Digital Watermarking Using Combined DWT And DCT

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Abstract

The growth of computer networks has boosted the growth of the information technology sector to a greater extent. Thus the digital information which includes images, videos, text etc. is readily available to anyone. At the same time care is taken to prevent the unauthorized use of the images commercially. To satisfy these need owners moved towards watermarking. In this paper the embedding and extraction technique for watermarking is presented based on DCT & DWT transforms. In this technique the insertion and extraction of the watermark in the gray scale image is found to be simpler than other transform techniques. Various values of PSNR's, NC's are analyzed for watermarked image quality and extracted watermark quality.

Keywords -*Digital watermarking, Discrete Wavelet Transform, Discrete Cosine Transform, Peak Signal to Noise Ratio (PSNR), Normalized Correlation (NC).*

1. Introduction

The development of effective digital image copyright protection methods have recently become an urgent and necessary requirement in the multimedia industry due to the ever-increasing unauthorized manipulation and reproduction of original digital objects. The new technology of digital watermarking has been advocated by many specialists as the best method to such multimedia copyright protection problem. It's expected that digital watermarking will have a wide-span of practical applications such as digital cameras, medical imaging, image databases, and video-on-demand systems, among many others. In order for a digital watermarking method to be effective it should be imperceptible, and robust to common image manipulations like compression, filtering, rotation, scaling cropping, and collusion attacks among many other digital signal processing operations. Current digital image watermarking techniques can be grouped into two major classes: spatial-domain and frequency-domain watermarking techniques. [4]

Compared to spatial domain techniques, frequency-domain watermarking techniques proved to be more effective with respect to achieving the imperceptibility and robustness requirements of digital watermarking algorithms. Digital Watermarking is an adaptation of the commonly used and well known paper watermarks to the digital world. Digital Watermarking describes methods and technologies that hide information, for example a number or text, in digital media, such as images, video or audio. The embedding takes place by manipulating the content of the digital data, which means the information is not embedded in the framearound the data. The hiding process has to be such that the modifications of the media are imperceptible. For images this means that the modifications of the pixel values have to be invisible.

The most commonly used transforms are Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT) .In this paper, a digital image watermarking algorithm is described which is based on combining two transforms; DWT and DCT. The DCT has high energy compaction property and requires less computational resources. The energy compaction property of an algorithm refers to the ability to concentrate most important information signal into as much as few low frequency component. On the other hand, DWT is a multi-resolution transform and variable compression can be easily achieved. The main disadvantages of DCT are introduction of false contouring effects and blocking artifacts at higher compression, and, that of DWT is requirement of large computational resources. In this paper we will describe the method of digital watermarking using combined DWT-DCT.

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The DCT and DWT transforms have been extensively used in many digital signal processing applications. In this section, the two transforms are briefly introduced, and outline their relevance to the implementation of digital watermarking.

1. Transform Techniques

A. Discrete Cosine Transform

The discrete cosine transforms is a technique for converting a signal into elementary frequency components. It represents an image as a sum of sinusoids of varying magnitudes and frequencies. With an input image, x, the DCT coefficients for the transformed output image, y, are computed according to (1). In this equation, x is the input image having M x N 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.

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

$$\cos\frac{(2m+1)u\pi}{2M}\cos\frac{(2n+1)v\pi}{2N}$$

where $\alpha_u=\frac{1}{\sqrt{2}}$ for u=0 and

$\alpha_u=1$ for u=1,2…..,M-1 (1)

The image is reconstucted by applying inverse operation according to (2).

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

$$\cos\frac{(2m+1)u\pi}{2M}\cos\frac{(2n+1)v\pi}{2N}$$

where $\alpha_v=\frac{1}{\sqrt{2}}$ for v=0 and

$\alpha_v=1$ for v=1,2…..,N-1 (2)

The 2D-DCT can not only concentrate the main information of original image into the smallest low-frequency coefficient, but also it can cause the image blocking effect being the smallest, this can realize the good compromise between the information centralizing and the computing complication. So it obtains the wide spreading application in the compression coding

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B. Discrete Wavelet Transform

Wavelets are special functions which, in a form analogous to sine and cosine in Fourier analysis, are used as basal functions for representing signals. For 2-D mages, 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 LL1, LH1, HL1 and HH1. The sub-band LL1 represents the coarse-scale DWT coefficients while the sub-bands LH1, HL1 and HH1 represent the fine-scale of DWT coefficients. Due to its excellent spatio-frequency localization properties, the DWT 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 LLx 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 HHx include the edges and textures of the image and the human eye is not generally sensitive to changes in such sub-bands. 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 LHx and HLx where acceptable performance of imperceptibility and robustness could be achieved.

2. Watermarking Algorithms

A. Insertion Algorithm

Steps for watermark insertion are given in flowchart as shown in Fig. (1).

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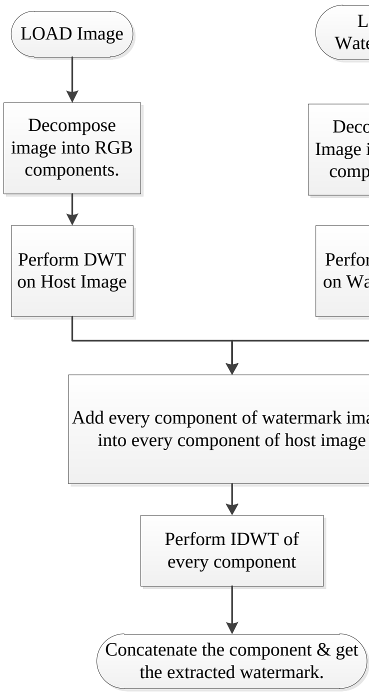

Fig. (1) Watermark Insertion

B. Extraction Algorithm

Steps for watermark extractionare given in flowchart as shown in Fig. (2).

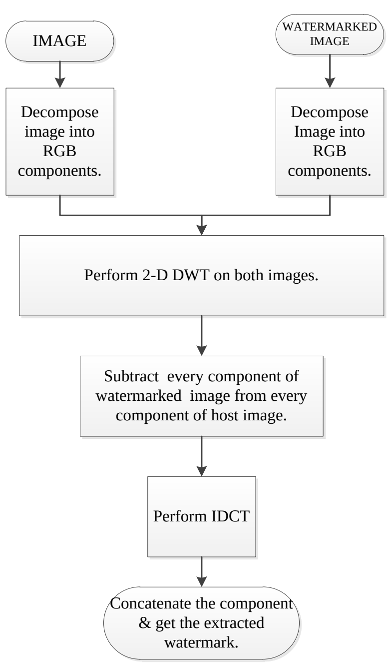

Fig. (2) Watermark Extraction

3. Resultsand Discussion

In this experiment, several colored host images and colored watermark logos are used. The experiment results are concluded in the form of watermarked image quality and extracted watermark quality. The quality metrics of watermarked image and extracted watermark are calculated in terms of Normalized Correlation (NC) [3], and Peak Signal to Noise Ratio (PSNR) and Universal Image Quality Index (Q).

The Normalized Cross-Correlation (NC) is given by(3)

$$NC = \frac{\sum_m \sum_n W_{(m,n)} W'_{(m,n)}}{\sum_m \sum_n W^2_{(m,n)}} * \frac{\sum_m \sum_n (1-W_{(m,n)})(1-W'_{(m,n)})}{\sum_m \sum_n (1-W^2_{(m,n)})} \quad (3)$$

The value of NC is between 0 and 1.The bigger the value is, the better the watermark robustness is.

PSNR is calculated mathematically by (4).

$$PSNR=10\log_{10}\left(\frac{MAX\ 1^2}{MSE}\right) (4)$$

Where Max 1 is the maximum pixel value of the image, I is the original image and K is the watermarked image.

The mean squared error (MSE) is for two $m \times n$ monochrome images I and K where one of the images is considered a noisy approximation of the other.MSE is given by (5).

$$MSE = \frac{1}{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [I(i,j) - K(i,j)]^2 \quad (5)$$

Universal image quality index is mathematically given by (6).

$$Q = \frac{4\sigma_{xy}\bar{x}\bar{y}}{(\sigma_x^2+\sigma_y^2)(\bar{x}^2+\bar{y}^2)} (6)$$

Wherex and y be the original and test image. [6]

Implementation. In this project, watermark insertion and extraction algorithms are implemented using

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MATLAB software. Using MATLAB commands different operations like DWT, DCT, and IDCT are performed on host image and watermark. One can see the results by simulating programs.

Combined DWT-DCT method gives better results for quality metrics than single DWT or DCT method. While adding the watermark, scaling can be used. This method reduces the noise in the original image improving the PSNR.

Different images used for analysis are shown in Fig.(3). The size of host image is 256x256 and size of watermark is 64x64.

Host images and watermarks

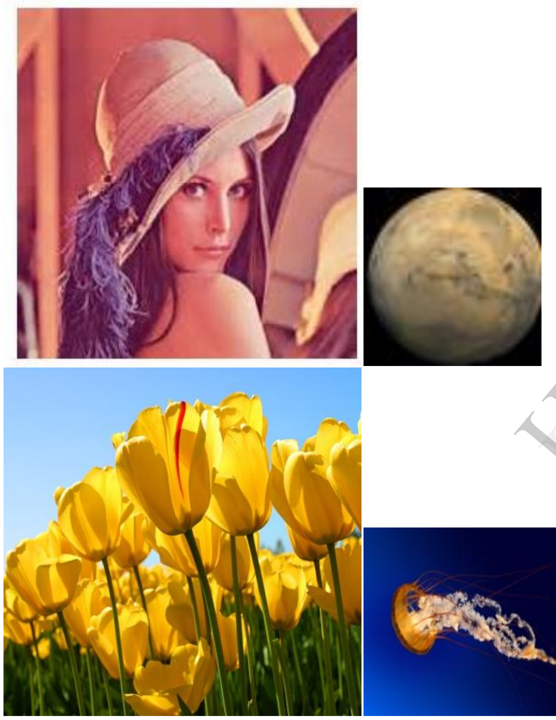

Fig. (3) Host and watermark images used in experiment

Table-I shows quality metrics for lena (256x256) as original image and different watermarks (64x64).

TABLE-I
Watermarked image quality metrics

Wavelet /Watermark		1	2	3	4
db1	PSNR	28.6843	27.613	27.7218	22.7736
	NC	0.9236	0.0039	0.2661	0.9922
	Q	0.9097	0.893	0.893	0.826

Table-II shows the effect of size of watermark on PSNR and NC. Resultsand Fig. (4) shows that as watermark size increases, the PSNR of image will go on decreasing.

TABLE-II
Effect of size of watermark

Original Image	Water Mark	Size of watermark	PSNR (db)
Lena	Jellyfish	32x32	30.3839
Lena	Jellyfish	64x64	28.6843
Lena	Jellyfish	128x128	25.0213
Lena	Jellyfish	256x256	20.4719

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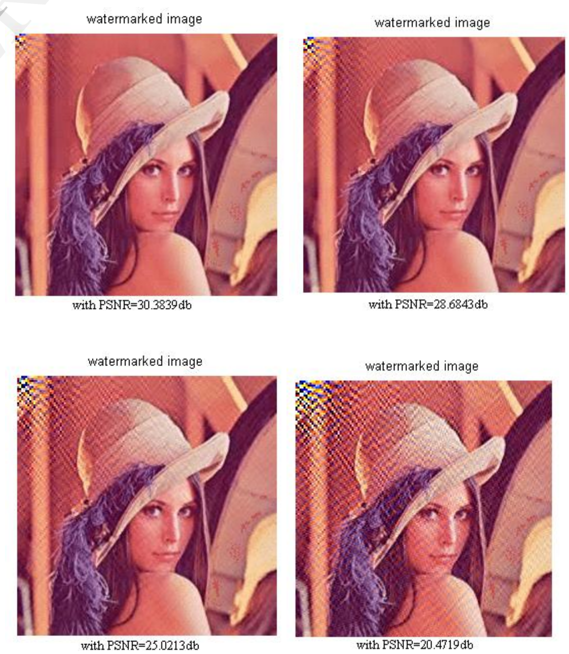

Fig. (4) Effect of size of watermark

Table-III shows the effect of scaling on the watermarked image in terms of PSNR values.

TABLE-III
Effect of Scaling

Scaling Factor	Q	PSNR (dB)
1	0.9097	28.6843
5	0.9788	32.6221
10	0.9913	34.9429
15	0.9949	34.9552

So with scaling one can get good watermarked image with high quality and less noise.

4. Conclusion

In this paper necessity of digital watermarking, different techniques of watermarking are discussed. Here a comparative study of different images has been done using PSNR, Qand NC. The proposed algorithm with colored images shows excellent PSNR to various images like LENA image. This algorithm shows that increase in size of watermark decreases the PSNR. So one can choose size of the watermark as per requirement.

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5. References

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