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Semi-Blind Color Image Watermarking on High Frequency Band Using DWT-SVD

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Abstract:- In this paper, robust color image watermarking technique based on discrete wavelet transform and singular value decomposition (DWT-SVD) is proposed. Today the increasing of multimedia content has created an urgent need for copyright enforcement technologies that can protect copyright ownership of multimedia data. Digital Image Watermarking is a technology that developed to protect digital image from illegal manipulations. Watermarking is different from encryption in the sense that it allows the user to interpret, view and access the image but protect the ownership of the digital content. To protect the ownership of content service provider is a crucial area of research. Robustness against geometric distortions is crucial issue in watermarking. We use DWT and IDWT transform to obtain four different frequency images. Watermark is embedded in high-frequency band by svd. Experimental evaluation demonstrates that proposed algorithm is able to withstand variety of attacks including common geometric attacks.

Keywords:- Copyright protection, Discrete wavelet transform (DWT), Multi frequency image, Singular value decomposition (SVD)

I. INTRODUCTION

An important factor that slows down the growth of multimedia networked services is that authors, publishers and providers of multimedia data are reluctant to allow the distribution of their documents in a networked environment. This is because the ease of reproducing digital data in their exact original form is likely to encourage copyright violation, data misappropriation and abuse. These are the problems of theft and distribution of intellectual property. Therefore, creators and distributors of digital data are actively seeking reliable solutions to the problems associated with copyright protection of multimedia data.

The ease with which perfect copies can be made may lead to large-scale unauthorized copying, which is a great concern to the music, film, book, and software publishing industries. Because of this concern over copyright issues, a number of technologies are being developed to protect against illegal copying. One of these techniques is the use of digital watermarks. A watermarking algorithm consists of the watermark structure, an embedding algorithm, and an extraction, or detection, algorithm. Watermarks can be embedded in the spatial domain or a transform domain. The major advantage of transform domain methods is their superior robustness to common image distortions. In multimedia applications, embedded watermarks should be invisible, robust, and have a high capacity [4]. Invisibility refers to the degree of distortion introduced by the watermark and its affect on the viewers or listeners. Robustness is the resistance of an embedded watermark against intentional attacks, such as noise, filtering (blurring, sharpening, etc.), re-sampling, scaling, rotation, cropping and lossy compression. Capacity is the amount of data that can be represented by an embedded watermark. Discrete cosine transform (DCT) and discrete wavelet transform (DWT), which are used in image compression standards JPEG and JPEG2000 respectively, are two main transform methods used in transform domain watermarking. As DWT decomposes images into four bands, DWT- based watermarking schemes can embed data in all frequencies. This result in robustness to a wide range of attacks for embedding in low and high frequency bands are complementary. Several watermarking methods resistant to geometric attacks have been presented in literature.

An important criterion for classifying watermarking schemes is the type of information needed by the detector [5]:

- Non-blind schemes: The original image, watermark and the secret key(s) for watermark extraction.
- Semi-blind schemes: The secret key(s) and the watermark bit sequence.
- Blind schemes: Only the secret key(s).

Recently, a transform called singular value decomposition was explored. In this paper, we present a hybrid SVD-DWT semi blind approach to embed the watermark to embed in high frequency band of the image. This is unlike traditional viewpoint that assumes watermarking should be embedded in low or middle frequency to have good robustness.

II. BACKGROUND AND THEORY

A. RGB Color Spaces

Some of researches have used RGB color space for watermark embedding. First R, G, B planes are separated by using equations 1, 2, 3 and either one of these planes or combination of two can be used for embedding.

R = image (: ; : ; 1)
G = image(: ; : ; 2)
B = image(: ; : ; 3)

But, RGB color space is complex in describing the color pattern and has redundant information between each component [5]. Since Pixel values in RGB color space are highly correlated, RGB color space is converted into YUV or YIQ color spaces.

B. YUV Color Spaces

Here, RGB color space is converted into YUV Color space and then Watermark is embedded. Initially color image is read and R, G, B components of original Cover Image are separated. Then they are converted into YUV color Space using following equations.

$$Y = 0.299 * R + 0.587 * G + 0.114 * B$$
$$U = -0.147 * R - 0.289 * G + 0.436 * B$$
$$V = 0.615 * R - 0.515 * G - 0.100 * B$$

After embedding the watermark using DWT, YUV color space is converted back into RGB color space using following equations.

$$R = Y + 1.140 * V$$
$$G = Y - 0.395 * U - 0.581 * V$$
$$B = Y + 0.2032 * U$$

C. Singular Value Decomposition (SVD)

Singular Values of the image gives very good stability. When a small value is added, it does not result too much variation. Hence Singular Value decomposition in linear algebra is used to solve many mathematical problems. Every real matrix A can be decomposed into product of three matrices $A=U\Sigma VT$, where U and V are orthogonal matrices such that, $UUT =1$ and $VVT = 1$and Σ is summation of diagonal entries $\lambda 1, \lambda 2\cdots$ gives the singular vectors of A. These diagonal entries are called as Singular Values of A and the decomposition is called as 'Singular Value Decomposition'. Thus we have,

$$A = \lambda_1 U_1 V_1^T + \lambda_2 U_2 V_2^T + \ldots\ldots\ldots.. + \lambda_r U_r V_r^T$$

Where r is the rank of matrix A. In SVD-based watermarking, several approaches are possible. A common approach is to apply SVD to the high frequency band of the Original image, and modify the singular values to embed the watermark data. An important property of SVD based watermarking is that the largest of the modified singular values change very little for most types of attacks.

There are three main properties of SVD from the viewpoint of image processing applications:

- The singular values of an image have very good stability, that is, when a same perturbation is added to an image, its Singular values do not change significantly [6].
- Each singular value specifies the luminance of an image layer while the corresponding pair of singular vectors specifies the geometry of the image [7].
- Singular values represent intrinsic algebraic image properties.

		
Fig. 2 Original image	Fig. 3 Watermark to be embed	Fig. 4 Watermarked Image

A theoretical analysis of the effects of ordinary geometric distortions on the singular values of an image is provided in a recent paper [8]. Because of these properties, SVD may be used as a tool to develop semi-blind watermarking schemes.

D. Discrete Wavelet Transform (DWT)

The Discrete Wavelet Transform (DWT) is obtained by filtering the signal through a series of digital filters at different scales. The scaling operation is done by changing the resolution of the signal by the process of sub sampling. The analysis filter bank consists of a low-pass and high pass filter at each decomposition stage. When the signal passes through these filters, it splits into two bands. The low-pass filter, which corresponds to an averaging operation, extracts the coarse information of the signal. The high-pass filter, which corresponds to a differencing operation, extracts the detail information of the signal. The output of the filtering operation is decimated by two. A two dimensional transform is accomplished by performing two separate one-dimensional transforms. First, the image is filtered along the row and decimated by two.
The DWT is a system of filters. There are two filters involved, one is the “wavelet filter”, and the other is the “scaling filter”. The wavelet filter is a high pass filter, and scaling filter is a low pass filter. DWT includes transforms, such as Haar wavelet, Daubechies wavelet, and others. In our thesis utilizes the Haar wavelet. Figure 1 shows the workflow of DWT. After applying a 1-level DWT on an image, we get the approximation sub band *A*, the horizontal sub band *H*, the vertical sub band *V*, and the diagonal sub band *D*. Moreover, if we want to apply a 2-level DWT on the image, we just simply apply another 1-level DWT on the approximation sub band *A*. After applying a 2-level DWT, we also get the approximation sub band *A2*, the horizontal sub band *H2*, the vertical sub band *V2*, and the diagonal sub band *D2* of the approximation sub band *A* other than sub bands *H*, *V*, *D*.

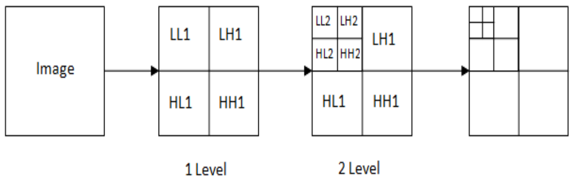

Fig. 2 Workflow of DWT

An advantage of DWT over other transforms is it allows good localization both in time and spatial frequency domain. Because of their inherent multi-resolution nature, wavelet-coding schemes are especially suitable for applications where scalability and tolerable degradation are important**.** Applying IDWT to *A, V, H, and D*, we can get four different frequency's images that are low frequency image, middle-low frequency image, middle-high frequency image, high frequency image separately [9].

III. LITERATURE REVIEW

V. Santhi and Dr. Arunkumar Thangavelu[5] presented SVD based digital image watermarking scheme in discrete wavelet transform (DWT) domain. The embedding is done by modifying the singular values of the wavelet transformed sub-bands with the singular values of the watermark image. This method is robust against different attacks because of using all bands in embedding process, but it is a non-blind method and the transparency of the watermarked image is not good. Moreover, they showed/asserted that modifications in all frequencies make watermarking schemes using DWT robust to a wide range of attacks. However, embedding data in high frequency band is more robust to geometric attack.” So, for making more robust SVD-DWT scheme we proposed a new watermarking scheme in this we embed the watermark in only high frequency band and develop a new hybrid Semi-blind image watermarking scheme that is resistant to a variety of attacks.

IV. PROPOSED METHOD

Assume the dimension of the Original image I is $N \times N$ and dimension of the watermark to embed W is $N \times N$.

A. Watermark Embedding:

1. Take the color image and separate the R, G and B color
2. Convert into Y, U and V color model
3. Decompose the Y channel using DWT in 4 sub bands: A, H, V, and D.
4. Apply IDWT to D and get high frequency image I^h.
5. Apply SVD to high frequency image $I^h = U^h S^h V^h$
6. Apply SVD to watermark to embed $W = U^w S^w V^w$
7. Modify $S = S^h + \alpha S^w$ where α is scaling factor.
8. Obtain the modified high frequency image $I^h = U^h S^h V^h$
9. Apply DWT to I^h and get modified D: $D = DWT(I^h)$
10. **U**sing A, H, V, and D apply IDWT to obtain the watermarked image I^***.**

B. Watermark Extraction:

1. Take watermarked image I^* and separate the R, G and B color
2. Convert into Y, U and V color model
3. Decompose the watermarked image I^* into 4 sub bands: A H V and D Using DWT.
4. Apply IDWT to D^* and get modified high frequency image I^{*h}
5. Apply S VD to $I^{*h} = U^{*h} S^{*h} H^{*h}$

6. Apply S VD to watermark W: $U^w S^w V^w$
5. Extract the singular values of watermark: $S^{*h} = (S^{*h} - S^{w)}/ \alpha$ where S^{*h} are the singulars of origin image.
6. Original the watermark from D band: W: $U^w S^{*w} V^{w'}$

V. PERFORMANCE EVALUATION

A. Psnr

This scheme is implemented in Matlab. Results are tested, analyzed for all channels in YUV, RGB color spaces. Here, two performance parameters are applied to measure the performance of watermarking scheme: ‘Perceptual Transparency’ and ‘Robustness’.‘Perceptual Transparency’ is measured in terms of ‘Peak Signal to Noise Ratio’. Bigger is PSNR, better is quality of image. PSNR for image with size M x N is given by:

$$PSNR = 20 * \log_{10}(255 / sqrt(MSE)) \qquad (1)$$

The PSNR is employed to evaluate the difference between original image and the watermarked image. The MSE can be described as the mean of the square of the differences in the pixel values between the corresponding pixels of the two images. For the robust capability, mean absolute error (mse) measures the mean of the square of the original watermark and the extracted watermark from the attacked image.

B. Correlation Coefficient

Correlation coefficient, r, is widely used in Pattern reorganization and image processing methods. The correlation coefficient r has the value, r =1, if the two images are absolutely identical, r = 0 if the two images are completely uncorrelated, r = -1 if they are anti-correlated. It is used to compare the two images taken at different times. The r value indicates that image has been altered or moved. In theory, we would obtain value of r=1 if the images are intact and r less than 1 if the images are altered.

VI. EXPERIMENT

We test the proposed scheme on color image of 512 x 512 and watermark with the size 256 x 256. They and the watermarked image are shown in Figure 2, Figure 3 and Figure 4. We used the scaling factor α as 0.05.

The proposed watermarking scheme was tested using ordinarily image processing: Gaussian noise, rotation, and salt & pepper. The correlated coefficient of the original watermark, psnr and extracted watermark is shown in the Table I. In this we observe that this scheme is robust against various attacks.

Table I : Attacks, extracted watermark, PSNR and Correlated coefficient of the original watermark

ATTACKS		EXTRACTED WATERMARK	PSNR	Correlation
Rotation			32.134756	0.333867
Gaussian Noise			34.510765	0.352757

Salt & Pepper			39.702894	0.360930
All Three attack			31.988526	0.354000

VII. CONCLUSION

1). In our scheme watermark is embedded in high frequency. It has good performance in a variety of image processing.
2). SVD decomposition belongs to spatial domain transform and has robustness to geometrical attack. For considering this, we use DWT and IDWT transformation to obtain the high frequency image. Accordingly the scheme has robustness to geometrical attack.
3). We notice there are three frequency image (low frequency image, middle-low frequency image, middle-high frequency image) are not used. Different watermarks can be embedded in them.
4). It is a semi-blind scheme so when extraction is done without need of original image, only original watermark and the algorithm is required for detection of content ownership.
5). The PSNR shows that the extracted watermark from the attacked image is closer to the original watermark.

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