Visible image watermarking using biorthogonal wavelet transform

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Abstract

In this paper, visible image watermarking algorithm based on biorthogonal wavelet transform is proposed. The watermark (logo) of type binary image can be embedded in the host gray image by using coefficients bands of the transformed host image by biorthogonal transform domain. The logo image can be embedded in the top-left corner or spread over the whole host image. A scaling value (α) in the frequency domain is introduced to control the perception of the watermarked image. Experimental results show that this watermark algorithm gives visible logo with and no losses in the recovery process of the original image, the calculated PSNR values support that. Good robustness against attempt to remove the watermark was shown upon attempting different attacks, such as histogram equalization, double winner filtering and scaling.

Keywords: Biorthogonal Wavelet Transform (BWT), Discrete Fourier Transform (DFT), Discrete Wavelet Transform (DWT), Finite Impulse Response (FIR)

العلامة المائية المرئية للصورة باستعمال مرشحات المويجات المتقطعة الثنائية المتعامدة

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المستخلص

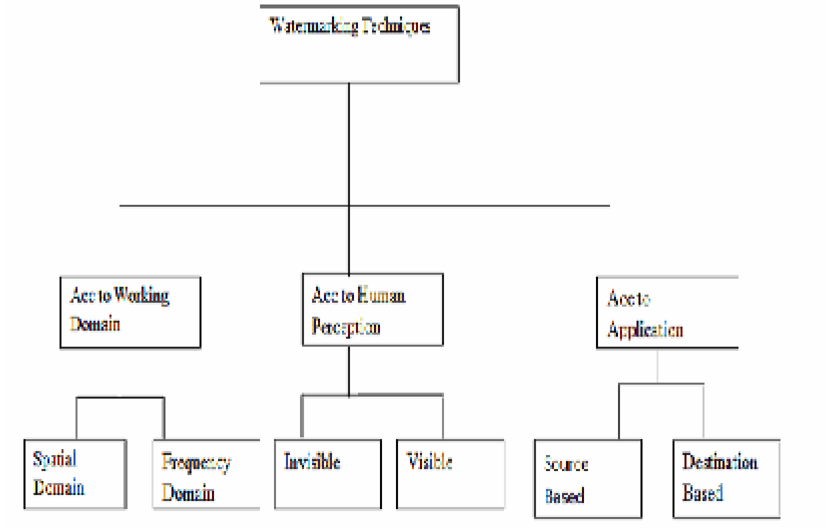
تم في هذا البحث اقتراح خوارزمية العلامة المائية المرئية للصورة اعتمادا على مرشحات المويجات المتقطعة الثنائية المتعامدة والعلامة المائية المستخدمة هي صورة ثنائية تطمر داخل الصورة المضيفة ذات المستوى الرمادي باستعمال معاملات المستويات للصورة المحولة بمرشحات المويجات المتقطعة الثنائية المتعامدة. الصورة ممكن طمرها في الزاوية العليا او نشرها على الصورة المضيفة باكملها , وادخال المعامل (α) في مجال تحويلة المويجة يتحكم بوضوح الصورة الناتجة.

اوضحت النتائج ان الخوارزمية تبقي الصورة مرئية وليس هناك ضياع في عملية استرجاع الصورة الاصلية وقيم PSNR التي قمنا بحسابها تدعم ذلك. وأظهرت النتائج كذلك مقاومة جيدة لمحاولات ازالة العلامة المائية واسطة عدد من طرق المهاجمة مثل طريقة مساواة التوزيع البياني وترشيح ونر المضاعف و المقايسة.

1. Introduction

Due to the rapid and extensive development of high speed internet and communication technologies, the use of multimedia applications is becoming more and more widespread [1]. Digital watermarking is one of such applications, it is the process of computer-aided information hiding in a carrier signal.

Digital watermarks may be used to verify the authenticity or integrity of the carrier signal or to show the identity of its owners [2]. It is prominently used for tracing copyright infringements and for banknote authentication. Like traditional watermarks, digital watermarks are only perceptible under certain conditions, i.e. after using some algorithm, and imperceptible anytime else if a digital watermark distorts the carrier signal in a way that it gets perceivable, it is of no use [3]. Digital watermarking is defined as a process of embedding data (watermark) into a multimedia object to help to protect the owner's right to that object. The embedded data (watermark) may be either visible or invisible [4]. There are many techniques of Watermarking that are described in Figure1.



Visible watermarking schemes are named after the fact that they introduce visible patterns, usually text or logo which carries information about the picture or the creator. Invisible watermarking schemes on the other hand, introduce information in a way that the watermarked images do not show visible signs of being altered. Visible watermarking has the advantage of being low in implementation complexity and does not require the need for an explicit extractor to extract out the watermark before it can be decodable, but it has the problem of degrading the visual quality of the image that is to be watermarked. On the other hand, invisible watermarking techniques do not have this problem, but at the cost of increased implementation complexity and the need for an explicit extractor to extract the watermark before it is decodable [5].

A summary of the properties of both watermarking schemes is shown in Table 1.

Table 1. Summary of watermarking schemes

Properties	Visible	Invisible
Perceptibility	Perceptible	Imperceptible
Complexity	Low	High
Message Form	Meaningful patterns	Arbitrary
Message Notifying	Active	Passive
Explicit Extractor	Not Needed	Needed

In transform domain the watermark is embedded by modifying the frequency coefficients of the transformed image. The common methods in the transform domain are Discrete Fourier Transform (DFT), Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT), etc [7]. In this paper we propose a visible watermarking algorithm using Biorthogonal Wavelet Transform (BWT), first the host image translated to transform domain and then insert the Watermark (logo) in the host image.

2. Biorthogonal Wavelet Transform

The Decomposition of a signal in terms of a wavelet basis is termed as wavelet transform. A biorthogonal wavelet is a wavelet where the associated wavelet transform is invertible but not necessarily orthogonal. Designing biorthogonal wavelets allows more degrees of freedoms than orthogonal wavelets. One additional degree of freedom is the possibility to construct symmetric wavelet functions.

Property of perfect reconstruction and symmetric wavelet functions exist in biorthogonal wavelets because they have two sets of low pass filters (for reconstruction), and high pass filters (for decomposition) [8]. Bi-orthogonal wavelet has the characteristics of close support and symmetry and accurate signal reconstruction can be completed by using a Finite Impulse Response (FIR) filter. In addition, the linear phase character of bi-orthogonal could effectively reduce the signal reconstructing error and at the same time the good coherence between different frequency bands of orthogonal wavelet is reserved. Thus, a wavelet coefficient of different resolutions almost has no redundant information [9]. In biorthogonal wavelets, the decomposition and reconstruction filters are obtained from two distinct scaling functions associated with two multiresolution analyses in duality. Another advantageous property of biorthogonal over orthogonal wavelets is that they have higher embedding capacity if they are used to decompose the image into different channels. All mentioned properties make biorthogonal wavelets promising in the watermarking domain. In the biorthogonal case, there are two scaling functions, which may generate different multiresolution analyses, and accordingly two different wavelet functions. For orthogonal wavelets, the scaling function φ and mother wavelet ψ are given by the recursion relations defined by following equations [9].

their scaled translates are denoted by

$$\varphi(x) = \sqrt{2}\ \textstyle\sum_k h_k\ \varphi(2x-k) \qquad (1)$$

$$\Psi(x) = \sqrt{2}\ \textstyle\sum_k g_k\ \varphi(2x-k) \qquad (2)$$

In the case of biorthogonal wavelet, rather than a single scaling function there is a dual scaling function and mother wavelet.

$$\varphi_k^n(x) = 2^{\frac{n}{2}}\varphi(2^n x - k) \qquad (3)$$

$$\Psi_k^n(x) = 2^{\frac{n}{2}}\Psi(2^n x - k) \qquad (4)$$

When the image is decomposed using normal DWT, if the embedding rate becomes high, data imperceptibility becomes lower and robustness performance is also decreased. Interference may occur as different sets of spreading codes (used for different watermark messages) are added with the decomposed cover image signal using single scaling function. Moreover, the decomposition does not always yield low correlation with the code patterns and high robustness may not be achieved. This problem can be solved to a great extent, if image signal is decomposed properly in different directions, so that low correlation value with the code patterns can be satisfied. When the correlation between the code pattern and the image decomposition coefficients obtained using several DWT and biorthogonal DWT is calculated, it is observed that the biorthogonal DWT provides lower correlation with the code patterns. This is possibly due to the complementary information present in two wavelet systems that offers better directional selectivity compared to classical wavelet transform [10].

3. Visible Watermarking Embedding Algorithm

The design of embedding visible watermarking and the recovery process based on biorthogonal transform domain for gray-scaled images is presented in this section. Logo image was embedded within the grayscale images in two different locations of the host image, first at the top-left corner and second the logo spread over the whole image, a robust watermarking scheme must sustain all kinds of attacks, plus it should preserve the visual quality of the original image after embedding the watermark.

The embedding algorithm for the proposed scheme is outlined step by step as follows:

Embedding algorithm for the logo in host image

Input: Watermark image (W), original host image (I), scaling value (α)

Output: Watermarked image I'

Step 1: Read the original host image I

Step 2: Read the watermark image (Logo) W

Step3: Apply 1st level decomposition using biorthogonal transform on the host image to obtain (LL1, LH1, HL1, and HH1).

Step 4: Perform preprocessing process such that the size of W must equal ¼ from the size of the LL1 if the logo spread on the whole image, and 1/16 from the size of the LL1 if the logo is to be placed in the top left corner

Step5: Take pixel by pixel from W and perform processing on four coefficients from LL1**,** increasing coefficients of LL1 by α if the pixel from W equal to 1 and leaving them if the pixel from W equal to 0.

Step6: Apply inverse biorthogonal transform on the transformed image to obtain the watermarked image I'

The algorithm for the recovery of the original host image is outlined described as follows:

Step1: read the watermarked image I'

Step2: read the watermark (logo) W

Step3: Apply biorthogonal transform on the watermarked image (I') to obtain (LL1', LH1', HL1', and HH1')

Step4: Take pixel by pixel from W and perform processing on the four coefficients of LL1', decreasing them by scaling value (α) if the pixel from W equal to 1 else leave them

Step5: Apply inverse biorthogonal transform on the transformed watermarked image to obtain the original host image I

4. Experimental Results

The proposed watermarking scheme has been implemented and tested on four different gray scale images, Lena, Cameraman, Apple and plane. Any one of them is of size (512 * 512), they are shown in figure (2). The size of the logo must be either (64 * 64) or (128* 128) depending on our proposed algorithm. The logo is shown in figure (3), where the computer science logo was selected.

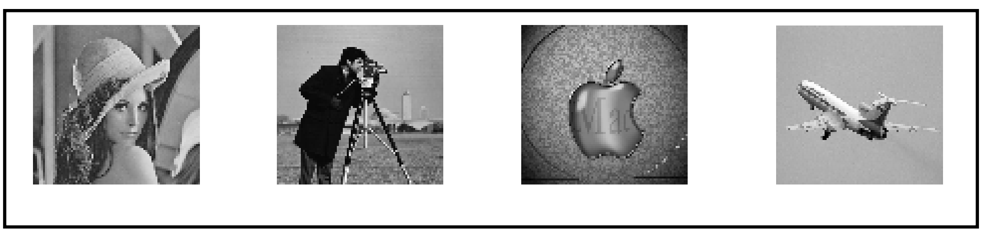


Figure 2: Different host images.

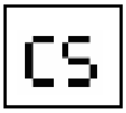


Figure 3: Logo image.

Figure (4) shows the watermarked images in the first location at the top-left corner of the host image.

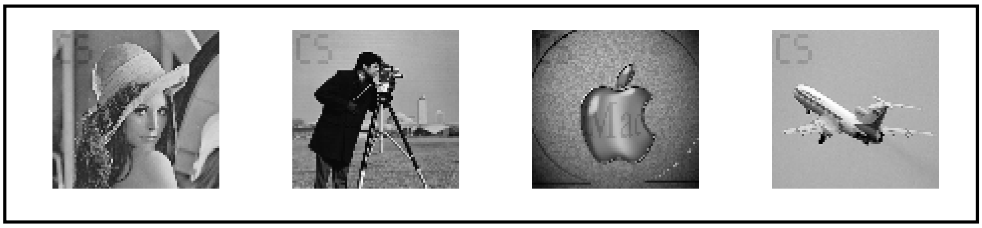


Figure 4: Watermarked image with visible logo (CS) at the top-left corner.

Figure (5) shows the watermarked image where the logo over the whole host image.

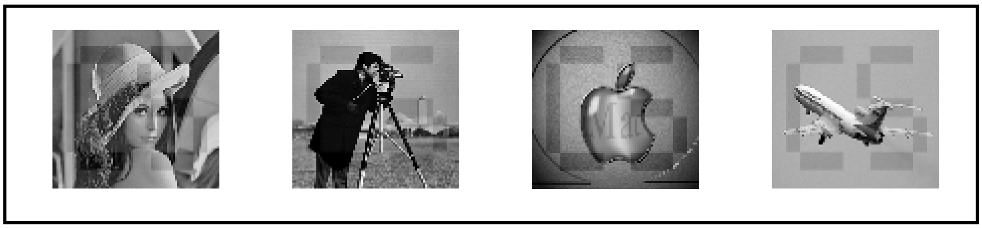


Figure 5: Watermarked image with visible logo (CS) over the whole host image.

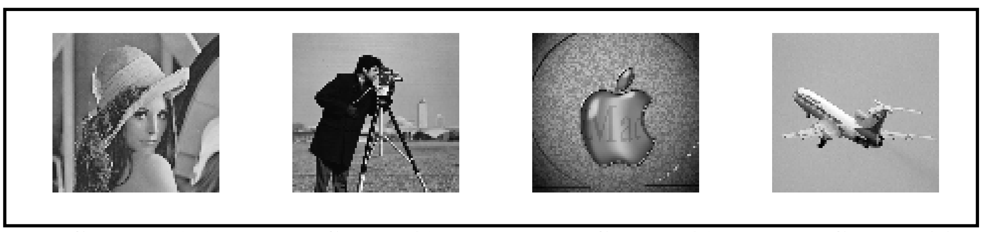
Figure (6) shows the results from the recovery process four all the four images, we can see from the recovery result that there is no loss of information in the reconstruction of the host image. The peak signal to noise ratio values are shown under each image.

In order to measure the quality of the image, Peak Signal to Noise Ratio (PSNR) measure will indicate quality of image with watermarking process. It Denoting the pixels of the original image by Pi and the pixels of the reconstructed image by Qi (where $1 \le i \le n$), first define the mean square error (MSE) between the two images as:

$$MSE = \frac{1}{n}\sum_{i=1}^{n}(P_i - Q_i)^2 \quad (5)$$

It is the average of the square of the errors (pixel differences) of the two images. The root mean square error (RMSE) is defined as the square root of the MSE, and the PSNR is defined as [11]:

$$PSNR = 20\log_{10}\frac{max_i|P_i|}{RMSE} \quad (6)$$



PSNR= 39.3 PSNR=43.8 PSNR= 41 PSNR= 44.7

Figure 6: the restored image with the values of PSNR

To test the robustness of the proposed algorithm, several types of attacks were performed on the watermarked image, such as histogram equalization, double Winner filtering and scaling. Figure (7) illustrates the results of those different attacks, we presented cameraman image as an example to demonstrate the experimental results.

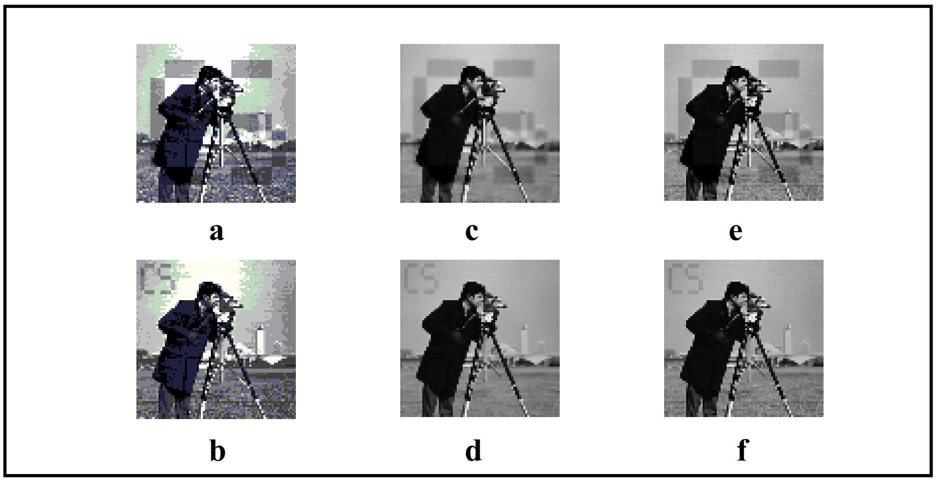


Figure 7: different types of attacks (a and b) histogram equalization, (c and d) double winner filtering, (e and f) scaling twice time

5. Conclusion

A visible watermarking technique has been proposed and implemnted using biorthogonal wavelet transform, this gives more robustness than the invisible method. For achieving placed more robustness, the watermark used with different size can be at different locations using the sub bands of the host image after transforming them from the spatial domain to transform domain. Using the scaling value (α) improve the perceptual watermark. Good result for the recovered images with lossless reconstruction and high PSNR values, the proposed algorithm provides robustness to several types of attack, this is shown in figure (6)

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