International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-7 Issue-5, June 2018

A Novel Video Watermarking Scheme Based on DWT and PCA

Nidhi Chawla, Vikram Singh

Abstract: ***Digital Video Watermarking is one of the great applications of hiding the data in the video for many kind of application like copyright information hiding, secure data travelling etc. Various watermarking techniques are popular in the research community e.g. Discrete wavelet transform (DWT), Discrete cosine transform (DCT), Principal component analysis (PCA). In this paper, Video Water Marking (VWM) scheme related to DWT and PCA is used.DWT and PCA are utilized in the proposed algorithm which enhances the watermarking embedding and decrypting technique. An Arnold's cap map method has been introduced in the DWT mechanism due to which the algorithm become more robust and difficult for the attackers. Data are embedded in the LL –HH sub-band of wavelet coefficients and decoding is encountered based on difference and comparison of elements of the first principal component. The resultant video is unsusceptible to much kind of attacks like uniform, Gaussian Noise and Median Filtering.***

Keywords: ***Principal Component Analysis (PCA), Watermarking, Frame Extraction, Discrete Wavelet transform (DWT), Visual Saliency.***

I. INTRODUCTION

In 1979, the digital watermarking comes into existence firstly. The use of multimedia over network especially at World Wide Web increases the number of users of the videos, images, and audios. The concept of security arises here for the owners of the videos clips, audio or image creators. So, the concept of digital watermarking comes in the picture which is very important for us and also the topic of implementation. Data hiding techniques are important as it has many application in today's world i.e. Steganography, copyright protection, fingerprinting etc. The watermarking is of two types (Figure 1) visible and invisible. Transparency (i.e. invisibility of hidden data), capacity (how many numbers of bits can be adjusted or hidden), robustness, security issues and mathematical complexity during embedding and decoding the watermarking data are the vital parameter for the video watermarking.

The MPEG4 (Moving Picture Experts Group) standard videos are most preferably used for watermarking. As the luminance component is less sensitive to the human eye than chrominance components, the watermark logo is embedded in the luminance (Y) component of each frame of the un-coded video. The video is just a collection of a sequence of images.

Manuscript published on 30 June 2018.
***** Correspondence Author (s)
Nidhi Chawla, M.Tech. Scholar, Department of Computer Science and Engineering, Chaudhary Devi Lal University, Sirsa (Haryana), India.
Vikram Singh, Professor, Department of Computer Science and Engineering, Chaudhary Devi Lal University, Sirsa (Haryana), India.

One may detect this number of images as one separate image and provide some watermark on this image and reconfigure the data images to reconstruct the video. This is one of the straightforward ways for data embedding in the video [4]. This method is more susceptible to attack such as frame rate change and compression attacks [2]. 3D transform can also be used for embedding such as DFT [3], DCT [4], DWT [5] etc. Frame by frame embedding encountering temporal characteristics of video [6]. There are many methods discussed in [7] to [11].

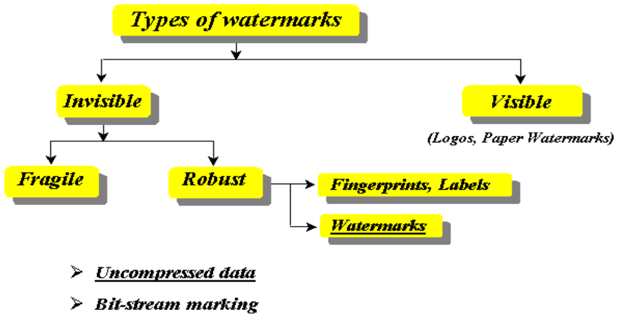

Fig. 1: Types of Watermarking [7][11]

Fig. 2: Video Watermark Example

1.1. Conventional Watermarking Technique

The watermarking system needs both types of the system i.e. for embedding the sequence of the binary message of the owner and decode the video stream into the frames and secure information. In figure 3, the block diagram shows the Embedding system and shows the Decoding System Inputs and outputs.

1.2. Watermarking Schemes

The selection of a number of ways as discussed in literature review contents is possible. We are dividing here all the analysis in the following way:

a. Embedding
    1. Decoding
        a. Scene change detection algorithm
        b. GOP extraction

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

2. "Side information" insertion
   a. Cube selection algorithm
   b. 2D wavelet transform
3. Encoding

b. Extraction
1. Decoding
   a. Scene change detection algorithm
   b. GOP extraction
2. "Side information" extraction
   a. Watermark cube detection Algorithm
   b. 2D wavelet transform
3. Encoding

1.3. A Detailed Discussion of Watermarking Technique

The procedure to follow the video watermarking has been discussed as follows:

1. Embedding:

The Embedding discussion is taken from the [8]. The cubes for the frames are selected based on the movement and complexity. While for data to be embedded are selected on the bases of decoding rule. This approach is enhancing the robustness of the method adopted in [8]. For the embedding interval embedding strength factor is kept constant while during decoding embedding strength factor is adaptively varied according to visual saliency.

2. Decoding

In [8], the decoding rule was the ML criterion. Here, the decoding rule is based on a certain Parameter derived from the data projected onto the first Principal component, which improves robustness.

3. Side information

In [8], the locations of the cubes where data were embedded, as well as the mean and variance of the wavelet coefficients of each cube, were stored as side information for decoding. Here, however, the semi-blind version of the algorithm (presented in this section) stores only the locations of the cubes where data are embedded, while the blind version (Section V) requires only a small key, both of which are much smaller than the side information in [8].

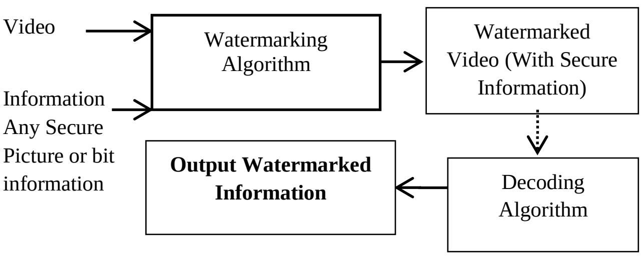

Fig 3. Block Diagram of Embedding Secure Information and Decoding

The whole paper is divided into the Six sections. In Section I the introductory part has been discussed. In section II literature review has been discussed and some problem gap has been found. In Section III, the proposed method has been shown to overcome the problems encountered in the literature review. In Section IV, the proposed algorithm in details with data flow diagram has been investigated and finally implemented and results have been discussed and analyzed in section V. Finally, in Section VI the conclusion on the basis of simulation has been done.

II. RELATED WORK

Spread spectrum modulation techniques are used in [9] for watermarking system development. The method in [9] using the Human visual system (HVS) model. The method used 1 dimensional Discrete Fourier Transform (DFT) and 2-dimensional Discrete Cosine Transform (DCT). This method was prone to temporal attacks and having limitations. This is also possible to compress the video file and use only the components which are important and needed to insert the data. This kind of approach is considered in [12]-[15].

In [2], the author implemented the hybrid watermarking system by using both types the DWT and PCA. The results are too much enhanced by means of this. The watermarked video in this technique was blurring. The limitation of this work is that the recovered watermark was not much clear.

On the base of decoding of data, the methodology divided into three important categories and these are blind, semi-blind and non-blind [16][17][18]. For the Blind system, the concept depends on additional information like a secret key. The secret key used to decrypt the information regarding the data to be extracted and extraction algorithm. Blind data system [20] does not require the host data like Video, Image etc. The Non- Blind system [30] requires the data to be extracted or to decrypt the required videos at the decoder. Side information is extracted by means of the semi-blind systems [7][8][19][20]–[28] and [29]. The system required the original host data (but not all the contents of host information) or watermark is needed to decrypt which is a limitation of this work. Moreover in Literature survey [13] proposed a DWT based video watermarking algorithm based on 3 level DWT using Haar filter. In [4] the author shows a PCA based algorithm for a binary logo watermarking into frames. The author implemented the PCA at both bands LL and HH. The DWT and PCA algorithm are applied separately in this work due to which the decrypted video was not properly regained [13] and watermarked video in [4] is more prone to the image rotation and pepper attacks In [7] the author implements the whole process by implementing the watermarking system using DCT process. By adjusting the blocks DCT coefficient of the image are invisible. In [1], the 2-level DWT and PCA are used for the purpose of watermarking. [12] Represents the important technique of using the PCA for Digital video watermarking. From the rigorous survey this is concluded that there is still scope of research in the DWT and PCA based watermarking technique. In this paper new algorithm have been proposed and implemented so that the blur in the recovered video after watermarking and bit error rate in the decrypted video can be improved.

III. PROPOSED METHOD

The DWT has a very special and excellent feature of spatio-frequency localization properties. The DWT can be used for identifying the watermarked area of the video where the watermarking has been implemented can be easily found or detect.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

Arnold's cap map [39] is an important encryption technique used to improve the security of digital watermarks. The size of the watermark is analyzed and on the basis of its size, the periodicity has been maintained at the same time many transforms have been applied at the logo. The watermark logo is recovered after many reverse transform process. Arnold's cap map is defined in the equation:

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ 1 & 2 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} modN, (x, y \in (0,1,2 \dots N-1) \qquad \dots 1$$

where x' and y' are the new coordinate of the original watermark logo after the transform process, x and y are the coordinates of the original image, and N is the total pixel number. Fig. 4 shows the process of Arnold's cap map. Assuming that the watermark image can recover over I transform processes, we define I as Arnold's cap map period of a watermark logo. There can be a repetition of the process before the embedding process start, Arnold's cap map as a scramble process. To recover the watermark, I - t repetitions of Arnold's cap map must be performed after finishing the retrieving process. So it can be viewed as a key for retrieving the watermark.

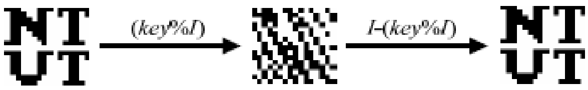

Fig.4. Watermark Logo Permutation by Arnold's cap Map Operation.

3.1. Watermark Embedding

Watermark embedding of video is an important part.

The Following steps are followed for Embedding process:

1. By using the Arnold cap map method watermark will be changed encrypted before the DWT change the pixel to the coefficient.
2. Application of Scene Change Detection algorithm is used to check out for the scene change information. Then the Group of Pictures (GOP) are selected for the framework.
3. Each frame in each GOP is divided into non-overlapping blocks of N0 × N0 pixels, creating a number of N0 × N0 × l pixel cubes in each GOP.
4. Cube Selection Algorithm is now implemented on the cubes inserted. To enhance the robustness of the extraction, cubes are selected based on their absolute mid-point difference:

$$|d| = \left| y_{1,\frac{m}{2}} - \left(\frac{1}{m-1} \sum_{\substack{i=1 \\ i \neq \left\lceil \frac{m}{2} \right\rceil}}^{m} y_{1,i} \right) \right| \qquad \dots 2$$

$$y_{1,\left\lceil \frac{m}{2} \right\rceil} + \left(\frac{1}{m-1} \sum_{i=1, i \neq \left\lceil \frac{m}{2} \right\rceil}^{m} y_{1,i} \right) \leq 0 \qquad \dots 3$$

The cubes for which are removed and the remaining are sorted in descending order of |d|.

5. Discrete Wavelet Transform (DWT)After Cube Selection 2-D DWT has been done. The wavelet transforms breaks down an image or video frame into a set of band fixed components which can be put together to rebuild the master copy [36, 38]. 2-d DWT is good for any decomposition and recombination of the video and pictures so the DWT techniques are used to decompose the video into the 2-dimensional multi-resolution filtering process. We can also use the DCT but one advantage of the DWT over DCT is that it can more accurately model the aspects of Human vision System as compared in [30, 34]. Fig. 5 shows the LL and HH component resulting from 2D DWT.

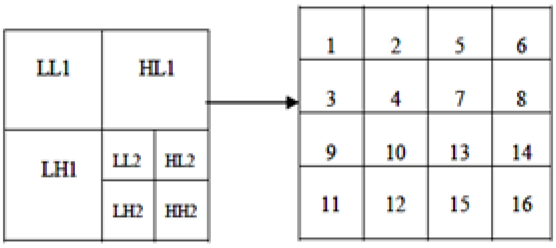

Fig 5. Two-Level DWT and Sub-Band Numbering

6. PCA Application on Blocks

An X matrix is formed from LL subband of each selected block; *m* coefficients are selected and arranged into the *l* ×*m*matrix **X** as rows. In this paper, we had *N*0 = 16; so, the LL subband is of size 4 × 4, and we select *m* = 5 non-nearest-neighbor coefficients (1, 1), (1, 3), (3, 1), (3, 3), and (4, 4) to be placed in the matrix **X**.

So the X matrix will be:

$$X = \begin{bmatrix} x_{1,1} & x_{1,2} & . & x_{1,m} \\ x_{2,1} & x_{2,2} & . & x_{2,m} \\ . & . & . & . \\ x_{i,1} & x_{i,2} & . & x_{i,m} \end{bmatrix} \qquad \dots 4$$

Principal component analysis (PCA) is applied on **X**, resulting in the matrix **Y** = $\mathbf{A}^T\mathbf{X}$, where **A** is the matrix composed of unit eigenvectors of the sample covariance $\mathbf{XX}^T$, arranged in decreasing order of the corresponding eigenvalues, and **X** is a centered version of **X**, with row means subtracted from each row. To illustrate the notation, matrices **X** and **Y** are shown in equation (3) and (3) below:

$$Y = \begin{bmatrix} y_{1,1} & y_{1,2} & . & y_{1,m} \\ y_{2,1} & y_{2,2} & . & y_{2,m} \\ . & . & . & . \\ y_{i,1} & y_{i,2} & . & y_{i,m} \end{bmatrix} \qquad \dots 5$$

The projection of the data onto the first principal component is given by the first row of **Y**, that is **y**1: = *(y*1, 1, *y*1, 2 . . .*y*1, *m).*

For each selected block, we define the auxiliary *(AU X)* bit according to the difference between the middle element of the vector **y**1, and the average value of other elements:

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

$$AUX = \begin{cases} +1, & y_{1,\lceil m/2 \rceil} - \frac{1}{m-1} \sum_{i=1, i \neq \lceil m/2 \rceil}^{m} y_{1,i} > 0, \\ -1, & y_{1,\lceil m/2 \rceil} - \frac{1}{m-1} \sum_{i=1, i \neq \lceil m/2 \rceil}^{m} y_{1,i} < 0. \end{cases} \quad \ldots 6$$

Due to its special importance in the proposed method, the difference between the middle elements of the vector **y**1: and the average value of other elements will be referred to as "mid-point difference" and denoted by

$$d: d = y_{1,\lceil m/2 \rceil} - \frac{1}{m-1} \sum_{i=1, i \neq \lceil m/2 \rceil}^{m} y_{1,i} \quad \ldots 7$$

$$x_{i,j}^{W} = \begin{cases} a.x_{i,j}, & When\ j = \lceil m/2 \rceil, AUX = W = +1, \\ \frac{1}{a}.x_{i,j}, & When\ j \neq \lceil m/2 \rceil, AUX = W = +1, \\ \frac{1}{a}.x_{i,j}, & When\ j = \lceil m/2 \rceil, AUX = W = -1, \\ a.x_{i,j}, & When\ j \neq \lceil m/2 \rceil, AUX = W = -1, \\ Skip & When\ AUX \cdot W = -1. \end{cases} \quad \ldots 8$$

The matrix shown in eq.4 is implemented for the watermarking process.

The content of embedding process is taken from [6]. Finally,, the 2-D IDWT has been done so that the complete video can be achieved with the watermarked feature. The video watermarking can be summarized easily. The original video sequence is firstly decomposed into the scene frames. And then GOP is taken for the cube selection the selected cubes are then subject to PCA process.

7. Decoding

The Decoding process is just reverse process of Embedding process but only in case of the PCA processed frames. The video watermarked frames are first needed to turn out. The watermarked video firstly undergoes the process of 2-D DWT and then the watermarked cube are selected with the help of side information. The Selected cubes undergo the revere process of finding the PCA and information bits in the watermarked cubes. The resultant watermarked information is then subject to addition so that the completed watermark can be achieved. Then we will reverse the process of Arnold cap map by (I-t) so get out encrypted watermark logo.

IV. PROPOSED ALGORITHM

The research gap in the discussed survey is tried to be encountered in the proposed algorithm. The DWT is applied on the video frame so that the recovered video quality could be maintained and PCA to make it robust to the attacks. The detailed algorithm is defined as follows:

A. Algorithm (Used to Develop Codes):

The Principal Component Analysis approach is applied to the wavelet subband SB_θ's transform coefficients where θ represents (LL or HH) as shown in the following steps:

Step1: The nxn nonoverlapping blocks subdivided by the wavelet subband SB_θ with NxN dimension (the block size should be appropriate to the subband size) where the number of blocks is given by nb = $N \times N / n \times n$

Step 2: In the LL band, each block can be processed by method1 in HH band each block can be processed by method2 as follows:

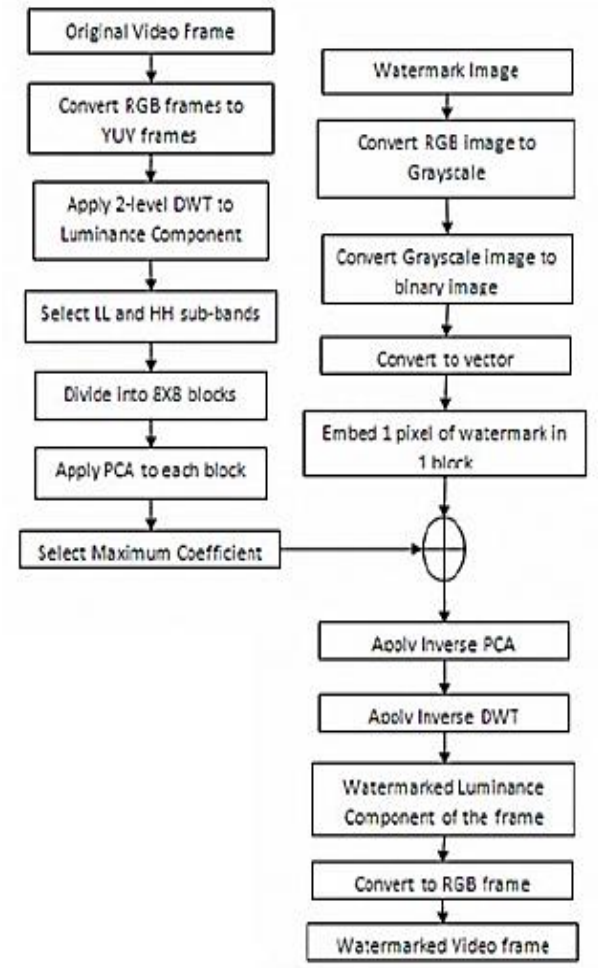

Figure 6. Watermark Embedding Procedure

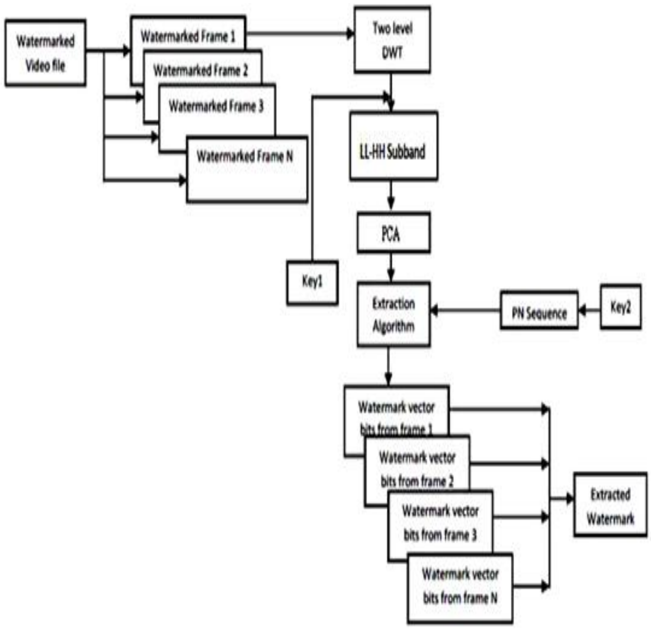

Figure 7: Decryption of Information from Watermarked Video

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

Method 1: Consider each block like a vector; data vectors defined as: $X_\theta = (X_{\theta 1}, X_{\theta 2}, X_{\theta 3} \ldots X_{\theta k})$ T, where vector $SB_{\theta i}$ represents the block number i with n2dimension.
Method 2: Each block can be considered as 2D array BLθ = $(BL_{\theta 1}, BL_{\theta 2}, BL_{\theta 3} \ldots BL_{\theta k})$ T, where array BLθi represents the block number i with size $n \times n$.

Step 3: For each block, the covariance matrix COi of the zero mean block Z is calculated as:

$$CO_i = ZiZi^T \qquad \ldots 9$$

Where T denotes the matrix transpose operation and Z is defined by:
Method 1: for a vector block as Zi=EX $(X_{\theta i} - mei)$.
Method 2: for 2D array block as Zi=EX $(BL_{\theta i} - m_{ei})$. Where mei is the mean of block and EX denotes expectation operation.

Step 4: Each block is transformed into PCA components by calculating the eigenvectors (basis function) corresponding to the eigenvalues of the covariance matrix:

$$CO_i\, \Phi = \lambda_i \Phi \qquad \ldots 10$$

Where λ is the matrix of eigenvalues and eigenvectors matrix is Φ, defined for:
Method 1: for block of vector as Φ = (ev1, ev2, ev3… ev $n \times n$) and λi = (λ1, λ2, λ3 … λ $n \times n$).
Method 2: for 2D block of the array can be defined as Φ = ev1, ev2, ev3… ev_n) and λi = (λ1, λ2, λ3 … λ_n). Φ vectors are arranged in descending order based onλi, where (λ1 ≥ λ2 ≥ λ3 ≥ ….≥ λn or ($\lambda_{n \times n}$)). The matrix Φ is an orthogonal matrix called basis function of PCA (PCA Eigen images).

Step 5: Calculate the PCA components of the block. The correlated block transformed into uncorrelated coefficients, by PCA, by taking the inner product of the block with the basic functions Φ:

$$PCi = \Phi T\, Zi \qquad \ldots 11$$

Where PCi is the PC block which represents the principal component of the block i.

Step 6: Apply inverse PCA on the modified PCA components to obtain the modified wavelet coefficients. The inversion can be performed by the following equation:

$$Zi = \Phi\, PCi \qquad \ldots 12$$

V. SIMULATION

As per the MATLAB simulations, we get separate results for each process involved in Watermark embedding and extraction.

The program computes the sublayers for the provided video file. A sub-layer extracted by the code is shown below, which can later-on provides the in-depth information for Watermark security and reliability.

Fig. 8: Embedding Frame

After inserting the encrypted watermark image, this video file is again giving the same resolution video at the output. The output/final watermarked video must show no difference to that of the original video file, and it makes the important feature for a watermarking scheme. A watermarked Video's screen grab is shown below.

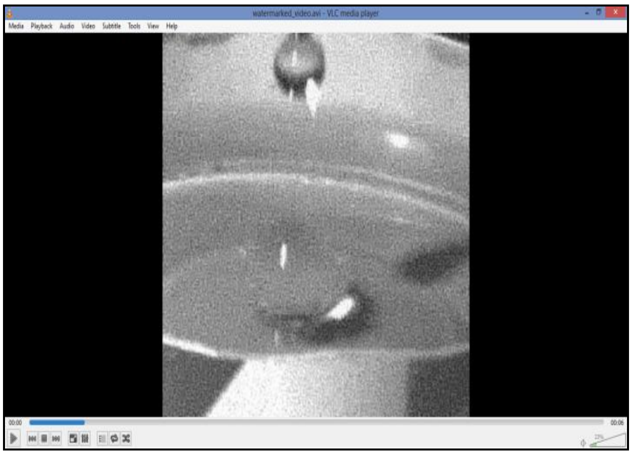

Fig. 9 Embedded Frames

Above screen grab is slightly noisier than that of the original video. It's SNR and PSNR values, as computed by our program, are substantial and thus make such differences. The SNR and PSNR values are shown in below figure.

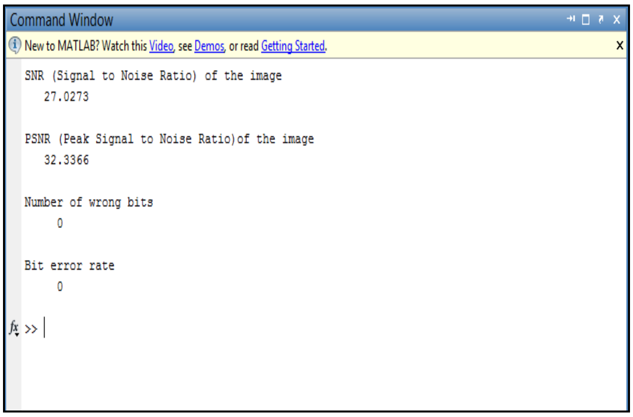

Fig. 10: PSNR and SNR

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

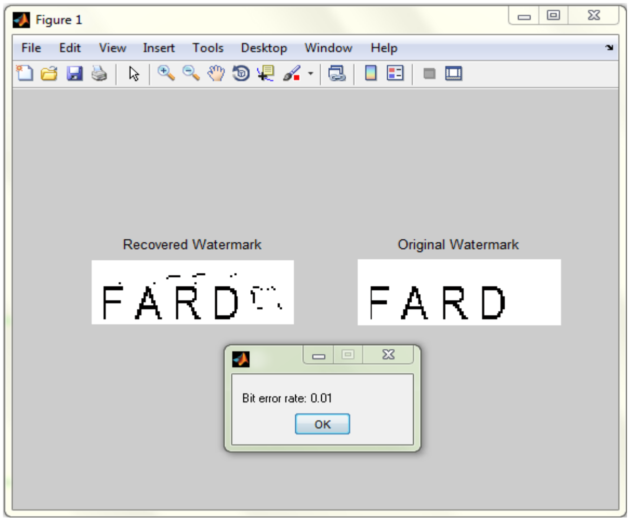

Fig. 11: Processed Water Mark through Attack and BER

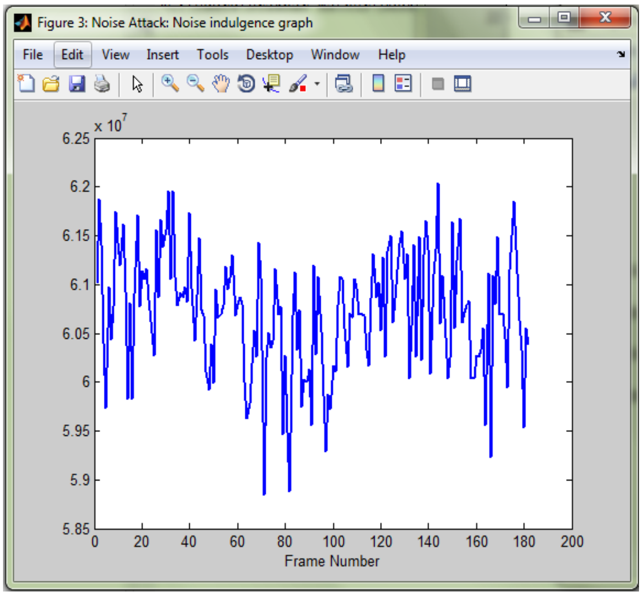

Fig. 12: Noise Graph

The Fig. 11 shows the BER of recovered watermark after the attack. Fig. 12 shows the Noise Graph. The whole point of discussion is the analysis of the Noise attack on the watermarked video. Fig. 13 shows the PSNR and SNR.

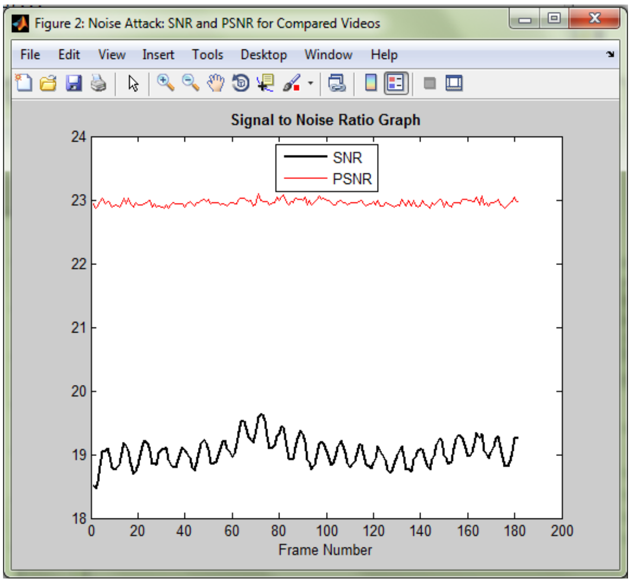

Fig. 13: PSNR and SNR

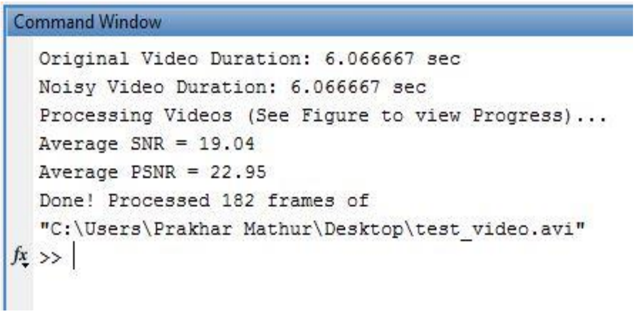

Fig. 14: Values of PSNR and SNR

Finally, as per this paper's demand, watermark must be recovered with almost full information. Further, no discrepancies would exist between the Original Watermark Image and the Recovered Image. Screen grab of the Recovered and original watermark images are shown below Fig. 15.

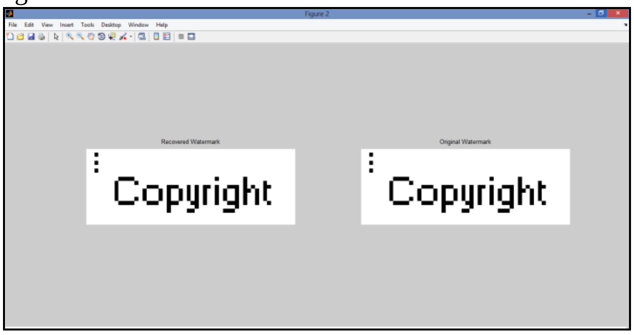

Fig. 15 Recovered Watermarks From Without Attacked Video

VI. CONCLUSION

In this paper, we proposed a method for video-watermarking that employs PCA. Data in the form of the image embedded in some parts of the video that offer the best possibility for PCA decoding, while maintaining transparency. The strength of the image embedding factor is determined on the basis of clustering of high-frequency content, which is a representative of texture, and visual saliency, which indicates the likelihood of a region. SNR (Signal to noise ratio) is one of the deciding factors for during watermark image recovery. Algorithm described here is based on semi-blind method, for better performance, in which location is stored where the watermark is embedded as side information. This proposed method is particularly robust against additive noise and compression attacks. Compression is one of the most common attacks found in practice. Several aspects where the proposed method could be improved are the resilience against desynchronizing attack as well as improved detection of watermarked cubes in the blind version.

REFERENCES

1. T. Hsu and J. L. Wu, "DCT-based watermarking for video," IEEE Trans. Consumer Electron, vol. 44, no. 1, pp. 206–216, Feb. 1998.
2. L. Young-Yoon, J. Han-Seung, and L. Uk, "3D DFT-based video watermarking using perceptual models," in Proc. IEEE 46th Midwest Symp. Circuits Syst., vol. 3. Dec. 2003, pp. 1579–1583.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

3. H. Park, S. H. Lee, and Y. S. Moon, "Adaptive video watermarking by utilizing video characteristics in 3D-DCT domain," in Lecture Notes in Computer Science, vol. 4283. New York, NY, USA: Springer-Verlag, Nov. 2006, pp. 397–406.
4. P. Campisi and A. Neri, "Perceptual video watermarking in the 3D-DWTdomain using a multiplicative approach," in Lecture Notes in computer science, vol. 3710. New York, NY, USA: Springer-Verlag, Sep. 2005, pp. 432–443.
5. H. Khalilian, S. Ghaemmaghami, and M. Omidyeganeh, "Digital video watermarking in 3D ridgelet domain," in Proc. 11th ICACT, vol. 3. Feb2009, pp. 1643–1646.
6. A. Houmansadr, H. Pirsiavash, and S. Ghaemmaghami, "Robust content-based video watermarking exploiting motion entropy masking effect,"inProc. Int. Conf. Signal Process. Multimedia Appl., Aug. 2006, pp. 252–259.
7. H. Huang, C. Yang, and W. Hsu, "A video watermarking technique based on pseudo-3D DCT and quantization index modulation," IEEE Trans.Inf. Forensics Security, vol. 5, no. 4, pp. 625–637, Dec. 2010.
8. H. Khalilian and I. V. Bajic, "Multiplicative video watermarking with semi-blind maximum likelihood decoding for copyright protection,"inProc. IEEE Pacific Rim Conf. Commun., Comput. Signal Process., Aug. 2011, pp. 125–130.
9. A. Koz and A. Alatan, "Oblivious spatiotemporal watermarking of digital video by exploiting the human visual system," IEEE Trans.Circuits Syst. Video Technol., vol. 18, no. 3, pp. 326–337, Mar. 2008.
10. F. Deguillaume, G. Csurka, J. O'Ruanaidh, and T. Pun, "Robust3D DFT video watermarking," Proc. SPIE, vol. 3657, pp. 113–124, Jan. 1999.
11. F. Hartung and B. Girod, "Watermarking of uncompressed and compressed video," Signal Process., vol. 66, no. 3, pp. 283–301, May 1998.
12. D. Simitopoulos, S. Tsaftaris, N. Boulgouris, and M. Strintzis,"Compressed-domain video watermarking of MPEG stream," in Proc. IEEE ICME, Aug. 2002, pp. 569–572.
13. M. Noorkami and R. M. Mersereau, "Digital video watermarking in P-frames with controlled video bit-rate increase," IEEE Trans. Inf. Forensics Security, vol. 3, no. 3, pp. 441–455, Sep. 2008.
14. A. Golikeri, P. Nasiopoulos, and Z. J.Wang, "Robust digital video watermarking scheme for H.264 advanced video coding standard," J. Electron.Imaging, vol. 16, no. 4, pp. 043008-1–043008-14, Dec. 2007.
15. Z. Shahid, M. Chaumont, and W. Puech, "Spread spectrum-based watermarkingforTardos code-based fingerprinting of H.264/AVC video," inProc. IEEE ICIP, Sep. 2010, pp. 2105–2108.
16. I. J. Cox, M. L. Miller, J. A. Bloom, J. Fridrich, and T. Kalker, Digital Watermarking and Steganography, 2nd ed. San Mateo, CA, USA: Morgan Kauffman, 2008.
17. M. Arnold, M. Schmucker, and S. D. Wolthusen, Techniques and applications of Digital Watermarking and Content Protection. Norwood, MA, USA: Artech House, 2003.
18. F. A. P. Petitcolas and S. Katzenbeisser, Information Hiding: Techniques for Steganography and Digital Watermarking. Norwood, MA, USA:Artech House, 2000.
19. M. A. Akhaee, N. Kalantari, and F. Marvasti, "Robust audio and speech watermarking using Gaussian and Laplacian modeling," Signal Process., vol. 90, no. 8, pp. 2487–2497, Aug. 2009.
20. M. A. Akhaee, S. M. E. Saheaeian, and F. Marvasti, "Contourletbased image watermarking using the optimum detector in a noisy environment, "IEEE Trans. Image Process., vol. 19, no. 4, pp. 967–980, Apr. 2010.
21. M. A. Akhaee, S. M. E. Saheaeian F. Marvasti, and B. Sankur, "Robust scaling-based image watermarking technique using maximum likelihood decoder with optimum strength factor," IEEE Trans. Multimedia, vol. 11, no. 5, pp. 822–833, Aug. 2009.
22. J. Shieh, D. Lou, and M. Chang, "A semi-blind digital watermarking scheme based on singular value decomposition," Comput. Stand. Inter., vol. 28, no. 4, pp. 428–440, Apr. 2006.
23. V. Q. Pham, T. Miyaki, T. Yamasaki, and K. Aizawa, "Geometrically invariant object based watermarking using SIFT feature," in Proc. IEEE TIP, vol. 5. Oct. 2007, pp. 473–476.
24. J.-J. Shen and J.-M.Ren, "A robust associative watermarking technique based on vector quantization," Digit. Signal Process., vol. 20, no. 5, pp. 1408–1423, Sep. 2010.
25. G. Boato, F. G. B. De Natale, and C. Fontanari, "An improved asymmetric watermarking scheme suitable for copy protection," IEEE Trans.Signal Process., vol. 54, no. 7, pp. 2833–2834, Jul. 2006.
26. C. Lai and C. Tsai, "Digital image watermarking using discrete wavelet transform and singular value decomposition," IEEE Trans. Instrum. Meas., vol. 59, no. 11, pp. 3060–3063, Nov. 2010.
27. R. Z. Liu and T. N. Tan, "An SVD-based watermarking scheme for protecting rightful ownership," IEEE Trans. Multimedia, vol. 4, no. 1, pp. 121–128, Mar. 2002.
28. Y. Wang, J. F. Doherty, and R. E. Van Dyck, "A wavelet-based watermarking algorithm for ownership verification of digital images," IEEE Trans. Image Process., vol. 11, no. 2, pp. 77–88, Feb. 2002.
29. O. S. Faragallah, "Efficient video watermarking based on singularvalue decomposition in the discrete wavelet transform domain," Int.J. Electron.Commun., vol. 67, no. 3, pp. 189–196, Mar. 2013.
30. Salwa A.K Mostafa, A. S. Tolba, F.M. Abdelkader, Hisham M. Elhindy, Video Watermarking Scheme Based on Principal Component Analysis and Wavelet Transform, IJCSNS International Journal of Computer Science and Network Security, VOL.9 No.8, August 2009.
31. R. Reyes, C. Cruz, M. Nakano-Miyatake, Member IEEE and H. Perez-Meana, Senior Member IEEE, Digital Video Watermarking in DWT Domain Using Chaotic Mixtures, IEEE Latin America Transactions, VOL. 8, NO. 3, June 2010.
32. Xiaoli Li, Student Member, IEEE, Sridhar (Sri) Krishnan, Senior Member, IEEE, and Ngok-Wah Ma, Senior Member, IEEE, A Wavelet-PCA-Based Fingerprinting Scheme for Peer-to-Peer Video File Sharing, IEEE Transactions on Information Forensics and Security, VOL. 5, NO. 3, September 2010.
33. Xiangui Kang, Jiwu Huang, Senior Member, IEEE, Yun Q. Shi, Senior Member, IEEE, and Yan Lin, A DWT-DFT Composite Watermarking Scheme Robust to Both Affine Transform and JPEG Compression, IEEE Transactions on Circuits and Systems for Video Technology, VOL. 13, NO. 8, August 2003.
34. Ranjana Sinha, Prajnat Bardhan, Swarnali Pramanick, Ankul Jagatramka, Dipak K. Kole, Arun Chakraborty, Department of Computer Science & Engineering, St Thomas' College of Engineering and Technology, Kolkata, India, Digital Video Watermarking using Discrete Wavelet Transform and Principal Component Analysis, International Journal of Wisdom Based Computing, Vol. 1 (2), August 2011.
35. Nisreen I. Yassin1, Nancy M. Salem2, and Mohamed I. El Adawy National Research Centre, Cairo, Egypt, Block-Based Video Watermarking Scheme Using Wavelet Transform and Principal Component Analysis, IJCSI International Journal of Computer Science Issues, Vol. 9, Issue 1, No 3, January 2012.
36. S.K. Amirgholipour, A. R. Naghsh-Nilchi: Robust Digital Image Watermarking Based on Joint DWT-DCT, International Journal of Digital Content Technology and its Applications Volume 3, Number 2, pp. 42-54, June 2009.
37. Martin Zlomek, Charles University in Prague, Faculty of Mathematics and Physics, Department of Software and Computer Science Education, Video Watermarking.
38. M. Chandra, S. Pandey: A DWT Domain Visible Watermarking Techniques for Digital Images, International Conference on Electronics and Information Engineering, pp. V2-421 - V2-427, 2010.
39. G. Peterson, Linear Algebra, Arnold's cat map,1997.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)