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Performance and analysis of high capacity Steganography of color images involving Wavelet Transform

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ABSTRACT

This paper proposes a modified and simple method for high capacity Steganography in case of color images. This algorithm is usually based on the wavelet fusion technique which was not attempted for color images and it proves to be a simplest method than other techniques or algorithms for color images. Even though it uses transform domain technique which only provides robustness against attacks and eavesdropping and it is known that spatial domain techniques usually meet the capacity and quality requirements. In this paper the transform domain technique (Wavelet Transform) is used to attain high capacity along with security and maintains the quality of the cover image which acts as the key feature of this work. This improvement in the capacity–quality tradeoff is analyzed and proved experimentally in this paper and various image quality parameters have been evaluated to prove the above.

1. Introduction

The advancement in modern technology, software and networking has created major threats in obtaining secured data communication through communication networks [11–13]. This led to the research in the field of data security communication. One method of providing more security to data is information hiding [1]. There are three most important parameters for an information hiding system, known as capacity, imperceptibility and robustness. Robustness refers to protection against any manipulation or attack sought out by the hackers or the eavesdropper in the transmitted information. Imperceptibility refers to the fact that the original cover image and the hidden information are indistinguishable. Capacity refers to the amount of data or in case of image the size of image that can be hidden the cover image. The information hiding schemes are principally classified into Steganography and Watermarking [2–5], depending on the application. The term Steganography is derived from the Greek word, steganos meaning “covered” and graphia meaning “writing” hence called covered writing. In Steganography systems, our main aim is to provide more capacity, security and maintain the quality of the cover image in which the payload has been introduced. It usually deals with transmission of such hidden data along the communication network such that the hidden messages appear to be undetectable to the eavesdropper who will be putting all his efforts to get through it. The hidden messages include plain text, cipher text, images and videos.

It is known that the capacity requirements are met by the spatial domain techniques, that we call as the time domain techniques, e.g. gray scale manipulation and Histogram equalization, whereas transform domain techniques, e.g. Wavelet Transform and Discrete Cosine Transform (DCT) are meant for obtaining high robustness against attacks and eavesdroppers. As a result, most of the watermarking algorithms use this transforms domain techniques because of the high robustness, while spatial domain hiding methods are more attractive toward the Steganography schemes because of the capacity concerns. Despite of the basic trend due to increased number of compressed images in the internet and multimedia communication systems researchers are trying to include the capacity requirement in the transform domain, thus attaining both capacity and robustness against attacks at the same time itself.

In this paper we are using the wavelet domain techniques, i.e. Discrete Wavelet Transform (DWT) because it is having lots of advantages compared to other transform techniques like DCT such as progressive and low bit-rate transmission, quality scalability and region-of-interest (ROI) coding demand more efficient and versatile image coding that can be exploited for both image compression and watermarking applications and also it is compatible to Human Visual System (HVS) that provides proper perception quality. As a reference the recent compression technique JPEG2000 is also based on this Discrete Wavelet Transform technique. Hence it is best to consider this DWT technique for Steganography process.

This paper has been organized as follows. Section 2 entails the proposed algorithm. Section 3 presents the analysis and design.

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Table 1
Wavelet families in MATLAB.

Wavelet families	Wavelets (MATLAB notation)
Daubechies [6,7]	db1 or haar,db2,. . .,db10,. . .,db45
Coiflets	coif1,. . .,coif5
Symlets	sym2,. . .,sym8,. . .,sym45
Discrete Meyer	Dmey
Biorthogonal	bior1.1,bior1.5,bior2.2,bior2.4,bior2.6
Reverse Biorthogonal	rbio1.1,rbio1.3,rbio1.5,rbio2.2,rbio2.4

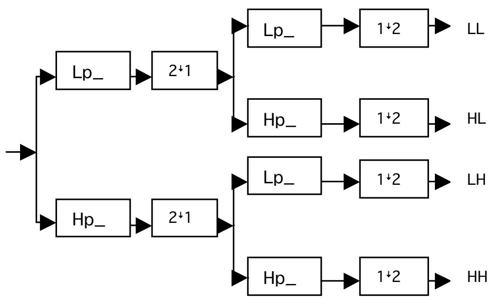

Fig. 1. Filter bank algorithm.

Section 4 covers the results and discussion. Section 5 provides us with conclusion.

2. Proposed algorithm

2.1. Wavelet Transform

Wavelet Transform is a technique that is used to convert the spatial domain into frequency domain and thus separates the high frequency and low frequency component of an image. In this case we usually use the filter bank algorithm in which first of all the image is convolved with the High Pass Filter and a Low Pass Filter that gives the high pass component and the low pass component pixel by pixel, further, each of the low frequency and the high frequency component is again convolved with the Low Pass Filter and High Pass Filters which provides us with the 2D Wavelet Transform of the image.

Of all the wavelets used Haar Wavelet is considered to be the simplest to implement the filter bank algorithm used for separating different frequency components which is given by,

$$\Phi(t) = \begin{cases} 1 & \text{if } 0 \le t \le 1/2 \\ 1 & \text{if } 1/2 \le t \le 1 \\ 0, & \text{otherwise} \end{cases}$$

By using Haar Wavelet, low frequency components are obtained by taking the average of the pixel values in the image provided whereas the high frequency coefficients are obtained by taking half of the difference of the pixel values of the image. Researchers have shown that in human perception, the retina of the eye splits the image into number of frequency channels having equal bandwidth which is similar to that of the multilevel decomposition and it is usually sensitive to only the low frequency components and not to the high frequency components. Because of this reason only Wavelet Transforms are used in this case for further operations. Other wavelets that are also considered here for comparison are shown in Table 1.

Here in this scheme Wavelet Transform of the cover image and payload image is taken using the Haar Wavelet and the payload is concealed into the cover image using wavelet fusion. As shown in Fig. 1 the two-dimensional Wavelet Transform decomposes the color images into four bands the LL, HL, LH and HH band which represents the low pass approximation, vertical, horizontal and diagonal detail coefficients of the color cover image. The LL band gives the soft approximation of the image which is very much sensitive to Human Visual System whereas the HL, LH and HH bands provide us with the details of the image. This process can be repeated for LL band. Fig. 1 shows the 2D wavelet decomposition of an image. Here we are using the Integer Wavelet Transform introduced in [5] (Fig. 2).

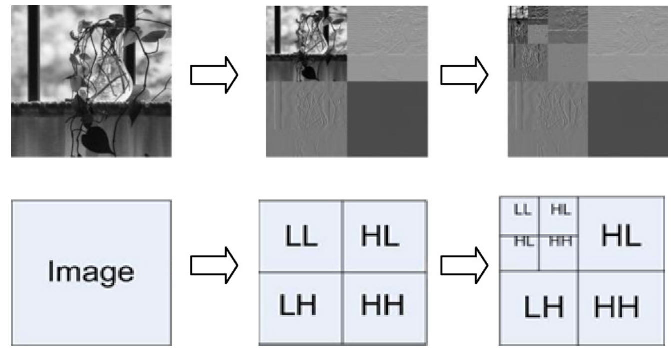

Fig. 2. 2D Wavelet Transform.

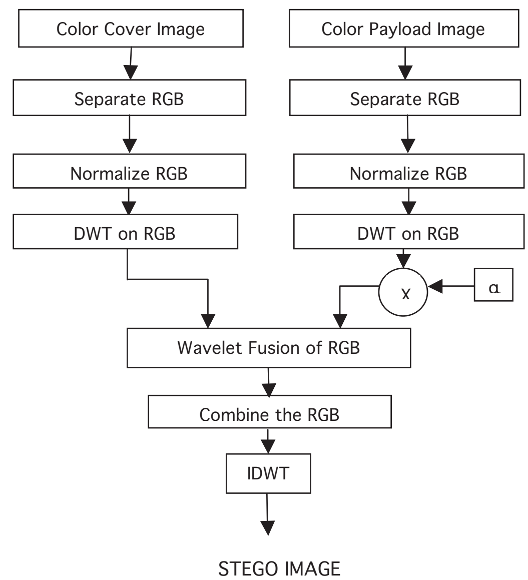

Fig. 3. Encoder block diagram.

2.2. High capacity and security Steganography using DWT

The idea behind the proposed algorithm is the wavelet based addition or fusion. It involves adding of the wavelet decomposition matrix of the normalized version of all the three (RGB) components (Red, Blue and Green) of the cover image and the payload into a single fused result and then combining them to form the original color image for analysis.

2.2.1. HCSSD encoder

The block diagram is shown in Fig. 3. In this first of all, we are separating the Red, Blue and Green components of both the cover and the payload image that is provided with. After that each of the Red, Blue and Green components are normalized to obtain the pixel ranging from (0,1) instead of (0,255). After that we are usually performing the Wavelet Transform using Haar Wavelet on each of the RGB components of the cover image and the payload image. Hence we are getting the two matrices book keeping matrix and the decomposition matrix. We are considering the decomposition