Hide Secret Messages in Raster Images for Transmission to Satellites using a 2-D Wavelet Packet

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Abstract

   The hiding of information has become of great importance in recent times. With dissemination through the internet, and communication through satellites, information needs to be secure. Therefore, a new algorithm is proposed that enables secret messages to be embedded inside satellite images, wherein images of any size or format can be hidden, using a system's image compression techniques. This operation is executed in three main steps: **first phase** – the original image is converted into a raster image; **second phase**– steganography, in which a binary secret message is hidden inside a raster image, using a 4×4 array as the secret key; and **third phase**– compression of the stego-image raster in L2 and L3 using a 2-D wavelet packet. The outcome is a highly efficient algorithm, which can rapidly conceal information inside transmitted satellite images, thus guarding against revealing information to potential cyber-attackers.

Keywords: Image raster, steganographic, secret message, image compression, 2-D wavelet packet, secret key.

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اخفاء رسالة سرية في صورة نقطة ونقلها الى الاقمار الصناعية باستخدام حزمة الموجة الثنائية الابعاد

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الخلاصة

   وقد أصبح إخفاء المعلومات ذا أهمية كبيرة في الآونة الأخيرة. مع نشر عبر الإنترنت، والاتصالات من خلال الأقمار الصناعية، يجب أن تكون المعلومات آمنة. لذلك، تقترح خوارزمية جديدة تمكن الرسائل السرية من تضمينها داخل صور الأقمار الصناعية، حيث يمكن إخفاء الصور في أي حجم أو شكل، وذلك باستخدام تقنية ضغط صورة النظام. يتم تنفيذ هذه العملية في ثلاث خطوات رئيسية: المرحلة الأولى – يتم تحويل الصورة الأصلية إلى صورة نقطية، المرحلة الثانية الاخفاء حيث يتم إخفاء رسالة سرية الثنائية داخل صورة النقطية، باستخدام مصفوفة ٤×٤ كمفتاح سري، والمرحلة الثالثة – ضغط صورة النقطة الاخفاء في المستوى الثاني والمستوى الثالث باستخدام حزمة الموجة الثنائية الابعاد. والنتيجة هي خوارزمية عالية الكفاءة، تخفي بسرعة المعلومات داخل الصور القمر الصناعي المرسلة، وبالتالي تحمي من المعلومات التي تكشف عن مهاجمين الانترنيت المحتملينز

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1. Introduction

Image treatment is highly desirable for the efficient storage, representation and transport of data. Data compression has become a required stage for making the best use of storage demands and transport time, minimising the number of bits needed to represent an image by taking out spatial and spectral iterations [1]. Usually, lossy or lossless image compression is used. As lossless image compression focuses on how well the image iscompressed, the completed compression ratio is very low. Hence, one cannot keep the source safe by using lossless image compression[2]. Lossy image compression is where an image is compressed in such way that image quality is reduced (partial data discarding), but without the viewer really noticing a loss in quality[3]. In lossless compression, the compression is achieved by eliminating spatial and spectral iterations, which produces changes in image quality that cannot be observed by the human eye [4]. One of the main requirements of information concealment is that such information must be imperceptible. The use of steganography provides many characteristics that are very helpful in digital image treatment that can make them appropriate for a wide range of applications. In this new research area, the internet has great potential for transmitting large amounts of information in, and between, various parts of the world [5].

2. Raster Images

An image is a structure of objects and space, which can be represented in raster format by disassembling it into its constituent points. Each point is characterised by its placement in a row and a column as illustrated in Figure- 1. Representing such 'space objects' as a raster or vector image has advantages and disadvantages, but the raster image contains more convergent sites of the represented structure [6]. A collection of raster data, such as a picture, is georeferenced using a control layer [7]. This layer involves known coordinates, used as indicators for georeferencing, such as points, lines and areas, as shown in Figure-1 [7], [8].
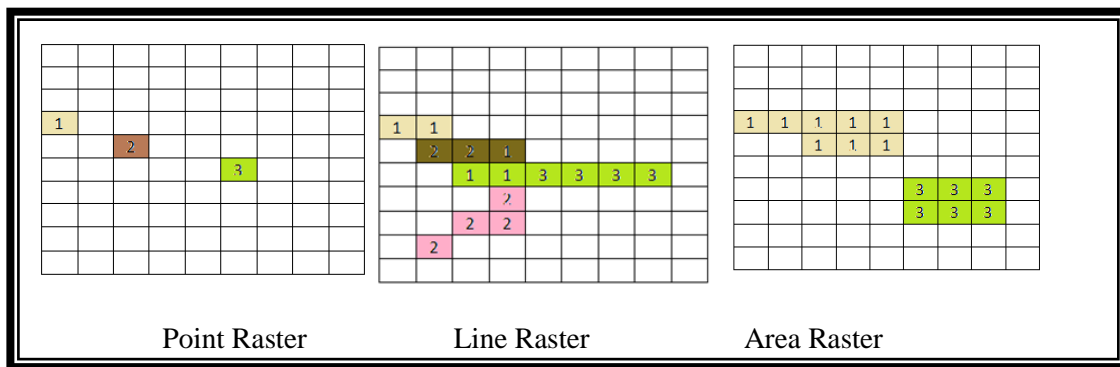
Figure 1- Components of a raster image

The cell-based raster data, in raster data groups (picture and network), are particularly appropriate for representing classical geographic phenomena that change continuously in space, such as high, slop and heavy rain [9].

3. 2-D Wavelet Packet

The calculation schema for 2-D wavelet packet generation is simple because it uses a perpendicular wavelet. It will be started for two filters of length 2N [4].

$W_n(x)$,   n= (0,1,2,3)

$W_n(x) = \sqrt{2} \sum_{k=o}^{2N-1} h(k) Wn(2-k)$

$W_{2n+1}(x) = \sqrt{2} \sum_{k=o}^{2N-1} g(k) Wn(2x-k)$ (1)

where h(k) and g(k), conformable to the wavelet $w_0(x) = \Phi(x)$, is the gradation job and $w_1(x) = \Psi(x)$ is the wavelet job. The idea of a 2-D wavelet packet is the same as for a wavelet. The single difference is that a 2-D wavelet packet has a more complicated and elastic analysis. In a 2-D wavelet packet analysis, the details, as well as the approximation, are split. The wavelet packet tree for 3-level decomposition [10] is shown in Figure-2. The top left represents the main picture and the top right is the compressed image. The technique of compression includes a global thresholding of the wavelet packet's coefficients of the picture to be compressed [11]. The wavelet packet technique is a

generalisation of wavelet decomposition that offers better representation of high-frequency information. In wavelet transformation, the approximation component of the image is further decomposed for next-level decomposition, whereas in wavelet packet transformation, approximation as well as detailed components are decomposed [12]. The structure of two-level decomposition of a wavelet packet is shown in Figure-2. Wavelet packet atoms are indexed by three parameters: position, scale and frequency [11-13].

LL_1LL_2	LL_1HL_2	HL_1LL_2	HL_1HL_2
LL_1LH_2	LL_1HH_2	HL_1LH_2	HL_1HH_2
LH_1LL_2	LH_1LH_2	HH_1LL_2	HH_1HL_2
LH_1LH_2	LH_1HH_2	HH_1LH_2	HH_1HH_2

Figure 2-Decomposition of a 2-D wavelet packet.

4. Related Work

In 2007, Liuetal. proposed a new, local discriminant coordination method, based on wavelet packets, for facial recognition to distinguish differences. This method uniformly selects the most discriminant coordinates from all space frequency sub-bands to overcome the deficiency of conventional wavelet-based methods, providing a robust outcome for facial recognition, despite differences in illumination and expressions [14].

In 2007, Gornale proposed new wavelet coding that is one of the most used methods for compressing and denoising images. The stream compression system uses biortho gonal, instead of perpendicular, wavelet filters because perpendicular filters have a nice ownership of energy keeping, whereas biorthogonal filters reduce this. This proposes using Daubechies, Symlet and Coiflet filters. The outcome has the special property of greater energy conservation, more demise moments, "regularity and asymmetry than other biorthogonal filters, and found that to get the highest compression ratio, the order and level must be high" [15].

In 2014, Castetsetal. described how the raster network format was shaped in Ocelet to permit joint use of the vector format together with an interaction diagram, for the key notion and records for collection of the two spatial formats. In this formalisation, structures could be cells with various predefined formats (e.g., square, beehive), and the operation can then be substantive, with relations between cells that are treated like suitable structures with their own properties, as defined by the modeler. The outcome mostly in explain this raster integral in Ocelet allows the creation of models that use both vector and raster data to represent space dynamics on two various scales [16].

5. Performance Evaluation

There are two error metrics used to contrast picture compression quality in 2D HWTP for levels two and three: applying mean square error (MSE) and peak signal to noise ratio (PSNR) colour coefficients to the terminal node and wavelet tree [17].

1- Mean Square Error (MSE)

The lower error value of MSE uses equation 2:

$$MSE= \frac{\Sigma_{M,N}[I1(M,N)-I2(M,N)]}{M \times N} \tag{2}$$

2- Peak Signal to Noise Ratio (PSNR)

The computation of PSNR uses equation 3:

$$PSNR= 1- Log_{10} \frac{R^2}{MSE} \tag{3}$$

In this paper, I used any size and format images to convert a satellite image into a raster image depended on row and column as point, line, and area raster as illustrated in Section 2, and hide a secret message into the raster image.

6. Proposed System

The proposed system as illustrated in flowchart for hiding a secret message, using embedded and extracted algorithms into a raster image as shown in Figure-3,which also illustrated the compressed stego-image raster by 2D Haar Wavelet Packet (2DWHP). And using compression in two levels: level two and level three in this way.
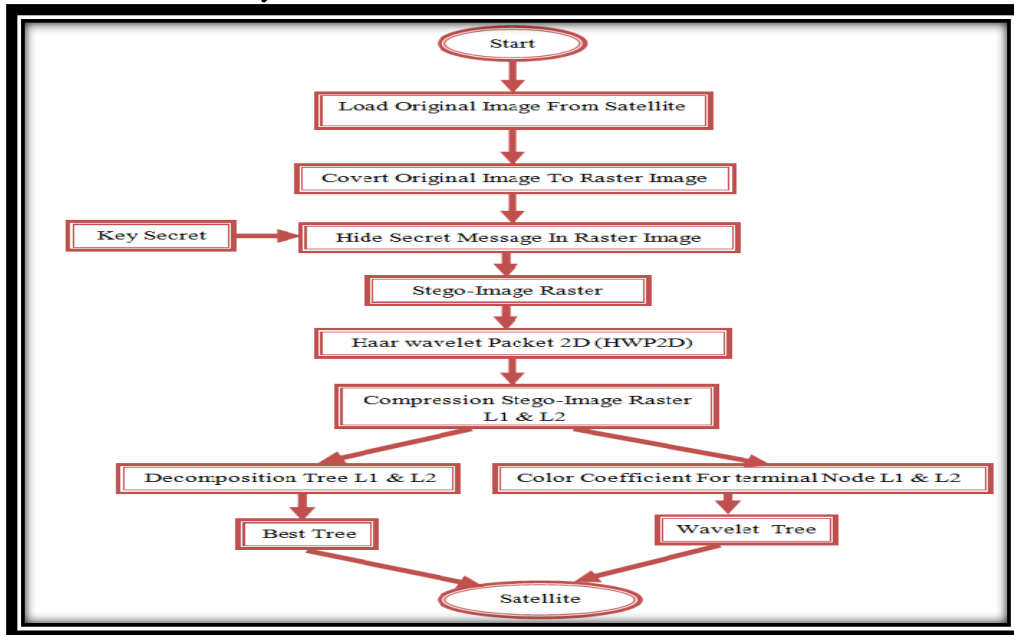

(a)
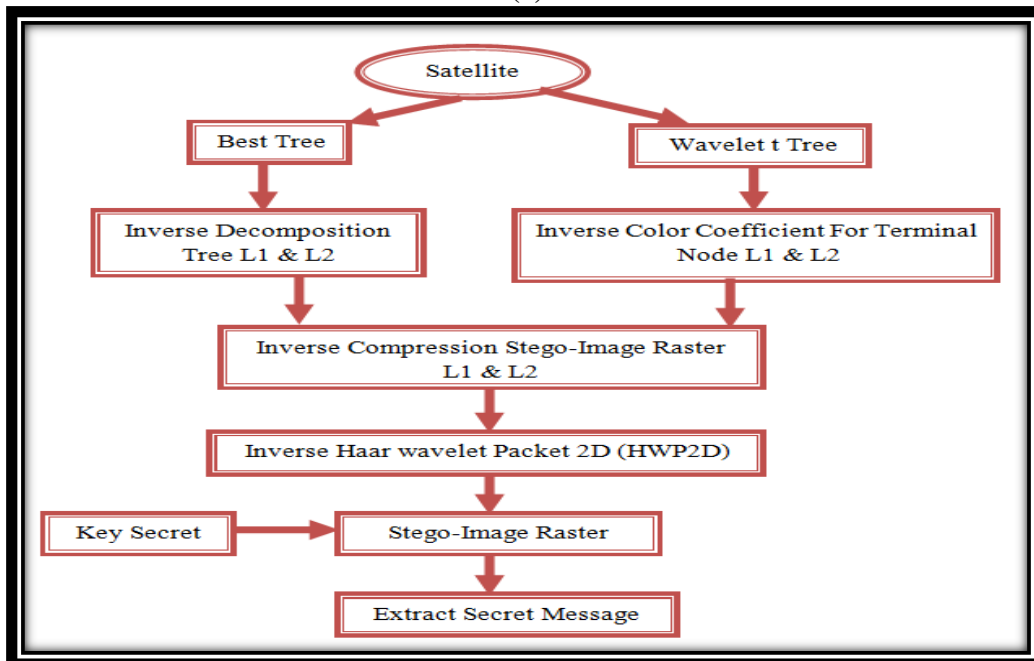
(b)

Figure 3-The flowchart of proposed system, (a) Embedded secret message (b) Extracted secret message.

This proposed is implemented by using three main steps to embed a secret message such as the follows.
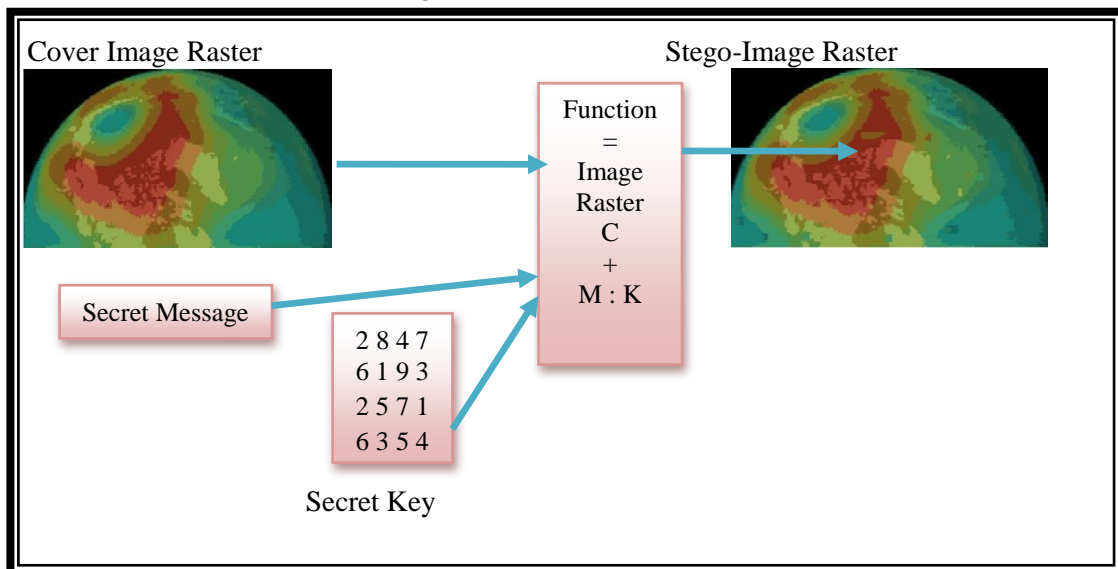
First phase: image rasterisation

Load the original colour image from the satellite in any size or formats and convert it to a raster image to distinguish it from the colour image, using a k-means algorithm to obtained chromatic gradation, as shown in Figure-4.

(a)   **(b)**
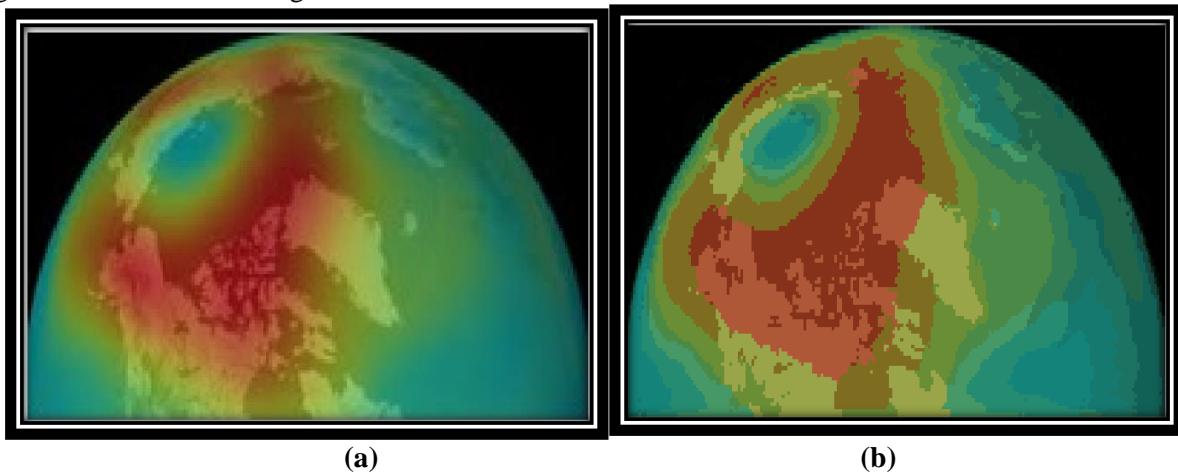
Figure 4-The image rasterisation, (a) Original image (b) Raster image.

Second phase: steganography raster image

Hide the secret message using a secret key, which comprises a 4×4 array of 16 equal elements, each of which is positioned to jump from location to location, so as to embed one bit from the secret message within the array inside the cover image raster as a pixel in LSB. From this, a stego-image raster (SIR) is obtained, as shown in Figure-5.

Figure 5-Stego-image raster (SIR).

Third phase: image compression

This stego-image raster is compressed using the 2-D Haar wavelet packet tree (2DHWP) at level tow and level three. The stego-image raster compression is analyzed in two steps: 1) decomposition tree and best tree at L2 and L3, as shown in Figures-(6 , 7and 2) coloured coefficient for terminal node and wavelet tree at L2 and L3, as shown in Figures-(8, 9). This uses a Haar filter and Shannon, entropy, where the transmitted stego-image compression is for receipt by a satellite, the reception can be decompressed using inverse 2DHWP without loss data from the stego-image raster, and the secret message in the stego-image raster received can be extracted using the secret key.
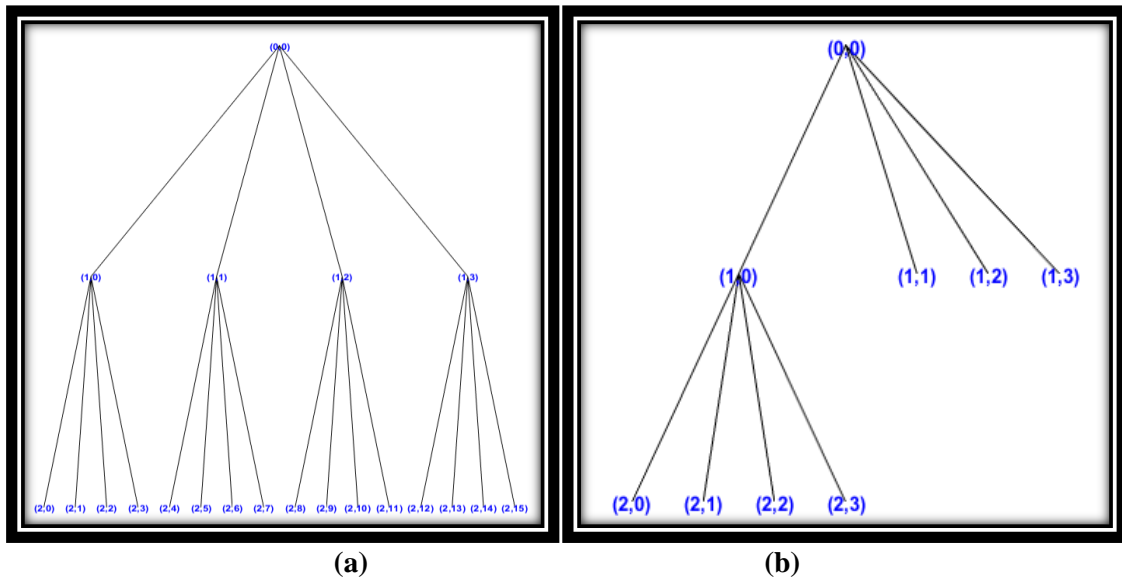
(a)   **(b)**

Figure 6-Applied 2DHWP in L2, (a) Decomposition tree in L2 (b) Best tree in L2.
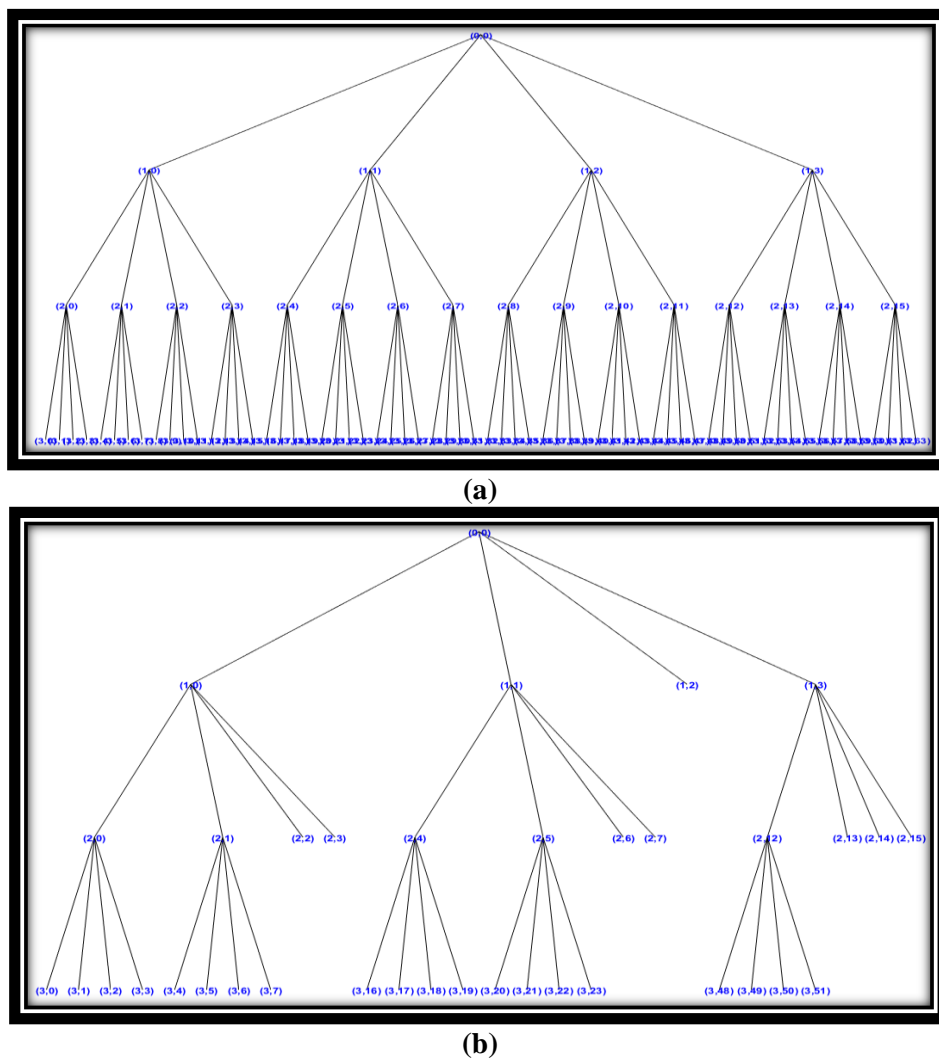

(a)

(b)

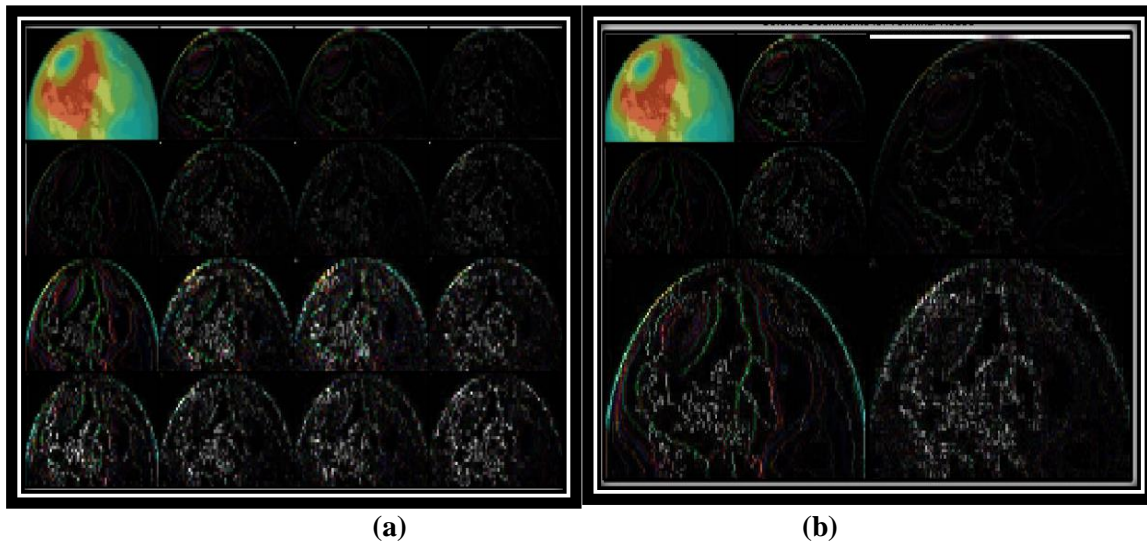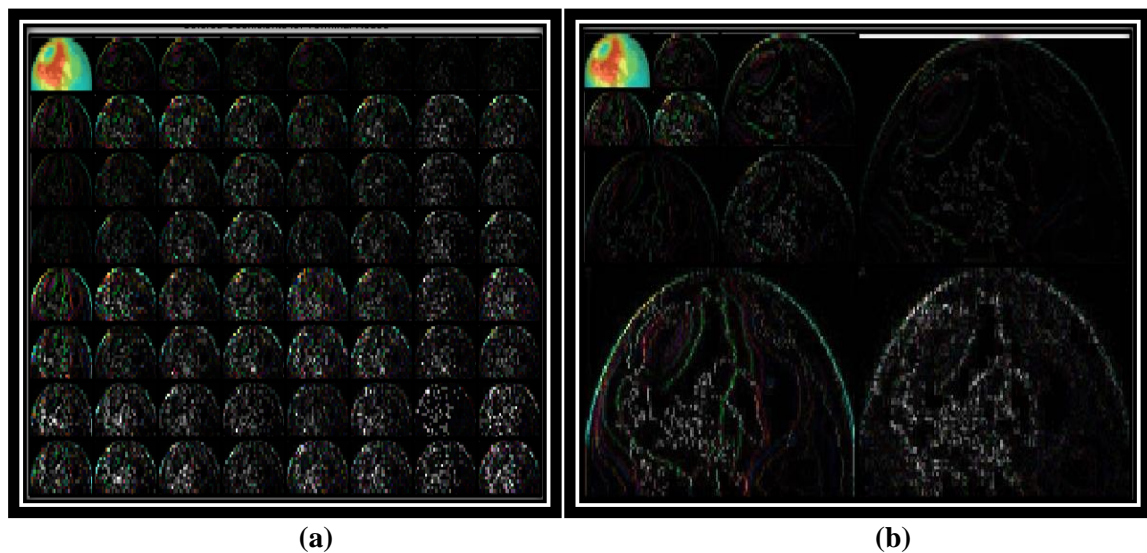**Figure 7-**Applied 2DHWP in L3, (a) Decomposition tree in L3 (b) Best tree in L3.

(a)   **(b)**

Figure 8-Applied 2DHWP coloured in L2, (a) Coloured coefficient for terminal node in L2 (b) Wavelet tree in L2.

(a)   **(b)**

Figure 9-Applied 2DHWP coloured in L3, (a) Coloured coefficient for terminal node in L3 (b) Wavelet tree in L3.

The computation of a histogram and cumulative histogram for compression of the stego-image raster at L2 and L3 is shown in Figures-10 and 11.

(a)   **(b)**
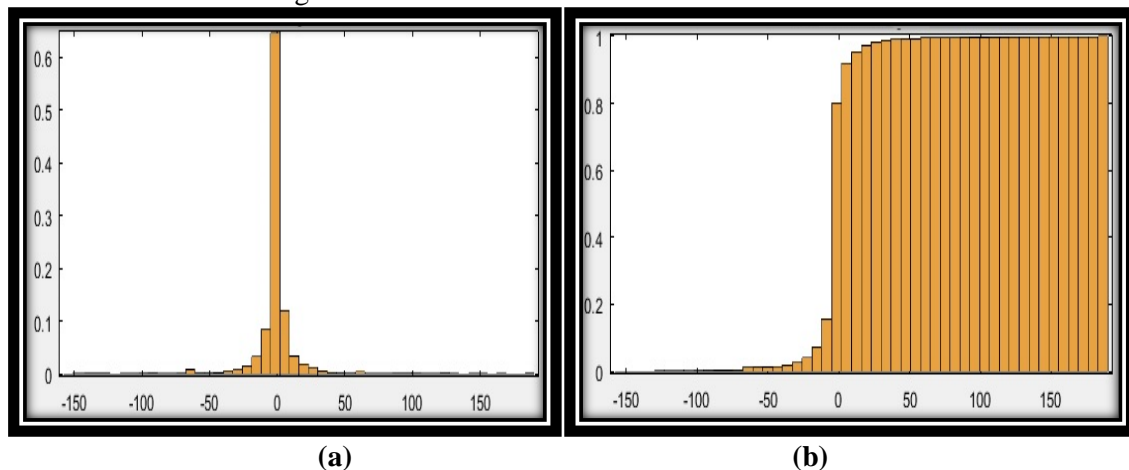
Figure 10-Applied histogram in L2, (a)Histogram at L2 (b)The Cumulative Histogram In L2.

(a)   **(b)**
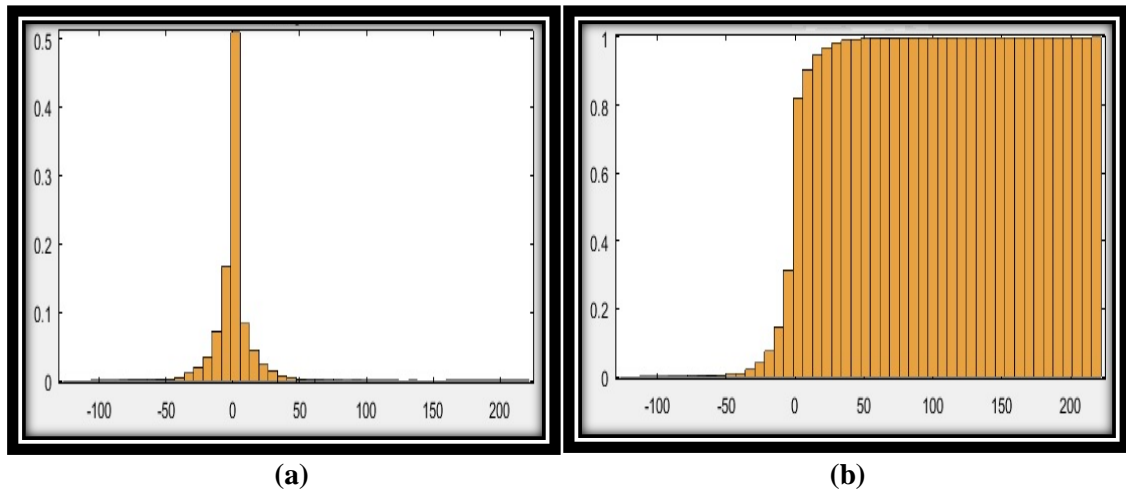
Figure 11-Applied histogram in L3, (a) Histogram at L3(b) Cumulative histogram at L3.

Embedding Process

Embedding algorithm
Process:
Input: Original image, secret message, secret key.
Output: Stego-image raster.
Initial:
A= Load original image.
B= Load raster image (cover image).
C= Load secret key array 4×4.
D= Load stego-image raster.
E= Load compression stego-image raster in L2 and L3.
F= Put the result stego-coloured coefficient for terminal nodeinL2 and L3.
G= Put the result stego-wavelet tree inL2 and L3.
Step1: Load original image in A.
Step2: Converted original image to raster image in B.
Step3: Find location in image raster.
step4: Select element of array 4×4 (secret key) each element consider of jump location in image raster in C.
Step5: Embedding secret message inside image raster (cover image) using secret key to obtain stego-image raster in D.
Step6: Compression stego-image raster 2D HWP in L2, obtain stego-coloured coefficient for terminal node and stego-wavelet tree in E.
Step7: Compression stego-image compression 2D HWP in L3, obtain stego-coloured coefficient for terminal node and stego-wavelet tree in E.
Step8: Result (put the result stego-coloured coefficient for terminal nodein L2 and L3 in F).
Step9: Result (put the stego-wavelet tree in L2 and L3 in G).

Extraction Process

Extraction algorithm
Process:
Input: Stego-wavelet tree and stego-coloured coefficient for terminal node, secret key.
Output: Secret message.
Initial:
A= Load stego-wavelet tree in L2 and L3.
B= Load stego-coloured coefficient for terminal node in L2 and L3.
C= Extraction decompression 2D HWP in L3.

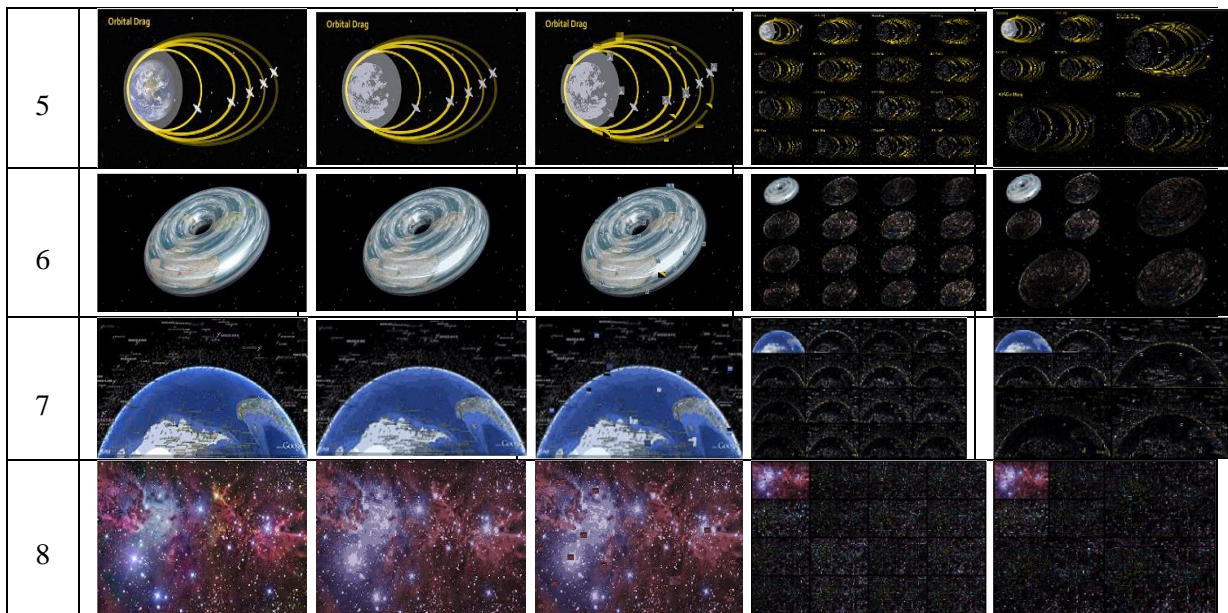| |
|---|
| D= Extraction decompression2D HWP in L2. |
| E= Extraction stego-image raster. |
| F= Location secret key array 4×4. |
| G= Extraction secret message. |
| Step1: Load stego-wavelet tree in A. |
| Step2: Load stego-coloured coefficient for terminal node in B. |
| Step3: Decompression 2D HWP in L3 in C. |
| Step4: Decompression 2D HWP in L2 in D. |
| Step5: Extraction stego-image raster in E. |
| Step6: Find location from array 4×4 (secret key) in F. |
| Step7: Put the resulting secret message in G. |

7. Results and discussion

This part in paper is give the results of the proposed system, hide secret message into raster image, and obtained stego-image raster (SIR), and uses 2DHWP method, for applied the coloured coefficient for the terminal node and wavelet tree at L2, and L3, and the difference between them, as shown in Tables-(1, 2). Here, the image change in each step is compare and given the security for secret message without sensitive by attacker during transmit satellites, and the measures of PSNR and MSE are compute, as shown in Tables-(3, 4).

In these Tables-(3, 4) is give a good outcome from PSNR and MSE system tests proves the robustness of the technique. PSNR increased the raster image and steganography image, which decreased in 2D HWP in L2 and L3, whereas the MSE decrease in the raster image and steganography image, and increases in 2D HWP in L2 and L3.

The 2D HWP in L2 includes ranges of PSNR from0.36731 to 0.27873 and 0.28657, whereas the ranges of MSE were from 43906.80 to 48146.09and 47752.30.

For 2D HWP in L3,the ranges of PSNR were from0.36731 to 0.32866 and 0.25393, whereas the ranges of MSE are from 43906.80 to 45700.78 and 49417.86.

Table 1-System of image steganography 2DHWP colour coefficient and wavelet tree in L2

No.	Original image	Raster image	Steganography image	2DHWP Colour coefficient terminal node L2	2DHWP Wavelet tree L2
1					
2					
3					
4					

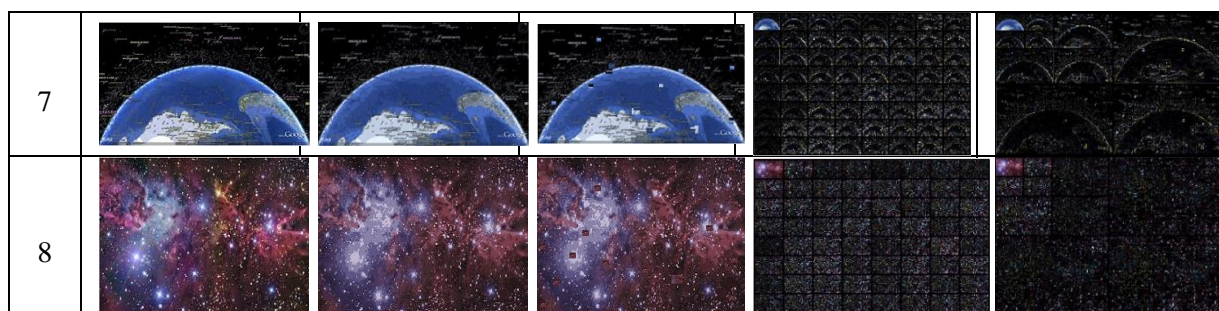|					
5					
6					
7					
8					

Table 2-System of image steganography 2DHWP colour coefficient and wavelet tree in L3.

No.	Original image	Raster image	Steganography image	2DHWP Colour coefficient terminal node L3	2DHWP Wavelet tree L3
1					
2					
3					
4					
5					
6					

Table 3-Measurements of PSNR and MSE in 2DHWP in L2

No.	Original image	Raster image	Steganography image	2DHWP Colour coefficient terminal node L2	2DHWP Wavelet tree L2
1	PSNR=0.36731 MSE=43906.80	PSNR=0.37162 MSE=43712.20	PSNR=0.37150 MSE=43719.55	PSNR=0.27873 MSE=48146.09	PSNR=0.28657 MSE=47752.30
2	PSNR=0.15350 MSE=54993.60	PSNR=0.14054 MSE=55766.43	PSNR=0.37150 MSE=43719.55	PSNR=0.26155 MSE=49023.19	PSNR=0.26893 MSE=48644.19
3	PSNR=0.28345 MSE=47908.46	PSNR=0.26600 MSE=48793.87	PSNR=0.27056 MSE=48.560.70	PSNR=0.28450 MSE=27855.49	PSNR=0.24421 MSE=49927.35
4	PSNR=0.62439 MSE=33901.42	PSNR=0.63584 MSE=33522.82	PSNR=0.65034 MSE=33050.53	PSNR=0.28450 MSE=47855.49	PSNR=0.36759 MSE=43896.19
5	PSNR=0.45269 MSE=40237.60	PSNR=0.43445 MSE=40990.13	PSNR=0.43044 MSE=41157.94	PSNR=0.25710 MSE=49253.20	PSNR=0.25513 MSE=49355.83
6	PSNR=0.21232 MSE=51643.12	PSNR=0.19373 MSE=52674.95	PSNR=0.19907 MSE=52376.31	PSNR=0.26349 MSE=48922.93	PSNR=0.25400 MSE=49414.53
7	PSNR=0.42911 MSE=41213.83	PSNR=0.42356 MSE=41447.48	PSNR=0.44726 MSE=40459.76	PSNR=0.27871 MSE=48147.16	PSNR=0.29522 MSE=47321.93
8	PSNR=0.98446 MSE=24083.26	PSNR=1.00539 MSE=23625.65	PSNR=1.00159 MSE=23707.94	PSNR=0.43165 MSE=41107.30	PSNR=0.40960 MSE=42042.99

Table 4-Measurements of PSNR and MSE in 2DHWP in L3

No.	Original image	Raster image	Steganography image	2DHWP Color coefficient terminal node L3	2DHWP Wavelet tree L3
1	PSNR=0.36731 MSE=43906.80	PSNR=0.37162 MSE=43712.20	PSNR=0.37150 MSE=43719.55	PSNR=0.32866 MSE=45700.78	PSNR=0.25393 MSE=49417.86
2	PSNR=0.15350 MSE=54993.60	PSNR=0.14054 MSE=55766.43	PSNR=0.37150 MSE=43719.55	PSNR=0.29348 MSE=47407.79	PSNR=0.23463 MSE=50435.39
3	PSNR=0.28345 MSE=47908.46	PSNR=0.26600 MSE=48793.87	PSNR=0.27056 MSE=48.560.70	PSNR=0.28362 MSE=47899.77	PSNR=0.22142 MSE=51146.36
4	PSNR=0.62439 MSE=33901.42	PSNR=0.63584 MSE=33522.82	PSNR=0.65034 MSE=33050.53	PSNR=0.38099 MSE=43294.59	PSNR=0.29639 MSE=47263.91
5	PSNR=0.45269 MSE=40237.60	PSNR=0.43445 MSE=40990.13	PSNR=0.43044 MSE=41157.94	PSNR=0.29196 MSE=47483.19	PSNR=0.23480 MSE=50426.34
6	PSNR=0.21232 MSE=51643.12	PSNR=0.19373 MSE=52674.95	PSNR=0.19907 MSE=52376.31	PSNR=0.28331 MSE=47915.39	PSNR=0.24574 MSE=49847.15
7	PSNR=0.42911 MSE=41213.83	PSNR=0.42356 MSE=41447.48	PSNR=0.44726 MSE=40459.76	PSNR=0.27336 MSE=48418.37	PSNR=0.23435 MSE=50450.54
8	PSNR=0.98446 MSE=24083.26	PSNR=1.00539 MSE=23625.65	PSNR=1.00159 MSE=23707.94	PSNR=0.40908 MSE=45704.42	PSNR=0.32859 MSE=45704.42

8. Conclusions

   This paper describes the hiding of secret messages inside raster images, and compression of the raster image after embedding the secret message. This method works well, is fast, efficient and robust, enabling avoidance of exposure of the information to attackers because it uses HWP2D in L2 and L3, which makes the system is more efficient, and robustness through sent secret message across internet

or other any networks such as satellites or website by using images without sensitive by attackers or any personal unauthorized for detected the secret message store into images. This method is potentially very useful for transmitting between internet networks and satellites, and contains a high level of security.

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