Classification and Comparison of Digital Image Watermarking Techniques

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***Abstract*— Watermarking is a technique to hide information inside digital media so that any unauthorized person can't access it. It is a very important field which helps to protect copywrite digital material. This is exponentially growing field in today's world as information sharing has become much easier due to internet. Many researchers are studying and researching in this field. Using this technique, digital data that is watermarked can be accessed and modified by authorized person only. There are different techniques available so far for watermarking in digital image. This paper provides analytical survey on digital image watermarking based on their representation domain. Comparison has been made between frequency domain and spatial domain.**

***Key words*— Watermarking, Digital Media, Information, Authentication, Spatial Domain, Frequency Domain**

I. INTRODUCTION

Watermarking is a very important field in today's internet world, where data sharing is very much easy through internet. It is similar to stenography. Like stenography main goal of Watermarking is to hide information in cover without affecting cover data. This technique is used to hide proprietary information in digital media such as photo, music, video etc. which are use as cover. The main purpose of watermarking is to embed a code inside an image that acts as a digital signature giving an image a sense of ownership or authenticity [1]. This is necessary because image transfer over internet have no restriction or any kind of protection against copy right. There may be possibility that the image may be alter or duplicated or modified during transfer, to protect against that watermarking is required.

In this paper, survey of different watermarking techniques that are used for watermarking digital media has been provided. As stated earlier watermarking can be applied to digital media like photo, music, video etc. However this paper is limited to image domain only. This paper has been divided into six sections. In section II, requirements of watermarking has been listed. Section III describes types of watermarked. In section IV, applications of watermarking has been provided. In section V, watermarking techniques has been classified according to their representation domain.

II. REQUIREMENTS OF WATERMARKING

Major requirements of watermarking are described below:

A. *Transparency* - Quality of original image after will not be changed. That is a human can not distinguished between original image and watermarked image.
B. *Robustness* - Watermarked in image should survive basic image processing operation such as contrast or brightness enhancement, gamma correction etc.
C. *Security* - Unauthorized person can not detect watermarked even though algorithm for Watermarking is known. [3]
D. *Capacity or Data payload* - It state that watermark should carry minimum amount of information to determined uniqueness of image

III. WATERMARK CLASSIFICATION

Based on the watermark the watermarking classification are as bellow:

A. *Visible Watermarked* - They are directly visible in image can't be removed or crop from image [1].
B. *Invisible Watermark* - This watermark is hide inside image data and only authorize person can detect it.
C. *Fragile Watermark* - Any kind of operation or manipulation on image will destroy this watermark.

IV. WATERMARKING APPLICATION

Let us now briefly describe the application of watermarking.

A. *Copyright protection* - Watermarking can be used to protect digital material distributed on internet to verify the ownership of material.
B. *Content Achieving* - It can hide identity of digital material such as image, video, audio etc. within its material reduce possibility of tempering it.
C. *Mete-data insertion* - Meta-data is the data that describe the data. This data can be inserted using watermarking such as audio file can carry singer name or video file carry the subtitle.
D. *Broadcast monitoring* - Broadcast monitoring refers to the technique of cross verifying whether the content that was supposed to be broadcasted has really been broadcasted or not. [2].
E. *Tamper detection* - Data transfer over internet can be tamper or alter by other party which is detect by watermarking.

V. CLASSIFICATION OF WATERMARKING TECHNIQUES

The frequency sensitivity refers to the eye's response to spatial, spectral, or time frequency changes. Spatial frequencies are perceived as patterns or textures, and spatial frequency sensitivity is usually described as the eye's sensitivity to luminance changes [6]. It has been known that eyes are more sensitive to change in mid range spatial frequency and it is decrease at lower and higher frequency. Digital image watermarking categories in two parts according to their representation of image in two different domains.

A. Spatial domain techniques

Spatial domain watermarking can apply using separation. In that the watermark appears in only one of the color band. This render the watermark visibly sublet such that it is difficult to detect under regular viewing. However, the mark appears immediately when the colors are separated for printing. Spatial domain techniques have two methods for watermarking.

1. *Lest significant bit (LSB)* - The earliest work of digital image watermarking scheme embeds watermark in LSB of the image pixel [1]. As we know an image is represented in pixel and every pixel value is represented using 8-bits. In study it shows that the most of the valuable information of image is content within the MSB of every pixel while LSB contain very much less information. So in this LSB watermarking techniques we used cover image pixel's LSB to hide watermark. That is we replace LSB of cover image pixels wit MSB of watermark. This method is very easy to implement but dose not robust against attests.
2. *SSM modulation base 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 [4].

B. Frequency domain techniques

These techniques are more widely applied than others. The reason for watermarking in the frequency domain is that the characteristics of the human visual system (HVS) are better captured by the spectral coefficients [4]. That is human eye is more sensitive against low frequency component and less sensitive against high frequency component.

The most commonly used transformations are Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT), and Discrete Fourier Transform (DFT).

1. *Discrete Cosine Transformation (DCT)*

   Discrete Cosine Transformation (DCT) represents data in terms of frequency space rather than an amplitude space [5]. This technique is more robust compare to spatial domain techniques such as LSB or SSM modulation. This technique survives basic image processing operation such as brightness and contras adjustment, blurring, filtering etc. But it is very much difficult and expensive to implement. Accept from its robustness against basic image processing operation it is weak against geometric attests such as cropping, scaling, rotation etc.

   A. Discrete Cosine Transformation can be classified into Global Discrete Cosine Transformation watermarking and Block based Discrete Cosine Transformation watermarking. Hiding watermarked in the perceptually significant portion of the image has an advantage that during compression this part of image will be eliminated by the most compression schemes [2]. In spatial domain it represents the LSB however in the frequency domain it represents the high frequency component [7].

   B. Steps in DCT Block based watermarking algorithms [2].

   i. Segment the image into non-overlapping block of 8×8
   ii. Apply forward DCT to each of these blocks
   iii. Apply some block selection criteria (e.g. HVS)
   iv. Apply coefficient selection criteria (e.g. highest)
   v. Embed watermark by modifying the selected coefficient.
   vi. Apply inverse DCT transformation on each block.

2. *Discrete Wavelet Transformation (DWT)*

   A. Wavelet transformation is applied to remove noise from signal, audio-video compression. Wavelets are more effective for signal that frequently changes with time as their energy concentrated in time [8].

   B. Discrete Wavelet Transformation watermarking has the same steps as we have in Discrete Cosine Transformation watermarking. The main concept is same but the transformation of image into one domain to other domain varies, there for coefficient in both DCT and DWT are different. Harr wavelet filter, Daubechies Orthogonal Filters and Daubechies Bi-Orthogonal Filters are some wavelet filter used by Discrete Wavelet Transformation to transfer the image.

   C. DWT domain watermarking is classified into DWT based Blind Watermarking and DWT based Non Blind Watermarking. The difference between this two is that NON-Blind watermarking technique require original

image to detect watermark while blind watermarking technique dose not require original image to detect watermark.

3. Discrete Fourier transformation (DFT)

DFT is stronger against geometric attacks such as rotating an image at any angle, resizing an image, taking some part of image as an individual image etc. The phase of DFT is used to embed watermark because the phase is more important than the amplitude of DFT values. For the intelligibility of an image embedding watermark in this important component of an image improve robustness of watermark as any change in this component to remove watermark will degrade the quality of image. The other reason to use phase of DFT is that phase modulation often processes superior noise immunity in comparison with amplitude modulation.[9]

Table1. Comparison of Spatial Domain Watermarking and Frequency Domain Watermarking

Sr No.	**Properties**	**Spatial Domain**	**Frequency Domain**
1.	Computation cost	Less	More
2.	Robustness	Weak	Strong
3.	Perceptual quality	High control	Low control
4.	Computational complexity	Less	High
5.	Computation time	Less	More
6.	Capacity	More	Less

VI. CONCLUSION

After surveying different techniques used by researchers, we can conclude that different techniques have their special characteristics which can be used according to condition. Spatial Domain techniques are simple and easy to implement, but these techniques are not robust against geometric attacks such as scaling, cropping, rotating etc. Whereas Frequency Domain techniques are robust against this kind of geometric attacks, but they are complex and time consuming. Also data carried by these techniques are much less compare to Spatial Domain techniques. If low cost, high perceptual quality and more data capacity is desire than Spatial Domain techniques are much suitable. But if robustness is required than it is suitable to use Frequency Domain techniques.

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