Cosine,Walsh and Slant Wavelet Transforms for Robust Image Steganography

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***Abstract*— Image Steganography is an art and science of unseen communication. Image steganography technique is widely used to secure information utilized for covert communication, featured tagging, copyright protection, military agencies and for many more applications related to secure communications. Image steganography using transforms shows more robustness against attacks. Here, Cosine wavelet transform, Walsh wavelet transform and Slant wavelet transform are proposed to be used for image steganography. Experimentation is done on 10 cover images for hiding 10 assorted message images. Results show that, without attacks Cosine transform performs better but in case of attacks on stego such as Cropping, brightness, darkness, wavelets of Cosine, Walsh and Slant transform performs better than individual orthogonal transforms.**

Keywords— Cosine;Slant;Walsh; Wavelet transform;

I. INTRODUCTION

A wide variety of systems require invisible communication to hide existence of the secret message for secure exchange of information. Internet is the most used and fastest medium for communication but it faces many security related problems like hacking, copyright, eavesdropping etc. Cryptography is the technique which was created to secure the secrecy of communication. There are many different methods to encrypt & decrypt data in order to keep the message secret. Unfortunately, it is not enough to keep the content of a message secret, it is also important to keep the existence of message secret. The technique in which the existence of hidden message is kept secret is called as Steganography [1].

Steganography is the art and knowledge of unseen communication. The word Steganography is resulting from the Greek words “stegos” meaning “cover” and “grafia” meaning “writing” defining it as “covered writing”. This can be achieved by hiding information in other information visually plausible and thus the existence of communicated information is kept hidden. In image steganography, the secret message is hidden in digital images with various hiding methods. Image Steganography is nothing but hiding information exclusively in images. Image Steganography has terminologies as cover image, message and stego image. Cover-Image: is an image used as a carter to embed message into. Message: can be plain text or image as a message. Stego- Image: refers to the resultant image which is carrying a hidden message in it.

Figure 1 shows the basic block diagram of Image Steganography.

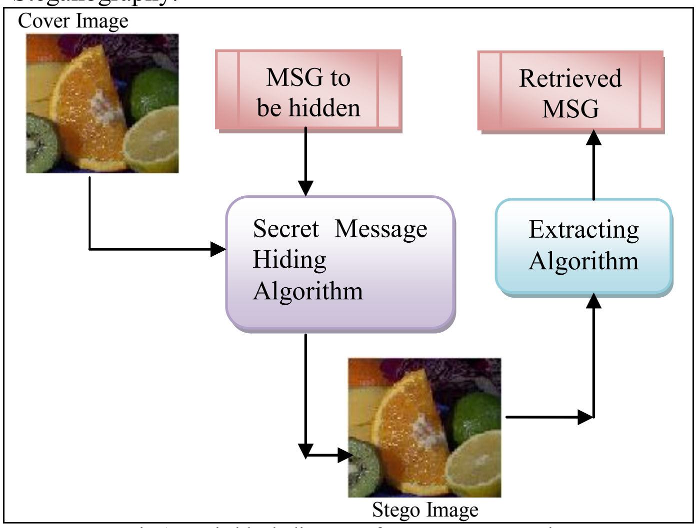

Fig.1. Basic block diagram of Image steganography

Image Steganography is mainly classified into two domains, Spatial and Transform. The embedding capacity of spatial domain techniques is better than the transform domain techniques but, transform domain techniques performs better in case of attacks and hence are more robust.

Here, wavelet transforms are generated for Cosine, Walsh, Slant transforms and used for Image Steganography. Section 2 gives introduction about Cosine, Walsh and Slant transform and their respective Wavelet transforms. Section 3 explains the secret message embedding and extraction methodology. Section 4 elaborates the experimentation environment. The result analysis is done in section 5 with conclusions presented in section 6.

II. TRANSFORMS AND WAVELET TRANSFORMS

A. Discrete Cosine Transform(DCT)

This is one of the most used transforms; this transforms the image from spatial domain to transform domain by altering the DCT coefficients. It can also separate image into three

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regions- high frequency, low frequency and middle frequency region.

2- D DCT is direct extension of 1-D DCT, the general equation for a 2D image (N by M) is given by equation 1

$$C(u,v)=\alpha(u)\alpha(v)\sum_{x=0}^{N-1}\sum_{y=0}^{N-1}f(x,y)\cos\left[\frac{\pi(2x+1)u}{2N}\right]\cos\left[\frac{\pi(2y+1)v}{2N}\right] \quad (1)$$

for u, v = 0, 1, 2, . . . , N-1. Here, the input image is of size N X M. c (i, j) is the intensity of the pixel in row *i* and column *j*; *C(u, v)* is the DCT coefficient in row *u* and column *v* of the DCT matrix. Signal energy lies at low frequency in image; it appears in the upper left corner of the DCT. Discrete cosine transformation (DCT) technique is used for image steganography in transform domain due to its energy compaction property [1, 4].

B. Walsh Transform

Unlike the Fourier transform, which is based on trigonometric terms, the Walsh transform consists of a series expansion of basis functions whose values are only -1 or 1 and they have the form of square waves. One main advantage of rectangular basis functions is that the computations are very simple [5, 8]. The Walsh transform is defined as equation 2 for two dimensional signals.

$$W(u,v)=\frac{1}{N}\sum_{x=0}^{N-1}\sum_{y=0}^{N-1}f(x,y)(-1)^{\sum_{i=0}^{n-1}(b_i(x)b_{n-1-i}(u)+b_i(y)b_{n-1-i}(v))} \quad (2)$$

C. Slant Transform

The slant transform is a well-known orthogonal transform, whose transfer matrices can be constructed in an iterative manner [6]. One prominent characteristic of slant matrices is that they have a constant value on the first row and a linear function on the second row. The Slant transform matrix of order N × N is given by the recursive expression as in equations 4,5,6,7

$$S_1=\frac{1}{\sqrt{2}}\begin{bmatrix}1 & 1\\ 1 & -1\end{bmatrix} \quad (3)$$

$$S_n=\frac{1}{\sqrt{2}}\begin{bmatrix}1 & 0 & & 1 & 0 & \\ a_n & b_n & 0 & -a_n & b_n & 0\\ 0 & & I_{(N/2)-2} & 0 & & I_{(N/2)-2}\\ 0 & 1 & & 0 & -1 & \\ -b_n & a_n & 0 & b_n & a_n & 0\\ 0 & & I_{(N/2)-2} & 0 & & -I_{(N/2)-2}\end{bmatrix}\begin{bmatrix}S_{n-1} & 0\\ 0 & S_{n-1}\end{bmatrix} \quad (4)$$

$$N=2^n,\ a_{n+1}=\left(\frac{3N^2}{4N^2-1}\right)^{\frac{1}{2}},\ b_{n+1}=\left(\frac{N^2-1}{4N^2-1}\right)^{\frac{1}{2}} \quad (5)$$

Where I_m denotes m x m identity matrix.

D. Wavelet Transform

Using any orthogonal transform of size M x M we can generate wavelet transform of size N x N, where N= M x M. In general, Wavelet transform matrix N x N can be generated using any orthogonal transform matrix Tx of size M x M as [2, 3, 9] shown in fig.3.

Tx_{11}	Tx_{12}	Tx_{13}	.....	$Tx_{1(M-1)}$	Tx_{1M}
Tx_{21}	Tx_{22}	Tx_{23}	......	$Tx_{2(M-1)}$	Tx_{2M}
Tx_{31}	Tx_{32}	Tx_{33}	.....	$Tx_{3(M-1)}$	Tx_{3M}
Tx_{41}	Tx_{42}	Tx_{43}	.....	$Tx_{4(M-1)}$	Tx_{4M}
:	:	:	.....	:	:
:	:	:	.....	:	:
Tx_{M1}	Tx_{M2}	Tx_{M3}	.....	$Tx_{M(M-1)}$	Tx_{MM}

Fig.2. Orthogonal Transform of size M x M

Figure 3 shows the Wavelet transform of size N x N, where N= M x M; generated from any orthogonal transform of size M x M.

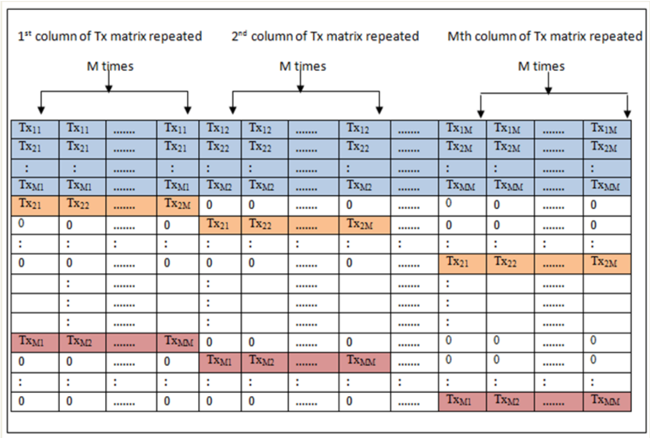


Fig.3. Wavelet Transform generated from any orthogonal transform

III. PROPOSED METHOD

A. Embedding Algorithm

The algorithm embeds the secret image into the lowest energy block of the transformed cover image.

- Apply transform on full cover image.
- Normalize the secret image to be embedded, where Secret image is exactly half size of cover image. This can be done by dividing every pixel value of the secret image by factor 255.
- Select lowest energy block of the transformed cover image to embed the secret image. Here we are selecting lower 1/4th part of cover image.
- Replace the selected block of the transformed cover by normalized secret image.
- Apply inverse transform on the modified cover. This gives us the stego image.

B. Extracting Algorithm

- Apply transform on full stego-image.
- Extract the lowest energy block where we embedded the secret image from the transformed stego-image.
- De-normalize the extracted data (Multiply each extracted secret image value by factor 255). This gives us the recovered secret image.

IV. EXPERIMENTATION

A. Platform

For the experimentation work we have used MATLAB 7.10.0 (R2010a), Processor Pentium IV and above, RAM 3 GB, Operating System Windows 7.

B. Database

The experimental results are tested for database of 10 cover images and 10 Secret message images. The cover image database is shown in Figure 4, Size of cover images 256 x 256 and Secret Message image database is shown in Figure 5.Size of Secret Message images is exactly half of cover image that is 128 x128.

V. RESULTS AND DISCUSSION

A. Testing for embedding into transform domain

Results obtained from embedding into Cosine, Cosine wavelet Transforms, Walsh Transforms, Walsh wavelet transforms, and Slant Transforms and Slant wavelet Transforms are shown in Fig.6. In case of embedding into transform domain, Cosine transform performs better in comparison with Cosine wavelet, Walsh Transform, Walsh Wavelet Transforms, Slant Transform and Slant Wavelet Transforms.

B. Testing of proposed method against attacks

Three types of attacks were applied on the stego image. (i) Brightness Attack (ii) Darkness Attack (iii) Cropping Attack. Our experimental results shows that Cosine transform, Walsh transform and Slant transform do not withstand these attacks. Fig 7, 8, 9 shows the effect of Brightness attack, Darkness attack, Cropping attack in case of Cosine transform, Cosine wavelet transform, Walsh, Walsh wavelet transform, Slant transform and Slant wavelet transform resp. Fig.10 shows the chart of average MSE values obtained from Cosine and Cosine wavelet transforms. From the chart it can be observed that wavelet transform can perform better than orthogonal transform in case of attacks. Fig.11 shows the chart of average MSE values obtained from Walsh and Walsh wavelets transforms. From Experimentation work it can be observed that Walsh wavelet transforms performs better than orthogonal Walsh transform against attacks. Fig.12 shows the chart of average MSE values obtained from Slant transform and Slant wavelet transforms. From Experimentation work it can be observed that Slant wavelet transforms performs better than orthogonal Slant transform in case of attacks on stego image.

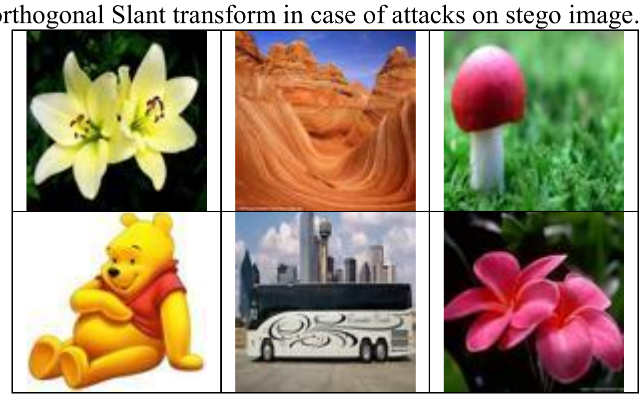


Fig.4. Cover Images Database.

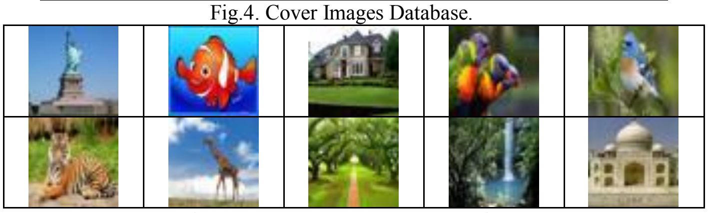


Fig.5 Secret Messages Images Database.

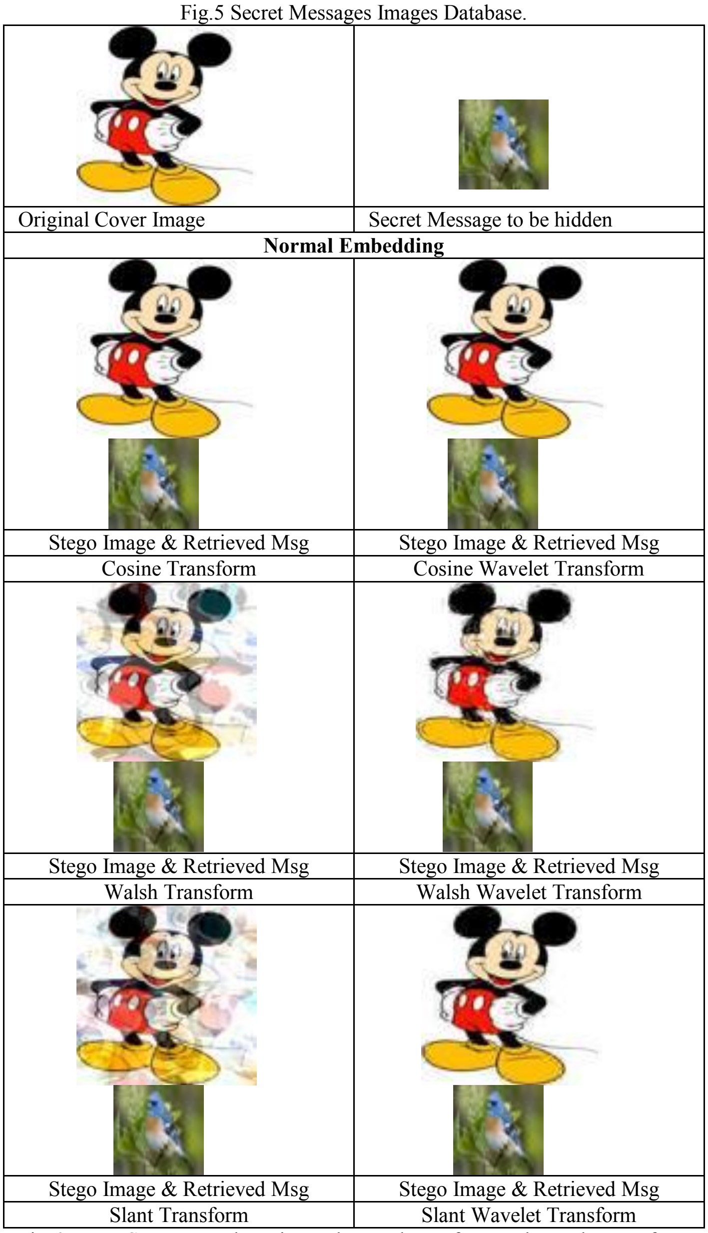


Fig.6 Image Steganography using orthogonal transform and wavelet transform without any attack on Stego Image.

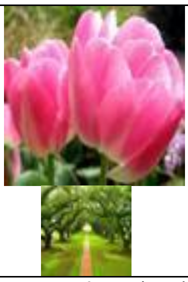
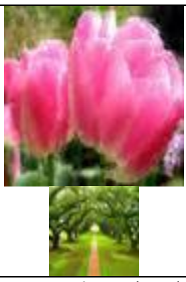
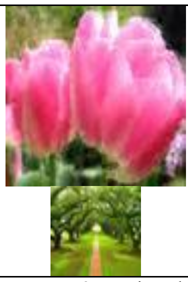
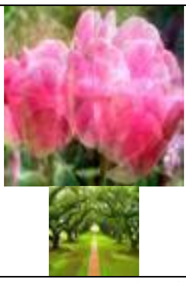
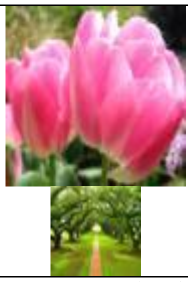
	
Original Cover Image	Secret Message to be hidden
Brightness Attack	
	
Stego Image & Retrieved Msg	Stego Image & Retrieved Msg
Cosine Transform	Cosine Wavelet Transform
	
Stego Image & Retrieved Msg	Stego Image & Retrieved Msg
Walsh Transform	Walsh Wavelet Transform
	
Stego Image & Retrieved Msg	Stego Image & Retrieved Msg
Slant Transform	Slant Wavelet Transform

Fig. 7 Image Steganography using orthogonal transform and wavelet transform with Brightness attack Stego image.

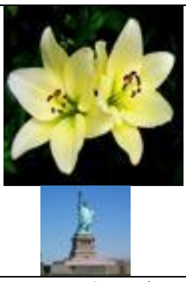
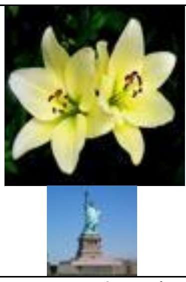
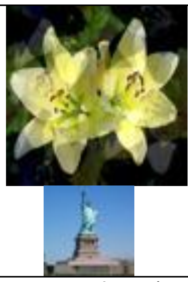
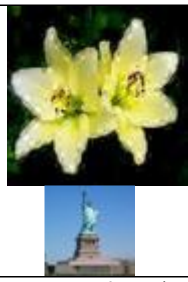
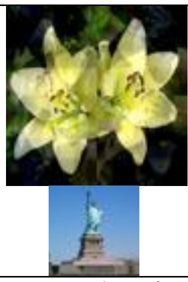
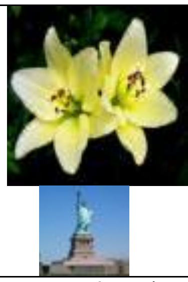
	
Original Cover Image	Secret Message to be hidden
Darkness Attack	
	
Stego Image & Retrieved Msg	Stego Image & Retrieved Msg
Cosine Transform	Cosine Wavelet Transform
	
Stego Image & Retrieved Msg	Stego Image & Retrieved Msg
Walsh Transform	Walsh Wavelet Transform
	
Stego Image & Retrieved Msg	Stego Image & Retrieved Msg
Slant Transform	Slant Wavelet Transform

Fig.8 Image Steganography using orthogonal transform and wavelet transform with Darkness attack on Stego Image.

	
Original Cover Image	Secret Message to be hidden
Cropping Attack	
	
Stego Image & Retrieved Msg	Stego Image & Retrieved Msg
Cosine Transform	Cosine Wavelet Transform
	
Stego Image & Retrieved Msg	Stego Image & Retrieved Msg
Walsh Transform	Walsh Wavelet Transform
	

	
Stego Image & Retrieved Msg	Stego Image & Retrieved Msg
Slant Transform	Slant Wavelet Transform

Fig.9 Image Steganography using orthogonal transform and Local wavelet transform with cropping attack on Stego Image.

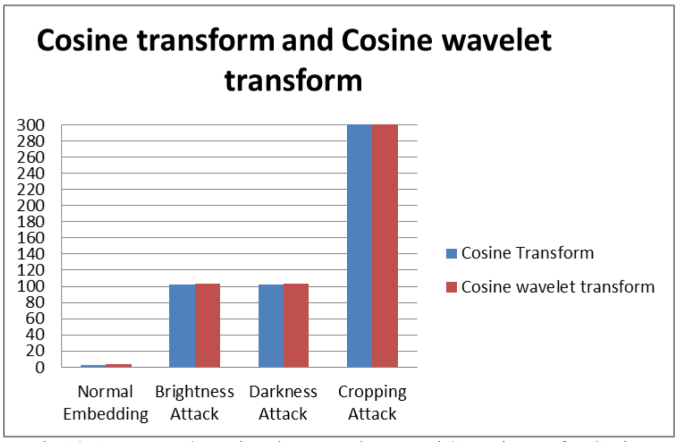


Fig.10 Average MSE values between Cover and Stego image for Cosine Transform and Cosine Wavelet Transforms.

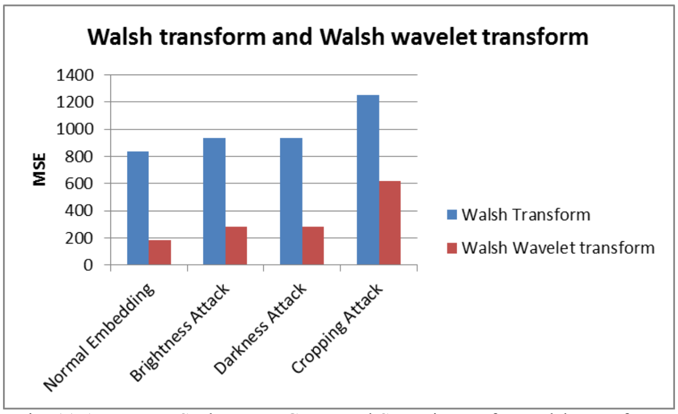


Fig. 11 Average MSE between Cover and Stego image for Walsh transform and Walsh Local Wavelet Transform

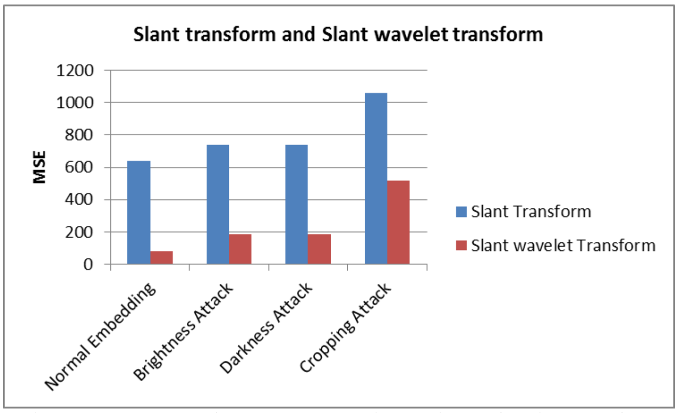


Fig. 12 Average MSE between Cover and Stego image for Slant transform and Slant Wavelet Transform

CONCLUSION

A novel and robust image steganography method using Wavelet transform is proposed. Cosine Wavelet transform, Walsh Wavelet transform and Slant Wavelet transform are generated from Cosine, Walsh, Slant transforms respectively. Experimental results show that Cosine transform performs better in case of normal embedding of secret message without attacks where as Cosine wavelet transform, Walsh Wavelet transform and Slant wavelet transform performs best in case of attacks. The steganography using wavelet transform is more robust against attacks such as brightness, cropping, darkness. The proposed method provides good balance of imperceptibility and robustness.

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