Image Steganography using DCT, DST, Haar and Walsh Transform

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ABSTRACT
Steganography is a means of hiding information within a more obvious form of communication. It exploits the use of host data to hide a piece of information in such a way that it is imperceptible to human observer. The major goals of effective steganography are High Embedding Capacity, Imperceptibility and Robustness. In this paper, the transform domain techniques of Image steganography have been discussed. The Orthogonal Transforms tested were DCT, DST, Haar and Walsh transform. The resultant stego images contained 4 different message images giving a 50% embedding capacity using these transforms. The message images have been normalized and then transformed to reduce the embedding error. The pixel values have been divided by a constant value of 255 to bring all the values into the range of 0.1 to 1.0.Therefore, High Embedding capacity has been achieved through the use of orthogonal transforms using the technique discussed in this paper. The paper compares image steganography schemes that hide secret message into simple orthogonal transforms such as DCT [Discrete Cosine Transform], DST [Discrete Sine Transform], Hartley, Walsh and Haar. The experimental results show that using DCT transform for image steganography achieve much better results as compared to DST, Walsh and Haar.

General Terms
Steganography, MSE, Transforms, Normalization.

Keywords
Stego Image, Cover Image

1. INTRODUCTION
Steganography is the art of hiding data within data so that nobody other than the recipient can detect and retrieve the hidden data. The word steganography is derived from the Greek words “Steganos” which means covered and “Graphei” which means writing. Steganography has a significant advantage over cryptography that messages are not detected at all therefore they do not end to attract attention. Encrypted messages and text are always visible to the naked eye and they will surely attract attention and arouse suspicion. It can be inferred that Cryptography protects a message’s content through encryption, while steganography protects the presence of the message itself.[1]

In Image steganography, the information is hidden exclusively within images. The message image is embedded in the cover image. There are several techniques of doing so. The cover image along with the message image embedded into it is known as Stego Image. Research in Steganography has mainly been carried out due to the weaknesses of cryptographic systems. There are three basic types of stego systems:

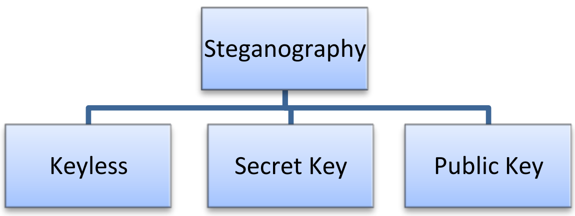

Figure 1: Types of Steganography

When a steganographic system does not require the use of any keys, it is known as keyless. A steganographic system is public when it does not require prior exchange of data like shared-keys. This kind of steganography does not rely on shared-key exchange. Instead it is based on the public-key cryptography principle in which there are two keys, one being the public key which can be usually obtained from a public database and the other a private key**.** Usually in this case the public key is used in the embedding process and the private key in the decoding process. The keyless system has been used in this paper.

2. ORTHOGONAL TRANSFORMS
The drawbacks of LSB technique are apparent in [2] to [11]. Therefore, the transform domain has been taken into consideration. Four orthogonal transforms have been implemented, namely DCT, DST, Haar and Walsh. The transforms can be described as follows:

Discrete Cosine Transform (DCT):[12]

The NxN cosine transform matrix C={c(k,n)},also called the Discrete Cosine Transform(DCT),is defined as

$$c(k,n)=\begin{cases}\frac{1}{\sqrt{N}} & k=0, 0\le n\le N-1\\ \sqrt{\frac{2}{N}}\cos\frac{\Pi(2n+1)k}{2N} & 1\le k\le N-1, 0\le n\le N-1\end{cases}$$ -----(1)

The one-dimensional DCT of a sequence {u(n),0≤n≤N-1} is defined as

$$v(k)=\alpha(k)\sum_{n=0}^{N-1}u(n)\cos\left[\frac{\Pi(2n+1)k}{2N}\right] \quad 0\le k\le N-1$$ ----(2)

Where $\alpha(0)=\frac{1}{\sqrt{N}},\alpha(k)=\sqrt{\frac{2}{N}}\ for\ 1\le k\le N-1$

The inverse transformation is given by

$$u(n)=\sum_{k=0}^{N-1}\alpha(k)v(k)\cos\left[\frac{\Pi(2n+1)k}{2N}\right], 0\le n\le N-1$$ ----(3)

Discrete Sine Transform (DST):[13]

The NxN sine transform matrix $\psi=\{\Psi(k,n)\}$, also called the Discrete Sine Transform (DST), is defined as

$$\Psi(k,n)=\sqrt{\frac{2}{N+1}}\sin\frac{\Pi(k+1)(n+1)}{N+1}$$ ----(4)

0≤k, n≤N-1

The sine transform pair of one-dimensional sequences is defined as

$$v(k)=\sqrt{\frac{2}{N+1}}\sum_{n=0}^{N-1}u(n)\sin\frac{\Pi(k+1)(n+1)}{N+1} \quad 0\le k\le N-1$$ ----(5)

The inverse transformation is given by

$$u(n)=\sqrt{\frac{2}{N+1}}\sum_{n=0}^{N-1}v(k)\sin\frac{\Pi(k+1)(n+1)}{N+1} \quad 0\le n\le N-1$$ ----(6)

Haar Transform:[14]

The Haar wavelet's mother wavelet function φ (t) can be described as

$$\varphi(t)=\begin{cases}1 & ,0\le t\le\frac{1}{2}\\ -1 & ,\frac{1}{2}\le t\le 1\\ 0 & ,Otherwise\end{cases}$$ ----(7)

And its scaling function $\varphi(t)$ can be described as,

$$\varphi(t)=\begin{cases}1 & ,0\le t\le 1\\ 0 & ,Otherwise\end{cases}$$ ----(8)

Walsh Transform: [15]

Walsh transform matrix is defined as a set of N rows, denoted Wj, for j = 0, 1, ..., N - 1, which have the following properties[9]

- Wj takes on the values +1 and -1.
- Wj[0] = 1 for all j.
- WjxWkT =0, for j ≠ k and WjxWKTWj has exactly j zero crossings, for j = 0, 1, ...N-1.
- Each row Wj is even or odd with respect to its midpoint.
- Transform matrix is defined using a Hadamard matrix of order N. The Walsh transform matrix row is the row of the Hadamard matrix specified by the Walsh code index, which must be an integer in the range [0... N-1]. For the Walsh code index equal to an integer j, the respective Hadamard output code has exactly j zero crossings, for j = 0, 1... N - 1.

3. PROPOSED SYSTEM

Embedding Algorithm:

a. Cover Image Transformation

The transform is applied on the cover image of size 512 X 512

b. Block division and energy calculation of transformed cover image

The cover image is divided into 16 non-overlapping blocks of size 128 X 128and the energy of each block is calculated.

c. Message image normalization and transformation

The message image is normalized by dividing each pixel of the image by 255 to reduce the embedding error. The transform is then applied to the image

d. Embedding secret normalized and transformed image

The message images are then embedded into 8 lower energy blocks of the cover and each of the message planes are embedded into the corresponding cover planes i.e: red message plane into red cover plane and so on

e. Obtaining Stego image by taking inverse transform on modified cover image

The inverse transform is applied on the cover image. The new image obtained is the Stego image.

Extraction Algorithm:

a. Transformation of Stego Image

The transform is applied on the Stego image to get the transformed image

b. Retrieval of secret message blocks

The message images are extracted block by block from the locations where they have been embedded

c. Apply inverse transforms

The inverse transforms are applied on these extracted message images

d. Denormalize retrieved secret message

The retrieved message images are denormalized i.e: multiplied by 255 to obtain the original secret message

Figure 2: Test bed of Secret Message

Figure 3: Test Bed of Cover Image

4. RESULTS AND DISCUSSION

These are the experimental results of the images shown in figure 2 used as secret messages and figure 3 used as cover images. This was carried out on DELL N5110 with below Hardware and Software configuration.

Hardware Configuration:

1. Processor: Intel(R) Core(TM) i3-2310M CPU@ 2.10 GHz.
2. RAM: 4 GB DDR3.
3. System Type: 64 bit Operating System.

Software Configuration:

1. Operating System: Windows 7 Ultimate [64 bit].
2. Software: Matlab 7.14.0.739 (R2012) [64 bit].

The experimental results show that by embedding 50% of the Cover image information as in Figure 3 with Secret Message image as in Figure 2 in various image transforms like DCT, DST, Walsh and Haar, DCT gives the least MSE(Mean Squared Error) between the Cover Image and the Modified Cover Image. Total five Secret Message Images (Left to Right and Top to Bottom, Image1 256x256, Image2 128x128, Image3 128x128 and Image4 128x128) were embedded into the Cover images (Left to Right and Top to Bottom, Image1, Image2, …..,Image6) of size 512 x 512.

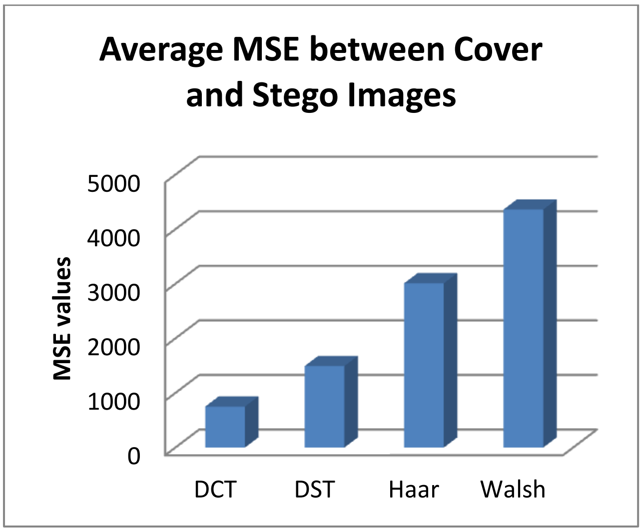

Figure 4: Average MSE values for all the four transforms

Table 1: MSE values for all the four transforms for the six cover images considered

	DCT	DST	Haar	Walsh
Image 1	15.63	25.82	494.00	377.52
Image 2	750.66	1492.46	2245.16	4361.113
Image 3	229.14	557.32	5293.83	3431.81
Image 4	785.20	1404.61	494.00	2980.02
Image 5	1530.44	2093.86	9907.59	3709.52
Image 6	34.76	101.09	2.584	11.33

As it can be seen from the comparison table, DCT has the lowest Mean Squared Error for most of the images. It can also be inferred from the average MSE graph above, DCT gives the lowest average MSE for embedding the images. This means that DCT gives the least amount of distortion when the message images are embedded in the cover as compared to the other transforms making it the most efficient transform among the four considered i.e: DCT, DST, Haar and Walsh.

5. CONCLUSION

After applying the transforms on a varied set of images, it was found that among all the transforms implemented, DCT gives minimum distortion between the original cover and stego images while Walsh gives the maximum distortion. DCT is the most efficient transform for embedding. It was also observed that normalization of the pixel values is essential as unnormalized pixel values were giving distortion in the image.

6. FUTURE SCOPE

The next research step could be to test wavelet transforms and hybrid wavelets for image steganography and to test them against various attacks like Histogram Equalization, Brightness, Salt and Pepper noise, Cropping etc.

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