Modified Color Image Watermarking Scheme using DWT and DCT Coefficients of R, G and B Color Channels

M.Vara Lakshmi[1] and P.Krishna prasad[2]
[1]Student, [2]Asst.Professor
Dept of Computer Science
Vasireddy Venkatadri Institute of Technology, AP, India.

Abstract: 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. This paper presents a new scheme of how watermark bits are embedding into R,G and B color channels based on DWT-DCT coefficients. In this scheme color image is decomposed into R, G and B color channels. Later 2 level DWT is applied B channel and after that divide that image into 4X4 blocks then DCT is applied on the each block. Then select the middle frequency coefficients to embed the watermark bits. 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: Watermark, DWT, DCT, Digital Image Watermarking, Watermark embedding, Watermark Extarction

Introduction

The copying of digital content without quality loss is not so difficult. Due to this, there are more chances of copying of such digital information. The specialty of watermark is it remains intact to the cover image even if it is copied. So it is difficult to remove or change the watermark.

Digital watermarking can be classified as visible and invisible. The visible watermarks are viewable to the normal eye such as bills, company logos and television channel logos etc. This type of watermarks is easily viewable without any mathematical calculation but these embedded watermarks can be destroyed easily. In the case of invisible watermarks, the locations in which the watermark is embedded are secret, only the authorized persons extract the watermark. Some mathematical calculations are required to retrieve the watermark. This kind of watermarks is not viewable by an ordinary eye. Invisible watermarks are more secure and robust than visible watermarks.

Digital image watermarking techniques can be classified into two major types: Spatial-domain and Frequency-domain watermarking techniques Compared to Spatial domain techniques.

Spatial domain refers to embed the watermark by directly changing pixel values of host images. Frequency domain watermarking refers to embed the watermark, frequency transformation is applied to host data.

Frequency-domain watermarking techniques proved to be more effective in achieving the imperceptibility and robustness compared to spatial domain technique.

Two types of frequency-domain transforms, viz. DWT and DCT are most popularly employed in watermarking. DWT is used to extract multi resolution characteristics of an image, DCT has Energy Compaction property which is used to pack all data into few coefficients. So both techniques are used to overcome the drawbacks of each technique.

This paper proposes an efficient use of mid-band coefficients of B channels of a color image. Apply 2 level DWT on B channel and then DCT is applied on the image which is divided into 4X4 blocks. To achieve the robustness, watermark bits are embedding into mid band regions of DCT blocks.

Related Works

The most important information about watermarking is proposed in [1]. How the DWT and DCT Techniques are used is proposed in [6]. It proposes working of DWT and DCT .

In[5] gives the idea of using wavelets types for example Haar Wavelet. R.Eswaraiah & E.Sreenivasa

ISSN 2229-5518
Reddy Proposes a new method of using DCT coefficients for making watermarking scheme more robust. The advantages of combing both DWT and DCT techniques are proposed in [7].

RGB color model

The **RGB color model** is an additive color model in which red, green, and blue light are added together in various ways to reproduce a broad array of colors.

Approximately 65% of all cones are sensitive to red light, 33% are sensitive to green light, and only about 2% are sensitive to blue.

DWT transform

. Wavelets are special functions that act analogous to sines and cosines in Fourier analysis, and used as basal functions to represent signals[13].

The basic idea of discrete wavelet transform (DWT) in image processing is to multi-differentiated decompose the image into 4 frequency districts which is one low frequency district(LL1) and three high frequency districts (LH1,HL1,HH1). L and H represent Low-pass and High-pass filter. 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 processed to attain the final scale N. At this stage, we have 3N+1 sub-bands consisting of the multi-resolution sub-bands LLN and LHx, HLx and HHx where x ranges between 1 to N.

Its excellent spatial-frequency localization properties, DWT is very effective to precisely define the areas in the host image where a watermark can be embedded effectively. The impact of this property is regulated with precision where the masking effect of the human visual system at its micro level is evident when a DWT coefficient is modified, only the region corresponding to that coefficient will be modified. Since most of the image's energy is concentrated at the lower frequency sub-bands LLx, the embedding watermarks in these sub-bands may degrade the image significantly. Yet, embedding in the lower-frequency sub-bands, could add to the robustness significantly.

Embedding the watermark in high frequency sub-bands includes edges so sub-bands are removed when image is compressed.

So embed the watermark in the middle frequency sub-bands LHx and HLx where acceptable performance of imperceptibility and robustness could be achieved.

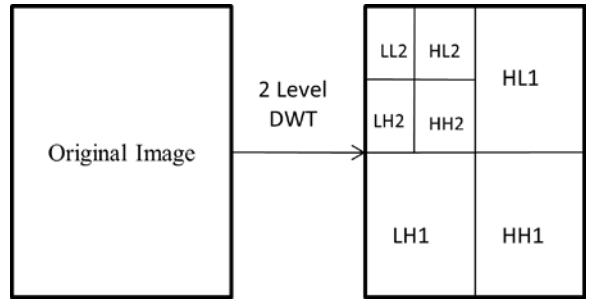

Fig.1 DWT Decomposition of an image using 2-level pyramid

Advantages of DWT

The compatibility of wavelet transform for image watermarking has primacy because of following reasons.

1. No need to block the input image and its basis functions have variable length avoid blocking artifacts.
2. More robust under transmission and decoding errors.
3. Good frequency resolution at lower frequencies, good time resolution at higher frequencies – good for natural images.
4. Consumes less time for both decomposition and reconstruction.
5. Allows good localization.
6. Edge and textures patterns in an image can be easily identified with the application of high resolution sub-bands

7. Visual artifacts are less compared to DCT because in DWT there is no need of Block processing

The DCT transform

The discrete cosine transforms (DCT) represents an image as a sum of sinusoids of varying magnitudes and frequencies. The DCT has special property called 'Energy Compaction Property' i.e., the most of the visually significant information (signal energy) of the image is concentrated in just a few coefficients of the DCT.

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.

$$y(u,v) = \sqrt{\frac{2}{M}}\sqrt{\frac{2}{N}}\,\alpha_u\alpha_v\sum_{u=0}^{M-1}\sum_{v=0}^{N-1} x(m,n)\cos\frac{(2m+1)u\pi}{2M}\cos\frac{(2n+1)v\pi}{2N} \qquad (1)$$

Where

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

$$\alpha_v = \begin{cases} \frac{1}{\sqrt{2}} & v=0 \\ 1 & v=1,2,\ldots,N-1 \end{cases}$$

The image is reconstructed by applying inverse DCT operation according to Eq. 2:

$$x(m,n) = \sqrt{\frac{2}{M}}\sqrt{\frac{2}{N}}\sum_{u=0}^{M-1}\sum_{v=0}^{N-1} \alpha_u\alpha_v y(u,v)\cos\frac{(2m+1)u\pi}{2M}\cos\frac{(2n+1)v\pi}{2N} \qquad (2)$$

The popular block-based DCT transform segments an image into non-overlapping blocks and applies DCT to each block resulting in three frequency sub-bands: low, mid and high frequency sub-bands. DCT-based watermarking relies 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. And 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. As a result the visibility of the image will remain un affected and the watermark remains intact even in case of compression.

Proposed Method

Our proposed method involves three steps

1. Image is Decomposed into R,G and B color channels.
2. B color channel is decomposed into three spatial components using DWT because B is sensitive to eye Hence achieve robustness.
3. Applying DCT to convert these components into respective frequencies.

The input cover image is decomposed into its R, G and B color channels. Apply 2 level DWT on B channel and get spatial components (LH, HL, HH). Then DCT is applied on resulting DWT image and generate frequency components of every spatial components. Then select only mid frequency coefficients to embed the watermark

Watermark embedding algorithm

1) Take a cover image 'C' and decompose that cover image into R, G and B channels of cover image 'C'.
2) DWT is applied on B channel separately to get the multi-resolution sub-bands LL_1, HL_1, LH_1, and HH_1.
3) Again DWT is applied to HL_1 (or LH_1) sub-bands of B channels and select HL_2 (or LH_2) sub-bands of B channel.
4) Divide the HL_2 (or LH_2) sub-bands of B channel into blocks of size 4X4.
5) DCT is applied on each of the blocks obtained in previous step .
6) Convert the watermark 'w' into bits.
7) The number of bits that can be embedded corresponds to the number of blocks in B channel.
8) The bits are embedding into middle coefficients of 4X4 blocks based on image size.
9) Repeat this process for all bits of the watermark.
10) Apply IDCT to the blocks of B channels .
11) Apply IDWT for 2 levels to B channels.
12) Combine R, G and B channels to get watermarked image 'WI'.

Watermark extraction algorithm

1) Obtain R, G and B channels of watermarked image 'WI'.

ISSN 2229-5518

2) Apply DWT to B channel to obtain the multi-resolution sub-bands LL_1, HL_1, LH_1, and HH_1.
3) Apply DWT again to HL_1 sub-bands of B channel and select HL_2 sub- B channel.
4) Divide the HL_2 sub-bands of B channel into blocks of size 4×4.
5) Apply DCT to B block obtained in previous step.
6) Water marking bits are extracted from first block of B channel and repeat this process until extraction of all bits from all 4X4 blocks
7) Then apply IDCT to all 4X4 blocks to get the watermarked image.

Performance Analysis

The quality of the watermarked image is studied with the ratio of peak signal to noise ratio (PSNR). PSNR in decibels (dB) is given below in Eq. 3. This is done by calculating the Normalized Correlation (NC) and Standard Correlation (SC) between the extracted and the original watermark. The MSE, PSNR, NC and SC are calculated using following equations.

Mean Square Error (MSE):

$$MSE = \frac{\sum_{R,G,B}\sum_{i=1}^{M}\sum_{j=1}^{N}(C[i,j]-C'[i,j])^2}{3MN}$$

Here, M and N are the height and width of image respectively. C[i, j] denotes the (i, j)*th* pixel value of the original image and I′[*i, j*] denotes the (i, j)*th* pixel value of watermarked image.

Peak Signal to Noise Ratio (*PSNR*):

$$\text{PSNR}=\log\frac{(2^n-1)^2}{MSE} \qquad (3)$$

Where n denotes the number of bits used for color representation.

Normalized Correlation (NC) :

$$NC = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}(C[i,j]C'[i,j])}{\sum_{i=1}^{M}\sum_{j=1}^{M}(C[i,j])^2}$$

Where I[i, j] denotes the original image and I′[i, j] is the modified image. M is the height of the image and N is width of the image.

Standard Correlation (SC) :

$$SC = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}\left(C[i,j]-I'\right)\left(J[i,j]-J'\right)}{\sqrt{\sum_{i=1}^{M}\sum_{j=1}^{N}(C[i,j]-I')}\sqrt{\sum_{i=1}^{M}\sum_{j=1}^{N}(J[i,j]-J')}}$$

Here, I[i, j] is the original watermark, J[I, j] is the extracted watermark, I′ is the mean of original watermark and J′ is the mean of extracted watermark.

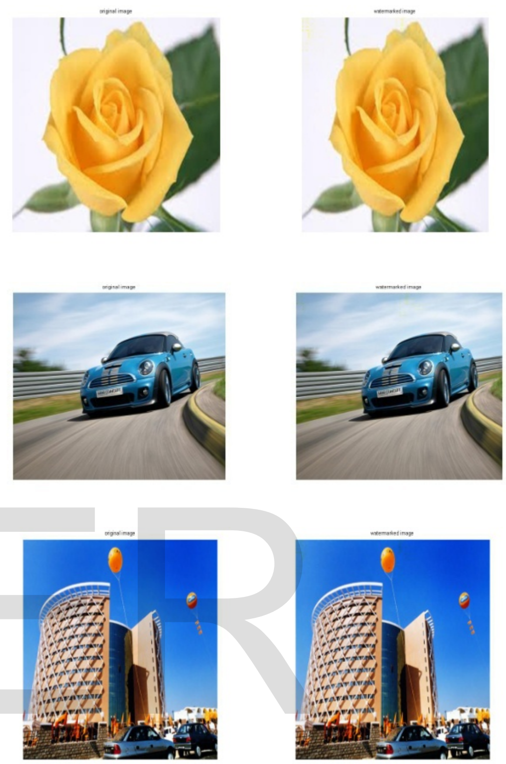

Figure 2: Test images of flower,car and building before and after watermarking.

Results

We used three color images of flower, house and bird of size 512×512 to test our method. Figure 2 shows the three test images before and after watermarking.

Watermark that we have used to embed into the above test images is shown in figure 3.

Figure 3: watermark

Blurring Attack:

Gaussian blur with disk radius 1 is applied on the watermarked images and the respective PSNR of the watermark extracted from the watermarked images is shown in table-2.

Salt and Pepper noise attack:

Salt and pepper noise with noise density 0.06 is added to the watermarked images and the respective PSNR of the watermark extracted from the watermarked images is shown in table-2.

Sharpening attack:

Sharpening operation can be performed with the help of filter. A two dimensional contrast enhancement filter is applied to the watermarked images with sharpness parameter set to 0.5 and the respective PSNR of the watermark extracted from the watermarked images is shown in table-2.

Cropping attack:

The watermarked images are cropped up to 30 percentage and the respective PSNR of the watermark extracted from the watermarked images is shown in table-2.

Gaussian noise attack:

Gaussian noise is added to the watermarked images and the respective PSNR of watermark extracted from the watermarked images is shown in table-2.

The values of MSE and PSNR between original and watermarked images are summarized in Table-1. From table-2 we can say that the proposed scheme sustained all the attacks and the quality of the extracted watermark is fine. Table-3 summarizes NC and SC values between original and extracted watermarks from different color images.

Table-1: MSE and PSNR between original and watermarked images

Image	MSE	PSNR
Flower	0.34	82.72
car	0.41	81.94
Building	0.38	82.72

Table-2: PSNR of extracted watermark from watermarked test images after attacks

	PSNR(dB)		
	Flower	Car	building
Gaussian Blur	63.66	62.99	63.37
Salt and Pepper noise	64.51	65.17	64.81
Sharpening	70.98	66.53	63.22
Cropping	67.33	61.57	59.49
Gaussian noise	79.99	77.07	73.80

Table-3: NC and SC between extracted and original watermarks of flower,car and building

Image	NC	SC
Flower	1.00	1.00
Car	1.00	1.00
building	1.00	1.00

Conclusion

DWT and DCT have been applied for B color channel. Watermarking was done by embedding the watermark in the DCT coefficients obtained from the DWT sub-bands of B color channels. Watermark bits are embedding using mid frequency coefficients of 4x4 blocks. DWT only applied on B channel because it is very sensitive to eye than R and G colors. Results proved that proposed scheme is robust against common attacks and more secure.

REFERENCES

[1] Potdar, V., S. Han and E. Chang, 2005. A Survey of Digital Image Watermarking Techniques, in Proc. of the IEEE International Conference on Industrial Informatics, pp: 716, Perth, Australia.

[2] R.Eswaraiah & E.Sreenivasa Redd" RobustWatermarking Method for Color Images Using DCT Coefficients of Watermark", Global journalof Computer science.

[3] Keshav S. Rawat, Sachin Goyal and Roopam Gupta, "Discrete wavelet based image watermarking: An idea leads to security", Journal of Biometrics,

Vol. 1, Issue 1, 2010, pp- 06-10

[4] Baisa L. Gunjal and Suresh N.Mali "Securedcolor image watermarking Technique in dwt- dct domain", International Journal of Computer Science, Engineering and Information Technology (IJCSEIT), Vol.1, No.3, August 2011

[5] Anuradha, Rudresh Pratap Singh, "DWT Based Watermakring Algorithm using Haar Wavelet", International Journal of Electronics and Computer Science and Engineeirng.

[6] Mahasweta J.Joshi, Prof. Zankahana H.Shah, Kevur N.Brahmbhatt, "Watermarking in DCT-DWT Domain, Mafasweta J.Joshi et al,/(IJCSIT) International Journal of Computer Science nad Information Technologies, Vol.2(2),2011,717-720

[7] Ali Al-Haj, 2007. "Combined DWT- DCT Digital Image Watermarking", Journal of Computer Science.

[8] N. Kaewkamnered and K. R. Rao,"Wavelet Based Image Adaptive Watermarking Scheme" ,IEEE Electronic Letters, vol.36, Feb.2000.

[9] Hsieh, M.,D.Tseng, and Y.Haung, 2001. "Hiding digital Watermarks using Multiresolution Wavelet Transform," IEEE Trans.on Industrial Electronics, 48(5):875-882.

[10] Reddy, A. and B.Chatterji, 2005. "A New Wavelet Based Logo-watermarking Scheme," Pattern Recognition Letters, 26(7):1019-1027