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A Survey On Wavelet Domain Watermarking

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ABSTRACT : *Digital watermarking is a technique considered in different areas where private and secure data transmission is a concern. Watermarking is the process of hiding information into any digital content for enhancing additional security to visual data. The objective of embedding information by digital watermarking can be either one or more of copyright protection, data authentication, identification of illegal copies and illegal changes made in the data. Transform domain techniques are better in robustness, imperceptibility and recoverability of cover and embedded information, than spatial domain techniques. Wavelet transforms have outperformed DFT and DCT in all branches of image processing. This paper gives an analysis of different types of DWT based watermarking techniques.*

Keywords - *Digital Watermarking, Wavelet transforms, SVD, DCT, DFT.*

I. INTRODUCTION

Digital image watermarking is the process of inserting some image called watermark into another image called host image. Insertion of watermark image should be done in such a way that the watermark is extractable from host image. Especially when host image is transmitted over network, many intentional and unintentional alterations can be performed on it. In such cases, survival of watermark image is desirable. The strength of a watermarking technique is evaluated by its invisibility, robustness and recoverability. Though there are visible watermarks like those used in printed materials or television displays, digital image watermarks are designed to be completely invisible within the cover image. The watermark must be scattered throughout the image in such a way that they cannot be identified and manipulated. The digital watermark must be robust enough so that it can withstand normal changes to the file, such as distortions due to noise or from lossy compression algorithms.

The image watermarking techniques are classified on the basis of domain like spatial domain or transform domain. The spatial domain techniques directly modify the intensity of some selected pixels. The spatial domain watermarking is simple as compared to the transform domain watermarking. The robustness is the main limitation of the spatial domain watermarking. In the transform domain watermarking, the image is represented in the form of frequency. Here firstly the original image is converted by a predefined transformation. Then the watermark is embedded in the transform image or in the transformation coefficients. Finally, the inverse transform is performed to obtain the watermarked image . Most commonly used transform domain methods are Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT) and Discrete Fourier Transform (DFT).

Discrete Fourier Transform (DFT) [1] is used for the periodic, digital signals or discrete-time f (x), offers robustness against geometric attacks like rotation, scaling, cropping, translation etc. DFT decomposes an image in sine and cosine form. The DFT based watermark embedding techniques are divided in two types: one is the direct embedding and the other one is the template based embedding. According to the direct embedding technique the watermark is embedded by modifying DFT magnitude and phase coefficients. The template based embedding technique introduces the concept of templates. A template is structure which is embedded in the DFT domain to estimate the transformation factor. Once the image undergoes a transformation this template is searched to resynchronize the image, and then the detector is used to extract the embedded spread spectrum watermark. The DFT is Rotation Scaling Translation (RST) invariant. So, DFT can be used to recover from geometric distortion, whereas the spatial domain, DCT and DWT are not RST invariant. Hence, it is difficult to overcome from geometric distortions. The main disadvantage of the DFT is that the output of the DFT is always in complex value and it requires more frequency rate. Its computational efficiency is very poor.

Discrete Cosine Transform (DCT) [1] like a Fourier Transform, it represents data in terms of frequency space rather than an amplitude space. DCT is applied in many fields like data compression, pattern recognition and every field of image processing. DCT watermarking is more robust as compared to the spatial domain watermarking techniques. Here firstly segment the image into non-overlapping blocks and apply forward DCT to each of these blocks. Then apply some block selection criteria (e.g. HVS) and coefficient selection criteria (e.g. highest) and embedded the watermark by modifying the selected co-efficient. Finally perform inverse DCT transform on each block. The Discrete cosine transform achieves good robustness against various signal processing attacks because of the selection of perceptually significant frequency domain coefficients. DCT is a real transform with better computational efficiency and gives a better performance in the bit rate reduction. However, they are difficult to implement and are computationally more expensive. At the same time they are weak against geometric attacks like rotation, scaling, cropping etc.

Discrete Wavelet transform (DWT) is a mathematical tool for hierarchically decomposing an image. It is useful for processing of non-stationary signals. The transform is based on small waves, called wavelets, of varying frequency and limited duration. Wavelet transform provides both frequency and spatial description of an images. Wavelets are created by translations and dilations of a fixed function called mother wavelet. The DWT splits the signal into high and low frequency parts. The high frequency part contains information about the edge components, while the low frequency part is split again into high and low frequency parts. The high frequency components are usually used for watermarking since the human eye is less sensitive to changes in edges.

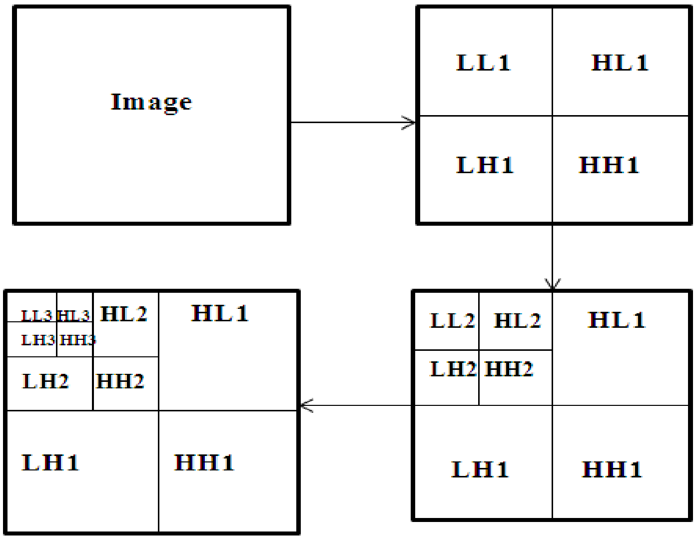

Figure: 3-Level Discrete Wavelet Decomposition

In two dimensional applications, for each level of decomposition, we first perform the DWT in the vertical direction, followed by the DWT in the horizontal direction. After the first level of decomposition, there are 4 sub-bands: LL1, LH1, HL1, and HH1. For each successive level of decomposition, the LL subband of the previous level is used as the input. To perform second level decomposition, the DWT is applied to LL1 band which decomposes the LL1 band into the four sub- bands LL2, LH2, HL2, and HH2. To perform third level decomposition, the DWT is applied to LL2 band which decompose this band into the four sub-bands – LL3, LH3, HL3, HH3. This results in 10 sub-bands per component. LH1, HL1, and HH1 contain the highest frequency bands present in the image, while LL3 contains the lowest frequency band. Wavelet transform can accurately model HVS than other transforms like DFT and DCT. This allows higher energy watermarks in regions where HVS is less sensitive. Embedding watermark in these regions allow us to increase robustness of watermark, with no much degradation of image quality. DFT and DCT are full frame transform. Hence, any change in the transform coefficients affects entire image except if DCT is implemented using a block based approach. However DWT has spatial frequency locality. It means it will affect the image locally, if watermark is embedded. Another advantage is that current image compression standard JPEG 2000 is based on wavelet transform. This survey elaborates the various methods of transformation in wavelet domain and focuses the merits and demerits of these techniques.

II. RELATED WORK

A. Improved Wavelet-Based Watermarking Through Pixel-Wise Masking

Barni et al. [2] proposed a new algorithm for enhancing the performance of water making in wavelet domain by exploiting the characteristics of human visual system (HVS). Here masking is done on pixel basis by evaluating the texture and luminance content of all the sub bands of the image. The watermark used here consists of pseudo random binary sequence. During embedding process the image to be watermarked will be first decomposed through DWT into four levels. Then the watermark will be embedded only on to the three largest detail sub bands. Highest level of strength is used for image contours, a medium strength for textures, and a lower strength for regions with high regularity which is more sensitive to human visual system. The texture activity around a pixel is composed of the product of the local mean square value of DWT coefficients in all detail sub bands and the local variance of the forth level approximation image. Both are calculated in a small 2x2 neighborhood of each pixel. Detection is made using correlation between the marked DWT coefficients and the watermarking sequence to be tested for presence. Then the value of the correlation is compared to a threshold to decide whether the watermark is present or not.

Barni's method is robust against image processing attacks like filtering, compression, cropping etc. Also a mask is built on pixel by pixel, gives the maximum amount of modifications that can be applied to the corresponding DWT coefficient in the detail band without compromising watermark invisibility. The disadvantage is that it is easy to erase the watermark since it is embedded in the last resolution level only.

B. Digital Image Watermarking in the Wavelet Transform Domain

Kamran et al. discussed two watermarking schemes: Joo's technique and Dote's technique based on DWT watermarking. In Joo's watermarking technique[3] during embedding process the gray image is decomposed into several bands by wavelet transform. To embed watermark a reference DC′ is prepared by taking low pass filtering to the original DC. The DC values are changed to values smaller or larger than the DC′ values in accordance with the corresponding watermark bits. To reduce image degradation, the watermark bits are embedded into locations with smaller differences between the DC and DC′. The same wavelet decomposition is applied to both the original and embedded images. During extraction process. Joo used the original image as required in extracting watermarks. Then the extracted watermarks are compared with the original watermarks generated by the user key.

Dote's [4] pesented a multilevel wavelet transformation technique. The host image and watermark are transformed into wavelet domain. Dote selected 5th level transformation for host image and 1st level for watermark. The transformed watermark coefficients were embedded into those of host image at each resolution level with a secret key. Extraction is done by applying inverse procedure at each resolution level using the same secret key. Both the techniques were found non-obtrusive in gray level images. For robustness, Joo's technique shows better results when compared with Dote's technique. Since the watermarks that are extracted from the noisy images has an acceptable degree of correlation in Joo's technique. Hence it is more robust for standard noise attacks than Dote's technique.

C. Image Watermarking Using 3-Level Discrete Wavelet Transform (DWT)

Here a new watermarking algorithm based on DWT technique for remote multimodal biometric authentication system was proposed. During watermark embedding process a 2-D, 3-level DWT (Discrete Wavelet Transform) [5] is applied to the gray scale host image which decomposes image into low frequency and high frequency components. In the same manner 2-D, 3-level DWT is also applied to the watermark image which is to be embedded in the host image. The wavelet used here is the wavelets of daubecheis. Alpha blending technique is used here for inserting the watermark. In this technique the decomposed components of the host image and the watermark are multiplied by a scaling factor and are added. Since the watermark embedded is traceable in nature or visible, it is embedded in the low frequency approximation component of the host image. During extraction process a 3-level DWT is applied to watermarked image and cover image which decomposed the image in sub-bands. After that the watermark is recovered from the watermarked image using alpha blending technique. After extraction process, 3-level Inverse discrete wavelet transform is applied to the watermark image coefficient to generate the final watermark extracted image. The watermarks generated with the proposed algorithm are invisible and the quality of watermarked image and the recovered image are improved.

D. Enhanced Digital Image Watermarking Scheme based on DWT and SVD

In order to improve the strength of watermark a hybrid digital image watermarking scheme based on discrete wavelet transform (DWT) and singular value decomposition (SVD) was proposed. Singular value decomposition is a linear algebra technique used to solve many mathematical problems. It can be applied to any kind of images either same or different dimensions. One of the important properties of the SVD is that singular values of a matrix do not exhibit prominent change when slight variation in the matrix elements is being carried out. This property encourages watermark insertion onto the singular values of the matrix. The 2D DWT is computed by performing low-pass and high-pass filtering of the image pixels. At each level, the high-pass filter generates detailed image pixel information, while the low-pass filter produces the coarse approximations of the input image. In the proposed approach after performing two level DWT, watermark is not embedded directly in the Wavelet Coefficients rather than watermark image approximation Wavelet coefficient values are inserted to the cover image Wavelet Coefficients. Approximation Wavelet coefficient has the maximum information of original watermark image.

In the proposed DWT-SVD watermarking [6] the first step in Watermark embedding is to use one-level DWT to decompose the cover image into four sub-bands (i.e., LL, HL, LH, and HH). In the next level the HL sub band undergoes second level of decomposition (i.e., LL1, HL1, LH1, and HH). LH1, HL1, and HH1 contain the highest frequency bands present in the image tile, while LL1 contains the lowest frequency component. Then apply SVD to HL1 sub band of the cover image and apply one-level HAAR, DWT to decompose the Watermark image W into four sub-bands (LLw, HLw, LHw, and HHw). Now modify the singular values of HL1 subband with Watermark image LLw coefficients to obtain modified DWT coefficients. During Watermark extraction use first level Haar DWT to decompose the watermarked image into four subbands. Then perform 2nd level DWT on HL subband to get LL1, HL1, LH1 and HH1 subbands. Then pply SVD to the HL1 subband and compute difference. Then extract watermark wavelet coefficients HL subband and obtain the watermarked image by performing inverse DWT with extracted watermark coefficients. The proposed technique provide significant improvement in both perceptibility and the robustness under various possible watermarking attacks and keeps the watermarked image imperceptible.

E. Digital Watermarking for Image Authentication based on combined DCT, DWT and SVD Transformation

This paper presents a hybrid digital image watermarking [8] based on Discrete Wavelet Transform (DWT), Discrete Cosine Transform (DCT) and Singular Value Decomposition (SVD) in a zigzag order. Here high bands are choose to embed the watermark using DWT and Zigzag method is applied to map DCT coefficients into four quadrants that represent low, mid and high bands. Finally, SVD is applied to each quadrant. During embedding process firstly two level DWT is applied to the original image and watermarked image. Then selecting HL / LH bands and apply DCT to the selected sub band. Then the image is divided into four quadrants. DCT coefficients are mapped to the four quadrants and apply SVD to each quadrant. Modify the singular values of each quadrant to the singular values of DCT transformed visual watermark. The four sets of modified DCT coefficients are obtained and are mapped to the original position. During watermark extraction. DWT is applied to the watermarked image and then apply DCT to the selected DWT coefficient. Zigzag sequence is used for mapping the DCT coefficients into four quadrants and extract the singular values from each quadrant. Using the singular vectors, construct the DCT coefficients of the four visual watermarks and apply inverse DCT and DWT to obtain the watermarks

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III. CONCLUSION

Digital watermarking is very useful method for providing security to the digital media on the internet technology. In this paper, survey of different techniques based on transformation domain has done. Digital watermarking is still a challenging research field with many interesting problems, like it does not prevent copying or distribution and also cannot survive in every possible attack. One future research pointer is the development of truly robust, transparent and secure watermarking technique for different digital media.

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