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# A DWT Method for Image Steganography

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***Abstract: In this era of Internet every digitized object is transferable and exchangeable over internet for various purposes. As every computer user knows that there are numerous security threats for digitized objects hence methods like steganography are getting more importance day by day. Though steganography is a very old method of hiding information behind some object, but still this is very effective for secure data transfer and data exchange. Today this method is used for digital objects like text, audio, video and images. In this paper a method for image steganography has been discussed, utilising basics of discrete wavelet transform.***

***Keywords: DWT, wavelet, coefficient, image steganography, decomposition, stego***

## I. INTRODUCTION

A wavelet is a small wave which oscillates and decays in the time domain. The Discrete Wavelet Transform (DWT) is a relatively recent and computationally efficient technique in computer science. Wavelet analysis is advantageous as it performs local analysis and multi-resolution analysis. To analyze a signal at different frequencies with different resolutions is called multi-resolution analysis (MRA). Wavelet analysis can be of two types: continuous and discrete. In this paper, discrete wavelet transform technique has been used for image steganography. This method transforms the object in wavelet domain, processes the coefficients and then performs inverse wavelet transform to represent the original format of the stego object.

## II. RELATED KNOWLEDGE

Wavelet transforms (WT) converts spatial domain information to frequency domain information. The Fourier transformed signal $X_{FT}$ (f) gives the global frequency distribution of the time signal x(t). The original signal can be reconstructed using the inverse Fourier transform [1]:

$$X_{FT}(f) = \int_{-\infty}^{\infty} x(t) e^{-j2\pi ft} dt$$
$$x(t) = \int_{-\infty}^{\infty} X_{FT}(f) e^{j2\pi ft} df$$

Before wavelet transform, most well known method for this purpose was Fourier transform (FT). Limitations of FT have been overcome in Short Time Fourier Transform (STFT) which is able to retrieve both frequency and time information from a signal. In STFT along with FT concept, a windowing concept is used. Here FT is applied over a windowed part of the signal and then moves the window over the signal.

$$X_{STFT}(\tau, f) = \int_{-\infty}^{\infty} x(t) g^*(t-\tau) e^{-j2\pi ft} dt$$

The advantage of wavelet transform over Fourier is local analysis. That means wavelet analysis can reveal signal aspects like discontinuities, breakdown points etc. more clearly than FT.

A wavelet basis set starts with two orthogonal functions: the scaling function or father wavelet □(t) and the wavelet function or mother wavelet ψ(t), by scaling and translation of these two orthogonal functions we obtain a complete basis set. Wavelet transform can be expressed by:

 

$$F(a,b) = \int_{-\infty}^{\infty} f(x)\, \psi^*_{(a,b)}(x)\, \mathrm{d}x$$

Where the * is the complex conjugate symbol and function ψ is called wavelet function or mother wavelet.

Wavelet transform can be implemented in two ways: continuous wavelet transform and discrete wavelet transform. Continuous wavelet transform (CWT) can be defined by:

$$X_{WT}(\tau, s) = \frac{1}{\sqrt{|s|}} \int x(t) \cdot \psi^*\left(\frac{t-\tau}{s}\right) dt$$

The transformed signal $X_{WT}$ (τ, s) is a function of the translation parameter τ and the scale parameter s. The mother wavelet is denoted by ψ, the * indicates that the complex conjugate [2].

Where CWT performs analysis by contraction and dilation of mother function, in discrete wavelet transform (DWT) this scenario is different. DWT uses filter banks to analyze and reconstruct signal. This appealing procedure was presented by S. Mallat in 1989 that utilizes the decomposition of the wavelet transform in terms of low pass (averaging) filters and high pass (differencing) filters. A filter bank separates a signal in different frequency bands. DWT of a discrete time-domain signal is computed by successive low pass and high pass filtering as shown in figure, which is known as ***Mallat Tree decomposition*** [3]. In the figure, the signal is denoted by the sequence x[n], where n is an integer. The low pass filter is denoted by $L_0$ while the high pass filter is denoted by $H_0$. At each level, the high pass filter produces detail information or detail coefficients, d[n], while the low pass filter associated with scaling function produces approximate coefficients, a[n]. The input data is passed through set of low pass and high pass filters. The output of high pass and low pass filters are downsampled by 2. Increasing the rate of already sampled signal is called upsampling whereas decreasing the rate is called downsampling.

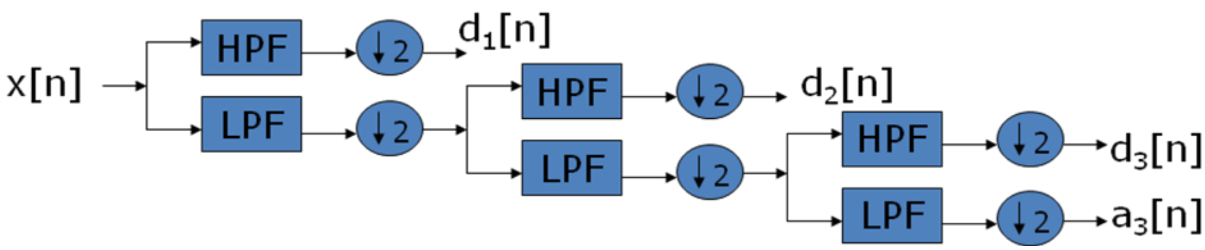


Figure 1: Three-level wavelet decomposition tree.

The DWT of an image represents the image as sum of wavelets. Here four isometrics $S_0$, $S_H$, $S_V$, and $S_D$ with mutually orthogonal ranges, satisfies the following sum rule:

$$S_0 S_0^* + S_H S_H^* + S_V S_V^* + S_D S_D^* = I$$

With I denoting the identity operator in an appropriate Hilbert space $\mathcal{H}$ are used.

Human eyes are less sensitive to high frequency details. Here the Haar DWT - simplest type of DWT has been applied. In 1D-DWT average of fine details in small area is recorded.
In case of 2D-DWT we first perform one step of the transform on all rows. The left side of the matrix contains downsampled low pass coefficients of each row; the right side contains the high pass coefficients as shown in the figure 2[4].

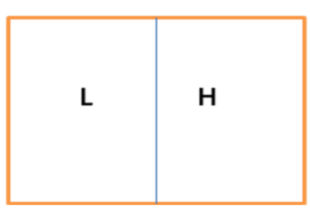


Figure 2: First stage of step 1 wavelet decomposition

 

Next, we apply one step to all columns. This results in four types of coefficients: LL,HL,LH,HH as follows:

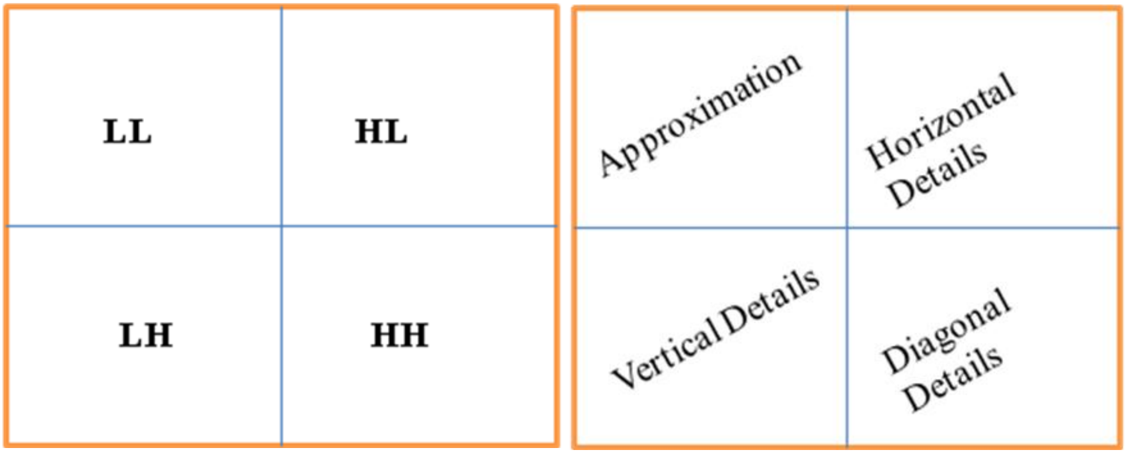


Figure 3: Final stage of step 1 wavelet decomposition

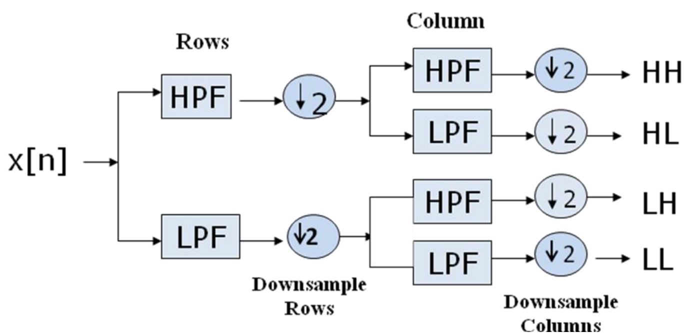


Figure 4: Block Diagram of 1 step 2-D DWT

For example:

Figure 5: original Image Figure 6: After 1 step decomposition by 2D-DWT

The subdivided squares represent the use of the pyramid subdivision algorithm to image processing, as it is used on pixel squares. At each subdivision step the top left-hand square represents averages of nearby pixel numbers, averages taken with respect to the chosen low-pass filter; while the three directions, horizontal, vertical, and diagonal represent detail differences, with the three represented by separate bands and filters. We can continue decomposition of the coefficients from low pass filtering in both directions further in the next step.

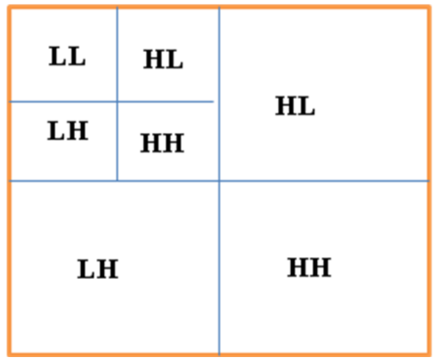


Figure 7: 2 step decomposition

## III. PROPOSED METHOD

If we apply DWT on an image, it divides the image in frequency components. The low frequency components are approximate coefficients holding almost the original image and high frequency components are detailed coefficients holding additional information about the image. These detailed coefficients can be used to embed secret image. Here we have taken an image as cover object and another small image as secret message. In embedding process, first we convert cover image in wavelet domain. After the conversion we manipulate high frequency component to keep secret image data. These secret image data further retrieved in extraction procedure to serve the purpose of steganography.

**Embedding Procedure**

In this step, insertion of secret message onto cover object is carried out. Additional components rather than usual steganographic objects used here is pseudo-random number. Pseudo-random sequences typically exhibit statistical randomness while being generated by an entirely deterministic causal process generator. A pseudo-random number generator is a program that on input a seed, generates a seemingly random sequence of numbers [5].

***Input:*** An m × n carrier image and a secret message/image.
***Output:*** An m × n stego-image.
***Algorithm:***
**Steps-**

1. Read the cover image ($I_c$)
2. Calculate the size of $I_c$
3. Read the secret image ($I_m$)
4. Prepare $I_m$ as message vector
5. Decompose the $I_c$ by using Haar wavelet transform
6. Generate pseudo-random number ($P_n$)
7. Modify detailed coefficients like horizontal and vertical coefficients of wavelet decomposition by adding $P_n$ when message bit = 0.
8. Apply inverse DWT
9. Prepare stego image to display

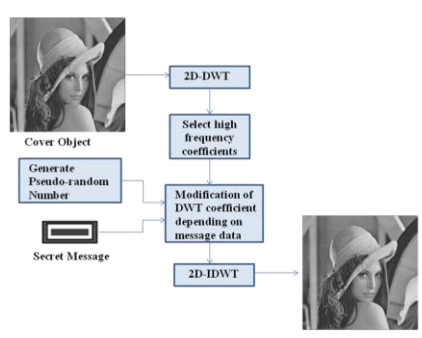


Figure 8: Block diagram of secret message embedding procedure of steganography.

 

**Extraction Procedure**

In this step extraction of secret message is carried out. Additionally correlation theory is being used. Correlation is the degree to which two or more quantities are linearly associated [6]. The correlation between two same size matrices can be calculated by:

$$r = \frac{\sum_m \sum_n (A_{mn} - \bar{A})(B_{mn} - \bar{B})}{\sqrt{\left(\sum_m \sum_n (A_{mn} - \bar{A})^2\right)\left(\sum_m \sum_n (B_{mn} - \bar{B})^2\right)}}$$

where $\bar{A}$ = mean2(A), and $\bar{B}$ = mean2(B).

***Input:*** An m × n carrier image and an m × n stego-image.
***Output:*** a secret message/image.
***Algorithm:***
**Steps-**

1. Read the cover image ($I_c$)
2. Read the stego image ($I_s$)
3. Decompose the $I_c$ and $I_s$ by using Haar wavelet transform
4. Generate message vector of all ones
5. Find the correlation between the original and modified coefficients
6. Turn the message vector bit to 0 if the correlation value is greater than mean correlation value
7. Prepare message vector to display secret image

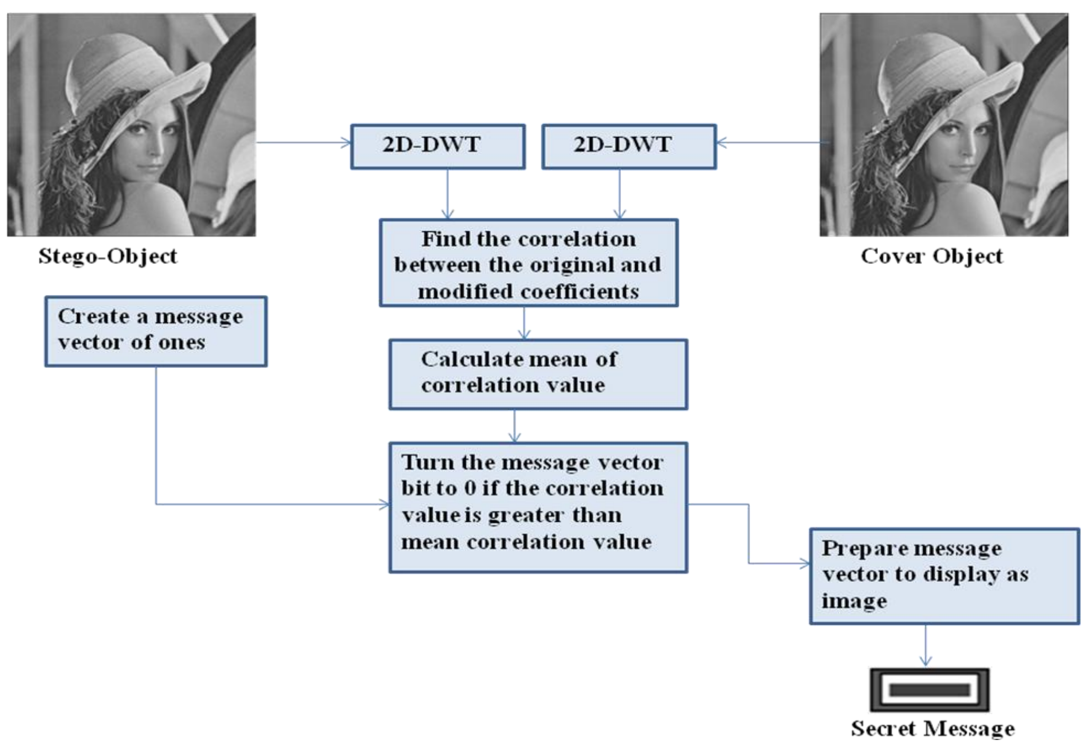


Figure 9: Block diagram of extraction of secret message from a stego object.

## IV. RESULTS & DISCUSSION

In this section some experiments have been carried out to prove the relationship between expected results and actual results of proposed methods. The proposed two algorithms have been simulated with MATLAB 7.7.0471. A set of 8-bit grayscale images of size 512 × 512 have been used as the carrier or cover object and a set object of size 100x100 have been used as message object. After the embedding procedure, the resultant object i.e. the stego object is quiet good in quality with respect to visibility. In extraction procedure it has been aimed to extract the original message intact which has been executed successfully by the above mentioned extraction algorithm.

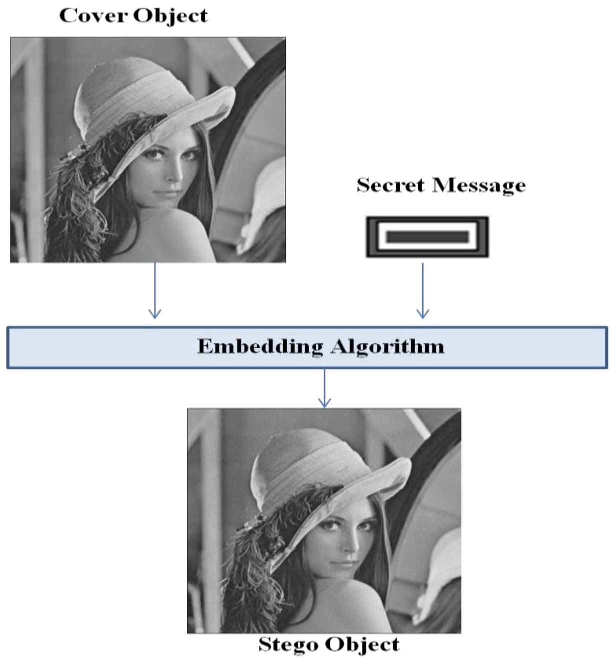


Figure 10: Experiment result of Embedding Procedure

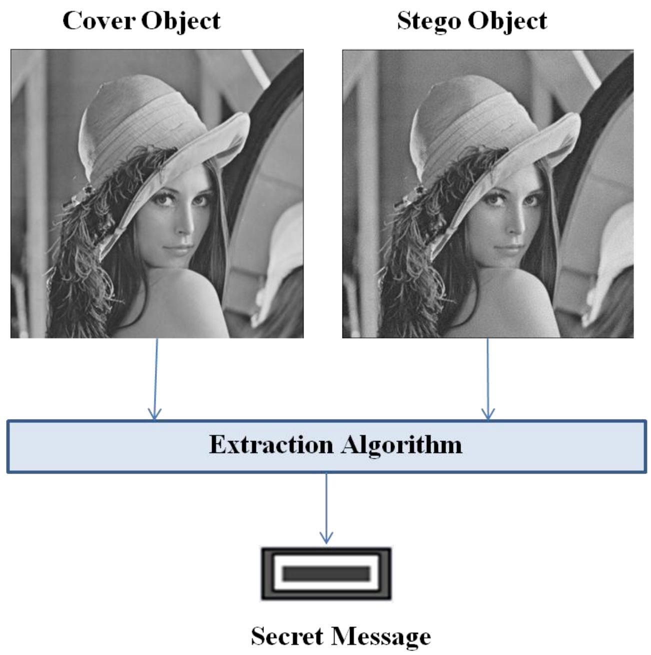


Figure 11: Experiment result of Extraction Procedure

## V. Conclusion

This work is related with steganography technique using discrete wavelet transform domain. Wavelet domain is pretty new and efficient transform domain than previously used Fourier Transform. This method maintains the prime objective of steganography, which is the secrecy. It has been shown in results & discussion section that the stego image preserve the visible quality of original cover image. This method succeeds to keep intact the original image, after the extraction of embedded secret message. Hence this proposed method can be termed as successful new technique of image steganography.

References

[1] Daubechies, I. *Ten Lectures on Wavelets*. Philadelphia, PA: SIAM, 1992.
[2] Chui, C. K. (Ed.). Wavelets: *A Tutorial in Theory and Applications*. San Diego, CA: Academic Press, 1992.

 

[3] Prof. Mark Fowler, Department of Electrical Engineering, State University of New York at Binghamton "*Wavelet Transform Theory*" Presentation.

[4] Mrs. Archana S. Vaidya, Pooja N. More., Rita K. Fegade, Madhuri A. Bhavsar, Pooja V. Raut, GES's R. H. Sapat College of Engineering, Management Studies and Research, Nashik, "*Image Steganography using DWT and Blowfish Algorithms*", IOSR Journal of Computer Engineering (IOSR-JCE) e-ISSN: 2278-0661, p- ISSN: 2278-8727 Volume 8, Issue 6 (Jan. - Feb. 2013), PP 15-19

[5] Mihir Bellare, Shafi Goldwassery and Daniele Micciancioz "*'Pseudo-Random' Number Generation within Cryptographic Algorithms: the DSS Case*", Advances in Cryptology - Crypto 97 Proceedings, Lecture Notes in Computer Science Vol. 1294, B. Kaliski ed., Springer-Verlag, 1997

[6] Kenney, J. F. and Keeping, E. S. "*Linear Regression and Correlation.*" Ch. 15 in Mathematics of Statistics, Pt. 1, 3rd ed. Princeton, NJ: Van Nostrand, pp. 252-285, 1962.

[7] M. Sifuzzaman, M.R. Islam and M.Z. Ali, "*Application of Wavelet Transform and its Advantages Compared to Fourier Transform*", Journal of Physical Sciences, Vol. 13, 2009, 121-134 ISSN: 0972-8791

[8] Emy V Yoyak, PG Scholar, Jaya Engineering College, Thiruvallur, India, "*Three Level Discrete Wavelet Transform Based Image Steganography*", International Journal of Engineering Research & Technology (IJERT) Vol. 2 Issue 4, April – 2013

[9] Rastislav Hovančák, Peter Foriš, Dušan Levický, Department of Electronics and Multimedia Telecommunications, Technical University of Košice, Slovak Republic "*Steganography Based On Dwt Transform*".

[10] Amitava Nag, Sushanta Biswas, Debasree Sarkar, Partha Pratim Sarkar, Dept. of Engineering and Technological Studies, University of Kalyani, "*A Novel Technique for Image Steganography Based on DWT and Huffman Encoding*" International Journal of Computer Science and Security, (IJCSS), Volume (4): Issue (6)

 