ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An UGC Approved Journal)

Website: www.ijareeie.com

Vol. 6, Issue 8, August 2017

Image Steganography Using DWT and Semi Hexadecimal Code Provide better PSNR and Capacity with high Correlation

Balkar Singh[1], Devki[2]

PhD Scholar, Department of CSE, Thapar University, Patiala, Punjab, India

Asst. Professor, Department of Computer Science, GGN Khalsa College, Ludhiana, Punjab, India

ABSTRACT: In this paper, a novel image steganography approach is proposed to enhance the visual quality of stego image. The cover image is decomposed using Discrete Wavelet Transform (*DWT*) to produce wavelet subbands and threshold value is calculated for each higher frequency wavelet subbands. Wavelet coefficients having magnitude larger than the threshold of its subband are selected to embed the secret data. Semi Hexadecimal Code (SHC) is proposed to convert pixel value of secret image into smaller equivalent value so that it distorts stego image as less as possible. Experimental results shows that maximum PSNR between cover image and stego image is more than 75 *d*B and maximum embedding capacity of cover image is more than 87%. Proposed approach is also compared with the existing approaches and this comparison shows that the proposed approach is better than the existing approaches.

KEYWORDS: DWT, PSNR, Correlation, EF, SHC, Threshold.

I. INTRODUCTION

Steganography is a process of hiding a secret message in an ordinary message and the extraction of secret message, whenever required. Image steganography techniques are divided into two categories: spatial domain and frequency domain steganography. In spatial domain techniques, secret message is embedded in the image pixels, while in frequency domain techniques, image is first transformed and then secret message is embedded in the transformed image. Frequency domain techniques hide messages in significant areas of cover image which make them more robust than spatial domain techniques. Several approaches have been proposed for frequency domain steganography using different transforms [1-2].

Market *et al.* [3] proposed a watermarking technique in which the secret image is decomposed into wavelet subbands using *DWT*. The watermark is embedded into largest coefficients of high and middle frequency wavelet subbands of an image. Maximum *PSNR* proposed by their technique is 32.7 *d*B which is 0.14 *d*B more than Hsu *et al.* method [4].

Toaba *et al.* [5] proposed a technique in which secret message is embedded into least significant bits of wavelet coefficient of an image. Some pre-processing steps are applied on cover image to adjust saturated pixel components in order to recover the embedding message without losing cover image data. Cover image is adjusted before applying Integer Wavelet Transform followed by two levels *DWT*. Permutation of stego key is used to embed the bit stream of secret image after inverse *IWT* after that stego image is collected. Extraction process is just reverse of embedding process. Maximum *PSNR* offered by their technique is 73.91 *d*B.

Chen *et al.* [6] proposed a data hiding technique to hide data in high frequency wavelet sub-bands. The proposed technique is divided into two modes and three cases. The modes are fixed and varying. The cases are low embedding capacity, medium capacity and high capacity. Sequence mapping tables are used in raster scan manner to embed the data. For fix mode, 46.83 *d*B is the highest *PSNR* value and 39.00 *d*B is lowest. For varying mode, highest *PSNR* is 50.85 *d*B and minimum *PSNR* is 44.76 *d*B.

Ataby *et al.* [7] proposed a high capacity image steganography technique to hide the secret message into DWT subbands of cover image. Secret message is arranged into one dimensional data and *RC4* is used to encrypt this data and then embedding is done. The maximum *PSNR* by their technique is 40.98 *d*B.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An UGC Approved Journal)

Website: www.ijareeie.com

Vol. 6, Issue 8, August 2017

Nag *et al.*[8] proposed a *DWT* based technique for image steganography in which two dimensional (2-*D*) *DWT* is applied on the cover image and Huffman encoding is performed on the secret message before embedding. Then each bit of Huffman code of secret message is embedded in the high frequency wavelet coefficients. Maximum *PSNR* is 55.11 *d*B with hiding capacity of 24.21%.

Kumar *et al.* [9] proposed dual transform technique for robust steganography in which the cover image is segmented into *4×4* size blocks and *DWT* is applied on each block. In the resulting *DWT* coefficients, blocks of vertical band of *2×2* each are considered and then *IWT* is applied to get a single coefficient. Then secret data is embedded into these coefficients using *LSB* method. Maximum *PSNR* is 39.8411 *d*B at maximum capacity of 25%.

Shejul *et al.* [10] proposed a biometrics based steganography technique. Secret data is hidden in the high frequency subbands of *DWT*. Two cases are considered for data embedding. First is with cropping and another is without cropping**.** Both the cases are compared and analyzed from different aspects. Main feature of cropping case is that this results into an enhanced security because cropped region works as a key at decoding side, while without cropping case uses embedding algorithm that preserves histogram of *DWT* coefficient after data embedding also by preventing histogram based attacks and leading to a more security. Maximum *PSNR* provided by proposed technique is 64.92 *d*B.

Ghasemi *et al.* [11] proposed a wavelet transform and genetic algorithm based steganography technique. Genetic algorithm based mapping function is used to embed data in *DWT* coefficients in *4×4* blocks of the cover image. The optimal pixel adjustment process is applied after embedding the message. Maximum *PSNR* is 51.88 *d*B with 50% capacity.

Bhattacharya *et al.*[12] proposed a *DWT* based steganography technique in which secret data is embedded in high frequency wavelet sub bands. An amplification factor is used to control the embedding effect. *PSNR* between cover image and stego image is 27.3850 *d*B.

Ioannidou *et al.*[13] proposed a novel image steganography technique to hide the data into sharp areas of image on the basis of the edges present in an image. A hybrid edge detector is used to detect the edges of the cover image. Maximum *PSNR* provided by the proposed technique is 46.88 *d*B.

From this analysis, one can conclude that there is the need to have trade-off between *PSNR* and capacity in image steganography. In this work, an approach is proposed, which provides better *PSNR* and high capacity.

II. RELATED TERMS AND DWT

2.1 Related Terms

Cover file is a file which can hide information inside of it. Stego file is one in which data has been hide inside it after steganography process. Capacity is the information which is to be concealed.

2.2 DWT

DWT is a transform used to decorrelate the image energy into few wavelet coefficients. When *DWT* on one level is applied on an image, combination of four sub-bands with low and high frequencies are obtained. These sub-bands are low low (LL_1), low high (LH_1), high low (HL_1) and high high (HH_1). *DWT* can be further applied on LL_1 to get the other four subbands which are LL_2, HL_2, LH_2 and HH_2, as shown in Figure 1.

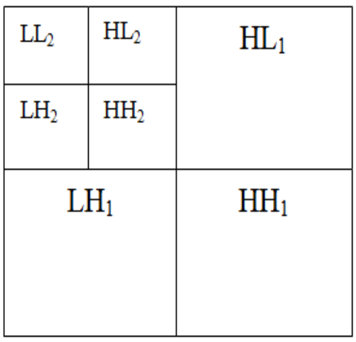

Figure 1. Two level DWT Structure

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An UGC Approved Journal)

Website: www.ijareeie.com

Vol. 6, Issue 8, August 2017

III. PROPOSED APPROACH

Proposed approach is based on two observations. First, if the wavelet coefficients are transformed into smaller equivalent coefficients, the distortion in stego image is less. Second, if the secret data is embedded into selected high frequency wavelet subbands of cover image, then also distortion in stego image is less. Selection of the wavelet coefficients is performed using threshold of the wavelet subband.

3.1 **Semi Hexadecimal Code**

Semi Hexadecimal Codes (*SHC)* are used to encode the secret image. These codes reduces the pixel values of the secret image, as less quantative value is required to represent a hexadecimal code than its decimal equivalent. It is beneficial to embed smaller value rather than larger value to affect the stego image as less as possible. It is semi in the sense, in this code we are not using *A, B, C, . . . , F* letters for 10,11, . . ., 15. We are using their exact value but at decimal place because *DWT* coefficient does not support alphabet embedding.

Algorithm 3.1 (Pseudo Code)

```
r1=Mod(N,16)
r2=Floor(N/16))
val=r2*10+r1;
if(r1<10)
   Hx=val;
else
   Hx=r2+r1/100;
end
```

Where *N* is the decimal number in base 10 and *Hx* is the equivalent *SHC* code. Mod operation finds the remainder of division of one number by another number. Floor function maps a real number to the largest previous integer.

For example, decimal number 26 is converted into 1.10 *SHC* and decimal number 200 is converted into 128 *SHC.*

3.2 **Threshold of a Subband**

After applying the *DWT* on cover image, threshold for each high frequency sub-bands (*i.e. LH, HL* and *HH*) is calculated using the approach proposed by Nick Method in [14] as

(1)

Where *T* is the threshold of a subband, is mean of particular sub-band, is a constant valued as -0.15 (Ni-black W., [14]. measured it -0.2), *C* is wavelet coefficient and are dimensions of sub band. Factor affects directly the threshold value and therefore capacity. Higher negative value of enhances the capacity but reduces the *PSNR*. In proposed work, slight lesser of than original constant proposed by Ni-black is considered.

3.3 Proposed Approach:

Embedding Process

i. Apply *DWT* on cover image which produces four wavelet subbands, named as *LL, HL, LH* and *HH.*
ii. Find the threshold *T* for *HL, LH* and *HH* using (1).
iii. If $S(x, y) \geq T$; embed the data using

   where is modified wavelet coeffient , is original wavelet coefficient, and *Hx* is semi hexadecimal representation of secret data which is obtained using Algorithm 3.1 and are spatial coordinate of subband. *EF* is the embedding factor which is used to balance the embedding effect.
iv. Apply *IDWT* to produce the Stego image.

Extraction process is just inverse of the embedding process.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An UGC Approved Journal)

Website: www.ijareeie.com

Vol. 6, Issue 8, August 2017

IV. IMPLEMENTATION AND EXPERIMENTAL RESULTS

The proposed approach is implemented in MATLAB 7.0. The cover image is decomposed into two levels using Haar wavelet. Embedding Factor *(EF)* is used to balance the embedding effect. It is better to use the lesser value of *EF*, so e^{-n} (*e* is base of natural logarithms) is used where *n* is a positive integer such as $n \geq 2$. Some of the images considered are shown in Figures 2-4.

Figure 2. (a) Original Lena cover image (*512×512*), (b) Original Barbara Secret image (*389×389*) (c) Stego Lena image that has image (b) inside it, and (d) Recover image from (c)

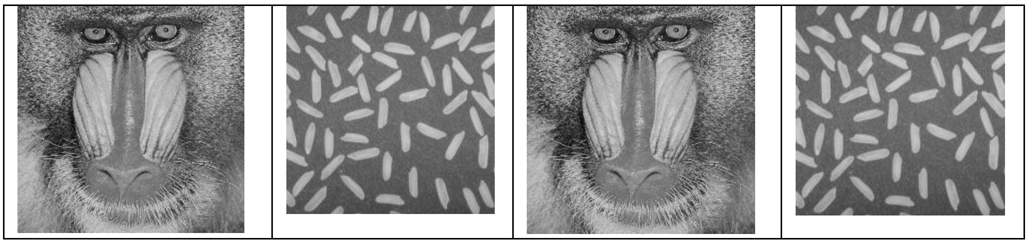

Figure 3. (a) Original Baboon cover image (*256×256*), (b) Original Secret rice image (*192×192*) (c) Stego Baboon image after embedding rice, and (d) Recover rice image from Baboon stego image.

Figure 4. (a) Airplane image (*512×512*), (b) Original Barbara Secret image (*433×433*) (c) Stego airplane image after embedding Barbara image, and (d) Recover Barbara image.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An UGC Approved Journal)

Website: www.ijareeie.com

Vol. 6, Issue 8, August 2017

Table 1. *PSNR*, capacity and correlation of secret images using proposed approach

Cover image	Secret image	*EF*	$PSNR^1$ (in *d*B)	$PSNR^2$ (in *dB*)	Capacity (in %)	Correlation between secret and recovered image	Run time for embedding (in seconds)
Lena *512×512*	Barbara 389×389	e^{-4}	48.2855	34.5368	57.7244	0.9963	3.5938
Baboon *256×256*	Rice 192×192	e^{-7}	75.1231	49.0147	56.2500	0.9997	0.7969
Airplane *512×512*	Barbara 433×433	e^{-5}	56.4701	31.2687	71.5214	0.9923	4.3906
Rose *256×256*	Grapes 212×212	e^{-5}	53.9722	26.8148	68.5791	0.9566	0.7031
Cat *256×256*	Grapes 198×198	e^{-5}	54.4364	27.5601	59.8206	0.9623	0.6875
Cat *256×256*	Banana 198×198	e^{-5}	55.3960	21.2022	59.8206	0.9345	0.7188
Bird *256×256*	Elephant *240×240*	e^{-7}	75.3142	34.3603	87.8906	0.9935	0.8125

$PSNR^1$ between cover image and stego image and $PSNR^2$ between secret image and extracted image.

The results shown in Table 1 are the *PSNR* between cover image and stego image, *PSNR* between original cover and recovered image, embedding capacity and corresponding correlation. Maximum capacity of the proposed approach is **87.8906**% with *PSNR value* of **75.3142** *d*B. Also, the extracted secret images are highly correlated to original secret images, as shown in Table 1.

The proposed approach is compared with the existing approaches and the results of this comparison are shown in Table 2. This comparison depicts that the proposed approach is better among existing approaches in terms of PSNR, correlation and capacity.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An UGC Approved Journal)

Website: www.ijareeie.com

Vol. 6, Issue 8, August 2017

Table 2. Comparison of proposed approach with existing approaches

Methods **Met-rics**	Ref. 4	Ref. 5	Ref. 6	Ref. 7	Ref. 8	Ref. 9	Ref. 10	Ref. 11	Ref. 12	Ref. 13	Proposed Approach
PSNR[1] in dB	41.7	73.9	50.8	40.98 #1 22.84 #2	55.1	39.84 #1 50.30 #2	64.9	51.88	27.39	46.88	75.314
PSNR[2] in dB	*N.A.*	*N.A.*	*N.A.*	*N.A.*	*N.A.*	*N.A.*	*N.A.*	*N.A.*	*N.A.*	*N.A.*	34.360
Correla-tion[3]	*N.A.*	*N.A.*	*N.A.*	*N.A.*	*N.A.*	*N.A.*	*N.A.*	*N.A.*	0.9381*1 0.8870*2	*N.A.*	0.993
Capaci-ty(in %)	*N.A.*	*N.A.*	*N.A.*	49.99 #1 73.83 #2	24.2	25#1 15.25 #2	0.807	50	50	*N.A.*	87.890

PSNR[1:] *between cover image and stego image*
PSNR[2]*: between secret image and recovered image*
Correlation[3] **:** between secret and recovered image
#1: Best case for PSNR, #2: Best case for Capacity,
**1: First image, *2: Second image, N.A.: Not Available*

A comparison between the maximum PSNR of the existing algorithms and proposed algorithm is carried out in Figure5. In this figure, *X*-axis represent approaches and *Y*-axis represents *PSNR* between cover image and stego image.

Figure 5. Graph among *PSNR* of proposed approach and other approaches.

From this figure, one can conclude that proposed approach has high PSNR values than the existing approaches. Hence visual quality of stego image is better.

V. CONCLUSION

In this paper, a novel image steganography approach based on *DWT* and *SHC* is proposed. Secret data is embedded into those pixels of cover image having magnitude greater than the threshold value. Maximum PSNR between cover image and stego images is more than 75 *d*B and maximum capacity is more than 87%. The comparative analysis between the proposed approach and the existing approaches shows the superiority of the proposed approach.

REFERENCES

1. Gonzalez R. C. and Woods R. E., "Digital Image Processing," Prentice Hall, 2nd Ed, 2002.
2. Morkel T., Eloff J. H. P., and Olivier M. S., "An Overview of Image Steganography," Proceedings of Fifth Annual Information Security South Africa Conference, Sandton, South Africa, pp. 1-12, 2005.
3. Hsieh M. S., Tsebg D. C. and Huang Y. H., "Hiding Digital Watermark Using Multiresolution Wavelet Transform," IEEE Transactions on Industrial Electronics, vol. 48, no. 5, pp. 875-882, 2001.
4. Hsu and Wu, "Hidden digital watermarks in images," IEEE Transactions on Image Processing, vol. 8, pp. 58-68, 1999.
5. Tolba M. F., Ghonemy M. A., Taha I. A. and Khalifa A. S., "Using Integer Wavelet Transform in Colored Image-Steganography," International Journal of Intelligent and Cooperative Information System, vol. 4 no. 4, pp. 75-85, 2004.
6. Chen P. Y., and Lin H. J., "A DWT Approach for Image Steganography," International Journal of Applied Science and Engineering, vol. 4, no. 4, pp. 275-290, 2006.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An UGC Approved Journal)

Website: www.ijareeie.com

Vol. 6, Issue 8, August 2017

7. Ataby A. A., and Naima F. A., "A Modified High Capacity Image Steganography Technique Based on Wavelet Transform," The International Arab Journal of Information Technology, vol. 7, no. 4, pp. 358-364, 2010.
8. Nag A., Biswas S., Sarkar D. and Sarkar P. P., "A Novel Technique for Image Steganography Based on DWT and Huffman Encoding," International Journal of Computer Science and Security, vol. 4, no. 6, pp. 561-570, 2010.
9. Kumar K. B. S., Raja K. B. and Pattnaik S., "Hybrid Domain in LSB Steganography", International Journal of Computer Applications, vol. 19, no. 7, pp. 35-40, 2011.
10. Shejul A. A., and Kulkarni U. L., "A Secure Skin Tone based Steganography Using Wavelet Transform," International Journal of Computer Theory and Engineering, vol. 3, no. 1, pp. 16-22, 2011.
11. Ghasemi E., Shanbehzadeh J. and Fassihi N., "High Capacity Image Steganography using Wavelet Transform and Genetic Algorithm," International Multiconference of Engineering and Computer Scientist, vol. 1, pp. 1-4, 2011.
12. Bhattacharya T., Dey N. and Chaudhuri S. R. B., "A Novel Session Based Dual Steganographic Technique Using DWT and Spread Spectrum," International Journal of Modern Engineering Research, vol. 1, no. 1, pp. 157-161, 2011.
13. Ioannidou A., Halkidis S. T., and Stephanides G., "A novel technique for image steganography based on a high payload method and edge detection", Expert Systems with Applications, Elsevier, vol. 39, pp. 11517-11524, 2012.
14. Khurshid K., Siddiqi I., Faure C. and Vincent N., "Comparison of Niblack inspired Binarization methods for ancient documents," Proceedings of 16th International Conference on Document Recognition and Retrieval, pp. 1-9, 2009.