Biorthogonal Wavelet Transform Digital Image Watermarking

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Abstract

With the growing popularity of Digital Medias through the World Wide Web, intellectual property needs copyright protection, prevention of illegal copying and verification of content integrity. The new data hiding techniques need to be developed that satisfy the requirements of Imperceptibility, Robustness, Capacity, or data hiding rate and Security of the hidden data etc. Watermarking has been utilized by researchers for the security of digital documents. In this paper we proposed a method which is an efficient scheme for protecting the copyrights of digital images with the aid of both biometrics and digital watermarking. Newer data hiding techniques that satisfy the requirements of imperceptibility, robustness, capacities, or data hiding rate and security of the hidden data etc., are being developed. Therefore the preference to go for digital image watermarking, to show resiliency against various unintentional or deliberate attacks has increased. In this paper implementation of two different watermarking algorithms in the frequency domain will be presented. The first algorithm is based on the Discrete Wavelet Transform (DWT), the second one is based on the Bi-orthogonal Wavelet Transform (BWT). Embedding the watermark is done by modifying the coefficients of the middle frequency band within region of non-interest (RONI) so that the visibility of the image and diagnosis capability will not be affected and the watermark will not be removed by attacks. All schemes are tested using medical images and the simulation results are compared and the comparison shows that the best scheme is that based on using BWT.

Keywords

Copyright, DCT, DWT, BWT, Attacks

1. Introduction

The task for this project has been to investigate the field of image watermarking. The major part of this project will be about a new method proposed for digital watermarking that utilizes Biorthogonal Wavelet Transforms to embed and extract the watermark. This method seems ideal, in that it promises to embed watermarks that cannot be detected by the eye, and being able to extract the watermarks from images exposed to severe alterations. The Biorthogonal wavelet transform is an invertible transform. The property of perfect reconstruction and symmetric wavelet functions exist in biorthogonal wavelets because they have two sets of low pass filters (for reconstruction), and high pass filters (for decomposition). One set is the dual of the other. Digital watermarking is a technique for inserting information into a digital media. The embedding-insertion is made in such a way that it must not cause serious degradation to the original digital media. Embedding must be done either in spatial or frequency domain. Frequency Domain Methods are the most popular in comparison with Spatial Domain Methods because when an image is inverse transformed, watermark is distributed irregularly over the image. Recently, for transforming images into frequency domain, Fourier transform, discrete cosine transform, wavelet transform etc are used. The methods in frequency domain, especially discrete cosine transform DCT, are more popular as the human visual system (HVS) features can be incorporated more effectively in watermarking especially when dealing with the transform domain.

The energy of the embedded signal in the transform domain will be spread over all pixels in the spatial domain. This is advantageous to invisibility. They can be implemented in compressed domain since most international image and video compression standards such as JPEG and MPEG are DCT Based. In this paper, a robust watermarking scheme is proposed for copyright protection using BWT. For embedding, host image is decomposed into four frequency sub-bands (LL, HL, LH, and HH) using BWT and watermark is embedded in to mid frequency range HL or LH Sub-band.

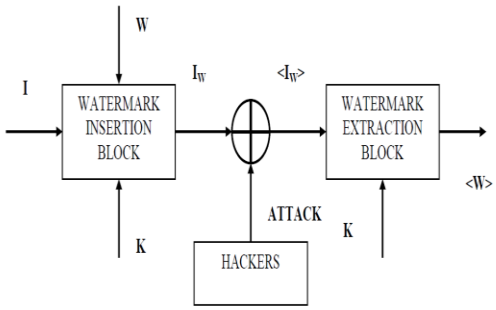


Fig.1: Generalized Model for a Watermarking System

2. The Discrete Wavelet Transform (DWT)

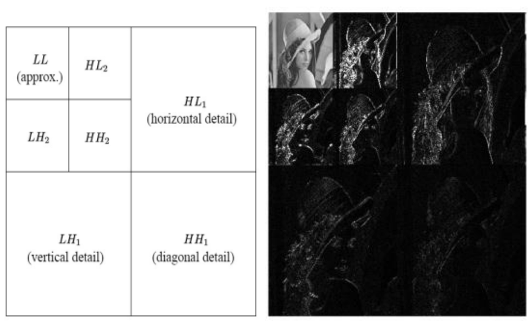
Two-Dimensional wavelet transform DWT performs a single-level decomposition and computes the approximation coefficients matrix and details coefficients matrices based on wavelet decomposition filters specified (low-pass filter or high-pass filter).

$\mathbf{\Phi(x) = \sum h_{\Phi}(n)\sqrt{2}\,\Phi(2x\text{-}n)}$

$\mathbf{\Psi(x) = \sum h_{\psi}(n)\sqrt{2}\,\psi(2x\text{-}n)}$

h_{Φ} – Scaling Coefficients

h_{ψ} – wavelet coefficients



2.(a): Decomposition Structure (b) Decomposed Image

2. Bi-Orthogonal Wavelet Transform

The scaling equations on the scaling functions and wavelets show that the decomposition and reconstruction of a signal from a resolution to the next one is implemented by perfect reconstruction filter banks.

$a_1[n] = a_0 * h_1[2n]$

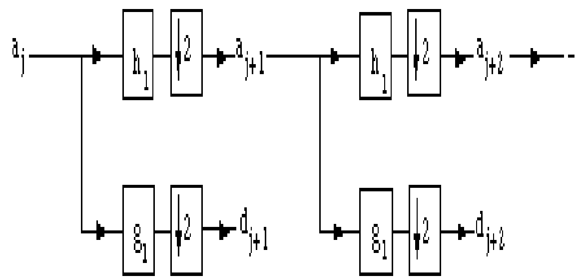
And

$d_1[n] = a_0 * g_1[2n]$.

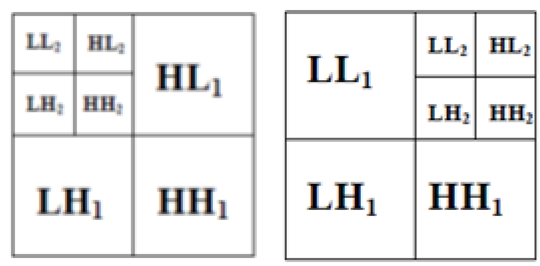
With

$h_1[n] = h[-n]$ and

$g_1[n] = g[-n]$.



In practice this recursion is initialized by considering that the discrete signal samples are some fine resolution coefficients.



3. (a): First Level decomposition (b) Second Level Decomposition

In second level decomposition L represents the approximation sub-band, HL represents the horizontal sub-band, LH represents the vertical, and HH represents diagonal sub-band.

3. Proposed Algorithm

The watermark embedding process of the proposed algorithm using BWT can be explained in seven steps

1. The intensity values of original image or Host image which is Nuclear Medicine image of size 256X256 (MXN) are obtained into matrix I.
2. DWT is applied to host image (I_{MXN}) to obtain LL low frequency sub band and three LH, HL and HH high frequency sub bands of the host image.
3. The gray level values of watermark image to be hidden are obtained into the matrix W'_{mxn} of size 64x64 (mxn).
4. The watermark is scaled with the scaling factor ‘k’. The value of scaling factor is decided by the content of watermark and the

Host image which gives a tradeoff between watermark strength and visible distortion.

5. The intensity values of scaled watermark are placed into the mid frequency sub band of the Host image i.e. HL sub band of host image is replaced with W'_{mxn} (64x64). These four sub bands LL, LH of Host image, W'_{mxn} the watermark and HH of host image are nothing but the transform domain image of watermarked image.
6. Inverse DWT is applied to these sub bands LL, LH, W'_{mxn} and HH to obtain the Watermarked image.

(b) Watermark Extraction Process

In order to recover the watermark, reverse process of embedding process is applied. The BWT decomposes the watermarked image into single Low and three High frequency sub bands where in the watermark intensity values are the one of the LH, HL and HH sub band of the watermarked image. The sub band where the watermark is embedded is to be divided with the scaling factor 'k' to obtain the watermark.

Watermark embedding using BWT:

1. Apply DWT to cover image
2. Embed the watermark image into the HL components of the cover image
3. Inverse-DWT is applied to get the watermarked image.

Watermark extraction using BWT:

a. Apply DWT to watermarked image.
b. Obtain mid frequency coefficients (HL) of watermarked image. Apply inverse DWT to obtain watermark extraction.

4. Experimental Results

Our proposed technique performed better than the other wavelet-based techniques. This is due to some reasons. First of all, the type of wavelet we use in our technique is the biorthogonal wavelet transform, which involves certain properties like the perfect reconstruction and the linear phase properties. So, our technique produces more accurate results in most cases. Another reason is that we use a different way in embedding. In the embedding process involves adding two PN sequences in the wavelet decomposed coefficients. Whereas, in our technique we embed only one PN sequence. Therefore, the technique in results in much more artifacts in the watermarked image than in our technique. Moreover, both techniques differ in the way they decompose the host image. Our technique decomposes the image as shown in Fig 3. (a), whereas the method in decomposes the image as in Fig3.(b). The proposed algorithm is implemented and tested with Brain scan image for invisibility and robustness the results are shown in Figures 1, 2, 3 and 4. To measure image distortion, Peak Signal to Noise Ratio (PSNR) which is the most popular distortion measures in the field of image and video coding is used. It is usually measured in decibels. The PSNR is given by:

$$PSNR(Iorg, Iw) = 10 * log\left(\frac{255^2}{MSE(Iorg, Iw)}\right)$$

Where MSE is mean square error between the original image (I_{org}) and the watermarked one (I_w). The MSE is defined as:

$$MSE(Iorg, Iw) = \frac{1}{N * N}\sum_{i=0}^{N-1}\sum_{J=0}^{N-1}(Iorg(i,j) - Iw(i,j))^2$$

Where N is image dimensions.

MSE is taken as average MSE of the three channels in RGB image. The results are compared with DCT-SVD algorithm. Two wavelets are introduced in Biorthogonal wavelets. One, ϕ, is used in the analysis, and the other, ψ, is used for synthesis as they appear in (1) and (2) respectively.

$C_{j,k} = \int S(x)\varphi_{q,j}(x)dx$

$S = \sum_{j,k} C_{j,k} \Psi_{j,k}$

Digital Image Watermarking Using Localized Biorthogonal Wavelets, where s is a signal, and j,k are integers. Experimental analysis is carried out using various host and watermark gray scale images. It is observed that proposed BWT method is more robust in comparison with DWT. The results of proposed algorithm for host or original image 'Nuclear Tele-Medicine image' of size 256X256 as shown in Figure:(a) and patient information as watermark image of size 64X64 as shown in Figure:(c) are shown. After embedding the watermark into host image watermarked image is obtained as shown in Figure: (b) and the extracted watermark is as shown in Figure: (d) which is nearly similar to watermark embedded. The results for Peak signal to Noise Ratio (PSNR) are tabulated for various attacks as shown in Table1.

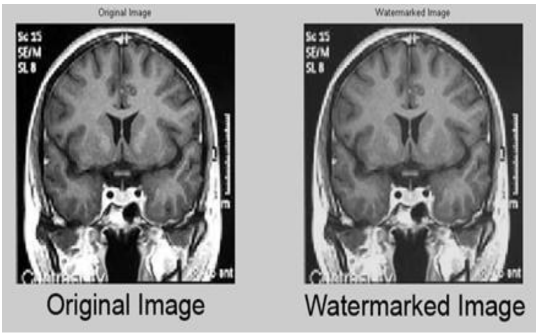


Figure 4(a): Original image (b) watermarked image

Figure 4(c): Used Watermark (d) Retrieved Watermark

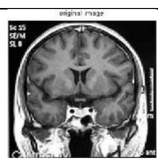
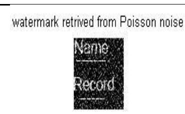
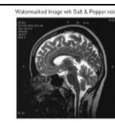
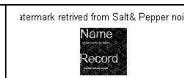
Attack	**Watermarked Image**	**Retrieved Watermark**
No attack		
Gaussian		
Speckle		
Poisson		
Salt and pepper		

Table 1: PSNR values from proposed method.

ATTACK	**Proposed BWT Method**	**DWT Method**	**DCT Method**	**Improvement**
	PSNR	PSNR	PSNR	PSNR
No Attack	40.9068	32.9070	23.2319	7.9998
Gaussian	29.2598	22.3281	19.8146	6.9317
Cropping	24.6328	20.1285	19.3681	4.5043
Salt & pepper	30.2598	24.6219	20.8318	5.6379
Poisson	31.2733	28.1344	19.3452	3.1389
Rotation	26.3265	21.3658	19.8965	4.9607
Speckle	31.7884	31.7840	18.3481	0.0044

5. Conclusion

Wavelet based algorithms can be implemented in signal processing, image processing and other applications. Its algorithm is simple but robust to the attacks. Transferred nuclear medicine images can suffer from malicious attacks so an image watermarking is needed like DWT to protect these images against attacks. Compared to conventional algorithms like Discrete cosine Transform DCT, Singular Value Decomposition SVD, The Discrete Wavelet Transform DWT can be used where the PSNR and MSE can be improved an another version of DWT called Biorthogonal Wavelet Transform is proposed by which PSNR is drastically improved as shown in table 1 Nuclear medicine is emerging branch of science becoming a desired method because of its features like less expensive, more information provided by the images like depth of resolution, clarity so yields more precise information than exploratory surgery.

Using Tele-nuclear medicine can enable increased availability of nuclear medicine in underserved areas which will enhance health care. There is tradeoff between PSNR and CORR. The experimental results and comparison with existing schemes clearly demonstrates the performance of watermarking scheme is improved using BWT in terms of imperceptibility and robustness against different kind of attacks. In this study, we have proposed a novel watermarking technique using Biorthogonal wavelets (BWT). The technique is highly robust against numerous non-geometric attacks such as additive noise, median filtering, and compression. The watermark is extracted fairly accurately even if the watermarked images are almost destroyed.

From the above results you can conclude that we have greatly improved the peak signal to noise ratio by using our proposed transform when compared to all other transforms like DCT, DWT etc. The Table 1 shows the comparisons between the different transforms and our proposed transform when an image is affected from different noises. Modifications to an original work that clearly are noticeable commonly are not referred to as watermarks. But in our work these modifications are purely invisible. Future work concentrates on improving the technique robustness to withstand geometric attacks such as cropping and rotation. A newer version of BCT namely Distributed Multiresolution Biorthogonal Wavelet transform (D-MR-BCT) is proposed, which is localized in both time and frequency domain. On the basis of D-MR-BCT, a robust watermarking scheme is proposed in which it exploit the advantages of DWT, which make proposed scheme robust enough and superior than DWT and DWT-SVD methods. With no change in the system configuration or software, the present methodology can be integrated with spatial domain technique to watermark other types of patient data such as EEG, PCG etc. A newer version of BWT namely Distributed Multiresolution Biorthogonal Wavelet transform (D-MR-BWT) is proposed, which is localized in both time and frequency domain. On the basis of D-MR-BWT, a robust watermarking scheme is proposed in which it exploit the advantages of DWT, which make proposed scheme robust enough and superior than DWT and DWT-SVD methods. Future work concentrates on improving the technique robustness to withstand geometric attacks such as cropping and rotation.

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