DIGITAL WATERMARKING FOR COLOR IMAGES USING WAVELET TRANSFORM

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Abstract: The technique of digital watermarking is one of the best methods for copyright protection. In this paper, we propose a digital watermarking scheme with color images based on discrete wavelet transform in order to protect the digital media copyright efficiently. In this scheme, third level discrete wavelet transform (DWT) is applied to the original cover image and a watermarked image is used as watermark for the original cover image. During watermark embedding, it should be clear that the size of watermark used should be same as that of the LL3 sub-band of the cover image. Two parameters (alpha and beta) are used to decide that what amount of watermark to be embedding in the cover image. Image quality is measured by calculating the peak signal to noise ratio (PSNR). The higher is the PSNR; the better is the imperceptibility of the watermark. Experimental results show that PSNR between the original cover image and the watermarked image is greater than 42dB. Due to this, watermarked image shows no perceptual degradation and image becomes more secure now.

Keywords: Digital image watermarking; Discrete wavelet transform (DWT); Watermarked Mark; Peak signal to noise ratio (PSNR)

I. INTRODUCTION

Currently, all the information is available in the form of digital multimedia format. Due to the rapid growth of the internet, people can share whatever they want to share like images, documents, paintings, text, audio, video, books etc. and unlimited copying of the digital data without any loss of quality is possible as they all are available in the digital multimedia format. By using the image processing tools, it becomes easy to modify and distribute this digital media to a large no. of peoples in a cost effective way. So, the security and the need for copyright protection of the digital media has turned out to be of great significance due to the widespread use of the internet.

Many solutions have been proposed to solve these problems and are available in the literature like Cryptography, Steganography and Digital Watermarking [1]. Classification of information hiding techniques is shown in Fig. 1. By using the Cryptography, only the authorized users holding decryption keys can access the content (text or images). It provides tools to secure sensitive information. In cryptography, message is usually scrambled and unreadable. However, when communication happens, it is known.

![Fig. 1 Classification of information hiding Techniques]

Steganography on the other hand derived from the Greek for covered writing and essentially means “to hide the plain sight”. It is the art and science of communicating in such a way that presence of a message cannot be detected and it is one to one communication [1]. While cryptography is about protecting the contents of messages, Steganography is
about concealing their existence. Various types of Steganography are shown in Fig. 2.

![Fig. 2 Various types of Steganography]

However, Digital watermarking is the process of modification of the original multimedia data to embed the watermark containing key information such as authentication or copyright codes. The embedding method must leave the original data perceptually unchanged, yet should impose modifications which can be detected by using an appropriate extraction algorithm. Thus, watermarking is an approach to make sure that data are protected [2][3]. These information hiding techniques are used either to protect the information from attackers or to demonstrate the intellectual property rights or to ensure reliability (authentication).

Digital Watermarking have attracted enormous attention recently because it provides the best solution to prevent illegal copying, modifying and distributing the digital media. Digital Watermarking is one-to-many communication.

Watermark can be divided into the diverse categories in a wide range of ways as shown in Fig. 3. By studying these various types of watermarking, we proposed a technique for color images based on the transform domain which embeds the watermark in the color image in such a way that the watermarked image is undistinguishable from the original cover image. Some types of watermarking are described below.

According to the type of working domain, watermarking techniques can be divided into two categories as follows: Spatial domain and Frequency (or transform) domain.

![Fig. 3 Types of Digital Watermarking]

In spatial domain methods (LSB substitution, Patchwork) data is embedded directly by modulating the pixel values. This is much computationally simple and straightforward. But these methods are not much robust against image attacks. Whereas other techniques modify the transform coefficients of the cover image in transform domain i.e. DCT (Discrete Cosine Transform), DWT (Discrete Wavelet Transform) or DFT (Discrete Fourier Transform) domain. Transform domain algorithms are more robust against image attacks as compared to the spatial domain algorithms [2][3]. Presently, advanced choice among all the transform domain methods is
probably the DWT. Main advantages of wavelet transform domain for watermarking applications are:

1. Multi-Resolution Representation
2. Space frequency localization: it provides good space frequency localization for the analysis of edges and textured areas.
3. Adaptability: it is flexible and easily adapts to a given set of images or applications.
4. Linear complexity: Wavelet transform has a linear computational complexity of O(n).
5. Better energy compaction than both the FFT & DCT in the sense that it is closed to the optimal Karhunen-Loeve transform.

A major advantage of DWT lies in the fact that it performs analysis similar to that of the HVS (Human Visual System) [4]. An effective watermarking technique must successfully deal with the requirements of imperceptibility, robustness, security and capacity in order to achieve the copyright protection and security. These 4 key issues are described in brief as follows [2]:

- **Imperceptibility:** Watermark and the cover image should be perceptually indistinguishable that is, the viewer cannot see any information embedded in the contents. In case of any dispute over the digital media data, embedded watermark can be extracted and it can be used to identify the owner because the watermark contains the required information.

- **Robustness:** Watermarked data should not be removed by unauthorized distributors; only the owner of the image ought to be able to extract the watermark.

- **Security:** Watermark should only be detected by the authorized person.

Each of these must be taken into consideration when applying a certain digital watermarking technique. Digital image watermarking is the process of embedding an image called watermark into another image called cover image. Outcome of this insertion process is called watermarked image. Watermark embedding process must be such that watermark is extractable from the watermarked image.

Extensive recent researches on watermarking techniques have been introduced. Some of the watermarking techniques embed the watermark in the components of first level DWT or to the second level. Yang and Zhang [5] have proposed a watermarking technique using iterative blending based on wavelet transform. The method was based on decomposing host image and watermarking image by DWT & then embedding the significant coefficients of watermarking image into the same part of host image using iterative blending. In this technique, there was not a visual difference between the original host images and the watermarked images when the watermarked images were not distorted. Watermark used in this technique was gray images or binary image.

In 2011, Salama et. al. [6] proposed a new technique for watermarking a dual digital image watermarking which embed & extract the watermark in images using Haar wavelets. In this scheme, watermark was embedded by adaptively adding a scaled logo to the wavelet coefficients at the third level of DWT of an image. After applying the 3rd level, the PSNR was greater than what we have at level 2 & level 1 respectively.

In this paper, a digital image watermarking scheme for color images based on DWT is presented. Third level DWT is applied on the cover image using Haar wavelet. After applying the 3rd level, the PSNR was greater than what we have at level 2 & level 1 respectively. There was not a visual difference between the original cover image and the watermarked images when the watermarked images were not distorted. Color images are used as watermark in this paper.

Remainder of the paper is organized as follows: Section II presents the proposed watermarking
technique including watermark embedding and extraction processes. Experimental results are presented in Section III. Finally, Section IV introduces the main conclusion.

II. PROPOSED METHOD

In this section proposed scheme is described in 2 Sub-sections. Sub-section A deals with watermark embedding technique and watermark extraction is explained in Sub-section B.

A. Watermark embedding technique

Consider the color cover image of size 512x512 and 2 watermark images, watermark 1 and watermark 2 of sizes 64x64 and 8x8 respectively. The proposed watermarking technique decomposes the images using DWT with Haar filter.

Steps of embedding process are as follows:

1) First, separate the watermark image 1 (WM1) of size 64x64 to three color RGB channels respectively, R(64x64), G(64x64) and B(64x64).
2) For every layers of the watermark image 1(WM1), decompose it with DWT, in this paper we use 3-level DWT. Figure 4 illustrates the sub-bands in 3 level wavelet decomposition.
3) Embed the watermark 2 (WM2) of size 8x8 into the LL3 sub-band of the watermark 1. By doing this, we get the modified LL3 sub-band of watermark 1.

![Fig. 4. Three level wavelet decomposition](image)

\[ \text{Modified LL3}_{WM1} = \text{LL3}_{WM1} + \beta \times \text{WM2} \]

4) Reconstruct the processed image by using the IDWT & we obtain the watermarked mark as shown in fig. 5. This watermarked mark acts as a mark for the original cover image of size 512x512 as shown in Fig. 6.

![Fig. 5 Watermark embedding procedure 1](image)

5) Repeat steps 1 & 2 for the original cover image of size 512x512.
6) Now, embed the watermarked mark of size 64x64 into LL3 sub-band R, G and B channel or layer of the original cover image. The only difference in this step is that instead of using the beta, we use alpha parameter.

\[ LL3_{\text{cover}} = LL3_{\text{cover}} + \alpha \times \text{watermarked mark} \] (2)

7) Reconstruct the processed image using IDWT & finally we obtain the watermarked Cover Image (512x512).
B. Watermark extraction process

Watermark extraction process is the inverse of the embedding process. Steps of the watermark extraction process are as follows:

1) Watermarked color cover image (512×512) is divided into the 3 color layer R, G and B.
2) Decompose every layer of this image with 3-level DWT to obtain the wavelet coefficients.
3) Similarly, repeat steps 1 & 2 for the original color cover image.
4) Now, R channel of watermarked mark is extracted by subtracting the R channel of the original cover image from the R channel of the Watermarked cover image and result is then divided by alpha parameter.
5) Similarly, G and B channels or layers of the watermarked mark can also be extracted.
6) By combining these R, G and B layers, extracted color watermarked mark is obtained as shown in Fig. 7.

III. EXPERIMENTAL RESULTS

The experimental results of the proposed algorithm are presented in this section. The proposed technique works on color images. Our technique was tested on 512×512 “Lena” image used as the cover image. Two color images of size 64×64 and 8×8 are used as watermark. We performed three level DWT with the use of Haar filter wavelets. A watermarked mark is used as the watermark for the original cover image.

We applied the Peak signal to noise ratio (PSNR) to measure the image quality & performance of the proposed scheme. The equation of PSNR is described as:

\[ PSNR = 10 \log_{10} \left( \frac{255^2}{MSE} \right) \]  \hspace{1cm} (3)

On the other hand, mean square error (MSE) of an image with h×w pixels is defined as

\[ MSE = \frac{1}{h \times w} \sum_{i=1}^{h} \sum_{j=1}^{w} (A_{ij} - B_{ij})^2 \]  \hspace{1cm} (4)

where A is the original image pixel values and B is the processed image pixel values.

The higher is the PSNR; the better is the invisibility of the watermark

Watermark 1 WM1 (64×64)

Original Cover image (512×512)

Watermarked Mark Image (64×64)

Original Cover image (512×512)

Watermarked Mark Image (64×64)

Watermark embedding procedure 2
Fig. 7 Watermark Extraction Process

- Watermarked Cover Image
- Original Cover Image

DWT

Red
Green
Blue
R
G
B

DWT

DWT

DWT

DWT

(Red_LL3-R_LL3) / alpha

(Blue_LL3-B_LL3) / alpha

(Green_LL3-G_LL3) / alpha

Extracted R Mark

Extracted G Mark

Extracted B Mark

Extracted Watermark RGB

Fig. 8 PSNR between the watermarked and original “Lena” image

Fig. 9 PSNR between the extracted watermark and the original watermark (“Football”)

- PSNR between the watermarked and original “Lena” image
- PSNR between the extracted watermark and original watermark (“Football”)

Fig. 10 PSNR between the watermarked and original “Lena” image

Fig. 11 PSNR between extracted watermark and original watermark (“Pepper”)

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From fig. 8, 9,10 and 11, it is observed that as the value of beta and alpha parameters increases, the PSNR between the original cover image and the watermarked image decreases.

In case of extraction, for a value of beta parameter, PSNR remains almost same for all values of alpha parameter. As the value of the beta increases, the extracted image PSNR starts decreasing. So, by selecting the minimum value of beta parameter, good results of PSNR in both cases can be obtained. In our scheme, we vary the beta and alpha in 0.1-0.9 and 0.01-0.9 respectively. TABLE 1 shows the input images on which this algorithm is tested and also shows some outputs of this algorithm.

### TABLE 1 Input and output images for beta=0.1 and alpha 0.01.

<table>
<thead>
<tr>
<th>ORIGINAL COVER IMAGE</th>
<th>WATERMARK 1</th>
<th>WATERMARK 2</th>
<th>WATERMARKED COVER IMAGE</th>
<th>EXTRACTED WATERMARK</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="original_cover.png" alt="Image" /></td>
<td><img src="watermark1.png" alt="Image" /></td>
<td><img src="watermark2.png" alt="Image" /></td>
<td><img src="watermarked_cover.png" alt="Image" /></td>
<td><img src="extracted_watermark.png" alt="Image" /></td>
</tr>
</tbody>
</table>

**IV. CONCLUSION**

In this paper, we propose a new color image watermarking scheme based on watermarked mark embedding techniques which embed and extract the watermarked mark in the original cover image using Haar wavelets.

The scheme embeds the watermarked mark to the wavelet coefficients at the 3rd level of the DWT of an original cover image. After applying the 3rd level of DWT, the PSNR was greater than what we have at the level 2 and level 1; respectively. It is observed that decreasing the level of DWT, the image gets more distorted. It is not only affect the watermarked image but also affect the extracted watermark.

Our experimental results show that as the value of beta and alpha parameters increases, the PSNR between the original cover image and the watermarked image decreases. So, by selecting the minimum value of beta parameter, good results of PSNR in both cases can be obtained as shown in figure 9 and 11. This scheme works well for all color images which are rich in content (colors), not for the sparse images having very less amount of color contents like graph images etc.

**REFERENCES**


