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Comparative Analysis of Watermarking in Digital Images Using DCT & DWT

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Abstract- Digital Watermarking has emerged as a new area of research in an attempt to prevent illegal copying and duplication. In this paper, I represent both methods i.e. DCT&DWT based algorithm for watermarking in digital images. In order to compare the imperceptibility & robustness of the both algorithms make use of simple attacks such as resizing, rotation &cropping.

Index Terms- digital watermarking, discrete cosine transform (DCT), discrete wavelet transforms (DWT), and Peak Signal to Noise Ratio (PSNR), Mean squared Error (MSE).

I. Introduction

The success of the Internet and digital consumer devices has profoundly changed our society and daily lives by making the capture, transmission, and storage of digital data extremely easy and convenient. However, this raises a big concern is how to secure these data and preventing unauthorized use. This issue has become problematic in many areas. For example the music and video industry loses billions of dollars per year due to illegal copying and downloading of copyrighted materials from the Internet. As a solution, Digital watermarking is used very frequently. Hence, digital watermarking becomes very attractive research topic. Digital watermarking is a technology that creates and detects invisible markings, which can be used to trace the origin, authenticity, and legal usage of digital data. Ideally, they should be hard to notice, difficult to reproduce, and impossible to remove without destroying the medium they protect. In the future the main development of digital watermarking is like this: copyright protection, pirate tracking, copying protection, image authentication, cover-up communication. [1][3].

Robustness means that the watermark is able to withstand with some changes in the watermark-embedded signal; while imperceptibility represents the invisibility to human eyes, or for audio clips, the inaudibility to human ears. A good watermark algorithm should be by all means is simultaneously robust and imperceptible.

In terms of the embedding domain, watermarking algorithms are mainly divided into two groups: spatial domain method which embed the data by directly modifying the pixel values of the original image and transform domain method which embed the data by modulating the transform domain coefficients. A frequency-domain watermarking, value of certain frequencies is altered from their original & embeds the watermark into the transformed image. This is more robust than the spatial domain technique.

In frequency-domain technique multiple transforms used for watermarking purpose such as DCT, DFT, DWT. The most commonly used transforms for digital watermarking are DFT (Discrete Fourier Transform) DCT (Discrete Cosine Transform) and DWT (Discrete Wavelet Transform). Now Frequency domain watermarking is more useful for all practical internet applications. DCT based frequency domain watermarking useful in pan card, i-card of employee of companies, fingerprint identification, medical imaging where is low cost required, whereas DWT based frequency domain watermarking mainly used when we want to transfer more confidential matter through internet to anyone, in military application, government application, broadcast monitoring i.e. entertainment & advertisements, & banks application .[1]

II. Discrete Cosine Transform (DCT)

The Discrete cosine transform (DCT) is most popular due to several reasons. One of the reason is that most of the compression techniques developed in the DCT domain (JPEG, MPEG, MPEG1, and MPEG2) & therefore image processing is more familiar with it.

DCT is one of the most common linear transformations in digital signal process technology.

Two-dimensional discrete cosine transform (2D-DCT) is defined as

$$F(jk)=a(j)a(k)\sum_{m=0}^{N-1}\sum_{n=0}^{N-1} f(mn)\cos\left[\frac{(2m+1)j\pi}{2N}\right]\cos\left[\frac{(2n+1)k\pi}{2N}\right] \quad \textbf{(1)}$$

The corresponding inverse transformation (Whether 2DIDCT) is defined as

$$f(mn)=\sum_{m=0}^{N-1}\sum_{n=0}^{N-1} a(j)a(k)F(jk)\cos\left[\frac{(2m+1)j\pi}{2N}\right]\cos\left[\frac{(2n+1)k\pi}{2N}\right] \quad \textbf{(2)}$$

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, which can realize the good compromise between the information centralizing and the computing complication [3].

The DCT allows an image to be broken up into different frequency bands, making it much easier to embed watermarking

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information into the middle frequency bands of an image. In order to invisibly embed the watermark that can survive lossy data compressions, a reasonable tradeoff is to embed the watermark into the middle-frequency range of the image.

The middle frequency bands are chosen such that they have minimized that they avoid the most visual important parts of the image (low frequency) without over-exposing themselves to removal through compression and noise attacks. DCT domain watermarking can survive against the attacks such as noising, compression, sharpening, and filtering.

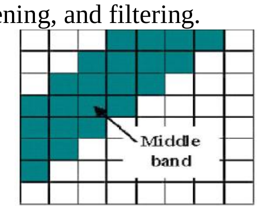

Fig.2.1 Middle Band Frequencies In 8x8 Dct Block

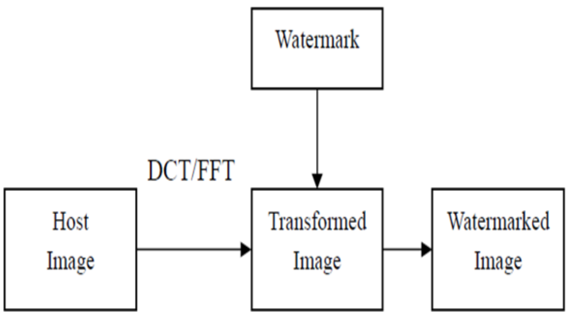

Fig.2.2 Watermark Embedding in DCT

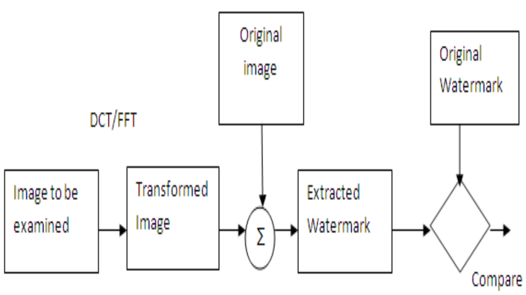

Fig.2.3 Watermark Detection in DCT

III. DISCRETE WAVELET TRANSFORM (DWT)

Discrete wavelet transforms (DWT), which transforms a discrete time signal to a discrete wavelet representation. It converts an input series x_0, x_1,x_m, into one high-pass wavelet coefficient series and one low-pass wavelet coefficient series (of length n/2 each) given by:

$$H_i = \sum_{m=0}^{k-1} x_{2i-m} \cdot s_m(z) \qquad (3)$$

$$L_i = \sum_{m=0}^{k-1} x_{2i-m} \cdot t_m(z) \qquad (4)$$

Where

S_m (Z), t_m (Z): wavelet filters,

K: the length of the filter, and i=0... [N/2]-1.

In practice, such transformation will be applied recursively on the low-pass series until the desired number of iterations is reached.

The new JPEG2000 standard has adopted a new technique, the wavelet transform. The basic idea in the DWT for a one dimensional signal is the following. A signal is split into two parts, usually high frequencies and low frequencies. The edge components of the signal are largely to the high frequency part. The low frequency part is split again into two parts of high and low frequencies. This process is continued an arbitrary number of times, which is usually determined by the application at hand

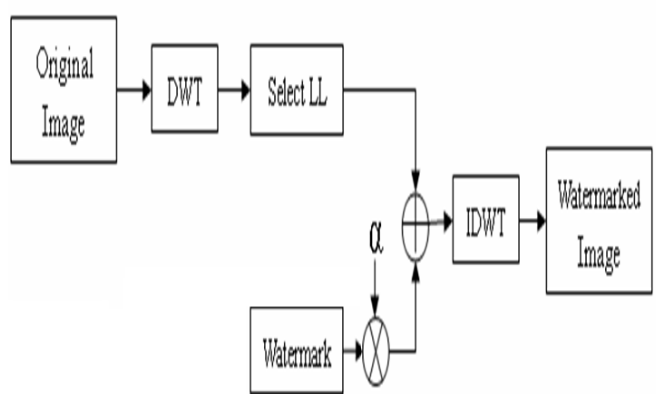

Fig. 3.1 Watermark Embedding using DWT

A step of wavelet transform decomposes an image into four parts: HH, HL, LH and LL in Figure. LL is low frequency coefficient, LH is high frequency coefficient horizontally, HL is high frequency coefficient vertically, and HH is high frequency coefficient diagonally. Watermark should be embedded in low frequency coefficients.

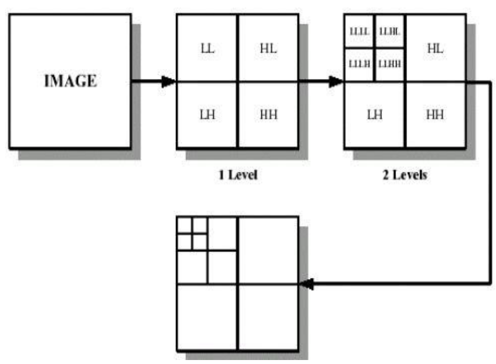

Fig.3.2 Flow of DWT Process

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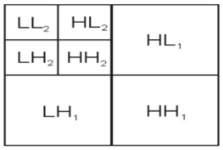


Fig.3.3 Scale -2 Dimensional DWT

One of the many advantages, the discrete wavelet transform is the watermarking method has multi resolution characteristics and is hierarchical.DWT has effective also in structural attacks as compare to DCT. DWT has significant advantages over geometric attacks such as compression, scaling & cropping. It is generally observed that DWT is more robust to cropping.

One more advantage of DWT is that it shows acceptable performance with scaling attacks whereas DCT technique doesn't work with scaling attacks.

IV. 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 = $10\log_{10}(255^2/MSE)$ Db

MSE = $(((I_1 - I_2)^2/(m*n))$

Where

I_1: retrieved image

I_2: original image

m: no. of rows

n: no. of column

When PSNR is 40 dB or greater, original and reconstructed images are virtually indistinguishable by human observers.

4.1 Imperceptibility

Imperceptibility means that the perceived 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).

4.2 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 digital signal processing attacks such as resizing, cropping & rotation.

V. EXPERIMENTAL RESULTS

For simulation purpose there is the development of DCT based watermarking GUI&DWT based watermarking GUI which is as shown in figure.

For simulation we used three images i.e. splash, girl, mandrill respectively of size 512x512 as original image & 500 image of size 128x85 as the key image.

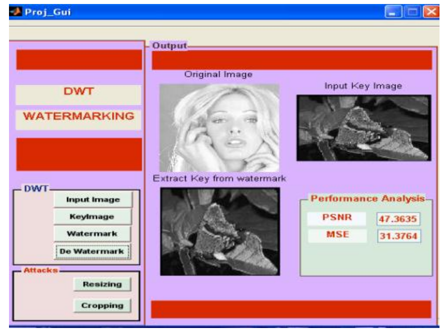
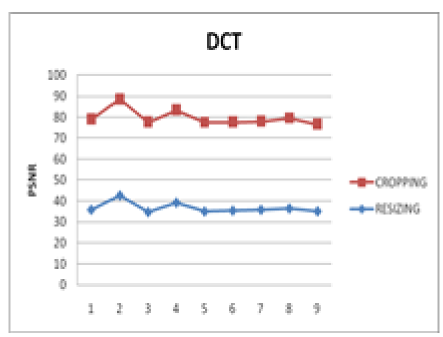


Fig.5.1 GUI for DWT Based Watermarking

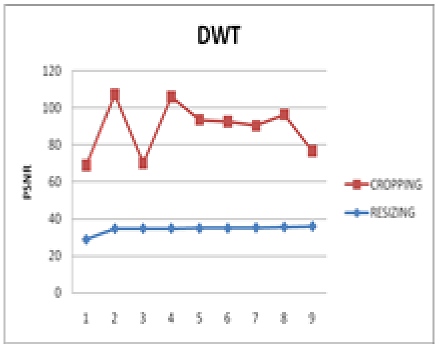
Fig.5.2 GUI for DCT Based Watermarking

Table 5.1: Results for imperceptibility

original image	key image	PSNR IN DWT	PSNR IN DCT
SPLASH	0.jpg	91.5	49.02
GIRL	0.jpg	91.5	35.57
MANDRILL	0.jpg	91.5	49.02



Graph 5.1 Result of DCT



Graph 5.2 Result of DWT

VI. CONCLUSION

In this paper it is described that recent developments in the digital watermarking of images in which the watermarking technique is invisible and designed to exploit some aspects of the human visual system. Many of these techniques rely either on transparency (low-amplitude) or frequency sensitivity to ensure the mark's invisibility. The watermark's imperceptibility obtained more in DWT as compare to DCT. From the results and graphs shown above it is evident that DWT is more robust against attacks such as cropping and resizing as compare to DCT.

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