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RESEARCH ARTICLE

Analysis of Robustness of Hybrid Digital Image Watermarking Technique under Various Attacks

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Abstract— ***Protection of digital multimedia content has become an increasingly important issue for content owners and service providers. As watermarking is identified as a major technology to achieve copyright protection, the relevant literature includes several distinct approaches for embedding data into a multimedia element (primarily images, audio, and video).Digital watermarking is the process of embedding information into digital multimedia content such that the information can later be extracted or detected for a variety of purposes including copy prevention and authentication proof. In this paper, we propose a method of non-blind transform domain watermarking based on DWT-DCT-SVD The parameters used to test the robustness of the proposed algorithm are the Peak Signal to Noise Ratio (PSNR) and Weighted Peak Signal to Noise Ratio (WPSNR) and correlation coefficient (ρ). The experimental results show that the proposed method is more robust against different kinds of attacks and the watermarked image has good transparency.***

Key Terms: - Digital watermarking; Discrete Cosine Transform; Discrete Wavelet Transform; singular value decomposition; Peak Signal to Noise Ratio; Mean squared Error; correlation coefficient.

I. INTRODUCTION

Watermarking is the process of embedding data called a watermark (also called digital signature) into the multimedia object such that watermark can be detected or extracted later to make an assertion about the object [1,2].The object may be an audio ,image or video .a simple example of digital watermark would be a visible "seal" placed over an image to identify the copyright. However the watermark might contain additional information including the identity of the purchaser of a particular copy of the object. Based on the purpose of the watermark, it is embedded either visibly or invisibility [2].

Fundamentally, the procedure of digital watermarking can be delineated as a method for embedding information into another signal (a digital signal). In case of digital images, the embedded information can be either visible or hidden from the user. In this project, we will concentrate on imperceptible watermarks .The principal intention of digital watermarks is to provide copyright protection for intellectual property that is in digital format [3]. Typical usage scenarios for watermarking are such as copyright protection and data authentication.

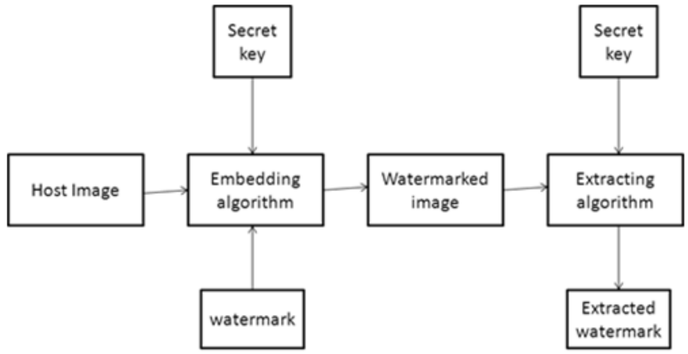

Fig. 1 Digital Watermarking System

The embedding and detecting procedure for watermarking technique based on DCT-DWT-SVD Computing PSNR function (peak single-to-noise ratio) and WPSNR for purpose of measuring the distinctive distortion between the watermark image and the extracted watermark image.[5]Applying the checkmark software by means of MSE function for the original watermarks and extracted watermarks.

II. DCT BASED WATERMARKING

The discrete cosine transform (DCT) is a function that has the ability to convert a signal into elementary frequency components. It represents an image as a sum of sinusoids of varying magnitudes and frequencies. The popular block-based DCT transform segments an image non-overlapping block and applies DCT to each block. This result in giving three frequency sub-bands: low frequency sub band, mid-frequency sub-band and high frequency sub-band. DCT-based watermarking is based on two facts [10]. The first fact is that most of the signal energy lies at low-frequencies sub band which contains the most important visual parts of the image. The second fact is that high frequency components of the image are usually removed through compression and noise attacks. [3] The watermark is therefore embedded by modifying the coefficients of the middle frequency sub band so that the visibility of the image will not be affected and the watermark will not be removed by compression.

III. DWT BASED WATERMARKING

The wavelet transform decomposes the image into three spatial directions i.e. horizontal, vertical and diagonal. Hence wavelets reflect the isotropic properties of HVS more precisely. Watermark detection at lower resolutions is computationally effective because at every successive resolution level the few frequency bands involved for this pair of values, there is no degradation in watermarked image. High resolution sub bands helps to easily locate edge and textures patterns in an image. DWT is a hierarchical transform and analyzes the signal into different bands and levels. It supports resolution of a signal in successive levels. DWT is a separable transform (like DCT) and it can be applied on a two dimensional matrix (i.e. image) separately in each dimension [6, 7] .Two dimensional DWT (2D-DWT) analyzes the initial image in four frequency bands. The first band (LL) contains the low frequencies both in horizontal and vertical direction. The second band (HH) contains the high frequencies both in horizontal and vertical direction. The third band (HL) contains the high frequencies in horizontal direction and low frequencies in vertical direction. The forth band (LH) contains the low frequencies in horizontal direction and high frequencies in vertical direction. The LL band represents the approximation of the image and is the most significant band as it carries most of the image energy. The other three bands contain the details of the image (texture of the image) [12].

IV. SVD

Singular value decomposition is a numerical technique used to diagonalize matrices in numerical analysis. It is an algorithm developed for a variety of applications. Any matrix 'M' is decomposed into three sub matrices [u, s, v] such that:

$M=u*s*v^T$

Where 'u' and 'v' are the orthogonal matrices such that $u^* u^T = I$ and $v^* v^T = I$ where 'I' is the Identity matrix and 's' is the diagonal matrix. These values are known as singular values, and matrices u and v are known as corresponding singular vectors [3]. The above decomposition is termed as Singular Value Decomposition. A SVD, applied to the image matrix, provides singular values (diagonal matrix's') that represent the luminance or color intensity of the image while the matrices 'u' and 'v' represents the geometry of the image. It has been scientifically proved that slight variation in the singular values doesn't change the visual perception of the image [11].

The work thus implements the SVD to provide better visual perception along with the robustness. The increased robustness is due to the stability of singular values. The stability of singular value indicates that, when there is a little disturbance with A, the variation of its singular value is not greater than 2-norm of disturbance matrix. 2-norm is equal to the largest singular value of the matrix. Singular values exhibit some more properties like rotation invariance, translation invariance, transposition invariance, etc. These all properties of SVD are much desirable in image watermarking.

V. DWT-DCT-SVD BASED WATERMARKING

This method utilizes the wavelet coefficients of the cover image to embed the watermark. Any of the three high frequency sub bands of wavelet coefficients can be used to watermark the image. The DCT coefficients of the wavelet coefficients are calculated and singular values decomposed. The singular values of the cover image and watermark are added to form the modified singular values of the watermarked image. 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. Watermark embedded using this algorithm is highly imperceptible. This scheme is robust against all sorts of attacks. It has very high data hiding capacity. . The new method was found to satisfy all the requisites of an ideal watermarking scheme such as imperceptibility or fidelity, robustness and good capacity. Also, the method is robust against different kinds of mentioned attacks.

VI. EMBEDDING TECHNIQUE FOR DWT-DCT-SVD BASED WATERMARKING

- .Let "*A*" be the cover image.
- Apply DWT to decompose the image into four sub-bands LL, HL, LH and HH. Take any of these four sub-bands.
- Apply DCT to the chosen sub-band. Let "*B*" denote the matrix obtained after applying DCT.
- Apply SVD so that "*B*" can then be written as
  $B = U_B \Sigma_B V_B^T$
- where U_B and V_B^T are the orthonormal unitary matrices of *B*. The term Σ_B constitutes the singular values of the matrix of *B*.
- Let "*W*" represent the watermark.
- Apply DWT to decompose the image into four sub-bands LL, HL, LH and HH. Take any of these four sub-bands.
- Apply DCT to the chosen sub-band. Let "*S*" denote the matrix obtained after applying DCT.
- Apply SVD so that "*S*" can then be written as
  $B = U_S \Sigma_S V_S^T$
- Where U_S and V_S^T are the orthonormal unitary matrices of *S*. The term Σ_S constitute the singular values of the matrix *S*.
- Modify the singular values of *B* using singular values of *S*. Then perform IDCT followed by IDWT to obtain the watermarked image.
- The four sets of DWT coefficients can be used to embed four different visual watermarks or the same watermark.


Host Image


Watermark


Watermarked Image

Fig. 2 Embedding Technique

VII. EXTRACTION TECHNIQUE FOR DWT-DCT-SVD BASED WATERMARKING

- Let “W^*”be the watermarked image.
- Apply DWT and take any of the four sub-bands.
- Apply DCT to the chosen sub-band.
- Let “A^***”** denote the matrix obtained after applying DCT. Apply SVD so that “B^*” can then be written as

$$B^* = U_{A^*} \Sigma_{A^*} V_{A^*}^T$$

- Where $U_{A^*}$and $V_{A^*}^T$ are the orthonormal unitary matrices of *A**.
- Σ_{A^*}Constitutes the singular values of the matrix of *A**.
- Watermark is extracted by subtracting the singular values obtained from embedding process.


Watermarked Image


Extracted Watermark

Fig. 3 Extraction Technique

VIII. PERFORMANCE EVALUATION

This section presents the simulations and experiments of the proposed scheme and the results obtained.

A. PSNR

Imperceptibility means that the perceived quality of the host image should not be distorted by the presence of the watermark. As a measure of the quality of a watermarked image, the peak signal to noise ratio (PSNR) is typically used and it is based on mean square error.PSNR in decibels (dB).

$$PSNR = 10 \log_{10}\left(\frac{255^2}{MSE}\right)$$

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

Where y and x are respective luminance values of original and watermarked image.

B. WPSNR

The weighted PSNR (WPSNR) has been defined as an extension of the traditional PSNR. The PSNR metric does not take into account image properties such as flat and textured regions. If the watermark is embedding into textured regions and into edges, so the PSNR is inadequate to measure image quality in this case. The solution of this problem is using weighted PSNR.NVF characterizes the local image properties and identifies texture and edge regions. This allows us to determine the optimal watermark location and strength for watermark embedding stage.

$$WPSNR = 10\log_{10}\frac{(255)^2}{WMSE}$$

$$WMSE = \frac{MSE}{[1 + var(i,j)]^2}$$

Where var(i , j) is maximum local variance of image.

C. Correlation Coefficient (ρ)

Comparability of extracted watermark with the original watermark is quantitatively analyzed by using correlation coefficient. Value of ρ is between 0 and 1. The bigger the value of ρ, better is the robustness of watermark.

$$\varrho(W,\overline{W}) = \frac{\sum_{i=1}^{r} W(i)\overline{W}(i)}{\sqrt{\sum_{i=1}^{r}\overline{W}^2(i)}\sqrt{\sum_{i=1}^{r}W^2(i)}}$$

Where W is the singular values of original watermark, is the extracted singular values and r=max($M1$, $N1$).

Fig.4 Watermarked Image after Salt & Pepper Attack

Fig.5 Extracted Watermark

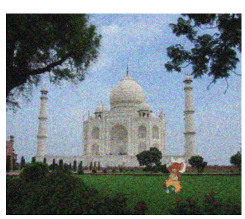

Fig.6 Watermarked Image after Gaussian attack

Fig.7 Extracted Watermark

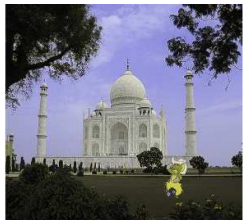

Fig.8 Watermarked Image after Sharpened attack

Fig.9 Extracted Watermark

Fig.10 Watermarked Image after Contrast Adjustment

Fig.11 Extracted Watermark

Attacks	PSNR(dB)	MSE	ρ	WPSNR(dB)
Without Attack	**52.3295**	**0.38031**	**0.99996**	**80.2034**
Salt and Pepper	**47.3899**	**1.186**	**0.99987**	**75.3853**
Gaussian Noise	**43.1322**	**3.1613**	**0.99966**	**71.1477**
Sharpened	**41.3842**	**4.7279**	**0.99949**	**70.5133**
Contrast Adjustment	**46.3421**	**1.5096**	**0.99984**	**74.8932**

Table.1Values of parameters between original and extracted Watermark without attack and with attacks

IX. CONCLUSION

The proposed watermarking scheme based on discrete cosine transform, wavelet packet transform and singular value decomposition have been applied successfully in many digital images .The DCT-SVD based method is very time consuming because it offers better capacity and imperceptibility. DWT-SVD method is found to be similar to the DCT-SVD scheme except that the process was fast. The new hybrid method is satisfying all the requisites of an ideal watermarking scheme such as imperceptibility or fidelity, robustness and good capacity. Also, the method is robust against different kinds of attacks. This method can be used for authentication and data hiding purposes.

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