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Color Image Steganography by Using Dual Wavelet Transform (DWT, SWT)

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Abstract: ***The aim of steganography is to hide the existence of the embedded information within carriers. Different types of multimedia carriers can be used for steganography like Video, Audio, image etc. In this project Image is used as a carrier. Here 'Cover image' is the color image and 'Secret image' is the grayscale image. This algorithm first separates RGB color planes of cover image. Then extracts either Discrete Wavelet Transform (DWT) or Stationary Wavelet Transform (SWT) coefficients of both B plane of cover image and secret image. These two extracted coefficient values are fused into single image by using wavelet based fusion technique. By taking IDWT/ISWT of fused image the stego image is obtained. Different combinations of DWT and SWT can be used for embedding process (DWT-DWT, DWT-SWT, SWT-DWT, and SWT -SWT). The same combination of transforms is used in extraction process. Here, we concentrated for perfecting the visual effect of the stego image and robustness against the various attacks by using different wavelet families.***

Keywords: Color image steganography, DWT and SWT, fusion process, Wavelet families

1. Introduction

While exchanging the information through internet one of the most important facts is security of information. Some methods were developed to encrypt and decrypt data in order to keep the message secret. One of that was Cryptography; it is sometimes not enough to keep the contents of a message secret. It is unable to keep existence of the message secret. The technique used to implement this, is called steganography [10].

Steganography is the art of hiding information in such a way that, keeps the existence of the message secret. Steganography, derived from the Greek words "stegos" meaning "cover" and "grafia" meaning "writing" defining it as "covered writing"[1]. Steganography can be used for wide range of applications such as in defiance organizations, intelligence agencies, in smart identity cards where personal details are embedded in the photograph itself for copyright control of materials, medical imaging.

The wavelet domain is growing up very quickly. Wavelet transform is a very powerful tool and it is used in many diverse fields, including approximation theory; signal processing, physics, astronomy, and image processing. There are many advantages of using Wavelet transform domain for steganography and it is proved different practical tests. The use of such transform mainly increases the capacity and robustness of the Information Hiding system. Here the steganography is implemented in the Wavelet domain [13].

2. Related Work

In the last few years, numerous methods / algorithms have been developed for Steganography using Wavelet Transform. Overview of this is presented as follows:

Chen and lin [12] proposed A DWT Based Approach for Image Steganography, it uses LSB based image steganography techniques, proposed algorithm is divided into two modes and 5 cases, depending upon embedding capacity and image quality.

Nilanjan Dey, Anamitra Bardhan Roy, Sayantan Dey [4] proposed A Novel Approach of Color Image Hiding using RGB Color planes and DWT, where The color cover image and the color secret image both are decomposed into three separate color planes and each plane of the images is decomposed into four sub bands using DWT. Each color plane of the secret image is hidden by alpha blending technique.

Fawzi Al-Naima et al., [8] proposed a modified high capacity image steganography technique that depends on wavelet transform with acceptable levels of imperceptibility and distortion on the cover image with high levels of overall security.

H S Manjunatha Reddy, K B Raja, [10] proposed high capacity and security steganography using discrete wavelet transform (DWT). The wavelet coefficients of both the cover and payload are fused into single image using embedding strength parameters: alpha and beta. This provides increased capacity and security with acceptable value of PSNR
.

S. K. Muttoo et al., [11] presented a multilayered secure, robust and high capacity image steganography algorithm. This algorithm achieved three layers of security, better in terms of imperceptibility, robustness and embedding capacity compared with corresponding algorithms based on DWT.

M. Fahmy Tolba and Al-said Ghonemy, [18] proposed High Capacity Image Steganography using Wavelet-Based Fusion this combine DWT coefficients of both cover image and secret image. Here color images are used for steganography.

3. Methodology

3.1 The use of Wavelet Transform in steganography

The wavelet domain is growing up very quickly. Wavelet transform is a very powerful tool in many diverse fields, including approximation theory; signal processing, physics, astronomy, and image processing. Many practical tests propose to use the Wavelet transform domain for steganography because of a number of advantages that can be gained by using this approach. The use of wavelet transform for steganography increases the data hiding capacity and robustness. Here the steganography is implemented in the Wavelet domain. The hierarchical nature of the Wavelet representation allows multi evolutional detection of the hidden message. The wavelet transform clearly separates the high frequency and low frequency information on a pixel by pixel basis and hence it is more suitable for Steganography. For high resolution images Wavelet transform provide good compression ratios. Wavelets perform much better than competing technologies like JPEG, both in terms of signal-to-noise ratio and visual quality.

3.2 Discrete Wavelet Transform (DWT)

The discrete wavelet transform (DWT) was developed to apply the wavelet transform to the digital world. It has a key advantage over Fourier transforms is temporal resolution: it captures both frequency and location information. The Discrete Wavelet Transform (DWT) is found to yield a fast computation of Wavelet Transform. It is easy to implement and reduces the computation time and resources required. DWT is the wavelet transform for which the wavelets are discretely sampled.

Discrete wavelet transform can offer a more precise way for image analysis. It decomposes a image into low frequency band and high frequency band in different levels, and it can also be reconstructed at these levels. The low-frequency component usually contains most of the frequency of the signal. This is called the approximation. The high-frequency component contains the details of the signal. DWT is applied to the entire image or to its subparts. The embedding process is done by modifying some coefficients that are selected according to the type of protection needed. If we want the message to be imperceptible, choose a high range of frequency. If we want the message to be robust, choose a low range of frequency.

3.3 Stationary Wavelet Transform (SWT)

The Stationary Wavelet Transform (SWT) is a time invariant transform. In SWT the down-sampling step of the decimated algorithm are suppressed and filters are up-sampled by inserting zeros between the filter coefficients. The output of each level of SWT contains the same number of samples as the input and hence the SWT is an inherently redundant scheme

Similar to DWT, SWT can also be used for image analysis, but it does not use down - sampling, hence the subbands will have the same size as the input image.

3.4 Fusion Process

Now a day, image fusion becomes essential sub-topic in digital image processing area. Image fusion is nothing but a process of combining two or more different images into a new single image retaining important features from each image.

Here wavelet based fusion is used. It is used to hide seceret image into cover image. It involves merging of the wavelet coefficients both the cover image and the secret image into a single image called as fused image. In a normalized image the pixel components take on values that span a range between 0.0 and 1.0 instead of the integer range of [0, 255]. Hence, the corresponding wavelet coefficients will also range between 0.0 and 1.0.

The wavelet-based fusion actually merges the wavelet coefficients of both the cover image and the secret image into a single fused result using the following equation:

$$f'(x, y) = f(x, y) + \alpha\, g(xm, ym) \qquad (1)$$

Where,

f is the modified DWT coefficient,
f' is the original DWT coefficient,
g is the message coefficient, and
α is the embedding strength (ranges from 0.0 to 1.0).

4. Proposed Work

In the proposed method dual wavelet transforms are used for steganography. These two transforms are Discrete Wavelet Transform and Stationary Wavelet Transform.

4.1 Embedding Process

4.1.1 Algorithm for Embedding process

1) Get Color Cover Image.
2) Separate Cover Image into R, G, and B plane and take B plane.
3) Get Grayscale Secret Image.
4) Apply image pre- processing and correction process.
5) Apply dual transforms technique on B plane of Color Cover image and Gray scale Secret Image.
6) By applying SWT/DWT, extract the approximation coefficients of matrix LL and detail Coefficients matrices LH, HL, HH of B plane Cover Image.
7) By applying DWT/SWT extract the approximation coefficients of matrix LL and detail coefficient matrices LH, HL, HH of the Secret Image.
8) Apply fusion operation on extracted coefficients and get merged image.
9) Finally apply ISWT/IDWT on fused image to form the stego image.

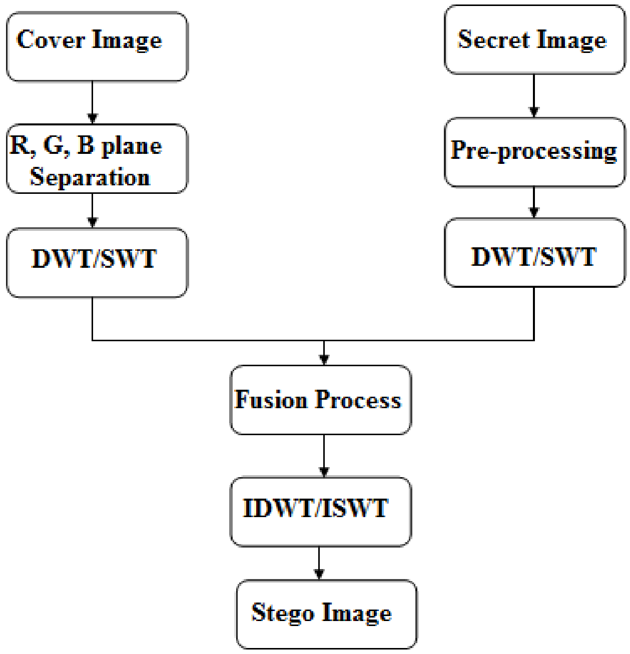


Figure 1: Shows Embedding Process

4.2 Extracting Process

The extraction process involves subtracting the original cover image from the stego image in the wavelet domain to get the coefficients of the secret message. Then the embedded message is retrieved by applying inverse transform IDWT.

4.2.1 Algorithm for the Extracting Process

1. Extracts the DWT/SWT coefficient values of Stego image and B plane of Cover image.
2. Apply Inverse fusion process to get fused image.
3. Take IDWT/ISWT of the fused image to reconstruct the Secret image.

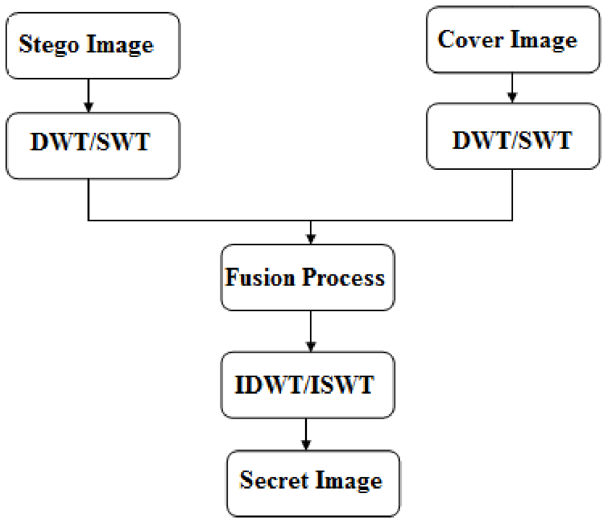


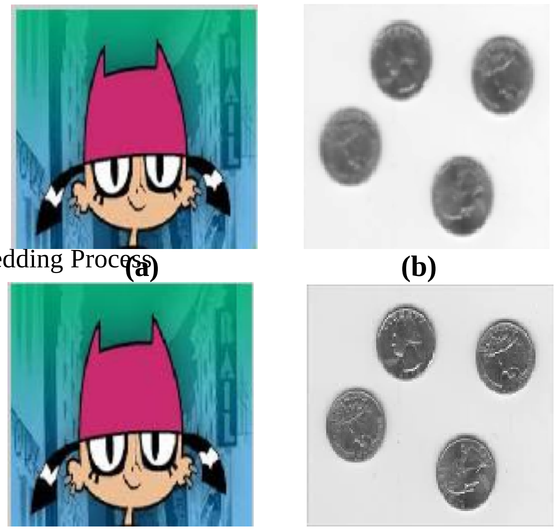
Figure 2: Shows Extracting Process

5. Result

There are four combinations of two transforms; these are DWT-DWT, DWT-SWT, SWT-DWT, and SWT-SWT. The implemented algorithm is tested on images with different file format and having different size. The images with different file format used are JPEG, TIFF, PNG, and BMP. The input dataset consist of 30 images. It includes 15 Color images as a cover image and 15 gray scale images as a secret image.

5.1 Performance Evaluation by using Images with different file formats and sizes

Here for performance evaluation statistical parameters used are Root Mean Square Error (RMSE), Peak Signal to Noise Ratio (PSNR) and Entropy (EN). Small value of RMSE and large value of PSNR of stego image indicates quality of stego image is good. And the Entropy equal to zero indicates security of payloads (secret image) is high.



(a) (b)

(c) (d)

Figure 3: Steganography using SWT-DWT combination of transform,(a)Cover Image (cartoon.tiff) (b) Secret Image (coins.png), (c) Stego Image, (d) Extracted Image.

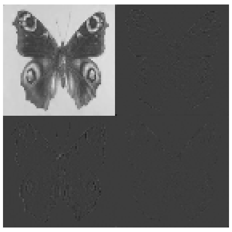
Table no. 1 shows performance evaluation of all four combination of dual transform with images of different file formats and sizes.

All combinations gives better results. But by comparing all combinations, SWT-DWT gives best result because it gives small value of RMSE and large value of PSNR, entropy is also approximately equal to zero. That means this combination provide good quality stego image with better security.

5.2 Performance Evaluation by using different Wavelet Families

Here different wavelet families are used for performance evaluation of all possible combination of DWT and SWT. Wavelet families used are Haar, Daubechies, Biorthogonal, Reverse Biorthogonal, Symlets, Coiflets.

(a) (b)



(c) **(d)**

(e) **(f)**

Figure 4: Shows results of SWT-SWT using db2/sym2, (a) Cover Image (butterfly.bmp), (b) Secret Image (Barbara.bmp), (c) SWT of Cover Image, (d) SWT of Secret Image, (e) Stego Image, (f) Extracted Image.

Table no. 2 shows performance evaluation of all four combination of dual transform with different wavelet families.

All combinations give better quality Stego image for all wavelet families. By comparing all combinations we can see that, SWT-SWT gives good quality Stego image as well as good quality Extracted secret image.

Table 1: Performance evaluation with images of different file formats and sizes

Images		DWT-DWT			DWT-SWT			SWT-DWT			SWT-SWT		
	Size	RMSE	PSNR	EN	RMSE	PSNR	EN	RMSE	PSNR	EN	RMSE	PSNR	EN
Bird.jpg	259x194	21.26	34.86	2.54	53.83	30.82	0.12	12.1	37.3	0.15	19.88	35.15	0.06
Text.jpg	512x512												
Cartoon.tiff	248x140	39.04	32.22	5.34	81.07	29.04	0.02	9.82	38.21	0.12	35.07	32.68	0.01
Coins.png	248x195												
Bird.jpg	259x194	26.72	33.86	5.38	69.13	29.73	0.05	11.44	37.55	0.18	23.38	34.44	0.04
Coins.png	248x195												
Bird.jpg	259x194	23.28	34.46	7.49	57.24	30.55	0.08	11.76	37.43	0.25	17.83	35.62	0.04
Dog.tiff	236x213												
Bird.jpg	259x194	22.27	34.65	7.33	52.74	30.91	0.05	11.82	37.4	0.29	16.03	36.08	0.03
Flower.bmp	275x183												
Fruits.png	503x389	21.28	34.85	2.54	54.48	30.77	0.19	7.09	39.63	0.36	19.64	35.2	0.13
Text.jpg	512x512												
Lena.bmp	512x512	22.77	34.56	2.5	56.42	30.62	7.68E-04	4.83	41.3	9.43E-04	21.08	34.9	9.43E-04
Text.jpg	**512x512**												

Table 2: Performance evaluation with different wavelet families

Cover Image (bird. jpg)	Secret image (Text. jpg)	Wavelet families	RMSE	PSNR	CC	EN	AD	SC	MD	NAE	UIQI
DWT	DWT	Db1/haar/bior1.1/rbio1.1	19.876	35.1475	0.9925	0.06	1.1113	0.993	0	0.0077	0.983
		Db2/sym2	19.876	35.1475	0.9264	0.06	6.5747	0.955	0	0.0446	0.929
		Bior1.3	19.876	35.1475	0.824	0.06	12.22	0.9242	0	0.0817	0.932
		Rbio1.3	19.876	35.1475	0.826	0.06	11.935	0.9273	0	0.0798	0.882
		Coif1	19.876	35.1475	0.8261	0.06	11.973	0.9259	0	0.08	0.882
DWT	SWT	Db1/haar/bior1.1/rbio1.1	32.124	33.0625	0.9925	0.28	1.1113	0.993	0	0.0077	0.983
		Db2/sym2	31.962	33.0844	0.9853	0.31	2.3004	0.9942	0	0.016	0.973
		Bior1.3	31.846	33.1002	0.9797	0.31	2.7794	1.0007	0	0.0193	0.973
		Rbio1.3	31.8	33.1065	0.9798	0.29	2.7112	1.0024	0	0.0189	0.974
		Coif1	31.805\	33.1058	0.9809	0.3	2.8404	0.9975	0	0.0198	0.969
SWT	DWT	Db1/haar/bior1.1/rbio1.1	12.16	37.2814	0.9723	0.14	6.3455	0.8877	0	0.0437	0.954
SWT	SWT	Db1/haar/bior1.1/rbio1.1	19.876	35.1475	0.9925	0.06	1.1113	0.993	0	0.0077	0.983
		Db2/sym2	19.876	35.1475	0.9925	0.06	1.1113	0.993	0	0.0077	0.983
		Bior1.3	19.876	35.1475	0.9925	0.06	1.1113	0.993	0	0.0077	0.983
		Rbio1.3	19.876	35.1475	0.9925	0.06	1.1113	0.993	0	0.0077	0.983
		Coif1	19.876	35.1475	0.9925	0.06	1.1113	0.993	0	0.0077	0.983

6. Conclusions and Discussions

Whole combination of DWT and SWT provides better value of PSNR and RMSE. Thus it can be said that this algorithm performs better in terms of visual quality. All Statistical parameters, SC, Entropy, NAE, AD, MD, UIQI are used to measure the quality of the extracted Secret image and value of all parameters is in the acceptable range, thus it can be concluded that proposed method extracts secret image with good quality. Out of all combinations of DWT and SWT, SWT-DWT gives the better result by using images with different sizes and file formats, and SWT-SWT gives the better result by using different wavelet families.

Thus we can conclude that our proposed method is applicable to some information hiding applications such as secret communication, medical imaging systems and online content distribution system.

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