Image Security using DT-WT Steganography Enhanced with High Boost Filter

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Abstract - Steganography is an art of hiding information such as text, audio, video and image data to prevent them from unauthorized access. From the ancient times time to present time security of confidential information is always a significant issue. Image security is the exigent task to thwart it from illegal use or accessing. In this paper, we use steganography and cryptography algorithm (SHA) with dual –tree wavelet transform (DTWT). Cryptography is a technique to convert the data from plain text to cipher text which is unreadable data. The DTWT decomposes the original image recursively to find the high-frequency components of it since human eyes are less sensitive to high frequency then again apply high boost filter which decomposes the high-frequency components of an original image to locate singular value matrix where secret data can be concealed securely. The experimental analysis of the proposed work is done in MATLAB-2012a using simulation toolbox and performance measurement take pace using performance metrics such as PSNR, MAE, NAE and NCC etc. The results of the proposed method are much better than the existing method it means that our method makes image data much secure from unauthorized access.

Keywords - Cryptography, JPEG Compression, DT-WT, SHA Algorithm, High Boost Filter, LSB steganography, PSNR, MSE, NCC, NAE.

1. INTRODUCTION

In the present era, communication through computer network requires more security. Two techniques are used for secret communication. One is cryptography, where the sender uses an encryption key to encrypt the message, this encrypted message is transmitted through the insecure public channel, and decryption algorithm is used to decrypt the message. The reconstruction of the original message is possible only if the receiver has the decryption key. The second method is steganography, where the secret message is inserted in another medium [1]. Steganography is the art of hiding information through original files in such a manner that the existence of the message is unknown. The term steganography comes from Greek word stegano, which means, “Covered Writing”. The original files can be referred to as cover text, cover image, or cover audio. After inserting the secret message it is referred to as stego-medium. A stego-key is used for hiding process to restrict detection and/or recovery of the embedded data. While cryptography protects the content of messages, steganography hides the message so that intermediate persons cannot see the message [1].

A. Difference between Cryptography and Steganography

- The principle of cryptography is to secure communications by changing the data into a form that cannot be understood.
- Steganography techniques, on the other hand, hide the subsistence of the message itself, which makes it complicated for a third person to uncover out where the message is.
- Sometimes sending encrypted information may draw attention, while invisible information will not.
- Consequently, cryptography is not the good solution for secure communication; it is only part of the solution. Both techniques can be used together to better protection of information.

B. Types of Steganography

The steganography can be classified according to its importance and goals [2].Steganography Techniques are broadly classified into two categories; spatial domain techniques and transform domain techniques. Spatial domain methods, which are more popular, take the advantage of a human visual system and directly embed data by manipulating the pixel intensities. In transform domain procedures, the image is first transformed into a frequency domain and then the message is embedded. Depending upon the embedding and extraction procedures used, Steganographic systems can again be classified into the following three different categories [3]:

1) Pure Steganography (No Key Steganography -NKS): This is the simplest and weakest form of Steganography in which the secret message is directly embedded into the cover image without any encryption. The success of this hidden communication depends on upon the assumption that parties other than the intended receivers (attackers) are not aware of the existence of the secret message within.

2) Public Key Steganography (PKS): This method uses a pair of public and private keys to hide the secret information. The key benefits of this system are its robustness as well as easy key management. The method is robust because the parties other than the intended receivers need to know both the private and public keys used for

embedding and the encryption algorithms used, in order to be able to extract the hidden information.

3) Secret Key Steganography (SKS): In this form of Steganography, both the receiver and transmitter have commonly agreed upon secret keys. The secret message is embedded into and extracted out of the stego image using these keys. The keys can be separately shared between both parties using some confidential channel prior to the actual transmission starts. The robustness of this system, of course, lies with the secrecy of the keys and the difficult part in this method is how to share the keys between the transmitting and receiving parties maintaining their secrecies.

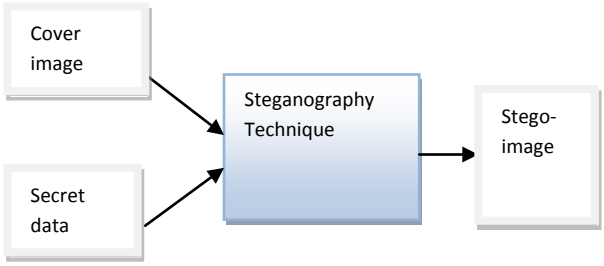

Figure 1.1: Image Steganography process

In this work, we use steganography and cryptography algorithm with DTWT high boost filter technique to make our image data highly secure. The experimental result and analysis are performing by MATLAB2012a simulation tool. The comparative analysis is done using some performance measuring parameter PSNR (Peak Signal to Noise Ratio), MAE (Mean Absolute Error), NAE (Normalized Absolute Error) and NCC (Normalized Cross Correlation). The organization of the remaining section is arranged in this way: Section II discusses the literature work. In section, III discusses our proposed methodology. Section IV present experimental result and its analysis and last section conclude the whole paper.

2. RELATED WORK

Lots of works have been done in the field of image security. In This section presents the former work done by different researchers to prevent the image from unauthorized access.

Chouksey et al. [4] proposed a combination of DWT decomposition and singular value decomposition (SVD) to achieve effective hiding of secret information into an image. The proposed technique finds out the pixels to hide secret data (Text) by performing two approaches successively. The first approach (DWT) decomposes the cover image iteratively to find the high-frequency components of it since human eyes are less sensitive to high frequency. The second approach (SVD) again decomposes the high-frequency components of the cover image to find singular value matrix where secret data can be hide securely. The BER has been used as a comparison parameter for proposed work and previous work. In addition to this, noise is also added before transmitting the data hidden image called ‘Stego' image. The BER between retrieve data and original data is simulated. ***Gunjal et al. [1]*** proposed technique use a combination of steganography and cryptography for improving the security. The proposed technique use Discrete Cosine Transform (DCT) and Blowfish algorithm. The proposed method calculates LSB of each DC coefficient and replaces with each bit of secret message. The proposed embedding method using DCT with LSB obtained better PSNR values. Blowfish algorithm is used for encryption and decryption of text message using a secret-key block cipher. This technique makes sure that the message has been encrypted before hiding it into a cover image. Blowfish is an improvement over DES, 3DES, etc designed to increase security and to improve performance. ***Shah et al.[5]*** presented an image steganography that combines Discrete wavelet transform(DWT),Least significant bit(LSB) and Encryption techniques on raw images to enhance the security of secret message. Initially, DWT algorithm is used to transform the image from spatial domain to frequency domain. Then we encrypt our message using DES. Finally, we embed secret bits into the cover image to derive stego-image using LSB. ***Bharathi et al. [6]*** proposed a multi-resolution wavelet domain by collaborating the concepts of steganography and cryptography. Initially, we use a modified blowfish algorithm and will embed the encrypted message into an image. At the later part of the technique discrete wavelet transform is used so that the stagnated image is transformed into approximation and detailed image. The final reduced image is subjected into the receiver and the vice versa of the technique is used to obtain the plain text. The experimental results of this technique are unanimous and it’s found to be less suspicious. ***Prasad et al. [7]*** proposed a Highly Secure steganography algorithm. This process contains three stages. In the first stage, the text is encrypted by using a traditional encryption method i.e. Caeser method. In the second stage the cipher text is again encrypted by using the chaotic neural network and in the third stage, the resulting encrypted text is embedded inside the image using DWT. High security can be achieved by encrypting the text using Chaotic Neural Network. The binary sequence of the encrypted text created by Chaotic neural network is unpredictable making it highly secure. The Proposed algorithm is tested against different gray scale images considering PSNR, MSE, and SSIM for evaluation. It is observed that the security is increased with acceptable PSNR compared to other methods. ***Vijay et al. [8]*** proposed an Integer Wavelet Transform is performed on a gray level cover image and in turn, embeds the message bit stream into the LSB's of the integer wavelet coefficients of an image . The main purpose of the

proposed work is to focus on improving embedding capacity and bring down the distortion occurring to the stego image. The refinement of the algorithm plays an important role in accomplishing higher embedding capacity and low distortion rate. The experimental results prove that the assessment metric such as PSNR is improved in a high manner. The experimental results show that the algorithm has a high capacity and a good invisibility. ***Tripathy et al. [9]*** proposed a secured steganography method using the genetic algorithm to protect against the RS attack in color images. The proposed steganography scheme embeds a message in integer wavelet transform coefficients by using a mapping function. This mapping function based on GA in an 8x8 block on the input cover color image. After embedding the message optimal pixel adjustment process is applied. By applying the OPAP the error difference between the cover image and stego image is minimized. Frequency domain technique is used to increase the robustness of proposed method. Use of IWT prevents the floating point precision problems of the wavelet filter. GA is used to increase the hiding capacity of image and maintains the quality of an image. Experimental results are shows that the proposed steganography method is more secured against RS attack as compared to existing methods. The result showed that Peak signal to noise ratio and image utilization, 49.65 db and 100% respectively.

3. PROPOSED METHODOLOGY

In the proposed steganography method, here for the information hiding using a hybrid combinatorial method of applying compression to the image and then encryption is done on the compressed image so that the information hide is made secure from various attacks. Finally, the encrypted image is embedded with the cover image using Spread Spectrum based method, after that at the reverse process they used high boost designed filter for enhancement purpose of the revert image quality.

Main steps of the proposed method are as follows:

1. Called input image via uigetfile() dialog and a secreted image
2. Apply JPEG-LS based technique into the original image, the proposed JPEG-LS compression generates a series of more than 50 compressed images with the included compression factor from which the most compressed image is taken.
3. The highly compressed image is then encrypted using Block Cipher.
4. Finally, the encrypted is embedded with the cover image to get the resultant steganography image which is then sent to the receiver.
5. Now for the retrieval of information from the steganography image receiver needs to apply reverse procedure.
6. The received steganography image is then decrypted using the same Block Cipher technique.
7. Apply high boost filter to improve image quality with gauss method.
8. On the Decrypted image decompression is done using JPEG-LS technique.
9. Finally Information retrieval is done using spread spectrum technique.

3.1 INPUT IMAGE & SECRETE IMAGE

For the testing of the proposed methodology several Gray scale and Color, images are taken from various sources of various types. The images include high dynamic images as well as Gray level images and Color images so that the proper working of the methodology is computed.

3.2 JPEG-2000 LS COMPRESSION TECHNIQUE

The figure shown below is the standard architecture or the working of the proposed JPEG-2000 LS compression technique. The compression technique proposed consists of various phases such as preprocessing, DWT and quantization and arithmetic coding and bit-stream organization. The input JPEG 2000 image may contain one or number of components. Since a typical color image contains three components i.e. RGB or YCbRr.

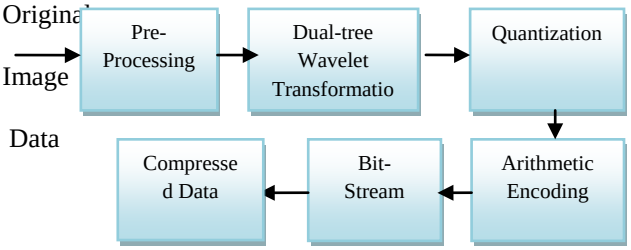

Figure 3.1 Flow chart of the JPEG-2000 LS Compression Technique

3.2.1 Pre-Processing

The pre-processing is the first stage of the jpeg-2000 ls compression which includes the partition of an input image into a number of rectangular and non-overlapping tiles of equal size. The size of the tiles depends on the size of the original input image. Each tile is compressed independently using its own set of specified compression parameters. Tiling is particularly useful for applications where the amount of available memory is limited compared to the image size.

Now the unsigned samples from each of the components are level shifted by subtracting a fixed value of 2^{B-1} from each of the samples to make its value symmetric around zero. Signed sample values are not level shifted. Similar to the level shifting performed in the JPEG standard, this operation simplifies certain implementation issues (e.g., numerical overflow, arithmetic coding context

specification, etc.), but has no effect on the coding efficiency. Part 2 of the JPEG2000 standard allows for a generalized DC offset, where a user-defined offset value can be signaled in a marker segment.

Finally, the level-shifted values can be subjected to a forward point-wise inter-component transformation to de correlate the color data. One restriction on applying the inter-component transformation is that the components must have identical bit-depths and dimensions. Two transform choices are allowed in Part 1, where both transforms operate on the first three components of an image tile with the implicit assumption that these components correspond to red–green–blue (RGB). One transform is the irreversible color transform (ICT), which is identical to the traditional RGB to YCbCr color transformation and can only be used for lossy coding. The forward ICT is defined as:

$$\begin{pmatrix} Y \\ C_b \\ C_r \end{pmatrix} = \begin{pmatrix} 0.299 & 0.587 & 0.114 \\ -0.16875 & -0.33126 & 0.500 \\ 0.500 & -0.41869 & -0.08131 \end{pmatrix} * \begin{pmatrix} R \\ G \\ B \end{pmatrix}$$

The above-defined equation can be written as:

$$Y = 0.299(R - G) + G + 0.114(B - G),$$

$$C_b = 0.564(B - Y), C_r = 0.713(R - Y),$$

While the inverse ICT is given by

$$\begin{pmatrix} R \\ G \\ B \end{pmatrix} = \begin{pmatrix} 1.0 & 0 & 1.402 \\ 1.0 & -0.34413 & 0.71414 \\ 1.0 & 1.772 & 0 \end{pmatrix} * \begin{pmatrix} Y \\ C_b \\ C_r \end{pmatrix}$$

The other transform is the reversible color transform (RCT), which is a reversible integer-to-integer transform that approximates the ICT for color de correlation and can be used for both lossless and lossy coding. The forward RCT is defined as

$$\boldsymbol{Y = \left\lfloor \frac{R + 2G + B}{4} \right\rfloor, U = R = G}$$

$$\boldsymbol{V = B - G}$$

Where b c w denotes the largest integer that is smaller than or equal to w: The Y component has the same bit-depth as the RGB components while the U and V components have one extra bit of precision. The inverse RCT, which is capable of exactly recovering the original RGB data, is given by

$$\boldsymbol{G = Y - \left\lfloor \frac{U + V}{4} \right\rfloor, R = U + G, B = V + G}$$

At the decoder, the decompressed image is subjected to the corresponding inverse color transform if necessary, followed by the removal of the DC level shift. Since each component of each tile is treated independently, the basic compression engine for JPEG2000 will only be discussed with reference to a single tile of a monochrome image.

3.2.2 Dual-Tree Wavelet Transformation

In this technique, DT-WT has been employed in order to preserve edges (i.e) high-frequency components of the image. The DT-WT has good directional selectivity as compared to discrete wavelet transform (DWT).The DTWT is approximately shift invariant, unlike the critically sampled DWT. The redundancy and shift invariance of the DT-WT means that DT-WT coefficients are inherently interpolable[8].In this method, DT-WT is used to decompose an input image into different low and high-frequency subband images.The real 2-D dual-tree DWT of an image x is implemented using two critically-sampled 2-D DWTs in parallel. Then for each pair of sub-bands sum and difference is calculated. The complex 2-D DT-DWT also gives wavelets in six distinct directions. The complex 2-D dual-tree is implemented as four critically-sampled separable 2-D DWTs operating in parallel as shown in figure(3.2).The pair of conjugate filters applied to two-dimensional images (x, y) can be expressed as :

$$(h_x + jg_x)(h_y + jg_y) = (h_x h_y - g_x g_y) + j(h_x h_y + g_x g_y)$$

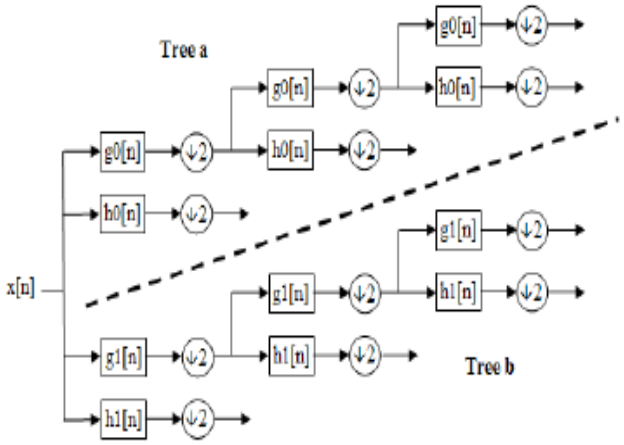

Figure 3.2: Structure of DT-WT

3.2.3 Quantization

The JPEG baseline system employs a uniform quantizer and an inverse quantization process that reconstructs the quantized coefficient to the midpoint of the quantization interval. A different step size is allowed for each DCT coefficient to take advantage of the sensitivity of the human visual system (HVS), and these step-sizes are conveyed to the decoder via an 8 * 8 quantization table (q-table) using one byte per element. The quantization strategy employed in JPEG2000 Part 1 is similar in principle to that of JPEG, but it has a few important differences to satisfy some of the JPEG2000 requirements.

3.3 SHA algorithm for Authentication

Step 1: Append Padding Bits….

The message is "padded" with a 1 and as many 0's as necessary to bring the message length to 64 bits fewer than an even multiple of 512.

Step 2: Append Length....

64 bits are appended to the end of the padded message. These bits hold the binary format of 64 bits indicating the length of the original message**.**

Step 3: Prepare Processing Functions….

SHA1 requires 80 processing functions defined as:

f(t;B,C,D) = (B AND C) OR ((NOT B) AND D)(0 <= t <= 19)

f(t;B,C,D) = B XOR C XOR D (20 <= t <= 39)

f(t;B,C,D) = (B AND C) OR (B AND D) OR (C AND D) (40 <= t <=59)

f(t;B,C,D) = B XOR C XOR D(60 <= t <= 79)

Step 4: Prepare Processing Constants....

SHA1 requires 80 processing constant words defined as:

K(t) = 0x5A827999(0 <= t <= 19)

K(t) = 0x6ED9EBA1(20 <= t <= 39)

K(t) = 0x8F1BBCDC(40 <= t <= 59)

K(t) = 0xCA62C1D6(60 <= t <= 79)

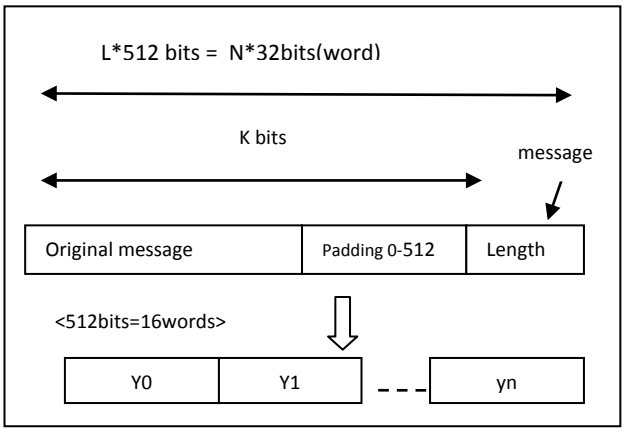

Figure 3.3: Flow chart of the SHA Technique

3.4 WORKING OF SPREAD SPECTRUM

1. Take an input image and a secreted image.

2. Choose alpha value which denoted signal strength factor in spread spectrum algorithm, here in our work we assume alpha=5;

3. Calculate DTWT of the original image which is used for the transformation of the image to be embedded.

4. Calculate a total number of pixels of the original image and steganography image.

5. Calculate aj=bj where ir<=j<(i+1)r.

6. Calculate signal as wj=alpha*aj*pj, where pj= {+1,-1}.

7. Now they will find the kernel of the image by taking kernel size 31 and by taking the level of the kernel size as 3 we will find the kernel image of the original image by calculating kernel image = (1/(2*pi*s^2))*exp(-((X-m).^2 + (Y-m).^2)/(2*s^2));

8. This signal is then embedded with the kernel image to get the final steganography image.

The embedding process is carried out by first generating the signal W by using secured information bits, chip rate and PN sequence. The steganography information bits b= {bi}, where bi = {1,-1} are spread by r, which gives

$$a_j = b_i, \qquad ir \le j < (i+1)r$$

The sequence aj is then multiplied by alpha>0 and P. The signal W= {wj},where

$$w_j = \alpha a_j P_j$$

Where, pj= {1,-1} the steg signal generated is added to the encrypted signal, to give the steganography signal Cw.

$$C_w = C + W = c_{wi} = c_i + w_i, \qquad \forall_i = 0,1, \dots\dots, L-1$$

The encrypted value of M2 denoted by C2 is

$$c_{2i} = (m_{2i} + k_{2i})\ mod\ 255 \ \ \forall_i = 0,1, \dots\dots, L-1$$

3.5 Kernel Based Image Detection

1. ksize_image = 31;

It is the kernel size that we want to make the sie of the kernel.

2. kernel = zeros(ksize_image);
Whatever the size of the kernel makes the pixel value of all zeros.
3. s = 3;
It is the segmented part from the kernel image.
4. [X, Y] = meshgrid(1:ksize_image);
Generate X and Y arrays for 3-D plots from 1 to the size of the kernel and stores rows and columns in X and Y.

5. kernel_image = (1/(2*pi*s^2))*exp(-((X-m).^2 + (Y-m).^2)/(2*s^2))
6. Now calculate the original kernel by reducing the total size and the size of the kernel taken.Kernel image is used for the embedding of kernel region in the image the total effect of blurriness is pointed out so that it will be helpful for the detection of embedding part of the image.

3.6 FLOW CHART OF THE METHODOLOGY

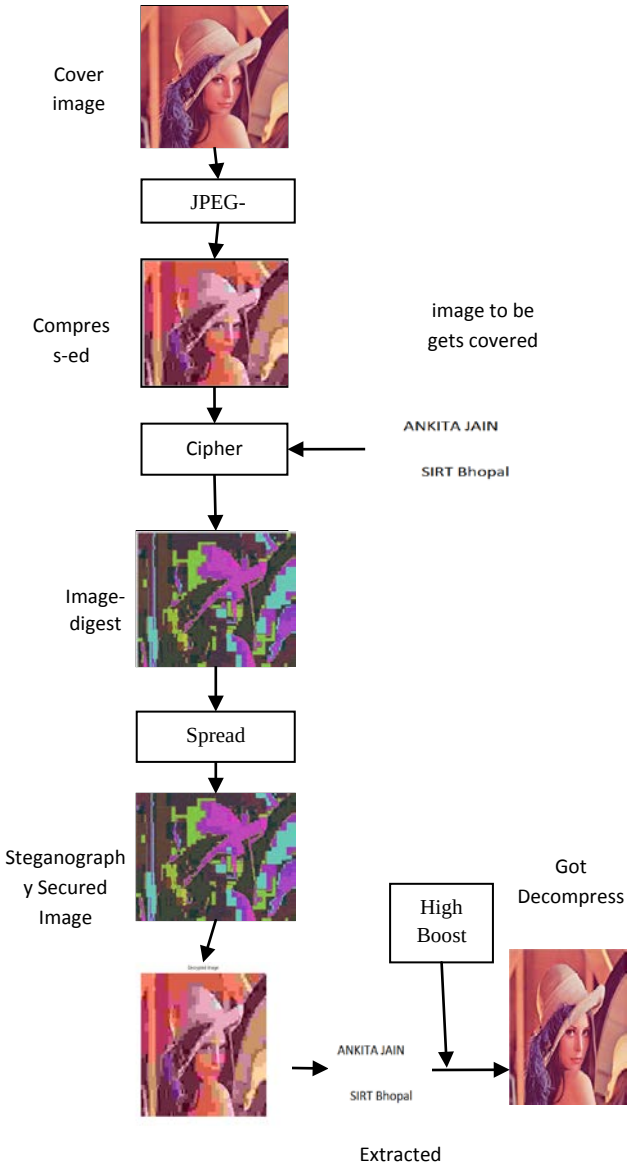

Figure 3.3: Flow Chart of the Proposed Methodology

The proposed methodology applied here for the security of information that is hidden inside the original image is implemented here. The proposed methodology is a combinatorial method of applying compression and encryption and steganography for the successful prevention of various attacks in the network. The information to be hidden is first compressed using JPEG-2000 LS compression technique; JPEG-2000 LS compression generates a series of compressed images on the basis of compression ratio.

The most compressed image is then taken for further process. The compressed image is taken and is encrypted using block cipher. The encrypted image and the cover image is taken and steganography this two image to generate steganography image using spread spectrum method. The flow chart shown above is the separate working process of the methodology.

4. EXPERIMENTAL RESULTS

This chapter describes the used dataset while result testing, implementation methodology and details of the experimental result analysis.

Experimental Setup

To investigate the effectiveness of the proposed methodology, there are lots of programming language and simulation are available in the current scenario, but here we chose a most reputed and high-level fourth generation high-level language Matlab 2012a with windows 7 professional version for experimental setup, in addition Intel Core I3-2.20 GHz processor, 4 GB RAM, NVIDIA graphics hardware are used.

4.1 SNAPSHOTS

The figure shown below is the original image which needs to get steganography. The figure 4.1(a) shows the original cover image, figure 4.1 (b) shows the compressed image and the figure 4.1 (c) show the compressed image including encrypted image.

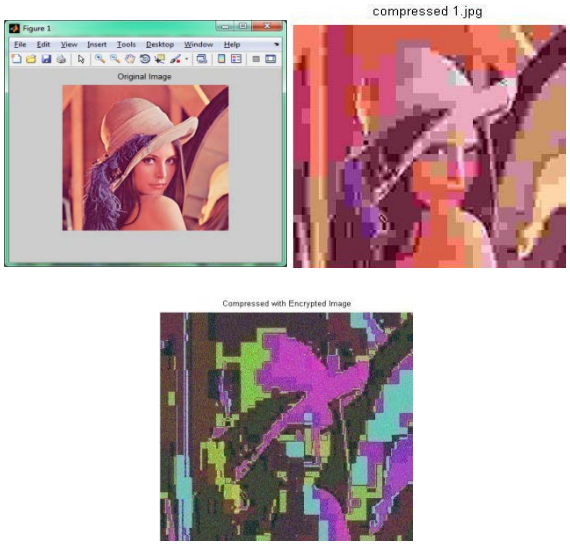

Figure 4.1: a) original Image b) compressed image c) encrypted image

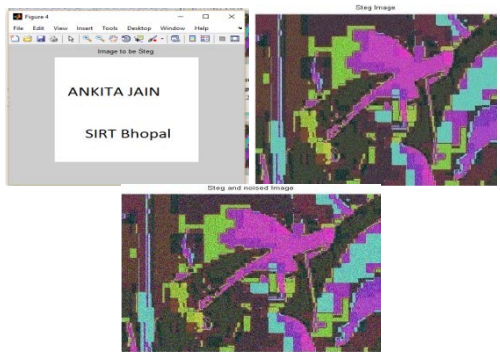

Figure 4.2: a) processed image and noisy image

The figure shown below is the image to be get embedded and the resultant steganography image and the secured image containing noise. The figure 4.2 a) is the images to be watermarked figure 4.2 (b) shows the resultant image and figure 4.2 (c) is the resultant image with noise.

The figure shown below is the extraction process where the extraction of stego image is to be done. The figure shows the extracted stego image and decompressed image and the decrypted image respectively.

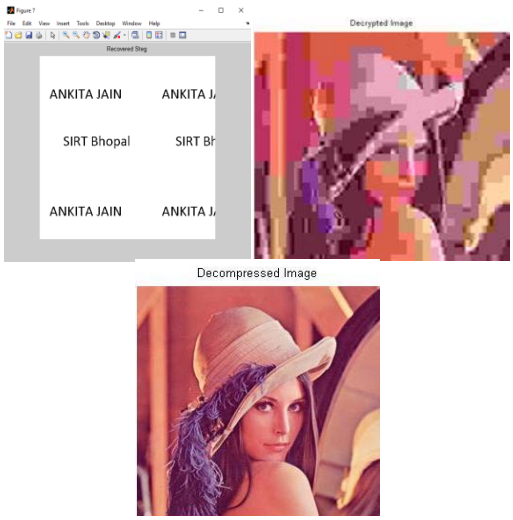

Figure 4.3: a) extracted image b) decompressed image c) decrypted image

4.2 RESULT ALANYSIS

The table shown below is the analysis of various encoding algorithm used for the compressing of images. The analysis is done on the basis of various parameters such as Peak Signal to Noise Ratio, MAE, NAE and NCC for various methodologies. The experimental results are performed on different Standard images and show that comparative analysis of different parameters and found that the proposed methodology produced the better result.

Table 4.1: Result analysis of proposed method

Image's	PSNR-P	MAE-P	NAE-P	NCC-P
lena	59.7925	0.0682	4.9522	1
pepper	53.3044	0.2413	0.0012	1.0001
pills	57.4229	0.1177	7.7347	1
f15.tif	58.2171	0.098	8.0205	1
f16.tif	58.2477	0.0973	5.2709	1
bandon.tif	49.983	0.6528	0.0033	0.998
brandyrose.tif	56.4028	0.1489	8.7987	1

Table 4.2: Result analysis of Existing method

Image's	PSNR-E	MAE-E	NAE-E	NCC-E
lena	26.0403	12.7211	0.0509	1.0208
pepper	27.3175	10.9816	0.0508	1.0208
pills	26.7469	11.7273	0.0489	1.0187
f15.tif	23.9793	16.1279	0.0566	1.0277
f16.tif	28.7937	9.2652	0.0326	1.0131
bandon.tif	34.5913	4.7531	0.0633	1.013
brandyrose.tif	28.6449	9.4253	0.041	1.0127

Table 4.1 and table 4.2 shows the experimental result analysis of the proposed and existing method in which we found that the proposed method gives better results than the exiting method. The PSNR and NAE (Normalized Absolute Error) results of our method are much more than the existing method which should be more and MAE (Mean absolute error) and NCC (Normalized Cross Relation) results of our method are very less than existing method which should be less. It means that our proposed approach is much better than the existing method and the comparative analysis is shown through a graph.

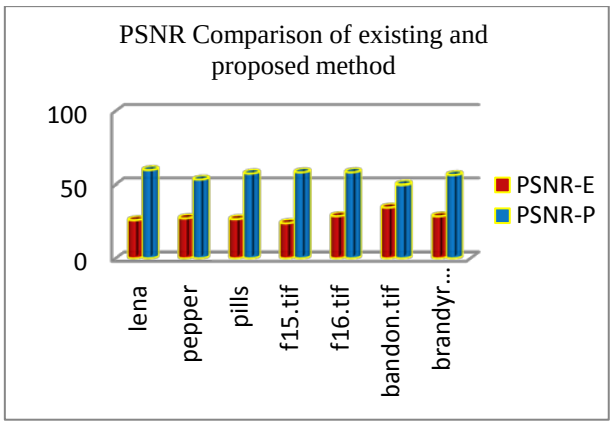

Figure 4.4: PSNR Comparison of existing and proposed method

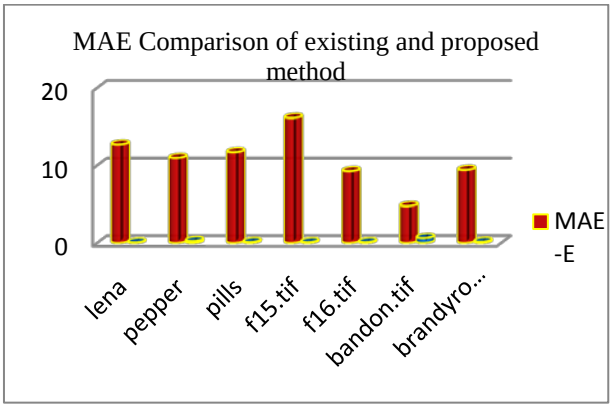

Figure 4.5: MAE Comparison of existing and proposed method

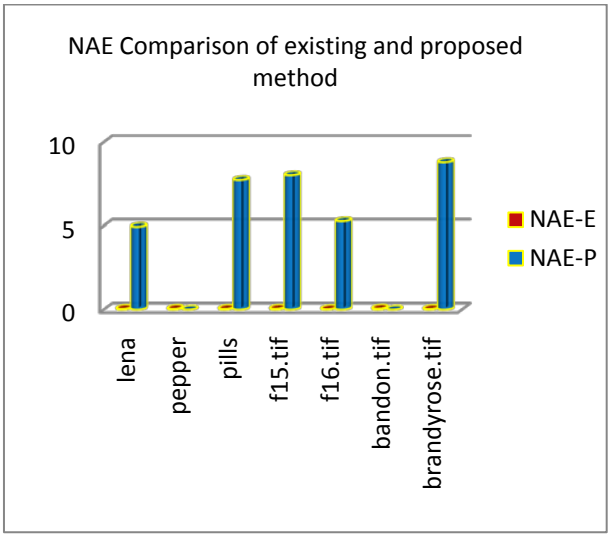

Figure 4.6: NAE Comparison of existing and proposed method

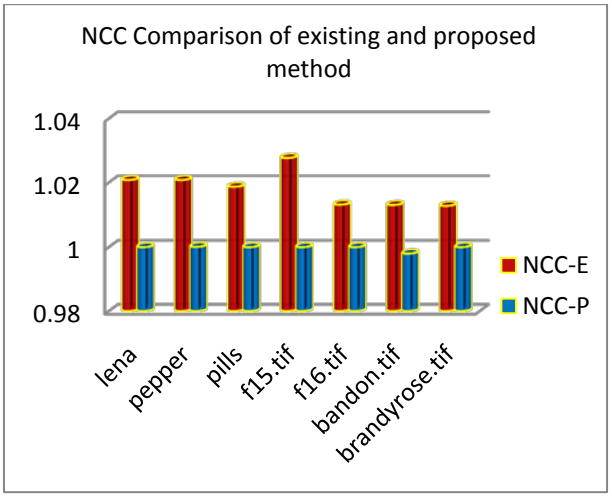

Figure 4.7: NCC Comparison of existing and proposed method

5. CONCLUSION

To provide high security to image data steganography and cryptography is combined. The proposed method uses the DTWT with high boost filter and SHA algorithm. This method encrypts secret information before embedding it in the image. For encryption and decryption use SHA algorithm which provides better security to image. The comparison of the proposed methods is done with existing method which gives better results with respect to PSNR, MAE, NAE and NCC performance measuring the parameter. By embedding capacity of this method outperforms than the existing method.

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