International Journal of Research
International Journal of Research (IJR)
e-ISSN: 2348-6848, p- ISSN: 2348-795X Volume 2, Issue 05, May 2015
Available at http://internationaljournalofresearch.org

Digital Image Watermarking: An Overview

Ramandeep Singh
Dept. of Microelectronics, BMSCE, Sri Muktsar Sahib, Punjab, India.
er.ramandeepshillon@gmail.com

ABSTRACT

With the growth in the information technology and the sharing of digital data over the internet the electronic publishing is becoming more popular. These improvements in the computer technologies increase the problems of copyright and ownership. Digital watermarking has emerged as an answer to this problem. In the initial part of this paper there is information about the watermarking and then there is classification of different types of watermarking. At the end is given the parameters on which we can conclude which watermarking technique is best.

KEYWORDS Watermarking; Spatial domain watermarking; Frequency Domain Watermarking; LSB; DFT; DCT ; DWT; SVD; MSE; PSNR; BER

1. INTRODUCTION

In the earlier days the cameras used were of analog type. The photographic film used in those was exposed to the light for capturing the shot for a very small time and then were kept in the dark for safety purposes, so that the captured image do not get degraded. The problems faced with those were, the quality was not so good and if you want a good quality image you must be a professional photographer and another problem was that you cannot review the images immediately. You have to develop the photographs first only then you can see them and analyze them. But with the advancement of technology and the evolution of cameras people can actually see the wonderful moment captured through the Digital Camera at anytime. The best thing is people can review the pictures from the screen available on digital cameras. And these even allow the storage of the captured photographs digitally on the digital storage media.

Now a days with the increase in the use of internet the purchasing and distribution of digital images is being done quite easily. But with this ease there exists a problem of copyright protection and ownership. Over the past few years the technology of watermarking has came up as a solution for the ownership of digital images.

2. DIGITAL WATERMARKING

A digital watermark is a pattern of bits inserted into a digital image that identifies the file's patent information. The bits representing the watermark must be sprinkled throughout the file in such a way that they cannot be recognized and customized. The digital image watermarking system consists of watermark embedder and watermark detector. Watermark embedder inserts watermark in the original image to be protected from copying and the watermark detector detects the watermark in the watermarked image and prove its ownership and copyright. The general process of embedding and extraction is as shown in the figure 1. below:

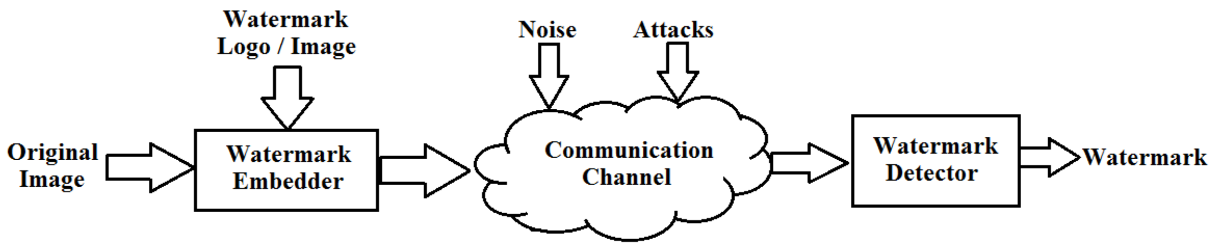

Fig. 1 Digital Image Watermarking

We can divide the watermarks into two main groups – visible and invisible watermarks.

a) **Visible Watermark** – A visible watermark is a visible semi transparent text or image imposed on the original image. It allows the original image to be viewed, but it still provides copyright security by marking the image as its owner's belonging. Visible watermarks are stronger against image transformation thus they are more favored for strong copyright protection.
b) **Invisible Watermark** – An invisible watermark is an implanted image which cannot be perceived with human's eyes. Only electronic devices with special software can extract the buried information to recognize the patent possessor and show its genuineness.

3. WATERMARKING TECHNIQUES

The watermarks can be embedded in the images with the different techniques. These can be broadly classified in the following types according to the domains in which they are embedded.

3.1 SPATIAL DOMAIN TECHNIQUES

Spatial domain techniques are the techniques in which the watermarks are embedded in the host image as it is without changing the domain of the host image. In these techniques the user replaces the bits of the value of the pixel. Different methods are available for the replacement of different bits of the values of pixels. Some are as given below:

3.1.1 LEAST SIGNIFICANT BIT (LSB)

In digital images the whole image is stored in the form of bits on digital storage media. So the information we want to add in the image can be added directly in every bit or only the busy areas can be calculated for adding the watermark information in it, still replacing the bits in that area. The digital image consists of pixels and each pixel consists of 8-bits. The combination of these 8-bits represents a number from 0 to 255 in decimal system. A total of 256 combinations represent different colors of grey 0 being black and 255 being white. Altering only the last bit does not change the color much but the watermark is successfully embedded in the image. Even if the last two bits are altered even then the difference between the original

International Journal of Research (IJR)
e-ISSN: 2348-6848, p- ISSN: 2348-795X Volume 2, Issue 05, May 2015
Available at http://internationaljournalofresearch.org

and watermarked image cannot be noticed by naked eye. As we shift from LSB to MSB the effect of watermark starts to become visible because then with the change of a single bit there is a great change in the resultant value of the pixel and the watermark logo is partially visible. This effect is as shown in the images below:

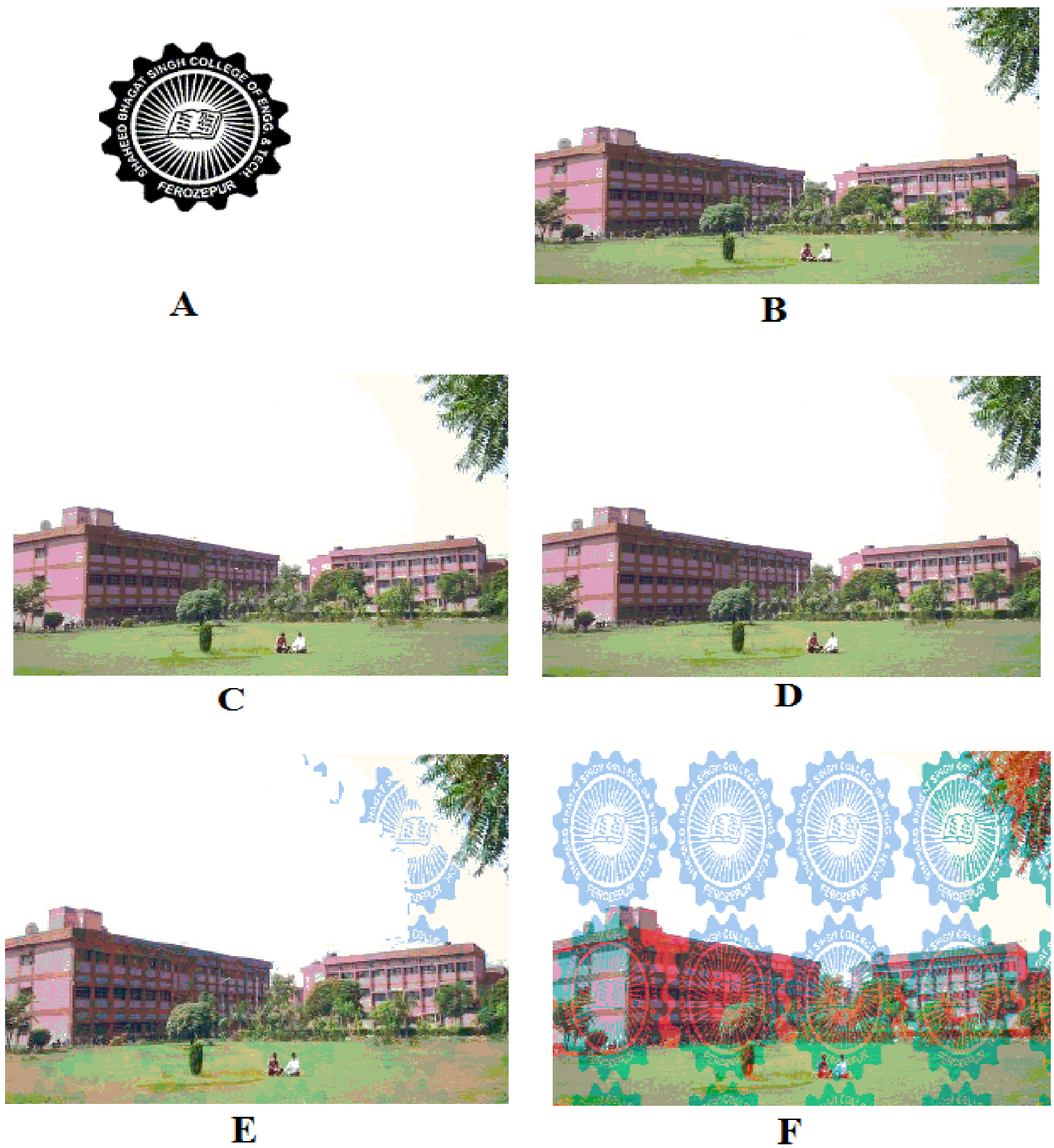

Fig. (A) Watermark Logo to be inserted. (B) Original image in which watermark is to be embedded. (C) Watermark embedded in LSB. (D) Watermark embedded in 4th bit. (E) Watermark embedded in 6th bit. (F) Watermark embedded in 8th bit (MSB).

International Journal of Research (IJR)
e-ISSN: 2348-6848, p- ISSN: 2348-795X Volume 2, Issue 05, May 2015
Available at http://internationaljournalofresearch.org

3.1.2 SSM MODULATION BASED TECHNIQUE

Spread-spectrum techniques are methods in which energy generated at one or more discrete frequencies is deliberately spread or distributed in time or frequency domains. This is done for a variety of reasons, including the establishment of secure communications, increasing resistance to natural interference and jamming, and to prevent detection. When applied to the context of image watermarking, SSM based watermarking algorithms embed information by linearly combining the host image with a small pseudo noise signal that is modulated by the embedded watermark.

3.2 FREQUENCY DOMAIN TECHNIQUES

As compared to the spatial domain techniques, the frequency domain techniques are more widely used. In these techniques the watermarks are embedded in the spectral coefficients of the original image. By transforming spatial domain data into another domain the pixels become statistically independent. The watermark is distributed irregularly throughout the image in the spatial domain after the inverse transform. So it becomes difficult for the attackers to crack the watermark. The most commonly used transforms are the Discrete Cosine Transform (DCT), Discrete Fourier Transform (DFT), Discrete Wavelet Transform (DWT), Discrete Laguerre Transform (DLT) and the Discrete Hadamard Transform (DHT). The main advantage of embedding the watermark in frequency domain is that the human eye can detect the variations in the lower frequency but not at the higher frequencies and lower frequency components are safe from the attacks as if lower frequency components are altered then it damages the original image. But higher frequency components can achieve better invisibility but can be easily affected by attacks. So by converting to frequency domain we can embed the watermark in mid range frequencies rather than the lower or higher frequencies. Some of the frequency domain watermarking techniques are as given below:

3.2.1 DISCRETE FOURIER TRANSFORM (DFT)

The DFT of a function provides a quantitative representation of the frequency content in terms of magnitude and phase. This is significant in the processing and investigation of images. It is important to know the properties of DFT so that it can be used efficiently. Scaling in the spatial domain causes inverse scaling in the Fourier domain. If we rotate the image in the spatial domain by an angle ɸ it will cause the Fourier representation to be rotated by the same angle ɸ.

3.2.2 DISCRETE COSINE TRANSFORM (DCT)

The embedding of the watermark in the frequency domain instead of the spatial domain increases the robustness of the watermarked image. The DCT coefficients of the original image will be modified in order to embed the watermark by using the embedding rule and the information of the watermark. For best results the watermark is embedded only in the mid range frequencies. DCT like a Fourier Transform, it represents data in terms of frequency space rather than an amplitude space. Such algorithms are robust against simple image processing operations like low pass filtering, brightness and contrast adjustment, blurring etc. However, they are complicated to apply. At the same time they are weak against geometric attacks like rotation, scaling, cropping etc. The main advantage of DCT is that it is a sequence of real numbers if and only if the input to it is a sequence of real numbers.

3.2.3 DISCRETE WAVELET TRANSFORM (DWT)

A wave is a periodic oscillating disturbance that propagates through space and time, usually with transference of energy. In contrast, wavelets are localized waves that have their energy concentrated in time or space and are suited to analysis of transient signals. DWT is a mathematical tool for hierarchically decomposing an image. Wavelet transform provides both frequency and spatial details of an image. When we apply DWT on an image the image is processed by 2-D filters in each dimension. The original image is divided into four sub-bands after breakdown. The four sub-bands contain approximation sub-band (LL), Horizontal detail sub-band (LH), Vertical detail sub-band (HL) and a diagonal detail sub-band (HH). This process can be repeatedly applied on the approximation sub-band to generate the next coarser scale of wavelet coefficients. This process of breaking continues until some final scale is reached. The DWT divides the signal into high and low frequency parts. In two dimensional applications, for each level of breakdown, the DWT is first performed in the vertical direction and then in the horizontal direction. After the application of first level DWT, there are four sub-bands LL1, LH1, HL1 and HH1. For each next level of breakdown, the LL sub-band of the previous level is used as the input. To apply 2nd level DWT the input would be LL1 and for the 3rd level DWT the input would be LL2 and so on. This is as shown in figure below:

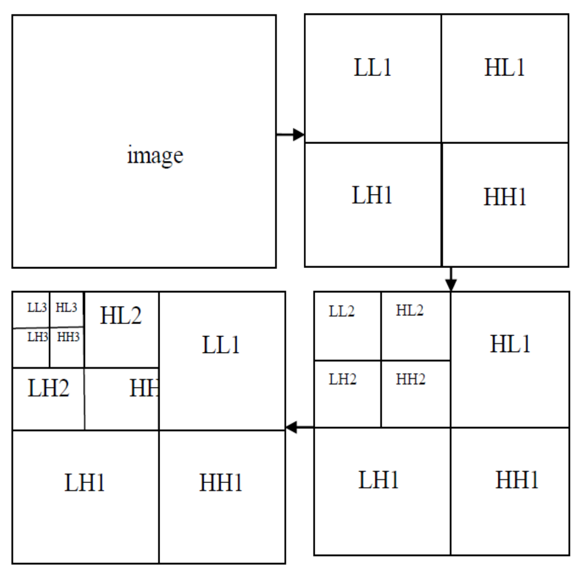

Fig. 3 level DWT breakdown

Generally most of the image energy is concentrated at the lower frequency sub-bands LL_x , so embedding the watermarks in these sub-bands would increase robustness but degrade the image quality. The high frequency sub-bands HH_x include the edges of the image and the human eye is not generally sensitive to changes in edges.

3.3 HYBRID TECHNIQUES

These are the latest techniques being used these days. In the hybrid techniques we use the combination of two or more techniques mentioned above. For the colored images we can even use single technique for embedding more than one watermark either on single layer or on different layers. The mostly used hybrid techniques are combinations of DCT and DWT, DCT and SVD or DWT and SVD. In these techniques we mostly use two different logos or images for watermark. Both are processed in different domains and then embedded in the original image or they are first combined then embedded in the original image. Here we are having different combination options so we can choose any one of them according to our need.

4. PERFORMANCE EVALUATION

The above techniques undergo the performance evaluation parameters to find the best out of these. Some of the performance evaluation parameters are as follows:

4.1 MEAN SQUARE ERROR (MSE)

It is defined as the average squared difference between a reference image and a distorted image. It is calculated by the formula given below:

$$MSE = \frac{1}{m * n} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [I(i,j) - K(i,j)]^2$$

m and n are the height and width of the image respectively. I(i,j) is the pixel value of the original image and K(i,j) is the pixel value of the watermarked image.

4.2 SIGNAL TO NOISE RATIO (SNR)

SNR measures the sensitivity of the imaging. It measures the signal strength relative to the background noise which gets added during the transmission. It is calculated by the formula given below:

$$SNR_{dB} = 10 \log_{10}\left(\frac{P_{signal}}{P_{noise}}\right)$$

4.3 PEAK SIGNAL TO NOISE RATIO (PSNR)

The PSNR is used to determine the degradation in the embedded image with respect to the host image. It is calculated by the formula given below:

$$PSNR = 10 \log_{10}\left[\frac{R^2}{MSE}\right]$$

Where R represents maximum fluctuations or value in the image, its value is 255 for 8-bit unsigned number.

4.4 BIT ERROR RATE (BER)

The BER is the ratio that describes how many bits received in error over the number of total bits received. It is calculated by comparing bit values of original image and embedded image.

$$BER = P / (H*W)$$

H and W are the height and width of the watermarked image. P is the count number initialized to zero and it increments by one if there is any bit difference between the original image and embedded image.

5. CONCLUSION

In this paper we have studied about the importance of watermarking and different techniques used for it. Frequency domain watermarking is better than the spatial domain watermarking but the hybrid techniques are even better. We can conclude this on the basis of the performance parameters. The PSNR is high for hybrid techniques and MSE is less for these and out of these the combination of SVD and DWT is best as its results for the performance parameters are the best out of all. MSE is the mean difference between the pixels of original image and the watermarked image. PSNR is peak signal to noise ratio, where signal is original image and noise is considered as watermarked image.

REFRENCES

[1] Khaled Mahmoud, Sekharjit Datta, and James Flint "Frequency Domain Watermarking: An Overview" The International Arab Journal of Information Technology, Vol. 2, No. 1, January 2005.

[2] Puneet Kr Sharma and Rajni "ANALYSIS OF IMAGE WATERMARKING USING LEAST SIGNIFICANT BIT ALGORITHM" International Journal of Information Sciences and Techniques (IJIST) Vol.2, No.4, July 2012.

[3] Abdullah Bamatraf, Rosziati Ibrahim and Mohd. Najib Mohd. Salleh "A New Digital Watermarking Algorithm Using Combination of Least Significant Bit (LSB) and Inverse Bit" JOURNAL OF COMPUTING, VOLUME 3, ISSUE 4, APRIL 2011, ISSN 2151-9617.

[4] Mei Jiansheng, Li Sukang and Tan Xiaomei "A Digital Watermarking Algorithm Based On DCT and DWT" Proceedings of the 2009 International Symposium on Web Information Systems and Applications (WISA'09).

[5] Pratibha Sharma, Shanti Swami " Digital Image Watermarking Using 3 level Discrete Wavelet Transform" Conference on Advances in Communication and Control Systems 2013 (CAC2S 2013).

[6] Navnidhi Chaturvedi "Various Digital Image Watermarking Techniques And Wavelet Transforms" International Journal of

Emerging Technology and Advanced Engineering Volume 2, Issue 5, May 2012.

[7] Hongqin Shi "DWT and SVD based Watermarking Scheme with Circulation" JOURNAL OF SOFTWARE, VOL. 9, NO. 3, MARCH 2014.

[8] Surya Pratap Singh, Paresh Rawat, Sudhir Agrawal "A Robust Watermarking Approach using DCT-DWT" International Journal of Emerging Technology and Advanced Engineering Volume 2, Issue 8, August 2012.

[9] Mr. Saurabh Athalye, Mrs. Minal Puranik "Robust dual watermarking using DWT & SVD" International Journal of Emerging Trends & Technology in Computer Science (IJETTCS) Volume 2, Issue 4, July – August 2013.