Digital Watermarking: Combining DCT and DWT Techniques

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ABSTRACT: *The rapid expansion of the internet in the past years has rapidly increased the availability of digital data such as audio, images and videos to the public. The problem of protecting multimedia information becomes more and more important and a lot of copyright owners are concerned about protecting any illegal duplication of their data or work. This is an interesting challenge and this is probably why so much attention has been drawn toward the development of digital information protection schemes.*
The idea of watermarking of images is to embed information data within the image with an insensible form for human visual system and the goal is to produce an image that looks exactly the same to a human eye but still allows its positive identification in comparison with the owner's key if necessary.

Keywords- Discrete cosine transform (DCT), Discrete wavelet transform (DWT), digital watermarking

I: INTRODUCTION

Cryptography and steganography have been used throughout history as means to add secrecy to communications during times of war and peace. Some of the early methods to hide information include text written on wax-covered tablets, invisible writing using invisible ink and shaving the head of a messenger and tattooing the message on the scalp. In World War II null ciphers were used in which the secret was camouflaged in an innocent sounding message. Although steganography and watermarking both describe techniques used for covert communication, steganography typically relates only to covert point to point communication between two parties. Steganography methods are not robust against attacks or modification of data that might occur during transmission, storage or format conversion.

Watermarking, as opposed to steganography, has an additional requirement of robustness against possible attacks. An ideal steganography system would embed a large amount of information perfectly securely, with no visible degradation to the cover object.

An ideal watermarking system, however, would embed an amount of information that could not be removed or altered without making the cover object entirely unusable. As a side effect of these different requirements, a watermarking system will often trade capacity and perhaps even some security for additional robustness.

The working principle of the watermarking techniques is similar to the steganography methods. A watermarking system is made up of a watermark embedding system and a watermark recovery system. The system also has a key which could be either a public or a secret key. The key is used to enforce security, which is prevention of unauthorized parties from manipulating or recovering the watermark. The embedding and recovery processes of watermarking are shown in Figure.

II: ELEMENTARY WATERMARKING SYSTEM

a) Information coding
b) Watermark embedding
c) Watermark concealment

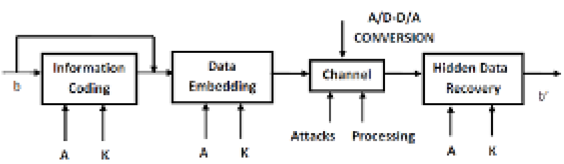


Fig. 1.1: Different stages of watermarking system

III: THE DCT AND DWT TRANSFORMS

The DCT and DWT transforms have been extensively used in many digital signal processing Applications. In this section, we introduce the two Transforms briefly, and outline their relevance to the Implementation of digital watermarking system.

The DCT transform: The discrete cosine transforms is a technique for converting a signal into elementary Frequency components [9]. 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 accordingly.

The popular block-based DCT transform segments an image non-overlapping block and applies DCT to each block. This results in giving three frequencies Sub-bands: low frequency sub-band, mid-frequency sub-ban and high frequency sub-band. DCT-based watermarking is based on two facts. The first fact is that much of the signal energy lies at low-frequencies sub-band which contains the most important visual parts of the image. The watermark is therefore embedded by modifying the coefficients of the middle frequency sub-band so that the visibility of the image will not be affected and the watermark will not be removed by compression

The DWT transform: Wavelets are special functions which, in a form analogous to sines and cosines in Fourier analysis, are used as basal functions for representing signals [7]. For 2-D images, 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. To obtain the next coarser scale of wavelet coefficients, the sub-band LL1 is further processed until some final scale N is reached. When N is reached we will have 3N+1 sub-bands consisting of the multi-resolution sub-bands LLN and LHx, HLx and HHx where x ranges from 1 until N.

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 ub-bands LHx and HLx where acceptable performance of imperceptibility and robustness could be achieved.

IV: Discrete Cosine Transform algorithm

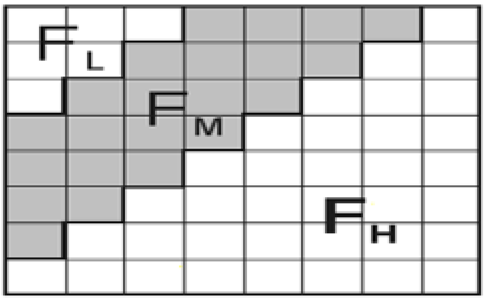


Fig. 1.2: Definition of DCT regions

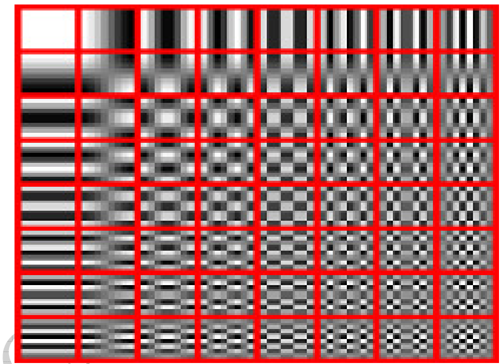
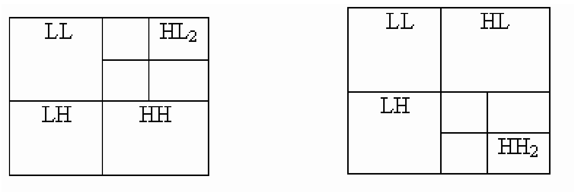


Fig 1.3: Two-dimensional DCT frequencies

IV: Discrete wavelet Transform algorithm



(a) (b)

Fig. 1.4: Multi-resolution DWT sub-bands of the original image

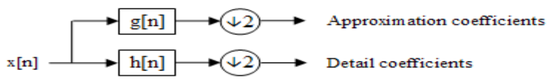


Fig. 1.5: Single stage DWT system

V: Combined DCT-DWT algorithm:

In this algorithm first of all the DWT of image is taken which gives us 4 different components of the image out of which I am embedding the watermark in either horizontal or vertical component by taking its DCT.

After embedding watermark we are taking inverse DCT and inverse DWT respectively to get original view of image back.

Step 1: Apply DWT to decompose the watermarked image into four non-overlapping multi-resolution sub bands: LL1, HL1, LH1, and HH1.

Step 2: Apply DWT to HL1 to get four smaller sub bands, and choose the sub-band HL2, as shown in Fig.1.4 (a) Or, apply DWT to the HH1 sub-band to get four smaller sub-bands, and choose the HH2 sub-band, as shown in Fig. 1.4 (b).

Step 3: Divide the sub-ban HL2 (or HH2) into 4´4 Blocks.

Step 4: Apply DCT to each block in the chosen sub-band (HL2 or HH2), and extract the mid-band coefficients of each DCT transformed block.

Step 5: Regenerate the two pseudorandom sequences (PN_0 and PN_1) using the same seed used in the watermark embedding procedure.

Step 6: For each block in the sub-band HL2 (or HH2), calculate the correlation between the mid-band coefficients and the two generated pseudorandom sequences (PN_0 and PN_1). If the correlation with the PN_0 was higher than the correlation with PN_1, then the extracted watermark bit is considered 0, otherwise the extracted watermark is considered 1.

Step 7: Reconstruct the watermark using the extracted watermark bits, and compute the similarity between the original and extracted watermarks.

Step 8: Apply inverse DCT (IDCT) to each block after its mid-band coefficients have been modified to embed the watermark bits as described in the previous step.

Step 9: Apply the inverse DWT (IDWT) on the DWT transformed image, including the modified sub-band, to produce the watermarked host image.
The watermark extraction procedure is depicted in Fig. 3, and described in details in the following steps. The combined DWT-DCT algorithm is a blind watermarking algorithm, and thus the original host image is not required to extract the watermark.

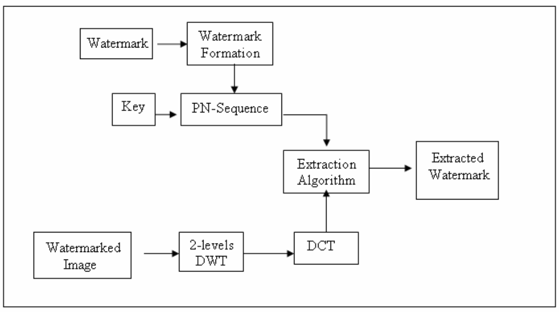


Fig. 1.6: Combined DWT-DCT watermark extraction procedure

Step 1: Apply DWT to decompose the watermarked image into four non-overlapping multi-resolution sub bands: LL1, HL1, LH1, and HH1.

Step 2: Apply DWT to HL1 to get four smaller sub bands, and choose the sub-band HL2, as shown in Fig. 1.4 a. Or, apply DWT to the HH1 sub-band to get four smaller sub-bands, and choose the HH2 sub-band, as shown in Fig. 1.4 b.

Step 3: Divide the sub-ban HL2 (or HH2) into 4□4 blocks.

Step 4: Apply DCT to each block in the chosen sub-band (HL2 or HH2), and extract the mid-band coefficients of each DCT transformed block.

Step 5: Regenerate the two pseudorandom sequences (PN_0 and PN_1) using the same seed used in the watermark embedding procedure.

Step 6: For each block in the sub-band HL2 (or HH2), calculate the correlation between the mid-band coefficients and the two generated pseudorandom sequences (PN_0 and PN_1). If the correlation with the PN_0 was higher than the correlation with PN_1, then the extracted watermark bit is considered 0, otherwise the extracted watermark is considered 1.

Fig. 1.6: 'Lena' host image

Fig. 1.7: Original watermark

Results of DCT algorithm:

Fig. 1.8: DCT algorithm

Results of DWT algorithm

Fig. 1.9: DWT algorithm

Results of combined DCT-DWT algorithm:

Fig. 2.0: Combined DCT-DWT algorithm

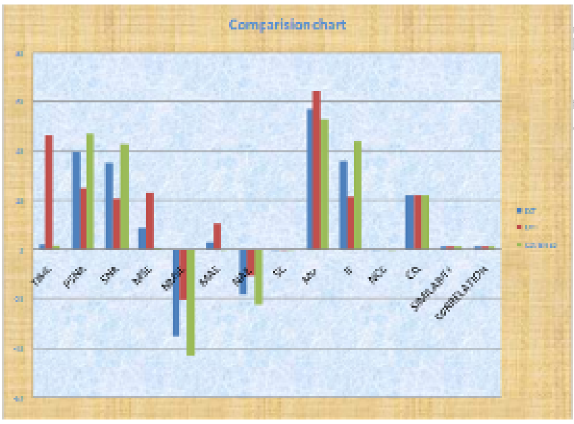


Fig 2.1 Comparative study of algorithms:

VI Performance Evaluation

We evaluated the performance of the combined DWT-DCT image watermarking algorithms using a 512´512 'Lena' as the original cover host image, and a 256´256 grey-scale image of the expression copyright' as the watermark image. The two images are shown in Fig. 1.7 and 1.8, respectively.

Performance Evaluation Metrics: Watermarking algorithms are usually evaluated with respect to two metrics: imperceptibility and robustness. 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. As a measure of the quality of a watermarked image, the peak signal to noise ratio¯(PSNR) is typically used.

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 major digital signal processing operations (Attacks): Gaussian noise, image compression and image cropping. The three attacks are a few; however, they are good representatives of the more general attacks. That is the Gaussian noise is a watermark degrading attack, JPEG compression is a watermark removal attack and cropping is a watermark dispositioning geometrical attack.

Performance results: We carried out the watermark embedding algorithm described in the previous section.

Applying the 1-level DWT of the 'Lena' image produced four 256256 sub-bands; LL1, LH1, HL1 and HH1. Since embedding the watermark beyond the first DWT level is more effective, we decided to embed the watermark in HL2 (or HH2). The selected 128´128 sub-band was divided into 4´4 blocks giving a total of 1024 blocks.

The DCT transform was then applied to each block in the chosen sub-band, after which the watermark was embedded according to Eq. 3 and 4.

Imperceptibility: We evaluated imperceptibility of the combined DWT-DCT algorithm by measuring PSNR for the HL2 and HH2 sub-bands. HL2 gave a PSNR value of 97.072 while HH2 gave 97.083. The difference is small between the two PSNR values indicating comparable performance of the two sub-bands. In contrast, and as shown in Table 1, the difference between the PSNR values of the DWT-Only and the combined DWT-DCT algorithms is relatively large. This indicates that improvement in imperceptibility can be achieved by applying DCT on a DWT transformed HL2 (or HH2) sub-band.

Robustness: Table 1 shows the correlation values between the original watermark and the watermarks Extracted from sub-bands HL2 and HH2 after being subjected to different attacks, independently**.**

The correlation values given in Table 1 show clearly that the combined DWT-DCT watermarking algorithm outperforms the conventional DWT-Only approach with respect to robustness against the Gaussian noise and cropping attacks.

VII RESULTS AND DISCUSSION

We described the performance of the combined DWT-DCT watermarking algorithm. For the sake of comparison, we also evaluated the watermarking performance when DWT-Only was used. The results we obtained for the DWT-Only approach indicated a better imperceptibility performance was obtained when the watermark was embedded in the HL2 or HH2 sub bands.
The robustness performance, however, was not acceptable. To improve performance, we combined DWT with another equally powerful transform; the DCT. The combined DWT-DCT watermarking algorithm's imperceptibility performance was better

VIII CONCLUSIONS

The discrete wavelets transform (DWT) and the discrete cosine transform (DCT) have been applied successfully in many in digital image watermarking. In this paper, we described a combined DWT-DCT digital image watermarking algorithm. Watermarking was done by embedding the watermark in the first and second level DWT sub-bands of the host image, followed by the application of DCT on the selected DWT sub-bands. The combination of the two transforms improved the watermarking performance considerably when compared to the DWT-Only watermarking approach. In conclusion, in DWT-based digital watermarking applications, combining appropriate transforms with the DWT may have a positive impact on performance of the watermarking system
After comparing the three algorithms we can conclude from the comparison chart that the combined DCT-DWT algorithm is good with respect to the individual DCT and DWT algorithms from each and every parameter which is measured

1. Spatial domain watermarking algorithms are better in context to the perceptibility of watermarked image to the human eye as they are affecting very less to the image quality.
2. Transform domain watermarking algorithms are better in context to the robustness of
3. Watermarked image as they are very hard to remove from the watermarked image.

IX REFRENCES

[1] Stefan Katzenbeisser and Fabien A. P. Petitcolas, "Information Hiding Techniques for Steganography and Digital Watermarking," Artech house, Computer security series, pp.15-23, 97-109, 2000.

[2] Neil F.Johnson, Zoran Doric and Sushil Jodie, "Information Hiding, Steganography and Watermarking-Attacks and Counter Measures," Kluwer academic publisher, pp. 15-29, 2003.

[3] Navas. K A, Sreevidya S, Sasikumar M "A benchmark for medical image watermarking", 14th International workshop on systems, signals & image processing and 6th EURASIP Conference focused on speech & image Processing, Multimedia Communication and services IWSSIP-2007 & EC-SIPMCS-2007, Maribor, Slovenia, 27-30 June 2007, pp 249-252.

[4] Alexander Sverdlov, Scott Dexter, Ahmet M. Eskicioglu "Robust SVD DCT based watermarking for copyright protection", IEEE Transactions on Image Processing, 10(5), May 2001, pp. 724-735.

[5] R. Mehul and R. Priti, "Discrete Wavelet Transform Base Multiple Watermarking Scheme," Proceedings of IEEE Region 10 Technical Conference on Convergent Technologies for the Asia-Pacific, Bangalore, India, October 14-17, 2003.

[6] E. Ganic and A. M. Eskicioglu, "Secure DWT-SVD Domain Image Watermarking: Embedding Data in All Frequencies," ACM Multimedia and Security Workshop 2004, Magdeburg, Germany, September 20-21, 2004.

[7] Vetterli, M. and J. Kova_evi_, 1995. Wavelets and Subband Coding. Prentice Hall, USA.