Available online at www.elixirpublishers.com (Elixir International Journal)

Computer Engineering

Elixir Comp. Engg. 79 (2015) 30349-30352

ISSN: 2229-712X

Digital image watermarking using DWT based DCT technique

Ankit Kalariya, Setu Chaturvedi and Lokesh Singh
Computer Science & Engineering Department TIT, Bhopal, India.

ARTICLE INFO

Article history:
Received: 4 January 2015;
Received in revised form:
20 January 2015;
Accepted: 7 February 2015;

Keywords
Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT), Watermarking.

ABSTRACT
In the recent era, the extensive and rapid growth in internet technology is creating a important need to develop several newer techniques to protect authentication, ownership, copyright and content integrity of digital data. A proposed solution to this kind of problem is to digital watermarking. Digital watermarking has viable technique to the need of authentication, ownership, copyright and content integrity of digital data. Discrete Wavelet Transform (DWT) and Discrete Cosine Transform (DCT) are two most popular tools used in watermarking algorithm to protect digital image. Aim of this paper is to provide robust technique based on combined DWT and DCT propose a new watermarking algorithm for digital image. Discrete wavelet transform is used to provide robustness and discrete cosine transform has shorter elapsed time, taking advantages of both this technique proposed a new digital image watermarking algorithm. Results show that this algorithm combines the advantages of these two transforms.

Introduction

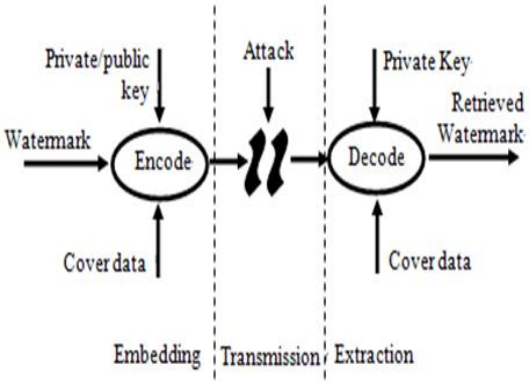


Figure 1. General processes in a watermarking system

The daily need to create copy, transmit and distribute digital data as a part of widespread multimedia technology in internet era. Hence copyright protection has become essential to avoid unauthorized copy problem. Digital image watermarking provides copyright protection to image by hiding appropriate information in original image to declare rightful ownership [1]. Elapsed Time, Robustness, are essential watermarking factors to determine quality of watermarking scheme [2][3]. Watermarking algorithms are broadly categorized as Spatial domain watermarking and transformed domain watermarking. In spatial domain, watermark is embedded by directly modifying pixel values of cover image. Least Significant Bit insertion is example of spatial domain watermarking. In Transform domain, watermark is inserted into transformed coefficients of image giving more information hiding capacity and more robustness against watermarking attacks because information can be spread out to entire image [1]. Watermarking is the process that embeds data called a watermark or digital signature or tag or label into a multimedia object such that watermark can be detected or extracted later to make an assertion about the object as shown in Fig. 1. Digital watermark is a sequence of information containing the owners copyright for the multimedia data. It is invisibly into other image so that it can be extracted later as an evidence of authentic owner. Usage of digital image watermarking technique has grown significantly to protect the copyright ownership of digital image data as it is very much prone to unlawful and unauthorized replication, reproduction and manipulation. The watermark may be a logo or image in digital image watermarking.

Discrete Cosine Transform (DCT)

Table 1. A random value input data.

33	6	15	43	25	11	5	27
21	63	44	30	0	39	40	14
34	20	1	42	41	16	38	17
57	45	32	23	29	24	4	28
47	7	31	2	19	51	3	52
35	46	62	36	49	54	36	18
8	58	56	9	59	10	60	53
22	48	12	61	26	55	50	13

Discrete Cosine Transform or DCT is a popular transform domain watermarking technique. [4] Discrete Cosine Transform uses the cosine transform to represent original data as shown in Table 1. The watermark is cast by first computing the N×N DCT coefficient matrix of an N×N image. This result in giving three frequency sub-bands low frequency sub-band, mid-frequency sub-ban and high frequency sub-band. DCT-based watermarking is based on two different facts. The first fact is that much of the signal energy lies at low-frequency Sub-band which contains the most important visual parts of the image. The second fact is that high frequency component of the image are usually removed through compression and noise attacks. The watermark is 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 [5][6][7][8]. Hence, the low frequency component and high frequency component can be neglected so mid frequency components is used in order to achieve effective DCT watermarking as shown in Table 2.

Tele:
E-mail addresses: ankitkalariya@yahoo.co.in

Table 2. DCT mid frequency sub band is selected

0	2	5	9	14	20	27	35
1	4	8	13	19	26	34	42
3	7	12	18	25	33	41	48
6	11	17	24	32	40	47	53
10	16	23	31	39	46	52	57
15	22	30	38	45	51	56	60
21	29	37	44	50	55	59	62
28	36	43	49	54	58	61	63

Algorithm for DCT

Step 1:- Read image to be a container, generate a watermark of random numbers ranging 1 to N.

Step 2:- Make sure the watermark coefficients do not exceed the number of pixels available in the host image.

Step 3:- Compute the Discrete Cosine Transform of the host image.

Step 4:- These are the values to be modified meaning storing the watermark.

Step 5:- Modify the mid DCT values of calculated DCT.

Step 6:- Compute the inverse DCT of the modified DCT Image and display it.

Step 7:- Write the watermarked image into a file with any image format.

Discrete Wavelet Transform (DWT)

To understand the basic idea of the DWT focus on one dimensional signal. A signal is split into two parts, normally high frequencies and low frequencies. The low frequency part is further split into two parts of high and low frequency (analysis). This process is continued until the signal has been entirely decomposed or stopped before by the user at hand [4]. For image watermarking applications, generally no more than 2 decomposition steps are computed [9]. For many signals, the content in low-frequency is the most important part. It is that gives the signal its identity. The high-frequency component, on the other side, imparts flavor or nuance. Consider the human voice. If remove the high frequency components, the voice sounds will be different, but one can still tell what's being told [10]. However, if you remove most of the low-frequency components then you hear gibberish. This kind of two-dimensional DWT leads to a decomposition of approximation coefficients at in four components orientations (approx, horizontal, vertical, and diagonal). The following Fig. 2 and Fig. 3 shows the basic decomposition steps of images. Observe an interesting reaction of wavelet transform on images depending on the nature of the images. After two-level DWT decomposition, have obtained 7 sub bands for each image [11]. The low frequencies (obtained by successive low-pass filtering) are concentrated in the upper-left corner and look like a scaled-down version of the original signal, therefore this sub band is also called approximation sub band [12]. The high frequency components of the image are represented in the remaining 6 detail sub bands[10]. A smooth image has a more significant coefficient value. One can compare a smooth image with a more textured image.

<table>
<tr><td>LL_2 (approx.)</td><td>HL_2</td><td rowspan="2">HL_1 (Horizontal Detail)</td></tr>
<tr><td>LH_2</td><td>HH_2</td></tr>
<tr><td colspan="2">LH_1 (Vertical Detail)</td><td>HH_1 (Diagonal Detail)</td></tr>
</table>

Figure 2. Sketch Map of Image DWT Decomposed

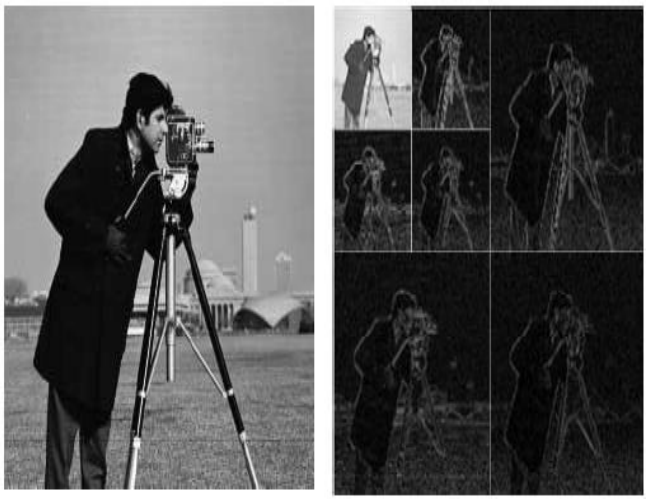


Figure 3. Illustration of 2 level DWT for an image

Algorithm for DWT

Step 1:- Read the image to be a container and the watermark image.

Step2:- Compute the approximate region of Discrete Wavelet Transform of the container image.

Step 3:- Encoding process.

Step 4:- Compute the Inverse Discrete Watermark Transform of the watermarked image.

Step 5:- Write the watermarked image into a file with any image format.

DWT Based DCT Watermarking Technique

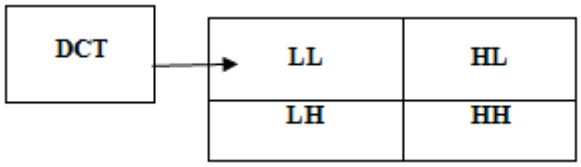


Figure 4. DWT based DCT Technique

In previous section describe about existing watermarking methods DCT and DWT, from that two technique taking the advantages of both i.e. As DCT is having smaller processing time and DWT have good robustness so proposed solution to developed hybrid which is combination of DWT and DCT technique which have better performance then alone DCT and DWT. In this technique first of all taking the DWT of the original image from which will get 4 coefficients of image named approximate, horizontal, vertical and diagonal coefficients. Out of these four elements the approximate coefficients carry maximum information so it cannot change that coefficients and the diagonal, horizontal and vertical coefficients are of high frequency so will be affected more by noise. Here in this algorithm first of all taking the DWT of the original image and then taking the DCT of the approximated coefficients of the DWT i.e. LL as shown in Fig. 4. After wards embedding the watermark in the DCT and taking the inverse DWT of the coefficients of the modified image which is our watermarked image using the combined DCT-DWT algorithm.

Algorithm for DWT based DCT

Step 1:- Apply DWT technique to decompose the cover host image into four non-overlapping multi-resolution sub-bands LL, HL, LH, and HH.

Step 2:- Divide the sub-band LL into 16 x 16 blocks.

Step 3:- Apply DCT watermarking to each block in the chosen sub-band (LL).

Step 4:- Reconstruct the grey-scale watermark image into a vector of zeros and ones.

Table 3. Result of circuit.bmp image(embedding)

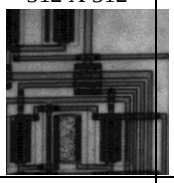
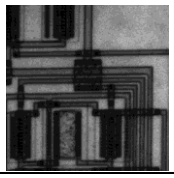
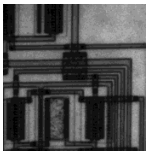
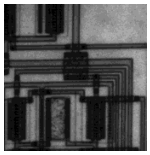
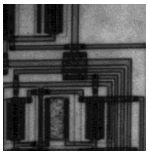
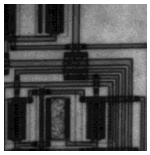
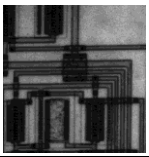
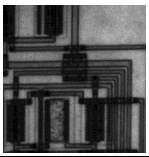
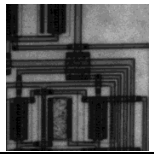
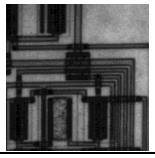
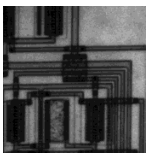
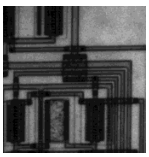
Sr. No	Original Image	Message Image	Watermarked Embedded image	Elapsed Time
1	circuit.bmp 512 X 512 	four.bmp 50 X 20 	Dctcircuit.bmp 512 X 512 	Embedding 3.18 sec
2	circuit.bmp 512 X 512 	four.bmp 50 X 20 	Dwtcircuit.bmp 512 X 512 	Embedding 13.95 sec
3	circuit.bmp 512 X 512 	four.bmp 50 X 20 	Dct-Dwtcircuit.bmp 512 X 512 	Embedding 3.04 sec

Table 4: Result of circuit.bmp image(decoding)

Sr. No	Watermarked Embedded image	Extraction Result	Watermarked Extracted image	Elapsed Time	Remark
1	dctcircuit.bmp 512 X 512 	Edctfour.bmp 50X20 	EDctcircuit.bmp 512 X 512 	Extraction 3.02 sec	Detect almost clearly
2	Dwtcircuit.bmp 512 X 512 	Edwtfour.bmp 50X20 	EDwtcircuit.bmp 512 X 512 	Extraction 21.04 sec	Detect unclearly
3	Dct-Dwtcircuit.bmp 512 X 512 	Edctdwfour.bmp 50X20 	EDct-Dwtcircuit.bmp 512 X 512 	Extraction 2.54 sec	Detect clearly

Step 5:- Generate two uncorrelated pseudorandom sequences. One pseudorandom sequence is used to embed the watermark bit 0 (PN_0) and the other sequence is used to embed watermark bit 1 (PN_1). Number of elements in each pseudorandom sequences must be equal to the number of mid-band elements of the DCT-transformed DWT sub-bands.

Step6:- Embed the our two pseudorandom sequences, PN_0 and PN_1, in the DCT transformed 16x16 blocks of the selected DWT sub-bands of the host image. Embedding is not applied to all coefficients of the DCT block, but only to the mid-band DCT coefficients. If use term X as the matrix of the mid-band coefficients of the DCT transformed block, then embedding is done as follows

If the watermark bit is 0 then

$$X' = X + * PN\_0$$

If the watermark bit is 1 then

$$X' = X + * PN\_1$$

Step 7:- Apply inverse DCT (IDCT) to each block after its mid-band coefficients have been changed to embed the watermark bits as it described in the previous step.

Step 8:- Apply the inverse DWT on the DWT transformed image, including with modified sub-band, to generate the watermarked host image.

Result Comparison

Table 3 and 4 shows original circuit image which has the size of 512x512(Bitmap file) format and four.bmp message shows the digital image watermarked using three discussed different technique DCT, DWT and combined DWT based DCT and result of this technique after embedding and decoding. It also shoes that the combined DWT based DCT technique has lower elapsed time and good resultant image visual quality then alone technique DCT and DWT hence main aim is achieved through combined DWT based DCT technique.

Conclusion

The results here obtained for the DCT and DWT approach indicated a better imperceptibility performance was obtained than alone. So finally conclude that The discrete wavelet transform (DWT) and the discrete cosine transform (DCT) have been applied successfully on digital image watermarking. This paper described a combined both DWT based DCT digital image watermarking algorithm. Watermarking was done by embedding the watermark in the first level DWT sub-bands of the host image, after the application of DWT based on the DCT watermarking sub-bands. The combination of the two transforms improved the watermarking performance considerably when compared to the DCT and DWT Only watermarking approach. In conclusion, in DCT and DWT based digital watermarking applications, combining appropriate transforms may have a positive result on performance of the watermarking system.

Future scope

Combined DWT based DCT technique is still applied only on images, but technique can also developed and apply on audio and video. Audio data generally represented in cosine signal form and frequency component and our hybrid technique is also represented in frequency component that's answer why it can applicable on audio data. It also applicable on videos, video is considered as collection or combination of different image frames so watermarking technique is used in each image frame and can be inserted in that make video watermarking.

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