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Performance Evaluation of LSB Substitution and DWT Method for Steganography

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Abstract— Data secrecy has become a main concern in the recent period. Many new techniques are employed to hide the secret data in some or the other form. This method of hiding the data into another form is called as Steganography. Likely, an old term in Ancient Greek, Steganography is derived from steganos meaning "concealed" and graphein meaning "writing". This paper emphasizes on the two major techniques employed in Steganography – Discrete Wavelet Transform and LSB Substitution.

Keywords— Secret data, Host data, DWT, LSB substitution.

I. INTRODUCTION

Traditionally, some people used a secret way to hide data from open view. This secret data was hidden into an image with some kind of invisible ink which was visible under strong sunlight or through some lenses. This method of data hiding became familiar in the 18th century. Some among them were Cartographers who used these techniques to hide a treasure on a map. This most valued and significant technique which added security aspect is known as Steganography. But over a period of 8-12 years there has been a significant transition from Analog data to digitally transformed data. A digital data can be processed since it is encoded in two digits. With the growth of internet, prominent advancements took place in the internet banking and other online transactions.Hence a need of more secure and sophisticated methodology to protect the data emerged.

In the digital world, various schemes are adopted to hide data. The commonly used among those are Steganography and Watermarking. Steganography is applying some cover image to protect data from Intruder [1]. On the other hand Watermarking protects the copyright of the owner by embedding a signature into it. This technique is employed to digital albums, documents, records etc [1][2]. Steganography system must follow three main conditions: (1) **Invisibility**: The secret data should not be visible with naked eye view. (2) **Capacity**: A cover image must hold more embedded secret data, this will increase the image size to a greater extent but still huge data is embedded. Consequently image quality will degrade to a greater extent. So a trade-off between these two factors must be maintained [3].(3) **Robustness**: The Stego image must hold secret data even after some noise is added to it.

These three condition holds the reliability and prevention against most popular attacks like Steganalysis [4].

Steganography incorporates two major algorithms, firstly embedding algorithm [5] and other one is extracting the Secret image. Technical names used for images are Host image which is visible to everyone.Secret image which is to be hidden.Stego image containing visible host image and hidden Secret image.Extracted Secret image is the data retrieved from a Stego image.

Steganography is divided into two main categories:

1. Spatial Domain and
2. Frequency Domain.

Spatial Domain includes Least Significant Bit Substitution, DC Coefficient LSB and Frequency Domain includes Discrete Wavelet Transform, Discrete Cosine Transform etc. Each category has its own advantages. LSB substitution has more embedding capacity while DWT has more robustness.Different parameters like Peak Signal to Noise Ratio (PSNR) and Mean Square Error (MSE) are used to measure the efficiency of the Stego image.

The following paper is organized as follows: Section 2 provides a brief idea of prior related work, section 3 gives the algorithm and general information of LSB Substitution method. In section 4, algorithm and selection criteria of DWT are discussed. Section 5 gives quality parameters. Section 6 demonstrates analysis and results of different images under test. Section 7 briefs the best applicable technique for different class of images.

II. RELATED KNOWLEDGE

A significant work was carried on LSB method by SHIUH-JENG WANG [6].In Fig 1, Wang demonstrated a technique that increasedthe security of an image by first embedding the secret image C into Host Image H and the Stego Image Z

was obtained by multiplying C with aSubstitution matrix. Here k is the length of the LSB bits. The image C is then decomposed to get C' which is then randomized to increase security and results into C''. R contains the LSB bits of H. C'' is then subjected to N*N substitution matrix which increases the embedding capacity. C^x is the optimal image with minimum MSE. The k LSB bits of H are replaced with C^x to get the Stego image.

Kekre [5] made the use of DCT wavelet transform for hiding image. This method uses middle frequency coefficients for embedding secret data. The use of middle frequency coefficients proved to be robust for lossy Image compression Khaled, Loukhaoukha [7] used DWT and single value decomposition. This technique provides uncorrelated coefficients. DWT decomposes an image into 4 major sub bands which are described in the section 4.

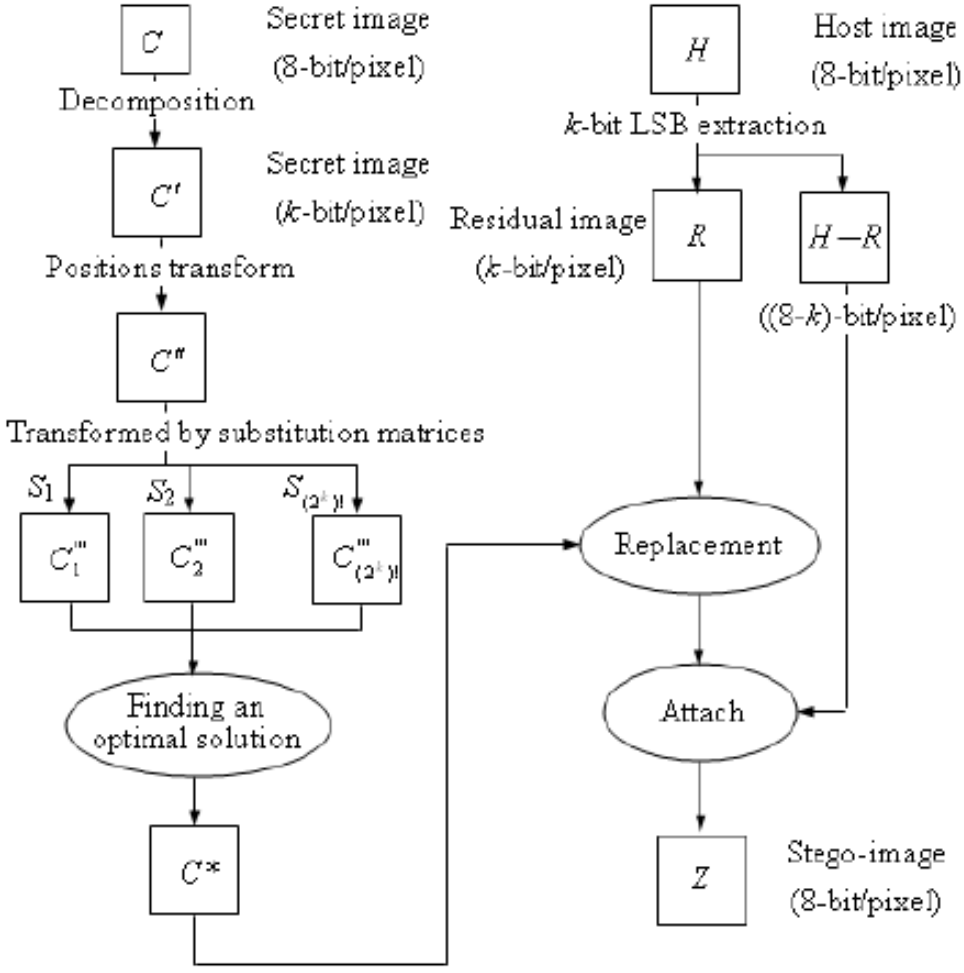

Fig 1. Shiuh-Jeng Wang Model

III. LEAST SIGNIFICANT BIT SUBSTITUTION

LSB substitution is the most adapted method to increase capacity by reducing the quality of image.A digital image is represented by two digits that is 1 or 0. The concept of LSB is associated with the bit position in an image. The lower (rightmost) bits in an 8 bit grey level plane of host image carries very less significant information. While the most significant bits (leftmost) carries the most of the information. LSB substitution makes use of this bit position and smartly replaces the least significant bits of host image with most significant bits of secret image.

The mathematical representation of LSB method can be given as [1]:

$$x_i' = x_i - x_i \bmod (2^k) + m_i \quad (1)$$

In equation (1),

x_i' denotes I_{th} pixel values of Stego image.

m_i is the decimal value of the I_{th} block in secret image.

k is the number of LSB substituted.

On the other hand, the mathematical representation of extracted image is given as[1]

$$m_i = x_i' \bmod 2^k \quad (2)$$

Thus a simple bit shift that is permutation gives straight forward results.

As seen from Fig 2 and Fig 3, the host and the secret image need to be of same dimension for carrying out LSB method.

The value of "n" decides the number of bits t be substituted.

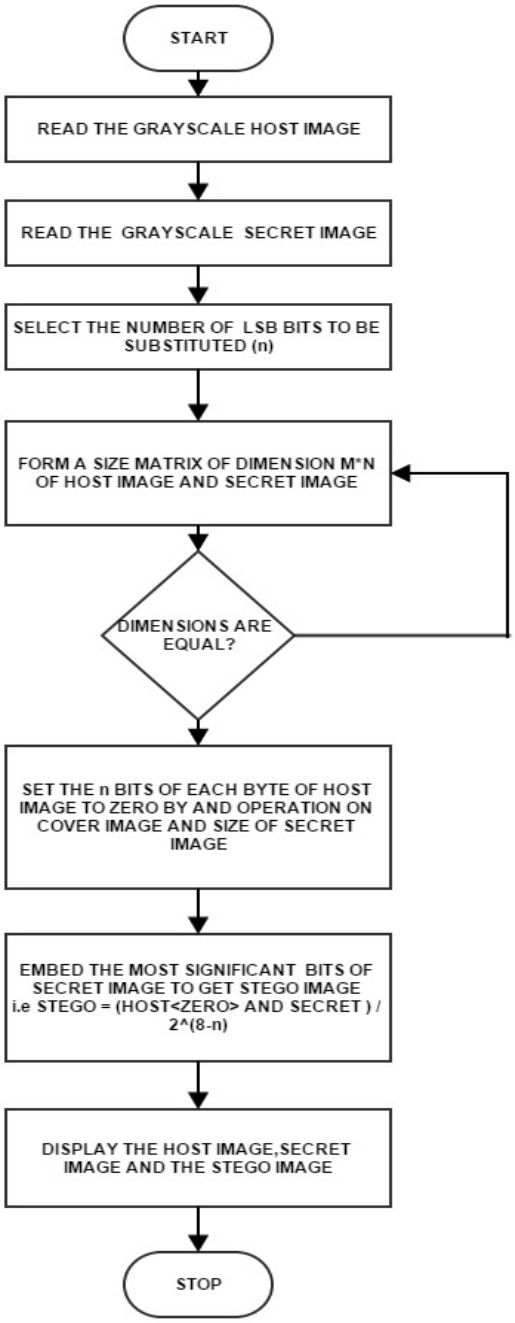

Fig 2. Flowchart for embedding the data using LSB substitution

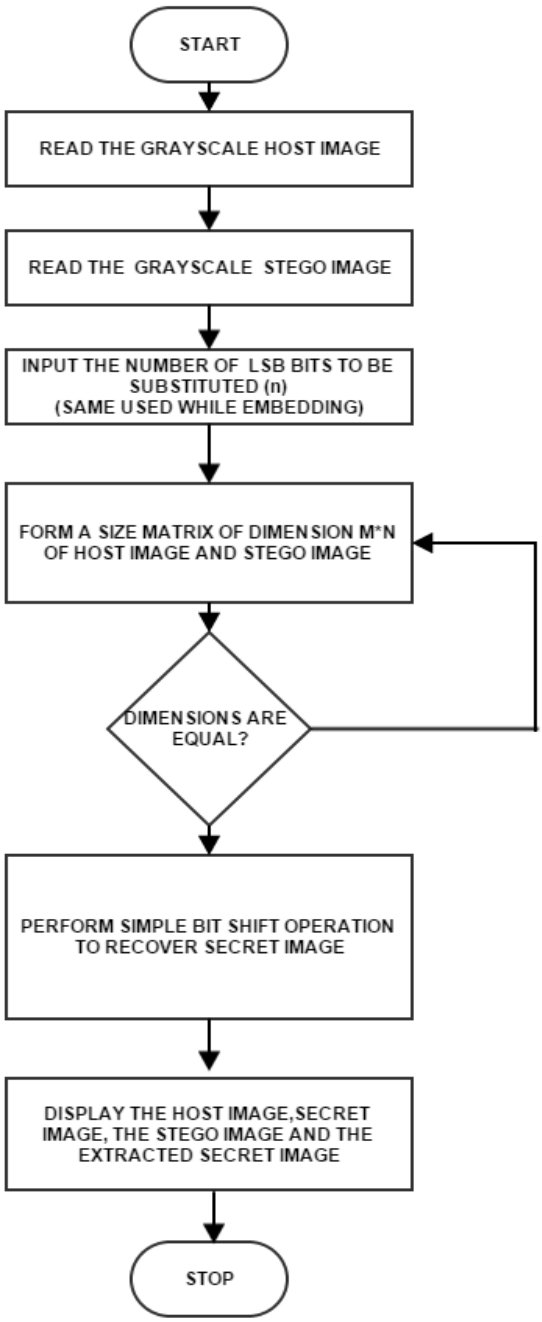

Fig 3. Flowchart for extracting the data using LSB substitution

IV. DISCRETE WAVELET TRASFORM:

Transformation is generally used to uncorrelate the wavelet coefficient. It converts an image from spatial domain to frequency domain. The mathematical representation of wavelet transform is given by formula [8]:

$$F(a,b) = \int_{-\infty}^{\infty} f(x)\Psi^{*}_{(a,b)}(x)\,dx \qquad (3)$$

Wavelet transform is a convenient means to split an image into 4 frequency bands.

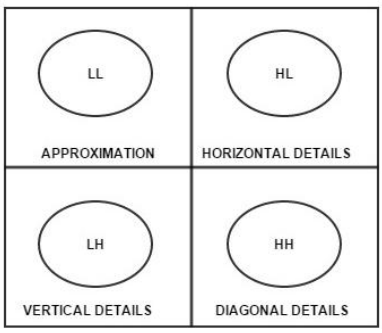

Fig 4. Frequency bands in DWT

As seen from the Fig 4, LL band is low frequency band containing most of the information of the secret image. Steganography makes use of this band for altering or modifying data to make it undetectable with human eye.Thus more decomposition levels are applied to an image to make it look like an unaltered image.

The embedding algorithm describes 3 level of decomposition to more approximate details of an image.

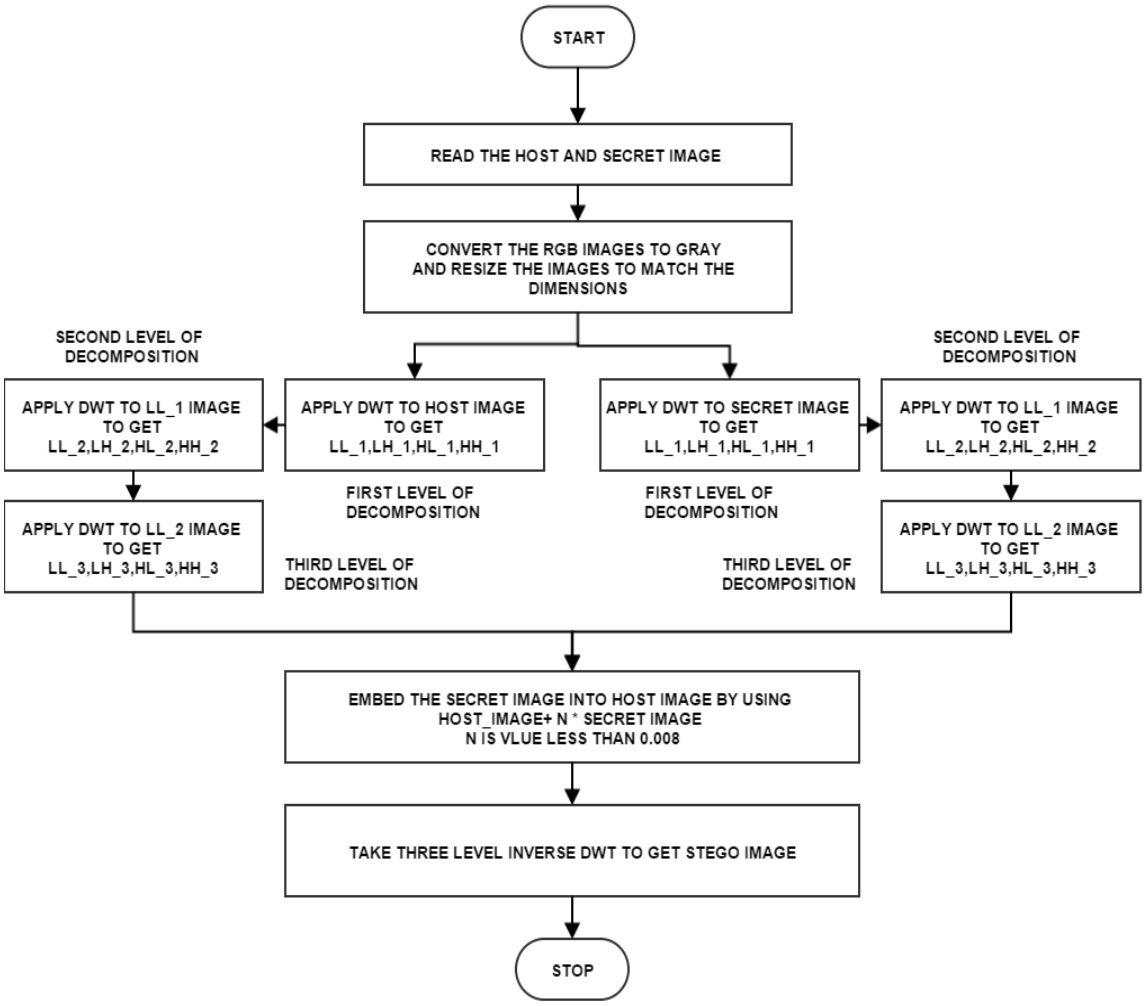

Fig 5. Embedding algorithm for LSB substitution with 3 level of DWT

Three level decomposition is employed as shown in Fig 5. to get more detailed image that is LL band.

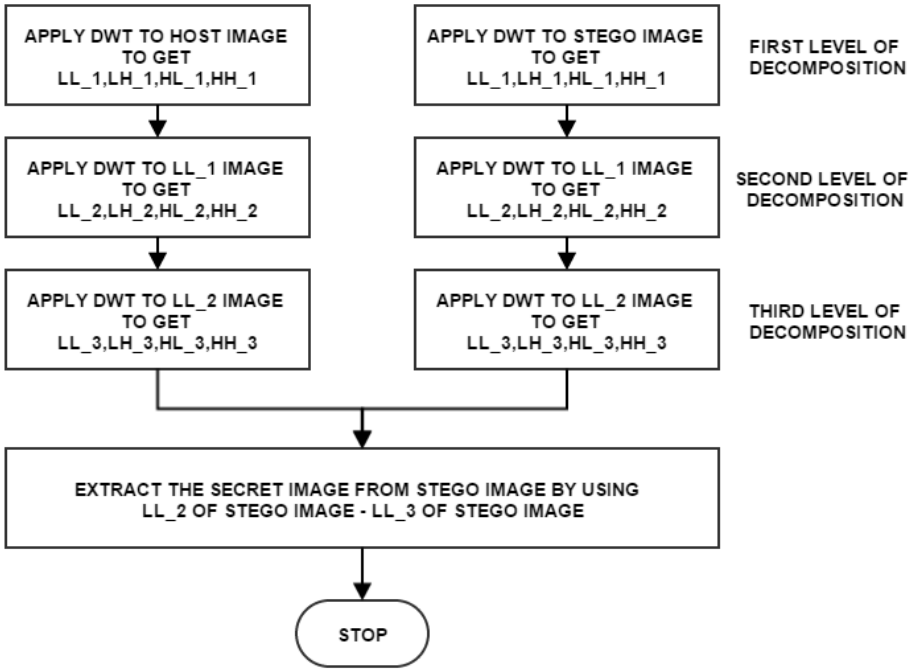

Fig 6. Extracting algorithm for DWT method

V. QUALITY PARAMETERS

The two factors which describes the quality of Steganographed image are.

MEAN SQUARED ERROR (MSE): It is a factor to indicate difference in the error. I is grey level image and K is noisy approximation

$$\boldsymbol{MSE} = \frac{1}{m.n}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2 \quad (4)$$

PEAK SIGNAL TO NOISE RATIO (PSNR): It states the fidelity of the system and gives the quality of reconstructed data. It is mathematically represented as:

$$\boldsymbol{PSNR} = 10.log_{10}\left(\frac{MAX_I^2}{MSE}\right)$$

$$= 20.log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right)$$

$$= 20.log_{10}(MAX_I) - 20.log_{10}(MSE) \quad (5)$$

MAX_i is maximum pixel value

VI. RESULTS

LSB Substitution and DWT was performed on different class of images to get a visual indication of best suitable technique for different images. Host image used was landscape.jpg for both the cases.

Results using LSB Substitution method:

Table I Psnr And Mse Values Of Image Of Different Class Using Lsb Method

Class	Secret Image	PSNR	MSE
HUMAN	 girl.jpg	42.2442	3.0323
	 mona.jpg	44.2542	5.0099
	 man.jpg	43.0344	3.0955
ANIMALS	 elephnt.jpg	47.3439	3.3304
	 monkey.jpg	44.0333	4.4655
OTHERS	 fruits.jpg	45.5534	5.5555
	 car.jpg	44.4344	4.6533

	 boat.jpg	43.4577	5.4712

LSB Substitution gives high level of embedding but at the cost of image quality. If more bits are stuffed to hide the data then the secret image traces are visible on the cover image. LSB Substitution is suitable for dark cover image and secret image, where the bits substituted can be hardly visible to a human eye. In our case elephant.jpg is converted into grayscale image gives a PSNR of 47.3439. This high value indicates good quality of reconstructed image. LSB Substitution is apt for ANIMAL CLASS, OTHERS CLASS images.

Results using DWT method:

Table II Psnr And Mse Values Of Image Of Different Class Using Dwt Method

Class	Secret Image	PSNR	MSE
HUMAN	 girl.jpg	48.2332	5.0323
	 mona.jpg	46.2322	4.0099
	 man.jpg	49.0322	4.0955
ANIMALS	 elephant.jpg	45.3439	5.0004
	 monkey.jpg	43.04443	4.5655
OTHERS	 fruits.jpg	45.55454	4.0055
	 car.jpg	43.4454	5.0033
	 boat.jpg	42.3455	5.6711

DWT method decomposes the entire image. It transforms the image rather than manipulating bits. This method produces a irreversible image in terms of quality, image size and brightness and contrast ratio. DWT method gives highest image quality for any light toned image.DWT is suitable for HUMAN CLASS.

Table III comparision of lsb and dwt

Sr. N0	Host Image	Secret Image	Stego(LSB) [4 Bits]	Stego(DWT)	Extracted Image	PSNR (LSB)	PSNR (DWT)
I	 landscape.jpg	 lena.jpg				46.2333	50.2324
II	 landscape.jpg	 parrot.jpg				49.3524	46.1525
III	 landscape.jpg	 duck.jpg				46.2425	42.2435
IV	 landscape.jpg	 plane.jpg				48.3226	46.8276

TABLE III gives a comparative study of LSB substitution and DWT method. Four different class images were considered. The cover image used for all the cases was landscape.jpg. In the case of DWT, lena.jpg gave high PSNR value as compared to other images. On the other hand parrot.jpg, duck.jpg, plane.jpg gave high PSNR using LSB method. This states that a HUMAN CLASS image which has less variation in luminance will be embedded perfectly inside the secret image. LSB substitution method gives high embedding for the images containing variation in the brightness.

VII. CONCLUSION

In this paper, some commonly known steganography techniques were implemented. LSB substitution and DWT are widely used for the same. Each of the method has its own advantage. LSB method embedded about 60% of data bits and retained the same size of the image because only the pixels values were shuffled. In DWT method, the given data is decomposed to get uncorrelated data which changes the image composition. This operation affects the entire image and hence the reconstructed image is smaller in size. DWT method has high privacy and hides secret image very well.

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