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RESEARCH ARTICLE

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A ROBUST VIDEO WATERMARKING SCHEME USING 'ARNOLD', 'DWT' AND 'SVD' TRANSFORMATIONS

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ABSTRACT

Now a day's multimedia is becoming a part of our life, with the growing popularity and digital media, we propose a method of non-blind transform domain video watermarking scheme which is based on the Discrete Wavelet Transform (DWT), Singular Value Decomposition (SVD) and Arnold Transform. The DWT based compression offers scalability so its coefficients are used to embed the watermarking information. The ARNOLD transform has been used for scrambling the watermark so that strangers cannot be identifying the watermark. We also used SVD based digital watermarking which is a method of authentication data embedding in image characteristics with expectation to show resiliency against different types of unintentional or deliberate attacks. Here DWT plays the important role of an efficient tool due to its multi-resolution capability. Along with this wavelet transform we mix up another very strong mathematical tool called the singular value decomposition (SVD). Though till date both of them have individually been used as a tool for watermarking of digital media, very few works have utilized their skills in tandem, especially in this area. This scheme provides a hybrid technique developed the protection of the intellectual property with better robustness against the popular malicious attacks. This we have seen practically by attacking the watermarked image against simulated attacks and recovering the watermark from it.

Key Words: Digital Video watermarking, Copyright Protection, Discrete Wavelets Transform (DWT), Singular Value Decomposition (SVD), Frame Selection Techniques and Arnold Transform.

INTRODUCTION

Digital video is becoming popular more than ever due to the widespread of video-based applications such as Internet video, videophones, wireless video, video conferencing, among many others. However, a byproduct of such popularity is the worldwide unauthorized copying and distribution of digital video. Digital watermarking has been proposed in recent years to prevent illegal and malicious copying and distribution of digital media by embedding unnoticeable information (called a watermark) into the media content. The watermark is usually a copyright message identifying the ownership information of the media object. Effective watermarking has many requirements, the most important of which are imperceptibility and robustness [1]. Imperceptibility refers to perceptual transparency and it requires that the watermarking algorithm to embed the watermark in such a way that the quality of the underlying video frames is not affected. As for the robustness requirement, the watermark must always remain in the watermarked video frames, even if the quality of the frames is degraded intentionally or unintentionally.

Current video watermarking techniques can be grouped into two major classes; spatial-domain watermarking techniques and transform (i.e. frequency) domain watermarking techniques. Spatial-domain techniques embed a watermark in the frames of a given video by modifying its pixels directly. These techniques are easy to implement and require few computational resources. However, they are not robust against common digital signal processing operations such as video compression. On the other hand, transform-domain watermarking techniques modify the coefficients of the transformed video frames according to a pre-determined embedding scheme [2]. The scheme disperses the watermark in the spatial domain of the video frame, hence making it very difficult to remove the embedded watermark. Compared to spatial domain techniques, transform-domain watermarking techniques proved to be more effective with respect to achieving the imperceptibility and robustness requirements of digital watermarking algorithms.

LITERATURE REVIEW

A digital watermarking technique was not very popular in past decades, but after some time (during 1997 - 98) some authors wrote many research papers on Multi-resolution watermarking for digital images. M. Barni has proposed a method of a DCT-domain system for robust image watermarking. Further F. Gonzalez et al (1999) wrote a tutorial on Digital watermarking and also gave Multimedia watermarking Techniques. After that (during 2000) Robustness of a Blind Image watermarking scheme and in 2001 many authors contribute their research papers on multipurpose watermarking for image authentication and protection. P. Tay et al (2002) has proposed an Image watermarking using wavelets; after that R. Mehul (during 2003 - 05) presented discrete wavelet transform (DWT) based multiple watermarking schemes and also a new wavelet based logo-marking scheme. Chin-Chen C. et al (in 2007) presented a digital watermarking scheme based on singular value decomposition (SVD). In this transformation mainly two algorithms have been proposed. In the first algorithm, watermark bit information is embedded in the SVD-transformed video in a diagonal-wise fashion, and in the second algorithm bits are embedded in a block-wise fashion. The performance of the two proposed algorithms was evaluated with respect to imperceptibility, robustness and data payloads. Both algorithms showed a similar but high level of imperceptibility, however, their performance varied with respect to robustness and payload. The diagonal-wise based algorithm achieved better robustness results, while the block-wise algorithm gave a higher data payload rate. V. Santhi et al (2009) has worked on DWT-SVD combined full band robust watermarking for color images in YUV color space. Baisa L. Gunjal et al (2011) has presented a comparative performance analysis of DWT-SVD based color image watermarking technique in YUV, RGB and YIQ color spaces. Also Mehdi Khalili presented A novel effective, secure and robust CDMA digital image watermarking in YUV color space using DWT. D. Samiappan et al (2012) presented a Robust digital image watermarking for color images and Yogesh kumar et al proposed a Semi-blind color image watermarking on high frequency band using DWT-SVD.

In this scheme, a Digital watermarking algorithm for multimedia applications, based on Arnold [3], DWT-SVD Transform is proposed. The previous schemes like DCT-SVD and DWT-Arnold transform based methods are very time consuming and ambiguous [4]. The main purpose of this proposed scheme is to:

Achieve more robustness, imperceptibility, flexibility and effectiveness in extracting the watermark, Reduce the time required to embed a watermark on the video. Achieve unambiguity in the frame selection process.

PROPOSED METHODOLOGY

The proposed Arnold, DWT & SVD watermarking scheme consist of two algorithms, the first embeds the watermark into the original video clip, while the other extracts it form the watermarked version of the clip.

A) Watermark embedding algorithm: The embedding procedure is depicted in the block diagram shown in Fig.1. First apply the Arnold transform on watermark image (W) and change the watermark image to the Arnold scrambling, then follow the steps [5].

Step 1: Divide the video clip into video scenes Vsi.

Step 2: Convert every video frame F from RGB to YUV color matrix format.

Step 3: Process the frames of each video scene using DWT and SVD as described in steps 4-10.

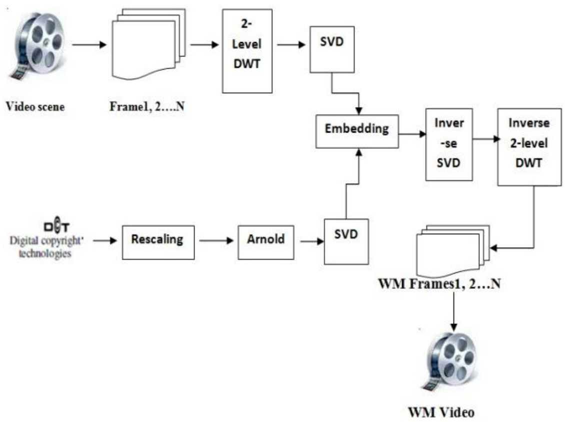

Fig.1: Arnold, DWT-SVD watermark embedding procedure

Step 4: Compute the 2-level DWT for the Y (luminance) matrix in each frame F. This operation generates seven DWT sub-bands [LL1, LL2, LH1, LH2, HH1, HH2 and HL2]. HL2, Each sub-band is a matrix of DWT coefficients at a specific resolution. Fig.2 shows the sub-bands produced by the 2-level DWT decomposition.

Step 5: Apply the SVD operator on the HL2 sub-band. The SVD operator decomposes the sub-band's coefficient matrix into three independent matrices:

$$HL2 = U_{HL2} S_{HL2} V_{HL2} \quad (1)$$

Step 6: Rescale the watermark image so that the size of the watermark will match the size of the HL2 sub-band which will be used for embedding.

Step 7: Embed the binary bits of watermark Wvsi into S_{HL2} by substituting the watermark bit Wi with the LSB (Least significant Bit) bit of S_{HL2} (i, i):

$$LSB(S_{HL2}(i, i)) = Wvsi \quad (2)$$

Step 8: Apply the inverse SVD operator on the modified S_{HL2}' matrix to get a modified coefficient matrix H'. The inverse SVD operation is as follows:

$$HL2' = U_{HL2} S_{HL2}' V_{HL2}^{T} \quad (3)$$

Step 9: Apply the inverse DWT on the modified coefficient matrix HL2'. This operation produces the final watermarked Video frame F'.

Step 10: Convert the video frames F' from YUV to RGB color matrix.

Step 11: Reconstruct frames into the final watermarked Video scene Vsi'.

Step 12: Reconstruct watermarked scenes to get the final watermarked Video clip.

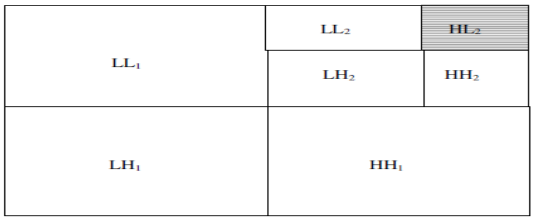

Fig.2: Frame's 2-level DWT sub-bands

B) Watermark extraction Algorithm: The proposed Arnold, DWT-SVD algorithm is blind in the sense that it does not need the original video in the extraction process. Therefore, we can extract the watermark image from the watermarked video frames from the LSBs directly as depicted in the block diagram shown in Fig.3 and described in details in the steps that follow:

Step 1: Divide the watermarked Video clip V ' into watermarked scenes Vsi'.

Step 2: Convert the video frame F' from RGB color matrix to YUV.

Step 3: Process the watermarked frames of each watermarked video scene using DWT and SVD as described in steps 4 ~ 6.

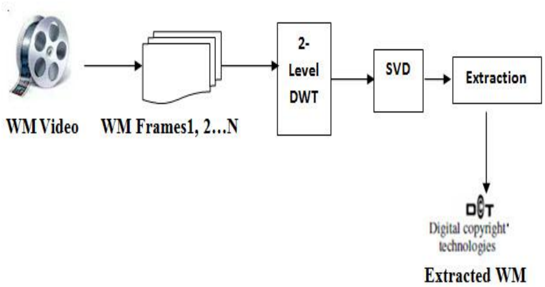

Fig.3: Arnold, DWT-SVD watermark extraction procedure

Step 4: Compute the 2-level DWT for the frame F'. Let the seven sub-bands produced after this process is: [wLL1, wLL2, wLH1, wLH2, wHH1, wHH2 and wHL2]

Step 5: Apply the SVD operator on the wHL2 sub band. The SVD operator decomposes the sub-band's coefficient matrix into three independent matrices:

wHL2 = UwHL2 SwHL2 VwHL2 (4)

Step 6: Extract the embedded watermark from the diagonal matrix SwHL2 as follows:

Wvsi (i) = LSB(SHL2 (i, i)) (5)

Step 7: Construct the image watermark WVsi by cascading all watermark bits extracted from all frames.

Step 8: Repeat the same procedure for all video scenes.

RESULTS AND DISCUSSION

To demonstrate this experiment we carried out much iteration to verify the validity of the proposed watermarking scheme. The color video which is converted into many frames of size 240 × 360 is used for watermarking and the color image of size 240×360 is used as the watermark image.

The peak signal-to noise ratio (PSNR) was used as a measure of the quality of a watermark image. To evaluate the robustness of the proposed approach, the watermarked video frames are tested with many multimedia attacks such as compression, rotation, Gaussian noise, Frame dropping, salt & pepper noise, etc. To compute the PSNR between the original image and extracted image we use the formula (6).

$$PSNR = 10 \log \left[\frac{(M*N)^2}{MSE}\right] \qquad (6)$$

Where mean-squared error (MSE) between the original watermark and the estimated watermark provides a convenient way to measure how well a watermark resists estimation. MSE can be calculated by using formula (7).

$$MSE = \frac{1}{MN}\sum_{i=1} M + \sum_{j=1}^{N} (X_{ij} - Y_{ij})^2 \qquad (7)$$

The values in Table 1 compare the peak signal to noise ratio (PSNR) of our proposed method with Ref 6 Method, for different frames of watermarked video as well as for extracting watermark. After comparing the average PSNR value of frames of the proposed method and ref 6 methods [6], we can observe that the proposed method has given better performances.

Thus, the proposed method is the best method for watermarking the video i.e. the proposed method is an effective and efficient watermarking technique in digital watermarking.

Similarly, The values in Table 2 compares the peak signal to noise ratio (PSNR) of our proposed method with Ref 6 Method, for different multimedia attacks on a video. The stranger may apply any kind of multimedia attacks on the watermarked frame to remove the watermark, but he/she will not be able to remove the embedded watermark. From this table we can observe that, the PSNR value of proposed method is more than the PSNR value of ref 6 method.

Table 1: Experimental Results on different frames

Watermarked Frames / Extracted Watermark	Proposed Method (PSNR)	Ref 6. Method (PSNR)
Frame 1	88.89	
Frame 2	86.75	
Frame 3	85.34	59.11
Frame 4	89.72	
Average of Proposed Method	87.67	
Watermark 1	49.69	
Watermark 2	51.79	30.28
Average of Proposed Method	50.74	

Table.2: Experimental Results for various multimedia attacks

Original Image	Multimed-ia Attacks	Proposed Method (PSNR)	Ref 6. Method (PSNR)
	Gaussian	68.47	38.32
	Crop	60.41	56.00
Frame 1	Salt-Pepper	70.29	30.09
	Blur Attack		
	Poisson	69.93	37.83
		71.89	46.23

Thus, the proposed scheme is not only used for embedding and extracting the watermark, but it can also be used to extract the watermark from the attacked video.

Fig.4 gives the images used for the result analysis, those are (a) Original Frame Selected from Video, (b) Watermarked Frame, (c) Original Watermark and (d) Recovered Watermark.

1. Original Frame Selected from Video

(b) Watermarked Frame

(c) Original Watermark

(d) Recovered Watermark

Fig.4: Result analysis images

Fig.5 shows various multimedia attacks such as (a) Salt & Pepper Noise Attack, (b) Gaussian Noise Attack, (c) Blur Attack, (d) Poisson Noise Attack

(a) Salt & Pepper Noise Attack

(b) Gaussian Noise Attack

(c) Blur Attack

(d) Poisson Noise Attack

Fig.5: Different Multimedia Attacks

CONCLUSION

In this paper, a Digital Watermarking Algorithm based on Arnold, DWT and SVD is proposed. The DCT-SVD based method is very time consuming while the process of SVD-DWT and Arnold Transform method is found to be very fast and this new method was found to satisfy all the requisites of an ideal watermarking scheme such as imperceptibility, robustness and good capacity. This method can be used for authentication & data hiding purposes and the mentioned objectives have been achieved. The use of this scheme can be extended to various video formats like .avi, .flv, .mp4, .3gp etc and watermark can be embedded on black-white as well as on color videos and also to solve the problems regarding frame ambiguity.

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