Analysis and Implementation of Steganography in Frequency Domain

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Abstract - As the escalation of internet is one of the major traits of information technology, data hiding techniques has taken a significant role for the transmission of multimedia content. One of the essential properties of digital information is that it's in theory very simple to make and share out unlimited number of its duplicates. The fact that a vast number of perfect copies of text, image, audio and video records are often illegally created and distributed requires studying ways of embedding copyright information and serial numbers in image, audio and video data. Steganography brings a spread of very substantial technique the way to conceal key information in an imperceptible and/or irremovable way in data like image, audio and video. The simulation results of our work indicates that this method achieves well especially when embedding secret data at higher LSB bit positions. There are few procedures that try to improve the quality of stego image by embedding secret data only in the channels of least importance. Peak Signal to Noise Ratio (PSNR) and Mean Square Error (MSE) is used as a performance index to show the quality of steganographic image.

***Index Terms* – Steganography, LSB, Color Images, Data Hiding**

I. INTRODUCTION

In this time, internet offers great convenience in transmitting large amounts of knowledge in several parts of the planet. However, the security and security of long distance communication remains a problem. Cryptography was created as a way for securing the secrecy of communication and lots of different methods are developed to encrypt and decrypt data so as to stay the message secret. Unfortunately it's sometimes not enough to stay the contents of a message secret, it's going to even be necessary to stay the existence of the message secret. In order to unravel this problem has led to the event of steganography schemes.

Steganography is that the art and science of writing hidden messages in such how that nobody , aside from the sender and intended recipient, suspects the existence of the message, a form of security through obscurity.

Steganography differs from cryptography within the sense that where cryptography focuses on keeping the contents of a message secret, steganography focuses on keeping the existence of a message secret [1]. Steganography and cryptography are both ways to guard information from unwanted parties but neither technology alone is ideal and may be compromised. Once the presence of hidden information is revealed or even suspected, the purpose of steganography is partly defeated [1]. The strength of steganography can thus be amplified by combining it with cryptography.

In this paper, we have studied spatial domain technique is used in image processing for application like data hiding i.e. steganography. It is observed that data hiding using image is more useful than data hiding through text. The objectives of thesis are:

1. To hide the data like text and image, cover selection is important.
2. To achieve steganography in spatial domain LSB substitution method is used. Also this chapters suggested types of steganography and various attacks.
3. To compare the performance of all these methods with each other.
4. To study the effect of variation of parameter on Power Signal to Noise Ratio (PSNR) and Mean Square Error (MSE).
5. Comparison of performance parameters, i.e. PSNR for different images.

This paper is organized as follows. Section II discusses the basic idea of steganography technique and literature review involved in this paper. Section III describes performance parameters of images. Section IV shows implementation of those methods and their results. Finally section V gives the conclusion.

II. STEGANOGRAPHY

Steganography may be a branch of data hiding during which secret information is camouflaged within other information. The word steganography in Greek means "covered writing" (Greek words "stegos" meaning "cover" and "grafia" meaning "writing") [2]. The main objective of steganography is to communicate securely such a way that the true message is not visible to the observer. That is unwanted parties shouldn't be ready to distinguish any sense between cover-image (image not containing any secret message) and stego-image (modified cover-image that containing secret message). Thus the stego-image shouldn't deviate much from original cover-image. The advantage of steganography over cryptography alone is that messages don't attract attention to themselves. The schematic representation of the steganography is given in Fig. 1:

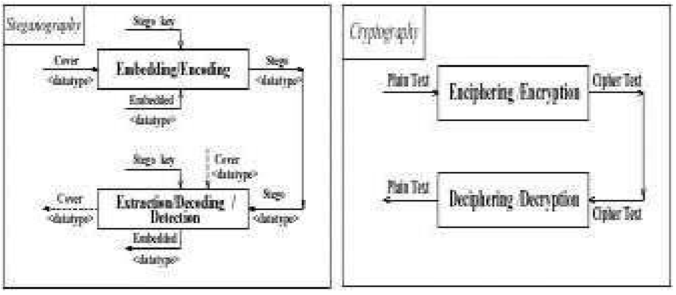


Fig. 1: Steganography versus Cryptography

The techniques of data hiding i.e. steganography, watermarking and cryptography are interlinked. The first two are quite difficult to tease especially for those coming from different disciplines. Table 1 summarizes the differences and similarities between steganography, watermarking and cryptography.

Table 1: Comparison of steganography, watermarking and crytography

Creterion/ Method	Steganography	Watermarking	Cryptography
Carrier	Any digital media	Mostly image/audio files	Usually text based
Secret Data	Payload	Watermark	Plain text
Key	Optional		Necessary
Inputt files	Atleast two unless in self-embedding		One
Output files	Stego-file	Watermarked-file	Cipher-text
Objective	Secrete communication	Copyright preserving	Data protection
Visibility	Never	Sometimes	Always
Flexibilty	Free to choose any cover	Cover choice is restricted	N/A
Fails When	It is detected	It is removed/replaced	De-ciphered

On the basis of the image formats i.e. Graphics Interchange Format (GIF), Joint Photographic Experts Group (JPEG), and to a lesser extent- Portable Network Graphics (PNG), image steganography are of three types:

- Steganography in the image spatial domain
- Steganography in the image frequency domain
- Adaptive steganography

Steganography in the image spatial domain: Here spatial features of image are used. This is a simplest steganographic technique that embeds the bits of secret message directly into the smallest amount significant bit (LSB) plane of the duvet image. In a gray-level image, every pixel consists of 8 bits. The basic concept of LSB substitution is to embed the confidential data at the rightmost bits (bits with the littlest weighting) in order that the embedding procedure doesn't affect the original pixel value greatly [3]. The mathematical representation for LSB is as equation 1:

$$x'_i = x_i - x_i \, mod \, 2^k + m_i \tag{1}$$

In Equation (1), x'i represents the ith pixel value of the stego-image and xi represents that of the first cover-image. mi represents the decimal value of the ith block within the confidential data. The number of LSBs to be substituted is k. The extraction process is to repeat the k-rightmost bits directly. Mathematically the extracted message is represented as in equation (2):

$$m_i = x_i \, mod \, 2^k \tag{2}$$

Hence, a simple permutation of the extracted mi gives us the original confidential data [4]. This method is straightforward and easy but this has low ability in touch some signal processing or noises. And secret data are often easily stolen by extracting whole LSB plane. A general framework showing the underlying concept is highlighted in Fig. 2.

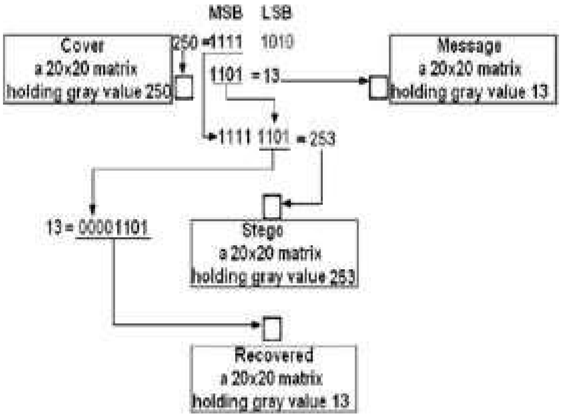


Fig. 2: Steganography in spatial domain. The effect of altering the LSBs up to the 4th bit plane

In the case of steganography, the reconstructed image is only an approximation to the original. Although many performance parameters exist for quantifying image quality, it is most commonly expressed in terms of mean squared error (MSE) and peak signal to noise ratio (PSNR). For a good steganography, MSE should be less. PSNR is provided only to give us a rough approximation of the quality of steganography. PSNR should be more permanently perception of received image.

Princymol Joseph et al., describes a quick study on steganography in their research paper. In steganography, information can be concealed in carriers such as text files, images, audio and video. Based on features such as carrying file, type of message to be rooted, methods of compression used etc., the technique used in steganography can contrast. The power of a steganographic technique lies in its capacity to retain the message, as secret as potential and also the amount of data that can be hidden, as large as possible. In malice of the point that numerous methods already exist in steganography, researches are going on in this field [5]. Amritpal Singh et al., suggested enhanced LSB based image steganography methods for RGB images. There are number of steganography techniques projected to hide data like LSB, DCT, pixel-value differencing, DFT etc. into images with accuracy level. But these techniques grief from some problems like less hiding capacity lower the quality of image and security of hidden data after hiding more data into it. To overwhelm these problems they proposed an improved LSB technique for color images by embedding the information into three planes of RGB image in a way that increases the quality of image and attains high embedding capacity [6]. Dilpreet Kaur et al, discussed about hybrid approach of cryptography, data compression and steganography has been proposed in their paper. Inspiration behind their work is to provide a smart image steganographic technique which must be skilled enough to offer better quality stego-image with a high data hiding capability. Projected method is a LSB based approach and enthused with the invention of H. B. Kekre in the field of image steganography. Maximum data hiding capability of proposed method are going to be assessed from kekre's algorithm [7]

III. Performance Parameter

Image quality measures are of excessive significance in various image processing applications. In the case of steganography and watermarking, the recreated image is only a guesstimate to the original. Although many recital parameters exist for measuring image quality, basically these two classes are objective eminence assessment approaches, viz Mean square error (MSE), peak signal to noise ratio (PSNR), and signal to noise ratio (SNR).

Mean Square Error: This parameter is demarcated as the mean square of difference of corresponding pixel values in the original image and stego-image. Likewise root mean square can be defined as the root mean square of variance of corresponding pixel values in the original image and stego-image. For a good data hiding techniques, MSE should be less. Further, the root mean square can be intended by taking square root of MSE. The mean square error can be expressed as in equation:

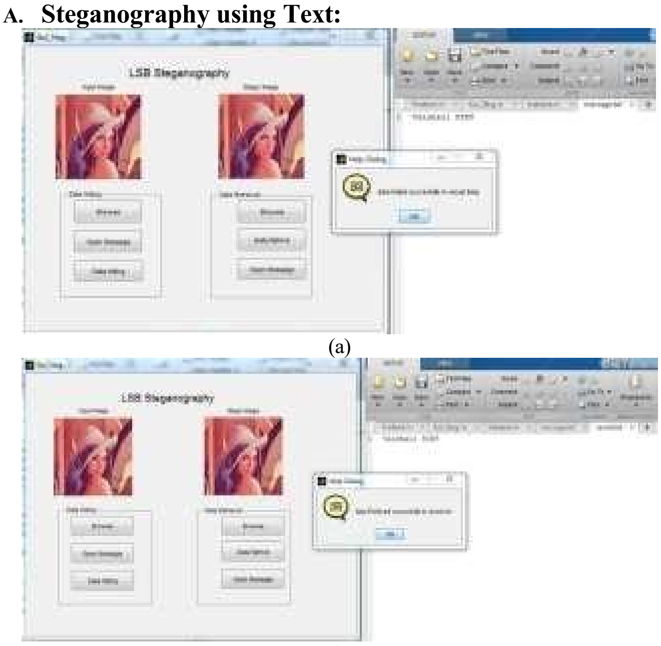
$$= \frac{1}{\quad} \sum_{=0}^{M-1} \sum_{=0}^{N-1} [f'(i,j) - f(i,j)]^2$$

Peak Signal to Noise Ratio (PSNR): The PSNR is the only scrupulously defined metric. The main motive for this is that no good rigorously defined metrics have been projected that take effect of the Human Visual System (HVS) into interpretation. PSNR is provided only to give us a rough approximation of the quality of steganography. The PSNR in mathematical form can be given as equation:

$$= 10 \quad _{10}\left[\frac{256 \times 256}{\quad}\right]$$

IV. Results & Simulation

A. Steganography using Text:



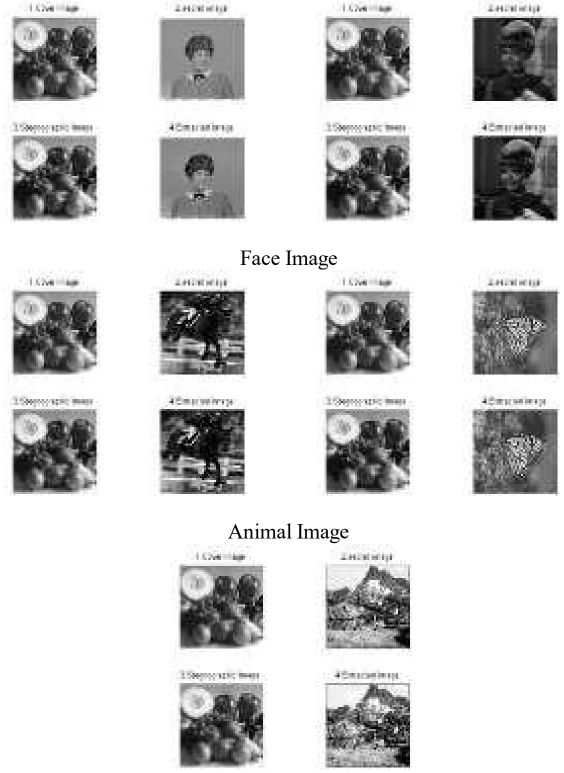
(a)

(b)

Fig 3: Illustration of various steps involves in steganography using text

B. Steganography in Gray Scale Image:

Cover image: fruit.jpg (256*256)
Message image: 3 categories (Face, Animals and Others)



Face Image

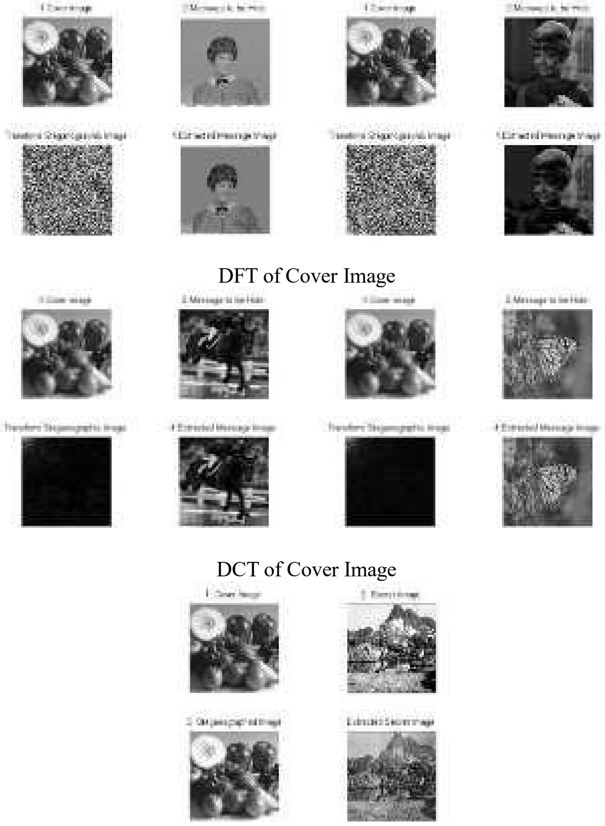
Animal Image

Mountain Image

Figure 4: Illustration of Steganography using LSB substitution (n=4)

C. Steganography using Transform of Cover Image:

Cover image: fruit.jpg (256*256)
Message image: 3 categories (Face, Animals and Others)



DFT of Cover Image

DCT of Cover Image

DWT of Cover Image

Figure 5: Illustration of Steganography using different Transform

Table 2: PSNR value between message image and extracted image

S.NO	Cover	Message	LSB	FFT	DCT	DWT
			PSNR (dB)			
1	Fruit	Face	11.3174	23.5799	29.1889	20.4167
2		Face	10.3681	23.3983	29.2284	20.3942
3		Animal	10.1214	23.4471	29.5353	18.0845
4		Animal	9.8182	23.0901	29.2825	19.9479
5		Mountain	9.8184	23.4479	29.1466	19.3847

V. Conclusion

It is witnessed form the simulation images and PSNR values acquired in the case of steganography; discrete cosine transform (DCT) is effective than spatial domain method because transform makes the steganographic image more robust. But the in Discrete Wavelet Domain stegaonograpic image is also effective as it has more capacity than DCT and DFT. These methods are more composite and gentler than spatial domain methods; however they are more protected and lenient to noises. Frequency domain transformation can be realistic in discrete Fourier transform i.e. DFT, discrete cosine transform i.e. DCT. Also by using LSB substitution method in color image we can achieve more robust steganography [7].

The future scope of this technique can be enhanced to embed colored nested messages in colored image. In addition, we can optimize and improve the spread spectrum algorithm to become faster and more intelligent.

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