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Implementation of Adaptive Digital Image Watermarking Technique in Discrete Wavelet Transform for Copyright Protection

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ABSTRACT: Digital watermarking is used for content protection, content authentication, copyright management and tamper detection. With the use of sophisticated signal / image processing algorithms, manipulations and duplications of audio, images and videos is much easier. Hence copyright of the content has become an urgent and important issue in this world. In this paper, digital image watermarking technique based on discrete wavelet transform and encryptionis proposed. Watermark embedding procedure algorithm using DWT coefficients, scaling factor and scrambling matrix is proposed. The technique results in PNSR greater than 50 dB and is resistance to noise, geometric and compression attack. The proposed technique may be applied for copyright and content authentication applications.

KEYWORDS: Image Watermarking, Discrete Wavelet Transform, Encryption, PSNR, Copyright Protection.

I. INTRODUCTION

The growth of high speed computer networks and World Wide Web (WWW) have explored means of new business, scientific, entertainment and social opportunities in the form of electronic publishing and advertising, massaging, real-time information delivery, data sharing, collaboration among computers, product ordering, transaction processing, digital repositories and libraries, web newspapers and magazines, network video and audio, personal communication and lots more. The cost effectiveness of selling software's in the form of digital images and video sequences by transmission over WWW is greatly enhanced due to the improvement in technology. Digital data can be stored efficiently and with a very high quality, and it can be manipulated very easily using computers. Furthermore, digital data can be transmitted in a fast and inexpensive way through data communication networks without losing quality. Digital media offer several distinct advantages over analog media. The quality of digital audio, images and video signals are higher than that of their analog counterparts. Editing is easy because one can access the exact discrete locations that need to be changed. Copying is simple with no loss of fidelity. A copy of a digital media is identical to the original.

With digital multimedia distribution over World Wide Web, authentications are more threatened than ever due to the possibility of unlimited copying. For digital data, copyright enforcement and content verification are very difficult tasks. One solution would be to restrict access to the data using some encryption techniques. However, encryption does not provide overall protection. Once the encrypted data are decrypted, they can be freely distributed or manipulated. Steganography deals with the methods of embedding data within a medium (host or cover medium) in an imperceptible way. All forms of digital data (still images, audio, video, text documents and multimedia documents) can be used as a cover medium for information hiding. Steganography is an area which is, more or less, a Hide-&-Seek game. Some important data or information is hidden in another medium. The cover medium has no relationship with the data or information hidden. Data or information which is hidden is not encrypted also [1]-[3]. The key issue in a steganography system becomes that no one should suspect that a particular medium is carrying any hidden data or information. We can extend the steganography concept for the authentication of digital multimedia data. Digital multimedia data which has to be protected is now the cover medium and then we can hide the copyright data into it. Characteristics of

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Watermarking Schemes [3] are imperceptibility, robustness, fragility, resilient to common signal processing operations, resilient to geometric operations, robust to subterfuge attacks and unambiguousness. Applications of Watermarking Techniques [3] are copyright protection, copy protection, temper detection, broadcast monitoring, fingerprinting and annotation applications.

Watermarking techniques can be categorized as spatial watermarking can also be applied using colour separation. In this way, the watermark appears in only one of the colour bands. This renders the watermark visibly subtle such that it is difficult to detect under regular viewing. However, the mark appears immediately when the colours are separated for printing. This renders the document useless for the printer unless the watermark can be removed from the colour band. This approach is used commercially for journalists to inspect digital pictures from a photo-stock house before buying unmarked versions. Watermarking can be applied in the frequency domain (and other transform domains) by first applying a transform like the Fast Fourier Transform (FFT) [4] – [6]. DCT based watermarking techniques are more robust compared to simple spatial domain watermarking techniques. Such algorithms are robust against simple image processing operations like low pass filtering, brightness and contrast adjustment, blurring etc. 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.

In this paper, digital image watermarking based on discrete wavelet transform and encryption is proposed. Watermark embedding algorithm is devised and results show better PSNR and resistance to attack. The paper is organized as section 2 describes the embedding and extraction algorithm, section 3 illustrates results and concluded in section 4.

II. WATERMARK EMBEDDING AND EXTRACTION ALGORITHM

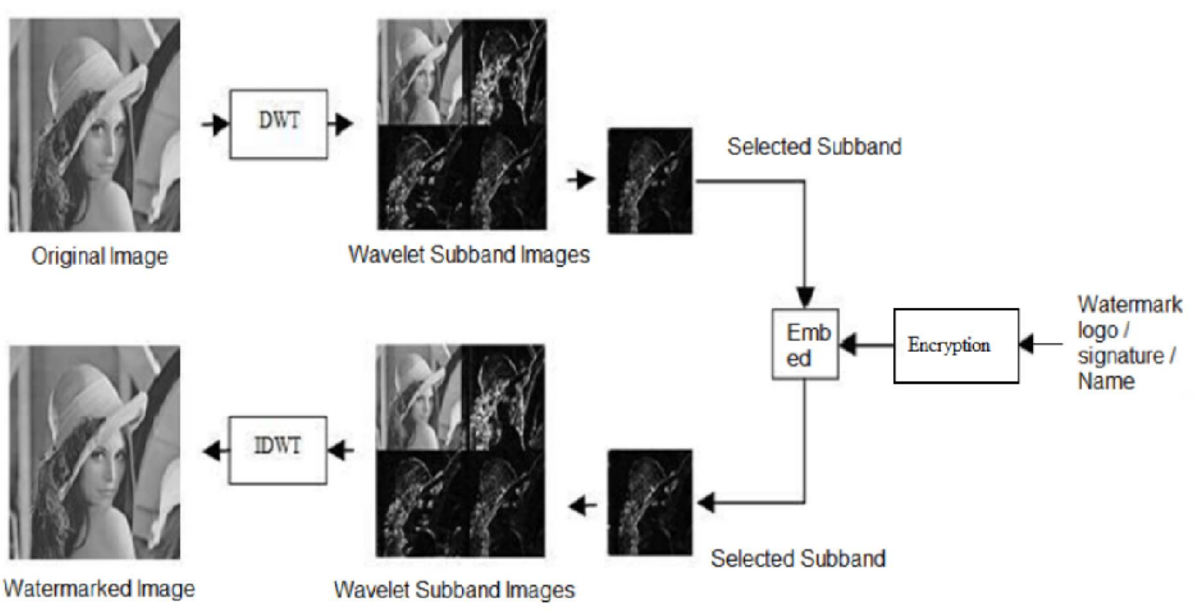

Fig. 1 Watermark embedding procedure

In the last few years wavelet transform has been widely studied in signal processing in general and image compression in particular. In some applications wavelet based watermarking schemes outperforms DCT based approaches. The wavelet transform decomposes the image into three spatial directions, i.e. horizontal, vertical and diagonal. Hence wavelets reflect the anisotropic properties of HVS more precisely [2]. Wavelet Transform is computationally efficient and can be implemented by using simple filter convolution [7] [8]. Magnitude of DWT coefficients is larger in the lowest bands (LL) at each level of decomposition and is smaller for other bands (HH, LH, HL) [1] [5] [6]. The larger the magnitude of the wavelet coefficient the more significant it is. Watermark detection at lower resolutions is computationally effective because at every successive resolution level there are few frequency bands involved [5]. High

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resolution subbands helps to easily locate edge and textures patterns in an image [1]. Figure 1 shows the method adopted for watermarking images. Wavelet coefficients of watermark image were encrypted using rows and columns rotations using random number generator. It increases security of watermark in case of removal of watermark from the original image [9] – [12]. Watermark was embedded using scrambling matrix as shown in figure 2.

$$z = \begin{vmatrix} 1 - alpha & 0 \\ 0 & alpha \end{vmatrix} \begin{vmatrix} x \\ y \end{vmatrix}$$

Fig. 2 Scrambling matrix

Where alpha is visibility coefficient and x is carrier image DWT coefficients & y is watermark image DWT coefficients. Watermark extraction is the reverse process of embedding. Wavelet coefficients of the watermark image were extracted using equation shown in fig. 3.

$$z = \begin{vmatrix} alpha - 1 & 0 \\ 1 / alpha & 0 \end{vmatrix} \begin{vmatrix} x \\ y \end{vmatrix}$$

Fig. 3 Descrambling matrix

Where alpha is visibility coefficient and x is watermarked image DWT coefficients & y is original image DWT coefficients. Watermark extraction procedure is illustrated in fig. 4.

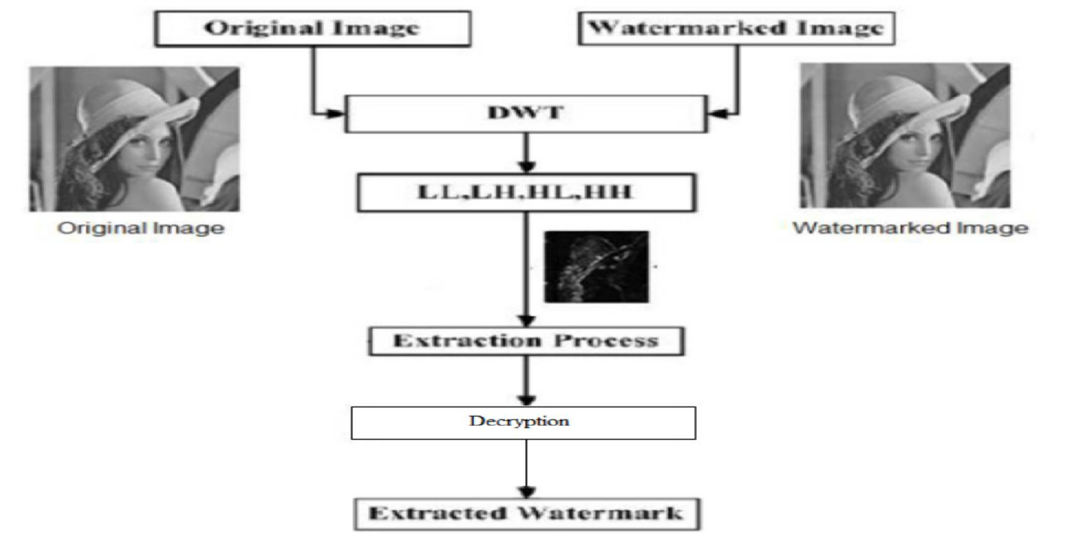

Fig. 4 Watermark extraction

III. RESULTS & DISCUSSION

Watermark embedding and extraction algorithm was implemented using MATLAB software and executed on intel i5 processor with 1 GB RAM and 3 GHz processing speed. Table 1 shows the results obtained for various input and watermark images. Algorithms show consistent values of PSNR and CC for all types of images. Fig. 5 shows the watermarks used in algorithms.

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Table 1 Watermark parameters

Parameter	Water mark	Lena	Complex	Baboon	Car	Fruits
MSE	Apple	0.22	0.22	0.23	0.21	0.17
	Rings	0.17	0.16	0.18	0.21	0.16
	Name	0.22	0.25	0.25	0.23	0.24
PSNR	Apple	54.66	54.69	54.38	54.77	55.67
	Rings	55.81	55.9	55.54	54.85	56.04
	Name	54.69	54.01	54.06	54.48	54.31
CC	Apple	0.99	0.98	0.98	0.99	0.99
	Rings	0.99	0.99	0.99	0.99	0.99
	Name	0.98	0.98	0.98	0.98	0.98

(a) Apple (b) Rings (c) Name

Fig. 5 Watermark images

Where PSNR is peak signal to noise ratio, mse is mean square error and CC is correlation coefficients. All the parameters were also obtained by affecting images using various attacks such as noise, geometrical and compression. Table 2 shows the watermark parameters obtained with attack. Fig. 6 and 7 shows the complete results obtained after watermark embedding and extraction algorithm for two watermarks. Fig. 8 shows the results for watermark using noise attack. Obtain results validate the concept of watermark embedding and extraction. Wavelet transform provides better embedding and extraction procedure.

Table 2 Watermark parameters with attack

Parameter	Lena			Baboon		
	Noise	Geometric	Compression	Noise	Geometric	Compression
MSE	0.24	0.22	0.23	0.23	0.22	0.21
PSNR	54.31	54.63	54.23	54.41	54.48	54.74
CC	0.98	0.99	0.99	0.98	0.99	0.98

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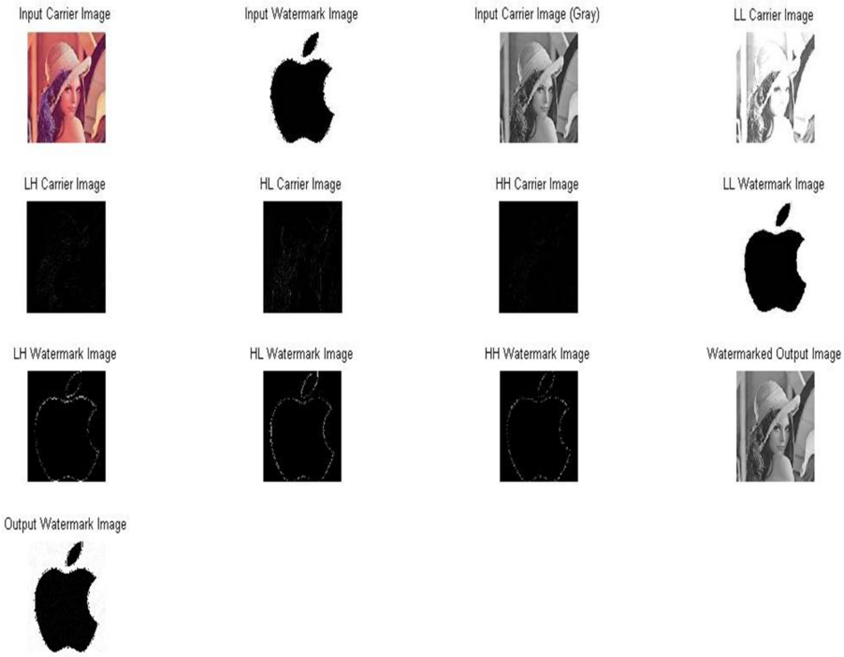

Fig. 6 Watermark algorithm results with watermark apple

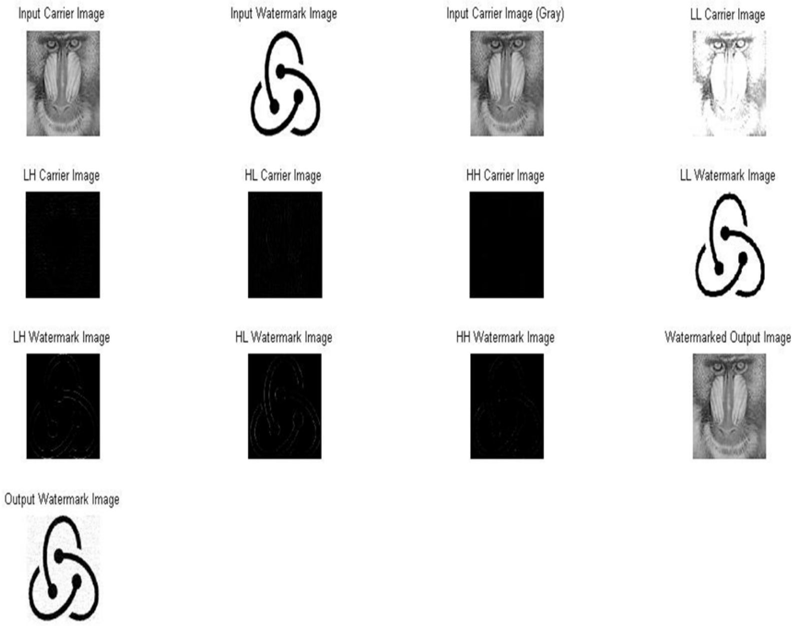

Fig. 7 Watermark algorithm results with watermark ring

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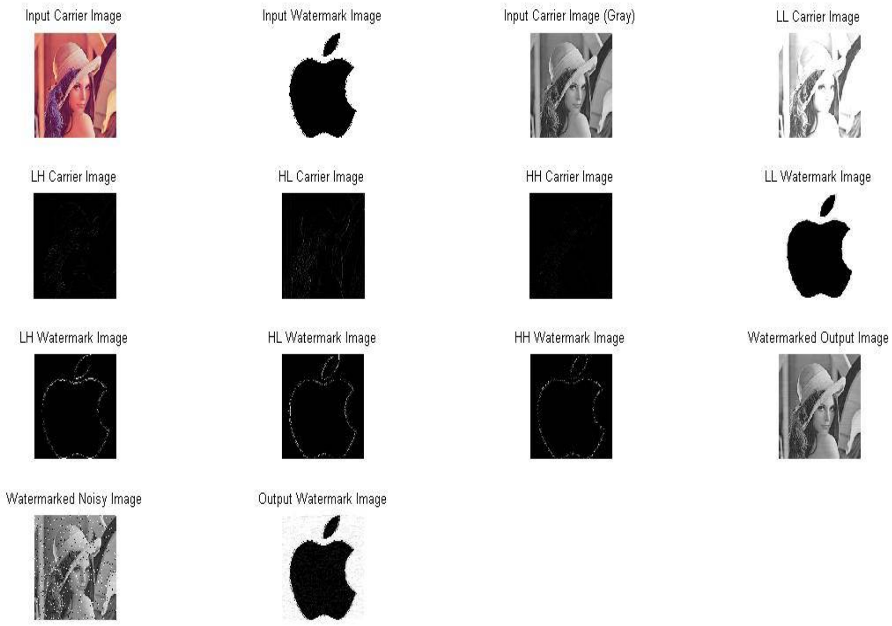

Fig. 8 Watermark algorithm results after noise attack (salt and pepper noise)

IV. CONCLUSION

More robust watermarks could be embedded in the transform domain of images by modifying the transform domain coefficients than spatial domain. Wavelet Transform is computationally efficient and can be implemented by using simple filter convolution. Wavelet coded image is a multi-resolution description of image. Hence an image can be shown at different levels of resolution and can be sequentially processed from low resolution to high resolution. Proposed watermark embedding and extraction algorithm results better PSNR of greater than 50 dB and correlation coefficients of greater than 0.97. Moreover, MSE, PSNR and CC these three parameters are closely related to a pattern of watermarking images so any modification of one of these factors influences directly the others. Watermarking algorithms robust against the geometrical distortions have been the focus of further research.

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