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Data Hiding In Contourlet Coefficients Based On Their Energy

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ABSTRACT

The data hiding is one of the most important subject in field of computer science, so a lot of technique was developed and modified to satisfy the optimum lend of hiding. In this research the contourlet transformation coefficients were studied to decide which of them are suitable to embed data on it a lot of parameters of the contourlet coefficients can be discussed one of them is the coefficient energy.The research covered most of the suggested events which could be met during the embedding state, one of them the size of the cover in addition to the size of the information were studied. Applying the suggested idea on different type of image with different size (cover image and the message image) shows that the coefficients with low level of energy are suitable to embedded the information, and the retrieved cover and message are so closed to the original one.

INTRODUCTION

With the rapid development of the internet technologies, digital media needs to be transmitted conveniently over the network. Attacks, unauthorized access of the information over the network become greater issues now a day Information Hiding provides solution to these issues.

Information Hiding techniques received very much less attention from the research community and from industry than cryptography, but this has changed rapidly [1].

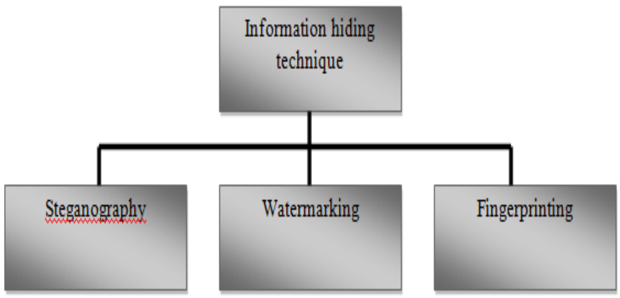

Figure 1. Information Hiding Classification

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Data hiding technique conceals the secret message into cover image, where the image embedded with secret message is called *stego*-image. Then this *stego-image* is being transmitted to prevent the third party from modifying, intercepting, and tampering, thus protecting the data.

There are two major research areas in data hiding techniques: irreversible data hiding and reversible data hiding. Irreversible data hiding technique cannot recover images back to cover images even after the receiver retrieved the embedded secret message, reversible data hiding technique, *stego-images* can be restored back to the original images after retrieving the embedded secret data [2].

Information hiding is one kind of quickly developed information security technology which uses redundant data and random component of carrier to embed secret messages into the carrier through the way could not be perceptible. In recent researches people generally choose digital media stream as the carrier, such as image, audio, video and so on [3].

In order to avoid the information data being copied or destroyed by the unauthorized persons, data hiding technology, therefore, was generated. It embedded secret data into an image and the viewer cannot observe the difference. The digital image before the secret data were hidden in it, called *cover image*. The image concealed the secret data called *stego-image* [4].

Previous works

Mahalingam Ramkuma, apply data hiding scheme in image which base on the magnitude of DFT coefficients, "A ROBUST DATA HIDING SCHEME FOR IMAGES USING DFT" [5].

Fitri Amia, present his research for improving perceptual' quality of a robust Discrete Cosine Transform (DCT) -domain watermarking scheme, a wavelet based image fusion is proposed instead of spatial masking techniques The robust watermarking is, achieved by inserting watermark sequences in the .low frequency DCT coefficients of a host image, "Perceptual Improvement of Robust DCT-Domain Watermarking through Wavelets Based Image Fusion" [6].

Naoya Sasaki.et.al., try to apply audio watermarking based on association analysis which is one of the typical analysis methods of data mining, " AUDIOWATERMARKING BASED ON ASSOCIATION ANALYSIS" [7].

In the research Thai Duy Hien.et.al., proposed new watermarking method in the curvelet domain. The curvelet transform was developed in order to represent edges along curves much more efficiently than the traditional transforms. They apply the transform to watermarking and evaluate the effectiveness of the method. Their watermarking algorithm embeds a watermark in curvelet coefficients which are selected by a criterion whether they contain as much edge information as possible, "DIGITAL WATERMARKING BASED ON CURVELET TRANSFORM" [8].

Tsz Kin Tsui, present his paper two vector watermarking schemes that are based the use of complex and quaternion Fourier transforms and demonstrates, "Color Image Watermarking Using Multidimensional Fourier Transforms" [9].

WATERMARKING TECHNIQUE

Digital watermarking is defined as an algorithm that can be used to hide secret signal into digital audio, video, image or documents in a manner that does reduce the overall quality of the original signal. The secret signal, identified as the watermark, can be copyright notices or authentication information or secret text. The original signal is called as "cover signal" or "host signal". The process of inserting the secret signal is called embedding and the image after embedding is called "watermarked image" [10].

The major point of digital watermarking is to find the balance among the aspects such as robustness to various attacks, security and invisibility A watermark is called imperceptible if the watermarked content is perceptually equivalent to the original, unwatermarked content

- Readily Extractable:- The data owner or an independent control authority should easily extract it.
- Unambiguous:- The watermark retrieval should unambiguously identify the data owner.
- Robustness:- It should tolerate some of the common image processing attacks.

A watermark is called robust if it resists a designated class of transformations. Robust watermarks may be used in copyright protection applications to carry copy and access control information [11].

CLASSIFICATION OF DIGITAL WATERMARKING

1) digital watermarking can be divided into robust watermarking and fragile watermarking according to its characteristics, Robust watermarking is mainly used to sign copyright information of the digital works, the embedded watermark can resist the common edit processing, image processing and lossy compression, the watermark is not destroyed after some attack and can still be detected to provide certification. Fragile watermarking is mainly used for integrity protection, which must be very sensitive to the changes of signal. We can determine whether the data has been tampered according to the state of fragile watermarking.

2) Digital watermarking can be divided into image watermarking, video watermarking, audio watermarking, text watermarking and graphic watermarking based on the attached media, Image watermarking refers to adding watermark in still image. Video watermarking adds digital watermark in the video stream to control video applications. Text watermarking means adding watermark to PDF, DOC and other text file to prevent changes of text. Graphic watermarking is embedding watermark to two-dimensional or three-dimensional computer-generated graphics to indicate the copyright.

3) Digital watermarking can be divided into visual watermarking and blind watermarking according to the detection process. Visual watermarking needs the original data in the testing course, it has stronger robustness, but its application is limited. Blind watermarking does not need original data, which has wide application field, but requires a higher watermark technology.

4) Digital watermarking can be divided into copyright protection watermarking, tampering tip watermarking, note anti-counterfeiting watermarking, and anonymous mark watermarking based on its purpose, Copyright protection watermarking means if the owners want others to see the mark of the image watermark, then the watermark can be seen after adding the watermark to the image, and the watermark still exists even if it is attacked. Tampering tip watermarking protects the integrity of the image content, labels the modified content and resists the usuallossy compression formats. Note anti-counterfeiting watermarking is added to the building process of the paper notes and can be detected after printing, scanning, and other processes. Anonymous mark watermarking can hide important annotation of confidential data and restrict the illegal users to get confidential data [12].

A complete digital watermarking system is composed of two basic modules:

watermark embedding module and watermark detection and extraction module. Watermark embedding module is responsible for adding the watermark signal to the original data.

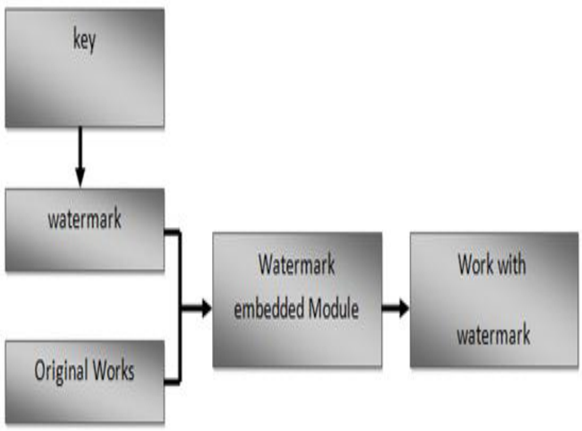


Figure 2. Watermark Embedding Module

Watermark detection and extraction module is used to determine whether the data contains specified watermark or the watermark can be extracted [12].

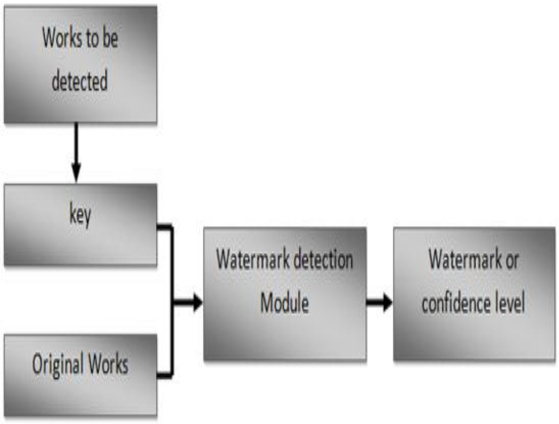


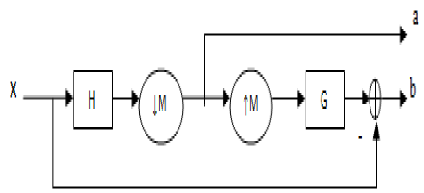
Figure 3. Detection And Extraction Module Of Watermark

CONTOURLET TRANSFORMATION

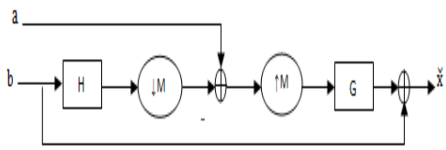
For piecewise *continous* 1-D signals, wavelets have been established as a right tool in generating efficient representation. However, natural images are not simply stacks of 1-D piecewise smooth scan-lines, but they have many discontinuity points along smooth curves and contours. Thus, separable wavelets cannot capture directional information in two dimensions. To overcome this shortcoming, many directional Image representations have been proposed in recent years. 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 [13], The contourlet transform is performed using double filter bank Structure[14], 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 [13].The Contourlet Transform is a directional transform, which is capable of capturing contours and fine details in images. The contourlet expansion is composed of basis function oriented at various directions in multiple scales, with flexible aspect [15].

FIRST: One way of achieving a multiscale decomposition is to use a Laplacian pyramid (LP), introduced by Burt and Adelson. The LP decomposition at each level generates a down sampled lowpass version of the original and the difference between the original and the prediction, resulting in a bandpass image as shown in Fig. 4(a). In this figure, ‘H’ and ‘G’ are called analysis and synthesis filters and ‘M’ is the sampling matrix. The process can be iterated on the coarse version. In Fig. 4(a) the outputs are a coarse approximation ‘a’ and a difference ‘b’ between the original signal and the prediction.

The resulting image is a low pass filtered version of the original image. The Laplacian is then computed as the difference between the original image and the low pass filtered image Thus the Laplacian pyramid is a set of band pass filters. By repeating these steps several times a sequence of images, are obtained. If these images are stacked one above another, the result is a tapering pyramid data structure, as shown in Fig. (5). and hence the name. Laplacian pyramid can thus be used to represent images as a series of bandpass filtered images, each sampled at successively sparser densities. It is frequently used in image processing and pattern recognition tasks because of its ease of computation



(a)



(b)

Figure 4. Laplacian Pyramid Scheme (a) Analysis, and (b)Reconstruction

SECOND: Directional Filter Bank In 1992, Bamberger and Smith introduced a 2-directional filter bank (DFB) that can be maximally decimated while achieving perfect reconstruction. The directional filter bank is a critically sampled filter bank that can decompose images into any power of two's number of directions.

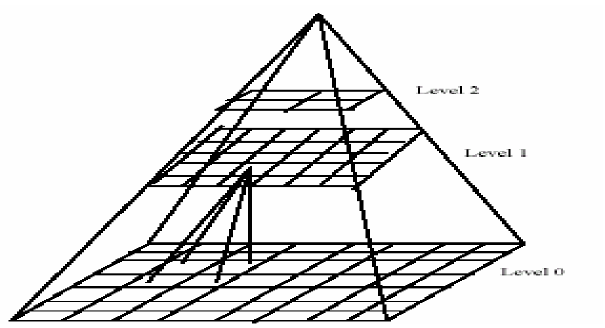
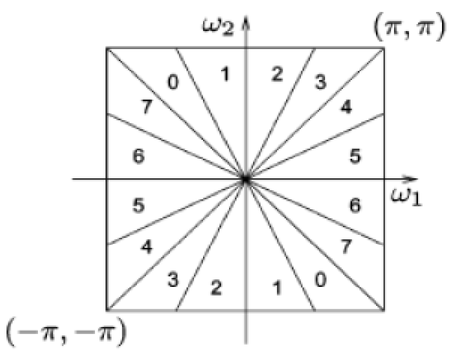


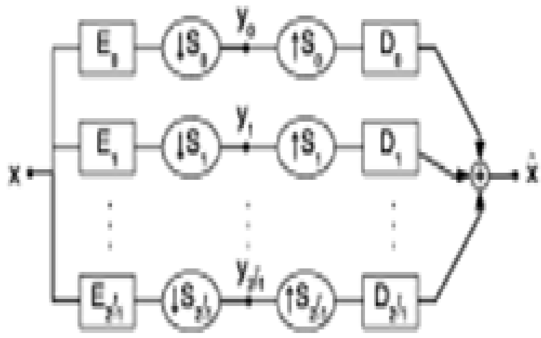
Figure 5. Laplacian Pyramid Structure

Wedge-Shaped frequency partition as shown in Fig. (6) the original construction of the DFB in involves modulating the input signal and using diamond shaped filters. Furthermore, to obtain the desired frequency partition, an involved tree expanding rule has to be followed. As a result, the frequency regions for the resulting subbands do not follow a simple ordering as shown in Fig. (5) based on the channel indices.

The DFB is designed to capture the high frequency components (representing directionality) of images. Therefore, low frequency components are handled poorly by the DFB. In fact, with the frequency partition shown in Fig. (6).

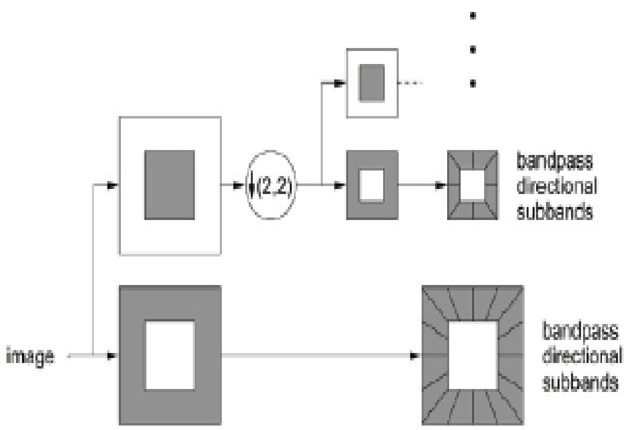


(a)

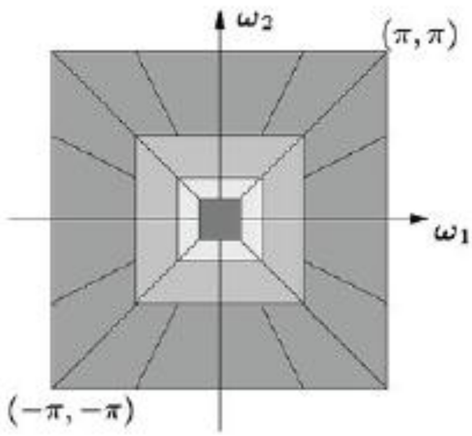


(b)

Figure 6.Directional filter bank. (a)Frequency partition where l=3 and there are 2^3 =8 real wedge-shaped frequency bands. Subbands 0-3 correspond the *mostly horizontal* direction, while subbands 4-7 correspond to the *mostly vertical* directions. (b) The multichannel view of an l-level tree-structured directional filter bank.



(a)



(b)

Figure 7.(a)Contourlet Filter Bank: Laplacian Pyramid As The First Stage And Directional Filter Bank As The Second Stage.(b)Example Of Frequency Partition

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By The Contourlet Transform.

low frequencies would leak into several directional subbands, hence DFB does not provide a sparse representation for images. To improve the situation, low frequencies should be removed before the DFB. This provides another reason to combine the DFB with a multiresolution scheme, Therefore, the LP permits further subband decomposition to be applied on its bandpass images. Those bandpass images can be fed into a DFB so that directional information can be captured efficiently. The scheme can be iterated repeatedly on the coarse image. The end result is a double iterated filter bank structure, named pyramidal directional filter bank (PDFB), which decomposes images into directional subbands at multiple scales. The scheme is flexible since it allows for a different number of directions at each scale[15].

contourlet transform is developed. Fig. 7(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. 7(b). This type of frequency partitioning leads to the sparsity of the contourlet coefficients, i.e., only the coefficients with both direction and location on the original image edges has significant values [8]. Fig. (8). shows the contourlet transform of the images Lena [15].

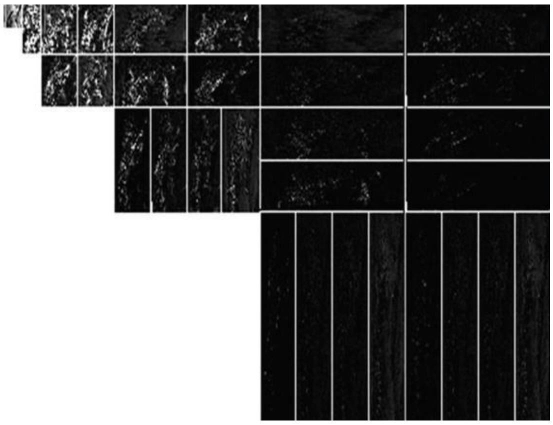

Figure 8. Contourlet Decomposition Of Lena

PROPOSED TECHNIQUE

Proposed algorithm contain two phase:

A. Embedding technique

1) acquisition of cover image.
2) acquisition the secrete message.
3) evaluate the contourlet coefficients for both cover and message on different level (2^k) based on cover and message size.
4) calculate the energy by using formula (1). of all coefficients of the contourlet for the cover image, the select the suitable coefficients (lowest energy) [16], for best accuracy of data hiding.

$$\epsilon = \sum_{i}\sum_{j} |\delta(i,j)|^{2} \qquad (1)$$

5) modify the cover coefficients with the values of the message coefficients as formula (2):

$$f'(i,j) = f(i,j) + \left(th * s(i,j)\right) \qquad (2)$$

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

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

Th: Factor to control and increase the strength and robustness Hidden posses.

In some cases of hiding processes a treatment of message coefficients {1,1} as doc for extra algorithm performance.

6) Inverse Contourlet Transform (ICT) is applied Access to data hidden in the cover cannot be detect to human visual system.
7) Measured the quality of hidden-operation by using PSNR, SNR, CORR2 and MSE.

B. Extraction technique

1) Apply contourlet transformation the same number of levels in the treatment of concealment on the original image and image containing hidden data.
2) Extract the hidden massage from specific locations in the process of concealment By using the inverse embedding formula (3):

$$\acute{s}(i,j) = \left(f(i,j) - \acute{f}(i,j)\right) / _{th} \qquad (3)$$

In some cases treatment of message coefficients {1,1} with IDCT when this massege coefficient process by DCT in the hidden operation.

3) Apply inverse contourlet transform to recover the secret message.
4) Apply inverse contourlet transform to recover the cover image.
5) To assess the quality and accuracy of the data retrieved using the PSNR, SNR, CORR2 and MSE.

PERFORMANCE EVALUATION

To investigate the performance of the technique, it is essential to subjectively or objectively evaluate the quality of the image after the embedding process and also evaluate the robustness of the embedded data:

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

The PSNR is most commonly used as a measure of quality of reconstruction of lossy compression codecs (e.g., for image compression) as seen in (4) [17]. The signal in this case is the original data, and the noise is the error introduced by compression. When comparing compression codecs 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 [18].

$$PSNR = 10\log_{10}\left[\frac{R^2}{MSE}\right] \qquad (4)$$

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 (5), It is defined as the ratio of signal power to the noise power. A ratio higher than 1:1 indicates more signal than noise [19] .

$$SNR = 10\log_{10}\left\{\frac{\sum_{x,y}[\mathcal{F}(\mathbf{x},\mathbf{y})]^2}{\left[\mathcal{F}(\mathbf{x},\mathbf{y}) - \acute{\mathcal{F}}(\mathbf{x},\mathbf{y})\right]^2}\right\} \qquad (5)$$

where $\mathcal{F}$ (x, y) and $\mathcal{F}$ ˆ(x, y) are the original image and restored image [20] .

C. Mean Square Error (MSE):

The MSE, as in (6), is the cumulative squared error between the compressed and the original image, A lower value for MSE means lesser error.

$$MSE = \frac{\sum_{X,Y}[I_1(X,Y) - \mathbf{I}_2(X,Y)]^2}{X * Y} \qquad (6)$$

x and y are the number of rows and columns in the input images, respectively [21].

D. Correlation Coefficient (NC):

Most correlation coefficients (assuming there really is 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.

$$COR = \frac{\sum_{ij}^{mn}\left(y_{ij-\mu_y}\right)\left(x_{ij-\mu_x}\right)}{\sqrt{\sum_{ij}^{mn}\left(y_{ij-\mu_y}\right)^{2}\sum_{ij}^{mn}\left(x_{ij-\mu_x}\right)^{2}}} \qquad (7)$$

In the (7), Where y i, j and x i, j 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 [22].

EXPERIMENTAL RESULT

We have carried out simulations with various secret massage and some of the well known host images such as Lena, cameraman and Peppers of different size. to evaluate the performance of the proposed embedding algorithm, experiment was conducted using 1024 X 1024 gray scale images. Simulations were done using MATLAB. The secret massage is a grayscale cameraman Fig. (9). of size 128x128, which contains a lots of curves and significant details, therefore; it can be a suitable candidate for measuring the performance.

Figure 9. Original Secret Massage

Embedding the data in high frequency components improves the perceptibility of the data massage Therefore, we have selected the highest frequency subband which possesses the maximum energy for massage embedding.

The majority of coefficients in the highest frequency subband are significant values compared to the other subbands of the same level, indicating the presence of directional edges Since the human visual system is less sensitive to the edges, embedding the massage in the directional subband improves the perceptibility of the massage, but it is hardly robust.

To achieve robustness, we can embed the massage in the lowpass image of the contourlet decomposition. However, the perceptibility of the massage degrades, although the massage is embedded into the highest frequency subbands, it is likely to be spread out into all subbands when we reconstruct the massage, due to the special transform structure of laplacian pyramid (LP). Fig. (11). provide comparison between original and hybrid cover lena image The original and retrieve secret massage also shown and Fig. (10). show energy level of lena image coefficient cover.

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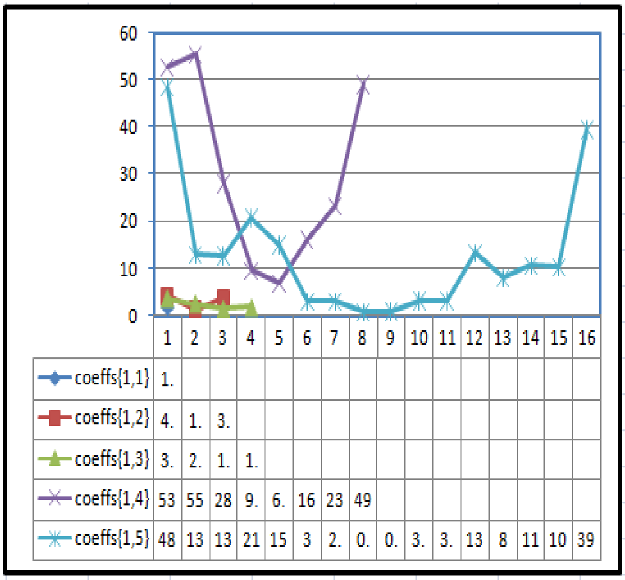


Figure 10. Energy Level Of Lena Image Coefficient Cover.

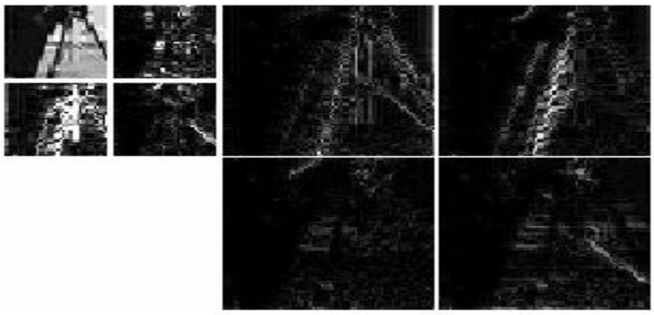
Retrieve massage
 NC=0.99
Hybrid image
 NC=1.0
Original image


Figure 11. comparison between original images and their corresponding hybrid image

EXAMPLE

Following step of proposed algorithm the cover contourlet coefficient and massage contourlet coefficient can be seen consequentially in Fig. 12(a) and (b). in addition to the original cover image and massage image in Fig. (13,14)

(a)



(b)

Figure 12. (a) Contourlet Decomposition Of Cover Lena Image. (b) Contourlet Decomposition Of Massage Image(Part Of Cameraman Of Size 128x128. embedding the massage coefficients in size the cover

Figure 13.original massage image

Figure 14.original cover Lena image coefficients well lead to a new cover coefficients.

reconstruct the cover image from it contourlet coefficients can be seen in Fig. (11), after that the efficiency of the proposed algorithm tested by measuring PSNR, SNR, MSE and NC.

In addition to the above example, appendix (I) show so many examples with different properties (different image dimension), and appendix (II) show energy level of different image coefficient cover use in this research.

CONCLUSION

Due to the result got from different type of image and so many properties of cover and massage images yield to so closed cover image from the original to be difficult distinguish between them which show robustness of the proposed technique algorithm to be achieve for data hiding on image. the result and the graphs shows that all the factors which adopted to measure the robustness of the algorithm appears that the effect of the size both the cover and massage is not an essential factor in data hiding on the proposed algorithm.

REFERENCES

[1] R. Yadav. (2011). "Study of Information Hiding Techniques and their Counterattacks: A Review Article". *IJCSCN*, Vo. 1, pp. 142-164.

[2] C. Lee, and K. Chen. (2011). "Reversible Data Hiding by Reduplicated Exploiting Modification Direction Method". *IIH-MSP*, pp. 256-259.

[3] X. Yan, S. Guan, and X . Niu. (2008). "Research on the Capacity of Error-Correcting Codes-Based Information Hiding". *IIH-MSP*. pp. 1158-1161.

[4] S. Jan et al., (2011). "An Improved Data Hiding Method Using Image Interpolation". *IIH-MSP*. pp. 185-188.

[5] M. Ramkumar, A. N. Akansu, and A. Alatan. (1999). "A ROBUST DATA HIDING SCHEME FOR IMAGES USING DFT". *ICIP*. vol. 2 ,pp. 211-215.

[6] F. Arnia. (2003). "Perceptual improvement of robust DCT-domain watermarking through wavelets based image fusion". *Communications*, Vol. 2. pp. 505-509.

[7] N. Sasaki, R. Nishimura, and Y. Suzuki. (2006). "A *nce on Signal Processing*. vol. 4.

[8] T. Hien et al.. (2007) "Digital watermarking based on curvelet transform *Its Applications*. pp. 1-4.

[9] T. Tsui, X. Zhang, and D. Androutsos. (2008). "Color Image Watermarking Using multidimensional Fourier Transforms". *IEEE Transactions on Information Forensics and Security*. vol. 3. pp. 16-28.

[10] S. Radharani, and M. L. Valarmathi. (2011). "Multiple Watermarking Scheme for Image Authentication and Copyright Protection using Wavelet based Texture Properties and Visual Cryptography". *International Journal of Computer Applications*. vol. 23. pp. 29-36.

[11] M. M. Sathik, and S. S. Sujatha. (2010). "An Improved Invisible Watermarking Technique for Image Authentication". *International Journal of Advanced Science and echnology*. Vol. 24. pp. 61-74.

[12] J. Xuehua. (2010). "Digital Watermarking and its Application in Image Copyright Protection". *International Conference on Intelligent Computation Technology and Automation* vol. 2. pp. 114-117.

[13] M. A. Akhaee et al.. (2010). "Contourlet-Based Image onment ". *IEEE Transactions on Image Processing* . vol. 19. pp. 967-980.

[14] P. S. Hiremath, P. T. Akkasaligar, and S. Badiger. (2011). "Performance Comparison of Wavelet Transform and Contourlet Transform based methods for Despeckling Medical Ultrasound Images". *International Journal of Computer Applications* . vol. 26 . pp. 34-41.

[15] S. Esakkirajan et al.. (2006). "IMAGE COMPRESSION USING CONTOURLET TRANSFORM AND MULTISTAGE VECTOR QUANTIZATION". *GVIP Journal*. Vol. 6. pp. 19-28.

[16] S. Khalighi et al. .(2009). "A new robust non-blind digital watermarking scheme in contourlet domain ". *ISSPIT* .pp. 20-25.

[17] Q. Huynh-Thu, and M. Ghanbari. (2008). "Scope of validity of PSNR in image/video quality assessment ". *Electronics Letters*. vol. 44. pp. 800-801.

[18] http://pediaview.com/openpedia/Peak_signal-to-noise_ratio.

[19]http://iitd.vlab.co.in/?sub=65&brch=179&sim=408&cnt=1

[20] A. Mallahzadeh, H. Dehghani, and I. Elyasi. (2008). "Multiscale Blind Image Restoration with a New Method". *International Journal of Computer Science and Engineering* . Vol. 2. pp. 19-22.

[21] http://www.debugmode.com/imagecmp

[22] V. R. Vijaykumar et al.. (2008). "High Density Impulse Noise Removal Using Robust Estimation Based Filter". *IAENG International Journal of Computer Science*. vol. 35. pp. 259-266.

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إخفاء البيانات في معاملات التحويلات الكنتورية بالاعتماد على الطاقة

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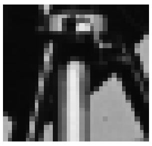
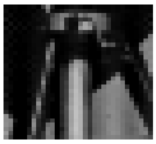
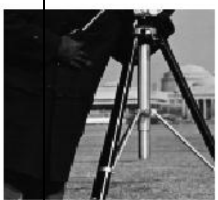
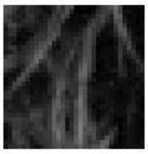
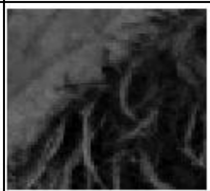
الخلاصة:

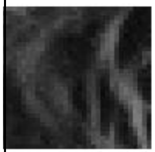
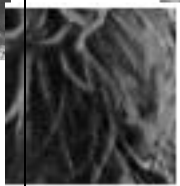
يعتبر إخفاء البيانات من أهم المجالات العلمية ضمن حقول علم الحاسوب، وقد طورت العديد من التقنيات لتحقيق الوصول إلى أفضل إخفاء. في هذا البحث تم تقديم دراسة لمعاملات التحويلات الكنتورية لانتخاب أفضل معامل بالاعتماد على الطاقة في ذلك المعامل لتضمين البيانات. وقد اشتمل البحث على تغطية اغلب المواضيع المحتملة خلال مرحلة التضمين، ومنها نسبة حجم الغطاء إضافة إلى حجم الصورة السرية, إن تطبيق الخوارزمية المقترحة على أنواع مختلفة من الصور وبإحجام مختلفة (صورة الغطاء والصورة السرية) أظهرت بان المعاملات ذات الطاقة المنخفضة أعطت أفضل النتائج في تضمين البيانات السرية واسترجاع صورة الغطاء والصورة السرية المستخلصة كانت اقرب ما يكون إلى الصورة السرية الأصل.

Appendix (I). Show So Many Examples With Different Properties (Different Image Dimension)

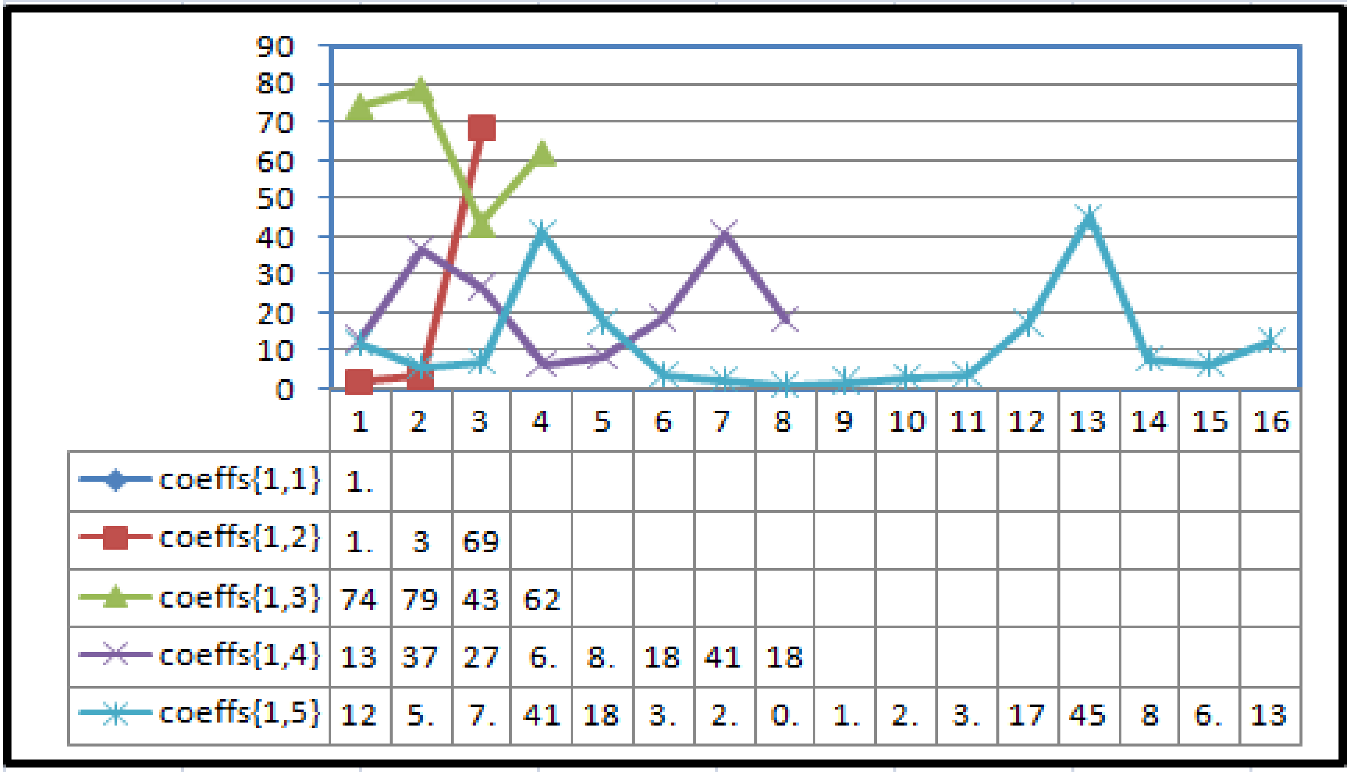
Lena Image Cover Size 1024x1024				
Massage Size	**Original Cover**	**Original Massage**	**Hybrid Cover**	**Retrieve Massage**
32x32			 **NC=1.0**	 **NC=0.99 SNR=24.105421**
64x64			 **NC=1.0**	 **NC=0.99 SNR=27.541234**
128x128			 **NC=1.0**	 **NC=0.99 SNR=30.435200**

256x256			 **NC=1.0**	 **NC=0.98** **SNR=34.486420**

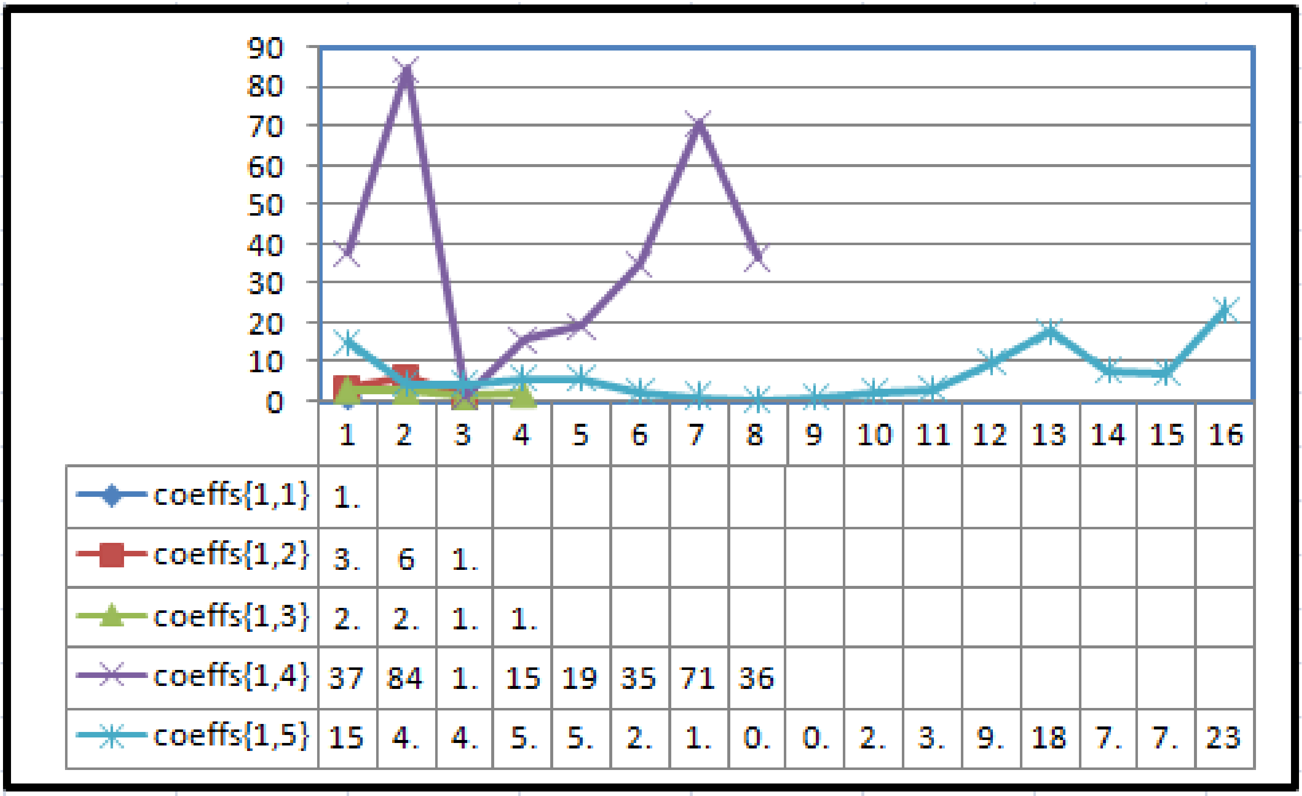
Cameraman Image Cover Size 512x512				
Massage Size	Original Cover	Original Massage	Hybrid Cover	Retrieve Massage
32x32			 NC=1.0	 NC=0.98 SNR=25.319225
64x64			 NC=1.0	 NC=0.98 SNR=28.455665
128x128			 NC=1.0	 NC=0.98 SNR=38.763777

Pepper Image Cover Size 256x256				
Massage Size	Original Cover	Original Massage	Hybrid Cover	Retrieve Massage
32x32			 NC=1.0	 NC=0.98 SNR=32.497833
64x64			 NC=1.0	 NC=0. 0.97 SNR=35.450504

Appendix (II). show energy level of images coefficients cover



Energy Level Of Pepper Coefficients Cover



Energy Level Of Cameraman Coefficients Cover