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# Watermarking in DCT-DWT Domain

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***Abstract - Digital image watermarking is one such technology that has been developed to protect digital images from illegal manipulations. Watermarking methods are classified into two main classes: spatial and frequency based approaches. All methods are aim at satisfying two basic requirements: watermark perceptual visibility and watermark robustness against to attacks. In particular, digital image watermarking algorithms which are based on the discrete wavelet transform have been widely recognized to be more prevalent than others. This is due to the wavelets' excellent spatial localization, frequency spread, and multi-resolution characteristics, which are similar to the theoretical models of the human visual system. In This paper introduces an algorithm of digital watermarking based on Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT) & applied various attacks and measure PSNR for Imperceptibility and NC values for Robustness.***

***Keywords – DCT, DWT, PSNR, NC, Entropy***

## I. INTRODUCTION

Watermarking is a branch of information hiding which is used to hide proprietary information in digital media like photographs, digital music, or digital video. The ease with which digital content can be exchanged over the Internet has created copyright infringement issues. Copyrighted material can be easily exchanged over peer-to-peer networks, and this has caused major concerns to those content providers who produce these digital contents. In order to protect the interest of the content providers, these digital contents can be watermarked. In this paper we provide a survey of the latest techniques that are employed to watermark images. Image watermarking techniques can be applied to digital videos as well. [5]

Digital watermarking techniques can be classified into two categories: spatial domain methods and transform domain methods. Spatial domain methods usually provide simple embedding schemes with inefficiency and low robustness. By contrast, watermarking techniques based on transform domain such as DFT, DCT , DWT can take full advantage of human perception and have a good robustness and invisibility. Several algorithms in mixed transform domain are recently presented to obtain high robustness and transparency.

Algorithms in DWT and DCT transforms are for audio and image watermarking respectively, which combines the advantages of multiresolution and the energy compression properties of the DWT and DCT. [6]

## II. METHODS

In digital image watermarking there are three methods introduced which is listed as follows.

### *A. Discrete Cosine Transform*

Compared to spatial-domain watermark, watermark in frequency domain is more robust and compatible to popular image compression standards. Thus frequency-domain watermarking obtains much more attention. To embed a watermark, a frequency transformation is applied to the host data. Then, modifications are made to the transform coefficients. Possible frequency image transformations include the Discrete Fourier Transform (DFT), Discrete Cosine Transform (DCT) and others. With the character of discrete Fourier transform (DFT), discrete cosine transform (DCT) turn over the image edge to make the image transformed into the form of even function. It's one of the most common linear transformations in digital signal process technology.

The first efficient watermarking scheme was introduced by Koch et al. In their method, the image is first divided into square blocks of size 8x8 for DCT computation. A pair of mid-frequency coefficients is chosen for modification from 12 predetermined pairs. Bors and Pitas developed a method that modifies DCT coefficients satisfying a block site selection constraint. After dividing the image into blocks of size 8x8, certain blocks are selected based on a Gaussian network classifier decision. The middle range frequency DCT coefficients are then modified, using either a linear DCT constraint or a circular DCT detection region. A DCT domain watermarking technique based on the frequency masking of DCT blocks was introduced by Swanson. Cox developed the first frequency-domain watermarking scheme. After that a lot of watermarking algorithms in frequency domain have been proposed [3] [2].

A widely accepted point now is the frequency-domain watermark should be embedded into the mid-band of the transformed host image. Watermarks in high frequency band tend to have less influence on the quality of original image, while watermarks in low band will achieve a better robustness and the mid-bind scheme is right a tradeoffs between the imperceptibility and robustness [2].

### *B. Discrete Wavelet Transform*

Wavelet transform is time domains localized analysis method with the window's size fixed and form convertible. There is quite good time differentiated rate in high frequency part of signals DWT transformed. Also there is quite good frequency differentiated rate in its low frequency part. It can distil the information from signal effectively.

The basic idea of discrete wavelet transform (DWT) in image process is to multi-differentiated decompose the image into sub-image of different spatial domain and independent frequency district. Then transform the coefficient of sub-image. After the original image has been DWT transformed, it is decomposed into 4 frequency districts which is one low-frequency district(LL) and three high-frequency districts(LH,HL,HH). If the information of low-frequency district is DWT transformed, the sub-level frequency district information will be obtained. A 2D image after three-times DWT decomposed can be shown as Fig.1. Where, L represents low-pass filter, H represents high-pass filter. An original image can be decomposed of frequency districts of HL1, LH1, and HH1.

The low-frequency district information also can be decomposed into sub-level frequency district information of LL2, HL2, LH2 and HH2. By doing this the original image can be decomposed for *n* level wavelet transformation [3] [2].

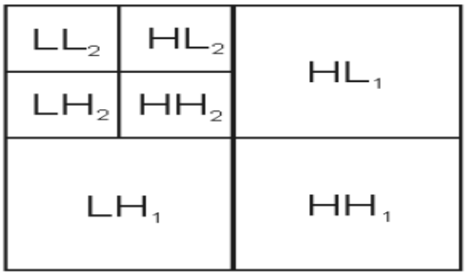



Figure: 1 DWT at 2 level

## III. ALGORITHM

Embedding procedure is same as in [3],but Distilling procedure is different.

### A. *Embedding algorithm*

Step 1:

For improving the robustness of the watermark algorithm and the secrecy of watermarking image, transform the watermark, that is to make the image DCT transformed and a disordered image will be obtained.

Step 2:

DWT transform: Decompose the host image X by L-levels using two-dimensional DWT. Then a approaching sub-image (low frequency band information) and 3L detail sub-images (high-frequency band information) are obtained. How to choose the DWT levels L is depended on the sizes of the original image and the watermarking signal. The higher DWT level is, the better the concealing effect of embedding watermark is.

Step 3:

Choose the streak blocks: The high frequency band information of DWT image is plotted into *2 * 2* image sub-blocks $B_k$. Then calculate entropy and square values of each image sub-block $B_k$. The image sub-block with small value of entropy should be smooth block, which with big value should be streak block or edge block. By choosing the right threshold of entropy, the streak blocks wanted $U_K$ ($k = 1 , 2 , ....., P\times Q$) will be obtained.

Step 4:

Embedding the watermark: Amend the wavelet coefficient values $C_k$ of the chosen streak blocks $B_k$ *to* complete the watermark embedding. And the embedding formula is as follow:

$$C_{k'} = C_k + a \times V_k , k = 1 , 2 , ... , P\times Q$$

Where, $C_k$ represents the former wavelet coefficient value of streak sub-block $U_k$, $V_k$ represents the No. $k$ component weight of one-dimensional digital watermarking sequence $V$, $C_{k'}$ represents the new Wavelet coefficient value of streak sub-block $U_k$ , $a$ represents the embedding depth for digital watermarking.

Step 5:

Inversing transform: After embedding the watermarking signal, unite the information of the lowest frequency band and the mended high frequency band. Then the wavelet transform of the image is inversed by the L-level, and the watermarked image is obtained.

### B. *Distilling algorithm*

Step 1:

DWT transform: Transform the original image and the watermarked image by L-levels using DWT. And the information of the lowest frequency band and the high frequency band are obtained.

Step 2:

Make sure the streak blocks: The high frequency band information, both of DWT image of the original and the watermarked one is plotted into *2 * 2* image sub-blocks. The streak block $U$, which is obtained from the high frequency band of original image after being DWT transformed, can be as index by using its position. Through the index, the streak block $U'$, corresponding to the sub-block of the high frequency band of the DWT transformed watermarked image, is obtained.

Step 3:

Distilling watermark signal V: Take the difference of watermarked image streak block and cover image streak block then divide it by factor $a$ which is same as that you have take in watermark embedding.

Step 4: Inversing transformation of watermark: Then the discrete cosine transform of the disordered watermarking image is inversed, and the watermark image is obtained.

## IV. RESULTS

### A. *Evaluation technique*

- Imperceptibility

Imperceptibility means that the perceived quality of the host image should not be distorted by the presence of the watermark. The watermark should be imperceptible to human observation while the host image is embedded with secret data. In this paper we employee the *PSNR* to indicate the transparency degree. The *PSNR* describe below

$$PSNR = 10\log_{10}\frac{255^2}{\frac{1}{N\times N}\sum_{i=0}^{N-1}\sum_{j=0}^{N-1}(x_{i,j}-\hat{x})^2}$$

Where $x_{i,j}$ and $\hat{x}_{i,j}$ are the gray-scale values of host and watermarked images and $N$ x $N$ is the size of image respectively[4].

- 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. We measured the similarity between the original watermark and the watermark extracted from image using Normalized Cross-Correlation (NC) as given below

$$\rho(w,\hat{w}) = \frac{\sum_{i=1}^{N} w_i \hat{w}_i}{\sqrt{\sum_{i=1}^{N} w_i^{\,2}}\sqrt{\sum_{i=1}^{N} \hat{w}_i^{\,2}}}$$

Where N is the number of pixels in watermark, w and w^ are the original and extracted watermarks respectively. The correlation factor may take values between 0 (random relationship) to 1 (perfect linear relationship). In general, a correlation coefficient of about 0.75 or above is considered acceptable [1].

*B. PSNR and NC value before applying any attack*

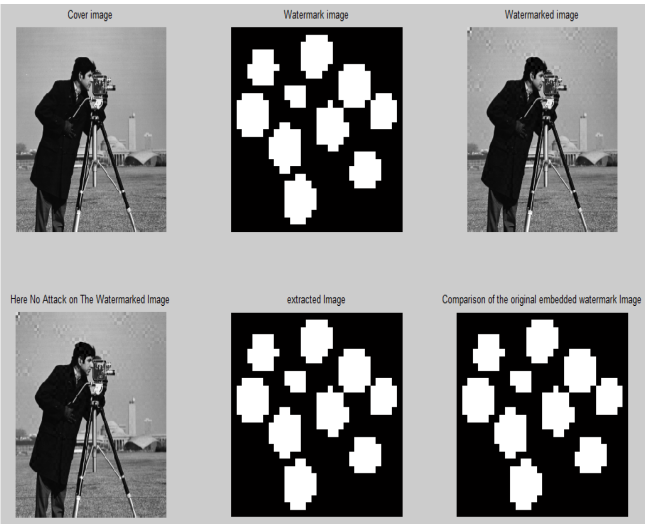



Figure:2 watermark image without applying any attack

| **Cover Image** | **Watermark image** | **PSNR** | **NC** |
|---|---|---|---|
| Cameraman.tif | Circuit.tif | 36.6311 | 1.0000 |
| | Cell.tif | 32.2456 | 1.0000 |
| | Coins.png | 37.1747 | 1.0000 |
| | Liftingbody.png | 42.8551 | 1.0000 |
| | Moon.tif | 37.4743 | 1.0000 |

Table :1 results without applying any attack

*C. PSNR and NC with applying some of the attack on Watermarked image*

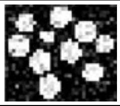
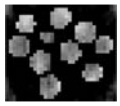
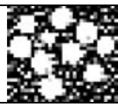
| | |
|---|---|
| Adding white Noise |  |
| Gussian Low Pass Filter |  |
| Image Cutting |  |
| Rotation with 10 degree |  |
| Blurring |  |
| Sharpening |  |

Table 2: Extracted image after applying attack

Cover Image : cameraman.tif

| **Attack** | **Watermark image** | **PSNR** | **NC** |
|---|---|---|---|
| Adding white Noise | Circuit.tif | 27.7108 | 0.9575 |
| | Cell.tif | 27.5027 | 0.9601 |
| | Coins.png | 27.7510 | 0.9502 |
| | Liftingbody.png | 28.1069 | 0.8524 |
| | Moon.tif | 27.8033 | 0.9475 |
| Gussian Low Pass Filter | Circuit.tif | 36.6311 | 1.0000 |
| | Cell.tif | 32.2456 | 1.0000 |
| | Coins.png | 37.1747 | 1.0000 |
| | Liftingbody.png | 42.8551 | 1.0000 |
| | Moon.tif | 37.4743 | 1.0000 |
| Image Cutting | Circuit.tif | 21.2284 | 0.7141 |
| | Cell.tif | 21.2730 | 0.2373 |
| | Coins.png | 21.2309 | 0.7493 |
| | Liftingbody.png | 21.2751 | 0.7647 |
| | Moon.tif | 21.2692 | 0.4733 |
| Rotation with 10 degree | Circuit.tif | 12.0843 | -0.0049 |
| | Cell.tif | 12.0894 | 0.0064 |
| | Coins.png | 12.0859 | 0.0024 |
| | Liftingbody.png | 12.0893 | 0.0029 |
| | Moon.tif | 12.0868 | -0.0163 |
| Blurring | Circuit.tif | 21.0527 | 0.0156 |
| | Cell.tif | 21.0429 | 0.1036 |
| | Coins.png | 21.0499 | 0.0141 |
| | Liftingbody.png | 21.0536 | -0.0020 |
| | Moon.tif | 21.0526 | 0.0043 |
| Sharpening | Circuit.tif | 15.3476 | 0.8820 |
| | Cell.tif | 15.0238 | 0.9469 |
| | Coins.png | 15.3664 | 0.8716 |
| | Liftingbody.png | 15.5124 | 0.6877 |
| | Moon.tif | 15.3826 | 0.8642 |

## V. CONCLUSION

This algorithm shows that it is providing robustness against Adding White Noise, Gaussian Filter and Sharpening attack. As incresing the size of cut image robustness is decresing. Against rotation and Blurring it does not provide Robustness.

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