DCT-DWT Digital Image Watermarking

Under the Guidance of **Dr. Dugesh Singh**

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1. Abstract

The proliferation of digitized media due to the rapid growth of networked multimedia systems, has created an urgent need for copyright enforcement technologies that can protect copyright ownership of multimedia objects. The commonly present disadvantages in traditional watermarking techniques such as inability to withstand attacks are absent in SVD based algorithms. They offer a robust method of watermarking with minimum or no distortion. DCT based watermarking techniques offer compression while DWT based compression offers scalability. Thus all the three desirable properties can be utilized to create a new robust watermarking technique. In this project, we propose a method of non-blind transform domain watermarking based on DWT-DCT-SVD. This method of watermarking is found to be robust and the visual watermark is recoverable without only a reasonable amount of distortion even in the case of attacks. Thus the method can be used to embed copyright information in the form of a visual watermark or simple text.

2. Introduction

The development of effective digital image copyright protection methods have recently become an urgent and necessary requirement in the multimedia industry due to the ever-increasing unauthorized manipulation and reproduction of original digital objects. In all frequency domain (DWT, DCT, etc) watermarking schemes, there is a conflict between robustness and transparency. If the watermark is embedded in perceptually most significant components, the scheme would be robust to attacks but the watermark may be difficult to hide.

Recently, Singular Value Decomposition (SVD) was explored for watermarking. The SVD was originally developed by geometers, who wished to determine whether a real bilinear form could be made equal to another by independent orthogonal transformations of the two spaces it acts on.

A. Discrete Wavelet Transform (DWT)

DWT is a partial transform and has the ability to multiscale analysis. The original image is decomposed into four sub-band images by DWT: three high frequency parts (HL, LH and HH, named detail sub-images) and one low frequency part (LL, named approximate sub-image). The detail sub-images contain the fringe information while the approximate sub-image is the convergence of strength of original image. Relative to the detail sub-images, approximate sub-image is much more stable, since the majority of image energy concentrates here. Therefore, watermark is embedded into approximate sub-image to gain better robustness.

B. Discrete Cosine Transform (DCT)

The discrete cosine transform (DCT) helps separate the image into parts (or spectral sub-bands) of differing importance (with respect to the image's visual quality). The DCT is similar to the discrete Fourier transform: it transforms a signal or image from the spatial domain to the frequency domain. It has been widely used because of its good capacity of energy compression and decorrelation. DCT is faster than DFT because its transform kernel is real cosine function while it is complex exponential in DFT

C. SINGULAR VALUE DECOMPOSITION

In linear algebra, the singular value decomposition (SVD) is an important factorization of a rectangular real or complex matrix, with several applications in signal processing and statistics. The spectral theorem says that normal matrices can be unitarily diagonalized using a basis of eigenvectors. The SVD can be seen as a generalization of the spectral theorem to arbitrary, not necessarily square, matrices. One advantage of SVD-based watermarking is that there is no need to embed all the singular values of a visual watermark.

Depending on the magnitudes of the largest singular values, it would be sufficient to embed only a small set. This SVD property can be exploited to develop algorithms for lossy image compression.

DWT-DCT-SVD BASED WATERMARKING

This method utilizes the wavelet coefficients (DWT) of the cover image to embed the watermark. Any of the four sets of wavelet coefficients can be used to watermark the image. The DCT coefficients of the wavelet coefficients are calculated and singular values decomposed. Similarly svd procedure is applied to the watermark also. The singular values of the cover image and watermark are added to form the modified singular values of the watermarked image. The modified DCT coefficients form the singular value decomposition triangular matrices. Then the inverse DCT transform is applied followed by the inverse DWT. This is the algorithm that clubs the properties of SVD, DCT and DWT. This is a technique that has never been used before. Watermark embedded using this algorithm is highly imperceptible. This scheme is robust against all sorts of attacks. It has very high data hiding capacity.

3. Literature Survey

1. **Prior Research**

   Many different image watermarking methods have been proposed to enhance the security of these images

   - Manpreet Kaur et al [1] present the comparison between various watermarking techniques, describing uses and the limitation of each technique. This paper presents a study of the various image watermarking techniques for the protection of the data.
   - Chaturvedi et al. [2] this paper compares the digital image watermarking methods DWT and DWT-DCT on the basis of PSNR and concluded that DWT-DCT method is the best technique for level one watermark embedding.
   - Hai Tao et al [3] this paper presents the analysis and the performance of the watermarking system in the transform and the geometric domain invariant region. The basic attributes of the watermarking are taken into consideration.

2. Proposed Methodology

The watermarking embedding process is divided into 8 steps and is briefly described as follows,

Step 1: We resize the cover image(I) to 512x512 and watermark image(W) to 256x256.

Step 2: This method utilizes the wavelet coefficients (DWT) of the cover image to embed the watermark.

Step 3: Any of the four sets of wavelet coefficients can be used to watermark the image. Here, we use the LL coefficient. We calculate it's DCT followed by SVD to get the matrices as U_3,S_3,V_3^t, where U_3 and V_3 are orthogonal matrices and S_3 is diagonal matrix.

Step 4: Similarly, we apply SVD to the watermarking image to get matrices as U_w,S_w,$V^t{}_w$.

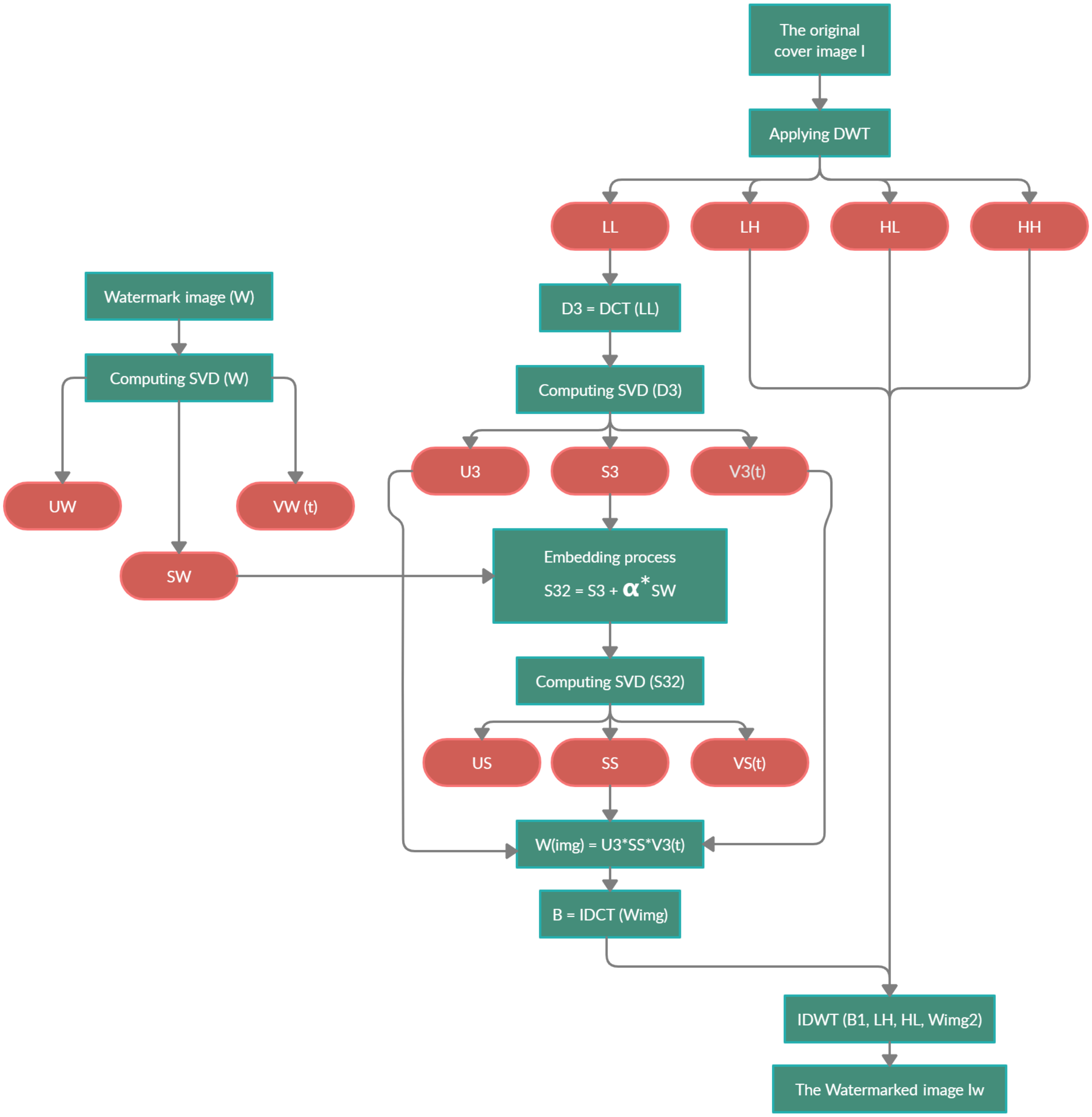
Step 5: The diagonal matrices (S_3 and S_w) obtained are modified as: S_{32}=S_3+alpha*S_w, where alpha(**α**) is a constant which is set to 10 in the code.

Step 6: Perform the SVD again of the matrix S_{32} to obtain the diagonal matrix, S_s.

Step 7: Multiply the modified S_s with the orthogonal matrices obtained from taking SVD of LL coefficient(U_3 and $V^t{}_3$) as U_3* S_s* $V^t{}_3$.

Step 8: At last, on applying IDCT followed by IDWT on the obtained matrix, we finally obtained our watermarked Image(I_w).

The below flowchart shows how the code is working:



4. Experimental Result

The performance evaluation of the proposed scheme is evaluated using Peak Signal to Noise Ratio (PSNR).The PSNR block computes the peak signal-to-noise ratio, in decibels, between two images. This ratio is used as a quality measurement between the original and a compressed image. The higher the PSNR, the better the quality of the compressed, or reconstructed image. The mean-square error (MSE) and the peak signal-to-noise ratio (PSNR) are used to compare image compression quality. PSNR represents a measure of the peak error. The lower the value of MSE, the lower the error.

$$\begin{aligned} PSNR &= 10 \cdot \log_{10}\left(\frac{MAX_I^2}{MSE}\right) \\ &= 20 \cdot \log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right) \end{aligned}$$

Here, the PSNR value for both DWT and DWT-DCT-SVD is evaluated as shown:

We can see that the image is not much disturbed on embedding watermark via DWT-DCT-SVD from the given values of PSNR. Higher the PSNR, the better it's quality. We can observe that for the 1st figure, on using only DWT, the PSNR score is 59.306 and on using DWT-DCT-SVD, the score increases to 79.3433. Likewise, for the 2nd figure, using only DWT gets the score of59.092 and combining DWT-DCT-SVD, the score increases to 79.3433.

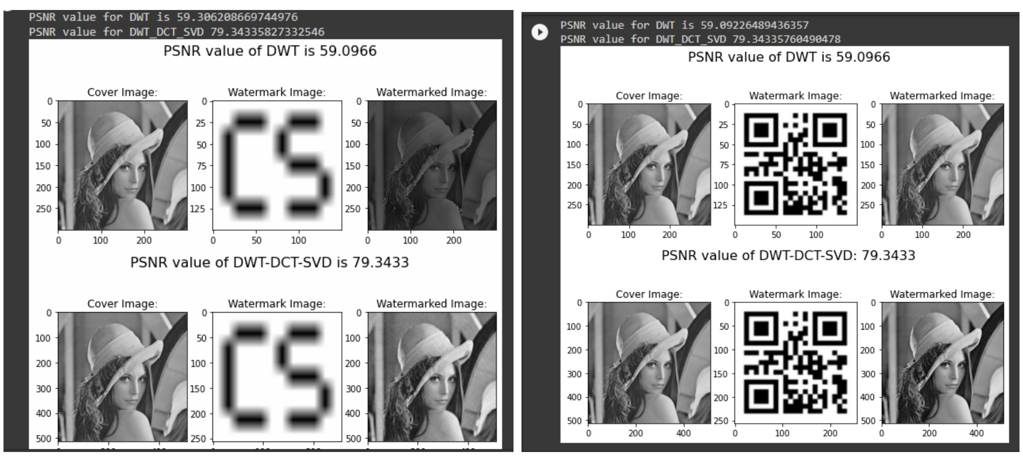


Figure: Essential information observed during watermark embedding

5. Conclusion

In this project, a novel approach of watermarking based on DWT-DCT-SVD is suggested.This method when compared with DWT algorithm gave better PSNR value.So the algorithm has a good performance on imperceptibility. The new method was found to satisfy all the requisites of an ideal watermarking scheme such as imperceptibility.

6. Reference

[1] Manpreet Kaur (2014), “Review Paper on Digital Image Watermarking Technique for Robustness “International Journal of Advanced Research in Computer Science and Software Engineering, Volume 4, Issue 5, Pp 948-952.

[2] Chaturvedi Navnidh (2012)i “Comparison of Digital Image watermarking methods DWT and DWT-DCT on the basis of PSNR,” International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET), Vol. 1, Issue 2,Pp 147 -153.

[3] Hai Tao(2014), “Robust Image Watermarking Theories and Techniques: A Review “Journal of Applied Research and Technology, Volume 12, Issue 1, Pages 122–138.