# Two Dimensional Data Hiding using Haar Wavelet Filter

Rahul Shrivastava, Mahendra Kumar Pandey

Dept. of Electronics and Communication Engineering, Rustamji Institute of Technology (RJIT), Tekanpur.

**Abstract –** Data hiding is a very important filed for security. Due to fast and wide distribution of digital data over internet, need of hiding techniques to secure digital data is required. In this paper, two dimensional data hiding using Haar Wavelet filter has been proposed. Secret data is secured by Discrete Wavelet Transform (DWT) which is embedded into the mid frequency sub-band of a cover data by using variable mixing factor (k). The efficiency and effectiveness of presented work is evaluated on the basis different parameter like as peak signal to noise ratio (PSNR), normalized correlation coefficient (NCC) etc.

***Index Terms— Data Hiding*, Haar Wavelet Filter, DWT, PSNR, NCC.**

## 1. Introduction

Data hiding is a very active research areas. Digital watermarking is a most popular branch of data hiding which is used to hide proprietary information in digital media like photographs, digital music, or digital video [1-2]. Watermarking is the method of embedding the watermark into cover image with the help of embedding algorithm for security and other purposes. Generally, the watermarking can be done in spatial domain or transform domain [3]. Compared to spatial domain techniques, frequency domain watermarking methods are more effective to achieve the imperceptibility and robustness [4]. In literature, various methods like; Discrete Wavelet Transform (DWT), the Discrete Cosine Transform (DCT) and Discrete Fourier Transform (DFT) etc. are used. However, DWT is popular and more frequently used due to its excellent spatial localization and multi-resolution characteristics.

## 2. Methodology

### *A. Discrete Wavelet transforms (DWT)*

DWT is a multi-resolution technique. It provides a framework in which an image is decomposed, with each level corresponding to lower frequency sub band and higher frequency sub bands. DWT analyze image at different frequencies by different resolutions. For 2-D images, filters divide the input image into four no overlapping multi-resolution sub-bands.

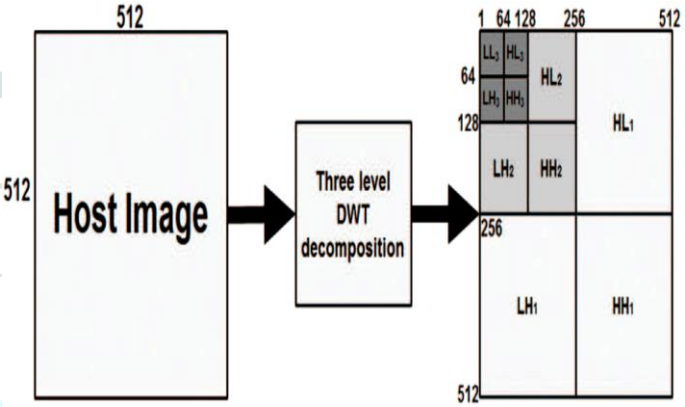



Fig. 1.Decomposition of image using Third level- DWT

Fig. 1 illustrates the DWT decomposition structure for Image, its produce the four different band of image. In the filter theory, these four sub images correspond to the outputs of low-low (LL1), low-high (LH1), high-low (HL1), and high-high (HH1) bands. By recursively applying the same scheme to the LL1 sub band multi resolution decomposition with a desire level can then be achieved.

## 3. Implementation

Proposed work has been used to hide the secret data using Haar wavelet filter using 3-level of Discrete Wavelet Transform (DWT). The implementation of proposed work has been divided into two parts which are explain below:

### *A. Embedding*

Here in embedding process, firstly we take the host image and 3-level DWT (Discrete Wavelet Transform) is applied to the image which decomposes image into frequency components. In the same manner, 3-level DWT is also applied to the watermark image which is to be embedded in the host image. The wavelet used here is the wavelets of Harr. In this technique, the decomposed components of the host image and watermark are multiplied by a visibility factor and are added.

Here, watermark embedded in the mid frequency component of the host image. The watermarked image is obtained by using the formula

$$WMHL3=HL3+k*HL3a; \quad (1)$$

Where WMHL3 = mid frequency component of watermarked image, HL3 = mid frequency component of the cover image obtained by 3-level DWT, HL3a =mid frequency component of Watermark image and k = mixing factor.

After embedding the watermark image with cover image, 3-level Inverse discrete wavelet transform is applied to the watermarked image coefficient to generate the watermarked image.

*B. Watermark Extraction*

In the extraction process, firstly 3-level DWT is applied to watermarked image and then cover image which decomposed the image in sub-bands. To recover the watermark image, we use the formula.

$$RW= (WMHL3-HL3)/k; \quad (2)$$

Where RW= mid frequency approximation of Recovered watermark, WM LL3= mid frequency of the watermark image, and HL3= mid frequency of watermarked image.

After extraction process, 3-level Inverse discrete wavelet transform is applied to the watermark image coefficient to generate the final extracted watermark image.

## 4. Results and Discussion

In this section, performance analysis of proposed work has been presented. The simulation work on MATLAB platform illustrate the efficiency and performance of proposed work on the basis of following parameters.

***A. Parameters***

The performance of proposed work is determined by using peak signal-to-noise ratio (PSNR) and Normalized Correlation Coefficient (NCC).

- **Peak Signal to Noise Ratio (PSNR) :-**

PSNR (Peak Signal to Noise Ratio) is a metric for the ratio between the maximum possible power of a signal and power of corrupting noise that affects the fidelity of its representation. For measurement of imperceptibility, PSNR in dB is given by:

$$MSE = \frac{1}{NM}\sum_{i=1}^{N}\sum_{j=1}^{M}\left(f_c(i,j) - f_{wm}(i,j)\right) \quad (5)$$

$$PSNR = 10\log_{10}\frac{f_c^2(i,j)}{MSE} \quad (6)$$

where, fc2 (i, j) indicates the peak brightness value of pixel and fc, fwm represent the brightness of host and watermarked images at different pixels values.

- **Normalized Correlation Coefficient (NCC):-**

To check the robustness and image quality, the value of Normalized Correlation Coefficient (NCC) is measured by:

$$NCC = \frac{\sum_{i=1}^{N}\sum_{j=1}^{M} g_w(i,j) * g_w'(i,j)}{\sqrt{\sum_{i=1}^{N}\sum_{j=1}^{M} g_w^2(i,j)}\sqrt{\sum_{i=1}^{N}\sum_{j=1}^{M} g_w^2(i,j)}} \quad (7)$$

where, gw and gw' are the brightness level of cover and extracted watermark at different value of pixel.

***B. Simulation Results***

Simulation results has been obtained on MATLAB platform using proposed technique in terms of parameters by taking Cover and RJIT Logo as a host and watermark image respectively [14].

- **Sample images**

(a)


(b)

Fig. 2. (a) Cover Image (b) RJIT Logo

Fig. 2 shows the cover image and watermark image

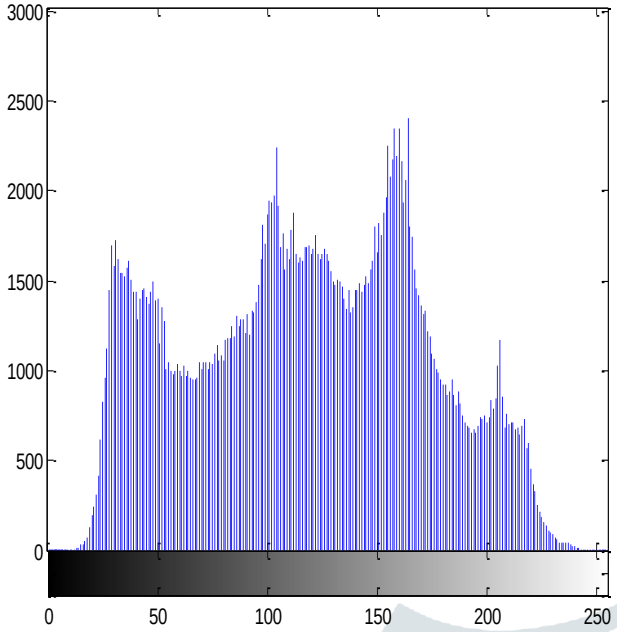



Fig. 3.Histogram of cover image

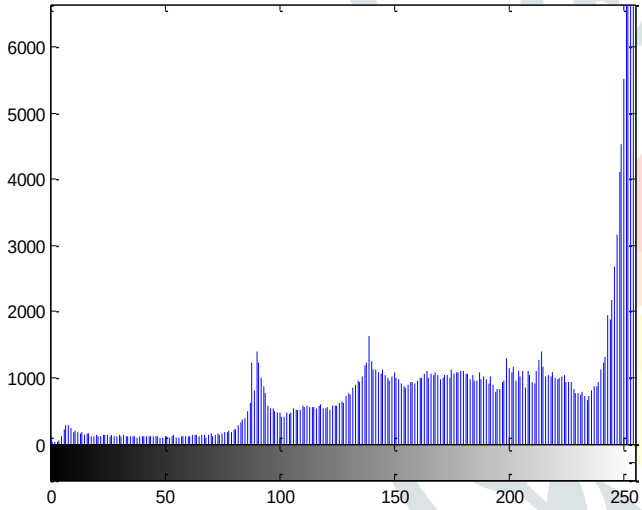



Fig. 4.Histogram of RJIT Logo image

| Mixing Factor | Proposed work | | |
|---|---|---|---|
| k | MSE | RMSE | PSNR(dB) |
| 0.02 | 7.3242e-04 | 0.0271 | 79.5172 |
| 0.03 | 0.0034 | 0.0585 | 72.8271 |
| 0.05 | 0.0178 | 0.1335 | 65.6552 |
| 0.07 | 0.0422 | 0.2055 | 61.9079 |
| 0.1 | 0.0833 | 0.2885 | 58.9609 |
| 1.0 | 7.7452 | 2.7830 | 39.2745 |

Table I: RMSE, PSNR Value at different mixing factor.

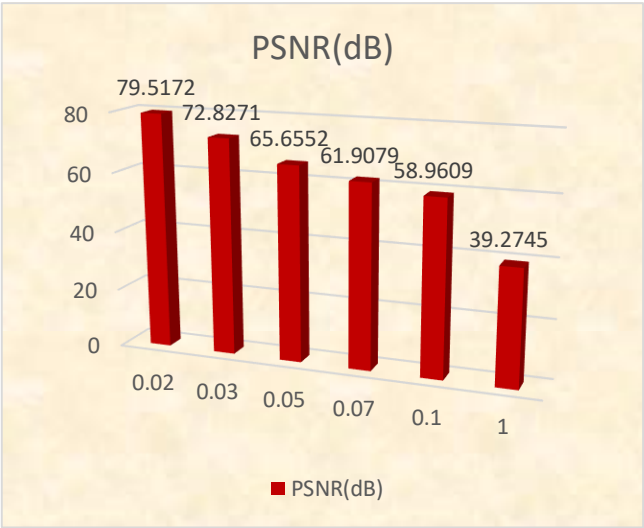



Fig. 5. Bar chart presentation of NCC values

### *C. Visual Presentation of simulation results*

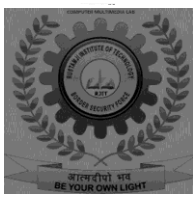
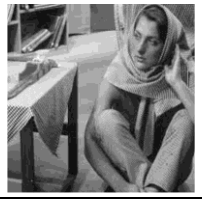
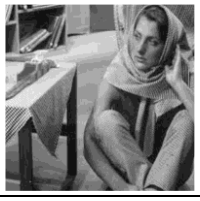
| Mixing Factor | Proposed work | |
|---|---|---|
| k | Watermarked image | Recovered Watermark |
| 0.02 |  |  |
| 0.03 |  |  |
| 0.05 |  |  |
| 0.07 |  |  |
| 0.1 |  |  |

Fig. 6. shows the visual representation of processed image at different value of SF.

| Mixing Factor (k) | Recovered NCC |
|---|---|
| 0.02 | 0.9949 |
| 0.03 | 0.9969 |
| 0.05 | 0.9984 |
| 0.07 | 0.9990 |
| 0.1 | 0.9994 |
| 1.0 | 1.00 |

Table II: NCC Value for different mixing factor.

Table I show the values of different parameter on varying values of mixing factor while Table II shows the values of NCC on varying values of mixing factor. These values also presented in bar chart form also in fig.7.

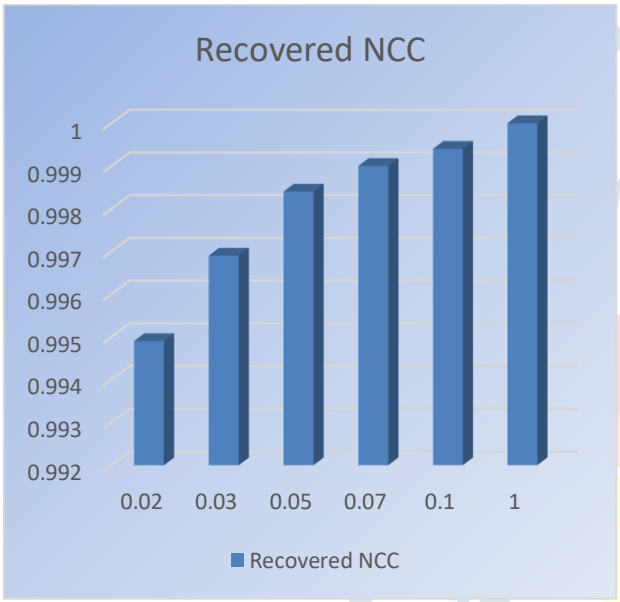



Fig. 7.Bar chart presentation of NCC values

As seen in simulated results shown in tables, it has been concluded that as the value of mixing factor play dominant role. As it decreases, the value of PSNR increases but the same time the value of NCC decreases which directly impact on image quality. The proposed method gives good results as shown in figures.

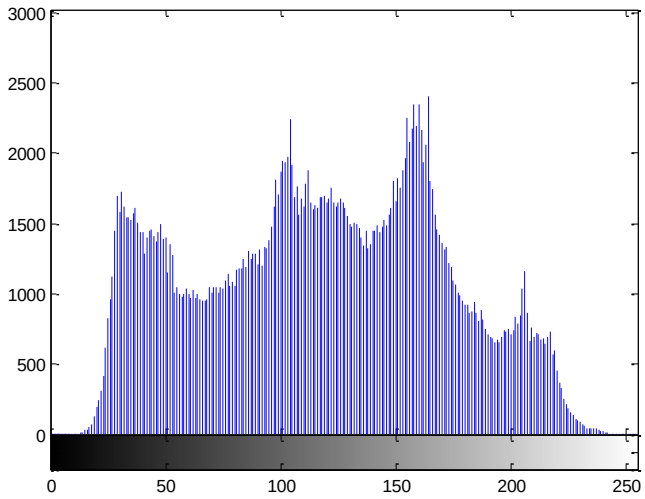



Fig. 8.Histogram of watermarked image

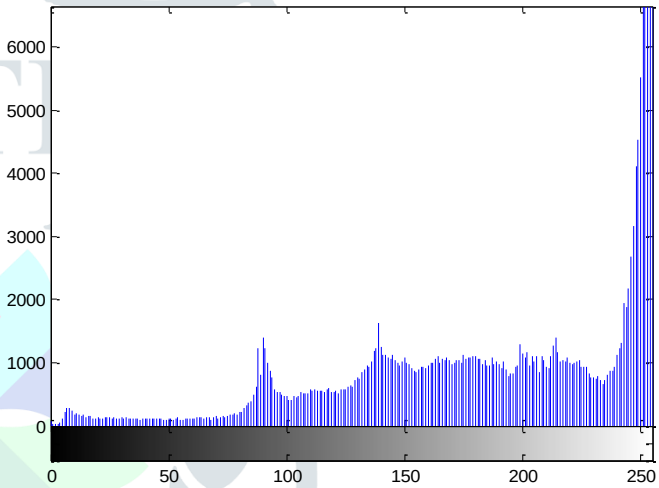



Fig. 9.Histogram of recovered watermark image

## 5. Conclusion

In this paper, data hiding using Haar wavelet filter has been implemented. This approach embed the secret image into mid frequency band using third level of DWT using Haar wavelet filter. Experimental results shows that the proposed work is working well to embed the watermark into cover image at different mixing factor. Finally it is concluded that the proposed work gives high stability and perfect reconstruction of images.

## 6. References

[1] W. Bender, D. Gruhl, N. Morimoto and A. Lu, "Techniques for Data Hiding", IBM System Journal, Vol. 35, NOS 3&4, pp. 313-336, 1996.

[2] CH.-Ch. Chang, K.-N. Chen, M.-H. Hsieh, “A robust public watermarking scheme based on dwt”, 6th IIH-MSP’10, pp. 21-26, 2010.

[3] P. H. W. Wong, O. C. Au and G. Y. M. Yeung, "A Novel Blind Multiple Watermarking Technique for Images", IEEE Transactions on Circuits and Systems for Video Technology: Special Issue on Authentication, Copyright Protection and Information Hiding, Sept. 2003.

[4] L. Hu, F. Wan, "Analysis on wavelet coefficient for image watermarking", Int. Conf. MINES'10, pp. 630-634, 2010

[5] J. Abdul Jaleel, Jisha Mary Thomas , "Guarding Images Using A Symmetric Key Cryptographic Technique: Blowfish Algorithm", ISSN: 2277-3754 ISO 9001:2008 Certified International Journal of Engineering and Innovative Technology (IJEIT) Volume 3, Issue 2, August 2013.

[6] M. Ibrahim, M. M. Rahman, and M. Iqbal, "Digital watermarking for image authentication based on combined DCT, DWT and SVD transformation", arXiv preprint arXiv:1307.6328, 2013.

[7] Makbol, Nasrin, and B. E. Khoo, "A new robust and secure digital image watermarking scheme based on the integer wavelet transform and singular value decomposition", Digital Signal Processing 33, pp. 134-147, October, 2014.

[8] S. Agarwal, Priyanka, and U. Pal, "Different types of attack in image watermarking including 2D, 3D images", International Journal of Scientific & Engineering Research, Vol. 6, No. 1, January, 2015.

[9] R. Liu, and T. Tan, "An SVD-based watermarking scheme for protecting rightful ownership", IEEE Transactions on Multimedia, Vol. 4, No. 1, pp. 121-128, March, 2002.

[10] P. H. W. Wong, O. C. Au and G. Y. M. Yeung, "A Novel Blind Multiple Watermarking Technique for Images," accepted by IEEE Transactions on Circuits and Systems for Video Technology: Special Issue on Authentication, Copyright Protection and Information Hiding, Sept. 2003.

[11] R.Tyagi and M. K. Pandey "An adaptive second level hybrid image Watermarking Technique using DWT-SVD in low frequency band'' Published in IJARCCE, Vol. 6, Issue 1, January 2017.

[12] R.Navaneethakrishnan "Robust Gray scale Watermarking Based on TwoLevels of DCT and SVD", ISRJournals and Publications Volume:3 Issue: 1 26-Jun-2014.

[13] N. Chaturvedi, S.J. Basha "A Novel SVD based Digital Watermarking Scheme using DWT and A comparative study with DWT-Arnold, SVDDCT and SVD-DFT based watermarking", ijdacr Volume 1, Issue 4, November 2012.

[14] P.Gautam, M.K. Pandey and S. Patsariya, "Comparative Performance Analysis of Multilevel Image Watermarking Using Cryptographic" International Journal of Computer Sciences and Engineering, Vol.-7, Issue-11, Nov 2019.

[15] USC-SIPI image database http://sipi.usc.edu/database/database.php