

Advance use of DWT and PCA in Digital Video Watermarking

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Abstract— Now a day there is use of digital multimedia applications are increased. Hence during extensive use of these applications it is necessary to provide security and copyright protection. Copyright protection for digital applications is improved by using a new technology "Digital Watermarking". In this paper an advance use of digital video watermarking is introduced. We propose advance use of Discrete Wavelet Transform and Principal Component Analysis in Digital Video watermarking. Firstly input video which consist of number of frames convert into binary frames. One frame (RGB) converts into YUV frame. Take Y component apply DWT. The binary watermark is then embedded into principle components of the low/high frequency wavelet coefficients. PCA helps in reducing correlation among the wavelet coefficients obtained from wavelet decomposition of each video frame thereby dispersing the watermark bits into the uncorrelated coefficients. The embedded watermark is imperceptible high bit rate which is robust against different attacks (cropping, rotation etc).

Index Terms— Discrete Wavelet Transform, Principle Component Analysis, binary watermark, digital video.

I. INTRODUCTION

The basic popularity of multimedia applications[1] is to provide copyright protection to prevent illicit copying and distribution of digital video. Copyright protection means inserting authentication data such as data such as ownership information and logo in the digital video that we want to protect. The authentication data can also extracted from the video and it can be used as authoritative proof to prove the ownership. Hence Digital Video Watermarking for copyright

protection[2,3] technique newly emerged in the field of research. Watermarking is the process in which data embeds called watermark into the video or any kind of object and it can also be detected and extracted from the video to make an assertion about video or object. Digital watermarking techniques provides criteria of imperceptibility as well as robustness against all attacks[4,5]. Many digital watermarking schemes have proposed for still images and videos [6]. Hence some of which operate on uncompressed videos [7-8], and others embed watermarks directly into compressed videos [7].

Video watermarking can be classified into two categories which is based on the method of hiding watermark bits into the host video. These two categories are: Spatial domain & Transform domain. In Spatial domain watermarking, embedding and detection of watermark are performed by directly selecting the pixel intensity values of the video frame. On the other hand Transform domain [9] techniques, alter spatial pixel values of the host video according to a predetermined transform and it is observed that Transform domain more robust than spatial domain techniques.

In this paper, I propose the advance use of Discrete Wavelet transform[10,11] & Principle Component Analysis[12] in Digital Video Watermarking. There are different types of transforms which are DFT, DCT, DWT etc. The DWT is more fast & computationally more efficient than other transforms. DWT has excellent spatio-frequency properties hence it is used to identify the areas to which the watermark can be embedded imperceptibly.

The watermark is embedded into the luminance component of the extracted frames as it is less sensitive to the human visual system (HVS).

The paper is presented in the form of chapters as follows; as chapter I contains introduction, chapter II contains watermarking scheme with DWT & PCA, chapter III

contains system flow, algorithms and performance analysis with results and finally chapter IV contains conclusion.

II. WATERMARKING SCHEME WITH DWT & PCA

The watermarking scheme contains algorithm which is implemented by using DWT & PCA. So, let us discuss about DWT & PCA.

1. Discrete Wavelet Transform

Discrete Wavelet Transform mostly used in the applications of signal processing. A single stage wavelet transformation consist of filtering operation that decomposes an image into four frequency bands as shown in (fig 1). It is 2D-DWT which is an application of 1D-DWT in horizontal & vertical directions. The top-left corner of the transformed image (‘LL’) is the original image. The top-right corner (‘HL’) consists of residual vertical frequencies, the bottom-left corner (‘LH’) contains residual horizontal frequencies and the bottom-right corner (‘HH’) contains residual diagonal frequencies. The wavelet decomposition has some important properties. First, the number of wavelet ‘coefficients’ is the same as the number of pixels in the original image and so the transform is not inherently adding or removing information. Second, many of the coefficients of the high-frequency components(‘HH’, ‘HL’ and ‘LH’ at each stage) are zero or insignificant. This reflects the fact that much of the important information in an image is low-frequency. Third, the decomposition is not restricted by block boundaries (unlike the DCT) and hence may be a more flexible way of de-correlating the image data (i.e. concentrating the significant components into a few coefficients) than the block-based DCT. Since the HVS is less sensitive to high frequencies, embedding the watermark in high frequency sub-bands makes the watermark more imperceptible while embedding in low frequencies makes it more robust against various attacks.

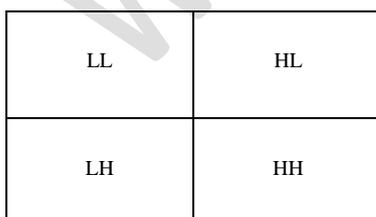


Figure 1. DWT sub-bands

2. Principle Component Analysis

PCA is a useful statistical technique that has found application in fields such as face recognition and image compression, and is a common technique for finding patterns in data of high dimension[13]. It uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of uncorrelated variables called principal components. PCA is used for identifying patterns in data and expressing it by their similarities and differences. The advantages that PCA is powerful tool in the analysis of data, also once patterns in data get identified data can be compressed by reducing number of dimensions without loss in information. It covers standard deviation, covariance, eigenvectors and eigenvalues[13]. The data with maximum covariance are plotted together and is known as the first principal component. The first principle component contains maximum energy concentration.

Standard Deviation :

The average distance from the mean of the data set to a point. The way to calculate it is to compute the squares of the distance from each data point to the mean of the set, add them all up, divide by n-1 and take the positive square root[13].

Covariance :

Covariance is such a measure. Covariance is always measured between 2 dimensions. A measure of how much each of the dimensions varies from the mean with respect to each other[13].

Eigenvectors :

Eigenvectors can only be found for square matrices. And, not every square matrix has eigenvectors. For n x n matrix there are n eigenvector[13].

III. SYSTEM FLOW

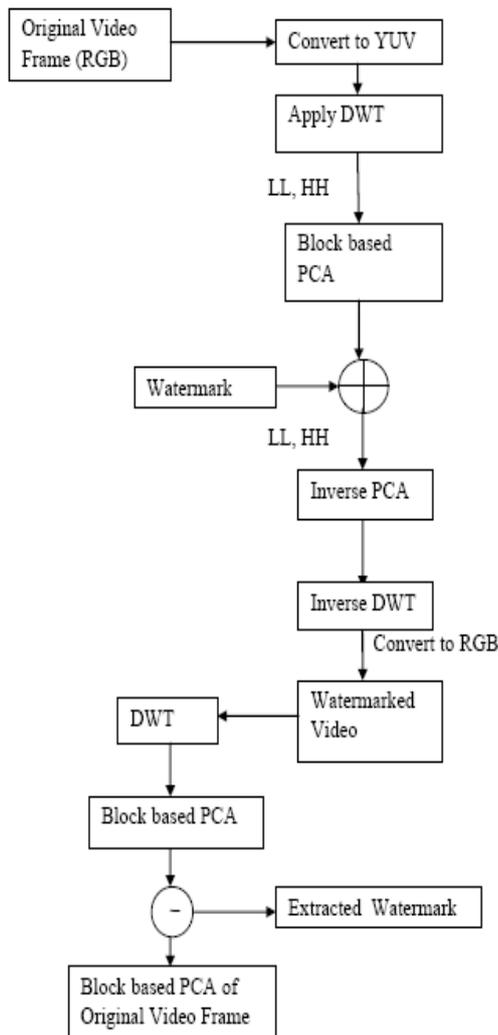


Fig.2 Block Diagram of Watermarking

3. Algorithms for watermarking using DWT and PCA

It consist of two algorithms, Algorithm 1 and Algorithm 2 .Algorithm 1 consist of embedding and extraction algorithms respectively.

Algorithm 1
 Embedding algorithm

Step 1: The original input video contains n number of frames, convert into binary frame of ‘0’s & ‘1’

Step 2: Take one frame and convert from RGB to YUV colour format

Step 4: Take luminance component of one frame and apply DWT we obtain four sub bands as shown in above diagram.

Step 5: Take LL component and apply PCA .

Step 6: From algorithm 2 obtain the principle component PC and watermark bits are embedded with factor α . The embedding is carried out by equation $PC'_i = PC_i + \alpha W$ where PC_i represents the principal component matrix of the i^{th} sub-block.

Step 7: Apply inverse PCA to the sub-blocks of the LL sub-band to obtain the modified wavelet coefficients.

Step 8: Apply inverse DWT we obtain the watermarked luminance component of the frame. The frame is in YUV format then convert into original RGB component.

Extraction algorithm

Step 1:The Extraction process is totally reverse process of embedding procedure.

Step 2: And finally watermark bits are extracted from the principal components of each sub-block as in equation $W'_i = (PC'_i - PC_i) / \alpha$ where W'_i is the watermark extracted from the i^{th} sub block.

Algorithm 2

The LL sub-band coefficients are transformed into a new coordinate set by calculating the principal components of each sub-block (size $n \times n$).

Calculate vector PC_i as

$PC_i = Z \times \text{coefficient}$

where PC_i represents the principal component matrix of the i^{th} sub-block.

Where $Z = (D - \mu) / \sigma$

Where D -row vector μ - mean σ -standard deviation

Performance Analysis

The performance of the algorithm has been measured in terms of its imperceptibility and robustness against the possible attacks like noise addition, filtering, geometric attacks etc. by using the nature of PSNR & NC.

PSNR :

The Peak-Signal-To-Noise Ratio (PSNR) is calculated by following formula:

$$\text{PSNR} = 10 \text{Log}_{10} (255^2 / \text{MSE})$$

where MSE (mean squared error) between the original and distorted frames.

Higher values of PSNR indicate more imperceptibility of watermarking. It is expressed in decibels (dB).

NC :

The normalized coefficient (NC) represents the robustness of watermarking and its peak value is 1.

The proposed algorithm is applied to a sample video sequence ‘Lake.wmv’ using a 32×32 watermark logo. The grayscale watermark is converted to binary before embedding. Fig. 3(a) and 3(b) show the original and the watermarked video frames respectively.



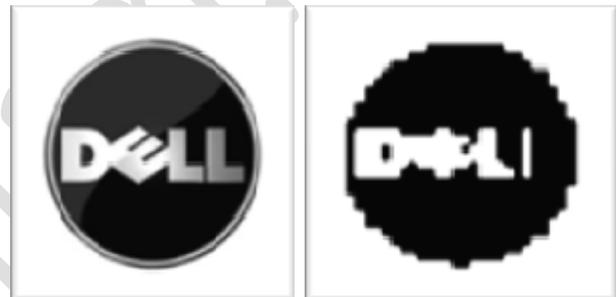
(a)



(b)

**Figure 3. (a) Original Video frame
(b) Watermarked video**

Also the following example fig.4 (a) & (b) shows the embedded watermark & extracted binary watermark image respectively.



(a)

(b)

Figure 4. (a) Original watermark (b) Extracted binary watermark

The following table.1 shows the value of the data collected from the watermarked video after performing the various attacks.

Table 1

ATTACK	PSNR	NC
GAUSSIAN NOISE	31.1564	0.6861
SALT & PEPPER NOISE	24.4592	0.6548
CROPPING	28.3373	0.6801
ROTATION	28.8256	0.6510
RESIZING	41.4628	0.6068

IV. CONCLUSION

The Digital Video Watermarking using DWT-PCA is robust and imperceptible in nature and embedding the binary watermark in the low LL sub band helps in increasing the robustness of the embedding procedure without much loss of information and quality of video. As a future work the video frames can be subject to scene change analysis to embed an independent watermark in the sequence of frames forming a scene, and repeating this procedure for all the scenes within a video. The future scope of this is used as Owner Identification ,Proof of Ownership ,Transaction Tracking, Content Authentication ,Broadcast Monitoring ,Device Control ,Automatic monitoring of copyrighted material on the Web etc.

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REFERENCES

- [1] Yeo and M.M. Yeung, "Analysis and synthesis for new digital video applications," icip, International Conference on Image Processing (ICIP'97), vol. 1, pp.1,1997.
- [2] M. Natarajan , G. Makhdumil, "Safeguarding the Digital Contents: Digital Watermarking," DESIDOC Journal of Library & Information Technology, Vol. 29, May 2009, pp. 29-35.
- [3] C.I. Podilchuk, E.J. Delp "Digital watermarking: algorithms and applications," Signal Processing Magazine, Vol 18, pp. 33-46, IEEE, July 2001.
- [4] G. Doërr, J.L. Dugelay, "Security Pitfalls of Frame-by-Frame Approaches to Video Watermarking," Signal Processing, IEEE Transactions, vol. 52, pp. 2955 – 2964, 2004.
- [5] S. Voloshynovskiy, S. Pereira, T. Pun, "Watermark attacks," Erlangen Watermarking Workshop 99, October 1999.
- [6] G. Langelaar, I. Setyawan, and R. Lagendijk, "Watermarking Digital Image and Video Data: A State of - Art Overview," IEEE Signal Processing Magazine, vol. , pp. 20-46, Sep. 2000.
- [7] F. Hartung and B. Girod, "Watermarking of uncompressed and compressed video," Signal Processing, 1998, vol. 66, no. 3, pp. 283-301.
- [8] T. Tokar, T. Kanocz, D. Levicky, "Digital watermarking of uncompressed video in spatial domain," 9th International Conference on Radioelectronics, IEEE, pp. 319-322, 2009.
- [9] C.H. Li and S.S. Wang, "Transform-Based Watermarking for Digital Images and Video," IEEE International Conference, June 1999
- [10] A-Haj and T. Manasrah, "Non-Invertible Copyright Protection of Digital Images Using DWT and SVD," Digital Information Management, 2007, ICDIM '07, 2nd International Conference ,vol. 1, pp. 448 – 453, 2007.
- [11] T. Hu, J. Wei, "A digital video watermarking scheme based on 1D-DWT", IEEE, International Conference on Biomedical Engineering and Computer Science , 2010, pp. 1-3.
- [12] E. Yavuz, Z. Telatar, "Digital Watermarking with PCA Based Reference Images", ACIVS 2007, Springer-Verlag, Lecture Notes in Computer Science, pp.1014-1023, 2007.
- [13] A tutorial on Principal Components Analysis Lindsay I Smith February 26, 2002
- [14] International Journal of Wisdom Based Computing, Vol. 1 (2), August 2011. "Digital Video Watermarking using Discrete Wavelet Transform and Principal Component Analysis