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Research paper

A novel method for copyright protection of digital videos using SWEA and ZPA technique

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Abstract

Digital copyright protection has become an effective way to prove the ownership and protect the multimedia contents from illegal use and unauthorized users. In order to prove the ownership of a video certain security program is embedded in a video and one of the ways of ensuring the ownership of a video is embedding the watermark in a video. In this paper, a new approach to digital video copyright protection, SWEA (Split watermark embedding algorithm) with Zero Padding Algorithm (ZPA) is proposed. With the help of this algorithm, it is hard to know the original pattern of watermark because of SWEA and minimizing the perceptual degradation of watermarked video because of ZPA. Here we are using 'db1' wavelet domain for embedding the watermark in the LL sub-band of the original identical frame (I-frame), based on the energy of high-frequency sub-band in an adaptive manner. SCD (Scene changed detection) is used to find out the identical frame (I-frame). The proposed algorithm has undergone various attacks, such as compression, uniform noise, Gaussian noise frame repetition and frame averaging attacks. The proposed algorithm, sustain all the above attacks and offers improved performance compared with the other methods from the literature.

Keywords:*Copyright Protection; Digital Videos; Dwt; SCD; Digital Watermark*

1. Introduction

TThe concept of individualism emerged under the influence of the philosopher John Locke and others in seventeenth-century in England [1], and this system replaced the absolute monarchy. During this period, printers and booksellers were in need of some kind of copyright protection, referring to the theory of intellectual property. A law hitherto known as the statute of queen Anne was passed on 10th April 1710. It was the first law of its kind on copyright as it gave recognition to the existence of an individual right to authors to be protected only with respect to their books.

The term of copyright belongs to a branch of law that grants an author, (where he is a writer, artist, musicians or another creator) protection of their work. Under the law of copyright, authors are entitled to protection against illegal or unauthorized use of their original contribution.

Digital watermarking techniques have been studied extensively. In this era, extensive use of video-based applications is growing which include the internet, multimedia, video recorder, video conferencing, etc. which increases the demand to secure the videos. The video watermark technique is having a different extension and also more complicated than the image watermark technique [2-5]. Some of the impactful video watermarking characteristics include:

1) Successive frames have a high correlation, so embedding, independent watermarks on each frame, an attacker could not remove significant portions of inserting watermarks by performing frame averaging.
2) Some of the applications require a real time processing like broadcasting, monitoring etc. and that's why they have low complexity.
3) The unbalance region between the motion and motionless regions.
4) The susceptibility of watermarked video sequences is very high to pirate attacks, namely frame swapping, digital-analog (AD/DA), statistical analysis, frame averaging and lossy compression.

To prove the ownership of a video is a big challenge. If a video becomes popular all of a sudden and people like to watch it over and over again or any video which can be a claim offense or innocence of a person then the price/cost of these videos hikes a lot. In this case, many people claim the ownership of the video..

To find out the authorized/legal owner out of all multiple people claiming the ownership, we perform the Digital Video Copyright Protection and this whole process is named as ownership Proof. The domestic digital copyright protection products basically depend on Real Network and Microsoft Windows Media for the future growth. The majority of these products follows only the protection of copyright of electronic publications, magazines, journals and static images. But still, the necessity to apply the copyright protection on digital videos professionally exists. In fig.1, we are showing the block diagram of our algorithm. Here we have applied SWEA & ZPA collectively to the input (watermark and video file). Now to extract the watermark, apply the watermark detection algorithm on watermarked video.

For many years, researchers have done their work in this field to protect the copyright of any multimedia document [5] and they have succeeded in achieving the same, but on the other hand, many hackers or attackers have also found out the way to crack or break the copyright technique.

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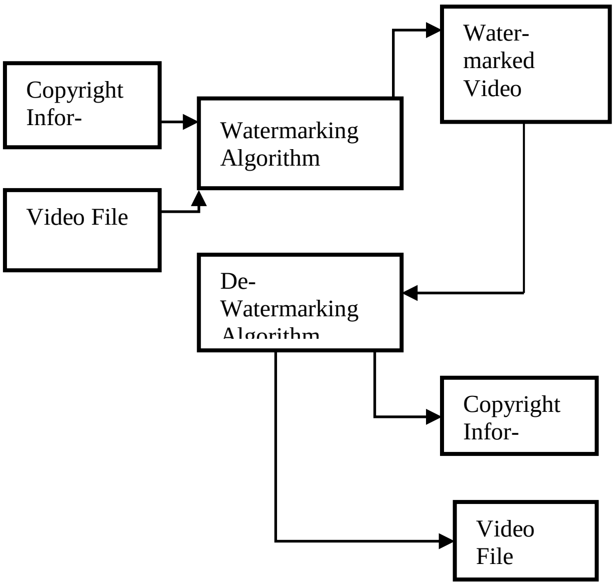

Fig. 1: Block Diagram of Video Watermarking.

In this paper, we are using the ZERO PADDING with SWEA technique to ensure the authorized owner of the video. In this technique, we have performed many attacks to ensure that the video can bear it in order to maintain its originality andauthorization. These attack techniques comprise of Spatial attack (Gaussian noise, uniform noise), compression attacks and temporal attacks (Frame repetition, frame averaging and frame swapping) etc. Out of all these attacks, the technique provides better results as compared with the literature.The remaining part of the paper is organized as follows. In section Related work, we have discussed various digital video copyright protection techniques. In section Proposed Method and Algorithm, we have proposed an algorithm for providing the copyright protection for digital videos. In section Result and Discussion, the results are discussed. Finally, the Conclusion section provides the conclusion of this paper.

2. Literature survey

For many years, researchers are doing their work in this field to protect the copyright of any multimedia document andthey have succeeded in achieving the same, but on the other hand, many hackers or attackers are also finding out the way to crack or break the copyright technique.

For the decoding process of the watermark, Data hiding techniques can be divided into three categories: Blind, Semi-blind, and non-blind.

Blind systems do not require the original host data (image, video, Audio etc.) to extract the watermark. For the sake of security, some additional information (e.g., A secret "key") may be needed in order to decode or decrypt the watermark. The key can be suppressed if additional security is not needed. Meanwhile, non-blind systems need to have the original host data at the decoder in order to decode the watermark. A semi-blind watermarking system can be imagined as a communication system with side information [6]. In such types of systems, the watermark or some information about the original host data (but not the entire host data) is required to extract the watermark sequence. This classification of watermarking system has shown in Table1.

In December 2013HaniehKhalilian [6] proposed an algorithm for video watermarking. The encoding of watermark was in the wavelet domain, but he decoded the watermark with the help of PCA. He also used a scene changed detection algorithm so that he can select the target frame where the watermark is to be embedded. But this algorithm also was not suitable for the protection of watermark pattern and quality of extracted watermark.

Table 1: Classification of Watermark System

Criterion	Class	Brief Description
Domain Type	Pixel	Manipulate the Pixel values to embed the watermark
	Transform	Modified the coefficients of Transform Domain to embed the watermark. These are the some popular Transform:- Discrete Cosine Transform (DCT) Discrete Wavelet Transform (DWT) Discrete Fourier Transform (DFT) Principle Component Analysis (PCA)
Watermark Type	PRNS	Detecting the presence or absence of a watermark statistically. A PRN Sequence is generated by feeding the generator with a secret seed.
	Visual	The visual quality of embedded watermark is evaluated.
Information Type	Non-blind	Both the original image and Secret key required.
	Semi-blind	The watermark and the Secret key required.
	Blind	Only the secret key required.

In the literature review [2-13], we have studied that an attacker may crack or damage or detect watermark with the help of some possible algorithms. But in SWEA, it is very difficult to detect the original pattern of inserted watermark. In this paper, we also improved the robustness & security of inserted digital watermark and transparency of watermarked media using ZPA.

3. Proposed approach

In the proposed method, a gray level image (256 x 256) is used as a watermark signal. As a gray image has 256 levels so 8 bits can represent each pixel. For embedding the watermark we have taken two video sequences first is 'Foreman' and the second is 'Car_race.mp4' video sequence. After applying scene changed algorithm on these video sequences, we obtain 77 and 97 scenes changed frames respectively. Before embedding the watermark inside the original media (original video), we have to preprocess the watermark and input video.
SWEA

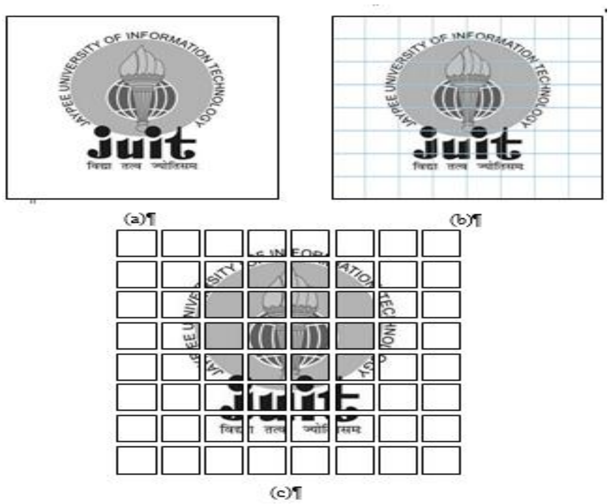

Fig. 2: Watermark Pre-Process.

(a) Original Watermark (b) Split of watermark using proposed algorithm
(c) 64 small pieces of original watermark after implementation of the proposed algorithm.
Here m = 77 for Formen video and m = 97 for Car_race video. So n=3 for both the cases

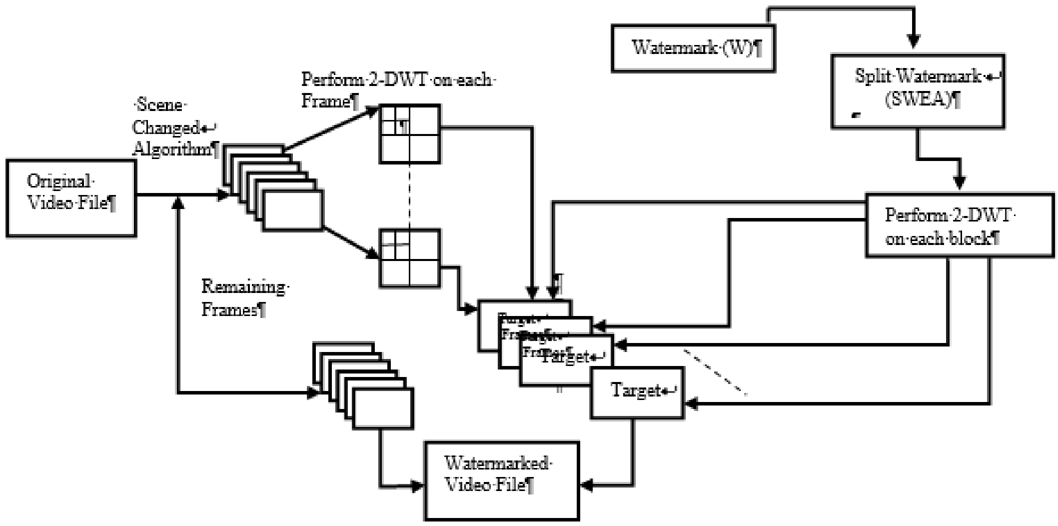

Fig. 3: Video and Watermark Pre-Process.

With the help of SWEA (split watermark embedding algorithm), we split the watermark. In the process of watermark embedding, at first we scale the watermark to a particular size with the help of this equation.

$$(4^{n} \leq m;\ n > 0) \tag{1}$$

In the above equation, m is the total no. of the scene changed frames of video and 4^n is the total number of split watermark in which n is an integer. In this case, the watermark will be divided into 4^n small images that are shown in fig. 2.
In fig. 2 we have an original watermark juit.jpg (256 x 256). Now apply the proposed algorithm SWEA on juit.jpg and we obtain small pieces of watermark (32 x 32) in fig 2(c).
In Fig. 3, a scene changed detection algorithm is applied to input video sequence and get the non-overlapping GOP [10]. Select the identical frame (I-frame) with the help of the identical frame selection scheme. After getting the I-frames, apply 2-level DWT and find out the second level coefficients [ca2, ch2, cv2, cd2].
In fig. 3, we have used 2-level 'db1' wavelet transform on both video sequence and watermark, to obtain the higher (HH, HL) and lower frequency band (LL LH) [11], 12]. After performing 2-DWT on each I-frame (Identical Frame) of video, we get LL-2 (2nd Level low frequency band), which is named as (Lf_2).
We are also applying the 2-DWT technique on each split watermark block and obtain LL-2, which is named as (Wm_2) and multiplied by a scaling factor β. After getting scaled (Wm_2) and (Lf_2) we add them with the help of ZPA (Zero Padding Algorithm) then apply IDWT (Inverse discrete wavelet transform) on video frame (Lf_2) and the result gets stored in WmI_i

$$WmI_i = (Lf_{2_i}) + \beta \times (Wm_{2_i}) \tag{2}$$

Wavelets are a more general way to represent and analyze multi-resolution images and it can also be applied to 1D signals. Wavelets are very useful for image compression and removing noise.
We don't need to calculate wavelet coefficients at every possible scale. It can choose scales based on powers of two, and get equivalent accuracy.

$$\psi_{j,k}(x) = 2^{j/2}\psi(2^{j}x - k) \tag{3}$$

We can represent a discrete function f(n) as a weighted summation of wavelets $\psi(n)$, plus a coarse approximation $\varphi(n)$

$$f(n) = \frac{1}{\sqrt{M}}\sum_{k} W_{\varphi}(j_0,k)\varphi_{j_0,k}(n) + \frac{1}{\sqrt{M}}\sum_{j=j_0}^{\infty}\sum_{k} W_{\psi}(j,k)\psi_{j,k}(n) \tag{4}$$

Where j_0 is an arbitrary starting scale, and n = 0, 1, 2, M
Now to find out the approximation coefficients we used equation 3. Approximation coefficients are those coefficients where we have to embed our watermark information. However, the embedding process should not distort the original approximate coefficients. So we are using the concept of ZPA (Zero Padding Algorithm).

Approximate coefficients

$$W_{\varphi}(j_0,k) = \frac{1}{\sqrt{M}}\sum_{x} f(x)\varphi_{j_0,k}(x) \tag{5}$$

Details coefficients

$$W_{\psi}(j,k) = \frac{1}{\sqrt{M}}\sum f(x)\psi_{j,k}(x) \tag{6}$$

As above, we have shown equation 2 and that implies the procedure of embedding the watermark for i^{th} frame. So with the help of equation 2 we can drive the equation 7 and this equation is showing the procedure of embedding the watermark in a video.

$$W_{video} = \sum_{i=1}^{m}\left[(Lf^{i}_{2}) + q \times (Wm^{i}_{2})\right] \tag{7}$$

ZPA (Zero Padding Algorithm)
In the equation 2 we are adding, (Lf_{2_i}) and (Wm_{2_i}) and their matrices dimensions are (72 x 88) and (8 x 8) respectively. But according to matrices property, we can add two matrices if and only if they are of the same dimensions. So with the help of ZPA we are converting the matrix of (Wm_{2_i}) as the same as of (Lf_{2_i}). The original matrices are

$$(Lf_2) = \begin{bmatrix} a_{11} & a_{12} \ldots a_{1n} \\ a_{21} & a_{22} \ldots a_{2n} \\ . & . \quad . \quad . \\ a_{n1} & a_{n2} \ldots a_{nn} \end{bmatrix},\ (Wm_2) = \begin{bmatrix} b_{11} & . \quad . & . & b_{1n} \\ . & . & . & . \\ . & . & . & . \\ b_{n1} & . & . & b_{nn} \end{bmatrix} \tag{8}$$

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In equation 8, matrix dimensions of (Wm_{2_i}) being8x8. But after applying ZPA on (Wm_{2_i}) the matrix dimensions will be changed in respect of (Lf_{2_i}) as in equation 9.

$$(Lf_{2_i}) = \begin{bmatrix} a_{1,1} & a_{1,2} & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & a_{1,87} & a_{1,88} \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & & \\ a_{36,1} & a_{36,2} & \cdot\cdot & a_{36,44} & a_{36,45} & \cdot\cdot & a_{36,87} & a_{36,88} & & \\ a_{37,1} & a_{37,2} & \cdot\cdot & a_{37,44} & a_{37,45} & \cdot\cdot & a_{37,87} & a_{37,88} & & \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & & \\ a_{72,1} & a_{72,2} & \cdot & \cdot & \cdot & \cdot & a_{72,87} & a_{72,88} & & \end{bmatrix} \tag{9}$$

$$(Wm_{2_i}) = \begin{bmatrix} 0_{1,1} & 0_{1,2} & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & 0_{1,87} & 0_{1,88} \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & & & \\ 0_{36,1} & 0_{36,2} & \cdot\, b_{36,44} & \cdot & \cdot\, b_{36,45} & \cdot\cdot & 0_{36,87} & 0_{36,88} & & \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & & \\ 0_{37,1} & 0_{37,2} & \cdot\cdot\, b_{37,44} & \cdot & \cdot\, b_{37,45} & \cdot\cdot & 0_{37,87} & 0_{37,88} & & \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & & & \\ 0_{72,1} & 0_{72,2} & \cdot & \cdot & \cdot & \cdot & \cdot & 0_{72,87} & 0_{72,88} & \end{bmatrix} \tag{10}$$

4. Embedding algorithm

1) InputOriginal video sequence (O_{video}) Watermark (W) [256, 256]
2) Extract scene changed frame (I) Total number of scenes changed frames= m
3) SWEAwhile $m \geq 4^n$

size of watermark blocks Wb(x,y) = $\left[\frac{256}{\sqrt{4^n}} \times \frac{256}{\sqrt{4^n}}\right]$

1) Take 2-level 2-dimensional DWT of I_i for i = 1 : m[Ca_i, Ch_i, Cv_i, Cd_i] = DWT2(I_i, "haar") j=i+1 [Ca_j, Ch_j, Cv_j, Cd_j] = DWT2(Ca_i, "haar")Calculate size of Ca_j [p q] = size (Ca_j)
2) ZERO PADDING in watermark block Z= zeros(p,q)size of Wb= [x y] Insert the values of Wb in
   $Z\left(\frac{p-x}{2}+1 : \frac{p-x}{2}+x\right)$ Row value insertion at
   $Z\left(\frac{q-y}{2}+1 : \frac{q+y}{2}\right)$ Column value insertion at Now,
   Zero padded watermark = ZW
1) Insert the zero padded watermarkZW into Ca_j
2) Now new coefficients will be mod Ca_i,mod Ca_jTake IDWT of modified coefficients
3) Finally get the zero padded watermarked frame (EW_f) and watermarked video (EW_{video})

5. Detection algorithm

1) Inputwatermarked video (EW_{video})
   Original Video (O_{video})
   Take watermarked frame (EW_f) from (EW_{video})Original frame (I_i) from (O_{video})
2) Subtract 1-level approximate coefficients of watermarked image (EW_f)from the 1-level approximatecoefficients of I-frame (I_i)
3) Now, $NewCa_i$ = mod Ca_i - Ca_i
4) Calculate cross correlation between $NewCa_i$and originalwatermark block

if correlation = = highThen, Stop the execution. The detected watermarkblockis similar to original watermark block.
Else if
Take 2-level approximate coefficients and repeat fromstep 3 until the detected watermark will get similaritywith original watermark.
Else
Watermark not found.

6. Experimental results and analysis

In this section we have taken two parameters, transparency and robustness for the result analysis. To implement this technique we have used original videos 'foreman. yuv' and 'car_race. mp4' at the dimension of 288 x 352 and 640 x 360 respectively, and the size of the original watermark image is 256 x 256. For comparison and analysis we have taken two references [6] & [7]. Fig. 4 & fig. 5 shows original video frames (foreman.yuv and car_race.mp4 respectively) and their 2-Level de-compositions.

Fig. 4: Original Forman Frames and their Decomposition.

Fig. 5: Original Car Frames and their Decomposition.

In fig. 4(b) we can see there are two types of rectangle blocks, the first one is (144 x 176) named as [LL-1 LH-1 HL-1 HH-1] and second (72 x 88) named as [LL-2 LH-2 HL-2 HH-2] starting from upper left corner. LL-2 is known as the approximate coefficient of second level where we have to embed the watermark information and rest of this known as detailed coefficients of second level, same as in fig.5 (b).
After embedding the first block of the watermark from fig. 2(c) in LL-2 of fig. 4(b), we have taken IDWT (Inverse discrete wavelet transform) of 4(b) that become fig. 6.

6(a). Watermarked Foreman video frame.

6(b). Watermarked car race video frame

Fig. 6: Watermarked Frames (After Embedding First Block ofWa-Termark)

Merging small pieces of extracted watermark images
Applied watermark detection algorithm on all the watermarked I frames e.g. Fig. 6(a) & 6(b) and collect all the small pieces of watermark picture. When one picture stops, a new picture always starts. It means that these pictures are not having over-end points. Vertical and horizontal axes of final matrix picture have the same rule.
Now Scan xyWhere x = number of rowsy = number of columns
We have all the pictures in fig. 2 of an object with the help of a proposed watermark split algorithm. These pictures are stored in the program folder with the same name given by the proposed watermark split algorithm. This algorithm creates a new empty image frame. With the help of 'for' loop all grayscale images are used. In Matlab, 'imread' function is used to read images. These empty image frames are composed of the read images & finally, the output image is created.
In equation 10, it has been shown in the form of a matrix.

$$\begin{pmatrix} \text{img}[1] & \dots & \text{img}[n] \\ \vdots & \ddots & \vdots \\ \text{img}[n] & \cdots & \text{img}[n] \end{pmatrix}$$

$$= \begin{pmatrix} [n[k]\ m[l]] & \dots & n[k]m[l] \\ \vdots & \ddots & \vdots \\ n[k]m[l] & \cdots & n[k]m[l] \end{pmatrix}$$

$$= \left[\sum_{i=1}^{n} n_i[k] \sum_{i=1}^{n} m_i[k] \right]_{10}$$

In our example we have taken a watermark image that has the dimension of 256 x 256 and we obtain total no of scene changed frames 77 and 97 for Foreman video and Car race video respectively. Here we have been extracted all the watermark blocks from foreman video and car race video with the help of the watermark detection algorithm. After getting all the watermark blocks, we have been merged them with the help of equation 10.

Table 2: Videos PSNR (in Db) after Watermark Embedding

Sequence	Average PSNR	Maximum PSNR	Minimum PSNR
Foreman	53.29	59.14	50.31
Car_Race	50.09	56.64	49.85

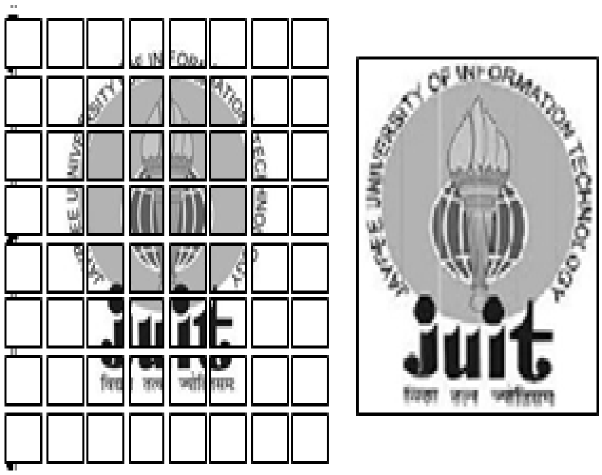

Fig. 7: (A) Extracted Watermark Blocks in Foreman Video.

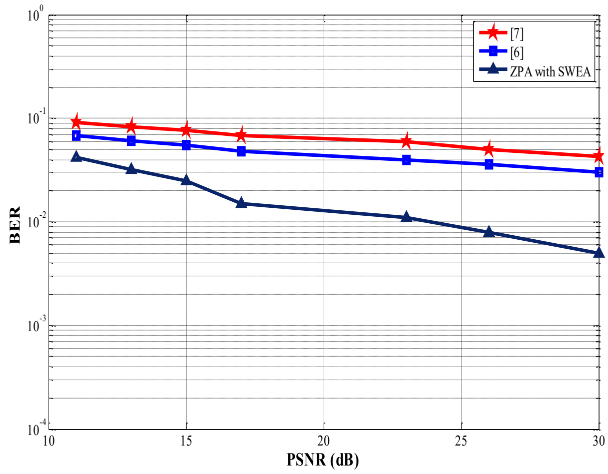

Fig. 8: BER (Log Scale) Under Spatial Attack (Uniform Noise).

The PSNR (Peak Signal to Noise Ratio) is known for distinguishing between the original and watermarked video. If the PSNR of watermarked video is high, it means the original and watermarked videos are same. So we can say that the watermark is not visible. In Table II we calculate the average, maximum and minimum PSNR offoreman video after embedding (8x8) watermark in all identical frames.
In the fig. 8, fig. 9, fig. 10 and fig. 11, we have shown the robustness against spatial attack (Uniform Noise& Gaussian Noise) and temporal attacks (Frame swapping & Frame repetition) and compared our results with [6] and [7].

7. Conclusion

Embedding the watermark into I-frame is more suitable and robust because I frame is independent and it has its own information only. The watermark embedding algorithm based on I-frame, entrenches watermark only in I-frame but simultaneously it guarantees the knowledge of the embedded watermark to each GOP. The proposed approach is more proficient because the quality of extracted watermark is better than [6, 7] in terms of PSNR and BER.
In the proposed technique we used SWEA and it provides a great security to our watermark, because no one can get the original pattern of inserted watermark and with the help of SWEA we also reduced the inserting bits as in the form of a watermark.
Using ZPA we are resizing the watermark dimensions in increasing order (in respect of original frame dimension) without adding the extra pixels. And that is why the proposed technique ZPA is used and it offers a high level transparency in between original and watermarked video.
Video watermarking is an essential need of copyright protection and a lot of research is still going on to find out the new methods for security and privacy of the multimedia contents. Current meth-

ods for video copyright protection techniques are extended form of image watermarking and there is a great scope of innovation. Research can be carried out to establish new strategies for digital video copyright protection.

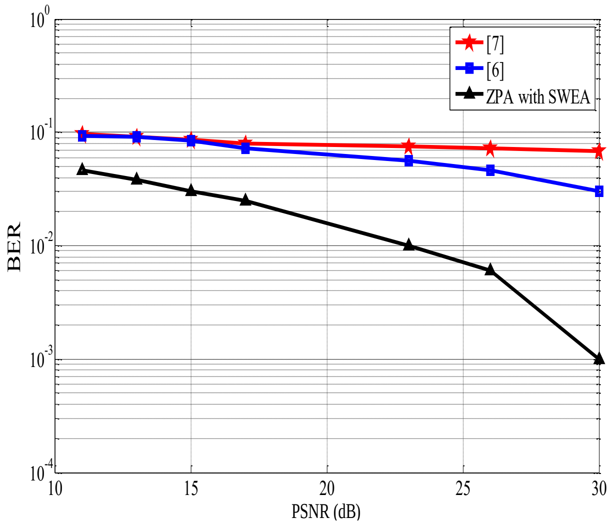

Fig. 8: BER (Log Scale) Under Spatial Attack (Uniform Noise).

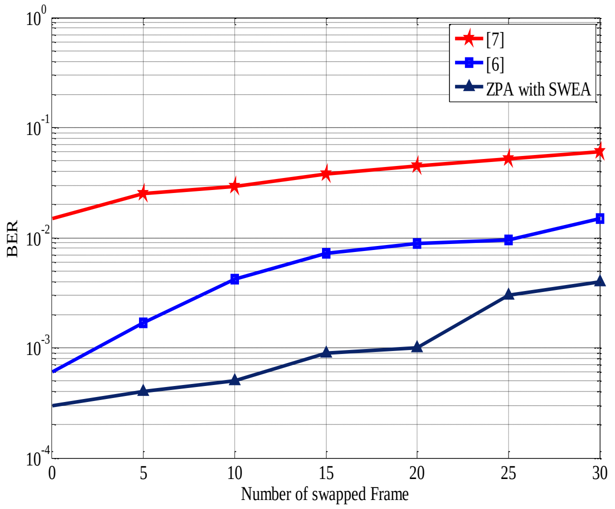

Fig. 9: BER (Log Scale) Under Spatial Attack (Gaussian Noise).

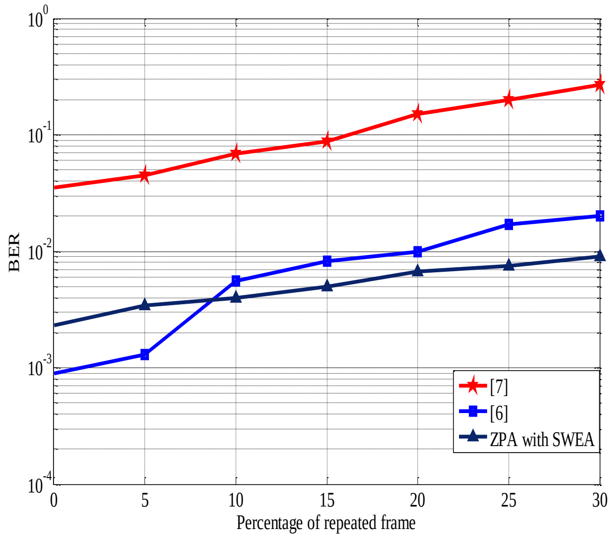

Fig. 10: BER (Log Scale) under Temporal Attack (Frame Swapping).

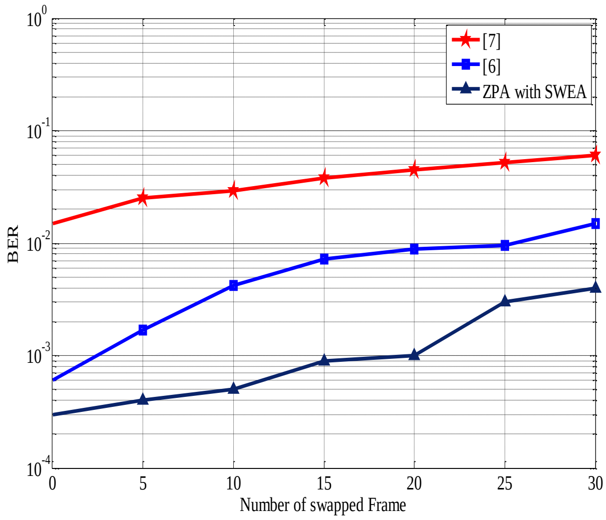

Fig. 11: BER (Log Scale) under Temporal Attack (Frame Repetition).

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