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Improved Qualitative Color Image Steganography Based on DWT

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***Abstract*— In this paper we propose a new steganography technique which embeds secrete color image into color cover work in frequency domain. Unlike the spatial domain approach, secrete image or data are embedded in the low frequency coefficients resulted from Discrete Wavelet Transform, as it is much sensitive to Human Visual System several researchers are not preferring to embed data in low frequency coefficients. This low frequency region provides excellent secure location for data hiding. So, firstly detecting low frequency region is performed in cover images and then Secret image, data embedding will be performed in Discrete Wavelet Transform domain as Discrete Wavelet Transform gives better performance than Discrete Cosine Transform while compression. Watermark algorithm is implemented in two way using Single level Discrete Wavelet Transform and Three levels Discrete Wavelet Transform taking single plane of the cover image for embedding secrete image or data as 4X4 blocks. Experimental results show that Peak Signal Noise Ratio generated by proposed method is better than previous with large amount data embedding.**

Index Terms*— *Steganography, HVS, DWT, Symlet, PSNR and MSE

INTRODUCTION

Nowadays, with the rapid growth of digital media, the issue of owner identification, proof of ownership, Transaction tracking, content authentication, and copy control of digital contents has become more and more vulnerable. To eliminate those vulnerabilities digital watermarking [1] is one way of achieving the above by embedding some message or content in the protected digital content. This embedded data can be called as watermark data. The watermark data can later be detected or extracted to verify the ownership when the dispute over the copyright of the digital content arises.

We have many techniques to imply data embedding among steganography is one. Steganography is evolved from two Greek words *steganos*, meaning "covered, concealed, or protected", and *graphein* meaning "writing". That means “covered writing”. It is used to hide data within anther one either of same type or of different. It maintains the beauty of data hiding by providing better security and imperceptibility of hidden message in cover object. The main process of steganography is done by hiding the secret content in cover media by using any steganography method shown fig. 1, so that any other party not able to identify the embedded message.

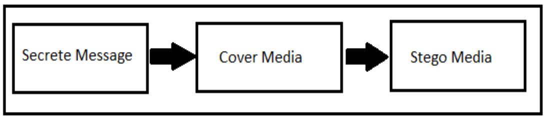

Fig. 1 Embedding Secrete Message

To get back the secret message the reverse of steganography, called steganalysis is used. Figure 2 explains the above in pictorial form.

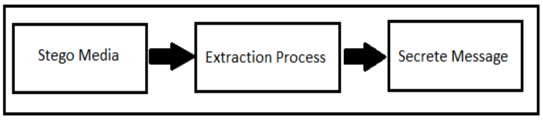

Fig. 2 Extraction of Secrete Message

steganography is different from cryptography. Steganography use different cover media like, text, image, video etc. Image is most common cover media for it and we call it Image Steganography. We divide it in two domains:

a. Spatial Domain
b. Frequency Domain

In spatial domain secret messages are inserted in the Least Significant Bits (LSB) of image intensity values by bit shifting [2, 3]. In Frequency domain [4], secret message is embedded in the high frequency coefficients of cover media in high frequency sub-band. In frequency domain Discrete Cosine Transforms (DCT), Discrete Wavelet Transforms (DWT) and etc.., are used as transforms functions from spatial domain to frequency domain. In this paper we convert spatial domain coefficient into frequency domain coefficient by using DWT.

The rest of the paper is organized as follows. In section II, discuss the DWT-Symlet functionality. In section III, discuss proposed method of implementation. In section IV, present results of Peak Signal Noise Ratio (PSNR) and capacity to set image for proposed method. In section V, concludes the discussion of proposed method.

DISCRETE WAVELET TRANSFORM

In comparison to other transforms, DWT transforms proved to be the best for image transformation. The frequency domain transform we applied in this research Symlet-DWT [5]. In its basic operations, it decomposes the input signal into set of functions which are called wavelets. For image applications in transform domain, wavelet transform of image is computed, then modifications are made and at final step, inverse of wavelet is taken to get resulted image. We can select any family of wavelet from discrete or continuous wavelets like Haar, Coiflet, Symlet, and Daubechies. In discrete wavelets, we have different levels like 1-Diamention (D), 2-D … n-D. This work presents in 2D-DWT. Original signal is decomposed twice in 2D-DWT in a way that makes use of scaling and wavelet functions of level 1 or 1D-DWT. Fig. 3 explains it in detail.

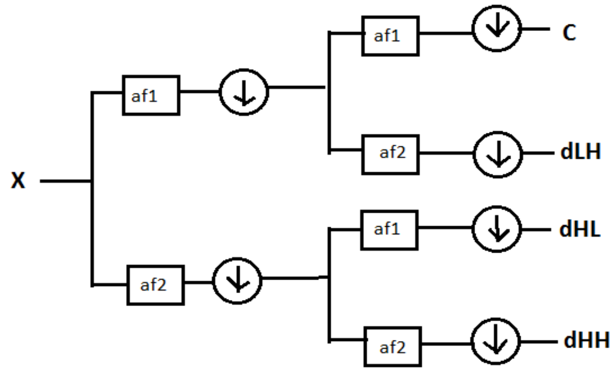

Fig. 3 ID-Symlet-DWT

DWT analysis divides signal into two classes (i.e. Approximation and Detail) by signal decomposition for various frequency bands and scales. DWT utilizes two function sets: scaling and wavelet which associate with low and high pass filters orderly. Such a decomposition manner bisects time separability. In other words, only half of the samples in a signal are sufficient to represent the whole signal, doubling the frequency separability. Fig. 4 shows the image Lena after one Symlet wavelet transform.

Fig. 4 The image Lena after one Symlet wavelet transforms

IMPLEMENTATION SINGLE LEVEL DWT

Let us assume cover work as a 512X512 color image and secrete message as 512X512 color image.

A. Procedure for Embedding using Single Level Wavelet Decomposition

- Perform single level 2D-Symlet DWT decomposition as follows [7]:
  - *i.* Take the cover image Joint Picture Expert Group [6] (JPEG) (512 x512) and separate its Red R, Green G and Blue B planes. Then perform single level 2D-DWT on the image R plane to obtain approximation coefficients (LLR1), horizontal coefficients (HLR1), and vertical coefficients (LHR1), diagonal coefficients (HHR1) respectively.
  - *ii.* Take the secrete image Joint Picture Expert Group (JPEG) (512 x512) and separate its Red R, Green G and Blue B planes. Then perform single level 2D-DWT on the image R plane to obtain approximation coefficients (llr1), horizontal coefficients (hlr1), and vertical coefficients (lhr1), diagonal coefficients (hhr1) respectively.
- Perform Embedding as follows:
  - i. Process LLR1 of cover image block by block (4x4).

	1	2	3	4
1	C	C	C	C
2	C	C	C	C
3	C	C	C	C
4	C	C	C	C

Fig. 5 Cover Image 4X4 block

  - ii. Process llr1 of secret image block by block (4X4).

	1	2	3	4
1	S	S	S	S
2	S	S	S	S
3	S	S	S	S
4	S	S	S	S

Fig. 6 Secrete Image 4X4 block

  - iii. The following formula is used to obtain the Embedded secret image block (4x4) which is basically swapping,

	1	2	3	4
1	E	E	E	E
2	E	E	E	E
3	E	E	E	E
4	E	E	E	E

Fig. 7 Stego Image 4X4 block

$$E(i,j)=(1-\alpha)*C(i,j)+(\alpha*S(i,j)) \quad \text{--- } 1$$

Here C is cover image intensity values at (i,j), S is secrete image intensity values at (i,j) and α in embedding coefficients in general for JPEG image that is 0.05.

  - iv. Perform single level 2D-Symlet inverses DWT for reconstruction which is the inverse process of single level 2D-Symlet DWT decomposition in order to obtain the stego image.
  - v. Similarly perform the above steps on G plane and B plane.

B. Procedure for Extracting using Single Level Wavelet Decomposition:

i. Perform single level 2D-Symlet DWT decomposition on the stego image as well the cover image as we did in the embedding procedure.

ii. Process LL1 of the stego image block by block (4x4).
iii. Process LL1 of the cover image block by block (4x4).
iv. Use the formula which follows to get the image blocks of the secret image.

$$S(i,j)=(E(i,j)-((1-\alpha)*C(i,j))/\alpha) \text{ ----2}$$

C. Validation of Stego Image Quality:

Calculate the PSNR for the decomposed stego image as well as the cover image for finding out in which sub band the secret image has been embedded. On examining we will find it out to be LL1.

IMPLEMENTATION THREE LEVEL DWT

Let us assume cover work as a 512X512 color image and secrete message as 64X64 color image.

A. Procedure for Embedding using Three Level Wavelet Decomposition [8]

- Perform three level 2D-Symlet DWT decomposition as follows:
  - i. Take the cover image as JPEG image (512 x512) size and separate its R, G and B planes. Perform first level 2D-DWT on the image to obtain approximation coefficients (LLR1), horizontal coefficients (HLR1), and vertical coefficients (LHR1), diagonal coefficients (HHR1) respectively.
  - ii. Take the approximation coefficient (LLRl) and perform second level 2D-DWT on the image to obtain approximation coefficients (LLR2), horizontal coefficients (HLR2), vertical coefficients (LHR2), diagonal coefficients (HHR2) respectively.
  - iii. Take the approximation coefficient (LLR2) and perform third level 2D-DWT on the image to obtain approximation coefficients (LLR3), horizontal coefficients (HLR3), vertical coefficients (LHR3), diagonal coefficients (HHR3) respectively.
  - iv. Take the secret image and separate its R, G and B plane. Perform transformation as cover image for three levels.

- Perform Embedding as follows:
  - i. Perform Embedding as same as in single level DWT transformation for three level transformation with same formula.
  - ii. Perform three level 2D-Symlet inverses DWT for reconstruction which is the inverse process of three level 2D-Symlet DWT decomposition in order to obtain the stego image.
  - iii. Similarly perform the above steps on G and B planes.

B. Procedure for Extracting using Three Level Wavelet Decomposition:

i. Perform three level 2D-Symlet DWT decomposition on the stego image as well the cover image as we did in the embedding procedure.
ii. Process LL3 of the stego image block by block (4x4).
iii. Process LLR3 of the cover image block by block (4x4).
iv. Use the formula which follows to get the image blocks of the secret image.

$$S(i,j)=(E(i,j)-((1-\alpha)*C(i,j))/\alpha) \text{ ----2}$$

C. Validation of Stego image Quality:

Calculate the PSNR value in order to check for the visual quality of the stego image.

$$PSNR = 10\log_{10}\frac{255^2}{MSE}$$

where Mean Square Error (MSE) stands for the mean squared difference between the cover-image and the stego image. The mathematical definition for MSE is:

$$MSE = \left(\frac{1}{M \times N}\right)\sum_{i=1}^{M}\sum_{j=1}^{N}\left(a_{ij} - b_{ij}\right)^2$$

In Equation , a_{ij} means the pixel value at position (i,j) in the cover-image and b_{ij} means the pixel value at the same position in the corresponding stego image.

The calculated PSNR usually adopts dB value for quality judgment. The larger PSNR is, the higher the image quality is (which means there is only little difference between the cover-image and the stego image). On the contrary, a small dB value of PSNR means there is great distortion between the cover image and the stego-image.

RESULTS ANALYSIS

Embedding and extraction results using 2D-Symlet DWT Cover image before embedding and after decomposed in to R, G and B plane as shown in fig. 8 by applying three level wavelet decomposition. After embedding stego image, after extraction secrete image and PSNR and MSE values as shown in fig. 9 by applying three level wavelet decomposition. Cover image before embedding and after decomposed in to R, G and B plane as shown in fig. 10 by applying single level wavelet decomposition. After embedding stego image, after extraction secrete image and PSNR and MSE values as shown in fig. 11 by applying single level wavelet decomposition. Table 1 explains the PSNR and MSE values for different input images in R, G and B plane separately in three level wavelet decomposition. Table 2 explains the PSNR and MSE values for different input images in R, G and B plane separately in single level wavelet decomposition. This analysis show that by increasing the capacity of image extracted image quality will be increased.

Results show that new image data hiding technique based on DWT, the stego-image is looking perfectly intact and has high PSNR value. Hence, an unintended observer will not be aware of the secrete image. The extracted secrete image perceptually similar to the original secrete image. In this paper the technique using single and three level DWT for hiding image in low frequency coefficients.

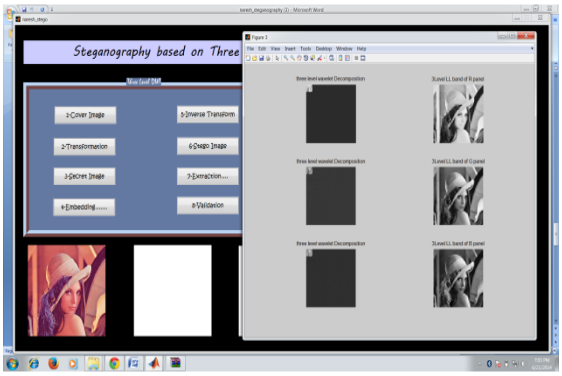

Fig.8 Apply 3-level wavelet decomposition

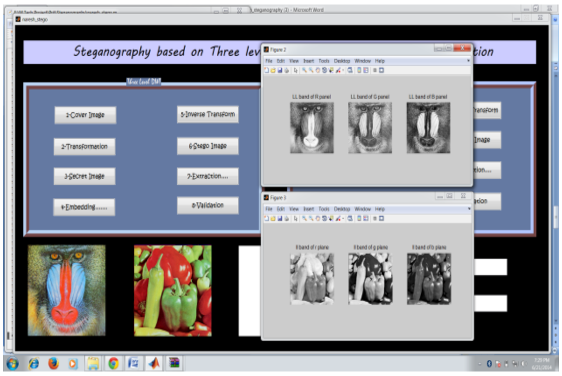

Fig.10 Apply 1-level wavelet decomposition

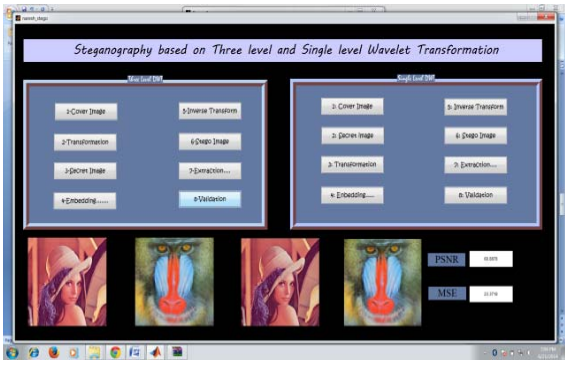

Fig. 9 Stego image and it's extracted output by applying 3-level wavelet decomposition

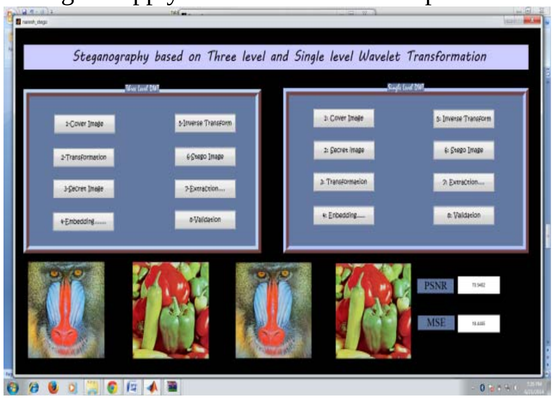

Fig. 11 Stego image and it's extracted output by applying 1-level wavelet decomposition

Secrete Image	Cover Image						Capacity (In pixels)
	nature		Img1		vegetables		
	PSNR	MSE	PSNR	MSE	PSNR	MSE	
mandrill	R:65.1064 G:63.7490 B:64.6095	R:36.1208 G:42.2307 B:38.2477	R:73.9059 G:78.6460 B:80.3512	R:13.1156 G:7.5994 B:6.2448	R:64.8169 G:74.1877 B:77.2555	R:37.3452 G:12.6968 B: 8.9188	32768
Peppers	R:65.3498 G:63.4301 B:63.9746	R:35.1228 G:43.8101 B:41.1482	R:74.1039 G:78.1066 B:79.2448	R:12.8199 G:8.0863 B: 7.0932	R:64.8958 G:73.8104 B:76.1833	R:37.0076 G:13.2606 B:10.0906	32768
Brick house	R:65.0380 G:63.9002 B:64.4860	R:36.4065 G:41.5020 B:38.7954	R:74.1250 G:79.0897 B:80.8918	R:12.7888 G: 7.2210 B: 5.8680	R:64.6846 G:74.1526 B:77.1032	R:37.9185 G:12.7483 B: 9.0765	32768

Table 1: PSNR and MSE values of Three level DWT

Secrete Image	Cover Image						Capacity (In pixels)
	nature		Img1		vegetables		
	PSNR	MSE	PSNR	MSE	PSNR	MSE	
mandrill	R:76.5214 G:69.7641 B:69.1342	R: 9.7053 G:21.1289 B:22.7180	R:69.3625 G:68.4049 B:68.2991	R:22.1287 G:24.708 B:25.0106	R:70.9058 G:69.1633 B:69.3406	R:18.5265 G:22.6421 B:22.1844	524288
Peppers	R:77.0059 G:66.2024 B:67.9147	R: 9.1788 G:31.8391 B:26.1423	R:68.2570 G:67.1220 B:77.1699	R:25.1322 G:28.6404 B: 9.0071	R:70.3820 G:67.4214 B:76.4770	R:19.6780 G:27.6700 B: 9.7551	524288
Brick House	R:72.0672 G:66.6940 B:64.4104	R:16.2077 G:30.0872 B:39.1345	R:68.2021 G:64.9738 B:65.7572	R:25.2915 B:33.5136 G:36.6765	R:67.4866 G:64.4880 B:65.4930	R:27.4632 G:38.7864 B:34.5487	524288

Table 2: PSNR and MSE values of Single level DWT

CONCLUSION

In this steganography, we are using two color images named cover image and secret image and applying DWT on these two images. Embedding process is done on LL bands of cover image and secret image at Single Level DWT and Three Level DWT separately. The result of the stego image has no more difference with cover image. So, we will embed the data in LL band also. At extraction process we get the secret image which is embedded in cover image. PSNR, MSE values are calculated between cover image and stego image. These PSNR and MSE values are the quality measurements of an image. The result of these PSNR and MSE are shown in Table1 and Table2. This paper is implemented in MATLAB tool.

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