DWT-SVD-ARNOLD TRANSFORM COMBINED WATERMARKING SCHEME FOR COLOR IMAGES IN YUV SPACE

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***Abstract*—In this paper an algorithm is been developed using DWT-SVD-ARNOLD transform combined watermarking scheme for color images in YUV space. The growing problem of unauthorized reproduction of digital multimedia has triggered worldwide efforts to identify and protect copyright ownership of multimedia contents. In the last decade digital watermarking techniques have been devised to answer the ever-growing need to protect the intellectual property. Digital watermarking is a technique in which a piece of digital information is embedded into an image and extracted later for ownership verification. Secret digital data can be embedded either in spatial domain or in frequency domain of the cover data. In the proposed approach firstly the RGB color spaces of the cover image are converted into YUV color space which in turn decomposed into different frequency bands using discrete wavelet transformation and then SVD is employed to obtain the singular values of cover image. Scrambled watermark is then embedded to the cover image to increase the robustness of the image. The security levels of this scheme are increased by using color space conversions, DWT domain and Arnold scrambling. The parameters used to test the robustness of the proposed algorithm are the Peak Signal to Noise Ratio (PSNR) and Normalized correlation coefficient (NC).Also, Robustness of the proposed algorithm is tested for various attacks including salt and pepper noise and Gaussian noise, cropping and histogram equalization attacks.**

Keywords—SVD,DWT,Arnold transform,YUV space,PSNR,NC.

I. Introduction

Advancement of digital technology has made copyright protection a necessity. More and more digital multimedia can be transmitted through the internet. It leads to the consequences of illegal production and redistribution of media. To achieve security, watermarking technology is used. Watermarking is the process of embedding a piece of information into multimedia content, such as images, video or audio. Watermarking, in general, can be grouped as: Spatial domain and Frequency domain methods. In spatial domain, information is embedded by directly modifying the intensity of pixel values. Whereas in frequency (transform) domain, the information is embedded by changing the frequency components. The features of watermarks are: robustness, imperceptibility, fidelity & security. Robustness is the resistance of an embedded watermark against attacks and to normal A/V processes such as noise, rotation, cropping, and lossy compression.

Imperceptibility refers to the degree of distortion that the watermark introduces and its affect on the viewers. Every watermarking algorithm consists of a watermark, embedding algorithm and a detection algorithm. Spatial domain methods are not robust to common image processing applications. Hence transform domain are used for more robust watermarking. If the watermark is embedded in the perceptually most significant components, the quality of the image may be degraded and the watermark may become visible. . On the other hand, if the perceptually insignificant components are used, then the scheme may be less resistant to attacks. Thus the place of watermarking is a trade-off between robustness and transparency.

In this paper I proposed a robust watermarking scheme that combines the features of discrete wavelet transform, Arnold transform & singular value decomposition. The advantages of the proposed algorithm are its robustness against various attacks. Robustness is achieved by embedding the scrambled watermark to the singular values of wavelet coefficients.

II. REVIEW OF RELATED WORKS

Review of literature survey has been conducted on singular value decomposition (SVD), discrete wavelet transform (DWT) combined with singular value decomposition techniques for hiding information in color images.

Liu et al. have proposed an SVD based watermarking scheme [1]. There the watermark is added to the SVs of the whole image or to an apart of the image. A single watermark is used, which may be lost due to attacks.

To avoid this disadvantage, the original image is decomposed into different frequency bands using discrete wavelet transformation and then SVD are employed to obtain the singular values of cover image.Even if some attacks affect the watermarked image, but watermark may survive [1].

In two-dimensional DWT, the transformation is applied to the whole image. But it is required to map the frequency

Coefficients from the lowest to the highest bands in order to apply SVD to each band. This DWT combined with SVD technique outperforms the pure SVD based watermarking scheme.

III. PRELIMINARIES

A. Singular Value Decomposition

SVD is one of the most powerful tools of linear algebra with several applications in image compression, and other signal processing fields. SVD decomposes the matrix I into three matrices U , S, V, where U and V are orthogonal matrix and S is the singular matrix which contains the singular values[1].

$$I=USV^T$$

We are exploiting the following properties of SVD:

1. SVD watermarking can be applied to both square matrix and rectangular matrix.
2. The singular values of an image has good stability ie, if we give any alternation to the image it will not affect the overall quality of the image.
3. Singular values represent all the algebraic properties of image

B. Discrete Wavelet Transform

DWT uses filters with different cut-off frequencies to analyse an image at different resolutions. the image is passed through a number of high-pass filters, known as wavelet functions, to analyse the high frequencies and it is passed through a number of low-pass filters, also known as scaling functions, to analyse the low frequencies. after filtering ,half of the samples can be eliminated according to the Nyquist criteria. This constitutes one level of decomposition.Thus; decomposition halves the time resolution and doubles the frequency resolution. The above procedure also known as sub-band coding is repeated for further decomposition in order to make a multiresolution analysis[4].

C. YUV Space

In svd and dct-svd techniques, color image is used as cover data, where the RGB value of each pixel is converted into RGB color spaces. Watermark can be embedded in any one of these three spaces. In RGB color spaces, the pixel values are highly correlated, so watermark can be embedded in YUV color spaces. The YUV color spaces defines a color space in terms of one luminance (Y') and two chrominance (UV) components [3]. The Y component determines the brightness of the color (referred to as luminance or luma), while the U and V components determine the color itself (referred to as chrominance or chroma). YUV signals are created from rgb source. The equation shown below transforms image in RGB to YUV.

$$\begin{bmatrix} Y \\ U \\ V \end{bmatrix} = \begin{bmatrix} .299 & 0.587 & 0.114 \\ -0.147 & -0.289 & 0.436 \\ 0.615 & -0.51499 & -0.100 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad (1)$$

D.Arnold Transform

To confirm the security and improve the robustness of the proposed watermarking scheme, the watermark should be pre-processed before embedded into the original image. Due to the periodicity process of the Arnold transform, the image can be easily recovered after the permutation concept. So the Arnold transform is applied to the original image watermark [4].

Let us consider the size of original image is N*N,(x,y)T and its coordinate of the watermark image's pixel(x',y')T and these coordinate are gained after the transform. Arnold transform can be expressed as

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ 1 & 2 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} (\mathrm{mod}\, N) \quad (2)$$

Where x,y {0,1…….N-1}

IV.PROPOSED ALGORITHM

In SVD and DWT-SVD-ARNOLD transform techniques, color image is used as cover data. Here the RGB value of each pixel is converted into RGB color spaces. Watermark can be embedded in any one or in the three colour channels. Since pixel values are highly correlated in RGB colour spaces, information can be embedded in YUV color spaces. The block diagram for the proposed method is shown in Fig1.below.

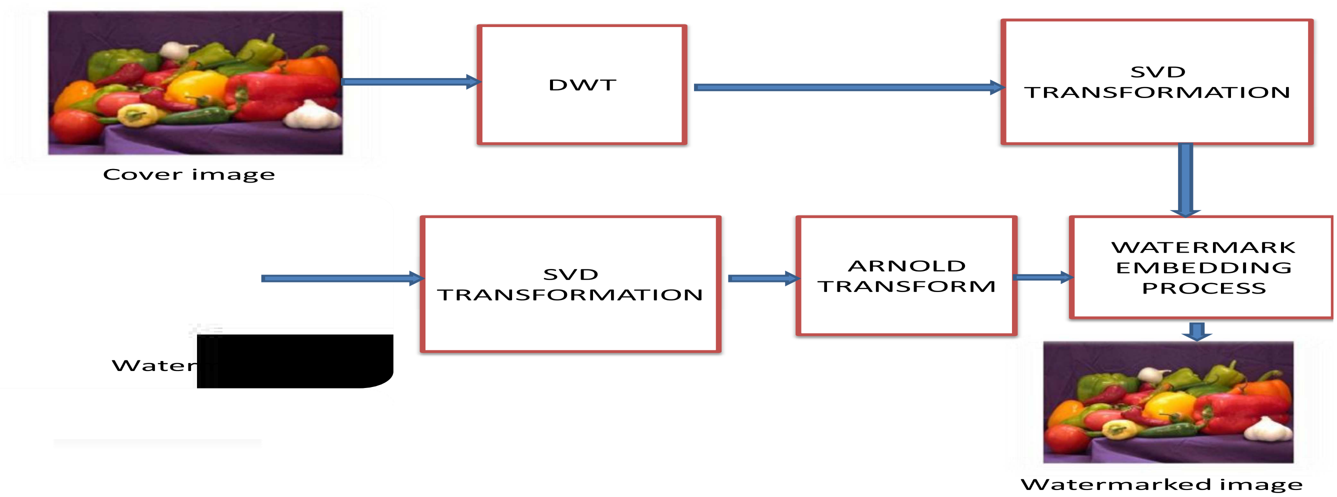

Fig1.Watermark Embedding

In this method, the RGB components of color image is converted into YUV color spaces, in which only Y components constitute Y color space, U components constitute U color space and V components constitute V color space[3]. Each color spaces of the original image I is decomposed into different frequency bands using DWT and then SVD is employed to obtain the singular values of cover image. Then the scrambled watermark is then embedded to the newly obtained matrices by using SVD technique. The watermarked image is built by combining these bands again into one matrix of the original image dimensions. The steps for embedding watermark in YUV space is as follows:

Step 1: RGB components of color image I is converted into YUV color space providing Y, U and V components.

Step 2: Each color spaces of the original image I of size 515*512 is first divided into different frequency bands by applying discrete wavelet transformation.

Step 3: SVD technique is applied to YUV color spaces as well as on the watermark. Then I get,

$$A=USV' \quad (3)$$

Step 4: Apply Arnold transform on watermark image.

Step 5: Scrambled watermark is added into the matrix S.

$$D=S+KW \quad (4)$$

Step 6: Inverse SVD is applied on watermarked D matrix to get the modified image Band. (Here k=0.1)

$$D=U_wS_wV'_w \quad (5)$$

Step 7: Inverse transformation Technique is applied to get the watermarked image matrices.

$$A_w=US_wV' \quad (6)$$

Step 8: YUV color space are converted into RGB color space.

Step 9: The obtained watermarked image Iw* having size of (512*512).

During the extraction process, the RGB components of the watermarked color image are converted into YUV color spaces which in turn can be converted into frequency coefficients of four bands. Each band of frequency is SVD transformed to extract watermark from the diagonal elements. In the extraction part, the watermark is extracted from the watermarked image, I_w*.

Step 1: Each color spaces of the watermarked image I_w* of size 515*512 is first converted to YUV color space.

Step 2: DWT is applied to YUV matrices i.e. A_w*.

Step 3: Again SVD is performed on A_w*

$$A_w^*=U^*S_w^*V'^* \quad (7)$$

Step 4: The watermark is extracted by

$$W^*=(D^*-S)/k. \quad (8)$$

Step 5: Apply inverse Arnold transform on retrieved watermark. The block diagram for the extraction of watermark is shown in the Fig2 below:

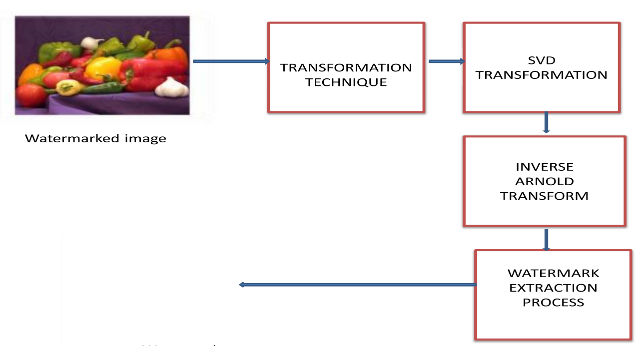

Fig 2.Watermark Extraction

V.RESULTS

In my study, the cover image (peppers) having size of 512*512 and watermark (iam Lena) having a size of 256*256 is used.MATLAB and Image Processing Toolbox are used for the experiments and attacks. Performance is computed using the PSNR (Peak Signal-to-Noise ratio) between the original image and the watermarked and NC (Normalized Correlation) between watermark and the extracted watermark.

TABLE I

PSNR VALUES IN NORMAL CONDITION

Frequency Band / Color channel	Low frequency PSNR (dB)	Middle frequency PSNR (dB)	Middle frequency PSNR (dB)	High frequency PSNR (dB)
Y channel	57.5518	57.5485	57.5511	57.5503
U channel	56.8748	56.8902	56.8431	56.8843
V channel	55.9199	55.9960	55.4684	55.4721

TABLE II

NC VALUES IN NORMAL CONDITION

Frequency Band / Color channel	Low frequency NC	Middle frequency NC	Middle frequency NC	High frequency NC)
Y channel	1.0000	1.0000	1.0000	1.0000
U channel	1.0000	1.0000	1.0000	1.0000
V channel	1.0000	1.0000	1.0000	1.0000

TABLE III

NC AND PSNR VALUES AFTER ATTACKS

Domain	Salt & pepper noise	Salt & pepper noise	Gaussian noise	Gaussian noise
	NC	PSNR	NC	PSNR
Y channel	1.0000	37.0288	1.0000	29.9491
U channel	1.0000	37.0764	1.0000	29.9557
V channel	1.0000	37.0372	1.0000	29.9506

TABLE IV

NC AND PSNR VALUES AFTER ATTACKS

Domain	Cropping	Cropping	Histogram Equalization	Histogram Equalization
	NC	PSNR	NC	PSNR
Y channel	1.0000	44.2714	1.0000	31.5849
U channel	1.0000	44.2714	1.0000	28.7701
V channel	1.0000	44.2759	1.0000	30.0812

VI.CONCLUSION

This paper presents watermarking using different schemes. Proposed methods include SVD based watermarking, SVD-DWT based watermarking and SVD DWT ARNOLD watermarking in YUV plane. In the first method watermarking is done on spatial domain but the watermark is resistant to many noises. The PSNR ratio is also good. Compared with Svd watermarking in spatial domain other methods have high PSNR ratio and NC value get unity.

VII.REFERENCES

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