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Modified Algorithm for Digital Image Watermarking Using Combined DCT and DWT

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Abstract

Digital Image Watermarking embeds identifying information in an image, in such a manner that it cannot easily be removed. In particular, digital image watermarking algorithms which are based on the discrete wavelet transform have been widely recognized to be more prevalent than others. If, this characteristic is combined with existing DWT watermarking algorithm, can improve the transparency of digital watermark. In this papermore imperceptible and a robust combined algorithm of digital watermarking based on Discrete Cosine Transform (DCT) and 3levelsDiscrete 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 beendiscrete Cosine transformed, is put into the high frequencyband 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 theperformance of the watermarking algorithms that are based solely on the DWT transform.

Keywords: Digital image watermarking,Imagecopyright protection, frequency-domain watermarking, Discrete Wavelet Transform (DWT), Discrete Cosine Transform (DCT).

1. Introduction

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 main terminology used in the Combined Dct and Dwt Algorithmare:

- The cover image,
- The watermark image,
- Secret key,
- Embedding algorithm,
- Extraction algorithm.

2. Classification of Watermark Algorithms

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

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

2.1 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

2.2 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]. Asanother example, an image is divided into the same size of blocks and a certain watermark data is added with the sub-blocks [4].

- **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).

3. 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 The M ×M transform matrix T is given by Equation (1) :

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

4. Discrete Wavelet Transform

In this section, we will discuss a brief explanation of the DWT.

4.1 2D Discrete Wavelet Transform

The 2D DWT is computed by performing low-pass and high-pass filtering of the image pixels as shown in Figure 1. 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 downsampled 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.

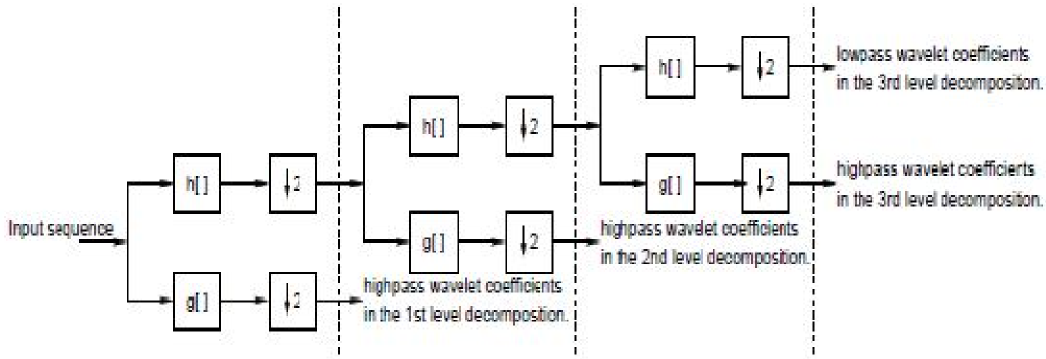

Figure 1: Three level 2D DWT decomposition of an input image using filtering approach.

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 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. Figure 3 also illustrates the second (d = 2) and third (d = 3) decomposition levels as well as the layout of the different bands.

5. Combined DCT-DWT Algortihm

Watermark EmbeddingAlgorithm: Explanation of the watermark embedding Procedure is given below.

Input: Coverimage, 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 valuesof the chosen streak blocks of watermark imageto 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.

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.

6. Performance Evaluation

We evaluated the performance of the combinedDWT-DCT image watermarking algorithms using a256*256 'Lena' as the original cover host image, and any32*32 grey-scale image as the watermark image. The two images are shown inFig. 2 and 4, respectively.

Performance Evaluation Metrics*:*Watermarkingalgorithms are usually evaluated with respect to twometrics: imperceptibility and robustness [7][9]. The twometrics are described below.

6.1 Imperceptibility

Imperceptibility means that the perceived quality of the hostimage should not be distorted by the presence of the watermark. The watermark should be imperceptible to humanobservation while the host image is embedded with secretdata. In this paper we employee the *PSNR* to indicate thetransparency degree. The *PSNR* describe below in Eq(2)

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

Where x $_{i,j}$and x^ ij are the gray-scale values of host andwatermarked images and *N* x *N* is the size of imagerespectively.

6.2 Robustness

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

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

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

7. 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 figures, 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 simulationis3.7284s

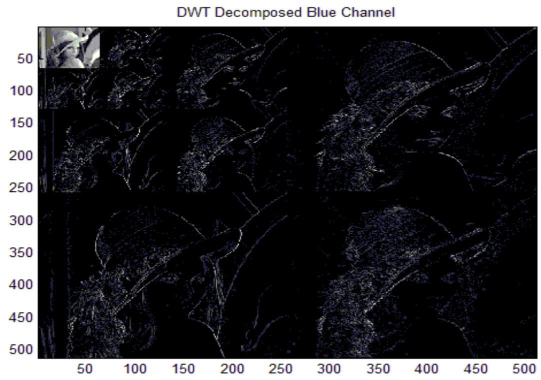

Fig. 2: Original cover image **Fig. 3**: Decomposed original cover image

Fig. 4: Original watermark **Fig. 5:** Decomposed watermark

Fig. 6: DCT-DWT watermarked image. **Fig. 7**: DCT-DWT extracted watermark image

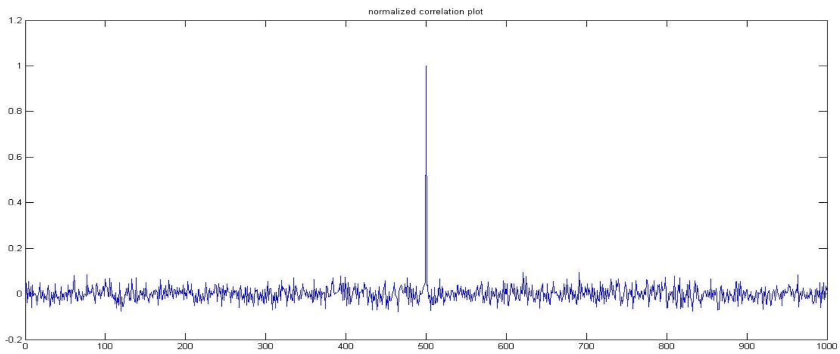

Fig. 8: Plot for correlation co-efficient.

8. 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 Cosine Transform (DCT) and Discrete Wavelet Transform (DWT), as PSNR (i.e. 56.7416 dB) and normalized correlation (i.e. 1) values are very high whereas, computational time (i.e. 3.7284s) is very low. Performance evaluation results shows that combining the two transforms improved the performance of the watermarking algorithms that are based solely on the DWT transform. The simulationresult shows that this algorithm is much better for invisible watermarking and has goodrobustness for some common image processing operations.

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