Dual Band Watermarking using 2-D DWT and 2-Level SVD for Robust Watermarking In Video

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Abstract: ***In this era any type of digital media such as image, text, audio and video, all are easily accessible and transferable through the use of high speed internet. As the use of internet increased, the need of security and authenticity also increased. To secure the multimedia data such as image, audio, text and video researcher has developed a watermarking technique which gives a watermark embedding and watermark extraction algorithm, and later it is used for proof of ownership. Here we are proposing a technique on video watermarking using 2D DWT and 2-level SVD technique. In this paper first we are taking a video which is decomposed into number of frames and embedding a watermark image on each frame. First 2-D DWT is applied on each frame. Dwt decompose each frame into low frequency, mid frequency and in high frequency (LL, LH, HL, HH) band then we applied SVD on LL and HL sub-band called it dual band. SVD convert it into three matrices as U1S1V1' of single matrix. A watermark image is taken which converted in to gray scale from RGB scale then resized it. And embed this watermark image into host frames with some scaling factor. After that we again applied SVD on this watermarked frames which further convert this single matrix into three matrices as U2S2V2' now multiply S2 matrix with U1 and V1 matrix component to make it more secure. To demonstrate the authenticity of this watermarked video we applied some attacks such as Gaussian filtering, median filtering, frame rotation, contrast adjustment and sharpness attack which show its PSNR and NCC value in comparison with the original video.***

Keywords: DWT, SVD, Matrix, Attacks, PSNR.

1. Introduction

Digital watermarking is a technique to hide the copyright information into the digital data through certain algorithm. The secret information to be embedded can be text, a logo and image with some special importance. This secret information is embedded to the multimedia data (images, audio and video) to ensure the security, data authentication, identification of owner and copyright protection. The watermark can be hidden in digital data either visibly or invisibly.

Watermarking technique first has been extensively used for still images. Nowadays many watermarking technique is proposed for other type of digital multimedia data. The so called new objects: text, audio, video, 3D meshes and hardware circuit. Watermark can be embedded in spatial domain or in frequency domain [1]. Spatial domain focus on modifying pixels value and in frequency domain the multimedia data is converted into frequency domain to directly load the data into image pixels.

In frequency domain to make some transforms are used like: Discrete cosine transform (DCT) and Discrete wavelet transform. In this paper we are proposing a frequency domain watermarking using DWT and SVD. Rajab et. all and Guo-juan used an hybrid scheme with DWT and singular value decomposition (SVD) that inserts the watermark on the coefficients of the cover frames [1], [2].

In this paper we are also inserting the watermark on the coefficients of video frames. And we are proposing a robust and imperceptible video watermarking algorithm which is based on 2D 1-level DWT technique and the singular value decomposition (SVD) technique.

The paper is organized as follows. In section 2 we discuss some theory related to DWT and SVD. In section 3 we are presenting a proposed method. The experimental results are discussing in section 4. In section 5 we are concluding the proposed method. Section 6 is the references.

2. Discrete wavelet transform (DWT)

The discrete wavelet transform is a transformation technique which converts the spatial domain into frequency domain. It provides an important tool for multi-resolution decomposition for images or frames [3]. Wavelet can separate these objects in four sub-bands (LL, HL, LH, HH) with the same bandwidth. The first level decomposition of wavelet is shown in following figure:

LL	HL
LH	HH

Figure 1: DWT decomposition in 1-Level

The sub-band with the lowest frequency components is referred to as the approximation sub-band and it contains most of the energy of the input frame. If the watermark is embedded in LL band that can provide some resistance against compression like MPEG compression, however middle and high frequencies channel have robust against noises addiction and several types of filter. Due to its excellent spatio frequency localization properties, DWT can identifies areas within a given frame in which a watermark can be imperceptibly embedded. If a DWT coefficient is modified only the region corresponding to that coefficient will be modified. The main advantage of wavelet is the easily adaption for human visual system (HVS).

3. Singular Value Decomposition (SVD)

Singular value decomposition is a mathematical approach for improving the robustness [4]. In SVD based water marking frame is treated as a single matrix which is decomposed by SVD into three matrices as U, S, and V'. SVD is an orthogonal process which leads to matrix decomposition of matrix A to its left and right singular matrices U and V' and to the diagonal matrix S as shown in the below equation:

$$A_{m \times n} = U_{m \times n} S_{m \times n} V_{n \times n}^{T} = \sum_{i=1}^{\min(m,n)} \sigma_i \, u_i \, v_i^{T}$$

Here U is the matrix that the columns are called the left singular vectors and the V columns are the right singular vectors of A.

In most literature but not in all SVD-based watermarking algorithms add the watermark information to the singular values σ_i of the diagonal matrix S in such a way to meet the imperceptibility and robustness requirements due to high stability of these singular values of SVD.

4. Proposed DWT-SVD based algorithm

The proposed video watermarking algorithm consists of two procedure in first procedure we embed the watermark in video. And in second procedure we extracts the watermark symbol from watermarked video, here we are proposing watermark embedding algorithm and watermark extraction algorithm in two section as follow:

4.1 Watermark Embedding Algorithm

Step 1. Take original video and convert it into frames f.
Step 2. Convert the frames from RGB to Grey as m1.
Step 3. Resize the m1 into m2 as 256x256.
Step 4. Take a watermark image (wm) of size 128x128.
Step 5. Divide this watermark image into half of the size with the Host frames as 128 x 128.
Step 6. Convert watermark image into two lengths from 1 to 64 and 65 to 128 and named as wm1 and wm2.
Step 7. Apply DWT on (m2) each and every frame f of original video. This operation generate four sub-bands as {LL, HL, LH, HH}, as shown in figure 1. Each sub-band is a matrix of DWT coefficients.
Step 8. Apply SVD operator on LL and on HL sub-bands. The SVD operator decompose each sub-band coefficient matrices into three independent matrices as follow

$$HL = U_{HL} \cdot S_{HL} \cdot V_{HL} \quad (1)$$
$$LL = U_{LL} \cdot S_{LL} \cdot V_{LL} \quad (2)$$

Step 9. Embed the wm1 and wm2 in S matrices with some scaling factor 'C' both in LL and HL sub-band. The given equation is as

$$A_{HL} = S_{HL} + C \times wm1 \quad (3)$$
$$A_{LL} = S_{LL} + C \times wm2 \quad (4)$$

where C is the scaling factor.

Step 10. Apply SVD on A_{HL} and A_{LL} which decompose this matrix into three sub matrices as

$$A_{CHL} = U_{CHL} \cdot S_{CHL} \cdot V_{CHL} \quad (5)$$

$$A_{CLH} = U_{CLH} \cdot S_{CLH} \cdot V_{CLH} \quad (6)$$

Step 11. Take these S matrices S_{CHL} and S_{CLL} and multiplied them with the U and V matrices which is generated from the first level SVD component, it is inverse SVD process.

$$A_{DHL} = U_{HL} \cdot S_{CHL} \cdot V_{HL} \quad (7)$$
$$A_{DLL} = U_{LH} \cdot S_{CLH} \cdot V_{LH} \quad (8)$$

Step 12. Apply inverse discrete wavelet transform and rearrange these coefficients to create the watermarked video (Aw).

4.2 Watermark Extraction Algorithm

Step 1. Rearrange the wm1 and wm2 for watermark symbol and resize it as 128x128.
Step 2. Resize the watermarked video as 256x256.
Step 3. Apply DWT on watermarked video (Aw), which decomposed it into four sub-bands as {WLL, WLH, WHL, WHH}
Step 4. Apply SVD in WLL and in WHL sub-bands. Which decompose it into three matrices as USV, equation is

$$D_{HL} = U_{WHL} \cdot S_{WHL} \cdot V_{WHL} \quad (9)$$

$$D_{LH} = U_{WLL} \cdot S_{WLL} \cdot V_{WLL} \quad (10)$$

Where D_{HL} and D_{LL} are the retrieved watermark
Step 5. For rebuilding the watermark image we are using following equation

$$W1 = (D_{HL} - S_{HL}) * 1/C \quad (11)$$
$$W2 = (D_{LH} - S_{LH}) * 1/C \quad (12)$$

Step 6: After applying this equation rearrange W1 and W2, to make the sequence as [w1 w2]. Then watermark image is extracted.

5. Experimental Results

In this section we will evaluated the performance of the proposed DWT-SVD video watermarking algorithm. We illustrate the proposed method checking some features: imperceptibility and robustness against different types of attacks. Algorithm is evaluated by taking a video of Rhino, size 320x240 pixels with 114 frames. For the watermark we have a color image of size 204x204 pixels value.

5.1 Imperceptibility

Imperceptibility means that the perceived quality of the host image should not be distorted by the presence of watermark. In this experiment we tested the watermarked video and compare it with the original video analyzing frame-by-frame, and checking the PSNR values for each frame that result a mean value: 75.23. At this PSNR value no quality degradation in the watermarked video was perceived.

$$PSNR = 10 \log_{10} \frac{\max size(host\ image)^2}{\sum i \sum j \, I(i,j) \times I_w(i,j)}$$

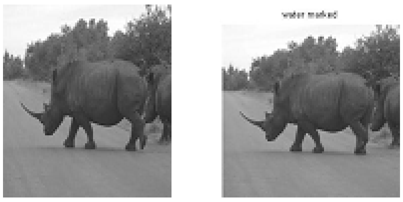

Figure 2: Comparison between the original frame and watermarked frame

5.2 Robustness Against Attacks

Robustness is a measure of the immunity of the watermark against attempts to remove it or degrade it by different types of digital signal processing attacks. In video watermarking robustness is usually measured against two types of attacks; standard attack and frame attacks. Standards attack include compression, rotation, Gaussian noise, salt & pepper noise and many others[3].For both type of attacks we measured the similarity between the original and extracted watermarks using the correlation factors which may vary between 0 to 1. In table 1: we measure the some standard image oriented attacks along with the PSNR value and in figure 4: it's normalize cross correlation (NCC) value.

$$NCC(w, w') = \frac{\sum\sum w(i,j) \times w'(i,j)}{\sqrt{\sum\sum w(i,j)^2 \times \sum\sum w'(i,j)^2}}$$

Table 1: Watermark attacks and corresponding PSNR and NCC value

S. No.	*Attack*	*Maximum PSNR value*	*Maximum NCC value*
1	Watermarked video without attack	75.2323	0.8446
2	Gaussian attack	59.9781	0.8516
3	Median filtering	59.9883	0.8458
4	Frame rotation	59.9781	0.8511
5	Histogram equalization	59.9781	0.8595
6	Contrast adjustment	59.9781	0.8394
7	Sharpness	59.9781	0.8535

Table 2: Extracted watermark image and watermarked frame on various attacks

S. No.	*Watermark attacks*	*Original watermark*	*Extracted watermark*	*Water marked video*
1	Gaussian attack			
2	Median filtering			
3	Frame rotation			
4	Histogram equalization			
5	Contrast adjustment			
6	Sharpness			

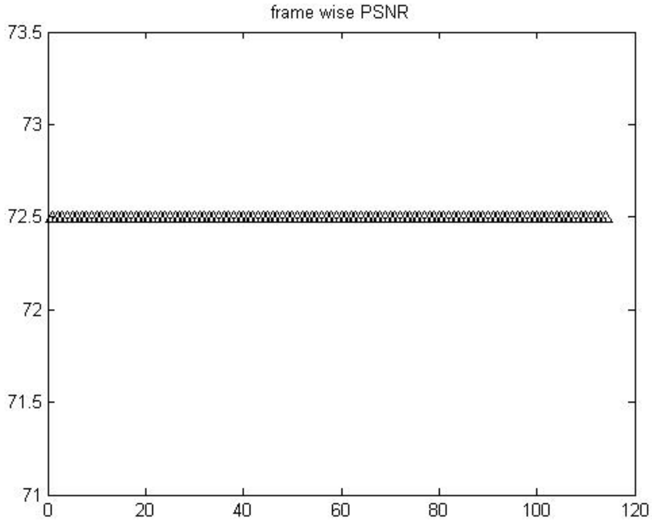

Figure 3: PSNR x Frames of watermarked video

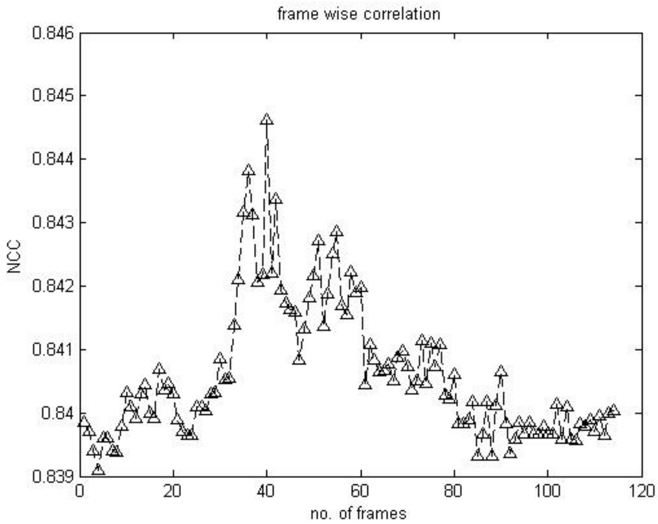

Figure 4: NCC x Frames of watermarked video

6. Conclusion

The proposed video watermarking technique based on DWT-SVD uses a 2D 1-Level DWT and 2-Level SVD technique which embedded the video for authentication in multimedia industry. Experiment result shows that this algorithm is more robust against signal processing attack and the value of PSNR and NCC is measured high. The watermark symbol can be recovered with the higher values of correlation when the watermarked video is attacked with the noise addition, frame rotation and gaussian filter.

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