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A ROBUST DIGITAL IMAGE COPYRIGHT PROTECTION USING 4-LEVEL DWT ALGORITHM

Dr. Sunny Arora
Guru Kashi University, Talwandi Sabo

ABSTRACT

The 4-Level DWT for ownership authentication is used in this research to safeguard digital images. The information is inserted in the original image using the LL4 sub-band and the modulus concealment algorithm. For extracting the binary watermark, no original picture or concealed information is required. Common image processing attacks such as JPEG, median filtering, and Gaussian filtering are all resistant to the proposed approach. In terms of Normalized Correlation Coefficient (NCC) and Peak Signal to Noise Ratio, experimental findings reveal that the proposed approach outperforms current schemes significantly (PSNR).

Keywords -- Digital Copyright Safety (Information Hiding Process), Discrete Wavelet Transform, Haarwavelet, Modulus Hiding, Normalized Correlation Coefficient (Ncc), Peak To Signal Ratio, Normalized Correlation Coefficient (Ncc), Normalized Correlation Coefficient (Ncc), Standardized Correlation Coefficient (Ncc), Normalized Correlation Coefficient (Ncc), Normalized Correlation (Psnr)

I. INTRODUCTION

Because digital media is easy to reproduce and transmit, the rapid expansion of the Internet and digital media reveals itself in widely used public forms such as the digital picture, MPEG, and so on. Many scholars are aware of copyright difficulties, picture authentication, and confirmation of ownership, among other things. As a result, several remedies have been presented. One of the solutions is to use copyright protection. This approach embeds information in such a way that it is difficult to detect; in other words, the viewer will not be able to notice any information contained in the contents. The copyright protection system has a number of significant flaws. To retain its protective secrecy, the implanted watermark should not compromise the image's quality and should be perceptually undetectable. Second, the watermark must be strong enough to withstand ordinary image processing assaults and difficult to remove; only the picture's owner should be able to remove the watermark. Third, blindness is required if obtaining the original picture and watermark is problematic. When the original image and watermark are not required for recovery, a copyright protection technique is referred to as blind.

The alteration of the original multimedia data to insert a watermark holding crucial information such as authentication or copyright codes is the process of digital copyright protection. The concealment approach must keep the original data perceptually untouched while imposing alterations that may be recognised with the help of a suitable recovery procedure. Images, music samples, and digital video are common sorts of signals to watermark. The application of digital copyright protection to still photos is discussed in this paper. The main technological problem is to create a highly reliable digital copyright protection technology that discourages copyright infringement by making the process of removing copyright protection time-consuming and expensive [1The current techniques for copyright protection of images described in the literature can be divided into two categories: transform domain methods [2, 3], which embed data by modulating transform domain coefficients, and spatial domain methods [1, 4], which embed data by directly modifying the pixel values of the original image. Data should be placed in the parts of the cover picture that include certain crucial features information to ensure robustness [5]. This is based on the basic premise that concealed data may be correctly recovered as long as the essential properties of the distinct areas in the cover picture are not substantially modified. Edge, texture, and high grey level curvature points, among other things, are some of the primary properties of a grey level picture [6]. If the watermark information is integrated in the appropriate transform coefficients of the picture features, robustness is strengthened even further. Several discrete Fourier transform (DFT) [7], Fourier–Mellin [8], discrete cosine transform (DCT) [9, 10], and discrete wavelet transform (DWT) [10, 11] digital picture copyright protection techniques have previously been published in the literature.

The modulus hiding approach is used to incorporate a 32 x 32 binary watermark into a 512 by 512 grey scale host picture utilising a powerful copyright protection mechanism based on DWT. The watermark is hidden using the fourth level approximation sub band (LL4). During the concealing process, each coefficient in the specified sub band is updated according to the watermark bit. To extract the watermark bits from a potentially attacked picture, a modulus decoder is utilised. Experiments demonstrate that the suggested technique reduces host picture distortion and is successful against JPEG compression, average filtering, and Gaussian filtering, with a PSNR value of better than 40dB for the watermarked image.

The remainder of the paper is laid out as follows: The second section provides some background information on DWT. The third component discusses information concealment and retrieval. In section 4, experimental findings are provided to show that the suggested strategy outperforms existing strategies by a significant margin. The ability to withstand the most prevalent assaults is also demonstrated. Finally, in section 5, the findings are presented.

II. DISCRETE WAVELET TRANSFORM

Wavelets are special functions that are employed as basic functions for describing signals in a manner similar to sines and cosines in Fourier analysis [12]. Applying DWT to 2-D pictures is equivalent to processing the image with 2-D filters in each dimension. The filters separate the input picture into four non-overlapping multi-resolution subbands: LL1, LH1, HL1, and HH1. The coarse-scale DWT coefficients are represented by the sub-band LL1, whereas the fine-scale DWT coefficients are represented by the sub-bands LH1, HL1, and HH1. The sub-band LL1 is further processed until some final scale N is attained in order to produce the next coarser scale of wavelet coefficients. When N is achieved, 3N+1 sub-bands will be created, consisting of the multi-resolution sub-bands LLN and LHx, HLx, and HHx, where x is a number between 1 and N.

The DWT is well suited to identifying locations in the host picture where a watermark may be efficiently placed due to its outstanding spatial-frequency localization capabilities. This trait, in particular, enables for the use of the human visual system's masking effect, which means that if a DWT coefficient is changed, just the region corresponding to that coefficient is changed. Because the majority of picture energy is concentrated in the lower frequency sub-band LLN, masking watermarks in that sub-band may drastically damage the image. However, hiding in the low frequency sub-band might considerably improve robustnessThe edges and textures of the picture, on the other hand, are included in the high frequency sub-bands HHx, and the human eye is not typically sensitive to changes in such sub-bands. This makes it possible to incorporate the watermark without it being visible to the naked eye. Many DWT-based copyright protection algorithms make the compromise of embedding the watermark in the intermediate frequency sub-bands LHx and HLx, where reasonable imperceptibility and resilience may be obtained [13, 14, 15].

HAAR WAVELET TRANSFORMATION:

Wavelets are a type of function that shows oscillating activity for a brief period of time before disappearing. Haar wavelet is the earliest and most fundamental wavelet system, consisting of a set of square waves of magnitude 1 in the interval [0, 1) [10, 11]. The Haar wavelet has two functions: the Haar scaling equation and the wavelet function, which are written as,

$$\varphi_0(t) = \begin{cases} 1, \; for\, 0 \le t < 1 \\ 0, otherwise \end{cases} \tag{1}$$

$$\varphi_1(t) = \begin{cases} 1, \; for\, 0 \le t < \frac{1}{2} \\ -1, \; for\, \frac{1}{2} \le t < 1 \\ 0, otherwise \end{cases} \tag{2}$$

All the other subsequent functions are generated from $\varphi_1(t) = \varphi_1(2^j t - k)$ (3)

Where

$i = 2^j + k,\, j \ge 0$ And $0 \le k < 2^j$. All the Haar wavelets are orthogonal to each other. From the Haar functions, the scale equation and wavelet equations are obtained as follows

$$\varphi(t) = \sqrt{2}\left(\tfrac{1}{\sqrt{2}}\varphi(2t) + \tfrac{1}{\sqrt{2}}\varphi(2t-1)\right)$$

$$\psi(t) = \sqrt{2}\left(\tfrac{-1}{\sqrt{2}}\varphi(2t) + \tfrac{1}{\sqrt{2}}\varphi(2t-1)\right)$$

From the equations 4 and 5, we get low pass components as $h_0 = h_1 = 1/\sqrt{2}$ and high pass components as $g_0 = -1/\sqrt{2}$, $g_1 = 1/\sqrt{2}$. Using these filter components Haar wavelet decomposition over one-dimension digital signals can be expressed as

$$\left.\begin{aligned} &\begin{pmatrix} C(j) \\ D(j) \end{pmatrix} = T.C(j+1), \quad \text{And} \\ &T = \begin{bmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 & 0 & 0 & . & . & . & 0 & 0 \\ 0 & 0 & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 & . & . & . & 0 & 0 \\ & & & . & & & & & & \\ & & & . & & & & & & \\ 0 & 0 & 0 & 0 & 0 & . & . & . & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ \frac{-1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 & 0 & 0 & . & . & . & 0 & 0 \\ 0 & 0 & \frac{-1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 & . & . & . & 0 & 0 \\ & & & . & & & & & & \\ & & & . & & & & & & \\ 0 & 0 & 0 & 0 & 0 & . & . & . & \frac{-1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \end{bmatrix}_{N \times N} \end{aligned}\right\} \tag{4}$$

From the equation (6), we can compute the approximation coefficients vector C(j) and detail coefficients vector D(j), through operating Haar wavelet decomposition over the vector C(j+1).

III. INFORMATION HIDING AND RECOVERY ALGORITHM

a) A host image is specified by an *m* X *n* matrix. This matrix is the "original image" to be watermarked. The digital information hiding process is divided into three steps and is briefly described below.

Step 1 – Discrete 2-D Wavelet Transform: The original picture is subjected to a single level discrete periodic 2-D wavelet transform, and the coefficient matrices are saved. This technique is repeated three times on the resultant LL band, yielding a four-level DWT with numerous coefficient matrices. The arrangement of the generated coefficient matrices is shown in Figure 1.

Step 2 – In the LL4 band, embed the first watermark: The watermark, represented by X, is embedded into the LL4 band, denoted by C, according to (1) established by Kang et al. [1], where C(i,j) and C'(i,j) signify the amplitude of the (i,j) th element in C and C', respectively, with C' being the watermarked LL4 band; xi,j signifies the (i,j) th element in X; It's worth noting that C and X must be the same size.

Step 3 – To get the watermarked picture, break apart the image's unique sub bands and use inverse DWT to recompose the LL4, LH4, HL4, and HH4 bands first, then the third level, the second level, and lastly the lowest level transform, back to get a watermarked image.

(b) The recovery is blind with respect to the original image. Recovery is completed with two steps, as follows:

Step 1 – Perform DWT on the watermarked image: The watermarked image is transformed into wavelet sub bands in as many levels as in the hiding, i.e. four.

Step 2 – Extract the watermark: In the LL_4 sub band, C containing the watermark, each coefficient c(i,j) is marked. If c(i,j) mod $\alpha > (\alpha/2)$, then the recovered binary

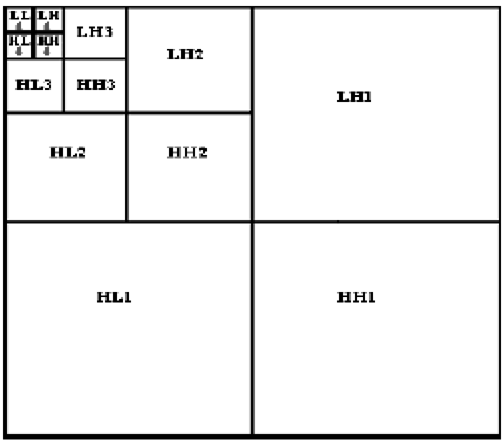

Figure 1: Four-Level Wavelet Decomposition.

$$
\begin{aligned}
&C'(i,j) = C(i,j) - (C(i,j) \bmod \alpha) + 0.75\alpha, && \text{if } x_{i,j} = 1 \text{ and } (C(i,j) \bmod \alpha) \geq 0.25\alpha \\
&C'(i,j) = [C(i,j) - 0.25\alpha] - [(C(i,j) - 0.25) \bmod \alpha] + 0.75\alpha, && \text{if } x_{i,j} = 1 \text{ and } (C(i,j) \bmod \alpha) < 0.25\alpha \quad \textbf{(5)} \\
&C'(i,j) = C(i,j) - (C(i,j) \bmod \alpha) + 0.25\alpha, && \text{if } x_{i,j} = 0 \text{ and } (C(i,j) \bmod \alpha) \leq 0.75\alpha \\
&C'(i,j) = [C(i,j) + 0.5\alpha] - [(C(i,j) - 0.5\alpha) \bmod \alpha] + 0.25\alpha, && \text{if } x_{i,j} = 0 \text{ and } (C(i,j) \bmod \alpha) > 0.75\alpha
\end{aligned}
$$

bit $x(i,j) = 1$; otherwise $x(i,j) = 0$. Recompose the binary watermark in the order of the elements $c(i,j)$.

c) PSNR is used to evaluate the quality between an attacked image and the original image. It is defined as follows:

$$\text{PSNR} = 10\log_{10} \frac{255 \times 255}{\frac{1}{M \times N} \sum_{x=1}^{M} \sum_{y=1}^{N} [f(x,y) - g(x,y)]^2} dB$$

Where M and N are the image's height and breadth, respectively. The values at coordinates (x, y) of the original picture and the attacked image, respectively, are f(x, y) and g(x, y). To determine the existence of the watermark and to measure the accuracy of an extracted watermark, the normalised correlation coefficient (NCC) is computed using the original watermark and the extracted watermark. It's described as

$$\text{NCC} = \frac{1}{m \times n} \sum_{i=1}^{m} \sum_{j=1}^{n} w(i,j) \times w'(i,j)$$

Where m and n are the height and width of the watermark, respectively. w(i, j) and w^{I}(i, j) are the watermark bits located at coordinates (i, j) of the original watermark and the extracted watermark

IV. EXPERIMENTAL RESULTS

Experiments are carried out in this part to determine the efficacy of the suggested algorithm. The tests employ three host images: Lena, Barbara, and Peppers (512 × 512 pixels, 8 bits/pixel). A binary watermark (32x32) is utilised. The setting for hiding strength was set to 90. When the cover picture size is increased, the resilience of the image is reduced, and the embed image quality degrades perceptually. Figures 2 and 3 exhibit the original Lena and its watermarked version, respectively.

There was no visual difference between the original and watermarked images. After copyright protection, the peak signal to noise ratios (PSNR) between the original and watermarked images were calculated and are shown in **Table 1**.

PSNR is 43.58 dB on average. On the Internet and in digital cameras, JPEG is one of the most widely utilised formats. The JPEG quality factor is a number ranging from 0 to 100 that assigns a numerical value to a compression level. Figure 4 shows the original and extracted watermarks for several specified quality levels for the Lena picture. The algorithm's resilience is demonstrated by the recovery information, even after JPEG compression with varied quality factors.

Image	PSNR(dB)
Lena	43.64
Barbara	43.61
gold hill	43.15

Table 1 .PSNR values of the three watermarked images

Figure 2: Host image **Figure 3**: Watermarked image

(Here the Images are look like same but the correlation between Host image &Watermarked is not same, means that information is inserted in the host image)

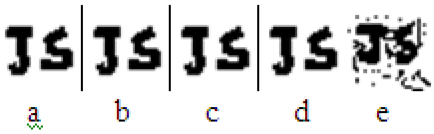

Figure 4: (a) original watermark (b) extracted watermark without attack (c) to (e) extracted watermarks from JPEG compressed Lena watermarked images with quality factors 70, 50, and 20 respectively

The suggested approach is compared to the methods of Li et al. (2006) and Lien and Lin (2006) using the Lena picture in this study; the results are provided in Table 2. Their techniques for copyright protection are based on wavelet decomposition and are blind.

			Lena	Barbara	Goldhill
Attacks	Li et	Lien&lin	Proposed method(NCC)		
PSNR(db)	40.6	41.54	43.64	43.62	43.15
Median (3x3)	0.35	0.79	0.98	0.98	0.95
Median (5x5)	0.15	0.17	0.91	0.85	0.86
JPEG (QF=10)	0.34	0.61	0.62	0.69	0.68
JPEG (QF=30)	0.52	0.79	0.99	0.99	0.99
JPEG (QF=50)	0.52	0.89	1	1	1
JPEG (QF=70)	0.63	0.97	1	1	1
JPEG (QF=90)	0.78	1	1	1	1
Sharpening	0.38	0.88	0.85	0.82	0.82
Gaussian Filter(3x3)	0.7	0.84	1	1	1
Gaussian Filter(5x5)	0.35	0.79	1	1	1
Average filter(3x3)	0.65	0.72	0.85	0.85	0.86
Average filter(5x5)	0.46	0.71	0.84	0.85	0.82

Table 2. Comparing the proposed method with Li et al's (2006) and Lien and Lin's (2006) method.

V. CONCLUSIONS

The 4-level DWT(Haar wavelet) based information concealment technique is suggested in this research as an unique oblivious copyright protection approach. The binary watermark is hidden using the LL4 subband of the host picture. The watermarked image has acceptable perceptual quality, and the watermark can effectively withstand JPEG compression (with a quality factor greater than 15). For JPEG compression, the suggested approach is more resistant to typical assaults such as median filter 3x3 and Gaussian filter. The suggested approach may be used for data concealing and picture authentication in addition to copyright protection. This is highly important in mobile communication and satellite photos to safeguard the data since the specifications of one device to another may not be the same in terms of memory, so the data is plainly compressed even if the information is secure and strong.

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