RESEARCH ARTICLE OPEN ACCESS

Wavelet Based Image Watermarking

Arun Babu
Asst. Professor, Dept. of ECE Heera College of Engineering and Technology Trivandrum, Kerala

Abstract
here it introduces an efficient multi-resolution watermarking methodology for copyright protection of digital images. By adapting the watermark signal to the wavelet coefficients, the proposed method is highly image adaptive and the watermark signal can be strengthen in the most significant parts of the image. As this property also increases the watermark visibility, usage of the human visual system is incorporated to prevent perceptual visibility of embedded watermark signal. Experimental results show that the proposed system preserves the image quality and is vulnerable against most common image processing distortions. Furthermore, the hierarchical nature of wavelet transform allows for detection of watermark at various resolutions, resulting in reduction of the computational load needed for watermark detection based on the noise level. The performance of the proposed system is shown to be superior to that of other available schemes reported in the literature.
Keywords: Watermarking, Wavelet transform, embedding algorithm, detection algorithm, human visual system

I. Introduction

Multimedia services have witnessed a splendid growth in recent years. This progress has created an everincreasing need for techniques that can be used to support some security issues such as copyright protection, copy protection, fingerprinting and authentication. Digital watermarking technology is an emerging field in computer science, cryptography, signal processing and communications. Digital watermarking is intended by its developers as the solution to the need to provide value added protection on top of data encryption and scrambling for content protection. In this paper, the special focus is done with copyright protection of digital images. Digital watermarking is a method that can be used to resolve this issue. In this means, the digital watermarking is considered as a way of embedding the copyright information (a symbol of identification) into an image such that the watermark data is perceptuallyinvisible and robust. Algorithm robustness is important from different point of views. In copyright protection an algorithm should be robust against all kinds of removal attacks including common signal processing distortions which an image encounters during transmission, and malicious removing attacks. In this regard, many different types of approaches have been reported in the literature. Some of them simplywork in spatial domain. At present, these algorithms are not in wide use; since their general robustness does not seem adequate. Some other algorithms use different types of 2-D image transforms to embed their watermark signal more robustly. Amongst these wavelet-based algorithms seem to be more promising. The wavelet-based algorithms have shown to be much more robust and perform greater perceptual invisibility than others [1, 2, and 3]. Some wavelet-based algorithm have been designed to embed the watermark signal into the lower level sub bands. Most of them do not consider the fact that embeddingwatermark in higher-level sub bands makes the algorithm much more robust due to quality degradation.In this paper, we present a robust multi-resolution image watermarking method with application to copyrightprotection of images. This method explicitly exploits the human visual system to guarantee that the embeddedwatermark is imperceptible. The proposed algorithm saves the image quality in spite of changing all waveletCoefficients of original image. In order to support algorithm robustness, the proposed algorithm is highly image dependent.We have described the proposed watermark embedding and detection system in Section 2. The experimental results are given in Section 3, followed by conclusion expression in Section 4.

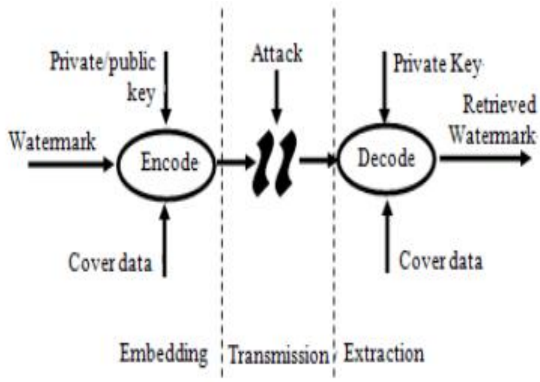

FIGURE I: GENERAL PROCESS OF IMAGE WATERMARKING

II. PREVIOUS WORK

There have been many proposed novel techniques to hide watermark in digital images. These techniques can be Maintaining the Integrity of the Specifications classified into different categories according to several criteria .The first criterion is the type of domain in which the data embedding takes place. There are two major domain types,spatial and transform domains. The transform domain image is represented in terms of its frequencies; however, in spatial domain it is represented by pixels. The second criterion is according to the ability of watermark to resist attack; fragile watermarks are ready to be destroyed by random image processing methods, the change in watermark is easy to bedetected, thus can provide information for image completeness, robust watermarks are robust under most image processing methods can be extracted from heavily attackedwatermarked image.

A. Spatial Domain (Additive Watermarking)

The most straightforward method for embedding the watermark in spatial domain is to add pseudo random noise pattern to the intensity of image pixels. The noise signal is usually integers like (-1,0,1) or sometimes floating point numbers.

Least Significant Bit Modification

A digital image version of this analogue image contains sampled values of the function at discrete locations or pixels.These values are said to be the representation of the image inthe spatial domain or often referred to as the pixel domain. Spatial embedding inserts message into image pixels.

B. Transform Domain

Transform domain embeds a message by modifying the transform coefficients of the cover message as opposed to the pixel values. Ideally, transform domain has the effect in the spatial domain of apportioning the hidden information through different order bits in a manner that is robust. There are a number of transforms that can be applied to digital images, but there are notably three most commonly used in image watermarking. They are Discrete Fourier Transform(DFT), Discrete Cosine Transform (DCT) and DiscreteWavelet Transform (DWT).

Discrete Fourier Transform Fourier Transform (FT) is an operation that transforms a continuous function into its frequency components. The equivalent transform for discrete valued function requires the Discrete Fourier Transform (DFT). In digital image processing, the even functions that are not periodic can be expressed as the integral of sine and/or cosine multiplied by a weighing function. This weighing function makes up the coefficients of the Fourier Transform of the signal. Fourier Transform allows analysis and processing of the signal in its frequency domain by means of analyzing and modifying these coefficients.

Discrete Cosine Transform : Discrete Cosine Transform is related to DFT in a sense that it transforms a time domain signal into its frequency components. The DCT however only uses the real parts of the DFT coefficients. In terms of property, the DCT has a strong energy compaction property and most of the signal information tends to be concentrated in a few low-frequencycomponents of the DCT. The JPEG compression techniqueutilizes this property to separate and remove insignificant high frequency components in images.

Discrete Wavelet Transform : Wavelet Transform is a modern technique frequently used in digital image processing, compression, watermarking etc. The transforms are based on small waves, called wavelet, of varying frequency and limited duration. A wavelet series is a representation of a square-integrable function by a certain ortho-normal series generated by a wavelet. Furthermore, the properties of wavelet could decompose original signal into wavelet transform coefficients which contains the position information. The original signal can be completely reconstructed by performing Inverse Wavelet Transformation on these coefficients. Watermarking in the wavelet transform domain is generally a problem of embedding watermark in the sub bands of the cover image.

III. SYSTEM DESCRIPTION

The block diagram of the proposed image adaptive watermarking algorithm is shown in figure II. As this figure shows, the proposed watermarking algorithm consists of three main steps. In the first step, we decompose an image into its n-level wavelet decomposition coefficients. As Daubechies is in wide-use in most image processing works, we have also chosen to use this filter as our basis function (there are many references which support this idea from theoretical point of view, some proof can be find in [4,5,6]).

In the second step, the watermark embedding step, the wavelet coefficients are used to embed the watermark strongly in perceptually most significant parts of the original image. Let Ỉ, W, W* denote the wavelet coefficients of the original image, the original watermark, and the weighted watermark, respectively. So,

$$w^*(x,y) = \tilde{i}(x,y) \times w(x,y) \qquad (1)$$

As equation (1) shows, * W is highly image dependent and its weights increase significantly in the perceptually important parts of the original image. Subsequently, we employ a thresholding procedure to encounter the properties of human visual system. In this procedure, we use the threshold level of noise visibility in different bands of wavelet decomposition of the image [4] to keep the watermark level under the threshold of visibility. Then, the watermark signal is added to the original image to construct the wavelet coefficients of the watermarked image. Then we have:

$$\tilde{I} = \tilde{I} + W^{**} \quad (2)$$

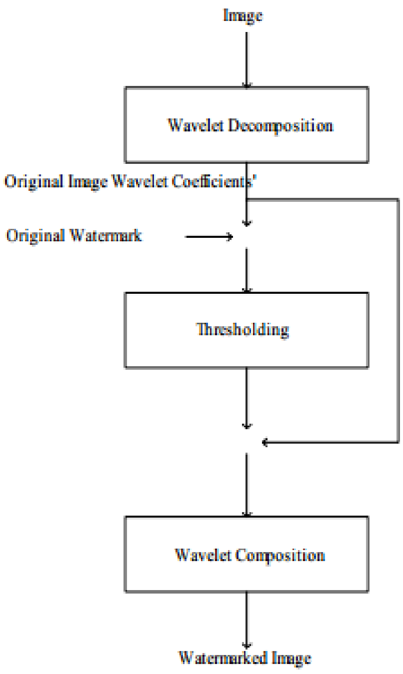

FIGURE II: HIGH LEVEL BLOCK OF THE SYSTEM

Where İ, denotes the wavelet coefficients of the watermarked image and W** denotes the threshold version of the original watermark signal. In the third step, the inverse wavelet transform of the watermarked image is computed to produce the watermarked image in spatial domain. Obviously, although we have changed all wavelet coefficients of the original image, our weighting function and its subsequent thresholding schemes aredesigned in such a way that it provides us with a robust algorithm, which preserves image quality very well.

In the watermark detection step, the wavelet representations of the received image and the original image are both computed. Then, the wavelet coefficients of the original image are subtracted from the wavelet coefficients of the received image (to extract the existing watermark from the received image). This by, we have obtained the threshold version of embedded watermark (W**). Furthermore, as in [7, 8] the thresholding error is modeled as an additive Gaussian noise. Here, we have considered the probability distribution function of extracted watermark to have the same probability distribution function as the original watermark (W). Consequently, we can now simply use the Cox similarity model [7] to determine whether or not the existing watermark is the initially inserted signal. In the next section, we will give our experimental results to prove our claims regarding the image quality and the algorithm robustness.

IV. IVEXPERIMENTAL RESULTS

A number of experiments are performed on the watermarked image to test the resilience of the proposed scheme towards common image processing attacks. 512x512 gray scale Lena and baboon images are used as cover image and watermark image respectively. These images are shown following.

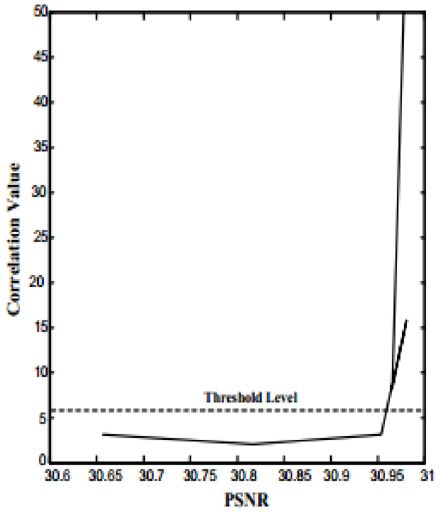

FIGURE IV. WATERMARK DETECTOR RESPONSE AGAINST DIFFERENT LEVELS OF ADDITIVE GAUSSIAN NOISE.

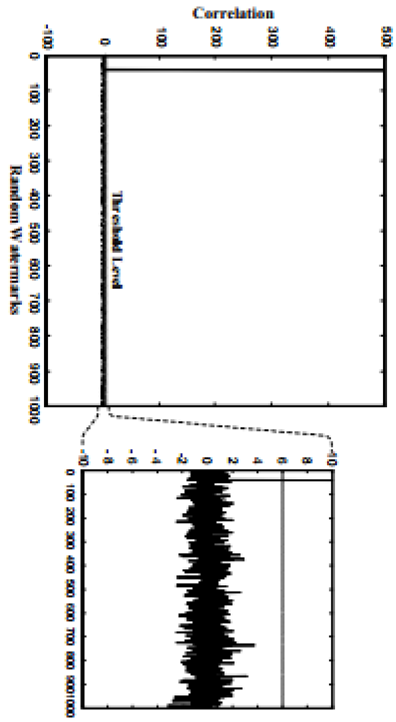

FIGURE III. WATERMARK DETECTOR RESPONSE TO 1000 RANDOMLY GENERATED WATERMARKS. THE THRESHOLD LEVEL IS DRAWN FOR EASE OF COMPARISON.

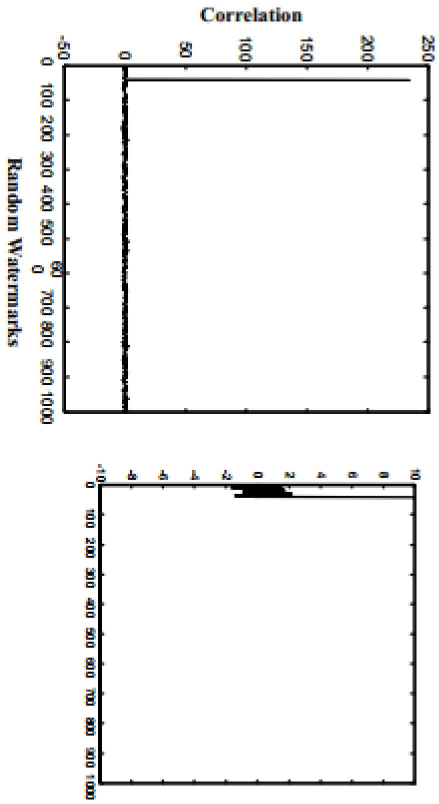

FIGURE V: WATERMARK DETECTOR RESPONSE TO 1000 RANDOMLY GENERATED ATERMARKS USING JUST THE LOWEST RESOLUTION BANDS AS DETECTOR INPUT.

Quality / Image	Excellent	Very Good	Good	Fair	Poor
Lena	88	12	0	0	0
Mandrill	94	5	1	0	0
Dessert	86	10	4	0	0
Peppers	8	82	10	0	0
Squares	5	26	49	15	5

FIGURE VI VI.COMPARISON FOR VARIOUS IMAGES

V. CONCLUSION AND FUTURE SCOPE

In this paper, a digital image watermarking technique based on discrete wavelet transform and discrete cosinetransform has been presented, where the method operates in the frequency domain embedding a pseudo-random sequence of real numbers in a selected set of DCT coefficients. And the watermark is added in select coefficients with significantimage energy in the discrete wavelet transform domain in order to ensure non- erasability of the watermark. Experimental results demonstrate that the watermark is robust to most of the signal processing techniques and geometric distortions. Result suggest that the proposed scheme can be used to extract a good quality watermark for various image processing attacks like JPEG compression, average filtering, median filtering and cropping. There is a scope of future work in this dissertation, as is observed from the qualitative results that the proposed scheme shows comparable results with that of the scheme proposed by earlier. These results can be improved to increase the utility of the proposed scheme for varying levels of compression.

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