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Digital Image Watermarking Techniques: A Survey

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***Abstract*– Due to the recent progress in internet technology and evolution of very high speed networks operating everywhere, protection of digital content is must. So, it has become a tough task to protect copyright of an individual's creation. The purpose of digital watermarking is to incorporate concealed information in multimedia content to ensure a security amenity or simply a labeling application. This paper then categorizes the various watermarking techniques into numerous categories dependent upon the domain in which the concealed data is inserted. We have also provided the comparative analysis of these techniques that can help us to know the positive and negative of these techniques. This comparison can further be used to improvise and propose various new techniques for the same.**

***Index Terms*– Watermarking, DCT, DWT, Spatial Domain, Frequency Domain, Fast Curvelet Transform and Multichannel DWT**

I. INTRODUCTION

DIGITAL information is available in World Wide Web in the appearance of Images, Audio and video in huge amount. It is very simple to create duplicate copy of digital information, to spread this data, to manipulate and obliterate by the impostors. Therefore it is required for shielding the integrity of the multimedia information [1]. Hence, the techniques which are essential to keep away from illegal replication or moderation of digital data.

This technique is named as Digital Watermarking. It is useful for fortification of images, video and text. Whenever any impostor tries to harm or alter the digital data, he or she can easily catch on the basis of retrieved watermark image. Watermarking is a important part of data hiding, which exists to shield copyright content in to multimedia. When the multimedia content is share over the Internet exchange of multimedia content copyright infringement issues are comes into the picture.

This paper includes the survey of the latest methods that are used for the Digital Image watermarking. These techniques can also be used for music files as well as video files. Every digital watermarking technique have certain characteristics such as imperceptibility, and robustness against various image manipulations like compression, filtering, rotation, scaling cropping etc [12]. Digital image watermarking techniques can be broadly classified into two major categories:

i). Spatial Domain Watermarking
ii). Frequency Domain Watermarking

II. SPATIAL DOMAIN WATERMARKING

Early watermarking schemes were introduced in the spatial domain, where copyrighted information is added by changing pixel values of host image. Least Significant Bit insertion is one of the examples of this category. But such algorithms have low payload, they can be easily discovered and quality of image after embedding the copyright information and extracted watermark is not acceptable as pixel strengths are directly changed in these algorithms [11]. One sample Spatial Domain watermarking algorithm with Least Significant Bit insertion is given in Fig. 2 [8]. Any watermarking algorithm has two parts: embedding algorithm and extraction algorithm.

III. FREQUENCY DOMAIN IMAGE WATERMARKING

In the Frequency domain the watermark is embedding into frequency coefficients of host image. Frequency domain watermarking provides more information hiding capacity and high robustness against various geometrical attacks. Frequency domain watermarking is more robust than spatial domain watermarking due to the embedding of watermark into the altered frequency coefficients of the transformed image [11]. Some well known watermarking transform domain are Fourier Transform (DFT), Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT) [13], [14], [15], [16]. In transform domain we have various techniques, Fourier Transform (FT), Short Time Fourier Transform (STFT), and Continuous Wavelet Transform (CWT), Discrete Wavelet Transform (DWT), Discrete Cosine Transform (DCT) or Combination of DCT and DWT.

A) Digital Image Watermarking Using Discrete Wavelet Transform

Concept of DWT is actually very analogous to theoretical model of Human Visual System (HVS).

DWT gives multi-resolution representation of an image and

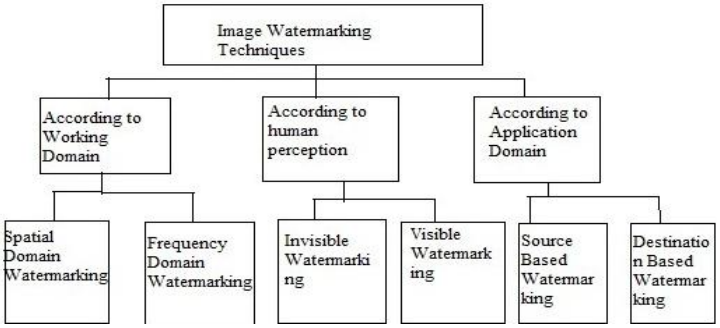

Fig. 1: Techniques of Digital Image Watermarking [11]

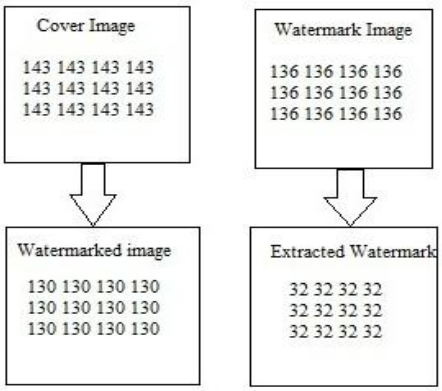

Fig. 2: Pixels of Cover image, Watermark, Watermarked Image and Extracted Watermark [8]

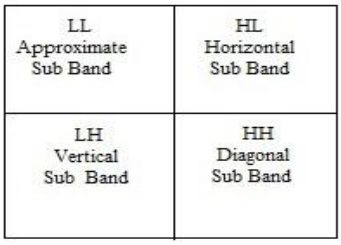

Fig. 3: One Level DWT- Decomposition [7]

perfect reconstruction of disintegrated image. We can represent DWT as the Image itself and also as the two dimensional signal [17]. DWT decomposes the image into sub bands of different resolutions [8], [9]. Whenever image is delivered decompositions of an image can be done at different DWT levels through series of low pass and high pass filters. This allows us to use higher energy watermarks in important regions that the HVS is known to be less sensitive to, such as the high resolution detail bands (LH,HL,HH). One Level DWT- Decomposition is given in Fig. 3.

It is globally well known fact that maximum energy of most of natural images is concentrated in 'approximate (LL) sub band' which is low frequency sub band. Hence modification to the coefficients of these low frequency sub bands would cause several and intolerable image deprivation. Therefore, we should not embed watermark in LL sub band. The good regions for embedding the copy right data in high frequency sub bands (vertical, horizontal and diagonal components). The generalized DWT based watermarking is shown in Figure 3. Actually, 'embedding' will include 'specific algorithmic steps' those are to be implemented in wavelet domain.

B) Digital Image Watermarking Algorithm Based on Discrete Cosine Transform

Discrete Cosine Transform or DCT is a most popular transform domain.

Cosine Transform: Let's suppose we have a cover image M having size SxS then DCT of the cover image can expressed as:

$$F_{(u,v)} = \sum_{i=0}^{S-1}\sum_{j=0}^{S-1} C_{(u)}C_{(v)}f_{(i,j)} \cos\left[\frac{\pi(2i+1)u}{2S}\right]\left[\frac{\pi(2j+1)v}{2S}\right]$$

$$f_{(i,j)} = \sum_{i=0}^{S-1}\sum_{i=0}^{S-1} C_{(u)}C_{(v)}\,F_{(u,v)} \cos\left[\frac{\pi(2i+1)u}{2S}\right]\left[\frac{\pi(2j+1)v}{2S}\right]$$

$$C_{(u)}C_{(v)} = \begin{cases} \sqrt{1/S}, u, v = 0 \\ \sqrt{2/S}, u, v = 1,2 \ldots S-1 \end{cases}$$

The DCT allows an image to be broken down into different frequency bands which are high, middle and low frequency bands. So it easier to choose the suitable band in which we are going to embed watermark. The literature survey deals mainly with middle frequency bands. The embedding of watermark in a middle frequency band does not spread out to the important visual important parts of the image i.e. the low frequencies. It does not overexpose them to remove through image compression and noise attacks where high frequency components are chosen [7].

There are various DCT based watermarking techniques. One such technique utilizes the comparison of middle-band DCT coefficients to embed a single bit into a DCT block [11]. FM is the middle-band frequency component of the 8x8 DCT block, FL is the lowest-band frequency component of the block, and FH is the higher-band frequency component. FM is chosen as the embedding region as to provide additional

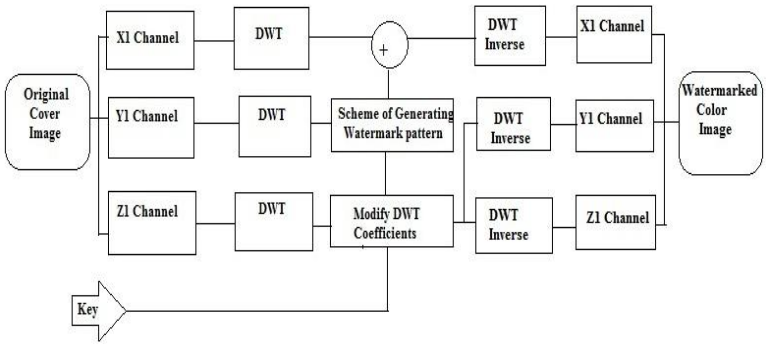

Fig. 4: Multichannel DWT Domain Watermark Embedding process [4]

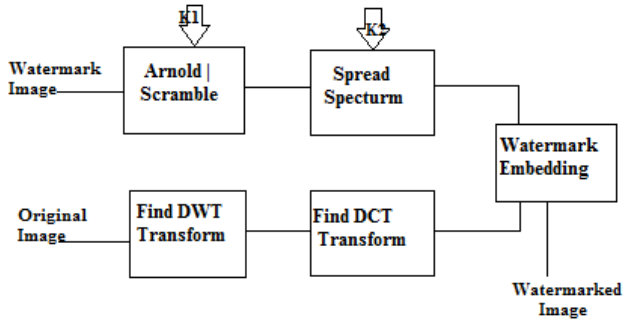

Fig. 5: Embedding Technique

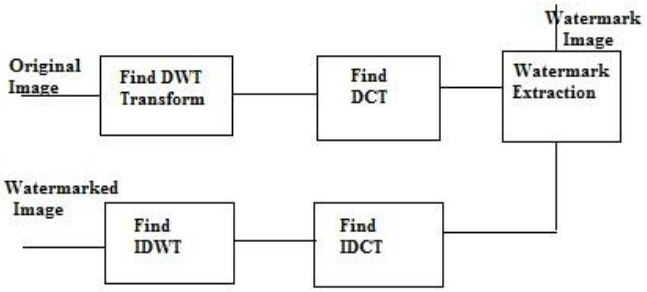

Fig. 6: Extraction Technique

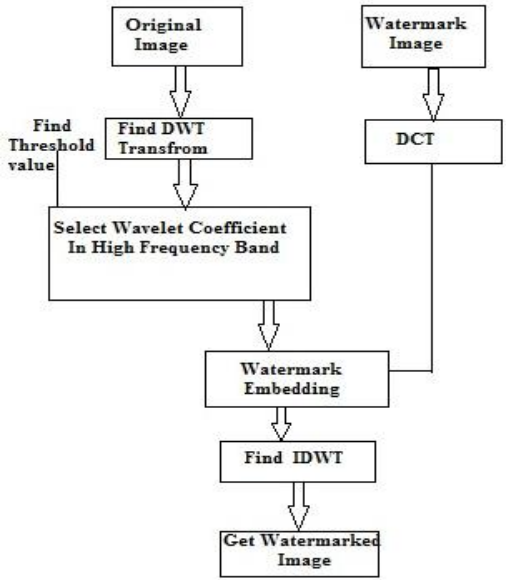

Fig. 7: Watermark Embedding Process

imperceptibility to lossy compression techniques, while avoiding significant modification of the cover image [7]. Then the extracted watermark bit will be considered 0, otherwise the extracted watermark bit will be considered 1.

C) A Color Image Multi-Channel Dwt Domain Watermarking

DWT based technique are most popular technique of image watermarking. In case of multi channel DWT domain scheme author introduce the concept of multi channel into DWT based scheme. It is also transformed domain scheme which

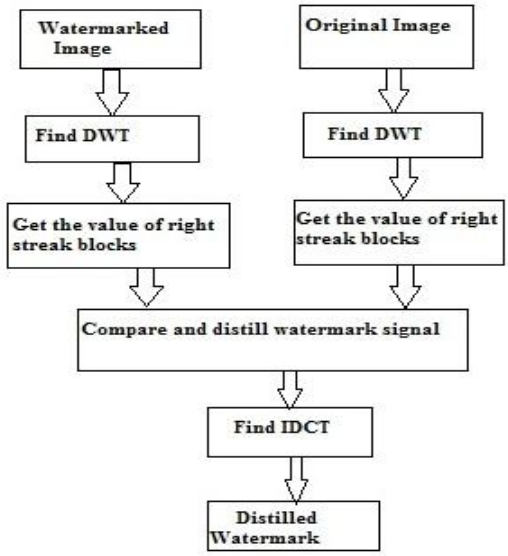

Fig. 8: Watermark Extraction Process

uses the DWT transform. In this scheme first we partition the cover image into three different channels X1, Y1, Z1 [5], [6]. After that we perform DWT transformation on these three channels.

Watermarking template is generated by transforming coefficients of DWT and chosen, HH frequency channels of Y1 and Z1. The generated watermark template is embedded into DWT coefficient's HH frequency channel of X1. As the channel which are used for generating watermarking pattern and the channel which will undergoes same geometric attacks. We first perform DWT transformation of three image channels X1, Y1 and Z1 respectively, and then get their HH frequency coefficients of these three channels.

$$X1_{hh} = \text{HH}\{\text{DWT}[X1]\}$$

$$Y1_{rhh} = \text{HH}\{\text{DWT}[Y1]\}$$

$$Z1_{bhh} = \text{HH}\{\text{DWT}[Z1]\}$$

D) A Digital Watermarking Algorithm Based On DCT and DWT

A discrete wavelet transform (DWT) digital watermarking technique is based on human vision characters. By using the block based image watermarking, signal is embedded into the HH, high frequency band of wavelet transformation domain. And before embedding watermark image, this watermark image is transformed using discrete cosine transform in order to improve its robustness.

The way of embedding watermark is shown in Fig. 5. It says that, first find the discrete cosine transform of watermark image and use these coefficients for inserting watermark. Now find the L level discrete wavelet transform of cover image. Then find the high frequency wavelet component. At last embed the DCT coefficient of watermark in the high frequency wavelet component of cover image. Find the inverse discrete wavelet transform and get the watermarked image.

In this paper, author has proposed a DWT-DCT based blind watermarking algorithm for protecting copyright. By using combination of the two transforms the watermarking performance can be improved as compare to DCT based watermarking approach. In this approach the watermark is scrambled and embedded in a spread spectrum pattern to improve the security and robustness. The embedded watermark first scrambled. In addition, after processing watermark by using scrambling algorithm, even if any attacker will detect the watermark signal, he would not be able to recover the original watermark without using scrambling algorithm. Arnold transform is used as scrambling method. In watermarking technique first apply discrete wavelet transformation to original image and chose LL sub-band at level 1. Divide this LL sub band into 8 x 8 blocks. Apply DCT to each block and then find mid band frequency coefficients. Then embedding is done as follows:

If watermark bit is 0 then

$$Y' = Y + \alpha * pn0$$

If watermark bit is 1 then

$$Y' = Y + \alpha * pn1$$

Where α is intensity factor of embedded.

In extraction procedure, first apply discrete wavelet transformation to original image and chose LL sub-band at level 1. Divide this LL sub band into 8 x 8 blocks. Apply DCT to each block and then find mid band frequency coefficients. Then calculate correlation between the mid band frequency coefficients and the pseudo random sequence pn0 and pn1. If the correlation with the pn0 is greater than the correlation with pn1:

The extraction of watermark process starts with reading of watermarked image. Perform DWT transform of the original image and the watermarked image by L-levels using DWT. And the data coefficients of the lowest frequency band LL and the high frequency band HH are obtained. The high frequency band coefficients of both DWT images are obtained. Now compare the both coefficients block by block and find difference. Then Find inverse discrete cosine transforms, and the watermark image is recovered.

V. CONCLUSIONS

This paper provides thorough outline of Digital Image Watermarking techniques. In Spatial domain as well as transform domains. The Transform domain based watermarking techniques are recommended to achieve robustness. This survey on different digital watermarking techniques shows different robustness level on different attacks. Spatial domain based technique (LSB technique) which is one the most popular technique of spatial domain image watermarking technique shows less robustness against different geometric attacks. Transformed domain techniques like DWT based watermarking techniques, DCT and DWT based composite watermarking technique, Multi channel DWT based technique are better than Spatial domain based technique.

IV. RESULTS AND DISCUSSIONS

Technique Used	**Attack**	**Robustness Level**
DWT-DCT based Watermarking For Copyright Protection	Blurring	High
	Scaled to half Size	High
	Resizing Of scaled image	Medium
	Scaling to 75% of original Image	High
	Cropping	Medium
Colour Image Multichannel DWT based image Watermarking	Blurring	Medium
	Scaled to half Size	Medium
	Resizing Of Scaled Image	Medium
	Scaling to 75% of original Image	High
	Cropping	Low
DCT Based Image Watermarking	Blurring	Medium
	Scaled to half Size	Medium
	Resizing of scaled Image	High
	Scaling to 75% of original Image	High
	Cropping	Medium
DWT Based Image Watermarking	Blurring	Medium
	Scaled to half Size	Medium
	Resizing Of scaled Image	Medium
	Scaling to 75% Of original Image	High
	Cropping	Low
LSB Based Image Watermarking	Blurring	Low
	Scaled to half Size	Low
	Resizing Of scaled Image	Low
	Scaling to 75% Of original Image	Low
	Cropping	Low

REFERENCES

[1]. Ibrahim, R. and Kuan, T. S., Steganography Imaging (SIS): Hiding Secret Message inside an Image. Proceedings of the World Congress on Engineering and Computer Science, San Francisco, USA, 2010.

[2]. YangQianli, CaiYanhong , "Digital Image Watermarking Algorithm Based on Discrete Wavelet Transform and Discrete Cosine transform," 2012 International Symposium on information Technology In Medicine and Education.

[3]. I. Cox, J. Killian, T. Leighton, T. Shamoon, "Secure Spread Spectrum Watermarking for Multimedia," IEEE Trans. Image Processing, Vol. 6, No. 12, pp. 1673-1687, 1997.

[4]. Jiang-Bin Zheng, ShaFeng, "A Color Image Multi-Channel DWT Domain Watermarking Algorithm For Resisting Geometric Attacks" Proceedings of Seventh International Conference on Machine learning and Cybernetics, Knnming,12-15 July 2008.

[5]. Zheng J.B., Feng D. D, Zhao R.C., "A Multi-channel framework for image watermarking," IEEE Proceeding of the 4th Int. Conf. on Machine Learning and Cyber, pp3096-3100, vol.4, 2005.

[6]. Wang Hongiun, Li Na," An algorithm of digital image watermarkindased on multiresolution wavelet analysis", International Workshop on VLSI Design and Video Technology, Proceedings, pp: 272-275, 28-30 May 2005.

[7]. JindongXu, Huimin pang, Jianping Zhao, "Digital Image Watermarking Algorithm Based on Fast Curvelet Transform", J. Software Engineering & Applications, 2010.

[8]. Baisa L. Gunjal, R.R Manthalkar, "An Overview of Transform domain Robust Image Watermarking Algorithms", Journal of Emerging Trends in Computing and Information Sciences" Volume 2 No.1 @2010-11 CIS Journal.

[9]. Tao, B. and Dickinson B., "Adaptive watermarking in the DCT domain," m IEEE Int. Conf. ASSP, 1997.

[10]. Song Qiang, Zhang Hongbin", Colour Image Self Embedding and Watermarking Based on DWT", 2010 International Conference on Measuring technology and Mechatronics Automation, pp: 978-0-7695-3962.

[11]. Chirag Sharma, Deepak Prashar, " DWT based robust technique of watermarking applied on Digital Images", International Journal of Soft Computing and Engineering (IJSCE),Volume-2,Issue-2,May 2012

[12]. Vikas Saxena, J.P Gupta "Towards increasing the Robustness of Image Watermarking Scheme against JPEG Compression" IMECS, Vol. II, pp 1903- 1906, Marc.

[13]. Falkowski, B.J., Lim, L.S., "Image Watermarking Using Hadamard Transforms", in IEE Electronics Letters, United Kingdom, vol. 36, no.3, pp. 211-213, February 2000.

[14]. P. Meerwald, and A. Uhl, "A Survey of Wavelet- Domain Watermarking Algorithm," in P.W. Wong and E.J. Delp, (eds.), Proceedings of Electronic Imaging 2001,Securityand Watermarking of Multimedia Contents III, San Jose, CA, pp. 505-515.,January 2001.

[15]. Mohamed A. Suhail, Mohammad S. Obaidat, "Digital Watermarking-Based DCT and JPEG Model", IEEE Transactions on Instrumentation and Measurement, Vol. 52, No. 5, October 2003.

[16]. Tao, P., Eskicioglu, A.M., "A Robust Multiple Watermarking Scheme in the Discrete Wavelet Transform Domain", in Symposium on Internet Multimedia Management Systems, Philadelphia, PA. October 25-28, 2004.

[17]. Lee, C., Lee, H., "Geometric attack resistant watermarking in wavelet transform domain," in Optics Express vol. 13, no. 4, pp. 1307-1321 2005.

[18]. Z .Zhang, H. Wei and J. Zhang, 2006 "Digital image watermark algoritm in the curvelet domain" International Conference on Intelligent Information Hiding and Multimedia pp.105-108

[19]. E. J. Candes, L. Demanet and D. L. Donoho, "Fast Discrete Curvelet Transforms [R]", Applied and Computational Mathematics, pp. 1-43, 2005.

[20]. T. D. Hien, K. Miyara, I. Kei and F. F. Ali, "Digital Watermarking Based on Curvelet Transform", 9th International Symposium on Signal Processing and Its Applications, Sharjah, pp. 1-4, Feb 2007.

[21]. H. Y. Leung, L. M. Cheng and L. L. Cheng. "A Robust Watermarking Scheme Using Selective Curvelet Coefficients," International Conference on Intelligent Information Hiding and Multimedia Signal Processing, Harbin, pp. 465-468, August 2008.

[22]. D. L. Donoho and M. R. Duncan, "Digital Curvelet Transform: Strategy, Implementation and Experiments," Proceeding of the SPIE on Wavelet Application VII, Orlando, 2000, pp. 12-30.