometrical structures that are key features in visual information[13].

Implementing the idea of combining subband decomposition with a directional transform, Do and Vetterli introduced a multidirectional and multiscale transform known as the contourlet transform, which consists of two major stages: the subband decomposition and the directional transform. Laplacian Pyramid (LP) filters are used as the first stage and Directional Filter Banks (DFB) as the second stage. First, for the multiscale decomposition it uses Laplacian Pyramid (LP) filters. The LP decomposition at each level generates a downsampled lowpass version of the original and the difference between the original and the prediction, resulting in a bandpass image. Fig. 2(a) and (b) depicts the decomposition and reconstruction processes as suggested in, where H and G are orthogonal analysis (lowpass) and synthesis filters, respectively, and M is the sampling matrix. The process can be iterated on the coarse (downsampled lowpass) signal. The directional decomposition stage is also constructed based on the idea of using an appropriate combination of shearing operators together with two-direction partition of quincunx filter banks at each node in a binary tree-structured filter bank, to obtain the desired 2-D spectrum division as shown in Fig. 2(c). It is instructive to view L an level tree-structured DFB equivalently 2^L as a parallel channel filter bank with equivalent filters and overall sampling matrices as shown in Fig. 3(d), where the equivalent (directional) synthesis filters are represented by $Dk^{(L)}$, $0 \leq k < 2^L$.



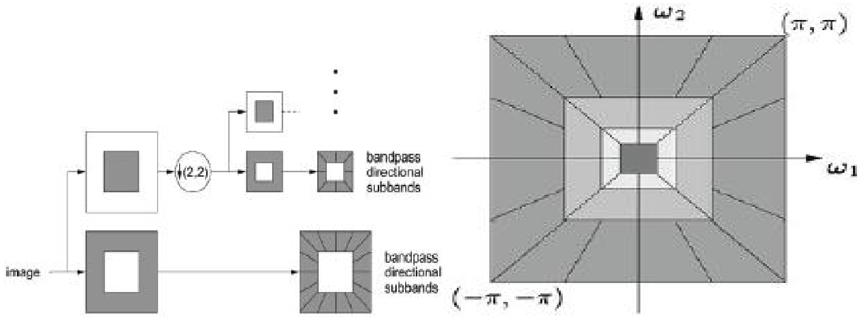
(a) (b)



(c) (d)

Fig.2. (a), (b) Laplacian pyramid one level of decomposition and reconstruction; (c), (d) directional filter bank frequency partitioning and the multichannel view of tree-structured directional filter bank.

Combining the Laplacian pyramid and the directional filter bank into a double filter bank structure the contourlet transform is developed. Fig. 3(a) shows the decomposition used in the contourlet filter bank. Bandpass images from the LP are fed into a DFB to capture the directional information. By iterating this scheme on the coarse image, the image decomposes into directional subbands at multiple scales. This cascade structure helps the user to decompose different scales into different directions. An example of frequency partition of the contourlet transform is shown in Fig. 3(b). This type of frequency partitioning leads to the sparsity of the contourlet coefficients[14].



(a) (b)

Fig.3. (a) contourlet filter bank: Laplacian pyramid as the first stage and directional filter bank as the second stage . (b) Example of frequency partition by the contourlet transform.

formula (1) describe contourlet transformation[15]:

$$\lambda_{j,k}^{(l)}(t) = \sum_{i=0}^{3} \sum_{n \in \mathbb{Z}^2} g_k^{(l)}[2n + k_i] \left(\sum_{m \in \mathbb{Z}^2} f_i[m] \phi_{j-1,2n+m} \right)$$
$$= \sum_{m \in \mathbb{Z}^2} \left(\sum_{i=0}^{3} \sum_{n \in \mathbb{Z}^2} g_k^{(l)}[2n + k_i] f_i[m - 2n] \right) \phi_{j-1,m(t)} \quad \text{......(1)}$$

6- PERFORMANCE EVALUATION

A. Peak signal-to-noise-ratio(PSNR):

The PSNR is most commonly used as a measure of quality of reconstruction of lossy compression codes. The signal in this case is the original data, and the noise is the error introduced by compression. When comparing compression codes it is used as an approximation to human perception of reconstruction quality, therefore in some cases one reconstruction may appear to be closer to the original than another, even though it has a lower PSNR a higher PSNR would normally indicate that the reconstruction is of higher quality[16].

$$PSNR = 10\log_{10}\left[\frac{R^2}{MSE}\right] \quad \text{......(2)}$$

R is the maximum fluctuation in the input image data type.

B. signal-to-noise-ratio(SNR):

Signal-to-noise ratio (often abbreviated SNR or S/N) is a measure used in science and engineering that compares the level of a desired signal to the level of background noise as seen in (3), It is defined as the ratio of signal power to the noise power. A ratio higher than 1:1 indicates more signal than noise[17].

$$SNR = 10\lg_{10}\left\{\frac{\sum_{x,y}[\mathcal{F}(x,y)]^2}{[\mathcal{F}(x,y)-\hat{\mathcal{F}}(x,y)]^2}\right\} \quad ......(3)$$

where $\mathcal{F}$ (x, y) and $\mathcal{F}$ ˆ(x, y) are the original image and restored image

C. Mean Square Error (MSE):

The MSE, as in (4), is the cumulative squared error between the compressed and the original image, A lower value for MSE means lesser error.

$$MSE = \frac{\sum_{X,Y}[I_1(X,Y)-I_2(X,Y)]^2}{X*Y} \quad ......(4)$$

X and Y are the number of rows and columns in the input images, respectively[18].

D. Correlation Coefficient (NC):

Most correlation coefficients (assuming there is really a relationship between the two variables you are examining) tend to be somewhat lower than plus 1.00 a correlation coefficient of 0.00 means that there is no relationship between your two variables based on the data, The closer a correlation coefficient is to 0.00, the weaker the relationship tell exactly what happens to one variable based on knowledge of the other variable. The closer a correlation coefficient approaches plus 1.00 the stronger the relationship tell exactly what happens to one variable based on the knowledge of the other variable.

$$COR = \frac{\sum_{ij}^{mn}\left(y_{ij}-\mu_y\right)\left(x_{ij}-\mu_x\right)}{\sqrt{\sum_{ij}^{mn}\left(y_{ij}-\mu_y\right)^2 \sum_{ij}^{mn}\left(x_{ij}-\mu_x\right)^2}} \quad ......(5)$$

In the (5), Where $y_{i,j}$ and x_{ij} denote the pixel values of the restored image and the original image, respectively. mxn is the size of the image. μ_x and μ_y represent the mean of the original and restored images[19].

7- PROPOSED TECHNIQUE

In this paper the contourlet based transform technique is proposed for gray scale image that used as host cover for watermark information correspond to secret image. Proposed algorithm contain two phase:

Embedding phase:

1- Accepted cover image (grayscale image).
2- Accepted secret massage (watermark which is grayscale image).
3- Decompose the host and secret massage using contourlet transformation with L-level, so 2^L directional subband will be generated (2^L coefficients).
4- The contourlet coefficient of the two last directional subband of the cover image are modified according to the formula(6).:

$$f^{*}(i,j) = f(i,j) + (th * s(i,j)) \quad \ldots\ldots(6)$$

Where $f(i,j)$: selected cover coefficient with position i,j.

$s(i,j)$: massage coefficient with position i,j.

th: Factor to control and increase the strength and robustness embedding.

5- Reconstracted the watermark image by reversing the embedding procedure.
6- Measured the quality of hidden-operation by using PSNR, SNR, NC and MSE.

Extracting phase: for retrieving embedding information we need original image and using formula (7), to extracted embedded watermark, extracted process consist with the following step:

$$\acute{s}(i,j) = \left(f(i,j) - \acute{f}(i,j)\right)/_{th} \quad \ldots\ldots(7)$$

1-Both watermark image and original image are transformed into contourlet domain with the same level in the embedding phase, and directional subband and lowpass band form secret massage will be retrieved by using formula (7).
2-Applying inverse contourlet transform to recover secret massage and retrieve cover image.
3-To assess the quality and accuracy of the data retrieved using PSNR, SNR, NC and MSE.

A complete block diagram in Fig.4 represents the proposed technique for embedding the watermark then different type of noise to be added to the watermark image.

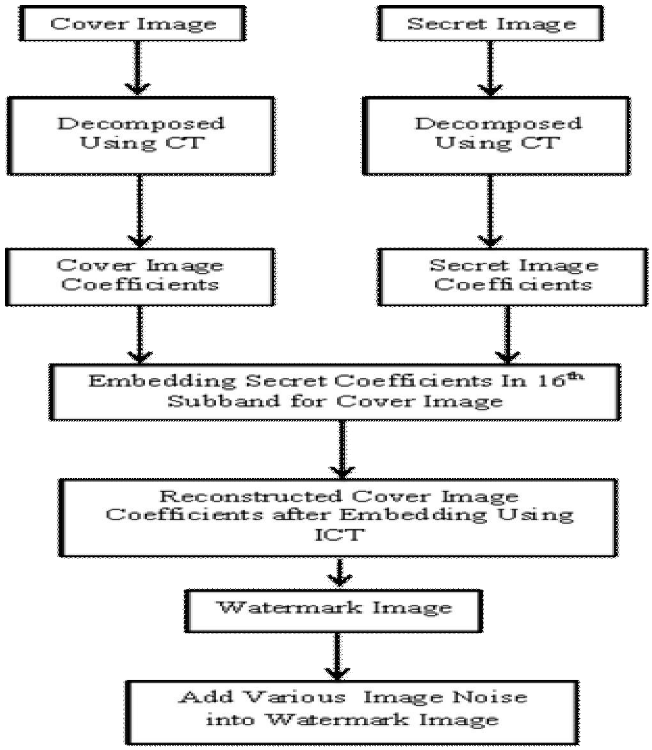


Fig.(4) Represents The Proposed Technique For Embedding The Watermark

8- EXPERIMENTAL RESULTS

Experiment performed with lena grayscale image as host image of size 512x512 and moon (.bmp) grayscale image as watermark of size 64x64 Fig. 5 (a) and (b)provide comparian between the original lena image and corresponding watermark image, the original watermark and extracted watermark without noise also shown in Fig. 6(a) and (b),respectively.

(a) (b)

Fig.(5), (a) Host image (lena.jpg), (b) Watermark image (lena.bmp)

(a) (b)

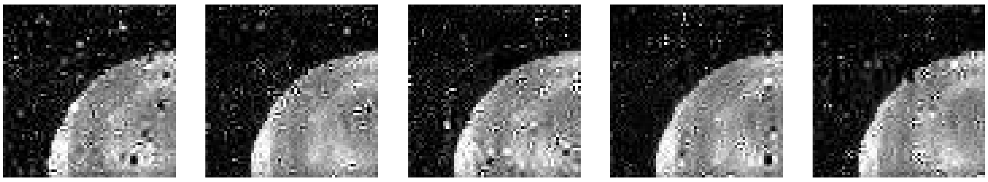
Fig.(6), (a) Watermark (moon.bmp), (b) Extracted watermark (moon.bmp)

Our experiment on the tested image prove that the 16^{th} directional subband have the highest priority for watermark embedding, the watermark image invisibility can be guaranteed at average of PSNR value of 43.58dB , NC value 0.98 for extracted watermark and 0.99 for retrieve host image, in table (1), show embedding and extracted watermark in 16^{th} directional subband for lena tested image without noise.

Table (1) Result for embedding and extracted watermark

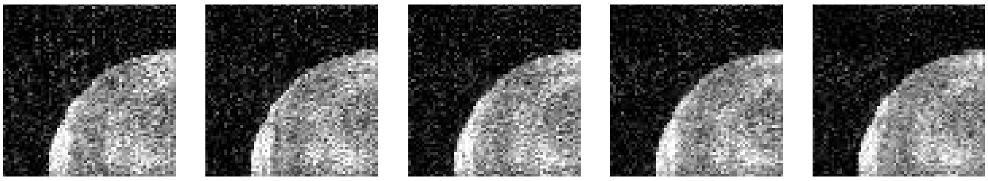
Measurements	Watermark image	Extracted watermark	Retrieve cover
MSE	2.849690	232.507212	0.042601
PSNR	43.582828	24.363647	61.836566
NC	0.999537	0.985178	0.999993
SNR	37.519532	17.078259	55.773270

Its known that when embedding the watermark in the16th high-frequency subband of the image is sensitive to the noise because of the noise value may be very near to the value of the image pixels, so this will have high effect on the watermark image, in Fig.(7), Fig.(8) and Fig.(9), show the robustness of watermark scheme when extracted watermark under various image noise, Gaussian noise, salt & pepper noise, speckle noise, and with different density as shown on table (2) and table(3) show retrieve cover image .



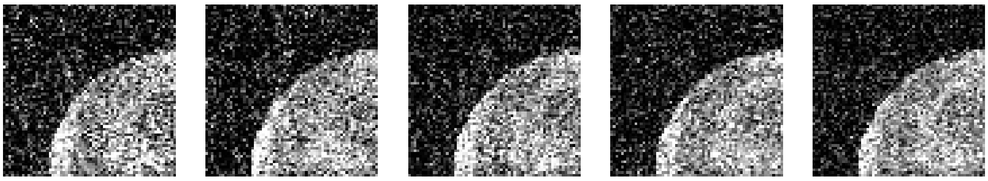
(a) (b) (c) (d) (e)

Fig.(7), Recovered watermark from Lena image after applying different noise,(a) Salt&Pepper (density = 0.001), (b) (density = 0.0009), (c) (density = 0.0008), (d) (density = 0.0007), (e) (density = 0.0006)



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

Fig.(8), Recovered watermark from Lena image after applying different noise,(a) Speckle (density = 0.001), (b) (density = 0.0009), (c) (density = 0.0008), (d) (density = 0.0007), (e) (density = 0.0006)



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

Fig.(9), Recovered watermark from Lena image after applying different noise,(a) Gaussian (density = 0.001), (b) (density = 0.0009), (c) (density = 0.0008), (d) (density = 0.0007), (e) (density = 0.0006)

Table (2) Result for extracted watermark under various image noise with different density

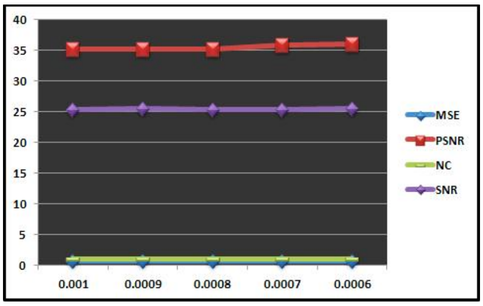
Measurements	**Extracted watermark under Salt& pepper noise**				
	0.001	**0.0009**	**0.0008**	**0.0007**	**0.0006**
MSE	1629.078014	1278.499916	1608.979313	1169.993914	1227.019315
PSNR	15.908592	16.961004	15.962506	17.346175	17.139497
NC	0.884283	0.907879	0.886713	0.914310	0.911891
SNR	8.623204	9.675616	8.677118	10.060787	9.854109
Measurements	**Extracted watermark under Speckle noise**				
	0.001	**0.0009**	**0.0008**	**0.0007**	**0.0006**
MSE	1430.207132	1269.471593	1233.412291	1062.653540	933.867280
PSNR	16.474021	16.991781	17.116928	17.764094	18.325159
NC	0.898524	0.909121	0.912135	0.922740	0.931434
SNR	9.188634	9.706393	9.831540	10.478706	11.039771
Measurements	**Extracted watermark under Gaussian noise**				
	0.001	**0.0009**	**0.0008**	**0.0007**	**0.0006**
MSE	4995.772899	4644.319315	3920.816225	3545.250841	3106.164130

PSNR	11.041984	11.358790	12.094246	12.531541	13.105767
NC	0.729144	0.749960	0.772726	0.783462	0.807516
SNR	3.756596	4.073402	4.808858	5.246153	5.820379

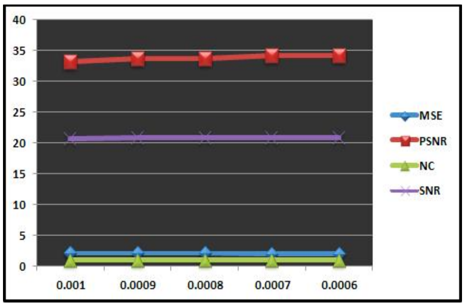
Table (3) Result for retrieve cover image under various image noise with different density

Measurements	**Retrieve cover under Salt& pepper noise**				
	0.001	**0.0009**	**0.0008**	**0.0007**	**0.0006**
MSE	16.831995	16.399153	16.541713	13.648072	12.996164
PSNR	35.869448	35.982590	35.944999	36.780091	36.992652
NC	0.997268	0.997337	0.997315	0.997784	0.997889
SNR	29.806152	29.919294	29.881703	30.716795	30.929356
Measurements	**Retrieve cover under Speckle noise**				
	0.001	**0.0009**	**0.0008**	**0.0007**	**0.0006**
MSE	16.000008	14.463158	12.803375	11.266757	9.644805
PSNR	36.089602	36.528172	37.057559	37.612814	38.287869
NC	0.997407	0.997654	0.997922	0.998171	0.998433
SNR	30.026306	30.464877	30.994263	31.549519	32.224574
Measurements	**Retrieve cover under Gaussian noise**				
	0.001	**0.0009**	**0.0008**	**0.0007**	**0.0006**
MSE	64.024557	58.130899	51.248882	45.146287	38.720609
PSNR	30.067338	30.486733	31.033960	31.584583	32.251382
NC	0.989732	0.990676	0.991761	0.992733	0.993760
SNR	24.004042	24.423438	24.970664	25.521288	26.188086

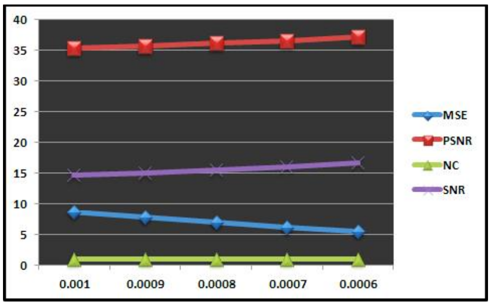
It is clear in Fig.(10), that the proposed algorithm has a stability for different types of noise also a very little variation in the performance evaluation factors (MSE, PSNR, NC and SNR) when the noise value changed.



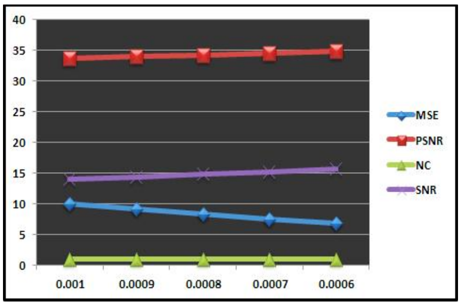
(a.1). Salt&Pepper noise



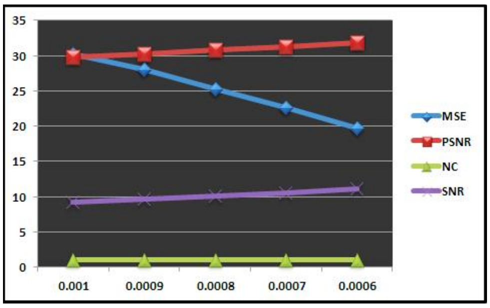
(b.1). Salt&Pepper noise



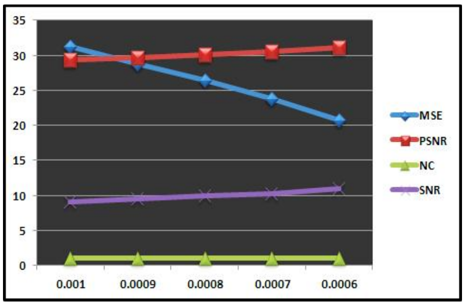
(a.2). Speckle noise



(b.2). Speckle noise



(a.3). Gaussian noise



(b.3). Gaussian noise

Fig.(10), Comparison between watermark image under various image noise when embedding in, (a)16^{th}, (b) 8^{th} directional subband

9- Conclusion

Due to the results got from the expermintal application, the proposed algorithm can be concluded by:

The watermark which was embedded in the 16th high-frequency subband image is sensitive to the noise.

The proposed algorithm show robustness of watermark scheme when extracted watermark under varios noise.

The study shows that the algorithm is stability for different type of noise.

very little variation on the performance factors were shown.

10- FEATURE WORKS

The proposed technique can be extended to cover the following idea as feature works:

Applied on different type of color image to discover which one is the most efficient.

The secret massage can be tested as a text massage to evaluate the effect of the noise on that massage.

Apply other transformation on the cover image.

11- REFERENCE

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