A Juxtaposition Between Integer Wavelet Transform and Discrete Wavelet Transform for Secure Image Steganography

Ravi Ranjan, Subham Thirani, M.Jasmine Pemeena Priyadarsini, G.K.Rajini, A.Jabeena

Abstract: Image steganography is a technique that is used to hide information. The information can be of various types like image, video, or audio. Steganography is done so that no one apart from the correct receiver can retrieve the information. This paper consists of all advantages and highlights of the wavelet transform but with the additional features like randomness and some default values that are already built-in it. Various algorithms can be used in steganography and they provide good hiding capacity and low detectability. Here we have hidden the image into the cover image using Integer Wavelet Transform (IWT) and also using Discrete Wavelet Transform (DWT) and compared which technique gives better results. It is very difficult to predict the presence of a hidden image inside the stego image since it looks exactly like the cover image. There is no loss in quality from the secret image to the extracted image since the PSNR (Peak Signal to noise ratio) is high for both of them. This process was done using both DWT and IWT and the results prove that that the IWT technique is not only simpler but also more efficient than the DWT technique since it gives higher PSNR values. Through the proposed algorithm, an increase in the strength and imperceptibility is noticed and it can also maintain various transformations such as scaling, translation, and rotation with algorithms that already exist. The final results, after comparing both the transforms prove that the algorithm which is being proposed in IWT is indeed effective.

Keywords: Discrete Wavelet Transform, Integer Wavelet Transform, MSE, PSNR, Steganography.

I. INTRODUCTION

Nowadays, hiding information is an extremely important aspect of information security. There are various techniques to provide security and one of them is steganography. Earlier there weren’t many security issues except copyright protection. But nowadays due to an increase in computer networks, we need to hide the information into some other medium such as image, audio, or video [1]. Steganography of the image using the transform domain approach transforms the hidden image into the image of the cover embedding the secret image in it. They're inserted in the cover picture frequency bands to reinforce them and make them more resilient for attacks.

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That also makes the exchange of confidential information much more appropriate. The original image is known as the cover image. The cover image along with the hidden image is known as stego image. Any unauthorized user will not be able to identify that there is a hidden image within the stego image [20]. Only the authorized recipient will be able to retrieve the confidential information. Steganography systems can be categorized into various transform domain and spatial domain methods [15]. Here, we use IWT and DWT to design the steganographic system and then compare the two methods.

A. Integer Wavelet Transform

Maximum information hiding techniques perform their embedding process by changing the contents of various media like image, video, and audio [6]. Due to this, there is some distortion in the cover image during extraction and as a result of this an analyzer can try to extract the confidential information [18]. These attacks can be prevented by using an Integer Wavelet Transform (IWT). To avoid distortion, IWT is a very efficient method because it maps integers to integers [9]. There are four sub-bands LL, LH, HL, and HH [14]. Among these four layers, in IWT, the LL subband is a very close copy of the original image on a smaller scale. Several methods of concealing data perform information embedding by modifying the composition of a source media. As a result, while extraction it causes some distortion in the cover image and thus the steganalyzer can try to extract the secret information [3]. This can be avoided by using Integer Wavelet Transform. The proposed algorithm uses the wavelet to convert coefficients to embed messages into four subbands of transforming a two-dimensional wavelet [19]. We used Integer Wavelet Transform to prevent problems with floating-point precision of the wavelet filters.

B. Discrete Wavelet Transform

DWT offers information on frequency and time domain simultaneously. Firstly, the time domain is passed through both low-pass and high-pass filters so that we can extract both low and high frequencies respectively [4]. This process is repeated many times and each time some part of the signal is drawn out. DWT mainly utilizes scaling and wavelet functions which are associated with low pass and high pass filters [10]. This feature is useful in bisecting time reparability [17]. Here we use the Haar wavelet which operates on data by...
computing the sums and differences of adjacent elements. [8]
It first operates on adjacent horizontal elements and later on
horizontal elements. An excellent property of the Haar wavelet transform is that the transform is equal to its inverse.
[7]. in 1-level DWT, with the help of high pass filter and low pass filter inputs are convolved. In 2-level DWT, initially 1-
level DWT is applied to all rows and then to all columns
[12].

II. METHODOLOGY

A. Taking Input
● We take a 256 x 256 secret gray scale image and 512 x
512 cover image. We also give an embedding coefficient
as input.

B. Embedding Process
● Split RGB color image in three cover planes i.e. Red,
Green, and Blue.
● Take the green plane of the cover image and compute
DWT and IWT by operating on it.
● Divide the output image of the DWT and IWT into
wavelet sub-bands i.e. Low Low (LL), Low High (LH),
High Low(HL), High High(HH).
● Take the secret image and divide it and the LL sub-band
of IWT and DWT into non-overlapping blocks of equal
size.
● Embed the secret image into LL sub-bands of IWT AND
DWT using the expression:

\[(1-\alpha)*\text{block1} + (\alpha*\text{block2})\]

Block 1 represents the block of LL subband of IWT and
DWT of the cover image, Block 2 represents the block
of the secret image, Alpha represents the embedding
coefficients [13].

C. Performing Inverse Transform
● Compute IIWT and IDWT and stego image with respect
to a green plane is obtained and then combine Red and
Blue plane information to the stego image.
● Stego output image of 512 X 512 image is obtained and
it is a color image.

D. Extraction Process
● On the stego image compute IWT and DWT.
● The extraction process is performed using

\[(\text{par1}-(1-\alpha)*\text{par2})]/\alpha\]

Par 1 represents LL band of stego image, par2 represents
secret image, Alpha represents embedding coefficient,
Hidden image is extracted from stego image

E. Parameters Calculation
● PSNR and MSE values for stego and the secret image is
calculated

F. Comparison Of Both Methods
● Comparisons of IWT and DWT method of
steganography are compared based on PSNR
and MSE values.

III. RESULT AND ANALYSIS

We need to compare and evaluate both the algorithms
used for image steganography. To analyze it we will use
Fabric.jpg as an input image and Mandi.tif as a secret
image. The cover image is of size 512 x 512 pixels and
the secret image has a size of 256 x 256 pixels [5]. They
are shown in Fig 2 a and b respectively. One level DWT
and IWT is performed on the blue plane of the cover
image and is shown in Fig 3. As we know that almost all
the energy is concentrated in the Low-low (LL) band,
hence it is taken for embedding the LL band [2]. The LL
band of the IWT and DWT is shown in Fig 4. The secret
image is embedded into the LL band of the DWT and
IWT of the cover image using the formula (1) and after
that IIWT (Inverse Integer Wavelet transform) and IDWT
(Inverse Discrete Wavelet Transform) is performed. As a
result, a stego image is obtained which contains both
cover image and secret image as shown in Fig 5 and 6
respectively.
Unauthorized users will not be able to recognize the secret picture embedded inside the cover image. The stego image is rather imperceptible and stable and the changes in the images are not detected.

The extraction process is performed to get the hidden image from the stego image, and the secret image is obtained as a result [16]. The extracted image is shown in Fig. The performance of both the algorithms is evaluated and proves that IWT is superior to DWT.

![Fig 3: Cover image and Secret image](image)

![Fig 4: One-level IWT of Cover image](image)

![Fig 5: LL band of DWT of Cover image](image)

![Fig 6: Stego image](image)

![Fig 7: Extracted Secret Image](image)

**Performance measures:** The efficiency of the technique proposed is estimated using commonly used metrics such as PSNR (Peak Signal to Noise Ratio) and MSE (Mean Square Error) [11].

**Performance comparison of IWT and DWT:** The evaluation of performance measure of IWT and DWT for different cover and secret images are done.

PSNR for stego image for both DWT and IWT is shown in Table 1. PSNR for extracted image for both DWT and IWT is shown in Table 2. MSE for stego image for both DWT and IWT is shown in Table 3. MSE for extracted image for both DWT and IWT is shown in Table 4.

| Cover Image | DWT Secret Image | IWT Secret Image |
|-------------|------------------|------------------|
| Trees       | 29.08            | 29.07            |
| Mandi Camera-man | 309.3 | 309.28 |
| Fabric      | 40.64            | 42.05            |
| Pepper      | 40.33            | 41.56            |
| Pears       | 34.83            | 35.76            |

**Table 1: PSNR for stego image for both DWT and IWT**

| Cover Image | DWT Secret Image | IWT Secret Image |
|-------------|------------------|------------------|
| Trees       | 42.05            | 42.758           |
| Mandi Camera-man | 36.64 | 37.80 |
| Fabric      | 40.64            | 42.05            |
| Pepper      | 40.33            | 41.56            |
| Pears       | 34.83            | 35.76            |

**Table 2: PSNR for extracted image for both DWT and IWT**
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![Table 3: MSE for stego image for both DWT and IWT](image)

| Cover Image | Secret Image | Secret Image |
|-------------|--------------|--------------|
| Trees       | Mandi        | Camera - man | Trees       | Mandi        | Camera - man |
| Fabric      | 5.59         | 4.068        | 3.446       | 14.705       | 10.774       | 9.193       |
| Pepper      | 6.022        | 4.499        | 5.547       | 15.50        | 11.60        | 14.35       |
| Pears       | 21.27        | 17.528       | 12.692      | 54.337       | 44.2413      | 32.553      |

**Table 3:** MSE for stego image for both DWT and IWT

![Table 4: MSE for stego image for both DWT and IWT](image)

| Cover Image | Secret Image | Secret Image |
|-------------|--------------|--------------|
| Trees       | Mandi        | Camera - man | Trees       | Mandi        | Camera - man |
| Fabric      | 5e-25        | 5e-25        | 3.5e-25     | 7.6e-27      | 7.5e-27      | 7.8e-27     |
| Pepper      | 5e-25        | 5e-25        | 4.9e-25     | 4.8e-27      | 5.1e-27      | 5.2e-27     |
| Pears       | 1e-24        | 1e-24        | 1.7e-24     | 1.7e-26      | 1.6e-26      | 1.7e-26     |

**Table 4:** MSE for stego image for both DWT and IWT

Analysis of different frequency sub-bands for IWT and DWT: In the Fig-7 shown below, it can be seen that LL and LH sub-band for IWT performance is better than DWT [14] but it is contrasting in HL and HH sub-band.

![Fig 8: Comparison of IWT and DWT for different subbands](image)

IV. CONCLUSION

In this paper, the secret image can be extracted from the original image without any distortion using both the algorithms. The higher the PSNR value, the less distortion. Integer to Integer mapping is consist of integers if the input consists of integers. The resulting output can be labeled with integers altogether in the case of IWT which can be seen in the PSNR value of both the algorithms. Thus IWT is better than DWT. Hence, it will allow us to independently transmit the secret information to the receiver, making it almost impossible for any unintended users to extract the secret information and recover the original host image when they access the Stego image. This approach provides good Stego-image efficiency with lower PSNR values compared to other approaches. This method, however, will allow us to independently transmit the secret information to the receiver, making it almost impossible for any unintended users to extract the secret information and recover the original host image when they access the Stego image. Hence, secret information can be transmitted safely without altering the original cover image.

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1022
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