A Robust Image Watermarking based on LWT and Spread Spectrum

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ABSTRACT

In Today's time, internet technologies are growing with very higher pace. This advancement is solving problems very easily but also generating problems like include unauthorized reproduction of digital media. This problem has also raised the new challenge in front of the research community to give new techniques to protect unauthorized reproduction of digital media. The various techniques have developed for digital image watermarking which have better performance and proved to be much robust than the existing ones. In this paper, we have proposed a new robust technique for image watermarking based on LWT and spread spectrum. This technique mainly uses LWT domain which is efficient computation of DWT and spread spectrum technique. A comparison of this technique has also been shown with the existing techniques.

Keywords: DCT (Discrete cosine transform), DWT (Discrete wavelet transform), DFT (Discrete Fourier Transform), FFT (Fast Fourier transform), PSNR (Peak signal to noise ratio), LWT (Lifting Wavelet Transform)

1. INTRODUCTION

Unauthorized access of digital media creates numerous problems. For example, if we visit wallpaper sites, we survey that all the wallpapers are created by the owners, which are their Intellectual Property Right (IPR). Any user can access these wallpapers. Now, imagine that a user copy these images and paste those images (either after modifying or original) on his/her websites. Three different issues may arise in this situation **[12]**:

1) How wallpaper owners know that there are \more web servers posting their wallpapers?
2) If the owner knows this fact, whom shall he make a complaint?
3) The very much important issue is how the owner will prove his ownership on the wallpaper images posted on another server? **[12].**

The above raise problem can be solved by hiding some watermark data into the multimedia content, which can be recovered later to prove the ownership. Same idea is implemented in bank currency notes by embedded with the watermark, finally which are used to check the originality of the note. The similar "watermarking" concept used in multimedia digital contents for proving the authenticity of the original content **[12]**.

Recent developments in the JPEG compression standard have provided idea to various new digital image watermarking techniques. Most of these popular techniques based on Discrete Wavelet Transform (DWT) and Discrete Cosine Transform (DCT).

The majority of image watermarking schemes consider Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT) as the method of preference. It has been be found in [1]. That DWT can enhance robustness of the image watermark against various robustness attacks. The main reason is that the former JPEG standard based on DCT. With the advent of JPEG 2000 compression schemes based on DWT are getting popularity.

The spatial domain techniques have least complexity and high payload but they are not robust against low pass filtering and common image processing attacks. The mainly accepted watermarking schemes are LSB, DFT, DCT and DWT etc. **[6][7][8][9]**. LSB Technique cannot be considered as a good technique for digital image watermarking because of low robustness. Cox et. al **[1]** used DCT domain for watermark embedding for the first time. JPEG images also use DCT technique for image compression. So it's always a good idea to explore robustness of watermark in DCT domain. A more robust technique by using DCT is proposed in **[8], [11]** and **[12].**

To overcome the limitations in image watermarking due to various methods like LSB Substitution method and to make the system much robust against robustness attacks, the watermark can be spread across the cover image. This technique ensures the protection of watermark under various attacks due to watermark redundancy. Each of the data bits is replaced by using a large number of bits.

The spread spectrum technique poses that spreads the transmitted or the narrowband watermark over a wide range frequency band, this large bandwidth signal is also called spreading signal. Pseudorandom sequences or the 1 and 2 PN sequences are used as the spreading sequences.

LWT is used for digital image watermarking. It is a best alternative solution for DWT to transform image into frequency domain **[15]** for different real time applications.

It is the second generation fast wavelet transform. In this, dilation and translation are not fundamental for obtaining Lifting wavelets. In comparison with general wavelet transforms, reconstruction of image by lifting wavelet transform is good because, it increases smoothness and reduces aliasing effects [16]. Applying LWT reduces information loss, increases intactness of embedded watermark in the digital image and helps to improve the robustness of watermark

The proposed paper contains a **new robust technique for image watermarking based on LWT and spread spectrum**. This paper has been divided into seven sections. Section 2 describes the common DCT based watermarking technique. Section 3 gives the description of the DWT based approach for watermark insertion. Section 4 describes the proposed technique and Section 5 describes the results and discussion followed by the conclusion in Section 6.

3. DCT DOMAIN WATERMARKING

It is very difficult to propose good watermarking techniques in the spatial domain. We can advance robustness and quality of the watermark if we exploit the properties of the cover image. For example, it is usually preferable to embed watermarking information in noisy regions and edges of images, rather than in smoother regions **[12]**.

Discrete Cosine Transform is a most popular transform for image watermarking technique. The DCT allows an image to be split into different frequency bands which are higher, middle and lower frequency bands of image. This makes it easier to choose the band in which we want to embed the watermark. The literature survey found that mostly the middle frequency bands are used. It does not overexpose them to removal through compression based and noise based attacks where high frequency components are chosen **[8]**.

There are various DCT based image watermarking techniques. One of the important techniques utilizes the comparison of middle-band DCT coefficients to encode a single bit into a DCT block **[12]**.

F_M is the middle frequency band of the 8x8 DCT block, F_L is the lowest frequency band of the block, and F_H is the higher frequency band. F_M is chosen as the main embedding region as to provide mode resistance against lossy compression techniques, while avoiding important modification of the cover image **[12]**.

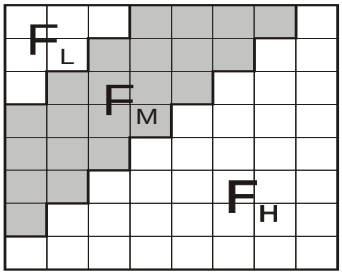

FIGURE 2.1 - DCT REGIONS [12]

The steps involved in any technique which is based on DCT **[12]** are as follows:

1) Divide the entire cover image into 8x8 block sized non-overlapping blocks.
2) Take the DCT of each block of sized 8x8.
3) Apply a block selection criteria based on the knowledge of HVS.
4) Use specific coefficient selection criteria for embedding watermark.
5) Embed the watermark by modifying the selected specific coefficients.
6) Take the inverse DCT of each block.

Almost all the algorithms for digital watermarking based on DCT are classified on the basis of step 3 and 4 i.e. the main differentiation between these algorithms is on the basis of block selection criteria or coefficient selection criteria **[12]**.

3. DWT DOMAIN WATERMARKING

Discrete wavelet domain is another capable domain for watermark embedding because of JPEG2000 compression. When DWT (Discrete Wavelet Transform) is applied to an image, It divide the image into four important components which are lower resolution approximation image (LL), horizontal (HL), vertical (LH) and diagonal (HH) detail components. This process of division can be iterated to compute multi-level discrete wavelet decomposition, as in the 2-level discrete wavelet transform shown below in figure 4.1.

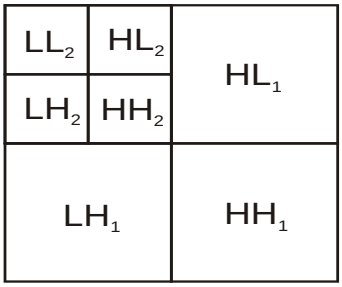

FIGURE 3.1 – 2-LEVEL DISCRETE WAVELET TRANSFORM [13]

One of the main advantages of the discrete wavelet transform is that it is thought to be most accurate model aspects of the HVS as compared to the FFT or DCT **[13]**. This technique allows using higher energy watermarks in HVS known less sensitive region, such as the high resolution detail bands {LH, HL, HH}. Robustness of watermark can be improved by embedding watermark in this region with no extra impact on image quality.

The wavelet based transform has recently gained popularity because of JPEG compression. However, DWT has been used in image watermarking most frequently due to its exceptional spatial localization and multi-resolution feature, which are similar to the theoretical model of HVS**[7][13]**. For improving performance in DWT based digital image watermarking techniques combining it with DCT. The idea is based on the fact that combined transforms could recompense for the drawbacks of each other, resulting in effective watermarking.

5. THE PROPOSED TECHNIQUE

This paper proposes a new image watermarking technique which is based on the LWT with spread spectrum based technique. In this approach, we have used LWT because of its advantages on DWT.

LWT is a good alternative solution for DWT to transform image into frequency transform for real time applications. Lifting wavelet transformation is the second generation fast wavelet transform. In lifting wavelet transformation, up sampling and down sampling is replaced simply by split and merge in each of the level. In comparison with other general wavelet transforms, reconstruction of image by lifting wavelet transform is good because, it enhance smoothness and reduces aliasing effects [13].Using LWT reduces loss in information, increases intactness of embedded watermark in the cover image and also helps to recover watermark.

The main feature of this algorithm is that we are using the advantages of LWT and spread spectrum technique of the image.

Steps of the Embedding algorithm are as follows:

1) Read the cover image, watermark image and key for watermarking.
2) Generate the PN- sequence based on key and watermark.
3) Take the LWT of the Cover image which decomposes the cover image into four components named as LL, HL, LH and HH. Here HL and LH coefficient is used for embedding.

LL	HL
LH	HH

FIG 4.1 SINGLE LEVEL LWT DECOMPOSITION

4) Now apply watermarking if message bit is 0. Add watermark in HL and LH coefficient.
5) Apply inverse LWT.

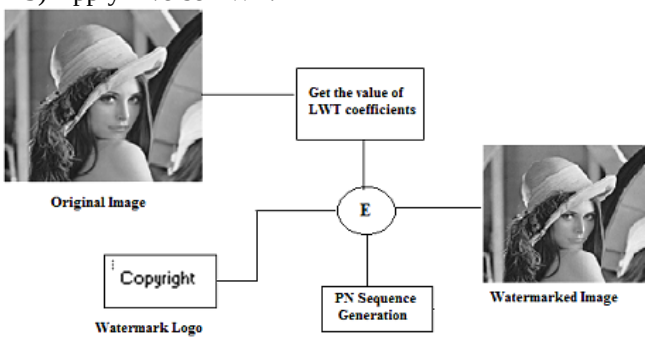

FIG 4.2 WATERMARK EMBEDDING

Steps of the extraction are as follows:

1) Read the cover image, watermark image and key for watermarking.
2) Generate the PN- sequence based on key and watermark.
3) Take the LWT of the Cover image which decomposes the cover image into four components named as LL, HL, LH and HH. Here HL and LH coefficient is used for embedding.
4) Apply correlation between PN-sequence and horizontal and vertical components. Recover the embedded watermark bit based on it.
5) Extract the watermark.

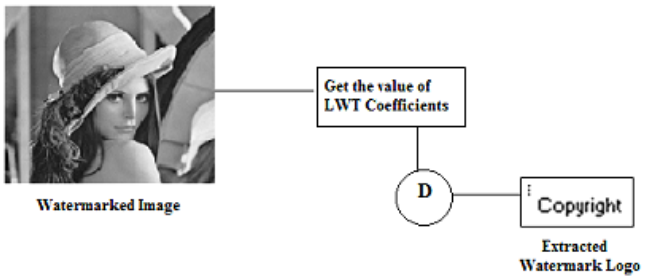

FIG 4.3 WATERMARK EXTRACTION

5. RESULTS & DISCUSSION

We have performed simulations on Cover image using Matlab 7.0. Cover image and the watermark image both are in .jpeg format. The watermark is embedded into the cover image and several attacks like Scaling, Blurring,

S.No.	Technique	Attack on watermarked image	PSNR	Correlation (b/w Watermarked & original image)	Correlation (b/w Recovered & original watermark)	Bit Error Rate
1	DWT Domain	Without any attack	729	0.9850	0.8281	0.0080
		De-Blurred			0.7128	0.0300
		Scaled to half size			0.0002	0.5050
		Scaling to 75% of original size			0.7232	0.0090
		Resizing of scaled image			0.3243	0.3190
		Rotation of 5 degrees and rotated back			0.0032	0.5010
		Cropping			-0.0214	0.5060
		Noise (Salt and Pepper)			0.0008	0.4200
2	LWT Domain	Without any attack	575	0.9750	0.9895	0.0020
		De-Blurred			0.9596	0.0080
		Scaled to half size			-0.0235	0.5080
		Scaling to 75% of original size			0.9895	0.0020
		Resizing of scaled image			0.4221	0.2920
		Rotation of 5 degrees and rotated back			0.3623	0.3600
		Cropping			-0.0245	0.3170
		Noise (Salt and Pepper)			0.6704	0.1020

TABLE 5.1- COMPARISON OF TECHNIQUES

Rotation, Cropping etc has been performed on the resulting Watermarked Image. After that, the watermark is retrieved using the extraction process. Then the robustness of the technique is compared with available well known techniques on the basis of parameters like time required for Embedding and Extraction, PSNR, BER, Correlation between the original watermark and the Extracted watermark which are shown in the above table 6.1. On the basis of this comparison, we can conclude that the proposed technique has proved to be fairly robust against common image processing attacks.

6. CONCLUSION

The proposed technique for digital image watermarking has shown robustness and it has a very small effect on the image quality too. There is still much scope for improvement while working on image watermarking. Still there are some attacks like rotation on which all the proposed watermarking algorithm or methods shows approximately no reluctance.

S.No.	Technique	Attack on watermarked image	Robustness Level
1	DWT Domain	Without any attack	High
		De-Blurred	Medium
		Scaled to half size	Low
		Scaling to 75% of original size	High
		Resizing of scaled image	Low
		Rotation of 5 degrees and rotated back	Low
		Cropping	Low
		Noise (Salt and Pepper)	Low
2	LWT Domain	Without any attack	High
		De-Blurred	High
		Scaled to half size	Low
		Scaling to 75% of original size	High
		Resizing of scaled image	Medium
		Rotation of 5 degrees and rotated back	Low
		Cropping	Low
		Noise (Salt and Pepper)	High

TABLE 6.1 – CONCLUSION TABLE

The Conclusion table (Table 6.1) on the basis of comparison of the proposed technique with existing techniques is shown above.

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