A Robust Color Video Watermarking Technique Using DWT, SVD and Frame Difference

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Abstract. In the last decade there has been a steep rise in the amount of digital media. This has made entertainment comfortable for the consumer but insecure for the producer. With affordable broadband and innumerable methods, protecting proprierty digital media assets is difficult. Digital watermarking is one way to protect these assets. In this paper, we propose an efficient watermarking method for a colour video sequence. This method improves the execution time than existing techniques due to choosing lesser number of frames to embed the watermark, while still maintaing the robustness against various attacks. The robustness is measured using PSNR values and the correlation coefficient.

Keywords: Frame difference video watermarking · Singular value decomposition · Discrete wavelet transform

1 Introduction

In digital watermarking, there is a host signal (cover signal) and a watermark signal. The vulnerability of easily available multimedia assets is due to many factors, like high speed internet, piracy etc. Copyright protection, authentication, traitor tracing are some of major issues in the industry [1]. Digital watermarking is considered to be a tool for verifying the owner and the unauthorized user of a document [2,3]. Watermarking of an image is usually performed in two domains, viz. Spatial domain and Transform domain. In the spatial domain, the pixels of the host image are directly modified [4]. In the transform domain, the host image is first transformed using transforms like DCT, DWT, DFT, etc., and the watermark is then embedded into the host image [5]. We propose a hybrid method that combines the benefits of transforms like DWT and SVD along with making use of frame differences, a term familiar in video encoding. Instead of adding a watermark into all the frames of an input, a random frame is selected to add the watermark [2,6], the frame differences are then added to this frame to generate a sequence of watermarked frames. In Sect. 2, the proposed algorithm is explained. In Sect. 3 the experimental setup and results are provided, explaining the improvement of the proposed technique over existing ones. In the end, we conclude that this is a robust as well as efficient algorithm.

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2 Proposed Method

Like every other watermarking algorithm, the proposed method too consists of an embedding and an extraction/detection algorithm. In this method, the stability of the singular values of an image is combined with the adaptive nature of DWT. To increase the efficiency of the algorithm, a basis frame is identified to be watermarked. As will be shown later, the novelty in this algorithm is reducing the watermark embedding time and improving the robustness of the embedded watermark too.

2.1 Embedding Algorithm

A frame is chosen randomly from the video sequence. In order to obtain the motion parts, this frame is subtracted from all frames over all channels. DWT is applied to the basis frame, the LL band is chosen and transformed further using DWT. Then the HH subband in this double transformed image is chosen and further processed using SVD. Simultaneously, the watermark image is also transformed using DWT, unlike the basis frame, DWT is applied only once on the watermark image. SVD is applied on the HH sub band. The frame's modified singular values are obtained by adding the watermark's singular values. Using this newly obtained singular values, the high frequency sub-band is reconstructed. The low frequency sub-band is reconstructed using IDWT. Using this low frequency sub-band, the watermarked frame is constructed. All the respective frame differences are added to this watermarked frame to obtain all the video frames. The video frames are then used for obtaining the watermarked video (Fig. 1).

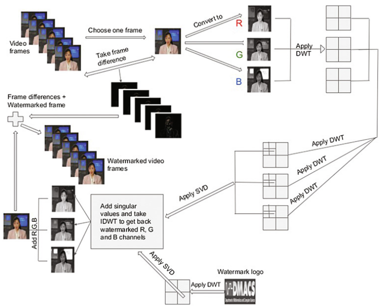

Fig. 1. Diagrammatic representation of the embedding process

2.2 Extracting Algorithm

The watermarked/attacked video frames are divided into RGB channels. DWT is applied to these frames to get the four sub-bands as in the step 3 of the embedding algorithm. DWT is applied to the low frequency sub-bands obtained in the above step as in the step 4 of the embedding algorithm. SVD is applied to second level high-frequency sub-bands (HH). The singular values obtained are then subtracted from the original singular values. These resultant singular values are then used for extracting the watermark from the watermarked or the attacked video.

3 Experimental Results

In our study, we consider two colour videos, one is a standard video called *Akiyo video* and the other one is a video made locally called *Sangsay sports video*. These videos consist of 233 and 173 frames respectively and are of dimension 1024×1024. Figure 2 shows a frame each, of the Akiyo video and the Sangsay sports video. In the Akiyo video, there is no change of background whereas in the Sangsay video, there is scene change with lot of motion. It is observed that the algorithm works well for both the cases. The watermark is a gray scale image, logo of our department in college as shown in Fig. 2 and is of size 512×512.

Akiyo video frame Sangsay video frame Watermark

Fig. 2. Sample frames of the videos and the watermark

PSNR measures the visual quality of the modified image and is expressed in decibel (dB) scale. There exists a direct proportionality between the quality of the image and the PSNR value of the image. The imperceptibility factor which plays a crucial role in watermarking is measured by PSNR [5,7]. The PSNR of 40 dB is regarded to have high frame quality. Here in this paper, we have obtained the PSNR values to be above 65 dB.

We compare the PSNR of the proposed technique with the existing methods, Pejman Rasti et al. [1], Lai and Tsai [8] and Agoyi et al. [9] in Figs. 3 and 4. The proposed method shows better results. Correlation coefficient is another metric used frequently in measuring the robustness of the watermark. It finds the similarity of the watermark that is extracted and the original embedded watermark.

In order to measure the proposed technique's robustness, the watermarked video was tested against attacks like frame averaging, cropping, compression, rotation and many more as mentioned in [10].

Figure 5 shows some of the various attacks that have been performed on the watermarked Sangsay sports video. Figure 6 shows the watermark images extracted after various attacks. Table 1 shows the correlation coefficient values of the watermarked Akiyo video frame and its comparison with the existing methods [1,8,9]. Table 2 shows the correlation coefficient values of the watermarked Sangsay sports video frame against the same methods.

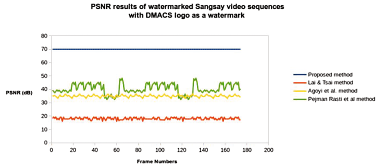

Fig. 3. PSNR values of watermarked Sangsay video frames with DMACS logo as a watermark

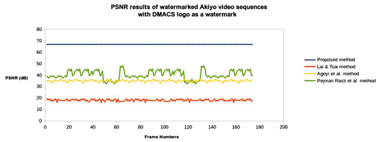

Fig. 4. PSNR values of watermarked Akiyo video frames with DMACS logo as a watermark

Frame Averaging Cropping Rotation Flipped

Fig. 5. Manipulated/attacked frames

Fig. 6. Extracted watermark images

3.1 Robustness and Efficiency Improvement

To show the robustness of the scheme, we performed multiple attacks on the same frame. It is observed that the correlation coefficient values are very good. Some of the combinations are (i) Gaussian, Poisson and Salt & pepper noise attacks, (ii) Blurring, Rotation and Gaussian noise attacks, (iii) Gaussian noise, Gamma correction and rotation, (iv) Poisson noise, sharpening and flipping, (v) Frame averaging, salt & pepper noise and flipping attacks. Figure 7 shows the frames that have been introduced to multiple attacks and their respective extracted watermarks. Table 3 shows the correlation coefficient results of the frames that have been exposed to multiple attacks. This shows that the proposed technique

Table 1. Correlation coefficient values of watermarked Akiyo video.

Attacks	Proposed method	Pejman Rasti et al.	Lai and Tsai	Agoyi et al.
Contrast enhancement	**0.9997**	0.9671	0.9149	0.1394
Gaussian noise	**0.97**	0.9454	0.7777	0.5199
Poisson noise	**0.9963**	0.9945	0.8245	0.5263
Salt & pepper noise	**0.9987**	0.9979	0.9103	0.5300
Blurring	**0.9999**	0.9336	0.1880	0.7051
Frame averaging	**0.9998**	0.9231	0.2543	0.3352
Frame rotation	**1**	0.9562	0.8652	0.5682
Flipping	**1**	1	0.9641	0.0422
Compression	**1**	0.9396	0.9194	0.0612
Gamma correction	**1**	0.9854	0.9476	0.0998
Cropping	**1**	0.9854	0.8552	0.2961
Sharpening	**0.9982**	0.9979	0.7570	0.8561

Table 2. Correlation coefficient values of watermarked Sangsay video.

Attacks	Proposed method	Pejman Rasti et al.	Lai and Tsai	Agoyi et al.
Contrast enhancement	**0.9899**	0.9671	0.9149	0.1394
Gaussian noise	**0.9961**	0.9454	0.7777	0.5199
Poisson noise	**0.9997**	0.9945	0.8245	0.5263
Salt & pepper noise	0.9869	**0.9979**	0.9103	0.5300
Blurring	**0.9861**	0.9336	0.1880	0.7051
Frame averaging	**0.9851**	0.9231	0.2543	0.3352
Frame rotation	**0.9999**	0.9562	0.8652	0.5682
Flipping	**1**	1	0.9641	0.0422
Compression	**0.9999**	0.9396	0.9194	0.0612
Gamma correction	**0.9864**	0.9854	0.9476	0.0998
Cropping	**0.9988**	0.9854	0.8552	0.2961
Sharpening	0.9481	**0.9979**	0.7570	0.8561

even survives the multiple attacks as it can extract the watermarks with high visual quality.

This technique includes the watermark being embedded only in the basis frame, much in contrary to other techniques where all the frames are watermarked by repeating the same embedding steps for each frame. Because of this, the execution time of the proposed embedding algorithm is very less in comparison to the other techniques. The proposed algorithm takes **3.975 s** to embed a watermark in a video whereas the other technique takes **95.020 s**. The time taken for embedding the watermark decreases by **24x**.

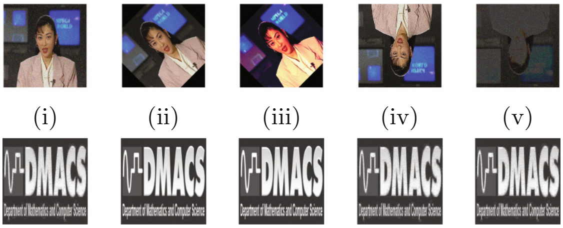

Fig. 7. Video frames introduced to multiple attacks and its respective extracted watermarks

Table 3. Correlation coefficient values of exposed to multiple attacks

Attacks	Correlation coefficient
Gaussian + Poisson + Salt & pepper	0.9164
Blurred + rotate + Gaussian	0.985
Gaussian noise+Gamma correction +rotation	0.9912
Poisson noise+Sharpening+Flipping	0.9597
Frame averaging+Salt & pepper noise+flipping	0.9415

4 Conclusion

The proposed technique of adding a watermark to all the frames by actually adding it to only a single frame, which is selected randomly, is the novelty of this algorithm. Since this scheme embeds watermark in all the color channels of all the frames, it survives temporal attacks like FDAS (frame dropping, averaging and swapping). The watermark is found even if multiple frames are dropped. If on a lower bandwidth, the watermarked video can be transferred as a pair of, watermarked frame and the frame differences. The recipient can reconstruct the watermarked video using this single frame and the differences. The watermark can be extracted from any of the frames to prove the authenticity of the media being transmitted. This method is robust against various attacks and even combinations of them. It outperforms the existing video watermarking schemes on the correlation coefficient and PSNR values.

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