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IMAGE WATERMARKING USING 2-LEVEL DWT

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Abstract- A novel multi resolution watermarking method has been introduced for digital images. The proposed method is based on 2-level discrete wavelet transform (DWT) and alpha blending technique. In this technique the insertion and extraction of the watermark in the gray-scale cover image is found to be simpler than other transform techniques. We have successfully implemented the digital watermarking technique on digital images based on 2-level discrete wavelet transform and compared the performance of proposed method with 1-level DWT by using statistical parameters peak signal to noise ratio (PSNR) and mean square error (MSE).
Key words- Image watermarking, 2-level DWT, Wavelet transform, Alpha Blending, MSE, PSNR

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Introduction

During the past decade, with the development of information digitalization and internet, digital media increasingly predominate over traditional analog media. However, as one of the concomitant side-effects, it is also becoming easier for some individual or group to copy and transmit digital products without the permission of the owner. The digital watermark is then introduced to solve this problem. *Watermarking* is a branch of information hiding which is used to hide proprietary information in digital media like photographs, digital music, or digital video [1-3]. The ease with which digital content can be exchanged over the Internet has created copyright infringement issues. Copyrighted material can be easily exchanged over peer-to-peer networks, and this has caused major concerns to those content providers who produce these digital contents.

Early watermarking schemes that were introduced, worked in the spatial domain, where the watermark is added by modifying pixel values of the host image. Examples of such techniques appear in [4,5]. Generally, spatial domain watermarking is easy to implement from a computational point of view, but too fragile to resist numerous attacks [5]. In order to have more promising techniques, researches were directed towards watermarking in the transform domain, where the watermark is not added to the image intensities, but to the values of its transform coefficients. Then to get the watermarked image, one should perform the transform inversely. Some of the transform based watermarking techniques used the Discrete Cosine Transform (DCT) like the one suggested in [6,7]

The wavelet transform is another type of the transform domain [8-10]. Wavelet based transform gained popularity recently since the property of multi resolution analysis that it provides. Discrete Wavelet Transform (DWT) is most commonly used wavelet transform.

DWT (Discrete wavelet transform) is the most effective and easy to implement techniques in watermarking [11-14]. DWT has been used in digital image watermarking more frequently due to its excellent spatial localization and multi-resolution characteristics. The biggest issue in DWT-based image watermarking is how to choose the coefficients to embed the watermark. The most common approaches include modifying the largest DWT coefficients in all decomposition levels or quantizing certain DWT coefficients in different levels and scales. This paper contributes to the implementation of 2 level DWT based image watermarking, in which the watermark is embedded in the image using the alpha blending technique.

Discrete Wavelet Transform

Discrete Wavelet transform (DWT) is a mathematical tool for hierarchically decomposing an image [10]. It is useful for processing of non-stationary signals. The transform is based on small waves, called wavelets, of varying frequency and limited duration. Wavelet transform provides both frequency and spatial description of an image. Unlike conventional Fourier transform, temporal information is retained in this transformation process. Wavelets are created by translations and dilations of a fixed function called mother wavelet. DWT is the multi resolution description of an image the decoding can be processed sequentially from a low resolution to the higher resolution [11]. The DWT splits the signal into high and low frequency parts. The high frequency part contains information about the edge components, while the low frequency part is split again into high and low frequency parts. The high frequency components are usually used for watermarking since the human eye is less sensitive to changes in edges [14].

The 1-level Discrete wavelet transform decomposes an image into lower resolution approximation image (LL1) as well as horizontal (HL1), vertical (LH1) and diagonal (HH1) detail components [9]. To compute 2 level of 2D-DWT the DWT algorithm is again applied on the LL1 which further decompose the LL1 part in four sub-bands LL2, HL2, LH2 and HH2. A 2 level 2D-DWT process is shown in the Figure 1.

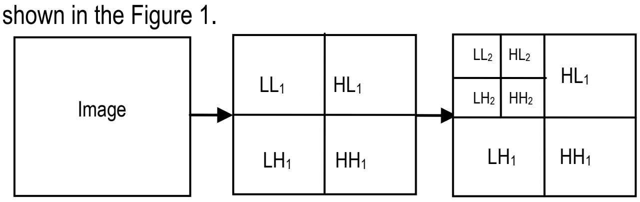


Fig. 1- Two-level discrete wavelet decompositions

DWT is currently used in a wide variety of signal processing applications, such as in audio and video compression, removal of noise in audio, and the simulation of wireless antenna distribution [8]. Wavelets have their energy concentrated in time and are well suited for the analysis of transient, time-varying signals. Since most of the real life signals encountered are time varying in nature, the Wavelet Transform suits many applications very well.

Proposed Watermarking Technique

In this process firstly the gray scale host image is taken and 2D 2-level DWT (Discrete Wavelet Transform) is applied to the image which decomposes image into low frequency and high frequency components. In the same manner 2D 2-level DWT is also applied to the watermark image which is to be embedded in the host image. The wavelet used here is the wavelets of daubecheis [13]. The technique used here for inserting the watermark is alpha blending [12, 15].

Watermark embedding

In this technique the decomposed components of the host image and the watermark are multiplied by a scaling factor and are added. Since the watermark embedded in this paper is perceptible in nature or visible, it is embedded in the low frequency approximation component of the host image.

According to the formula of the alpha blending [12] the watermarked image is given by

$$WMI = k*(LL2) + q*(WM2) \tag{1}$$

where WMI = low frequency component of watermarked image, LL2 = low frequency component of the original image obtained by 2-level DWT, WM2 = low frequency component of Watermark image, and k, q = Scaling factors for the original image and watermark respectively

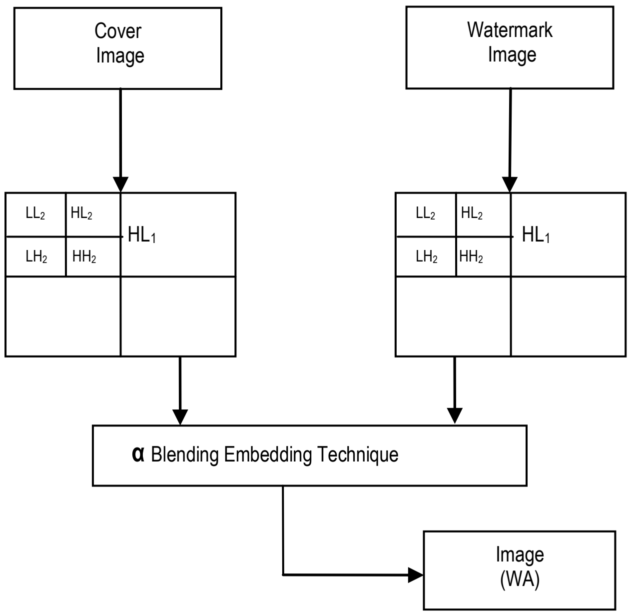


Fig. 2- Watermark embedding technique

After embedding the cover image with watermark image, 2-level Inverse discrete wavelet transform is applied to the watermarked image coefficient to generate the final secure watermarked image. Fig. 2 shows watermark embedding process.

Watermark extraction

In this process firstly 2-level DWT is applied to watermarked image and cover image which decomposed the image in sub-bands. After that the watermark is recovered from the watermarked image by using the formula of the alpha blending.

According to the formula of the alpha blending [12] the recovered image is given by

$$RW = (WMI - k*LL2) \tag{2}$$

where RW= Low frequency approximation of Recovered watermark, LL2=Low frequency approximation of the original image, and WMI= Low frequency approximation of watermarked image.

After extraction process, 2-level Inverse discrete wavelet transform is applied to the watermark image coefficient to generate the final watermark extracted image. Fig. 3 shows the watermark extraction process.

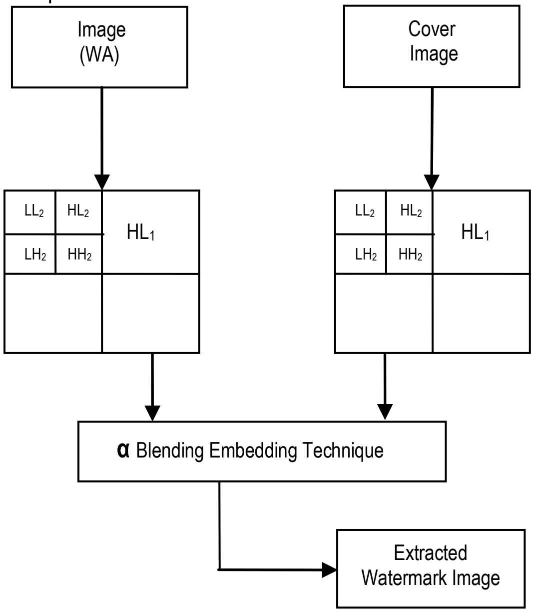


Fig. 3- Watermark Extraction technique

Experimental Results

We compare our proposed 2-level 2D DWT to the 1-level 2D DWT technique. For both the technique we have used grayscale images Lena as original image and the cameramen's image as the watermark. Both the images are of equal size of 256X256. Fig. 4 shows the original image and Fig. 5 shows the watermark image. For embedding of watermark in the original image the value of scaling factor k is varied from 1.5 to 0.2 by keeping q constant and best result is obtained for k=0.98 for both 2 level and 1 level DWT. As the value of k is decreased further to 0.2 the watermarked image becomes darker and finally becomes invisible. The best result is obtained for k= 0.98. Fig. 6 (a)-Fig. 6(d) show the watermarked image using 2-level discrete wavelet transform for different value of k. For the process of recovering the watermark from the watermarked image the value of k is kept constant at 0.009 and q is varied from 1.5 to 0.009. For the higher values of q the watermark becomes almost invisible and as the value of q is reduced best result is obtained, and if q is further reduced the recovered watermark becomes darker and PSNR decreases. The best result is obtained for q= 0.98

Fig. 4- Original image

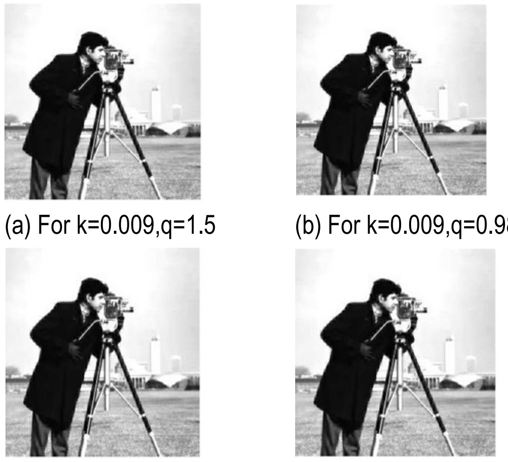
Fig. 5- Watermark

(a) For k=1.5,q=0.009 (b) For k=0.98,q=0.009

(c) For k=0.78,q=0.009 (d) For k=0.6,q=0.009

Fig. 6- Watermarked images using 2-level DWT for various values of scaling factors k

Recovered images are shown in Fig. 7.



(a) For k=0.009,q=1.5 (b) For k=0.009,q=0.98

(c) For k=0.009,q=0.78 (d) For k=0.009,q=0.6

Fig. 7- Recovered images using 2-level discrete wavelet transform for various values of scaling factors q

The values of the MSE and PSNR are calculated for various values of the scaling factors k and q for both 1- level DWT and 2-level DWT as shown in Table 1 and Table 2.

Table 1- Comparison of 1- level DWT and 2- level DWT for watermarked image in terms of MSE & PSNR for watermarked image

S. No.	k	q	MSE Level-1	PSNR Level-1	MSE Level-2	PSNR Level-2
1.	1.5	0.009	3.20e+03	13.08	3.16e+03	13.14
2.	1.0	0.009	1.44	46.55	1.421	46.60
3.	0.98	0.009	1.980	45.16	1.88	45.37
4.	0.95	0.009	21.33	34.84	20.85	34.94
5.	0.90	0.009	21.3	28.00	1.01e+02	28.08
6.	0.85	0.009	2.47e+02	24.21	2.42e+02	24.29
7.	0.78	0.009	5.51e+02	20.71	5.42e+02	20.79
8.	0.6	0.009	1.89e+03	15.36	1.86e+03	15.43
9.	0.4	0.009	4.32e+03	11.78	4.25e+03	11.84
10.	0.2	0.009	7.7e+03	9.25	7.62e+03	9.31

Table 2- Comparison of 1-level DWT and 2-level DWT for watermarked image in terms of MSE & PSNR for recovered image

S. No.	q	k	MSE Level-1	PSNR Level-1	MSE Level-2	PSNR Level-2
1.	1.5	0.009	4.45e+03	11.65	4.39e+03	11.7
2.	1.0	0.009	6.42e-27	3.1e+02	2.50e-26	3e+02
3.	0.98	0.009	7.11	39.6	7.016	39.67
4.	0.95	0.009	44.46	31.65	43.8496	31.71
5.	0.90	0.009	1.78e+02	25.6	1.754e+02	25.690
6.	0.85	0.009	4.0e+02	22.1	3.95e+02	22.169
7.	0.78	0.009	8.61e+02	18.78	8.49e+02	18.84
8.	0.6	0.009	2.85e+03	13.58	2.81e+03	13.649
9.	0.4	0.009	6.40e+03	10.067	6.31e+03	10.128
10.	0.2	0.009	1.14e+04	7.568	1.12e+04	7.6287

From Table 1 and Table 2, it can be observed that the value of PSNR is higher in case of 2-level DWT as compared to 1-level DWT for both the watermarked and recovered image. Thus the performance of the proposed 2-level algorithm is better than that of the performance of 1-level DWT.

Conclusion

In this paper, an image watermarking technique based on a 2-level discrete wavelet transform has been implemented. This technique can embed the invisible watermark into salient features of the image using alpha blending technique. Experiment results shows that the quality of the watermarked image and the recovered watermark are dependent only on the scaling factors k and q. Experiment results also shows that 2-level DWT provide better performance than 1-level DWT. All the results obtained for the recovered images and the watermark are identical to the original images

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