A Hybrid Watermarking Model for Video Authentication

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Abstract

Digital multi-media data can easily be replicated and distributed. The rapid proliferation of digital video raised concerns from content owners in terms of providing protection to their digital video. Video watermarking helps the owners to assert their ownership amidst several intentional and unintentional attacks on the video. In this paper, we propose a hybrid watermarking model for video authentication based on two powerful transform techniques, namely Discrete Wavelet Transform (DWT) and Singular Value Decomposition (SVD). This proposed model is simple to implement and will be robust against the attacks of frame dropping, averaging, filtering, swapping, tampering and geometrical attacks like rotation.

Keywords –digital watermarking, scene change detection, singular value decomposition, video authentication, wavelet transforms.

1. Introduction

Rapid developments in the field of digital multi-media technology have increased the popularity of video-based applications. Simultaneously this technical advancement also resulted in unauthorized copying, distribution or modification of digital video.

Watermarking is a technique that embeds data called a watermark into a multimedia object. This embedded watermark can be extracted later and the required analysis can be performed. Video watermarking started receiving prominent attention in the recent past and many algorithms were proposed. In a broad sense, there are two types of such algorithms – compressed video watermarking and uncompressed video watermarking. Video watermarking applications include copy control, broadcast monitoring, copyright protection, video authentication, enhanced video coding, fingerprinting, covert communication, to name a few. Prominent ongoing research in this field will result in several breakthroughs in the near future. Compared to image watermarking, several issues need to be addressed in video watermarking.

Based on the method of embedding the watermark information in the host video, video watermarking techniques can be classified as spatial domain watermarking and transform domain watermarking. In spatial domain watermarking, the pixel intensity values of the video frame are modified directly with the watermark content. However, in transform domain techniques, the host video frame information in the transform domain is altered with the watermark content. Compared to spatial domain watermarking, transform domain watermarking is not easier to implement but it increases the difficulty in removing the watermark through attacks like cropping, scaling, and geometrical attacks. The commonly used transform domain techniques are Discrete Fourier Transform (DFT), the Discrete Cosine Transform (DCT), and the Discrete Wavelet Transform (DWT).

In this paper, we propose an invisible semi-blind video watermarking algorithm for video authentication. In this algorithm, the significant aspects of two powerful transforms namely Discrete Wavelet Transform (DWT) and Singular Value Decomposition (SVD) are combined. For every scene change, a new watermark is embedded. For any motionless scenes in the video, the same watermark is embedded. Independent watermarks are used for successive different scenes [1]. The proposed algorithm is non-blind, as it requires the singular values of the original host video frames and the U and V matrices of the original watermarks. For video authentication, non-blind schemes are appropriate as watermark extraction or detection needs to take place in a special laboratory environment only when there is a dispute regarding the authenticity of the content [6].

2. DWT-SVD Domain Watermarking

2.1 DWT based Watermarking

Wavelet transforms form the basis for the multiresolution theory and have the powerful feature of providing both time and frequency localization. 2D – DWT results in four subbands of data – approximation (LL), horizontal (LH), vertical (HL) and diagonal (HH). To obtain another level of decomposition, the LL subband can be further decomposed. This process can be repeated to obtain the decomposition at the required level and this results in multi-resolution analysis. LL band comprises the perceptually significant (low frequency) information and is known as the approximation band. The remaining three bands give the horizontal, vertical and diagonal details of the signal (high frequency information).

In DWT based watermarking, the watermark data is embedded in the DWT coefficients. Embedding in low frequencies increases the robustness with respect to attacks that have low pass characteristics like filtering, lossy compression, and geometric distortions while making the scheme more sensitive to modifications of the image histogram. Watermarks embedded in middle and high frequencies are typically less robust to low-pass filtering, lossy compression and small geometric deformations of the image but are highly robust with respect to noise adding, and nonlinear deformations of the gray scale [6].

2.2 Singular Value Decomposition (SVD)

SVD is an important factorization of a rectangular real or complex matrix, with many applications in signal processing and statistics. It is a numerical technique for diagonalizing matrices in which the transformed domain consists of basis states that is optimal in some sense [5]. Applications which employ the SVD include computing the pseudo inverse, least squares fitting of data, matrix approximation, and determining the rank, range and null space of a matrix. SVD has also been used in several watermarking algorithms.

The SVD of an N x N matrix M is defined by the operation: $M=USV^*$ where U and V are unitary matrices, * denotes the transpose and S is a diagonal matrix. The diagonal entries of S are called the singular values of M and are assumed to be arranged in decreasing order $\sigma_i > \sigma_{i+1}$. The columns of the U matrix are called the left singular vectors while the columns of the V matrix are called the right singular vectors of M. Each singular value σ_i specifies the luminance of an image layer while the corresponding pair of singular vectors specifies the geometry of the image layer [5].

In SVD-based watermarking, a frame image is treated as a matrix decomposed into the three matrices; S, U and V^*. The watermark information can then be embedded in S, U or V^*.

2.3 DWT – SVD Watermarking

DWT and SVD watermarking techniques can be combined to extract the advantages of each technique into one simplified algorithm.

3. Proposed Method

The proposed video watermarking scheme comprises of the following stages as shown in the flowchart and explained below.

3.1 Video Pre-processing

The video pre-processing scheme consists of four steps namely choosing the original video, frame extraction, scene change detection, and RGB to YCbCr conversion.

Original video – This is the video that needs to be watermarked for providing authentication.

Frame extraction – Any video is a collection of frames. Each of these frames should be embedded with a watermark. Frames should be first extracted from the video

Scene change detection – Scene changes are detected from the video by applying the histogram difference method on the video stream. Based on the scene changes, the watermark to be embedded is changed. In each frame, only the red component is used to detect scene changes. Histograms of the corresponding frames are calculated. The total difference of the whole histogram is calculated using the following equation:

$$D = \sum_{k=1}^{N-1} |H(K) - H(K+1)|$$

where H(K) represents histogram of K^{th} frame

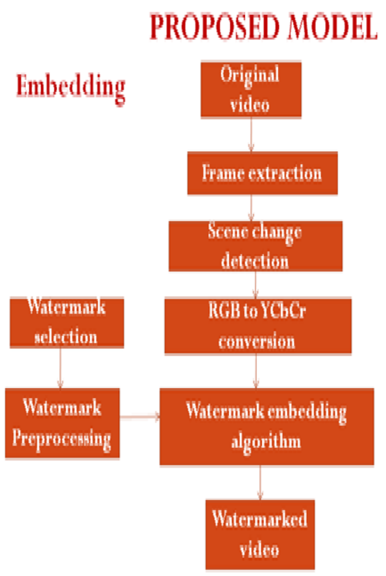
N is the number of frames

If D>Threshold (T), then there is a scene change [1].

RGB to YCbCr conversion – Each frame is in RGB format and is converted to YCbCr format. Only the Y-component is modified with the watermark information.

3.2 Watermark Pre-processing

Gray watermarks are chosen and are pre-processed such that their size is equal to the size of the DWT sub-band of the video frame. The number of watermarks required is equal to the number of scene changes detected in the host video.



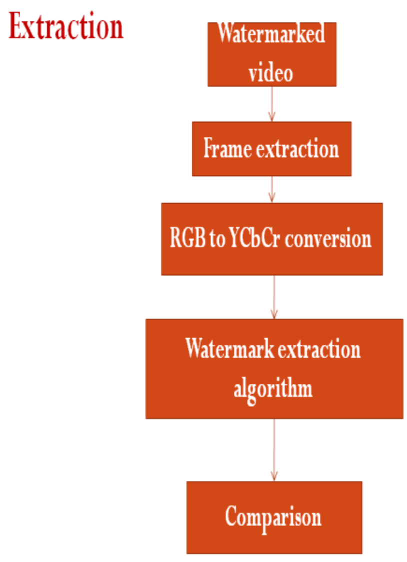


Figure 1. Flowcharts for Watermarking

3.3 Watermark Embedding Algorithm

1. Using DWT, decompose the Y component of each video frame A into 4 sub bands: LL, HL, LH, and HH. Single level wavelet decomposition is performed on the Y-component of each frame using Haar transform. This results in 4 sub-bands namely, approximation, horizontal, vertical and diagonal details.

2. Apply SVD to each sub band image.

3. Apply SVD to the visual watermark.

4. Modify the singular values of the cover image λ^k_i in each subband by adding a scaled version of the singular values of the watermark (λ_w). (α_k is the scaling factor chosen in accordance with the Subband)

5. Obtain the 4 sets of the modified DWT coefficients.

6. Apply the inverse DWT using the four sets of modified DWT coefficients to produce the modified Y component followed by YCbCr to RGB conversion.

7. Repeat the above steps for each frame in the video. Whenever a scene change is detected, embed a new watermark.

The completion of the above steps results in the watermarked video.

3.4 Watermark Extraction Algorithm

1. Using DWT, decompose the Y component of the video frame A^* into 4 sub bands: LL, HL, LH, and HH.

2. Apply SVD to each sub band image:

3. Extract the singular values corresponding to the watermark from each sub band by using the equation employed for watermark embedding.

4. Construct the four visual watermarks using the singular vectors.

5. Take the average of the watermarks extracted from the four subbands.

6. Repeat the above procedure for different scenes of video. The SVD values of watermarks will change according to the scene changes.

The completion of the above steps results in the extraction of watermarks from the watermarked video.

4. Results

A host video (RGB24) comprising of 102 frames with a frame rate of 25frames/sec and a frame size of 352x288 was used to test the algorithm. Four scene changes (fig. 1.5) were detected and thus four different gray watermarks were used as shown in fig.1.3. The algorithms were implemented using MATLAB software. The proposed algorithm was used for watermarking and the attacks including mean filtering, median filtering, unsharp masking, gaussian noise, salt and pepper noise, frame dropping, frame averaging, frame tampering, frame swapping and rotation were carried out on the watermarked video. In each case, the watermarks were extracted and correlation coefficient was calculated. Figs 1.7 – 1.14 show the results and correlation coefficients for some of the different attacks performed on the host video. These results explain the efficiency of the proposed algorithm for video authentication.

5. Conclusion

In this paper, we proposed a hybrid watermarking algorithm that aids in video authentication. This algorithm is simple to implement, and exploits the powerful features of DWT and SVD. Simulation results reveal the effectiveness of this algorithm when the video is subjected to several attacks.

Figure 2. Original Video Frames

Figure 3. Watermarks

Figure 4. Watermarked Frames

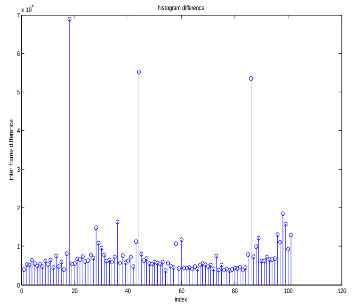


Figure 5. Scene Change Detection

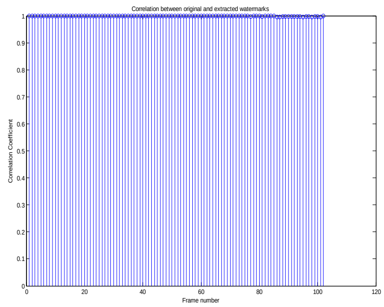


Figure 6. Correlation between Original and Extracted Watermarks

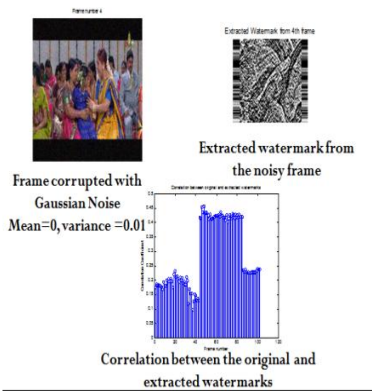


Figure 7. Gaussian Noise (mean=0, variance =0.01)

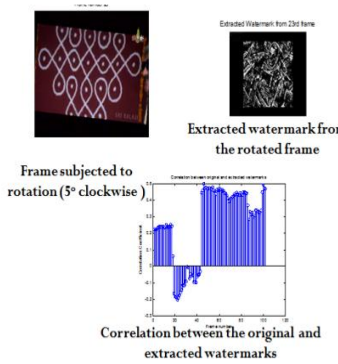


Figure 8. Rotation (5^{o} clockwise)

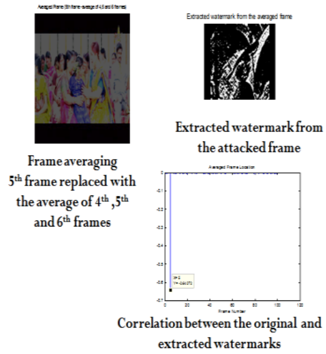


Figure 9. Frame Averaging

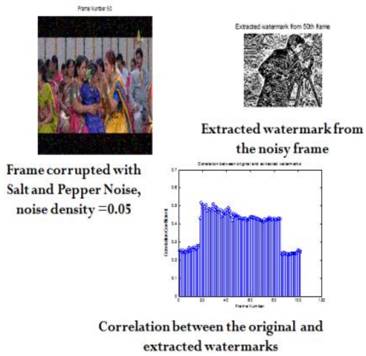


Figure 10. Salt and Pepper Noise (noise density=0.01)

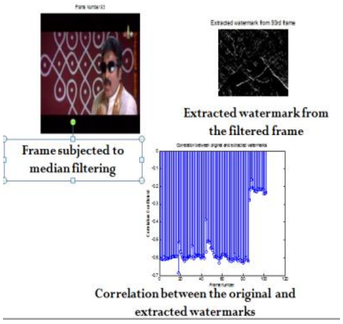


Figure 11. Median Filtering (3x3)

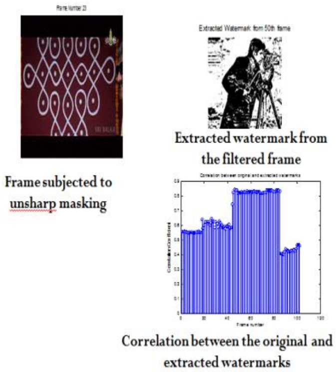


Figure 12. Unsharp Masking

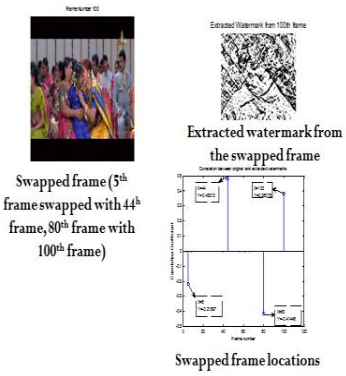


Figure 13. Frame Swapping

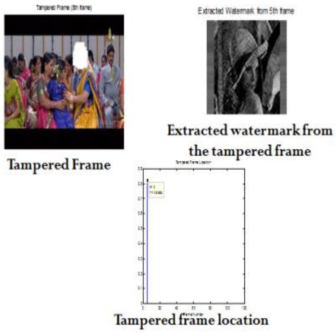


Figure 14. Frame Tampering

REFERENCES

[1] Chetan K.R, Raghavendra K, "A Blind and Robust Watermarking Scheme with Scrambled Watermark for Video Authentication", in Internet Multimedia Services Architecture and Applications (IMSAA), 2009 IEEE International Conference (1-6), December 2009.

[2] Rajab L, Al-Kathib, Al-Haj, "Hybrid DWT-SVD Video Watermarking", in International Conference on Innovations in Information Technology, 2008. IIT2008, Dec.2008.

[3] Fung C W H, Godoy W, "A novel DWT-SVD video watermarking scheme using side view", in Signal Processing and Communication Systems (ICSPCS), 2011 5th International Conference, Dec 2011.

[4] Chun-Xing Wang, Xiushan Nie, Xianqing Wan, Wen Bo Wan, and Feng Chao, "A Blind Video Watermarking Scheme Based on DWT" in Intelligent Information Hiding and Multimedia Signal Processing, 2009. IIH-MSP '09. Fifth International Conference.

[5] Lama Rajab Tahani Al-Khatib Ali Al-Haj, "Video Watermarking Algorithms Using the SVD Transform" in European Journal of Scientific Research, ISSN 1450-216X Vol.30 No.3 (2009), pp.389-401.

[6] Emir Ganic. Ahmet M. Eskicioglu, "Robust DWT-SVD Domain Image Watermarking: Embedding Data in All Frequencies", MM&SEC'04, September 20–21, 2004, Magdeburg, Germany.

[7] Gaurav Bhatnagar and Balasubrmanian Raman, "Wavelet packet transform-based robust video watermarking technique", in Sadhana, Vol. 37, Part 3, June 2012, pp. 371–388, Indian Academy of Sciences.

[8] G. Doerr and J. Dugelay, "A Guide Tour to Video Watermarking," Signal Processing: Image Communication, vol. 18, pp. 263-282, 2003.

[9] Rafael C. Gonzalez, Richard E. Woods, "Digital Image Processing", Prentice Hall.

[10] Raghuveer M. Rao, Ajit S. Bopardikar, "Wavelet Transforms – Introduction to Theory and Applications", Pearson Education.

[11] S Jayaraman, S Esakkirajan, T Veerakumar, "Digital Image Processing", McGraw Hill.