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Modified Approach of Digital Image Watermarking using Combined DCT and DWT

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Abstract: Digital image watermarking is the technology that has been developed to protect digital images from illegal manipulations. In particular, digital image watermarking algorithms which are based on the discrete wavelet transform have been widely recognized to be more prevalent than others. Also, DCT has an important characteristic of energy-compression. If, this characteristic is combined with existing DWT watermarking algorithm, can improve the transparency of digital watermark. In this paper more imperceptible and a robust combined algorithm of digital watermarking based on Discrete Cosine Transform (DCT) and 3 levels Discrete Wavelet Transform (DWT) has been proposed. This is an modified approach because in previous papers 2 level Dwt is used. In this algorithm, the information of digital watermark which has been discrete Cosine transformed, is put into the high frequency band of the image which has been wavelet transformed. PSNR, Normalized Correlation and Computational time has been taken as performance evaluation parameters. Performance evaluation results show that combining the two transforms improved the performance of the watermarking algorithms that are based solely on the DWT transform.

Keywords: Digital Image Watermarking, Image Copyright Protection, Frequency-Domain Watermarking, Discrete Wavelet Transform (DWT), Discrete Cosine Transform (DCT).

I. INTRODUCTION

Digital Image Watermarking embeds identifying information in an image, which is not always hidden, in such a manner that it cannot easily be removed. There is no evidence that watermarking techniques can achieve the ultimate goal to retrieve the right owner information from the received data after all kinds of content-preserving manipulations [1, 2]. Because of the fidelity constraint, watermarks can only be embedded in a limited space in the multimedia data.
The fundamental requirements of a watermark are:

- Imperceptibility
- Robustness
- Security
- Copyright protection
- Authentication
- Owner identification
- Image authentication

The main terminology used in the Combined Dct and Dwt Algorithm is:

- the cover image,
- the watermark image,
- secret key,
- Embedding algorithm,
- Extraction algorithm

II. TYPES OF WATERMARKS

With images widely available on the web, watermarks could be used to provide authentication in terms of a secondary image which is overlaid on the primary image, and provides a means of protecting the image. This overlay may be visible or invisible.

A. Visible Watermarks

Fig.1. Visible Watermarking.

Visible watermark is a visible translucent image that is overlaid on the primary image. Visible watermarks change the signal altogether such that the watermarked signal is totally different from the actual signal. The example in the fig.1 shows both a watermark and an image with the overlaid watermark. Reena et al., International Journal of Advanced Research in Computer Science and Software Engineering 3(7), July - 2013, pp. 429-435.

B. Invisible Watermarks

An invisible watermark is an overlaid image which cannot be seen, but which can be detected algorithmically. Invisible watermarks do not change the signal to a perceptually great extent, i.e., there are only minor variations in the output signal. A watermark which is destroyed when the image is manipulated digitally in any way may be useful in proving authenticity of an image. If the watermark is still intact, then the image has not been „doctored". If the watermark has been destroyed, then the image has been tampered with. The example in the fig.2 shows the invisibly watermarked image

Fig.2. Invisible Watermarking.

III. CLASSIFICATION OF WATERMARK ALGORITHMS

In this section, we discuss different classification of watermarking algorithms focusing on the domain in which watermark data is embedded. Watermark techniques can be divided into four groups according to the type of data to be watermarked.

- Text watermarking
- Image watermarking
- Video watermarking
- Audio watermarking

A. Based On Human Perception, Watermark Algorithms Are Divided Into Two Categories

Visible Watermarking: Visibility is associated with perception of the human eye so that if the watermark is embedded in the data in the way that can be seen without extraction, we call the watermark visible. Examples of visible watermarks are logos that are used in papers and video.

Invisible Watermarking: On the other hand, an invisible watermarking cannot be seen by human eye. So it is embedded in the data without affecting the content and can be extracted by the owner or the person who has right for that. For example images distribute over the internet.

B. Based On Processing-Domain, Watermark Techniques Can Be Divided Into

Spatial Domain: A watermark technique based on the spatial domain, spread watermark data to be embedded in the pixel value. These approaches use minor changes in the pixel value intensity. The simplest example of the former techniques is to embed the watermark in the least significant bits of image pixels [3]. As another example, an image is divided into the same size of blocks and a certain watermark data is added with the sub-blocks [4]. Reena et al., International Journal of Advanced Research in Computer Science and Software Engineering 3(7), July - 2013, pp. 429-435.

Transform Domain: To have imperceptibility as well as robustness, adding of watermark is done in transform domain. In this method, transform coefficients are modified for embedding the watermark. Transform domain is also called frequency domain because values of frequency can be altered from their original. The most important techniques in transform domain are Discrete cosine transform (DCT) and Discrete Wavelet Transform (DWT).

IV. DISCRETE COSINE TRANSFORM

The transform of a signal is just another form of representing the signal. It does not change the information content present in the signal. Discrete cosine transform is widely used in image and video compression applications such as JPEG and MPEG. These multimedia standards partition an input image into 8 × 8 blocks after that the DCT for each block is computed. The watermarking techniques embed watermarking data into the middle frequency bands of a transformed image. The middle frequency bands are chosen such that they avoid the most visual parts of the image (the low frequencies) without overexposing themselves to removal through compression and noise attacks (high frequencies). A 2D DCT is efficiently computed by 1D transforms on each row followed by 1D transforms on each column. There are different algorithms to compute the 2D DCT. For example, one such algorithm is by using matrix multiplication and it is explained as follows. The M ×M transform matrix T is given by Equation (1) :

$$T_{ij} = \begin{cases} \frac{1}{\sqrt{M}}, & \text{if } i = 0, 0 \leq j \leq M-1. \\ \sqrt{\frac{2}{M}} * \cos\frac{\pi(2j+1)i}{2M} & \text{if } 1 \leq i \leq M-1, 0 \leq j \leq M-1. \end{cases} \quad \textbf{(1)}$$

V. DISCRETE WAVELET TRANSFORM

In this section, we will discuss a brief explanation of the DWT. A. 1D Discrete Wavelet Transform Wavelet can represent a signal in time-frequency domain. Analyzing a signal with this kind of representation gives more information about the when and where of different frequency components. In other words, wavelet transform not only transforms the time domain representation of a signal to the frequency domain representation, but also preserves spatial information in the transform. This feature enhances the image quality especially for the low bit rate representation. The DWT is a multi-resolution technique that can analyze different frequencies by different resolutions. The low-pass and high-pass filter pair is known as analysis filter-bank. These low-and high pass filters are used in the (5, 3) filter transform. After applying the 1D DWT on a signal that has been decomposed into two bands, the low-pass outputs are still highly correlated, and can be subjected to another stage of two-band decomposition to achieve additional decorrelation. In addition, the 1D DWT can be easily extended to two dimensions (2D) by applying the filter-bank in a separable manner. At each level of the wavelet decomposition, each row of a 2D image is first transformed using a 1D horizontal analysis filter-bank (h0, h1). The same filter-bank is then applied vertically to each column of the filtered and sub-sampled data.

B. 2D Discrete Wavelet Transform

The 2D DWT is computed by performing low-pass and high-pass filtering of the image pixels as shown in Fig.3. In this figure, the low-pass and high-pass filters are denoted by h and g, respectively. This figure depicts the three levels of the 2D DWT decomposition. At each level, the high-pass filter generates detailed image pixels information, while the low-pass filter produces the coarse approximations of the input image. At the end of each low-pass and high-pass filtering, the outputs are down-sampled by two (↓ 2). In order to provide 2D DWT, 1D DWT is applied twice in both horizontal and vertical filtering. In other words, a 2D DWT can be performed by first performing a 1D DWT on each row, which is referred to as horizontal filtering, of the image followed by a 1D DWT on each column, which is called vertical filtering Reena et al., International Journal of Advanced Research in Computer Science and Software Engineering 3(7), July-2013, pp.429-435 © 2013, IJARCSSE All Rights Reserved Page | 432.

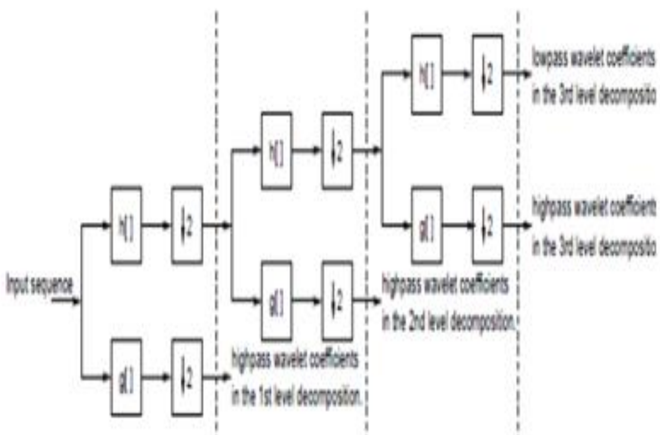

Fig.3. Three level 2D DWT decomposition of an input image using filtering approach.

The h and g variables denote the low-pass and high-pass filters, respectively. The notation of (↓ 2) refers to down-sapling of the output coefficients by two. Figure 1.3 illustrates the first decomposition level (d = 1). In this level the original image is decomposed into four sub-bands that carry the frequency information in both the horizontal and vertical directions. In order to form multiple decomposition levels, the algorithm is applied recursively to the LL sub-band. Fig.3 also illustrates the second (d = 2) and third (d = 3) decomposition levels as well as the layout of the different band.

VI. COMBINED DCT-DWT ALGORTIHM

A. Watermark Embedding Algorithm

Explanation of the watermark embedding Procedure is given below.

Input: Cover image, Watermark image, Key

Output: Computation time

- Select two images i.e Cover image and watermark image.
- RGB Cover image will be converted into gray scale image.
- Reading of both images so as to get matrices of both.
- Transform the watermark image using DCT for improving the robustness of the watermark algorithm and the secrecy of watermark image.
- Decompose the host image by L-levels using two-dimensional DWT.
- Then approaching sub-image (low frequency band information) and 3L detail sub-images (high-frequency band information) are obtained.
- The higher DWT level is, the better the concealing effect of embedding watermark.
- Key will be used in random interval to evaluate the k1,k2 factors that will be used to hide the watermark image.
- Amend the wavelet coefficient values of the chosen streak blocks of watermark image to complete the watermark embedding.
- **Inversing transform:** After embedding the Watermarked 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. Watermark Extraction Algorithm

Watermark extraction is same as that of embedding but it will be in reverse order.

Input: Original image, Key

Output: Extracted watermark image

- **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.
- Right streak block from both Transformed images are obtained.
- Comparison of streak blocks of both images, When this value is bigger than a certain threshold value, it‟s thought that there is watermarking component weight information in the streak block watermarked image. Then it‟s signed as 1, else 0.
- **Inverse transformation of watermark:** Then the discrete cosine transform of the disordered

watermarking image is inversed, and the watermark image is obtained.

VII. PERFORMANCE EVALUATION

We evaluated the performance of the combined DWT-DCT image watermarking algorithms using a 256*256 'Lena' as the original cover host image, and a 32*32 grey-scale image of the expression 'Hi‟ as the watermark image. The two images are shown in Fig. 1.4 and 1.6, respectively.

A. Performance Evaluation Metrics

Watermarking algorithms are usually evaluated with respect to two metrics: imperceptibility and robustness [7][9]. The two metrics are described below.

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 in EQ(2)

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

Where $x_{i,j}$ and x_{ij} are the gray-scale values of host and watermarked images and N x N is the size of image respectively. Reena et al., International Journal of Advanced Research in Computer Science and Software Engineering 3(7), July - 2013, pp. 429-435.

B. Robustness

Robustness is a measure of the immunity of the watermark against attempts to remove or degrade it, internationally or unintentionally. We measured the similarity between the original watermark and the watermark extracted from image using Normalized Cross-Correlation (NC) as given below in Eq.(3):

$$\rho(w,\hat{w}) = \frac{\sum_{i=1}^{N} w_i \hat{w}_i}{\sqrt{\sum_{i=1}^{N} w_i^2}\sqrt{\sum_{i=1}^{N} \hat{w}_i^2}} \quad \textbf{(3)}$$

Where N is the number of pixels in watermark, w and wˆ are the original and extracted watermarks respectively. The correlation factor may take values between 0 (random relationship) to 1 (perfect linear relationship).

VIII. IMPLEMENTATION RESULTS

All the simulations has been performed in MATLAB R2008a. After simulation of program some results or output parameters i.e. value of PSNR, computational time and value of normalized correlation has been driven along with some figs.4 to 10, representing input and output from the simulation. If we compare both the watermark analytically both have no difference, which is a good sign for proposed method in terms of correlation. Also, the calculated correlation value is 1. The PSNR value of extracted watermark is 56.7416 dB. The time which elapsed during whole simulation is 3.7284s.

Fig.4. Original cover image.

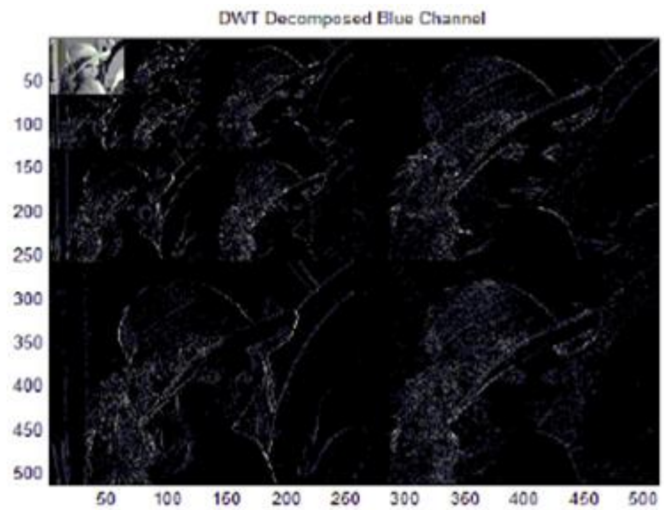

Fig.5. Decomposed original cover image.

Fig.6. Original watermark.

Fig.7.Decomposed Watermark.

Reena et al., International Journal of Advanced Research in Computer Science and Software Engineering 3(7), July-2013, pp. 429-435.

Fig.8.DCT-DWT watermarked image.

Fig.9.DCT-DWT extracted watermarked image.

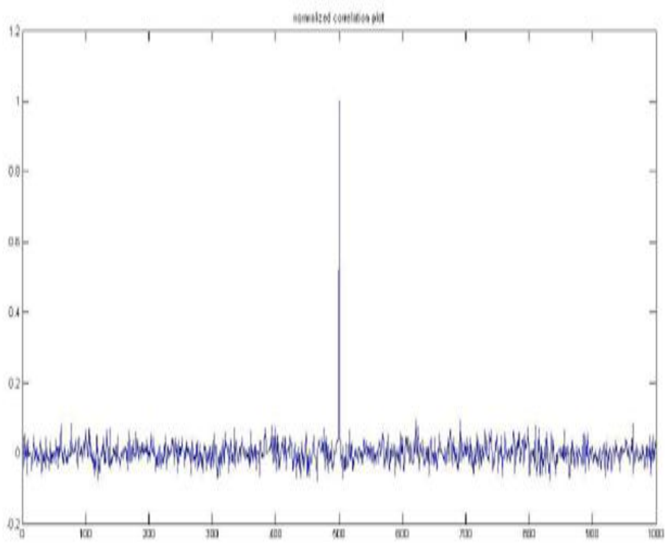

Fig.10.Plot for corelation co-efficient.

IX. CONCLUSION

From all the results derived, it can be concluded that proposed methodology is much efficient in terms of PSNR, correlation with original watermark, computational time, complexity and invisibility as compared to existing other methods for the same. Combined algorithm of digital watermarking, which is based on Discrete Consine Transform (DCT) and Discrete Wavelet Transform (DWT), as pSNR and normalized correlation values are very high whereas, computational time is very low. Performance evalution results shows that combining the two transforms improved the performance of the watermarking algorithms that are based solely on the DWT transform. The simulation results shows that this algorithm is much better of invisible watermarking and has good robustness for some common image processing operations.

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