Iraqi Journal of Physics, No-1, Vol.-1, pp. 29-35, Dec. 2002

New DCT-Based Image Hiding Technique

S. M. ALI
Remote Sensing Unit_ College of Science_ University of Baghdad
IRAQ _ BAGHDAD _AL-JADERYIA

ABSTRACT :
A new technique for embedding image data into another BMP image data is presented. The image data to be embedded is referred to as signature image, while the image into which the signature image is embedded is referred as host image. The host and the signature images are first partitioned into 8x8 blocks, discrete cosine transformed "DCT", only significant coefficients are retained, the retained coefficients then inserted in the transformed block in a forward and backward zigzag scan direction. The result then inversely transformed and presented as a BMP image file. The peak signal-to-noise ratio (PSNR) is exploited to evaluate the objective visual quality of the host image compared with the original image.

تقنية إخفاء جديدة تعتمد تحويلة جيب التمام المجزئة

أ.د. صالح مهدي علي
وحدة الاستشعار عن بعد_ كلية العلوم _ جامعة بغداد
العراق _ بغداد _ الجادرية

الخلاصة:
يتضمن البحث تقديم تقنية جديدة لإقحام بيانات صورة داخل صورة أخرى نوع BMP . تم الإشارة إلى الصور المطلوب إقحامها بصورة البصمة، بينما أشير إلى الصورة المتضمنة صورة البصمة بالصورة المضيفة. تعتمد التقنية أولا تجزئة الصورتين إلى قوالب كل منها ذات حجم 8×8 نقطة، ومن ثم تنفيذ تحويلة الجيب تمام على كل منها. يتم اختيار معاملات التحويل ذات الشأن في تمثيل المعلومات داخل كل قالب وتحذف المعاملات المتبقية. تقحم المعاملات المتبناة من قوالب الصورتين بطريقة المسح المتعرج ومن بداية القالب للصورة المضيفة و بشكل مخالف (ابتداء من أخر موقع داخل القالب) لمعاملات صورة البصمة. تم استخدام المقياس الكمي المعروف بذروة نسبة الإشارة إلى الضوضاء لتقيم كفاءة التقنية وبيان خاصية الصورة الناتجة.

1. Introduction:

Recently, the problem of data hiding and watermarking has received a great attention due to increasing use of digital multimedia; i.e. video, image, audio, and text. Data hiding techniques can be used to help identifying and retrieving relevant piece of multimedia data, by imbedding information such as keywords on the media. Currently, most data hiding researches deals with image data, only few considered video and audio data types [1,2, 3]. Little work has been reported on data hiding techniques for text or document [4]. Generally, the digital media (i.e. image, video, audio,…etc) could experience large changes without causing noticeable perceptual difference, which makes lossy compression possible. In fact, lossy compression methods, usually, get rid of redundant data from digital media while maintaining good perceptual effect. Based on the similar motivation comes out a new techniques called "Data Hiding". In this paper, a new technique for data hiding is presented. Our presented data hiding's algorithm utilizes the redundancy locations in the DCT domain for mounting the signature image transformed coefficients. The locations preserved for the signature coefficients are those presenting the host image high frequency information. Consequently, reconstructed hiding host image have, in general, high PSNR when compared with the original one.

2. The Proposed Hiding Technique:

It is well known that; human visual system is more sensitive to the changes in low frequency region than in highly textured region [5]. Therefore, hiding information in the textured regions is less likely to result in visible distortions compared to that less textured regions, which is the strategy behind our presented hiding algorithm. A block diagram demonstrating the procedures involved in our embedding-hiding scheme is shown in figure (1).

2.1 Image Decomposition and Cosine Transformation:

As it is clear in Figure (1), host and signature images are first sliced into their band's components. If the signature image was single band, then an index flag is reserved indicating this. Both host and signature images should then be divided into blocks, each of size 8×8 pixels. Each block is then transformed, using cosine transform, as given by the following equation

$$\mathbf{F(u,v)}=\frac{1}{4}C(u)C(v)\sum_{x=0}^{7}\sum_{y=0}^{7}\mathbf{f(x,y)}\cos\left(\frac{(2x+1)u\pi}{16}\right)\cos\left(\frac{(2y+1)v\pi}{16}\right) \qquad (1)$$

Where;

$$\mathbf{C(u)} \text{ and } \mathbf{C(v)} = \begin{cases} \frac{1}{\sqrt{2}} & \text{for } u \,\&\, v = 0 \\ 1 & \text{Otherwise} \end{cases} \quad \text{, and}$$

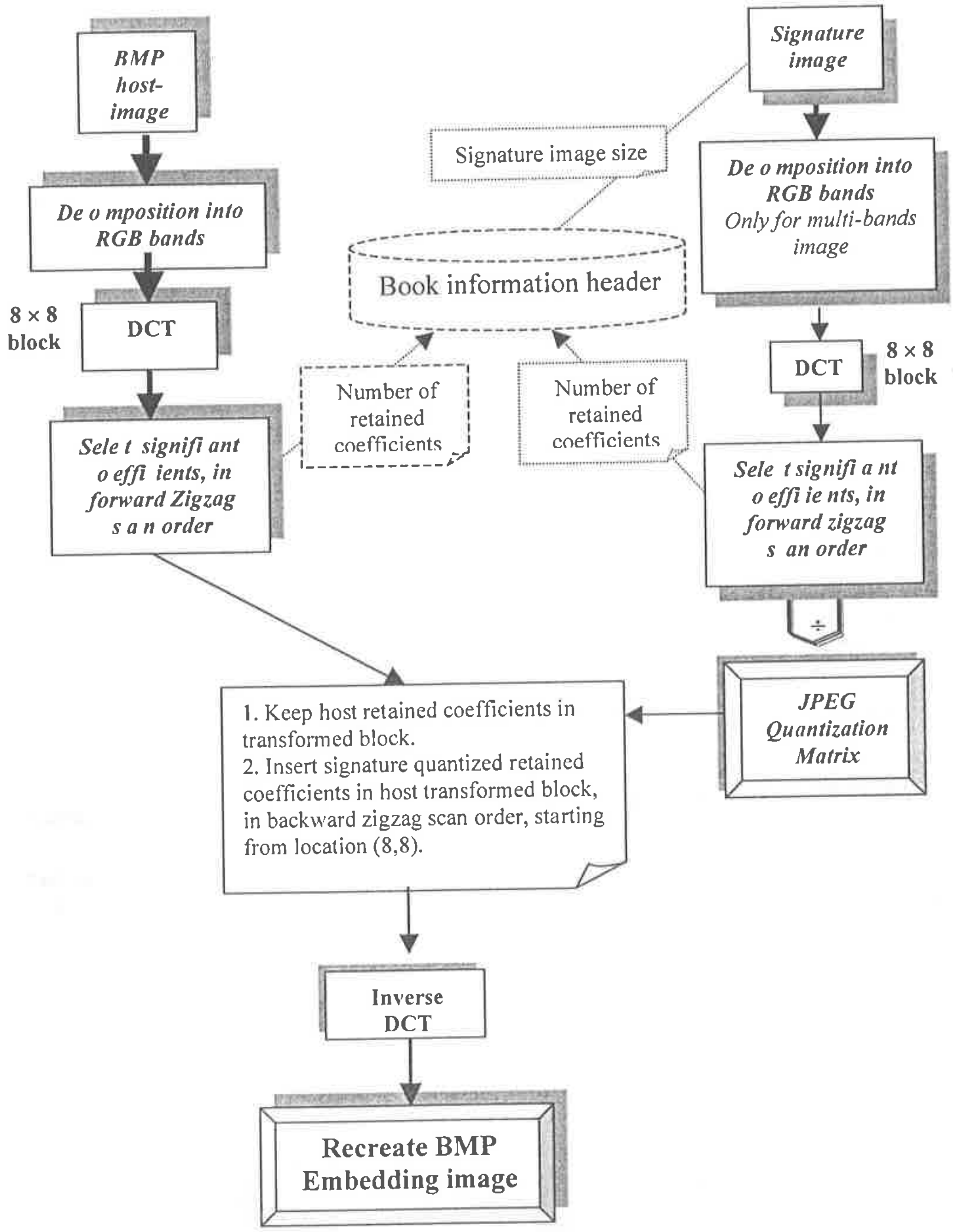
f(x, y) and **F(u, v)** represent, the block's elements and their transformed coefficients.

2.2 Selection of Significant Image Coefficients in Zigzag Sequence:

As it has been mentioned above, both host and signature images are subjected to DCT that produced 64 coefficients within each image block. The transform coefficients comprise a single 'DC' coefficients which is the average intensity level of the 8×8 block and 63 'AC' coefficients. The 'DC' coefficient alone represents the brightness within each image block, while the 'AC' coefficients are responsible for reproducing spatial frequencies (i.e. information) of each block. Fortunately, AC coefficients are ordered (from highest to lowest significant) in zigzag sequence, illustrated in Figure (2).

In our present research, a significant number of transform coefficients has been selected from the transformed blocks of the host image, which insured retaining good fidelity reconstruction. The retained coefficients are remained in their transformed locations, as shown in fig.(2). For the signature image, the retained transformed coefficients are first quantized; i.e. dividing each DCT coefficient by a quantization value given in the following chrominance quantization 8×8 array [7].

17	18	24	47	99	99	99	99
18	21	26	66	99	99	99	99
24	26	56	99	99	99	99	99
47	66	99	99	99	99	99	99
99	99	99	99	99	99	99	99
99	99	99	99	99	99	99	99
99	99	99	99	99	99	99	99
99	99	99	99	99	99	99	99



Figure(1): Block diagram of the proposed hiding scheme.

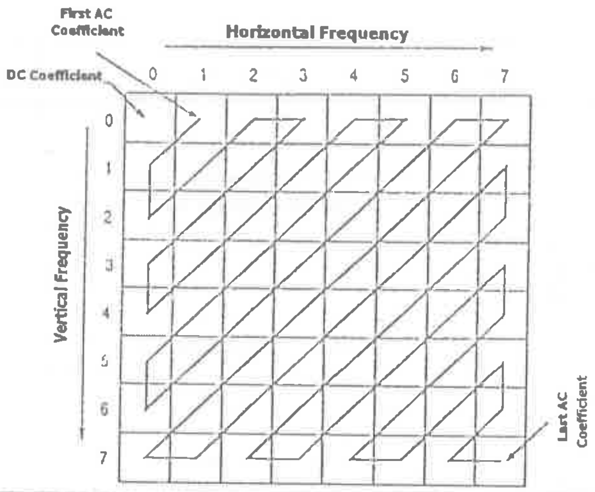


Figure (2): *Zigzag sequence order of transformed coefficients of 8×8 block [6].*

The retained quantized coefficients of the signature image then insert in the same transformed block of the host image. Starting from the position of the last AC coefficient, shown in fig.(2), the signature DC transformed value is located, followed by the other AC quantized coefficients in inverse direction to that shown in fig.(2). The resulted coded blocks, then, transformed inversely, using DCT method, given by;

$$f(x,y)=\frac{1}{4}\sum_{u=0}^{7}\sum_{v=0}^{7}C(u)C(v)F(u,v)\cos(\frac{(2x+1)u\pi}{16})\cos(\frac{(2y+1)v\pi}{16}) \quad (2)$$

Finally, the resulted embedded image is converted into BMP format which is ready to be decoded when ever be required. It should be noted that, the decoding procedures passes in an inverse "backward" directions as those of the coding procedures, demonstrated in fig.(1).

3.Experimental Results and Discussion:

Figure (3) shows sample of the host and signature images used in the experiment.

(a) Host Image (b) Signature Image

Figure (3): Samples of images used in the experiment, both of size 256×256 pixels; (a) Colored Scene, (b) half-tone CAT-face image.

To demonstrate the performance of our hiding algorithm, the Peak-Signal-to-Noise –Ratio 'PSNR' test is carried out on both reconstructed versions of the embedding and signature images. This fidelity test has been performed by [8]:

$$\mathbf{PSNR} = \sqrt{\frac{\text{Peak value of } f(x, y)}{\mathbf{e}_{rms}}} \qquad (3)$$

Where, f(x, y) is the original (unprocessed image), and $\mathbf{e}_{rms}$ is the root-mean-square error between processed g(x, y) image and unprocessed one, given by:

$$\mathbf{e}_{rms} = \sqrt{\frac{1}{N^2}\sum_{x=1}^{N}\sum_{y=1}^{N}[g(x,y) - f(x,y)]^2} \qquad (4)$$

Here, $\mathbf{N}^2$ represents the XY-image size.

For the host image, the PSNR tests were repeated for each of the RGB color band. The overall results, then, presented by:

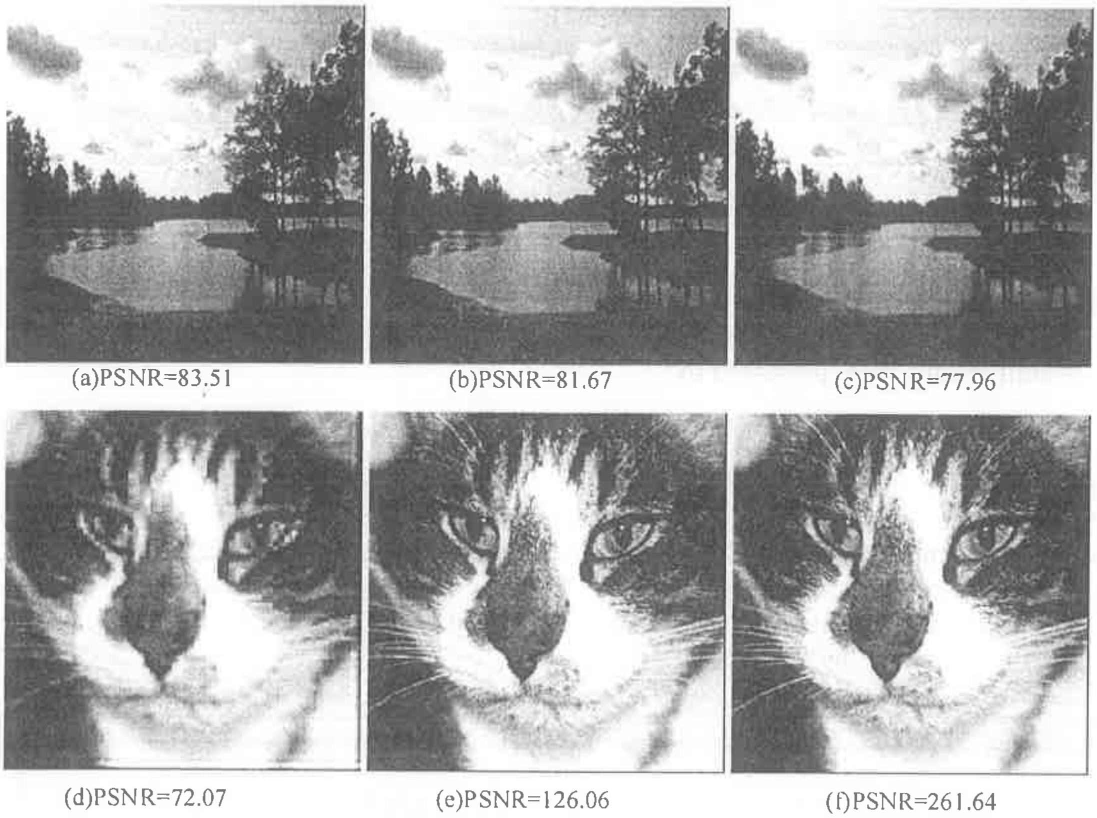
$$\mathbf{PSNR}_{Total} = \frac{\mathbf{PSNR}_R + \mathbf{PSNR}_G + \mathbf{PSNR}_B}{3} \qquad (5)$$

Table(1) represents the PSNR values for both reconstructed BMP-embedding and signature images. The tests have been performed by inserting given number of signature image transformed coefficients in the transformed RED-band of the host image.

TABLE(1)

No. of inserted Coefficients	PSNR for reconstructed RGB-BMP embedding image				PSNR of reconstructed signature image
	Red-band	Green-band	Blue-band	Overall	
5	77.93	87.91	84.67	83.51	72.07
10	77.16	87.91	84.67	83.24	85.98
15	76.35	87.91	84.67	82.98	87.65
20	75.51	87.91	84.67	82.70	93.39
25	74.39	87.91	84.67	82.32	106.60
30	73.68	87.91	84.67	82.09	116.52
35	72.43	87.91	84.67	81.67	126.06
40	70.82	87.91	84.67	81.14	138.90
45	69.58	87.91	84.67	80.72	154.77
50	67.66	87.91	84.67	80.08	174.47
55	65.33	87.91	84.67	79.31	208.73
60	61.29	87.91	84.67	77.96	261.64
64	23.31	87.91	84.67	65.30	∞

As it is clear, the overall PSNR of the embedding image is changed slowly, which means that the overall view of the reconstructed BMP image does not affected even when the red band has been ignored totally; i.e. signature coefficients occupied the whole red-band locations. However, even with 5 transformed coefficients, see last column of Table (1), signature image reconstruction proved well and yield a PSNR=72.07. For subjective test purposes, samples of embedding and signature images, reconstructed with different choice of inserted transformed coefficients, are illustrated in Figure (4).



Figure(4): Samples of embedding and signature images, reconstructed by selecting different number of transformed coefficients, respectively: 5 in a & d, 35 in b & e, and 60 in c & f.

References

[1] *Ross J, Anderson, ed. Information Hiding: first international workshop, Lecture notes in computer science. Springer Verlag, 1996.*

[2] *W. Bender, D. Gruhl, N. Morimoto, and A. Lu, Techniques for Data Hiding," IBM Systems Journal, Vol.35, pp. 313-336, 1996.*

[3] *J. J.K. O Ruanaidh, and T. Pun, "Rotation, Scale, and Translation invariant spread spectrum digital image watermarking," Signal Processing, Vol. 66, pp. 303-317, 1998.*

[4] *S. H. Low, N. F. Maxemchuk, and A. P. Lapone, "Document Identification for Copyright Protection Using Centroid Detection," IEEE Trans. On Comm., Vol 46, pp. 372-383, 1998.*

[5] *M. D. Swanson, B. Zhu and A. H. Twefik, "Data Hiding for Video-in-Video," Proceeding of IEEE International Conference of Image*

Processing (ICIP '97), Vol. 4. Pp. 676-679, Santa Barbara, California, 1997.

[6] *Herve Benoit, "Digital Television MPEG-1, MPEG-2 and principles of the DVB system," John Wiley & Sons Inc. New York, 1997.*

[7] *Alan Watt, and Fabio Policarpo, "The Computer Image" Addison Wesley Longman Limited, 1998.*

[8] *Gonzalez R.G., and Wintz P., "Digital Image Processing" 2nd ed. Addison-Wesley, 1987.*