ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645
Indian Journal of Science and Technology, *Vol 10(18), DOI: 10.17485/ijst/2017/v10i18/111377, May 2017*

Secure, Robust Video Watermarking to Prevent Camcorder Piracy

Chhaya S. Gosavi* and Suresh N. Mali

CSE Department, Dr. D. Y. Patil Institute of Engineering and Technology, Pune - 411018, Maharashtra, India;
chhaya.gosavi@gmail.com, snmali@rediffmail.com

Abstract

Objectives: The present work proposes a secure and robust video watermarking algorithm to detect the camcorder piracy using Discrete Cosine Transform (DCT) and Schur Decomposition. **Methods/Analysis:** Separate watermark for each video used to improve security. The watermark is further secured using scrambling by Arnold transform and then dividing it into subparts. These scrambled watermark chunks embedded into audio sequence and video frames using robust technique DCT and Schur decomposition. The security has been improved with randomness in frame selection block selection. Recovered information from extracted watermark can be used to authenticate the owner. **Findings:** Experimental results show that the proposed algorithm is not only robust to various attacks but also highly secure. Perceptual quality of watermarked frame has been compared with the original frame. The Peak Signal to Noise Ratio (PSNR) is 49.21 dB for MB.mp4 video and 48.88 dB for GT.mp4 video file after embedding watermark. Robustness of watermarked video has been tested against various signal processing, video processing attacks and camcorder attack. Extracted watermark is compared with original watermark and Normalized cross correlation (NK) value is calculated, which is coming nearly 1. The security has been strengthened with randomness in frame selection, block selection, Scrambling and division of the watermark. A Watermark is embedded in audio sequence and video frames. **Novelty/Improvement:** Position of pirate is estimated by comparing original video frames with watermarked video frames. Mean Absolute Error is 2.8 cm.

Keywords: Arnold Transform, DCT, Schur, SVD, SCD

1. Introduction

There is a great deal of tough work and investment in making a film. It is real easy to record it with a camcorder and sell in cheap rate in the marketplace. Due to this illegal recoding movie maker has to endure tons of avenue loss. Therefore, techniques are needed to prevent or at least detect camcorder piracy.

Video watermarking has been used for copyright protection for a tenner. Video contain more spatial and temporal redundancy, which creates more scope to hide watermarking information. Videos are stored as raw video or compressed video[1]. Many video watermarking algorithms discussed in the literature do not concentrate on audio information presented in the video. To consider the audio information is the primary motivation for the present research.

Copyright is the ownership information, which uniquely identifies the owner like a logo or signature. Authentication makes sure that the video is intact during the transmission. Watermark used for copyright protection should be robust to several attacks, so that at the receiving side, it should be taken out and applied as a proof for copyright claims[2]. Whereas, for authentication, the watermark should be fragile and should be destroyed after modification. Thus, if the watermark is retrieved successfully, then it shows the authenticity of the video. We have designed a watermark generation module which contains copyright information, timestamp and video signature as inputs and constructs the watermark for copyright protection and authentication. The information required to extract watermark divides the watermarking algorithms into two categories blind and non-blind. During extraction if we need original video then the algo-

**Author for correspondence*

rithms are called non-blind algorithms otherwise blind algorithm. Sender has to send original video along with watermarked video to the receiver. But practically it is not feasible and this does not serve the purpose of watermarking. Non-blind algorithms can be more robust compared with blind algorithms but not secure.

In literature, to implement video watermarking algorithms, three approaches are considered. The most simple and straight forward approach is to consider a video as a chronological sequence of images and apply image watermarking algorithm[3]. Another perspective can be considers and explore the temporal dimension in order to design new robust video watermarking algorithms[4]. One more approach considers a compressed video stream and the characteristics of these compression standards can be applied to get an efficient watermarking algorithm[5]. This paper follows the first approach.

Video frames can be mapped in the spatial domain and temporal domain. In the spatial domain frame is stored as pixel information, however the frequency domain video frame is given in terms of its frequencies. To convert a video frame to its frequency representation, reversible transforms like the Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT) or Discrete Fourier Transform (DFT) can be applied. These transforms show different features and represents the image in its own ways. The algorithms presented[1,2] used DCT approach to embed a watermark in the perceptually significant portion of the frame as most of the compression schemes remove the perceptually insignificant portion. Some researcher's used Singular Value Decomposition (SVD) for embedding the watermark information[3-8]. Other researchers tested to combine DCT and DWT methods[9-12]. Some of the researchers have combined DWT and SVD[13-15]. A method based on Redundant DWT and SVD[16]. In[17] used DWT and DFT combination. DCT and SVD combination is used[18-20].

The decomposed image I1 into 3 levels DWT and SVD is applied on HH band[21]. Singular value of HH band replaced by singular values of watermark. Reverse method is applied for extraction. Watermark embedding is based on Singular Value Decomposition presented[22,23]. In[24] used genetic algorithms and doing fitness test they extracted watermark. The embedded watermark in third level Discrete Wavelet Transform (DWT) of an Image. That is in LH3 sub-band[25] the embedding watermark in HH band of DWT of a Frame[26]. The embedded watermark using LSB method in watermark is embedded by using HH band of DWT method[27-30].

The literature presented by these researchers indicates that, to design a video watermarking algorithm with good security, imperceptibility and robustness is always a challenge.

To claim on this challenge, we propose secure, robust video watermarking algorithm for piracy detection. The paper is formed as follows: In the next section Materials and Methodology presented. Results elaborated in section 3. The conclusion is drawn in section 4.

2. Materials and Methods

The video sequences used for experiments are listed in Table 1.

Table 1. Sample video data set

Sr. No	Video Sequence	Size	No. of Frames	Frame Size
1	Atrium.avi	(22 MB)	431 Frames	(640X360)
2	GT.mp4	(1.62 MB)	299 Frames	(384X288)
3	Akiyo.mp4	(266 KB)	98 Frames	(352X264)
4	MB-MBBS.mp4	(3.36 MB)	299 Frames	(600X480)
5	Baby.mp4	(4.41 MB)	1254 Frames	(320X240)

Figure 1a. Experimental setup diagram.

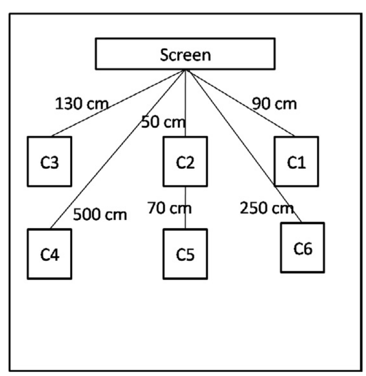


Figure 1b. Experimental setup diagram.

Experimental setup and setup diagram are shown in following Figure 1.

The proposed algorithm is divided into following modules

Watermark Generation Module - Algorithm 1

Watermark Embedding Module - Algorithms 2.1, 2.2, 2.3 Watermark Extraction Modules – Algorithm 3

Piracy Detection Module – Algorithm 4

2.1 Watermark Generation Module

In this module, video, timestamp and copyright information are taken as inputs. Figure 2 shows a block diagram for the generating watermark. Step wise explanation is given in algorithm 1.

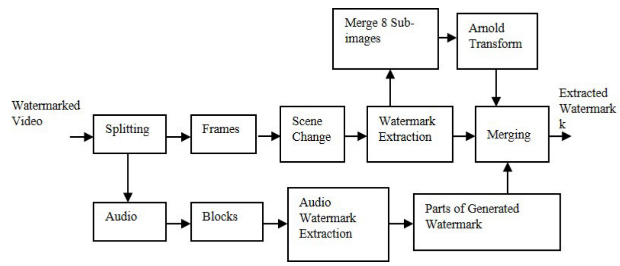


Figure 2. Watermark extraction.

Algorithm 1: Watermark Generation Methodology (FWMG)

Input – Video Sequence (V), Time Stamp (TS), Copyright Information (CI)

Output – Generated Watermark (GWM)

- Read Video sequence (V) and convert it into frames F1…Fn
- Select a random frame, Fm
- Divide Fm into 8 x 8 blocks and apply DCT as per Equation 1

$$D(i,j) = \frac{1}{4}C(i)C(j)\sum_{x=0}^{7}\sum_{y=0}^{7} p(x,y)\cos\left[\frac{(2x+1)i\pi}{16}\right]\cos\left[\frac{(2y+1)j\pi}{16}\right] \quad (1)$$

where, $C(p) = \begin{cases} \frac{1}{\sqrt{2}} & \text{if p=0} \\ 1 & \text{if p>0} \end{cases}$

- Calculate difference between DC values of adjacent blocks as follows

$$S_i = \sum_{j=1}^{8}\left(DC_i - DC_j\right) \quad (2)$$

$$Hi = \begin{cases} 1 & \text{if } S_i \geq 0 \\ 1 & \text{if } S_i, < 0 \end{cases}$$

where, Hi is one bit of frame signature derived from i[th] block

- 32 x 32 Matrix (Wm1) is formed used Signature H.
- Time Stamp and Copyright Information are accepted as Strings and converted to binary values of matrix 16 x 16 (Wm2 and Wm3 respectively).
- Combine Wm1, Wm2, Wm3 and Zero matrix, to Get Generated Matrix (GWM) of size 64 x 64.

This generated watermark is used to embed into video.

2.2 Watermark Embedding Module

Watermark embedding is done in 3 parts, Watermark Preprocessing, Video Watermarking and Audio Watermarking. This is shown in Figure 3.

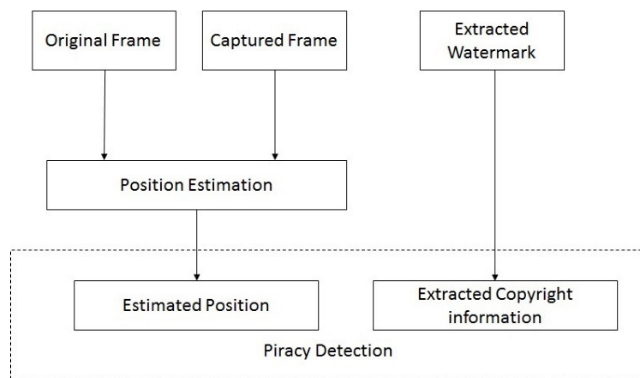


Figure 3. Piracy detection.

Algorithm 2.1 explains watermark preprocessing, Algorithm 2.2 explains video watermarking and Algorithm 2.3 explains audio watermarking.

Algorithm 2.1: Watermark Preprocessing:

Input – Generated Watermark (GWM)

Output – Scrambled sub-images, WM1…..WM8

- Using equations (3) and (4), apply Arnold Transform to Generated Watermark (GWM) to get scrambled image in N iterations.

$$New\_xi = (xi + yi) \% 255 \quad (3)$$
$$New\_yi = (xi + 2yi) \% 255 \quad (4)$$

- Divide scrambled image into 8 sub-images: WM1…..WM8.

Algorithm 2.2: Video Watermarking:

Input – Video (V), Watermark sub-images (WM1, …, WM8)

Output – Watermarked Video (VS)

- Split input video sequence into frames and Audio (A)
- Apply Scene Change Detection Algorithm on frames to find out scene change frames F1…Fn.
- Using energy equation (5), on each frame Fi, select the block for watermark embedding.

$$Bi = \sum_{n}\sum_{m}(DCT\ Coeff)^2 \quad (5)$$

- Using equation (6), apply Schur on block Bi to get Ui and Si matrices.

$$Bi = Ui \times Si \times Ui' \quad (6)$$

- Apply DCT on Si to get Di.
- Replace Di (3, 3) element by watermark bit.
- Apply IDCT and inverse Schur to get embedded block.

$$p(x,y) = \sum_{i=0}^{7}\sum_{j=0}^{7} C(i)C(j)D(i,j)\cos\left[\frac{(2x+1)i\pi}{16}\right]\cos\left[\frac{(2y+1)j\pi}{16}\right] \quad (7)$$

where

$$C(p) = \begin{cases} \frac{1}{\sqrt{2}} & \text{if p=0} \\ 1 & \text{if p>0} \end{cases}$$

- Repeat till all watermark bits get embedded into the frame.
- Merge embedded frames with other frames to get watermarked video sequence (VS).

Algorithm 2.3 Audio Watermarking

Input – Audio (A), Watermark sub-images (WM1, …, WM8)

Output – Watermarked Audio (AS)

- Divide audio into equal number of blocks as that of the size of watermark parts.
- Apply DCT on the selected block.
- Replace center element with the watermark bit.
- Apply IDCT to get watermarked block.
- Repeat until all watermark bits get embedded into audio sequence.
- Apply IDCT and get watermarked Audio (AS).

Then combine watermarked Video Sequence (VS) and watermarked audio sequence (AS) to get Watermarked Video (WV).

The following section explains the watermark extraction algorithm.

2.3 Watermark Extraction Module

Figure 4 explains watermark extraction algorithm

Algorithm 3:

Input – Probably modified Watermarked Video (WVm)

Output – Extracted Watermark (EW), Copyright Information

- Repeat steps 1-5 of algorithm 2.2.
- Extract Bi (3, 3) bit from each block and construct a sub-image.
- Extract all sub-images from scene change frames.
- Repeat steps 1–2 of algorithm 2.3.
- Extract a bit from center element.
- Combine these bits to get watermark sub-images.

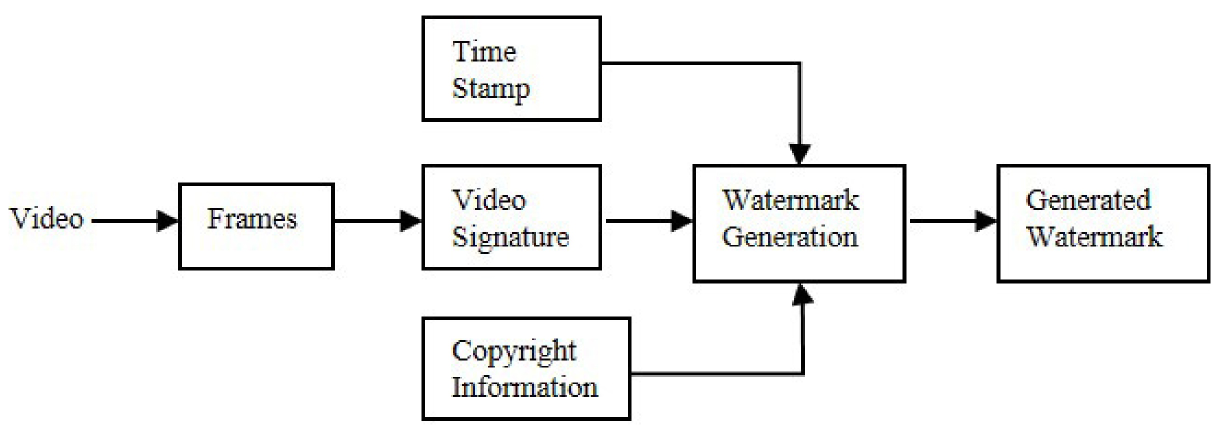


Figure 4. Watermark generation module.

- Compare sub-images extracted from audio with those drawn from frames for error correction.
- Merge all sub-images to get extracted watermark.
- Information for copyright protection, timestamp and video signature is then extracted from this watermark to prove ownership and legitimacy of the video.

2.4 Piracy Dectection Module

Figure 5 explains working of piracy detection algorithm
Algorithm 4:

Input – Extracted Watermark (EW), Original Frame (F1), Captured Frame +-(F2)

Output – Estimated position of pirate and Copyright Information

- Acquire copyright information and time stamp from extracted watermark.
- Compare original frame and captured frame and extract SURF features
- Compare inliers features to estimate angle of rotation
- From estimated angle calculate distance using Pythagoras theorem

Video Pad Video Editor, V 3.81 and Audacity v 1.2.4 are used to test robustness and to evaluate performance with respect to various attacks on video and audio respectively. The test results are shown in the next section.

3. Results and Discussion

The results of the watermark generation module are shown in Table 2. Copyright information is accepted from the user and timestamp is automatically captured from the system date.

The Implementation of most of the algorithms is done using JAVA jdk1.7 using Netbeans IDE v 7.0.1 and Xuggler 5.4. Some of the testing is carried out with MATLAB R2013. Extracted watermark is compared with original watermark using Normalized Cross Correlation (NK)

where,

$$NK = \frac{\sum_{i}^{M}\sum_{j=1}^{N}\left(x(i,j)\times y(i,j)\right)}{\sum_{i=1}^{M}\sum_{j=1}^{N}\left(x(i,j)\right)} \quad (8)$$

The image quality is measured using PSNR. PSNR > 30 implies better quality. The Mean Square Error (MSE) is calculated by equation (15) and it is used to calculate PSNR by equation (16).

$$MSE = \frac{1}{M*N}\sum_{i=1}^{M}\sum_{j=1}^{N}\left[F1(i,j)-F2(i,j)\right]^2 \quad (9)$$

where, M*N is size of frames, F1 (i, j) is pixel of original frame, and F2 (i, j) is pixel values of watermarked frame. Now, PSNR of two Frames F1 and F2 of size M x N,

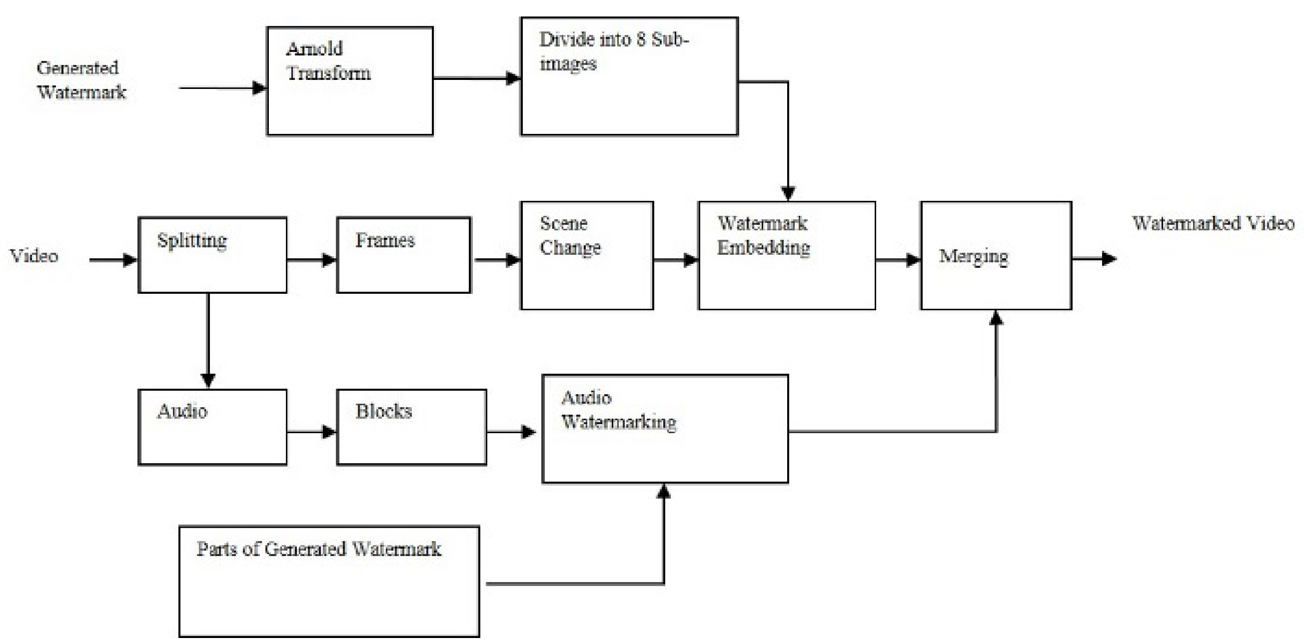


Figure 5. Watermark embedding.

$$PSNE(dB) = 10log_{10}\frac{255}{MSE} \quad (10)$$

Table 2. Watermark generation results

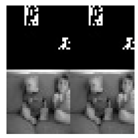
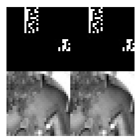
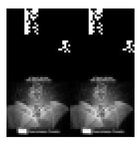
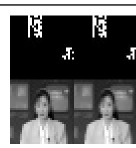
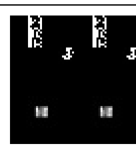
Copyright Information		Video Sequence	Generated Watermark
Name	***Address***		
Rakhi	CCOEW	Baby.mp4	
Archana	DYPIET	Atrium.avi	
Govind	Pravara	GT.mp4	
Manoj	SKNCOE	Akiyo.mp4	
Baisa	Amrutvahini	MB_MBB S.mp4	

Table 3 shows results of proposed method with respect to various attacks.

Original frame compared with embedded frame for perceptual quality test, as shown in Table 4

Table 3. NK of proposed methods with various attacks

Attack Type	Video Sequence (NK Values)				
	Akiyo	***Atrium***	***Baby***	***GT***	***MB***
Median Filter (3X3)	0.9850	0.9698	0.9642	0.9762	0.9655
Smoo-thing	0.9849	0.9548	0.9623	0.9631	0.9612
Weighted Average	0.9950	0.9648	0.9623	0.9631	0.9612
Gaussian Noise	1.0000	0.9849	0.9976	0.9896	0.9765
MPEG-4 Comp-ression	0.9648	0.9554	0.9634	0.9534	0.9532
Frame Dropping	1.0000	0.9877	0.9865	0.9844	0.9852
Frame Swapping	1.0000	0.9898	0.9913	0.9873	0.9905

Table 4. Perceptual quality test

Video Files	Proposed Method PSNR (dB)
Akiyo.mp4	48.59
Atrium.avi	49.67
Baby.mp4	48.35
GT.mp4	48.88
MB.mp4	49.21

Result of information extraction from extracted watermark has been shown in Table 5

Table 6 Shows results for camcorder attack, frames are captured using 32 MP camera and watermark extracted from these frames

Table 7 Shows results of position detection algorithm

Mean Absolute Error is calculated for by following equation

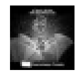
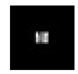
$$AE = \frac{\sum|Error|}{N} = 2.845 \text{ Where } N = 6 \quad (11)$$

Comparison of the proposed method with other blind methods is shown in Table 8.

Security of watermarking algorithm can be majored in three complementary ways

1. Randomness in embedding
   - Selecting frames using Scene Change Detection
   - Selecting Block using Energy
   - Embedding Watermark in Audio and Video

Table 5. Recovered Copyright information and video signature

Extracted Watermark	Copyright Information		Time						DC image of Video
	Name	*Address*	*Yr*	*Mn*	*Dt*	*Hr*	*Mi*	*Se*	
Akiyo.bmp	Manoj	SKNCOE	2014	12	5	12	52	21	
Atrium.bmp	Archana	DYPIET	2014	12	5	12	45	43	
Baby.bmp	Rakhi	CCOEW	2014	12	5	12	28	43	
GT.bmp	Govind	Pravara	2014	12	5	12	50	5	
MB_MBBS. bmp	Baisa	Amrutvahini	2014	12	5	12	54	28	

2. Robustness with respect to various attacks
3. Probability of breaking security

- P(F) = Probability of selecting frame
  = No. of selected frames / Total number of frames
  = sf / nf
- P(B) = Probability of selecting block
  = No. of selected blocks / Total blocks
  = sb / nb
- P(b) = Probability of selecting a bit to modify
  = 1/ number of bits in a block
  = 1/sz

Table 6. Results for camcorder attack

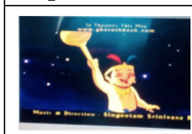
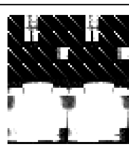
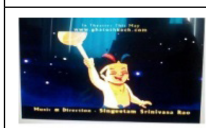
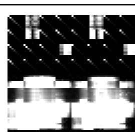
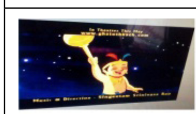
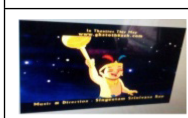
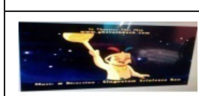
Captured Frame	Extracted Watermark	PSNR (dB)
		34.51
		30.09
		41.92
		42.16
		42.16

Table 7. Results for position detection

Frame	Original (Cm)	Estimated	Error
V1W1C1.bmp	90 cm	89.09 cm	0.91
V1W1C2.bmp	50 cm	49.80 cm	0.2
V1W1C3.bmp	130 cm	132.79 cm	2.79
V1W1C4.bmp	500 cm	509.82 cm	9.82
V1W1C5.bmp	70 cm	69.30 cm	0.7
V1W1C6.bmp	250 cm	247.35 cm	2.65

P(F) = Probability of selecting frame
= No. of selected frames / Total number of frames
= sf / nf
P(B) = Probability of selecting block
= No. of selected blocks / Total blocks
= sb / nb
P(b) = Probability of selecting a bit to modify
= l/ number of bits in a block
= l/sz

By the theorem on Compound Probability

$$P(F \cap B \cap b) = P(F).P(B/F).P(b/F \cap B) \tag{12}$$

Example – GT.mp4 (299 Frames, 384x288)
P(F) = 82 Scene Changes / 299 Frames = 0.27
P(B/F) = Probability (Select Block from frame)
block size (8 x 8)/ No. of blocks (384 x 288) = 64/1728
P(b/FandB) = Probability of selecting pixel which has to be modified

$$P(F) = 82/299 = 0.27$$
$$P(B/F) = 64/(384X288) = 0.037$$
$$P(b/F \cap B) = 1/64 = 0.0178$$
$$P(F \cap B \cap b) = 0.27X0.037X0.0178 = 0.000158$$

Table 8. Comparison of proposed methods with other blind methods

Ref No	Technique Used	Frame Selection	Watermark	PSNR	NK	Attacks
[21]	SVD, Multilevel DWT	Fixed	Binary	43.1	0.9391	Crop, Mean, Noise, Median, Rotation
[22]	DWT-SCHUR	All	Binary		0.9783	Noise, Rotation, Frame Swapping, Frame Averaging, Frame Dropping
[23]	SVD	All	Binary	40		Gaussian Noise, Salt and Pepper Noise, JPEG compression, Gamma Correction, Resizing, median filtering and lowpass filtering
[24]	DWT,PCA, SVD,GA	All	Binary	36.92	0.9782	Noise, Filter, Rotation
[25]	DCT, DFT	All	Binary (288 bits)	47.82		Rescale, Resolution
[26.	DWT	All	Binary (1024 bits)	26		Noise, Filter, Rotation
[27]	DCT, SQM	All	Binary (64X64)	43.05	0.927	Frame averaging, Frame removal, compression, Filter
[28]	DWT,SS	SCD	Binary (36X44)	36.77	0.9245	Frame dropping, frame averaging, Frame swapping, compression,
[29]	DWT	SCD	Binary		0.9751	Frame dropping, frame averaging, Frame swapping, compression, cropping, noise, filtering
[30]	DWT	SCD	Gray (64X64)	33.21	0.9050	Frame dropping, frame averaging, Frame swapping, Compression
Proposed	DCT-Schur	SCD	Gray (64 X 64)	49.77	0.9905	Frame dropping, Frame averaging, frame swapping, noise, filter and compression, Camcorder attack

Table 9. Comparison of proposed methods with other secure methods

References	P(F)	P(B/F)	P(b/F*B)	Probability
25	1	1	=288/(614*384) =288/235776 =0.00122	=0.00122*100 0.122%
28	=8/300 =0.0266	1	= (36 X 44) / (512*256) = 1584/131072 =0.0120	=0.000321*100 =0.0321%
29	1	1	32/(512*256) = 0.00275	=0.00275 *100 =0.275%
30	1	= 64/1584 = 0.040	=1/64 =0.015	= 0.0006 *100 =0.06%
Proposed	0.27	0.037	0.0178	= 0.000158 * 100 = 0.0158%

Table 9 compares security of proposed algorithm with the literature. It proves that proposed algorithm is highly secure and robust.

4. Conclusion

We have proposed secure and robust video watermarking algorithm for camcorder piracy detection. Experimental results indicate that the proposed algorithm is robust against attacks such as frame swapping, frame dropping, frame averaging, noise addition and filtering, compression and camcorder attack. A Watermark is embedded in frames and audio to provide extra security and error correction.

5. Acknowledgement

I like to thank Dr. D. Y. Patil College of Engineering, Cummins College of Engineering for Women and Technology and Sinhgad Institute of Technology and Science for encouragement and support.

6. References

1. Gwena Do.err, Dugelay JL. A guide tour of video watermarking. Science Direct, Signal Processing: Image Communication. 2003; 18:263–82.
2. Ingemar J, Cox, Joe Kilian F. Thomson Leighton, and Talal Shamoon.Secure Spread Spectrum Watermarking for Multimedia. IEEE Transactions on Image Processing. 1997,6(12), pp. 1673-1687.
3. Liu R, Tan T. A SVD-based watermarking scheme for protecting rightful ownership. IEEE Transaction on Multimedia. 2002; 4(1):121–8.
4. Chan PW, Lyu MR, Chin RT. A novel scheme for hybrid digital video watermarking: Approach, evaluation and experimentation. IEEE Transactions on Circuits and Systems for Video Technology. 2005; 15(12):1638-49.
5. Bhattacharya S, Chattopadhyay T, Pal A. A survey on different video watermarking techniques and comparative analysis with reference to H.264/AVC. IEEE 10th International Symposium on Consumer Electronics; 2006. p. 1-6.
6. Rajab L, Al-Khatib T, Al-Haj A. Video watermarking algorithms using the SVD transform. European Journal of Scientific Research. 2009; 30(3):389-401.
7. Zhang Y, Zhang Y. Research on video copyright protection system. IEEE 2nd International Conference Consumer Electronics, Communications and Networks; 2012. p. 1277–81.
8. Gosavi C, Warnekar CS. Study of multimedia security using watermarking tehniques. International Journal of Computer Science and Information Security. 2010; 8(5):64–72.
9. Elbasi E, Ahmet M. Eskicioglu. Robust video watermarking scheme in transform domains. Information Security and Cryptography Conference; Turkey. 2007. p. 1-6.
10. Doerr G, Dugelay JL. Security pitfalls of frame-by-frame approaches to video watermarking. IEEE Transactionson Signal Processing. 2004; 52(10):2955-64.
11. Chang CC, Hwang KF. Digital watermarking scheme using human visual effects. Informatica. 2000:505-11.
12. Kasmani SA, Naghsh-Nilchi A. A new robust digital image watermarking technique based on joint DWT-DCT transformation. IEEE 3rd International Conference on Convergence and Hybrid Information Technology; 2008. p. 539-44.
13. Shi H, Wang N, Wen Z, Wang Y, Zhao H, Yang Y. An RST Invariant image watermarking scheme using DWT-SVD. IEEE International Symposium on Instrumentation, Measurement, Sensor Network And Automation (IMSNA); 2012. p. 214-7.
14. Singh P, Agarwal S, Pandey A. A Hybrid DWT-SVD Based Robust Watermarking Scheme for Color Images and its Comparative Performance in YIQ and YIV color Spaces. 3rd IEEE International Advance Computing Conference (IACC); 2012. p. 1213-8.
15. Lai CC, Tsai CC. Digital image watermarking using discrete wavelet transform and singular value decomposition. IEEE Transactions on Instrumentation and Measurement. 2010; 59(11):3060-3.
16. Lagzian S, Soryani M, Fathy M. Robust watermarking scheme based on RDWT-SVD: Embedding data in all sub bands. IEEE. 2011:48-52.
17. Kang X, Huang J, Shi Q, Lin Y. A DWT-DFT composite watermarking scheme robust to both affine transform and JPEG compression. IEEE Transactions on Circuits and Systems for Video Technology. 2003; 13(8):776-86.
18. Rao SV, Shekhawat RS, Srivastava VK. A DWT-DCT-SVD based digital image watermarking scheme using particle swarm optimization. IEEE Students Conference on Electrical, Electronics and Computer Science (SCEECS); 2012. p. 1-4.
19. Foo SW, Dong Q. A normalization-based robust image watermarking scheme using SVD and DCT. World Academy of Science, Engineering and Technology. 2010;61.
20. Liu F, Han K, Wang CW. A novel blind watermark algorithm based On SVD and DCT. IEEE International Conference on Intelligent Computing and Intelligent Systems; 2009. p. 283–6.
21. Batra S, Talwar R. Blind video watermarking based on SVD and multilevel DWT. European Journal of Advances in Engineering and Technology. 2015; 2(1):80–5.

22. Rajab L, Al-Khatib T, Al-Haj A. A blind DWT-SCHUR based digital videowatermarking technique. Journal of Software Engineering and Applications. 2015; 8:224-33.
23. Kumar SN, Rao UN. Robust and blind video watermarking algorithm using SVD transform. International Journal of Engineering Research and Technology. 2014; 3(5):1359-64.
24. Shelke NA, Chatur PN. Blind robust digital video watermarking scheme using hybrid based approach. International Journal of Computer Science and Information Technologies. 2014; 5(3):3619-25.
25. Hai-yang D, Ya-jian Z, Yi-xian Y, ZHANG. Ru. Robust blind video watermark algorithm in transform domain combining with 3D video correlation. Journal of Multimedia. 2013; 8(2):161-7.
26. Razafindradina HB, Karim AM. Blind and robust image watermarking based on wavelet and edge detection. IJCIS. 2013; 3(3):23-30.
27. Babu DN, Jagadeesh D. A blind and robust video water marking technique in DCT domain. International Journal of Engineering and Innovative Technology. 2012; 2(2):128-32.
28. Masoumi M, Amiri S. A blind video watermarking scheme based on 3D discrete wavelet transform. International Journal of Innovation, Management and Technology. 2012; 3(4):487-90.
29. Chetan KR, Raghavendra K. DWT based blind digital video watermarking scheme for video authentication. International Journal of Computer Applications. 2010; 4(10):19-26.
30. Essaouabi A, Regragui F. A blind wavelet-based digital watermarking for video. International Journal of Video and Image Processing and Network Security. 2009; 9(9):37-41.