Robust Adaptive Image Security Using Mixed Frequency Domain

Mohammed G. Vayada
M.E. Student, E & C Dept., Parul institute of Engineering & Technology, Limda, Waghodia
Vayada.mohammed@gmail.com

Anil C. Suthar
Asst. Professor, E & C Dept., Electronics and Communication Department, LCIT – Bhandu
acsuthar@yahoo.co.in

Arvind R. Yadav
Asst. Professor, E & C Dept., Parul institute of Engineering & Technology, Limda, Waghodia
aryme@rediffmail.com

ABSTRACT

The explosion of digitized media due to the rapid growth of networked multimedia systems, has created an urgent need for copyright enforcement technologies that can protect copyright ownership of multimedia objects. Digital image watermarking is one such 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. 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, we describe an imperceptible and a robust combined DWT-DCT digital image watermarking algorithm.

KEYWORDS: ***Digital image watermarking; image copyright protection; frequency-domain watermarking; Discrete Wavelet Transform (DWT); Discrete Cosine Transform (DCT); Image Security; Mixed Transform.***

INTRODUCTION

Developments in digital content distribution have brought about immense prospects for business content suppliers and with that also claim to be a major threat because of the simplicity of illegal copying and distribution of the digital data. With the redundancy of the medium as image and voice, digital watermarking technology is to use the digital embedding method to hide the watermarking information into the digital products of image. As suggested by (Woo,2005), The watermarking signal being embedded into carrier is as a weak signal to add into a strong background, As long as the intensity of watermarking is lower than the contrast restriction of human visible system (HVS) or the apperceive restriction of human audio system(HAS), the watermarking signal won't be felt by HVS or HAS. This paper introduces an algorithm of digital watermarking based on Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT) which increases robustness and concealing of a watermarked image. The watermarking image will be discrete Cosine transformed at first. Because these DCT modulus contain the low frequency information of watermarking image, as long as these information do not lose or lose little then the watermarking image can be renewed well. This enhances the robustness and concealment. The host image is decomposed through DWT transform, and then chooses the appropriate wavelet modulus in the high frequency level. The watermarking information is embedding into the corresponding Position. Make the whole image IDWT transformed and get the watermarked image. The watermarking distilling is quite the contrary.

DISCRETE COSINE TRANSFORM

The discrete cosine transforms is a technique for converting a signal into elementary frequency components. 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 according to Eq. 1 shown below. In the equation, x, is the input image having N x M pixels, x(m,n) is the intensity of the pixel in row m and column n of the image, and y(u,v) is the DCT coefficient in row u and column v of the DCT matrix. (Ali Al-Haj (2007) and Ameya (2010))

$$y(u,v) = \sqrt{\frac{2}{M}}\sqrt{\frac{2}{N}} \propto_u \propto_v \sum_{u=0}^{M-1}\sum_{v=0}^{N-1} x(m,n)$$

$$\cos\frac{(2m+1)u\prod}{2M}\cos\frac{(2m+1)u\prod}{2N} \qquad \text{Eq. (1)}$$

Where

$$\propto_u = \begin{cases} \frac{1}{\sqrt{2}} & u = 0 \\ 1 & u = 1,2,N-1 \end{cases}$$

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DCT operation according to Eq. 2: DCT operation according to Eq. 2:

$$x(m,n) = \sqrt{\frac{2}{M}}\sqrt{\frac{2}{N}} \sum_{u=0}^{M-1}\sum_{v=0}^{N-1} \propto_u \propto_v y(u,v)$$

$$\cos\frac{(2m+1)u\prod}{2M}\cos\frac{(2m+1)u\prod}{2N} \qquad \text{Eq. (2)}$$

The popular block-based DCT transform segments image into non-overlapping blocks and applies DCT to each block. This results in giving three frequency sub-bands: low frequency , mid-frequency and high frequency sub-bands. 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 second fact is that high frequency components of the image are usually removed through compression and noise attacks. 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.

DWT (DISCRETE WAVELET 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. 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 LL_x and LH_x, HL_x and HH_x 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 algorithms, is to embed the watermark in the middle frequency sub-bands LHx and HLx where acceptable performance of imperceptibility and robustness could be achieved as suggested by (Xia, 1998).

ADVANTAGES OF DWT OVER DCT

Wavelet transform understands HVS model more closely than DCT.

No blocking artifacts: Visual artifacts introduced by wavelet coded images are less evident compared to DCT because wavelet transform doesn't decompose the image into blocks for processing. At high compression ratios blocking artifacts are noticeable in DCT however in wavelet coded image it's much clearer.

DFT and DCT are full frame transform and hence any change in the transform coefficients affects the entire image except if DCT is implemented using block based approach. However DWT has spatial frequency locality which means if signal is embedded it will affect the image locally. Hence wavelet transform provide both frequency and spatial description of an image.

Wavelet coded image is a multi resolution description of an image. Hence image can be shown at different level of resolution and can be sequentially processed from low resolution to high resolution.

Another limitation of the DCT is that the use of fixed length basis functions gives poor frequency resolution properties, leading to inefficient performance for some types of images. In particular, it is known that DCT coders don't perform very efficiently for binary images (such as FAX or pictures of fingerprints) characterized by large periods of constant amplitude as noted by (Rao, 2010).

DISADVANTAGES OF DWT OVER DCT

Computational complexity of DWT is more compared to DCT. It takes 54 multiplications to compute DCT for a block of 8x8, unlike wavelet calculation depends upon the length of the filter used, which at least 1 multiplication per coefficient.

It requires more memory for storing of coefficients at each level in hardware approach. (Srinivasa rao, (2010))

COPYRIGHT ALGORITHM

Fig.1 shows the sketch map of Hybrid Algorithm.

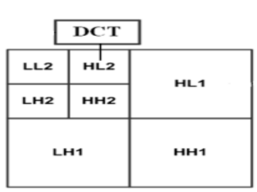

Fig.1 Sketch map of Combine Algorithm

The Algorithm used for embedding is shown in Fig. 2

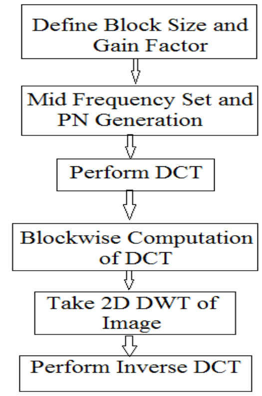

Fig. 2 Watermark Embedding Algorithm.

Fig.2 shows how secrete image can be embedded using DCT and DWT; this is the general form of watermark embedding or watermark encoding flow. The decoding algorithm for extracting the original secret image from the watermarked image is shown in Fig.3 (Suthar, 2010). This shows how the secrete image can be extracted from the watermark image. Transform operation is done and then PN sequence is checked, hence the extraction of watermark in host or cover image can be achieved.

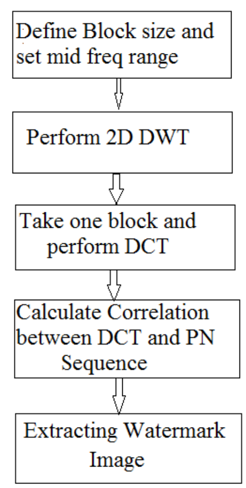

Fig.3 Watermark Extracting Algorithm

RESULTS AND ANALYSIS

There are some analysis parameters from which we can conclude robustness and concealing of watermarked image. The concealing of the watermark is quantitatively analyzed by using Peak Signal to Noise Ratio (PSNR) (Gonzalez, 2010). If the pixels of the original image are denoted by P_i and the pixels of the reconstructed image as Q_i, (where $1 \leq i \leq n$),we first define the mean square error (MSE) (Gonzalez, 2010) between n pixels of the two images as,

$$MSE = \frac{1}{n}\sum_{i=1}^{n}(Pi - Qi)^2 \qquad \text{Eq. (3)}$$

And, the root mean square error (RMSE) is defined as the square root of the MSE, and the PSNR is defined as

$$PSNR = 20log_{10}\frac{\max\,[pi]}{RMSE} \qquad \text{Eq. (4)}$$

Considering this parameters, the embedded image is shown in fig.4.

Fig.4 Secret Message

Fig.5 Host Image

The host image, in which the secret image is to be embedded, is shown in fig.5
Applying proposed algorithm for DWT and DCT, we can embed the image successfully in the host image. Fig.6 shows the embedded watermark image.

Fig.6 Watermark for Spline

Fig.7 Watermark for Skull

Fig.8 Watermark for Head-CT

Fig.9 Watermark for Barbara

Fig.10 Recovered Secrete Image from all watermarked Images.

We can retrieve the embedded image from the host image by decoding algorithm; the retrieved secure image is shown in Fig.7.

Table 1. Results of Different images and their PSNR and MSE

Image	PSNR	MSE
MRI Spine	39.0286	8.1324
Head CT	36.7224	13.8307
Skull	31.8288	42.6777
Barbara	36.5805	36.5805

Table 1. Illustrates PSNR (Peak Signal to Noise Ratio) and MSE (Mean Square Error) of watermarked image. Simulation results from comparative analysis suggest that algorithm developed by combining both DCT & DWT increases robustness & concealing properties image and also increases security aspects with respect to HVS system.

Simulation results suggest that we can observe visually not detectable difference between original host image and watermarked image. This suggest that after encoding message image on host or cover image, resultant image cannot be detected by HVS systems which ultimately increase security aspects of image on any communication media. On the other hand also we cannot detect any visual difference between message image and decoded message image after applying algorithm which also implies that important properties like robustness & concealing also increase of an image.

CONCLUSION

This paper introduces a hybrid algorithm based on combination of DCT (Discrete Cosine Transform) and DWT (Discrete Wavelet Transform),which will enhances robustness and concealing property of watermarked image . In this algorithm host image is transformed to 2nd level DWT to get higher frequency co-efficient of decomposed image. Then HHx image block of 2nd level is transformed using DCT, wherein secret message is encoded. Simulation results also suggest that this hybrid watermark technique is not detectable by HVS system, which also increases security aspect of this method.

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