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Analysis of Robustness of Digital Watermarking Techniques under Various Attacks

Yashovardhan Kelkar, Heena Shaikh, Mohd.Imran Khan
Department of Information Technology, MIT, Ujjain

Abstract—This project acquaints an algorithm of digital watermarking which is based on Least Significant Bit (LSB), Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT). In accord with the characters of human vision, the main objective of the project is to be focused on comparative analysis of this algorithms on the basis of invisibility, distortion and robustness to attacks. The simulation results show that this algorithm is invisible and has good robustness for some common image processing operations.By the use of Matlab software, the algorithms have been coded and then implemented properly.

Keywords—Digital watermarking, Least Significant Bit,Discrete Cosine Transform, Discrete Wavelet Transform, Peak Signal to Noise Ratio, Mean squared Error.

I. INTRODUCTION

At the present time, the aptitude in contemplation of accessing as well as sharing images has become progressively facile with the Internet allowing people to procure information remotely from anywhere in the entire world. Moreover, there has been also an expansion with regard to the number of the still digital images over the internet for the sake of the fact that a vast number of millions of people are capturing digital photos. This mentioned fact could bring forth the requirement for people to conserve their own images or intellectual properties. Given the motivation to protect intellectual property, Digital Watermarking technology has been referred to as fit for acceptance as a form of copyright protection and a preventing those who have such an ambition in order to get a hold of such multimedia date either image disproportionately[2,3].

Fundamentally, the procedure of digital watermarking can be delineated as a method for embedding information into another signal (a digital signal). In case of digital images, the embedded information can be either visible or hidden from the user. In this project, we will concentrate on imperceptible watermarks. The principal intention of digital watermarks is to provide copyright protection for intellectual property that is in digital format. Typical usage scenarios for watermarking are such as copyright protection and data authentication.Based on the digital watermarking for a still image,we are to formulate and encode the following methods:

- The embedding and detecting procedure for watermarking technique based on LSB transform.[1][2][3]
- The embedding and detecting procedure for watermarking technique based on DCT transform.[4]
- The embedding and detecting procedure for watermarking technique based on DWT transform.[4][5]
- Computing PSNR function (peak single-to-noise ratio) the resultant watermarked images from the techniques LSB/DCT/DWT for the purpose of measuring the distinctive distortion between the cover image and the watermarked image.[5]
- Applying the checkmark software by means of MSE function for the original watermarks and extracted watermarks from the LSB/DCT/DWT techniques.[5]

II. LEAST SIGNIFICANT BIT

LSB takes the watermark image embedded into the most unimportant places of vector images.This algorithm is very simple ,strong , real time , embedded stack information and can be accurate resume embedded information. One of the first techniques for watermarking is the least-significant bit modification. It is based on the substitution of LSB plane of the cover image with the given watermark[3].

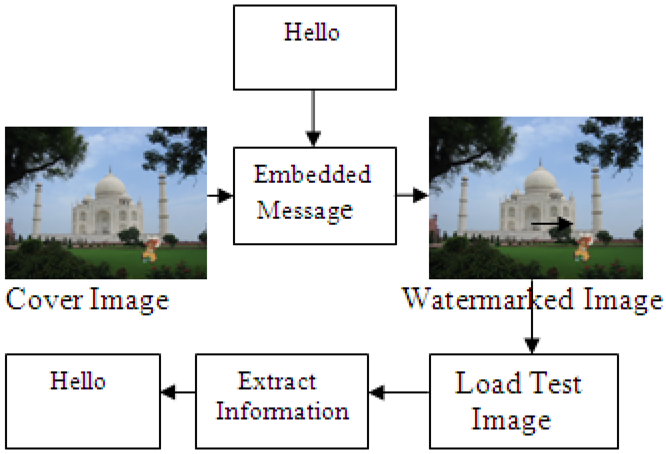


Fig. I **Least Significant bit substitution**

Make a function that replaces the least-significant bit plane of a grayscale cover image and replaces it with your binary watermark. Since your watermark is smaller than the cover image, you need tile several copies of you watermark together in order to achieve the correct size. You can assume that the dimensions of the cover image are divisible with the dimensions of the watermark. The function should take as input a cover image and a watermark. Thereafter, make a function that extracts your watermark from a watermarked image. The function should take as input a watermarked image and give the extracted watermark as output. The functions should be called embed_lsb and extract_lsb[3,4].

III. DISCRETE COSINE TRANSFORM(DCT)

The discrete cosine transform (DCT) is a function that has the ability to convert a signal into elementary frequency components. It represents an image as a sum of sinusoids of varying magnitudes and frequencies. The popular block-based DCT transform segments an image non-overlapping block and applies DCT to each block. This result in giving three frequency sub-bands: low frequency sub band, mid-frequency sub-band and high frequency sub-band. DCT-based watermarking is based on two facts. The first fact is that most of the signal energy lies at low-frequencies sub band which contains the most important visual parts of the image. The second fact is that high frequency components of the image are usually removed through compression and noise attacks[5]. The watermark is therefore embedded by modifying the coefficients of the middle frequency sub band so that the visibility of the image will not be affected and the watermark will not be removed by compression. With an input image, x, the DCT coefficients for the transformed output image, y, are computed according to Eq. shown below. In the equation, x, is the input imagehaving N x M pixels, x(m,n) is the intensity of the pixel in row m and column n of the image, and y(u,v) is the DCT coefficient in row u and column v of the DCT matrix[6].

$$C = (u,v)\alpha_u\alpha_v \sum_{x=0}^{M-1}\sum_{y=0}^{N-1} I(x,y)\cos\frac{\pi(2x+1)u}{2M}\cos\frac{\pi(2y+1)v}{2N}$$

$$for\ 0 \le u \le M-1\ ,\ o \le v \le N-1\ and$$

$$\alpha_u = \begin{cases} 1/\sqrt{M}, & u = 0 \\ \sqrt{2/M}, & 1 \le u \le M-1 \end{cases}$$

$$\alpha_v = \begin{cases} 1/\sqrt{N}, & v = 0 \\ \sqrt{2/N}, & 1 \le v \le N-1 \end{cases}$$

$$x(m,n) = \sqrt{2/M}\sqrt{2/N}\sum_{u=0}^{M-1}\sum_{v=0}^{N-1}\alpha_u\alpha_v\ y(u.v)$$

The image is reconstructed by applying inverse DCT operation according to Eq. shown below:

$$f(x,y)=\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}\alpha_u\alpha_v C(u,v)\cos\frac{\pi(2x+1)u}{2M}\cos\frac{\pi(2y+1)v}{2N}$$

$$for\ \ 0\le x\le M-1, 0\le y\le N-1$$

As defined above.

1. Embedding Technique for DCT

One such a vital technique utilizes the comparison of middle-band DCT coefficients to encode a single bit into a DCT block. There are two major processes, encoding and embedding processes[5].To commence, we first need to go through the initial method that is the encoding and break the image into 8 x 8 blocks then apply the DCT function and computing all the image blocks separately and converting them into frequency components based on the frequency domain and having the whole details and components of the cover image and the watermark converted from the spatial domain into the frequency domain.Secondly, the second procedure which is the embedding process, thus, we have to clarify the middle-band frequency components (F_M) of the image that consists of 8 x 8 DCT block. Then, generating the reduced image which is composed of middle-band frequency components and applying it for the watermark blocks; and with regard to the quantization table, we can select the two coefficients where we can insert the bits needed to embed the watermark. As a result, the watermarked image will be attained[6].

Cover Image

Test Image

Watermarked Image

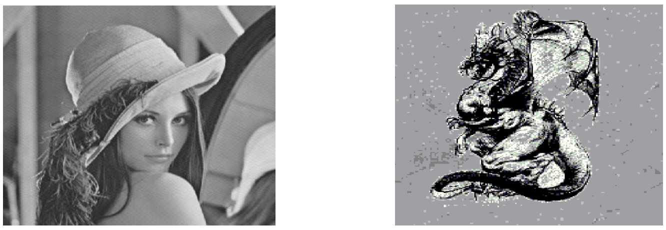
Fig. II **Embedding Technique for DCT**

2. Extraction Technique for DCT

This approach (watermark detection) could be attained by a blind detection either non-blind watermark detection. On assumption of the non-blind detection of a watermark, we have two operations, detecting and extracting process. Through the first conduct,we need to have the cover image, the watermarked image either the watermark signature and break them up into 8 x 8 blocks[8]. Then we should apply the DCT function and transform them into the frequency domain. The extracting process can then start by identifying the middle frequency components (F_M region) for the images and selecting their two coefficients by means of the quantization table; so that we can generate the reduce images and applying them to the watermark blocks and start to detect the bits where the watermark was embedded into therefore, the watermark signature will be extracted.

Watermarked Image

Watermarked Image



Watermarked Image Retrieved Image

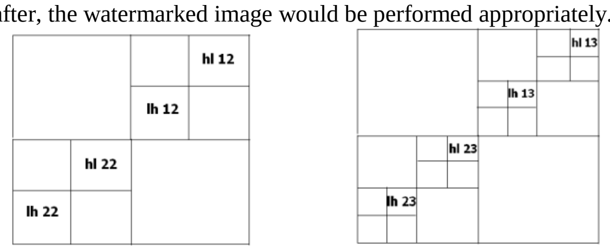
Fig. III **Extraction Technique for DCT**

IV. DISCRETE WAVELET TRANSFORM

The DWT transform, Wavelets are special functions which, in a form analogous to sines and cosines in Fourier analysis, are used as basal functions for representing signals. For 2-D images, applying DWT corresponds to processing the image by 2-D filters in each dimension. The filters divide the input image into four non-overlapping multi-resolution sub-bands (LL_1), (LH_1), (HL_1) and (HH_1). The sub-band (LL_1) represents the coarse-scale DWT coefficients while the sub-bands (LH_1), (HL_1) and (HH_1) represent the fine scale of DWT coefficients. To obtain the next coarser scale of wavelet coefficients, the sub-band (LL_1) is further processed until some final scale "$_N$" is reached. When "$_N$" is reached we will have 3N+1 sub-bands consisting of the multi-resolution sub-bands (LL_N) and (LH_X),(HLx) and (HHx) where "X" ranges from 1 until "N". Due to its excellent spatio-frequency localization properties, the FDWT is very suitable to identify the areas in the host image where a watermark can be embedded effectively. In particular, this property allows the exploitation of the masking effect of the human visual system such that if a DWT coefficient is modified, only the region corresponding to that coefficient will be modified. In general most of the image energy is concentrated at the lower frequency sub-bands (LL_X) and therefore embedding watermarks in these sub bands may degrade the image significantly. Embedding in the low frequency sub-bands, however, could increase robustness significantly. On the other hand, the high frequency sub-bands (HH_X) include the edges and textures of the image and the human eye is not generally sensitive to changes in such sub-bands.[9] This allows the watermark to be embedded without being perceived by the human eye. The compromise adopted by many DWT-based watermarking algorithm, is to embed the watermark in the middle frequency sub-bands (LH_X) and (HL_X) where acceptable performance of imperceptibility and robustness could be achieved.[8]

1. Encoding Technique For DWT

This technique will decompose the cover image of the two dimensional DWT into four frequency bands through the first pass as (LL_1), (LH_1), (HL_1) and (HH_1) frequency coefficients. The frequency bands where it has the lowest resolution of the 1st pass (LL1) can be also decomposed into a 2nd level (pass). Secondly, we are to apply the Gaussian Noise and can insert the watermark signature into the reset of the available frequency bands which include the high frequency coefficients without dealing with (LL) regions from all over the passes (levels). We must add the signal of the bands where the large frequency components to the signal of the Gaussian Noise and modifying them without moderating the original signal which resides in the (LL) band; thereafter, the watermarked image would be performed appropriately.[8,9]



(a) (b)

Fig.IV(a) **DWT sub bands of original message in level 2,** ***(b)*** **DWT sub bands of original message in level 3**

Cover Image Test Image

Watermarked Image
Fig. V **Embedding Technique for DCT**

2. Decoding Technique For DWT

In contemplation of achieving this procedure, we should have the cover image and the watermarked image readily applicable. Consequently, the DWT decoding technique will decompose those two images into four frequency bands through the 1^{st} pass as described previously [10]. Afterward, we are to select for instance one of those bands where the large frequencies reside through one of the levels (passes) in the decomposed cover image and the decomposed watermark. Let's suppose the selected band from both decomposed images is (HH_1), we have then to compare the difference of the frequency coefficients in those bands of the decomposed images and examine their cross correlation. Subsequently, if the cross correlation has detected a peak, then the watermark signature will be extracted; if not, then the same operation will continue on comparing the rest of the other bands consist the high frequency components from both of the decomposed images and investigate their cross correlation until the peak is detected; correspondingly, the watermark signature will be latterly recovered[9,10].

Watermarked Image Retrieve Image
Fig. VI **Extraction Technique for DCT**

V. PERFORMANCE EVALUATION

This section presents the simulations and experiments of the proposed scheme and the results obtained.For quantitative evaluation, PSNR (Peak Signal-to-Noise Ratio) is introduced to evaluate the performance of the proposed scheme and image quality, which is defined as

$$PSNR = 10\log_{10}\left(\frac{255^2}{MSE}\right) dB$$

$$MSE = \sum_{i=0}^{n-1}\sum_{j=0}^{m-1}\frac{(a_{i,j} - b_{i,j})^2}{n \times m}$$

Where $m \times n$ is the image size, ai,j and *b*i,j are the corresponding pixel values of two images.

Imperceptibility: Imperceptibility means that theperceived quality of the host image should not be distorted by the presence of the watermark. As a measure of the quality of a watermarked image, the peak signal to noise ratio (PSNR) is typically used.PSNR in decibels (dB).

Robustness: Robustness is a measure of the immunity of the watermark against attempts to remove or degrade it, internationally or unintentionally, by different types of digital signal processing attacks. In this chapter, we will report on robustness results which we obtained for three major digital signal processing operations (attacks): Gaussian noise, image compression, salt and pepper. That is the Gaussian noise is a watermark degrading attack, JPEG compression is a watermark removal attack.

Table I. **Comparison of PSNR Values under Different Attacks**

	Attacks			
Watermarking Techniques	No Attack	JPEG Compression	Salt & Pepper	Gaussian Noise
LSB	98.4146	Not Applicable	21.6668	16.8868
DCT	35.1676	30.756	29.7098	29.7065
DWT	42.3299	35.536	35.6743	35.6825

Table II. **Comparison of MSE Values under Different Attacks**

	Attacks			
Watermarking Techniques	No Attack	JPEG Compression	Salt & Pepper	Gaussian Noise
LSB	9.3675e-006	Not Applicable	443.0009	1331.680
DCT	19.7844	54.6363	17462.332	17475.47
DWT	478.7263	362.6444	82620.241	82649.42

VI. CONCLUSION

In this paper, we proposed a watermarking scheme based on discrete cosine transform, wavelet packet transform and Least significant bit. The Least Significant Bit (LSB) discrete wavelet transforms (DWT) and the discrete cosine transform (DCT) have been applied successfully in many in digital image watermarking. We tested our proposed watermarking scheme through extensive experiments. The experimental results clearly demonstrate the much improved performance of the proposed approach in terms of imperceptibility and robustness against attacks.

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