Digital Image Watermarking Using 3 level Discrete Wavelet Transform

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Abstract

In this paper a digital image watermarking based on 3 level discrete wavelet transform (DWT) is presented & compare it with 1 & 2 levels DWT. In this technique a multi-bit watermark is embedded into the low frequency sub-band of a cover image by using alpha blending technique. During embedding, watermark image is dispersed within the original image depending upon the scaling factor of alpha blending technique. Extraction of the watermark image is done by using same scaling factor as for embedding. Performance of method for different value of scaling factor is analyses & compare with 1& 2 levels DWT method by using statistical parameters such as peak-signal-to-noise-ratio (PSNR) and mean square error (MSE).*Keywords*: List four to six keywords which characterize the article.

Key word— Image watermarking, 3 level DWT, Alpha Blending, MSE, PSNR

1. Introduction

Due to the advancement of digital multimedia tools the storage and distribution of multimedia content is become very easy. Issues on security have emerged and there is a vital need for protecting the digital content against counterfeiting, piracy and malicious maniple.

Watermark--A visible or invisible signature embedded inside an image to show authenticity or proof of ownership. The hidden watermark should be inseparable from the host image, robust enough to resist any manipulations while preserving the image quality. Thus through watermarking, intellectual properties remains accessible while being permanently marked. This digital signature approaches use
in authenticating ownership claims and protecting proprietary hidden information, discourage unauthorized copying and distribution of images over the internet and ensure a digital picture has not been altered.

Watermarking adds the additional requirement of robustness. 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. So, watermarking is mainly prevent illegal copy or claims the ownership of digital media.[2]
There are four essential factors which make watermarking effective are:

Robustness: Watermark should difficult to remove or destroy. It is a measure of immunity of watermark against attempts to image modification and manipulation like compression, filtering, rotation, collision attacks, resizing, cropping etc.

Imperceptibility: quality of host image should not be destroyed by presence of watermark.

Capacity: It includes techniques that make it possible to embed majority of information.

Blind watermarking: Extraction of watermark from watermark image without original image

2. Theoretical Background

2.1. *General Model of Digital Watermarking*

Digital watermarking can be defined as the process of embedding a certain piece of information (technically known as watermark) into multimedia content including text documents, images, audio or video streams, such that the watermark can be detected or extracted later to make an assertion about the data A generalized watermark model consists of watermark encoding and detection processes as shown in Fig. 1 and Fig. 2. The inputs to the embedding process are the watermark, the cover object and a secret key. The key is used for security and to protect the watermark. The output of the watermarking scheme is the watermarked data.The output of the watermark recovery process is the recovered watermark [3].

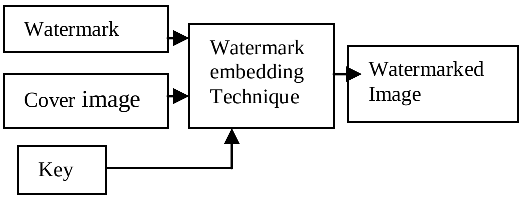

Fig.1 Watermark embedding.

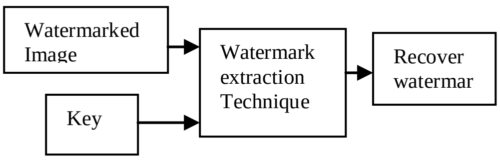

Fig. 2 Watermark detection

2.2. *Types of Digital Watermarking*

Digital image watermarking techniques can be grouped into two major classes: [4]

Spatial Domain Watermarking and Frequency Domain Watermarking.

Spatial domain (like LSB) and transform domain (like DCT, DWT) methods. spatial domain techniques which embed the data by directly modifying the pixel values of the original image Ex.- Least Significant bit (LSB) method. Transform Domain Method produce high quality watermarked image by first transforming the original image into the frequency domain by the use of Fourier Transform, Discrete Cosine Transform (DCT) or Discrete Wavelet transforms (DWT). The transform watermarking is comparatively much better than the spatial domain encoding.

Van et al. [5] proposed two LSB techniques. First replaces the LSB of the image with a pseudo-noise (PN) sequence, while the second adds a PN sequence to the LSB of the data. The problem with this paper is that data is highly sensitive to noise and is easily destroyed, image quality may be degraded by the watermark & watermark is not robust.

Blossom et al. [6] proposed a DCT based watermarking scheme which provides higher resistance to image processing attacks such as JPEG compression, noise, rotation, translation etc. In this approach, the watermark is embedded in the mid frequency band of the DCT blocks carrying low frequency components. Watermark is inserted by adjusting the DCT coefficients of the image and by using the private key. Watermark can then be extracted using the same private key Performance analysis shows that the watermark is robust

Nilanjan Dey [7] proposes a DWT based Steganographic technique. Cover image is decomposed into four sub bands using DWT. Encoded Secret image using spiral scanning is hidden by alpha blending technique in HH sub bands by alpha blending Technique. Encoded secret images are extracted to recover the original secret image. In this approach the generated stego image is imperceptible and security is high.

Gunjal[4] propose a digital Image Watermarking with DWT-DCT combined approach which can significantly improve PSNR with compared to only DCT based watermarking methods. DWT-DCT based Image watermarking improves PSNR compared to only DCT based watermarking.

Akhil et al. [8] proposed a robust image watermarking technique based on 1-level DWT (Discrete Wavelet Transform). This method embeds invisible watermark into the original image by using alpha blending technique. Experiment result shows that the embedding and extraction of watermark is depend only on the value of alpha.

Barni[9] proposed a new approach to mask the watermark according to the characteristics of the human visual system (HVS). In contrast to conventional methods operating in the wavelet domain, masking is accomplished pixel by pixel by taking into account the texture and the luminance content of all the image sub bands. The watermark consists of a pseudorandom sequence which is adaptively added to the largest detail bands. As usual, the watermark is detected by correlation. This method is robust to various attacks but complex than other transform.

Nikita jain [10] proposed a robust image watermarking technique based on 3-level DWT. This method embeds invisible watermark into the original image by using alpha blending technique. Experiment result shows that the embedding and extraction of watermark is depend only on the value of alpha.

2.3. *Application of Digital Watermarking*

There is a wide variety of applications for watermarking
1) Owner identification: It is similar to copyright protection to establish ownership of the content.
2)*Copy protection* : It prevent people from making illegal copies of Copyrighted content.
3) Content authentication: To detect modifications of the content, as a sign of invalid authentication.
4) Fingerprinting: to trace back illegal duplication and distribution of the content.
5) Broadcast monitoring: specifically for advertisements and in entertainment industries, to monitor content being broadcasted as contracted and by the authorized source.
6) Medical applications: use to provide both authentication and Confidentiality in a reversible manner without affecting the medical image in any way.[11]

3. Discrete Wavelet Transform (DWT)

Discrete Wavelet transform (DWT) is a mathematical tool for hierarchically decomposing an image. It gained widespread acceptance in signal processing, image compression & watermarking. It decomposes a signal into a set of basis functions, called wavelets. Wavelets are created by translations and dilations of a fixed function called mother wavelet.
Wavelet transform provides both frequency and spatial description of an image. Unlike conventional Fourier transform, temporal information is retained in this transformation process. Its multi-resolution analysis (MRA) analyzes the signal at different frequencies giving different resolutions. Discrete Wavelet Transformation is very suitable to identify the areas in the cover image where a secret image can be embedded effectively. This property allows the exploitation of the masking effect of the human visual system such that if a DWT co-efficient is modified, it modifies only the region corresponding to that coefficient. The embedding watermark in the lower frequency sub-bands may degrade the image as generally most of the Image energy is stored in these sub-bands. However it is more robust. The high frequency part contains information about the edge of the image so this frequency sub-bands are usually used for watermarking since the human eye is less sensitive to changes in edges so this frequency sub-bands.[7]
The DWT splits the signal into high and low frequency parts. The low frequency part contains coarse information of signal while high frequency part contains information about the edge components. The high frequency components are usually used for watermarking since the human eye is less sensitive to changes in edges [12].

In two dimensional applications, for each level of decomposition, we first perform the DWT in the vertical direction, followed by the DWT in the horizontal direction. After the first level of decomposition, there are 4 sub-bands: LL1, LH1, HL1, and HH1. For each successive level of decomposition, the LL sub band of the previous level is used as the input. To perform DWT on 2 level we perform DWT on LL1 & for 3Level decomposition we applied DWT on LL2 & finally we get 4 subband of 3 level that are LL3, LH3, HH3, HL3.

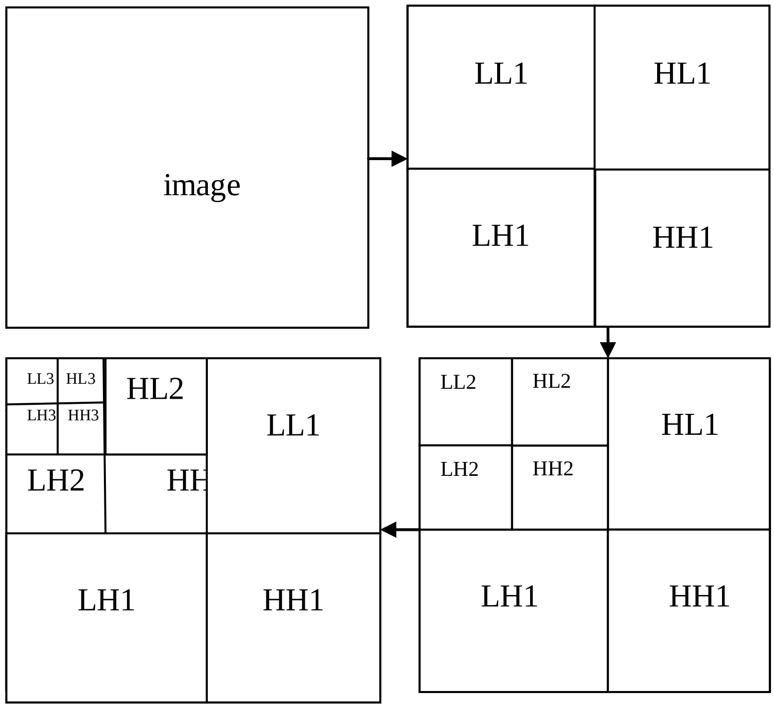

Fig 2 shows 3 level discrete wavelet decomposition

4. Proposed Technique

Digital image Watermarking consist of two process embedding & extraction.

4.1 Watermark Embedding

For this process firstly we apply 3 level DWT on host image decomposes the image into sub-images, 3 details and 1 approximation. The approximation looks just like the original. The same manner 3 level DWT is also applied to the watermark image .For this Haar wavelet is uesd. Then technique alpha blending [8, 12, 13] is used to insert the watermark in the host image. 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 low frequency approximation Component of the host image So it is perceptible in nature or visible.
Alpha blending**:** formula of the alpha blending the watermarked image is given by

WMI=k*(LL3) +q*(WM3)
WM3 = low frequency approximation of Watermark,
LL3 = low frequency approximation of the original image, WMI=Watermarked image, k, q-Scaling factors

After embedding the watermark Image on cover image Inverse DWT is applied to the watermarked image coefficient to generate the final secure watermarked image.

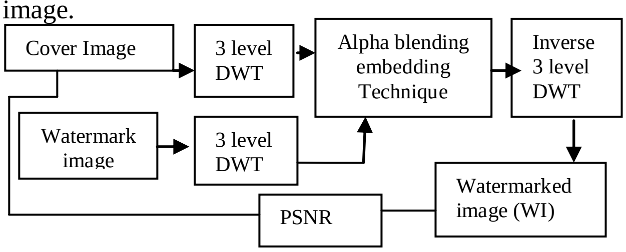

Fig.3 Watermark embedding process by 3 levels DWT.

4.2. Watermark Extraction

For this firstly we applied 3 level DWT to watermarked image and cover image which decomposed the image in sub-bands. After this we apply alpha blending on low frequency components.

Alpha blending: Formula of the alpha blending extraction for Recover watermark is given by

RW = (WMI - k*LL3) /q

RW= Low frequency approximation of Recovered watermark, LL3=Low frequency approximation of the original image, and WMI= Low frequency approximation of watermarked image.

After extraction process, Inverse discrete wavelet transform is applied to the watermark image coefficient to generate the final watermark extracted image. Fig. 4 shows the watermark extraction process.

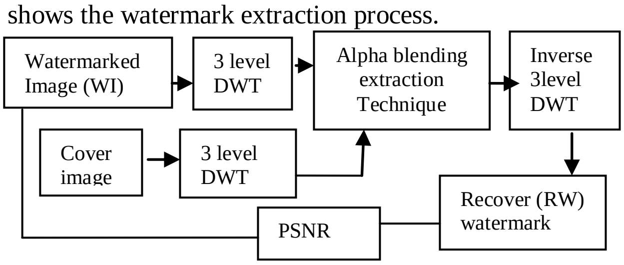

Fig. 4 watermark extraction process by 3 level DWT .

4. Experimental Result

To implement this technique we have used grayscale images of Lena as original image and the penguin's image as watermark. Both the images are of equal size of 256X256. Fig. 5(a) & 5(b) shows the original image and the watermark image. For embedding of watermark in the original image the Value of scaling factor k is varied from 0.2 to 2 by keeping q constant and best result is obtained for k=0.99 & q=0.009.

As the value of k is decreased further to 0.2 the watermarked image becomes darker and finally become invisible and when the value of K is further increase above 2 the value of PSNR are decreases & the value of MSE is increases. We can see the watermarked image using discrete wavelet transform for different value of k & q in fig 5 (a)-(e) and the value of PSNR & MSE in table I accordingly.

For the process of recovering of the watermark from the watermarked image the value of k and q are same as for embedding . In this Method we consider that the original image & value of k are known for extraction. Recovered image using 1, 2 and 3 level discrete wavelet transform are independent of scaling factor which are shown in fig 7 . Best result for watermarked image & recovered image is is obtained at k= 0.99 & q=0.009.


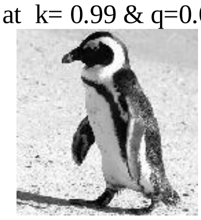

Fig 5 (a) Original image (b) watermark image

watermarked image using DWT for different value of k.

(a) k=0.2 q=0.009

(b) k=0.5 q=0.009

(c) k=0.99 q=0.009

(d) k=1.5 q=0.009

(e) k=2 q=0.009

Fig. 6 (a)-(d) watermarked images using DWT

Table I
PSNR & MSE for watermarked image

	q	PSNR	MSE	PSNR	MSE	PSNR	MSE	
0.2	**0.009**	**7.92**	**10506.29**	**7.97**	**10376.483**	**8.06**	**10167.720**	
0.5	**0.009**	**12.07**	**4032.757**	**12.13**	**3982.040**	**12.22**	**3900.448**	
0.75	**0.009**	**18.30**	**961.776**	**18.36**	**949.082**	**18.45**	**928.642**	
0.85	**0.009**	**23.01**	**324.854**	**23.08**	**320.270**	**23.18**	**312.882**	**BestResult**
0.99	**0.009**	**48.23**	**0.976**	**48.44**	**0.93123**	**48.78**	**0.860**	
1.25	**0.009**	**17.50**	**1157.003**	**17.55**	**1144.289**	**17.62**	**1123.906**	
1.5	**0.009**	**11.67**	**4423.212**	**11.72**	**4372.454**	**11.81**	**4290.97**	
2.0	**0.009**	**5.75**	**17292.82**	**5.80**	**17088.907**	**5.89**	**16763.99**	

Recovered watermark using 3 Level DWT

Fig. 7 Recovered watermark

Table II
PSNR & MSE for Recovered image

	1 level	2 level	3 level
PSNR	68.13 db	74.15 db	86.19
MSE	0.01000	0.00250	0.00016

6. Conclusion

A 3 level DWT based image watermarking technique has been implemented. This technique can embed the invisible watermark into the image using alpha blending technique which can be recover by extraction technique. Experiment results shows that the quality of the watermarked image are dependent only on the scaling factors k and q and the recovered watermark are independent of scaling factor. Results shows that the recovered images and the watermark are better for 3 level discrete wavelet transform then 1 & 2 level discrete wavelet transform. All the results obtained for the recovered images and the watermark are identical to the original images.

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