Journal of Advances in Computer Research
Quarterly pISSN: 2345-606x eISSN: 2345-6078
Sari Branch, Islamic Azad University, Sari, I.R.Iran
(Vol. 9, No. 3, August 2018), Pages: 71-86
www.jacr.iausari.ac.ir

A New Hybrid Method for Colored Image Steganography Based On DWT

Amir Massoud Bidgoli✉**, Sara Behrang**
Department of Computer Engineering, Tehran North Branch, Islamic Azad University, Tehran, Iran
drbidgoli@gmail.com; 1am_bidgoli@iau-tnb.ac.ir; sara_behrang86@yahoo.com

Received: 2017/11/24; Accepted: 2018/02/03

Abstract

Data transmission security has become an extremely important field of research. Steganography is an art of hiding information in image, audio and video files in a way that would meet the security requirements in the form of overt or covert. In this study, we propose a new hybrid steganography technique for color images that hide secret messages in the frequency domain of a cover image's blue channel. Hence this method provide robustness against attacks, eavesdropping and capacity. In addition, we use coding and compression algorithms to obtain high capacity along with security and maintains the quality of the cover image with considerable high value PSNR. In this paper a secret message can be either an image or text and our purpose is to improve three important parameters in steganography. Peak Signal to Noise Ratio (PSNR) values measures any steganography technique's performance. Higher PSNR values indicate that the performance of the system is better.

Keywords: *Steganography; Frequency and Spatial Domain; Coding and Compression Algorithms*

1. Introduction

Since the rise of the internet, one of the most important factors of information technology and communication is the security of information. Steganography is the art and science of invisible communication and is the process of hiding of a secret message within an ordinary message and extracting it at its destination. Anyone else viewing the message will fail to know that it contains secret/encrypted data. An information-hiding system is characterized by having three different aspects that contend with each other. These are, capacity, security, and robustness as shown in figure 1.

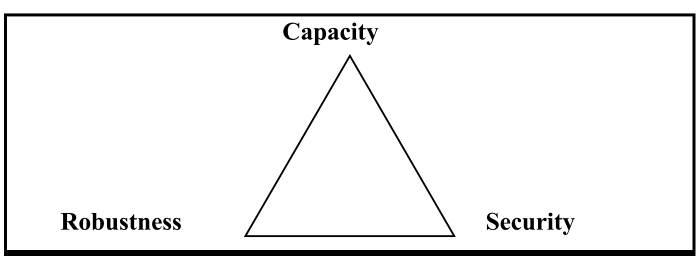

Fig 1. Capacity, Security and Robustness Triangle

Capacity refers to the amount of information that can be hidden in the cover medium. Security is the ability of the system to prevent an attacker to identify and extract hidden data. Robustness is the amount of changes the stego medium can withstand before an attacker can destroy hidden information. Peak Signal to Noise Ratio (PSNR) values measures any steganography technique's performance. Higher PSNR values indicate that the performance of the system is better. In any technique if the PSNR value is above 30dB it is considered to be a good technique. The remaining paper is organized as follows: Section 2, presents related work. Section 3, discusses methodology. Section 4, presents our proposed method. Section 5, discusses experimental results. In section 6, the proposed method is compared with existing methods. Finally, in section 7, we describe the conclusion.

2. Related Work

Least significant bit (LSB) insertion is a common, simple approach to embedding information in a cover image [2]. In this method the least significant bits of the carrier image pixels are replaced with the secret data bits. Payload capacity of LSB method can be increased if more than 1 LSBs are used for message embedding but it brings noticeable changes in the carrier image. The images which have comparatively large size are most suitable for this because of the large amount of space which could hide a large amount of data LSB method is simple to implement but it is vulnerable to many statistical attacks like RS, image processing operations and ChiSquare analysis etc.

Ekta Dagar and Sunny Dagar [2] proposed an approach for Image Steganography to enhance the level of security for data transfer over the internet. The 24-bit RGB image is chosen as a cover image which hides the secret message inside red, green and blue color pixel values. There is an X-Box mapping where several boxes are used which contains sixteen different values (X represents any integer value from 0-9). The values stored in the X-Boxes are mapped with the LSBs of the cover image. This mapping provides a level of security to the secret message which makes it difficult for the intruders to extract the hidden Information. However, in this method all three RGB channel is used and may cause a noticeable change in cover image.

Siraj Sidhik et al [1] proposed a modified and simple method for high capacity steganography in case of color images. The algorithm is usually based on Discrete Wavelet Transform (DWT) in which wavelet fusion is used for Steganography of color images. It has been shown that the three parameters capacity, security and robustness are maintained by this algorithm. However, the dataset used for experimental results were limited.

Sankaran.S et al [3] proposed an image steganography scheme named DWTSM in Blue Channel. The dual wavelet transform like DWT and IWT were applied in their experiment. And this method has achieved high capability and high security. However, the secret message used is only an image.

Rajeev Kumar et al [4] proposed a new image steganography scheme for colored images based on a cluster analysis. In this scheme, they analyze the secret data in order to make its clusters. This method is based on the similarity among the basic elements of the secret data. The basic elements in the text, image/video and audio/speech are characters, pixels and samples, respectively. Then the difference value between the secret data and the minimum value contained in the cluster will be calculated. In this technique the difference value is embedded equally into two channels of the image.

Hussain [11] have improved the Modified Kekre's Algorithm (MKA) which is based on LSB method. The improved scheme increases the embedding capacity while retaining the good quality of stego-image. In this technique all bytes of cover image have been used.

Hemalatha et al [34] proposed a technique so that the secret image itself is not hidden, instead a key is generated and then the key is encrypted and Run Length Encoded. The resultant key is then hidden in the cover image using Integer Wavelet Transform (IWT). This technique improved the security and also the capacity were improved to some extent since the key is compressed.

Most of these techniques that use DWT have a PSNR value close to each other but in the references [4], and [11] that used techniques other than wavelet transform have bigger PSNR in comparison with other methods. However, many of these methods have greater complexity and calculations are more complex. Hence, need more time to embed data in a cover image. In most of these papers, the secret message is an image or text and usually follows one of the three most important factors in steganography. However, in our paper secret message, type is not important, our algorithm input is a binary bit string, and our purpose is to maintain and improve the three important parameters in steganography.

3. Preliminary Knowledge

3.1 Wavelet Transform

The wavelet transform has the ability of reconstructing, so there is no information loss and redundancy in the process of decomposition and reconstruction. Discrete wavelet transforms map data from the time domain to the wavelet domain. The two-dimensional Wavelet transform decomposes the color images into four bands, the LL, HL, LH and HH band which represents the low pass approximation, vertical, horizontal, and diagonal features of the color image, respectively.

LL	HL
LH	HH

Fig 2. 2D wavelet transform

The whole procedure explained above is called the one-level 2-D Haar-DWT.

3.2 Huffman Encoding

Before embedding the secret data into cover image, it is first encoded using Huffman coding. Huffman encoding is a variable length lossless compression technique that map one symbol to one code word. A Huffman code is a particular type of optimal prefix code that is commonly used for lossless data compression Huffman encoding is used to serve the following three factors:

Lossless Compression: It increases the embedding capacity.

Security by means of encoding: Huffman encoded bit stream cannot reveals anything and to extract the exact meaning, the Huffman table is required to decode.

It provides one type of authentication, as any single bit change in the Huffman coded bit stream, Huffman table is unable to decode.

3.3 Data conversion interface

In the proposed method presented in this article, inputs are only image or text. Other types of text input, like Meta data (for example HTML or PDF) has not been used. The possibility to cover and support various data formats is one of the benefits that can be presented as a prominent feature in Steganography systems. In the proposed method, we presented a primary platform for creating this feature in the steganography system It means that it is not important what is input data type (image or text). The data is converted to a binary format. Hence, steganography system, works independent of data type. Just enough to make it possible to convert any object template into a bit string [36].

3.4 Differential encoding

In computer science and information theory, data compression means information coding in a way that have fewer bits than the original version. The purpose of image compression is to reduce photo content redundancy, to save or transfer data effectively. Image compression can be done lossless and lossy. Differential coding is a lossless technique in image format. In this coding, instead of storing a data directly, the differential coding technique stores the difference between them. The goal of this coding is to reduce the correlation between pixels. This method is used when the stego data is an image and is done on image before Huffman algorithm. By doing this the best possible compression will be achieved.

3.5 Complementary coding

We use this coding before embedding data in image. This algorithm works such that in embedding part, the data itself or its complementary is written in the image and this depends on the stored data in considered pixels and secret data. Whichever have less difference, is written in the image.

3.6 RGB (True color) Images

A Color Space is a mathematical representation of a set of colors. The three most popular color models are RGB (used in computer graphics), YIQ, YUV or YCbCr (used in video system) and CMYK (used in color printing). An RGB image, sometimes referred to as a true color image, is stored as an *m*-by-*n*-by-3 data array that defines red, green, and blue color components for each individual pixel.

The blue channel has the least sensitivity hence is used for embedding secret messages.

4. Proposed Method

In this paper, we proposed a steganography technique using Discrete Wavelet Transform (DWT) for hiding data with high security, a good invisibility and no loss of secret message. At first, data type is chosen by user and the other steps is done by system. The only difference between image and text is in differential encoding. Then the following steps are carried out:

4.1 Embedding Algorithm

1. Convert data into binary format.

2. Huffman encoding perform Huffman encoding on the data and calculate data size.
3. Choose proper image according to secret data size.
4. Separate Red, Blue and Green components of the cover image.
5. Compute 2D DWT of B component of cover image using HAAR Wavelet. And select HH sub-band for embedding the secret message.
6. Repeat for each bit obtained in step 2. Insert the 3 bits obtained in step 2 into 3 LSB position in each DWT coefficient of the selected sub-band by the help of complementary coding.
7. Apply inverse DWT.
8. Merge RGB component.
9. End.

For embedding part the sub bands are decimal numbers at first normal matrix of DWT. They are changed to an intensity matrix by scaling it between 0 and 1 and then multiply it by 255. Then secret data is replaced just with integer part. The other sub band is used for storing information about Huffman algorithm or other information that are needed in extraction algorithm. The proposed embedding process is shown in fig (3).

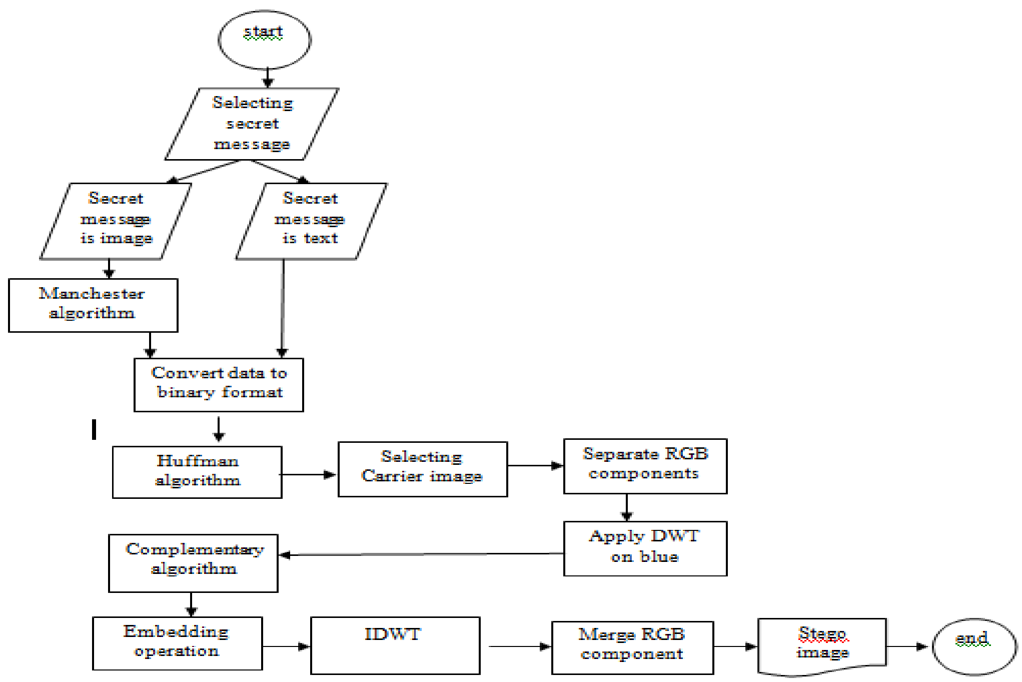

Fig 3: Formation of Stego Image

4.2 Extraction Algorithm

In extraction part, we do the inverse of embedding.

1. Choose secret data type.
2. Separate RGB component and do the following steps on blue channel.

3. DWT.
4. Inverse Complementary coding.
5. Inverse Huffman algorithm.
6. Inverse Data conversion interface.
7. Inverse Differential algorithm if secret data type is image.
8. End.

The proposed extraction process is shown in fig (4).

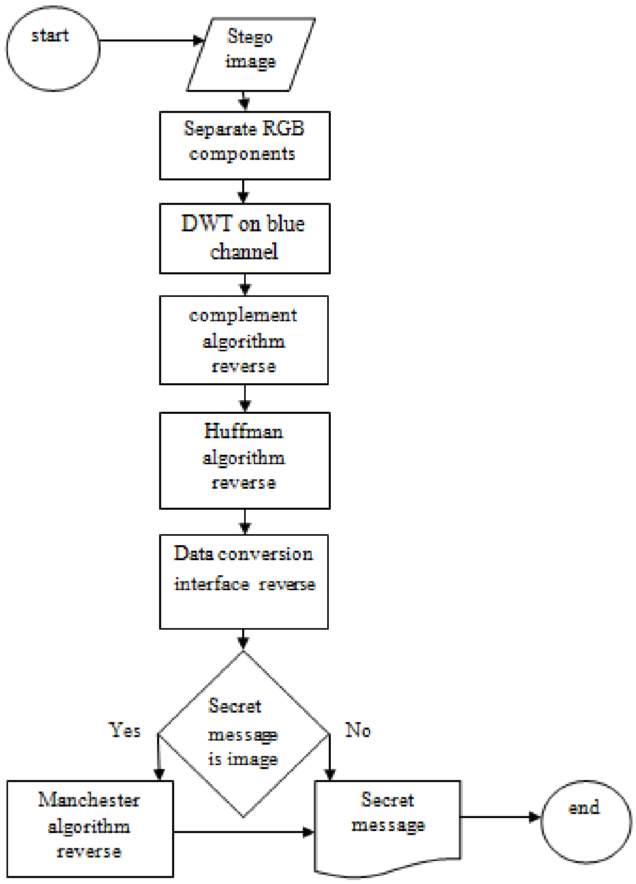

Fig 4: Extraction of the Secret Message

4.3 Performance parameters

We used PSNR and MSE to measure the distortion between the original cover image and the stego image.

4.3.1 Mean Square Error (MSE):

The distortion in the image can be measured using MSE. MSE can be defined as the measure of average of the squares of the difference between the intensities of the stego image and the cover image. It is popularly used because of the mathematical tractability it offers. It is represented as expression 1.

$$\mathbf{MSE}=\frac{1}{m*n}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}\left[I(i,j)-K(i,j)\right]^2 \qquad (1)$$

Where I(i,j) is the original image and K(i,j) is the stego image. A large value for MSE means that the image has poor quality and vice-versa.

4.3.2 Peak Signal to Noise Ratio (PSNR):

It is the measure of the quality of the image by comparing the cover image with the stego image, i.e., It measures the statistical difference between the cover and stego image. The PSNR depicts the measure of reconstruction of the transformed image. This metric is used for discriminating between the cover and stego image. In any technique if the PSNR value is above 30dB it is considered to be a good technique and is shown by expression 2.

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

5. Experimental and Simulation Results

The performance results of our transform domain technique based on DWT techniques were verified using MATLAB 2016 version. Table 1, shows The Performance Evaluation of proposed algorithm.

5.1 Evaluation criteria

The results are obtained with different cover images and as it is shown in the table 1, the PSNR value are different for each image. In this part the secret message type is text. The images that are used as cover image in this article are standard test images used across different institutions to test image processing and image compression algorithms. All these images are colored and have different dimensions and are used in different articles too [2, 4, 11, and 28].

Table 1. The PSNR values of different images

fruit	tulips	greens	football	pepper	Monarch	Cover image
44.4129	42.037	39.155	39.547	42.902	41.741	**PSNR (db)**

The images that are used in this article are shown in figure5.

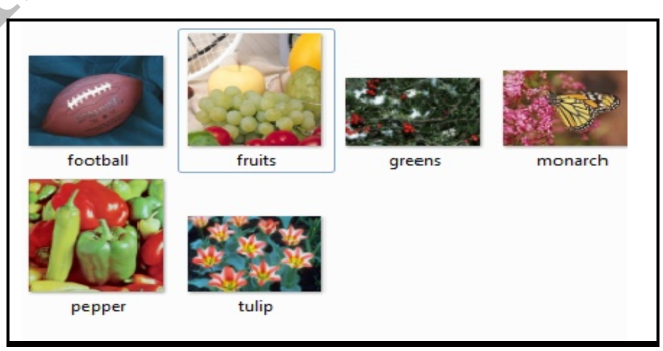

Fig 5. Images in directory

The secret message that is stored in a notepad file with ".txt" suffix is shown in figure 6.

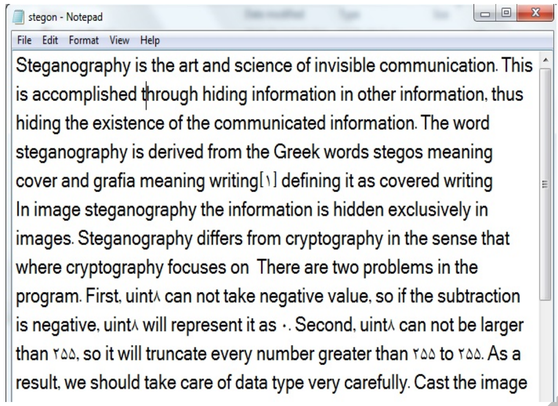

Fig6. Secret data

Figure7, shows the image after embedding the secret data.

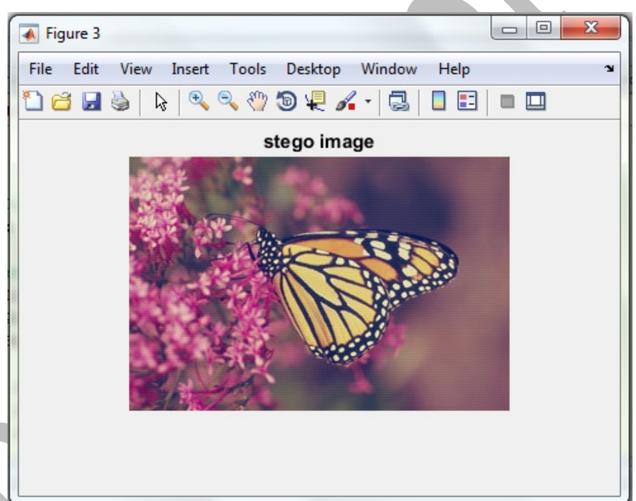

Fig7. Stego image

Figure8, shows the extracted message from stego image and as it shown it is exactly the same as the original secret text.

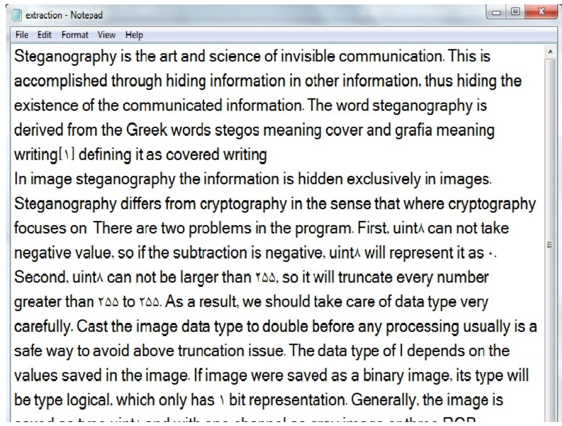

Fig 8. Extracted message

In the following, an example of the implementation of our algorithm has been explained when secret message is an image. Figure 7, shows a secret message chosen as an image type. The image can be color or gray. In color type, RGB channels of image are separated and each channel is considered to be a secret message and all of the steps that are mentioned in section 4 are applied to each channel. In extraction part, after extracting channels, the components of the RGB image are merged.

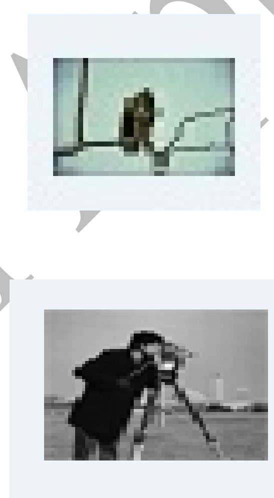

Fig 9. Secret messages (color image and grayscale image)

Figure 10, shows the cover image that has been used to hide the secret message of figure9.

Fig 10. A cover image used for the secret image in fig 7

The maximum size of secret image must be Quarter of HHb (HH band derived from DWT on blue channel of cover image).

As mentioned in the previous section, embedding algorithm when secret message is an image is similar to embedding algorithm when its type is text. However, in image type differential encoding is applied on secret message before Hufman algorithm.

Figure 11, shows the cover image after embedding the secret message.

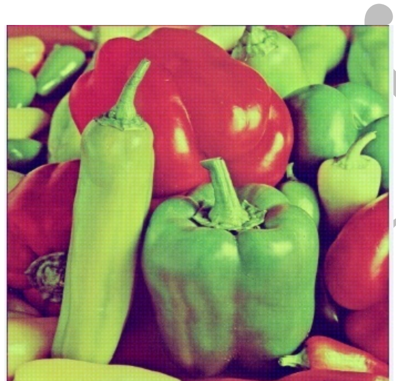

Fig 11. Stego image

Figure 12, shows the secret image after extracting process.

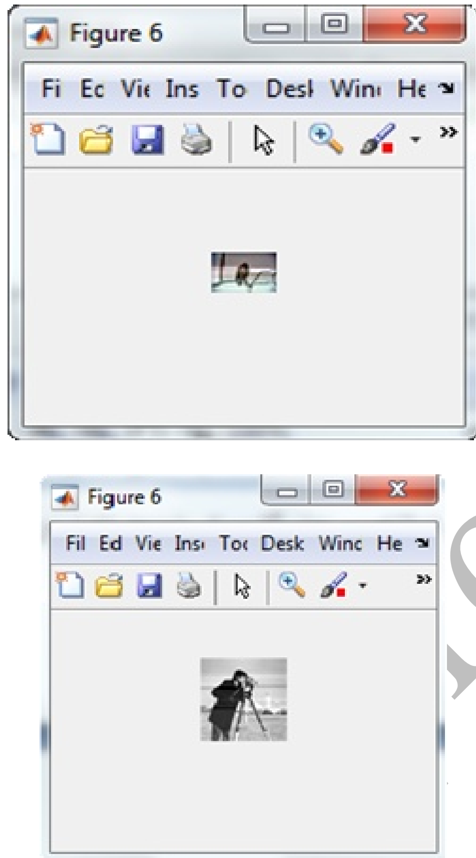

Fig 12. The secret image after extraction process

Table 2, shows the PSNR and MSE values calculated for different cover images with different text type secret messages.

Table 2. Experimental results of the proposed method while secret message is text

Number of character		Monarch 300*200	Tulips 768*512	Pepper 512*512
10	PSNR	41.7491	42.1097	43.0150
	MSE	1.4627e+04	1.5393e+04	1.8442e+04
1324	PSNR	41.7412	42.0372	42.9023
	MSE	1.4214e+04	1.5097e+04	1.8450e+04
1530	PSNR	41.8192	42.0391	42.9125
	MSE	1.4627e+04	1.5181e+04	1.8442e+04

Tables 3 and 4, show the results PSNR and MSE values calculated for different cover images as in table 2 but with different gray and color image type secret messages.

Table 3. Experimental results of the proposed method while the secret message is a gray image

Image pixel		Tulips 768*512	Pepper 512*512	Fruits 512*512
30*45	PSNR	42.1153	42.8326	44.3481
	MSE	1.6275e+04	1.9198e+04	2.7215e+04
50*50	PSNR	42.9674	42.7021	44.0808
	MSE	1.5798e+04	1.8653e+04	2.5590e+04

Table 4. Experimental results of the proposed method while the secret message is a color image

Image pixel		Tulips 768*512	Pepper 512*512	Fruits 512*512
30*45	PSNR	42.0842	43.0209	44.4184
	MSE	1.6275e+04	1.9198e+04	2.7215e+04
50*50	PSNR	42.0266	43.0217	44.3935
	MSE	1.5798e+04	1.8653e+04	2.5590e+04
30*20	PSNR	42.0627	43.0987	44.4330
	MSE	1.6079e+04	2.0411e+04	2.7753e+04

As it is shown in tables 2 and 3, by increasing the size of a secret message (text/image), the PSNR values will decrease, so when the secret message type is text, it would be best if the number of characters is not more than 1530.

When the secret message is of color/gray scale image type, the method used for storing Huffman algorithm information (symbols and number of their repetitions for generation of Huffman dictionary in information extraction part of the algorithm, cannot be larger than 255), the secret image size cannot be larger than the values that are mentioned in the table 4.

6. Discussion on the Results

The PSNR values of the proposed method and the existing methods are compared.

Table 5, shows the PSNR values of different techniques, according to their reference number mentioned at the reference section of this paper.

Table 5. Comparison of various steganography techniques with the proposed method

Proposed algorithm	[35]	[34]	[25]	[12]	[11]	[9]	[4]	[3]	[2]	[1]	Article Reference number
44.19	39.6	44.3	54.93	25.39	59	64	68	45	49.33	47.99	PSNR (db)

Figure 13, is a graph that shows the comparison between obtained PSNR values in different techniques.

Fig 11. PSNR comparison

The comparison is made with various steganography techniques that are mentioned in table 4.

According to table 4, in articles that used wavelet domain to achieve their goals, PSNR values are usually below 50. For example, paper [1] has used wavelet transform to achieve high capacity, along with security and maintain the quality of the cover image and have tried to keep the optimum values for three parameters. Also in article [3] Wavelet transform have been used to achieve quality, capacity, security, robustness and efficiency improvement. In ref [2] the method of an X-box is used to improve security. Ref [34] works in transform domain and instead of storing the real data, encrypted data has been stored in the cover image and safety and quality of cover image is maintained. However, in the references [4], [9] and [11] techniques other than wavelet transform are used and hence only one of the three most important factors in steganography have higher PSNR as compared with other methods. Also many of these methods have greater complexity and calculations .and therefore need more time for embedding data in cover image.

Our purpose in this article is to improve three parameters of capacity, security and robustness and we considered these parameters in proposed steganography system design. The point that should be noted is that the purpose of the proposed algorithm, is to reduce the size of stego data by the help of Huffman algorithm and hence storing more data, in addition to maintaining image quality and security. As a result, the stego image quality will be affected. and having these three parameters together leads to have less PSNR than some methods. Hence, we need to compromise between these three quantities and rely on the values of obtained PSNR.

Table 6, shows the size of stego data used for the proposed algorithm and as shown, the size of stego data, after applying Huffman algorithm, have dropped. One important purpose in this paper was to reduce the size of the stego data and this goal is achieved by applying Huffman algorithm. As can be seen from table 6, the size of stago data obtained after deployment of Huffman algorithm is reduced to %73 of original message.

This result is obtained from example mentioned in section 5.

Table 6. The size of stego data used for the proposed algorithm

	Size of stego data(bit)
Before Huffman algorithm	**21184**
After Huffman algorithm	**5809**

7. Conclusion

This paper proposes an integrated and combined method to improve three parameters of capacity, security and robustness in case of color image steganography. The algorithm is usually based on Discrete Wavelet Transform which caused robustness against attacks and increase hiding capacity. In this method, at first, format homogenization, eliminating redundancies and compression operation was done on a secret massage by Differential and Huffman algorithms. These algorithms would achieve higher security and quality and better PSNR ratio and increase steganography capacity. After choosing a cover image, DWT technique is applied on blue channel because a change in the intensity of Red plane is the most sensitive to human eyes and for Blue plane is least sensitive. Hence, the blue channel is considered for embedding the secret image and then with the help of complementary algorithm the massage was hidden in HH sub-band. Considering three parameters (robustness, capacity, security) together is important because it leads to have less PSNR than some methods that just use one of these parameters. The achieved PSNR in comparison with other technique's PSNR values that are mentioned in table 5 has shown considerably good result.

References

[1] S. Sidhik, S.K. Sudheer and V. P Mahadhevan Pillai, "Modified High Capacity Steganography for Color Images Using Wavelet Fusion", IEEE 4th International Workshop on Fiber Optics in Access Network, pp. 234-239, 2013.

[2] E. Dagar and S. Dagar, "LSB Based Image Steganography Using X-Box Mapping", IEEE, pp. 351-355, 2014.

[3] G. Prabakaran, R.Dr. Bhavani and S. Sankaran, "Dual Wavelet Transform Used in Color Image Steganography Method", IEEE International Conference on Intelligent Computing Applications, pp. 193-197, 2014.

[4] R. Kumar and S. Chand, "A New Image Steganography Technique Based on Similarity in Secret Message", IEEE, pp. 376-379, 2013.

[5] M. Hussain and M. Hussain, "A Survey of Image Steganography Techniques", International Journal of Advanced Science and Technology, Vol. 54, pp. 113-124, May, 2013.

[6] B.A. Usha et al, “A Survey on Secure and High Capacity Image Steganography Techniques”, International Journal of Advanced Research in Computer and Communication Engineering Vol. 3, Issue 4, pp. 6337-6340, April 2014.

[7] K. Sathish Shet, Nagaveni and A.R. Aswath, “Image Steganography Using Integer Wavelet Transform Based on Color Space Approach”, Springer, pp. 376-379, 2015.

[8] Y.L. Li and W.H. Tsai, “New Image Steganography via Secret Fragment-Visible Mosaic Images by Nearly-Reversible Color Transformation”, Springer, pp. 64–74, 2011.

[9] H. BKekre, A. Athawale and P. Halarnkar, “Performance Evaluation of Pixel Value Differencing and Kekre’s Modified Algorithm for Information Hiding in Images” International Conference on Advances in Computing, Communication and Control, pp. 342-346, 2009.

[10] H.C. Wu, N.I. Wu, C.S. Tsai and M.S. Hwang, “ Image steganographic scheme based on pixel value differencing and LSB replacement methods”, IEEE Proc. Vision Image Signal Process, vol. 152, pp. 611-615, 2005.

[11] M. Hussain and M. Hussain, “Pixel Intensity Based High Capacity Data Embedding Method” International conference on Information and Emerging Technologies, pp. 1-5, 2010.

[12] M. Hotinejad, “Image steganography in spatial domain based on Chaos approach”, National Conference on Engineering Science, pp. 1-5, new ideas 2014.

[13] P. Chandra Mandal and B.P. Poddar, “Modern steganographic technique: A survey”, International Journal of Computer Science & Engineering Technology (IJCSET), Vol. 3, No. 9, pp. 444-448, Sep 2012.

[14] A. Cheddad, J. Condell, K. Curran and P.M. Kevitt, “Digital image steganography: survey and analysis of current methods”, Science Direct, Vol. 90, No. 3, pp. 727-752, May-June 2016.

[15] T. Morkel, J.H.P. Eloff and M.S. Olivier, “An overview of image steganography”, In Proceedings of the Fifth Annual Information Security South Africa Conference (ISSA 2005), Sandton, South Africa, June/July 2005.

[16] P. Kruus, C. Scace, M. Heyman and M. Mundy, “A survey of steganography techniques for image files”, Advanced Security Research Journal, Vol. 5, No. 1, pp. 41-52, 2003.

[17] N.F. Johnson and S. Jajodia, “Exploring Steganography: Seeing the Unseen”, Computer Journal, pp. 1-4, February 1999.

[18] N. Provos and P. Honeyman, “Hide and Seek: An Introduction to Steganography”, IEEE, pp. 32-44, 2003.

[19] J. Lenti, “STEGANOGRAPHIC METHODS” in PERIODICA POLYTECHNICA SER. EL. ENG., Vol. 44, No. 3– 4, pp. 249–258, 2000.

[20] Ms. M. Kude, M. Borse and R.K Harshvardhan, “A DWT Based Steganography Using Haar Transforms”, 3 rd International Conference on Electrical, Electronics, Engineering Trends, Communication, Optimization and Sciences (EEECOS), pp. 884-887, 2016.

[21] S.i. Zagade and S. Bhosale, “Skin based Data hiding in Images by Using 'Haar' and 'db2' DWT Technique’s”, International Journal of Science and Research (IJSR), Vol. 3, pp. 2276-2281, June 2014.

[22] P. Deshmane and S.R. Jagtap, “Skin Tone Steganography for Real Time Images”, International Journal of Engineering Research and Applications (IJERA), Vol. 3, Issue 2, pp. 1246-1249, March -April 2013.

[23] E. Ghasemi, J. Shanbehzadeh and N. Fassihi, “High Capacity Image Steganography using Wavelet Transform and Genetic Algorithm”, Int. multiconf. Of Engineers & Computer Scientist, Vol. 1, pp. 1-4, 2011.

[24] S. Malik and V. Verma, “Comparative analysis of DCT, Haar and Daubechies Wavelet for Image Compression”, International Journal of Applied Engineering Research, Vol. 7, No. 11, pp. 1-6, 2012.

[25] A. Nag, S. Biswas, D. Sarkar and P.P Sarkar, "A Novel Technique for Image Steganography Based on DWT and Huffman Encoding", International Journal of Computer Science and Security, (IJCSS), Vol. 4, pp. 561-570, 2011.

[26] B.G. Banik and S.K. Bandyopadhyay, "A DWT Method for Image Steganography", International Journal of Advanced Research in Computer Science and Software Engineering (IJARCSSE), Vol. 3, Issue 6, pp. 983-989, June 2013.

[27] S. Hemalatha, U. D. Acharya, A. Renuka and P.R. Kamath, "A SECURE COLOR IMAGE STEGANOGRAPHY IN TRANSFORM DOMAIN", International Journal on Cryptography and Information Security (IJCIS), Vol. 3, No. 1, March 2013.

[28] R.NOLKHA, A. VERMA, G. AGRAWAL and V.P. VISHWAKARMA, "A Secured Image Steganographic Technique for RGB Images Using Discrete Wavelet Transform", International Journal of Signal Processing, Vol. 1, pp. 35-46, 2016.

[29] A. Dalvi and V.N. Patil, "Color Image Steganography Based on DWT and SWT", International Journal of Research in Electronics and Communication Technology (IJRECT), Vol. 1, Issue 3, pp. 78-80, 2014.

[30] L. Zhu and Y.M. Yang, "Embeded Image Compression Using Differential Coding and Optimization Method", IEEE, 2011.

[31] C. Saravanan and M. Surender, "Enhancing Efficiency of Huffman Coding using Lempel Ziv Coding for Image Compression", IJSCE, vol. 2, pp. 38-41, 2013.

[32] Y.K. Lee and L.H. Chen, "High capacity image steganographic model", IEEE, Vol. 147, pp. 288-294, 2000.

[33] S.V. Joshi, A.A. Bokil, N.A. Jain and D. Koshti, "Image Steganography Combination of Spatial and Frequency Domain", International Journal of Computer Applications, Vol. 53, pp. 25-29, 2012.

[34] S. Hemalatha , U.D. Acharya, A. Renuka and P.R. Kamath, "A SECURE COLOR IMAGE STEGANOGRAPHY IN TRANSFORM DOMAIN", International Journal on Cryptography and Information Security (IJCIS), Vol. 3, No. 1, pp. 1-8, March 2013.

[35] J.K. Mandal and M. Sengupta, "Steganographic Technique Based on Minimum Deviation of Fidelity (STMDF)", Proceedings of Second International Conference on Emerging Applications of Information Technology, IEEE Conference Publications, pp. 298–301, 2011.

[36] M.S. Azaminezhad and A.M. Bidgoli, "A new high capacity steganography based on bit-inverting method in DWT domain", Journal of Advanced Computer Science & Technology, Vol. 3, No. 2, pp. 169-178, 2014.