상관도 비교를 이용한 웨이블릿 기반 워터마킹1)

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Wavelet-based Watermarking using Correlation Comparison

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Abstract

This paper presents a wavelet-based digital watermarking scheme for color images. We insert watermarks in the DWT domain using spread-spectrum correlation-based watermarking in luminance component of the color image. The watermark, two pseudorandom patterns, is inserted by modifying the wavelet coefficients at subband HL2, LH2, HH2 according to message bits. To detect watermark, we calculate the correlation between the watermarked image and pseudorandom patterns. As compared with correlations, the watermark detector determines embedding message. Experimental results show that the scheme is not only invisible but also robust to various attacks such as JPEG compression, noise addition and so on.

I. Introduction

Recently, due to the rapid growth of Internet and communication technologies, there has been an explosion in the use and distribution of digital contents. Especially, as E-commerce has evolved to a huge business, digital contents distribution plays on important role in digital contents market.

Digital contents can be copied or manipulated easily without any control, and it is not easy to distinguish the original from the duplicated copy. Therefore, it is necessary to find methods that can observe manipulation of digital contents and prevent illegal copy.

So, the digital watermarking technology[1][2] has become the center of attention as a new method of protecting copyrights of digital contents. The goal of watermarking is to embed an unnoticeable form of information for human audio/ visual system, called a watermark, directly into the digital contents.

In this paper, we suggest a new approach for digital watermarking of color images providing robustness and imperceptibility concurrently. We concentrate on correlation-based watermarking methods[1][4][5][6][7] for still color images.

II. Color Representation[3]

In color representation, the perceptual attributes of color are brightness, hue and saturation. Brightness represents the perceived luminance. Hue of color refers to "redness", "greenness" and so on. Saturation is that aspect of perception that varies most strongly as more and more white light is

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added to a monochromatic light. Brightness (W*) varies along the vertical axis, hue (θ) varies along the circumference, and saturation (S) varies along the radial distance. Based on this representation, there are several coordinate systems that have come into existence for a variety of reason.

In this paper, we will use NTSC format. In NTSC format, image data consists of three components: luminance (Y), hue (I) and saturation (Q). The first component, luminance, represents grayscale information, while the last two components make up chrominance (color information). In this paper, the watermark will be inserted in the luminance (Y) components of the color image in DWT domain.

III. Pseudorandom Patterns Generation

Our embedding process is in DWT domain and is based on spread-spectrum correlation method that is adopted from digital communication. In digital communications, the information to be transmitted from one point to another is usually converted to binary form, that is, a sequence of zeros and ones, which are then transmitted to the intended receiver. To transmit a 0, we can transmit the signal sequence $x_0(n)$ for $0 \leq n \leq L-1$, and to transmit a 1 we can transmit the signal sequence $x_1(n)$ for $0 \leq n \leq L-1$, where L is some integers that denotes the number of samples in each of the two sequences. Very often, $x_1(n)$ is selected to be the negative of $x_0(n)$. Using the same analogy, we generate two pseudorandom patterns to represent bit 0 and bit 1 using a secret key. The pseudorandom patterns are composed by {-1} and {1} and have 4x4 dimension. The signs of the first pseudorandom pattern are reversed to make a new pattern with correlation coefficient equal to -1. In other words, the second pattern is the negative of the first pseudorandom pattern. These two patterns will represent bit 0 and bit 1 respectively.

Using two patterns to represent watermark bit (one for bit 0 and one for bit 1) show better result instead of using one pattern as shown in Figure 1. Most paper[1] use two uncorrelated patterns for watermark embedding. We conduct an experiment of watermark detection using two uncorrelated patterns, with using two patterns with correlation coefficient equal to -1. In Figure 2, it is shown that using two patterns with correlation coefficient equal to -1 show better result in detection process.

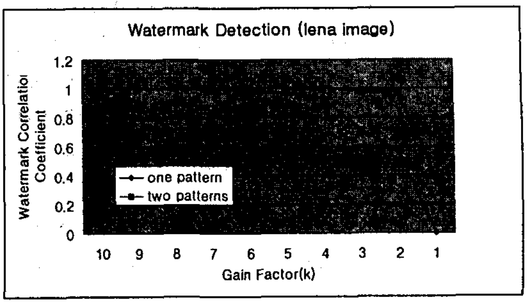


Fig. 1 Watermark detection using one pattern and two patterns

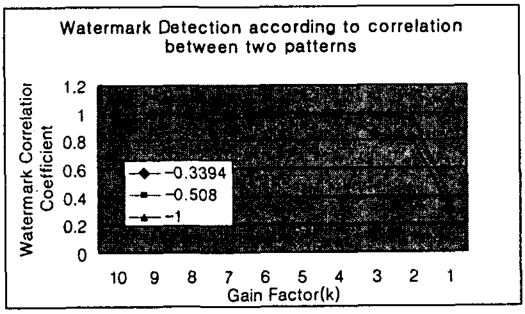


Fig. 2 Watermark detection according to correlation between two patterns

IV. Watermark Embedding

The first step is to extract the luminance component from the color image I size ($M \times N$). If the color image format is in RGB, then we need to convert it to YUV color space to get the luminance I_Y, and then decomposed it through DWT in two levels. Next, the subband HL2, LH2, HH2 is divided into blocks with 4x4 equal size. We embed the pseudorandom pattern in each block that represent one watermark bit by modifying the wavelet coefficient with following equation:

$$I'_{DY}(i) = I_{DY}(i) + k \cdot pattern$$

where $I_{DY}(i)$ is the wavelet coefficient of the luminance component I_Y in block i (size 4x4), k is the gain factor (watermark strength) and pattern is the pseudorandom pattern 1 or 2 (size 4x4). If the watermark bit is 0, the first pseudorandom pattern is embedded as watermark. Otherwise, we embed the second pattern. We can adjust the watermark strength k to balance the robustness and imperceptibility. We set a threshold T to decide the watermark strength. If wavelet coefficient exceeds a certain threshold T at gain factor k, we use an untouched k as a gain factor. But if wavelet coefficient is below a certain threshold T, a gain factor is changed a half of k. This will improve the quality of watermarked image.

After we insert the watermark, we do the DWT inverse transform to get the modified luminance component, and we compose the watermarked color image with the modified luminance component, hue and saturation components. Figure 3 shows the diagram of the first embedding process.

V. Watermark Detection

To detect the watermark embedded in DWT domain, we use correlation. First, we extract the luminance component of watermarked color image and then decomposed it through DWT into two levels and subband HL2, LH2, and HH2 are divided into 4x4 equal size blocks again. To extract the watermark bits, we calculate the correlation between each block of the DWT subbands with the pseudorandom patterns. If the correlation with the first pattern is larger than the correlation with the second pattern, the extracted watermark bit is 0, but if it is smaller then the extracted watermark bit is 1. This process is repeated for all blocks in each subband (HL2, LH2, and HH2) until all watermark bits are extracted.

VI. Experimental Results

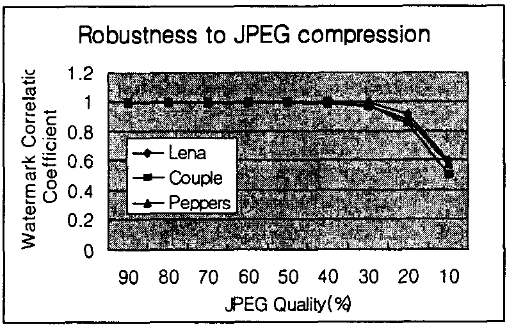
Figure 4 shows an original Lena image and the watermarked image. It is apparent that the watermarked image is undistinguished from the original image.

(a) (b)

Fig. 4 (a) Original Image (b) Watermarked image

We use 512x512 color Lena, Peppers and Couple images. We test our watermarking scheme under different quality of JPEG compression and other attacks i.e., noise addition, sharpen and blur.

For JPEG compression, we test with JPEG quality factor of 10% to 90%. Figure 5 shows that this watermark scheme is robust against JPEG compression.



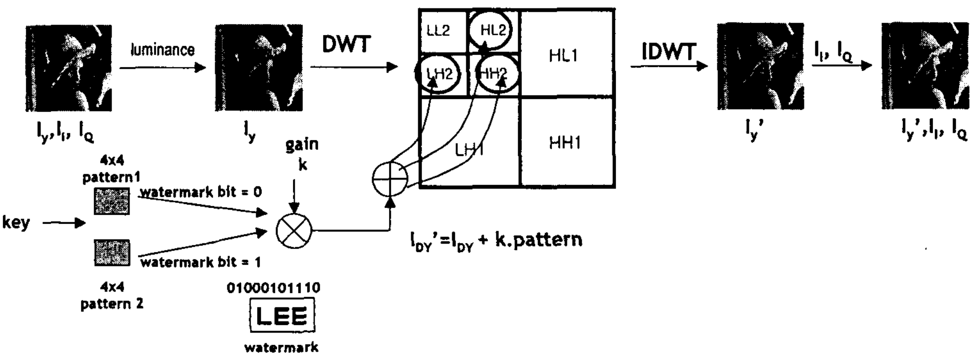


Fig. 3 Diagram block of watermark embedding

Fig. 5 Robustness to JPEG compression

Table 1 shows the test result under other attack. It is shown that the watermark scheme is robust to noise addition, blur and sharpen.

Type		Lena	Peppers	Couple
No Attack	PSNR[db]	52.7438	52.8891	53.6283
	Correlation	1	1	1
Noise Addition	5%	1	1	1
	10%	0.9661	0.9830	0.9834
	15%	0.9519	0.9498	0.9087
	20%	0.8071	0.8402	0.8071
Blur		1	1	1
Sharpen		1	1	1

Table 1 Robustness to other attack (k=5)

VII. Conclusions

We propose a watermarking scheme for color images where we embed the watermark in luminance component of the color image, in DWT domain using spread-spectrum correlation based watermark. As shown from the experiment result, this watermark scheme is robust to JPEG compression, noise addition, blur and sharpen.

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