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Comparative Study of DWT and DWT-SVD Image Watermarking Techniques

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Abstract – Digital image watermarking is hiding information in any form (text, image, audio and video) in original image without degrading its perceptual quality. Watermarking is done for copyright protection of the original data. In this paper, we have done a comparative study of two most recent techniques used in digital image watermarking; they are DWT and hybrid DWT-SVD. Both these techniques are very much robust and imperceptible. In case of DWT, decomposition of the original image is done to embed the watermark and in case of hybrid DWT-SVD firstly image is decomposed according to DWT and then watermark is embedded in singular values obtained by applying SVD. Here, the techniques are compared on the basis of PSNR value at different values of scaling factor, high value of PSNR is desired as it shows good imperceptibility of the technique.

Keywords – Watermarking, DWT (Discrete Wavelet Transform), SVD (Singular Value Decomposition), PSNR (Peak Signal to Noise Ratio).

I. Introduction

Now-a-days use of internet is increasing day by day. With the rapid advancement in technology, speed of data over networks has crossed the bars. There is urgent need to preserve the copyright of individual's creation, which is done by using digital image watermarking. There has been significant interest in watermarking in recent years mainly because of two reasons, one is digitization of documents and second is rapid and untroubled traffic over internet. Digital data offers many advantages and new potentials to the user. Digitized documents can easily be manipulated thus, losing its originality. In result of that watermarking techniques came in light [1]. To identify the owner of the image and to solve the problem of its ownership, digital image watermarking is required. Watermarking is a technique in which the original image also known as cover image is modified according to a watermark image. Certain characteristics of the cover image are altered in order to hide the data used for the identification of the owner of the original content. Cover image and watermark image are passed through any one of the watermarking technique and in result watermarked image is obtained.

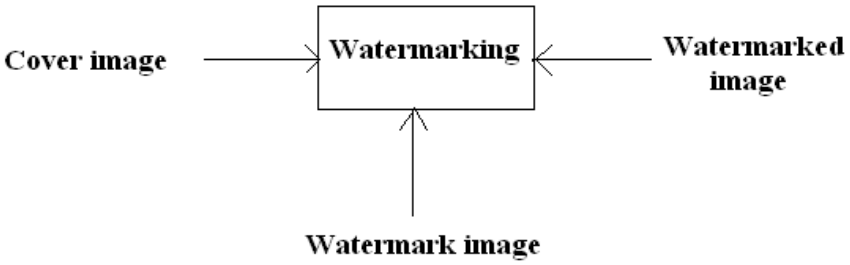

Fig.1 Block diagram of watermarking

There are numerous digital image watermarking techniques in various domains which are broadly categorized as [2]:

1. Spatial domain based watermarking techniques
2. Transform domain based watermarking techniques

Spatial domain based watermarking techniques are rarely preferred over transform domain based watermarking techniques because the watermark placed by them can be easily destroyed and modified by the attackers. Although in transform domain based techniques there are various other techniques available like DFT (Discrete Fourier Transform), DCT (Discrete Cosine Transform), but they have various pitfalls like less robustness (cannot withstand different types of attacks), less imperceptibility (degrades the perceptual quality of the original image) due to which we are considering DWT and hybrid

DWT-SVD techniques only, as they overcome all the pitfalls of earlier mentioned techniques. A comparison between such two techniques is given in the following text.

II. Discrete Wavelet Transform (Dwt)

Wavelet domain is a promising domain for watermark embedding. Wavelet refers to small waves. Discrete Wavelet Transform is based on small waves of limited duration and varying frequency [3]. This is a frequency domain technique in which firstly cover image is transformed into frequency domain and then its frequency coefficients are modified in accordance with the transformed coefficients of the watermark and watermarked image is obtained which is very much robust. DWT decomposes image hierarchically, providing both spatial and frequency description of the image [4]. It decompose an image in basically three spatial directions i.e, horizontal, vertical and diagonal in result separating the image into four different components namely LL, LH, HL and HH. Here first letter refers to applying either low pass frequency operation or high pass frequency operations to the rows and the second letter refers to the filter applied to the columns of the cover image [5].

- LL level is the lowest resolution level which consists of the approximation part of the cover image,
- Rest three levels i.e., LH, HL, HH give the detailed information of the cover image.

For second level of decomposition any one sub-band is selected and is further decomposed into four levels. Maximum the level of decomposition, maximum will be the robustness of the watermarked image. At every level of decomposition, the magnitude of DWT coefficients is larger in lower bands (LL), and is smaller in other three bands (LH, HL, and HH). Larger magnitude of wavelet coefficients shows their higher significance in comparison with the wavelet coefficients of smaller magnitude [6]. HVS (Human Visual System) is more sensitive to the low frequency parts (the LL sub-band), so watermark is preferably placed in other three sub-bands to retain the quality of original image.

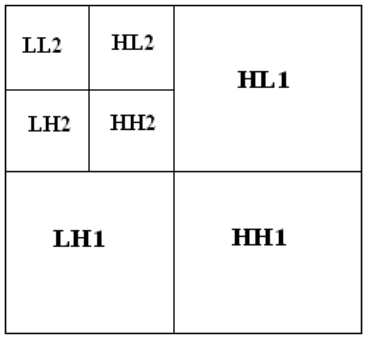

Fig.2 Two-level DWT

Algorithm for carrying out DWT:

Step1. Original image is decomposed in various sub-bands using DWT, in this paper two-level DWT is use.
Step2. Sub-band suitable for embedding watermark is chosen.
Step3. Wavelet coefficients of the selected sub-band are modified according to the watermark image.
Step4. After embedding watermark, watermarked image is obtained.

III. Singular Value Decomposition (Svd)

Singular Value Decomposition transform is a linear algebra transform which is used for factorization of a real or complex matrix with numerous applications in various fields of image processing [7]. As a digital image can be represented in a matrix form with its entries giving the intensity value of each pixel in the image, SVD of an image M with dimensions m x m is given by:

$$M = USV^T$$

Where, U and V are orthogonal matrices and S known as singular matrix is a diagonal matrix carrying non-negative singular values of matrix M.

The columns of U and V are called left and right singular vectors of M, respectively. They basically specify the geometry details of the original image. Left singular matrix i.e., U represents the horizontal details and right singular matrix i.e., V represents the vertical details of the original image. The diagonal values of matrix S are arranged in decreasing order which signifies that importance of the entries is decreasing from first singular value for the last one, this feature is employed in SVD based compression techniques.

There are two main properties of SVD to employ in digital watermarking schemes [8]:

1. Small variations in singular values does not affect the quality of image and,
2. Singular values of an image have high stability so; they do not change after various attacks.

IV. Hybrid Dwt-Svd

Hybrid technique is a fusion of two techniques. Here, DWT and SVD are used together to improve the quality of the watermarking. Advantages of both these techniques are employed in this. DWT and SVD are novel techniques used for watermarking so their fusion makes a very attractive watermarking technique.

Algorithm for hybrid DWT-SVD technique is [9]:

Step1. Using DWT the cover image is decomposed into various sub-bands depending on the level of decomposition used, here two-level decomposition is used.

Step2. Choose a sub-band in which desired watermark is to be embedded keeping in mind various properties of the sub-bans and HVS.

Step3. Apply SVD in the selected sub-band.

Step4. Modify the singular values of that particular sub-band with respect to the watermark image

Step5. After modification, inverse DWT of the image is taken which in result will give the watermarked image.

V. Experimental Results

To evaluate and compare the performance of two techniques i.e., DWT and DWT-SVD two parameters are taken into consideration. These parameters are given by [10]:

$$MSE = \frac{1}{MN} \sum_{i=1}^{M} \sum_{j=1}^{N} [I(i,j) - I'(i,j)]^2$$

Where, *MSE* is mean square error,

M x N is the dimension of the images,

I (i, j) is the original image,

I' (i, j) is the watermarked image.

Using the value of mean square error, PSNR (Peak Signal to Noise Ratio) for the images is calculated which gives the ratio of required signal to the noise content in the watermarked image. PSNR is calculated by the formula:

$$PSNR = 10 \log_{10} [\frac{255^2}{MSE}]$$

To carry out the experiments MATLAB R2010a software is used. Results obtained are:

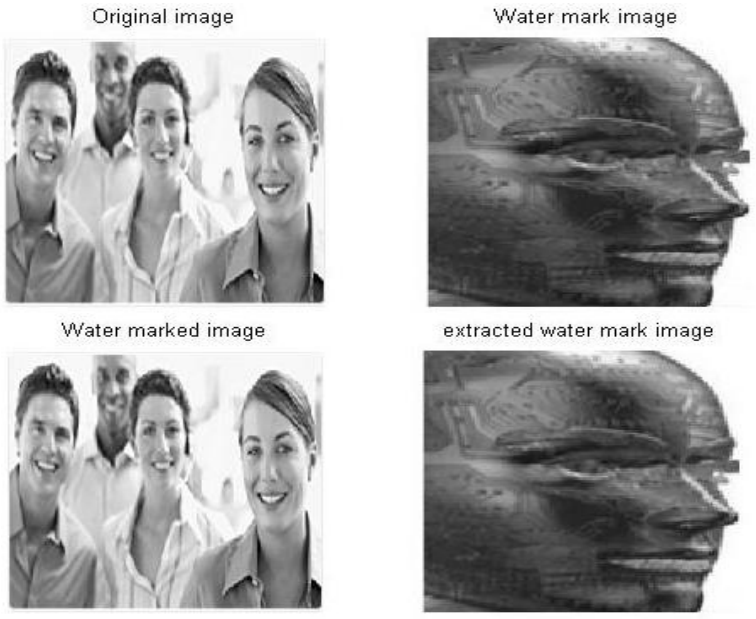

Fig.3 Images used in the evaluation of results

TABLE I
COMPARISON BETWEEN THE PSNR'S OF THE TWO TECHNIQUES

Value of Scaling Factor	Value of PSNR	
(C)	DWT	DWT-SVD
0.01	43.63	76.2096
0.02	37.58	60.8586

0.03	34.08	52.6066
0.04	31.57	49.4157
0.05	29.64	45.9157
0.06	28.04	43.1116
0.07	26.71	40.8654

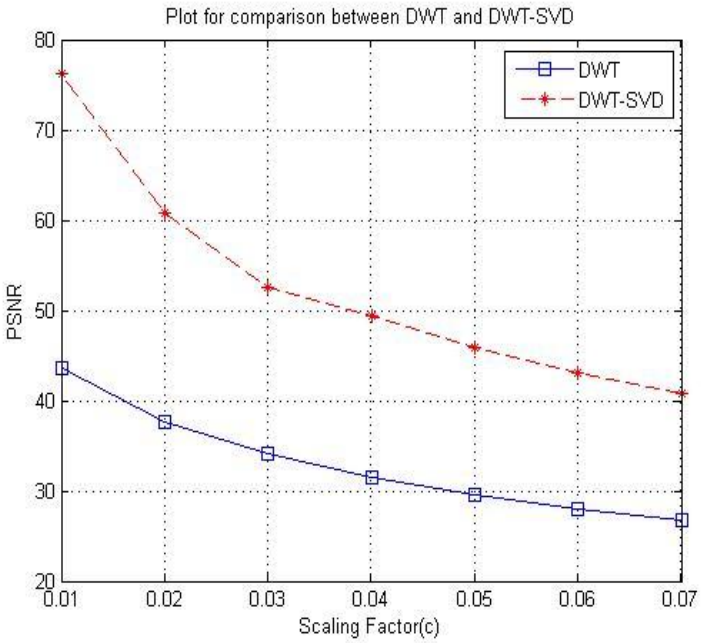

Fig.4 Graph plot for comparison between the two techniques

VI. Conclusion

On comparing the values of PSNR at different values of scaling factor C, it is concluded that the hybrid technique DWT-SVD is much better than DWT technique. As at every value of scaling factor, value of peak signal to noise ratio is more in case of the hybrid technique. Less the value of PSNR more will be the degradation in the quality of the original image. This shows that after watermarking, the quality of original image degrades more when DWT technique is used for embedding the watermark in comparison with DWT-SVD technique embedding.

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