Comparison of LSB and Subband DCT Technique for Image Watermarking

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Abstract
Digital Image watermarking is the process of hiding the digital data in the Image. It is used to protect the content of Image by insertion of digital mark into the Image. In this paper Least Significant Bit (LSB) based spatial domain technique and Sub band Discrete Cosine Transform (DCT) domain techniques are compared. Sub band DCT domain algorithm is more robust and secure as compared to LSB based technique.

Keywords: Watermarking, LSB, DCT, PSNR, MSE, NC.

1. Introduction

In the recent trend, Internet is widely used for communication from one end to another end. Due to Internet used worldwide the communication became faster. Everyone use Internet to communicate from one end to another end in the world. However, there is also increased the ways to hack the information from the Internet. This data can be slightly modified by unauthorised person and published over the internet without the permission of true owner. A major issue of digital multimedia data exchange over the internet is data authentication. Image attacks either intentional or unintentional try to remove ownership information (such as logo) [13]. So, to withstand against such type of attacks Digital watermarking is used. Digital Image watermarking is process of embedding digital mark or logo into the Image. A watermark can be perceived as an attribute of the carrier (cover). It may contain information such as copyright, license, tracking and authorship etc [1]. This digital data can be embedded into the Image using spatial domain algorithm or Transform domain algorithm [8]. In the spatial domain the watermark is embedded in the pixel domain. The watermark is embedded by manipulation of pixels of the original Image. Most Significant bits (MSB's) of any Image contain most of the information of Image [2]. Due to Least Significant Bits (LSB's) contain less information it can be replaced by watermark bits. By replacing the watermark bits the Original image is not distorted but it looks like original Image [7]. In the Transform domain methods the watermark is embedded by changing the frequency coefficient of the Original Image. The Image can be transform into frequency domain by using Discrete Cosine transform (DCT), Discrete Fourier transform (DFT) or Discrete Wavelet transform. In spectral domain low frequency contain most of the information of the Image while high frequency contains least Information like lines, curves etc [3], [4], [16]. For compression of Images most of the compression techniques neglects high frequency. So, watermark cannot be embedded into high frequency coefficients. Also, embedding the watermark into low frequency coefficients, it creates visible defects in the original Image. So, middle frequency coefficients are the best choice for watermark embedding [5], [9] [12]. Figure 1 shows the simple watermarking process in which the watermark is embedded by using spatial/transforms domain technique. Each watermarking application has its own requirements, but all watermarking methods must have certain properties like transparency, robustness, capacity, persistence, unobtrusiveness and security [14], [15]. Darshana Mistry [2] has compared watermarking methods. In this paper, the comparisons of watermarking methods in perspective of some key parameters like PSNR, MSE and NC. This paper is organised as follow. Section II describes two algorithms Least Significant Bit proposed by Puneet Kr Sharma and Rajni [6] and sub band DCT domain algorithm proposed by ZHAO Rui-mei et al [11]. Section III represents simulation results. Section IV represents comparison of spatial and transform domain. Section V represents Conclusion and Future work.

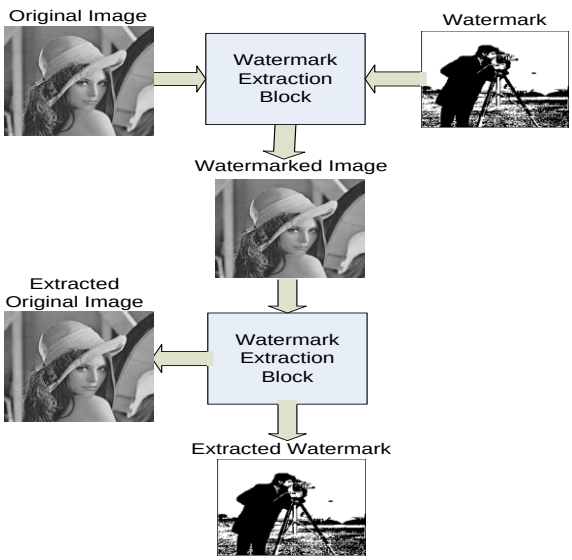


Figure 1 Generalised Process of Watermarking

2. Algorithms

Image watermarking is simply hiding the digital information into Image. In this section two algorithms are discussed proposed by P. Kr Sharma and Rajni [6] and Z. Rui-mei, L. Hua, P. Hua-wei, H. Bo-ning [11].

2.1 Least Significant Bit Algorithm:

The proposed algorithm by P. Kr Sharma and Rajni [6] is based on the LSB substitution by the watermark bits in the Cover Image. In this algorithm the watermark is embedded by changing the pixel values of the original Image (Cover Image) according to the watermark bit is one or zero. For this the Least Significant Bit of the Original Image is replace with the watermarking bit. Despite its simplicity for implementation the drawback of this method is that any addition of noise or lossy compression likely to defeat the watermark completely. The steps for proposed algorithm are as following:

Step 1: Convert Cover Image from RGB to Gray-scale Image.

Step 2: Find out size of the Cover Image and Watermark.

Step 3: In the first pixel of cover Image, replace LSB of the Cover Image with the MSB of first pixel of the watermark.

Step 4: Repeat step 3 until all watermark bits are embedded in the Cover Image.

2.2. Subband DCT Domain Algorithm:

Z. Rui-mei, L. Hua, P. Hua-wei, H. Bo-ning [11] proposed a subband DCT based blind watermarking algorithm in which watermark is embedded in the AC coefficients of the each block. The proposed algorithm is robust against some digital image attacks, like JPEG compression, noise, filtering and shearing. They were embedded 2-bit watermark image but I simulated this algorithm by using binary watermark. The watermarking steps of the proposed algorithm by ZHAO Rui-mei, LIAN Hua, PANG Hua-wei, HU Bo-ning are as following:

Watermark Embedding:

Step 1: The 2-bit watermark image W is transformed into W' by using Arnold transform. The W' is scanned on-line and then transformed into one-dimensional sequence A of size LxL; where, L is the size of W. The Arnold transform is given by

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ 1 & 2 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} (mod\ L) \qquad (1)$$

where x and y are pixel coordinates of the W and x' and y' are pixel coordinates after Arnold Transform.

Step 2: The original Image (Cover Image) is divided into 8x8 blocks and each block is transformed into DCT coefficients.

Step 3: The DCT coefficients are scanned by means of Zig-Zag and the one dimensional sequence $Z_i(m)$ ($m = 1,2,\ldots,64$) is getted. AV of all $Z_i(m)$ is calculated which is given by

$$AV = \frac{\sum_{i=1}^{L\times L} |Z_i(m)|}{L \times L} \qquad (2)$$

Step 4: The sequence A embeds in $Z_i(m)$ of each block by the following formula

$$Z_i(m) = \begin{cases} -|AV - \Delta| & a_i = 1\ and\ Z_i(m) > 0 \\ -|AV + \Delta| & a_i = 1\ and\ Z_i(m) < 0 \\ |AV + \Delta| & a_i = 0\ and\ Z_i(m) > 0 \\ |AV - \Delta| & a_i = 0\ and\ Z_i(m) < 0 \end{cases} \qquad (3)$$

where, $\Delta = \big||Z_i(m)| - AV\big|/10$.

Step 5: The Watermark image I' is achived after each block is transformed into IDCT data.

Watermark Extraction:

Step 1: The watermarked Image I' is divided into 8x8 blocks and each block is transformed into DCT coefficients. The DCT coefficients are scan by means of Zig-Zag. A one dimentional sequence B ($B = \{b_i\}, i = 1,2,\ldots L \times L.$) is getted. The value of b_i is given by

$$b_i = \begin{cases} 1 & Z_{i(m)} > 0 \\ 0 & Z_{i(m)} < 0 \end{cases} \qquad (7)$$

Step 2: The one-dimensional sequence *B* is recognized into two-dimensional image watermark *W'*.

Step 3: The image watermark *W'* is obtained by inverse Arnold transform.

3. Simulation Results

In this section, we simulate Two methods using Matlab and compare both methods by calculating the Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR) and Normalised Crosscorrelation (NC) parameters. The MSE and PSNR are two error matrix used to compare Image quality. This ratio is often used to measure the quality between original Image and watermarked Image. The lower the value of the MSE lower will be the error. The MSE is given by the equation [6]:

$$MSE = \frac{\sum_{i=1}^{k}\sum_{j=1}^{k}[I(i,j) - I'(i,j)]^2}{k \times k} \qquad (1)$$

where $I(i,j)$ is the original Image without watermark embedding, $I'(i,j)$ is the watermarked Image and k is the size of the Image. The PSNR represents measure of the Peak error. The PSNR is given by the equation [11]:

$$PSNR = 10log_{10}\frac{255 \times 255}{\sum_{i=1}^{k}\sum_{j=1}^{k}[I(i,j) - I'(i,j)]^2} \qquad (2)$$

where $I(i,j)$ is the original Image without watermark embedding, $I'(i,j)$ is the watermarked Image and k is the size of the Image. The Normalised Crosscorrelation is used to detect the similarity between original watermark and extracted watermark. The Normalised Crosscorrelation (NC) is given by the equation [11]:

$$NC = \frac{\sum_{i=1}^{L}\sum_{j=1}^{L}[W(i,j) \times W'(i,j)]}{\sqrt{\sum_{i=1}^{L}\sum_{j=1}^{L} W(i,j)^2}\sqrt{\sum_{i=1}^{L}\sum_{j=1}^{L} W'(i,j)^2}} \qquad (3)$$

where $W(i,j)$ is the original watermark, $W'(i,j)$ is the extracted watermark and L is the size of the watermark.In this section we provide the comparison of spatial domain LSB algorithm with transform domain subband DCT domain algorithm under different conditions. In the LSB algorithm the watermark used is of size 256x256 and in the subband DCT domain the watermark size is 64x64. Figure 2

shows the results of applying LSB algorithm to embed the binary cameramen Image as a watermak in the 8-bit Baboon Image.

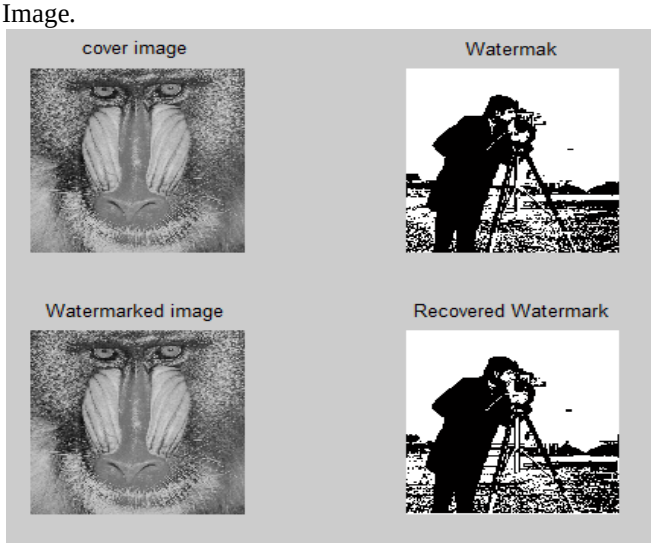


Figure 2 Output Result of using spatial domain LSB algorithm

Figure 3 shows the result of applying to hide 64x64 binary watermark in the 8-bit gray-scale baboon Image using subband DCT algorithm.

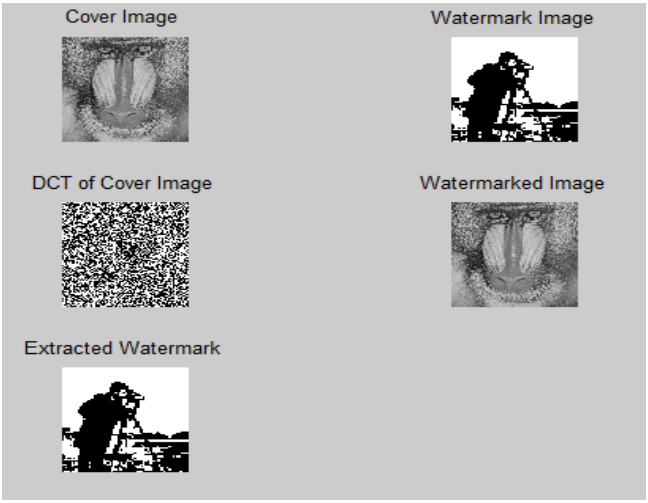


Figure 3 Output Result of using subband DCT algorithm

Table 1 shows the results of both algorithms without any attacks on the watermarked Image. Results shows that LSB algorithm provide good MSE but the Normalised crosscorrelation factor is not so good as compared to subband DCT algorithm. The NC of LSB algorithm is 0.8987 while it is 1 in case of subband DCT. The results of both methods under the salt and pepper noise is shown in the Table 2. In this condition also the PSNR and NC of subband DCT is good. Table 3 shows the results of applying this algorithms under the gaussian filtering. From the results we can see that in case of LSB algorithm the watermark is not recognised while it is perfectly extracted with good PSNR and NC factor using subband DCT algorithm. The PSNR in this case for subband DCT algorithm is 34.3954 and the NC is 0.9996 while in case of LSB algorithm it is 35.1402 and 0.5433 respectively.

Table 1 Comparison table of two methods without any attacks

Without any attacks the value of MSE,PSNR and NC of both methods are	
LSB algorithm	**Subband DCT algorithm**
Watermark Size is 256x256	Watermark Size is 64x64
MSE :- 0.2024 **PSNR** :- 55.0691 **NC** :- 0.8987	**MSE** :- 8.4033 **PSNR** :- 38.8863 **NC** :- 1

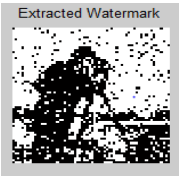
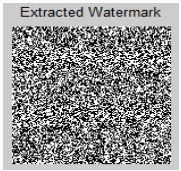
Table 2 Comparison table of two methods under the salt and pepper noise

Under the salt and pepper noise of 0.01 strength	
LSB algorithm	**Subband DCT algorithm**
Watermark Size is 256x256	Watermark Size is 64x64
MSE :- 1.4943 **PSNR** :- 46.3864 **NC** :- 0.8952	**MSE** :- 9.6366 **PSNR** :- 38.2916 **NC** :- 0.9268

Table 3 Comparison table of two methods under the Gaussian filtering

Under the Gaussian Filtering with sigma 0.5.	
LSB algorithm	**Subband DCT algorithm**
Watermark Size is 256x256	Watermark Size is 64x64
MSE :- 19.9096 **PSNR** :- 35.1402 **NC** :- 0.5433	**MSE** :- 23.6349 **PSNR** :- 34.3953 **NC** :- 0.9996

Table 4 Comparison table of two methods by extracted watermark

	LSB algorithm	**Subband DCT algorithm**
Without any attacks the extracted watermark		
Under the salt and pepper noise of 0.01 strength		
Under the Gaussian Filtering with sigma 0.5.		

4. Comparison Of Image Watermarking Algorithms

In this section, spatial and transform domain are compared in terms of robustness, security and complexity.

- LSB algorithm is simple to implement while Sub band DCT algorithm is complex as compared to LSB algorithm.
- LSB algorithm can resist simple attacks like addition of noise but it cannot provide robustness against different attacks while Sub band DCT algorithm is more robust to different attacks like filtering, addition of noise etc.
- In LSB algorithm shifting of watermark bit embedding position from LSB to MSB, the watermarked Image starts distorting while in the sub band DCT algorithm embedding watermark in the low frequency coefficients, the watermark Image get distorted.
- In LSB algorithm the capacity of bit embedding per Image is more as compared to Sub band DCT algorithm.
- Security in Sub band DCT algorithm is more as compared to LSB algorithm.
- In LSB algorithm, the better attack is making all the LSB's of watermark is 1's while in Sub band DCT algorithm not affected.

5. Conclusion And Future Scope

In this paper, we have compared spatial domain LSB algorithm with the Sub band DCT algorithm in terms of Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE) and Normalised Cross-correlation (NC). From the experiment results we discussed in section 3 we can conclude that transform domain method have NC factors and security as compared to Spatial domain algorithms. The watermark extracted in different conditions has better correlation with the original watermark in case of Sub band DCT algorithm as compared to LSB algorithm. These algorithms can be improved in future in terms of robustness and imperceptibility and also it can be implemented using DSP processor.

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