Image Watermarking Using Wavelet Transform

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Abstract
This paper is an effort to watermark an image into other image usi ng different levels of discrete wavelet transform approach. The wa termark image can act as security to encode the original image. In this original image and watermarked images are transformed into 3 level discrete wavelet transform. Then images are hided into det ailed coefficient of wavelet transform. The image quality of these images are measured in terms of mean square error and peak sign al to noise ratio. Based on these experiment it is clear that three le vel discrete wavelet transform gives better performance.

Keywords:
Image Watermarking; Discrete Wavelet Transform; Mean Square Error; Peak Signal to Noise Ratio.

1. Introduction

With increasing demand of digital media images, vi deo, and audio can be easily modified and altered over the i nternet without major loss. In order to prevent them digital watermarking can give effective approach. In this digital w atermark embeds in a small amount and further it can be ex tracted latter for verification. The watermark technique sho uld be invisible, difficult to remove, and should be robust. The overview on watermarking can be found. Watermarkin g techniques are classified into classified into two category (1) Spatial Domain watermarking and (2) Transform Doma in watermarking. Spatial domain techniques works on pixe l by pixel approach. The simplest spatial domain technique is Least Significant Bit (LSB). Although this technique is n ot very secure and not robust to image compression and oth er signal processing attacks. To improve robustness of spati al domain techniques block based watermarking techniques were used instead of pixel based watermarking. In transfor m domain watermarking techniques the host image is first converted into the new domain by various transformation methods like, Discrete Cosine Transform (DCT) or Discret e Wavelet Transform(DWT) provides higher image imperc eptibility and are more robust to image manipulations. How ever DWT has been used in digital image watermarking alg orithm more frequently due to its excellent spatial localizati on and multi resolution characteristics which are similar to the theoretical models of human visual system (HVS). Furt her performance evaluation improvement in DWT- based d igital image watermarking algorithm could be obtained by combining DWT with DCT. The main idea of applying two transforms could compensate for the drawbacks of each ot her to obtain effective watermarking approach. Fotopoulos and Skodras decompose the original image into four sub ba nds using Haar wavelet, and then perform DCT on each of t he bands and the watermark bit is embedded into the DCT coefficients of each band. Emek &Pazarci compared image dependent and additive blind watermarking algorithm that embed a watermark in the DWT-DCT domain by taking th e properties of the HVS into account.

Ali Al-Haj described a combined DWT-DCT digital image watermark in the first and second level of DWT coe fficient sets of the host image, followed by the application of DCT on selected DWT coefficient sets. However robust ness of common DWT and DCT transform method is incre ased by previous hybrid method despite their robustness ag ainst noise and cropping attack is not acceptable. In order t o solve this problem an image watermarking algorithm bas ed on jointly DWT-DCT method in proposed by Amirgholi pour and Nilchi. In this method, watermarking is done by al tering the wavelet coefficients of middle frequency coeffici ent sets of 3-level DWT transformed host image followed b y the application of the DCT transform on the selected coef ficient sets. The difference between above mentioned meth od and proposed method is in the selection of sub band and selection of bits for hiding watermark bit.

Amirgholipour and Nilchi has used all the HLx and LHx frequency sub-band in the middle frequency coefficie nts sets in 3-levels DWT transformed image. In proposed al gorithm all HH frequency sub-band is used in the middle fr equency coefficient sets of 3-level Haar-DWT transformed image. This method proposes a Haar discrete transformatio n (HDWT) based robust data hiding method that first transf orms a spatial domain image into frequency domain images and then utilizes the high frequency coefficient to hide the secret data. In general, most high frequency coefficients are good in case of various types of attacks like noises and co mpressions. Recently Geetanjali has done a comparative st udy of DWT and Singular Value Decomposition technique s. Rest of paper organized as section II represents detailed methodology, in section III describes experimental results a nd finally section IV concludes the paper.

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2. Methodology Used

A. Embedding Algorithm

For this process firstly we apply 3 level DWT on ho st image decomposes the image into sub-images, 3 details a nd 1 approximation. The approximation looks just like the original. The same manner 3 level DWT is also applied to t he watermark image .For this Haar, Symlet, Coiflet, etc wa velet is used. The embedding techniques are shown in Figu re 1.

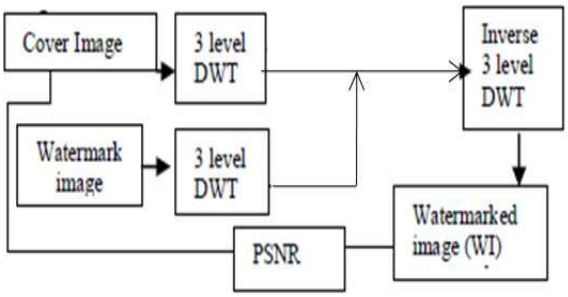


Figure 1 Watermark embedding algorithm

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

B. Watermark Extraction

For this firstly we applied 3 level DWT to watermar ked image and cover image which decomposed the image i n sub-bands. After extraction process, Inverse discrete wav elet transform is applied to the watermark image coefficient to generate the final watermark extracted image. Figure 2 s hows the watermark extraction process.

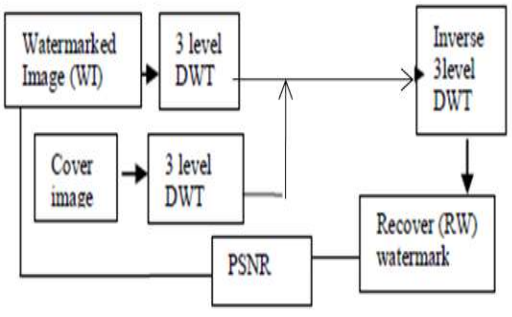


Figure 2 Watermark extraction process.

The wavelet transform of an image is shown in Figure 3 at level 1 and 2.

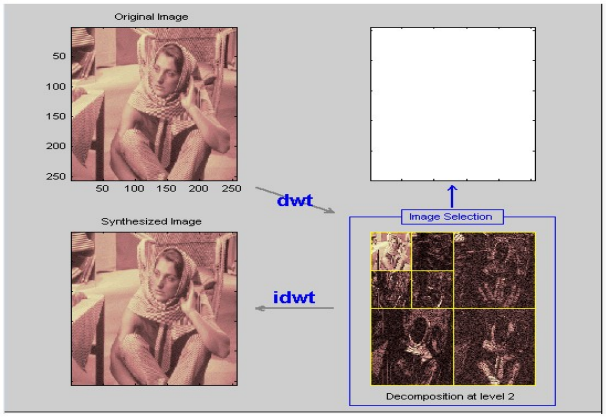


Figure 3 Wavelet transform of an image at level 1 and 2.

The 3-level DWT is shown in Figure 4 which has been use d in this paper.

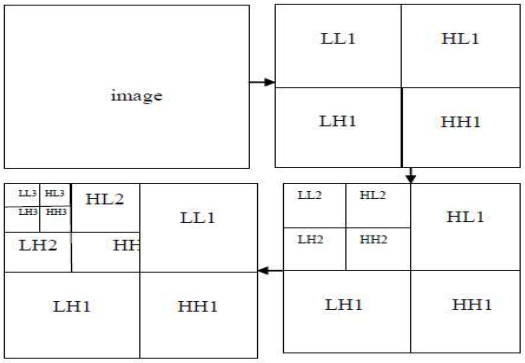


Figure 4 DWT transform at level 3.

C. Image Quality Measurement

Throughout this thesis, image quality has been meas ured with Mean Square Error (MSE) and used Peak Signal to Noise Ratio (PSNR) of the images.

1) Signal to Noise Ratio

It is most easily defined via the Mean Squared Error (MSE). For two m×n monochrome images I (x, y) and K (x, y), wh ere one of the images is considered a noisy approximation of the other, MSE is defined as:

$$MSE = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}\left[y(i,j) - x(i,j)\right]^2$$

2) **PEAK SIGNAL TO NOISE RATIO**

The phrase Peak Signal to Noise Ratio, often abbre viated PSNR, is an engineering term for the ratio between t he maximum possible power of a signal and the power of c orrupting noise that affects the fidelity of its representation. Because many signals have a very wide dynamic range, PS NR is usually expressed in terms of the logarithmic decibel scale.

The PSNR is most commonly used as a measure of quality of reconstruction in image compression etc. A high er PSNR value indicates that the watermarked image closel y resembles the original image. Generally, if PSNR value g reater than 35 dB the watermark image is within acceptable degradation level that is the watermark is invisible to huma n visual system.

3. Experimental Result

The experiment is performed in MATLAB 2015 usi ng these toolboxes and programming. The performance of t hese techniques are compared with various images. For test ing a standard images are used like Baboon.jpg, Lena.jpg, Pepper.jpg, Fruit.jpg, and dog.jpg. The original and water mark images are first converted into grey level images as s hown in Figure 5.

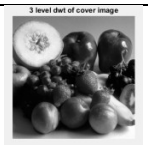
Figure 5 Grey scale conversion of Original Image and watermar k image

The wavelet decomposition of level 1, 2 and 3 are shown in Figure 6.

Figure 6 Image decomposition at level 1, 2, and 3.

The result obtained by applying this techniques are shown in Table 1 with input image, watermarked image, lo go image and their extracted image.

Table 1 Results of Watermarking extraction algorithm.

Sl. No.	Input Image	Watermarked Image	Logo Imag e	Extracted
Baboon.jpg				
Lena.jpg				
Pepper.jpg				
Fruit.jpg				

The quality of images obtained are shown in Table 2.

Table 2 Image quality

	MSE_Embed	PSNR_Embed	MSE_EXTRACT	PSNR_EXTRACT
Baboon	7.97E-09	182.4173	50.98	2.648
Lena	7.97E-09	183.3319	50.9813	2.648
Pepper	7.97E-09	184.6488	50.9813	2.648
Fruit	7.97E-09	186.7074	50.9813	2.648

4. Conclusion

Digital image watermarking is a hard problem that has not been fully solved despite a heavy industrial demand. However, the researchers have identified some useful tools that will be invaluable in the construction of industry-grade image watermarking software. One such tool is the Discrete Wavelet Transform. This thesis presented and analyzed image watermarking schemes that operate in the DWT domain. This technique is based on embedding copyright information directly into the digital content in such a way that it always remains present. The research presented in this thesis is the development of a new digital image watermarking algorithm based on multiwavelet transform for copyright protection application.

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