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ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Vol 4, Issue 3, March 2017

A Robust Fusion of DWT and PCA for Video Watermarking using Optimization Technique

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Abstract: -- **Watermarking is a component of inserting data into the multimedia, for example, image, audio or video. This paper propose for Fusion based video watermarking using hybrid technique to protect the copy right of images. In order to improve the efficiency of video watermarking two main processes are used namely watermark embedding process and watermark extraction process. Before embedding process the input video sequence convert into number of frames. Here Principal Component Analysisand Discrete Wavelet Transform is applied in watermark image. The swam optimization algorithm is proposed for generating random frame selection for the embedding process. The result obtain from the watermark embedding process is the watermark video sequence. Next watermark extraction process is carried out. It is the reverse process of watermark embedding. In watermark extraction process, it extracts the watermark image from the watermark video sequence. The experimental results show that this combine technique gives double security for the protection of video content and achieves good PSNR and NC.**

Keywords:-- **Video Watermarking, Fusion, Principal Component Analysis, discrete wavelet transform, ant colony Optimization.**

I. INTRODUCTION

The rapid growth of multimedia content in digital form has increased the need to develop secure methods for legal distribution of the digital content. With the speedy growth of the Internet and multimedia systems in distributed environments, it is easier for digital data owners to transfer multimedia documents across the Internet. Therefore, there is an increase in the concern over copyright protection of digital content [1], [2]. Security of digital data has become more and more important with the omnipresence of internet. The advent of image processing tools has increased the vulnerability for illicit copying, modifications, and dispersion of digital images. Against this background, the data hiding technologies for digital data such as digital watermarking have got a lot of attention recently [3]. Digital watermarking is put into practice to prevent unauthorized replication or exploitation of digital data [4], [5]. Digital watermarking is a technique that provides a way to protect digital images from illicit copying and manipulation. Watermarking is the process of embedding data into a multimedia element such as image, audio or video. This embedded data can later be extracted from, or detected in, the multimedia element for different purposes such as copyright protection, access control, and broadcast monitoring [12].

A digital watermark is an imperceptible signal added to digital data, called cover work, which can be detected later for buyer/seller identification, ownership proof, and so forth [12]. It plays the role of a digital signature, providing the image with a sense of ownership or authenticity. The primary benefit of watermarking is that the content is not separable from the watermark. A watermark is capable of exhibiting numerous significant characteristics. These comprise that the watermark is hard to perceive, endures common distortions, resists malicious attacks, carries numerous bits of information, is capable of coexisting with other watermarks, and demands little computation to insert or detect [13]. In order for a watermark to be useful it must be robust to a variety of possible attacks by pirates. These include robustness against compression such as JPEG, scaling and aspect ratio changes, rotation, cropping, row and column removal, addition of noise, filtering, cryptographic and statistical attacks, as well as insertion of other watermarks [14].

Digital watermarking technology has wide range of potential applications. The application areas are: copyright protection, authentication, image fingerprinting, hidden annotation, Broadcast Monitoring, Concealed Communication and more [7], [8]. Watermarks and watermarking techniques can be divided into various categories in various ways. According to the range of application, digital watermarking can be classified into image watermarking, video watermarking and audio watermarking [6]. Visible or invisible watermarks can be embedded into multimedia data by the process of watermarking. Visible watermarks are undoubtedly detectable in nature and a human observer can intentionally percept them. In order to prevent unauthorized access to an image visible watermarking is used [9]. In contrast, the owner or the origin of the host image can be identified using the invisible watermarking that can also be employed to identify a customer or to prove ownership by the detection of any unauthorized image copies [10] [11]. Invisible watermarking can be classified into two parts, robust and fragile watermarks.

Madhesiya et al. [6] proposed an advanced digital watermarking technique which was based on Singular Value Decomposition (SVD), Discrete Wavelet Transform (DWT), Discrete Cosine Transform (DCT) and Arnold transform. In this work the compression property of DCT, scalability of DWT, resiliency of SVD and robustness of Arnold transform utilized. For experimental purpose gray-scale image of Lena with size 256x256 was used and same image with dimension 64x64 used as watermark image. For performance measurement PSNR was calculated. Robustness of the technique was estimated using Gaussian noise attack, cropping and rotation attacks, JPEG compression and blurring attacks. This work was only limited for images only and can be extended for videos also.

Khan et al. [7] introduced a combined watermarking system for images using DCT, DWT and SVD. In this work for embedding the watermark firstly single level DWT was applied at cover image and then on HH band DCT is applied. After this, SVD applied at zigzag DCT coefficients. Traversing the embedding procedure in reverse order results in extraction of the watermark. PSNR and Normalized Correlation (NC) were computed. This work was only limited for images only and can be extended for videos also.

The proposed technique is based on watermarking and encryption algorithm in wavelet domain for enhancing security. Wavelet is more compatible as aspects to (HVS) human visual system and provide better localization both time domain & frequency domain. Experimental outcome show the efficiency of the proposed fusion method. Double security will be obtained by using hybrid technique of watermark & Encryption.

II. REVIEW OF RECENT RESEARCHES

A handful of watermarking schemes, which employs the robustness schemes for improved performance, have been presented in the literature for protecting the copyrights of digital videos. A brief review of some recent researches is presented here.

Yan Liua and Jiying Zhao [21] have proposed a 1D DFT (one-dimensional discrete Fourier transform) and Radon transform based video watermarking algorithm. An ideal domain which obtains the temporal information without losing the spatial information has been generated by the 1D DFT for a video sequence. A fence-shaped watermark pattern has been embedded in the Radon transform domain of the frames with highest temporal frequencies which they have selected with comprehensive analysis and calculation. The adaptive embedding strength for diverse locations has preserved the reliability of the watermarked video.

Reyes R. *et al.* [22] have presented a public video watermarking algorithm, a visibly identifiable binary pattern, such as owner's logotype has been embedded by their method. After separating the video sequences into distinct scenes, the scene blocks have been selected at random and the binary watermark pattern has been embedded into their Discrete Wavelet Transform (DWT) domain. The binary watermark pattern has been mapped to a noise like binary pattern by employing a chaotic mixing method to improve he security of their proposed method. The watermark has been proved to be invisible and robust to several attacks by means of simulation results.

Kareem Ahmed *et al.* [23] have proposed a 2-level Discrete Wavelet Transform decomposition of each RGB video frame component dependant video watermarking method. Independent watermarks have been embedded into separate shots by their method. The shots have been matched to watermarks by means of a genetic algorithm. Based on a key, any one of the HL1 of red, green or blue components of each frame has been selected by their proposed method and the error correcting code has been embedded into it.

Yun Ye *et al.* [27] proposed an efficient video watermarking scheme through modifying the third decoded luminance differential DC component in each selected macro block. The modification was implemented by binary dither modulation with adaptive quantization step. The scheme was based on the observation that luminance differential DC components inside one macro block are generally space correlated, so the quantization step can be adjusted according to adjacent differential components, to utilize properties of human visual system (HVS). The method was very robust to gain attacks since amplitude scaling will have the same effect on differential components and the quantization step. Experimental results showed that it can be implemented in real time with better visual quality than uniform-quantizing scheme.

III. PROBLEM DEFINITION

- The main motive of our proposed work is to solve the problems arising like copyright protection, copy protection, fingerprinting, authentication and data hiding.
- To improve the security.
- The demerits such as low PSNR and less correlation coefficient were also to be considered.
- Discrete Wavelet Transform is found to be an important tool in decomposing the images.
- The project implemented to extract the image having a good quality of data.
- To test the reliability of attacks such as removal, interference, geometric, cryptographic and protocol attacks.

The problem of resistance to video attacks, it is known that robustness is the critical issue affecting the practicability of any watermarking method.

IV. PROPOSED METHOD

There is an insistent require for copyright protection against pirating in quick growth of network distributions of images and video. To address this matter of ownership identification different digital image and video watermarking schemes have been suggested. This research suggests a competent scheme for video watermarking scheme by means of discrete wavelet transform to guard the copyright of digital images. The competence of the suggested video watermarking technique is achieved by two main steps:

1) Watermark embedding process
2) Watermark extraction process

Using shot segmentation the input video sequence segment into shots before the embedding process. Next, the segmented video shots are divided into number of frames for the embedding process. Below, the detailed process proposed method is elucidated and the block diagram of the proposed method is demonstrated in beneath,

A. Motion estimation

Motion estimation is the process of finding out the motion vector that explains the transformation from one 2D image to another; usually from adjacent frames in a video sequence. Then by comparing each nearest frames for finding image quality the mean square error (MSE) is computed. If the mean square error value is greater than the threshold value then choose that frame as the best frame.

MSE= Distance between two frames(1)

If MSE > threshold, then select that frame as the best frame for embedding process. Here the threshold value is optimized using Swam optimization technique

(i) *Swam optimization technique*

This is an intelligent computational method that produces optimal solution to different problems. This stochastic swarm intelligence is a population related optimization methodology which is initialized with a set of random population. PSO6 generates the optimum solution after several generations of keep informing the velocity and the position of the particles (population set). PSO concerns with changing the velocity of the particle over the search space towards its pbest and lbest. At every generation individual particles

ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Vol 4, Issue 3, March 2017

will have its own lbest and gbest value. By keeping track of this gbest and pbest values each individual particles travel towards the optimum result in the search space. PSO shares the information such as gbest, pbest, updated velocity and position to each and every single particle in the search apace. The Formula 1 given will describe the updating process of the velocity of each particle over the search space in order to reach the optimum point.

Vi (t+1) = *a* Vi + const1* random * (pb (t) – xi(t)) + const2 * random * (gb(t) – xi(t)) (1)

WhereVi (t+1) is the updated velocity and *a* is the search space control parameter called inertia weight. Const1 and const2 are the acceleration constants called cognition and social components which are usually set to 2 respectively. Finally pb is the best known solution of the particle which is achieved so far and gb is known as global best value known by all particles in the search space.

Pk (n+1) = Pk(n) + Vi (n+1) (2)

The mentioned Formula 2 is used for updating the particle's position accordingly in the provided search space where Xi (t+1) is the updated new position of the particle. In general, PSO is considered to have more similarities in its own way to that of the evolutionary computation techniques such as Genetic Algorithm (GA). They both start with an initial random group of population set and proceeds further with n number of iterations. These population set make the most use of fitness function to evaluate it against each other particle. With the help of random technique these population set searches for the optimum and tend to support local searching of particles with large inertia weight.

B. Watermarking

Watermarking is the sheltered methodology of embedding information into the data, for instance, audio or video and images. This procedure needs different properties depending on the real world applications, for example, robustness against attacks such as frame dropping, frame averaging attack. In proposed watermarking process initially read the watermark image next use the singular value decomposition (SVD) and discrete wavelet transform (DWT). It contains the subsequent steps the detailed procedure is elucidated below,

- Principal Component Analysis
- discrete wavelet transform

(i) Principal Component Analysis

In digital image processing field, PCA is considered as a linear transform technique to convey most information about the image to principal components. PCA is a method of identifying patterns in data, and expressing the data in such a way so as to highlight their similarities and differences. Once these patterns in the data have been identified, the data can be compressed by reducing the number of dimensions, without much loss of information. It plots the data into a new coordinate system where the data with maximum covariance are plotted together and is known as principal component. PCA transform is used to embed the watermark in each color channel of each frame of video. The main advantage of this approach is that the same or multi-watermark can be embedded into the three color channels of the image in order to increase the robustness of the watermark.

(ii) Discrete Wavelet Transform

Discrete Wavelet Transform (DWT) decays the image into four sub bands (LL, LH, HL, HH) with similar bandwidth. The filter used in 1D DWT biorthogonal filter. The sub band is separated by using this filter. This change can be replicated on the sub bands. Fig 3 shown in beneath,

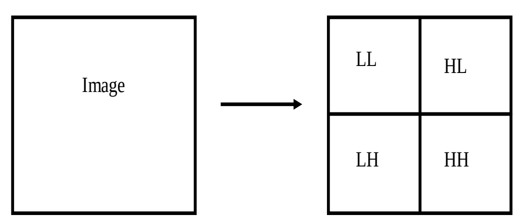

Fig.1 DWT level

In each sub band symbolizes LL (Approximate sub band), HL (Horizontal sub band), LH (Vertical sub band), and HH (Diagonal sub band). LL symbolizes the low frequency component of the image while HL, LH, HH contain high frequency component. Image degradation is caused by sub band in low frequency.

ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Vol 4, Issue 3, March 2017

There by watermark is not embedded in this LL band. Relatively the high frequency sub bands are first-class sites for watermark insertion as human visual system does not sense transforms in these sub bands. However in high frequency sub band HH has information about edges and textures of the images, so implanting is not desired in this band. Now the sub band HL is the most approximate site for watermarking. DWT based watermark, the chosen band can develop the watermark robustness.

(iii) Scan Based Encryption Method

A number of algorithms have been proposed for image encryption. Most image encryption algorithms are based on position permutations with or without disorder functions where the pixel values are scrambled to different positions on the 2D array. SCAN is a class of formal languages, which is applied to encryption, data hiding, compression etc. [1] A scanning of a two dimensional array is an order in which each element of the array is accessed exactly once. The SCAN is a formal language-based two dimensional spatial accessing methodology which can represent and generate a vast number of wide varieties of scanning paths. [2] SCAN language uses four basic scan patterns shown in figure 3. They are continuous raster C, continuous diagonal D, continuous orthogonal O, and spiral S. Each basic pattern has eight transformations numbered from 0 to 7. For each basic scan pattern, the transformations 1, 3, 5, 7 are reverses of transformations 0, 2, 4, 6, respectively. [17] A scanning of a two dimensional array is a collection in which each part of the array is accessed exactly once. The scan method includes image encryption and decryption method, in which image encryption is to reshuffle the pixel i.e. varying the position of the pixel of the image and alter the value of pixel. [19]

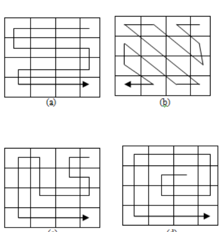

Fig-2 (a) Continuous Raster C (b) Continuous Diagonal D (c) Orthogonal O (d) Spiral

(iv) Watermark embedding steps

Input: input video sequence and watermark image
Output: watermark video sequence

- The original image is transformed into four sub bands using one level DWT
- The PCA is performed on the A matrix. $A=USV^T$
- The primary and secondary original input are fused using wavelet fusion
- The W matrix (fused image) is added to the SV's of the matrix
- The threshold value is optimized by using Improved Swam Optimization algorithm.
- After that choose the watermark image.
- After choosing the watermark image use singular value decomposition to the chosen watermark image.
- Attain watermark video sequence.

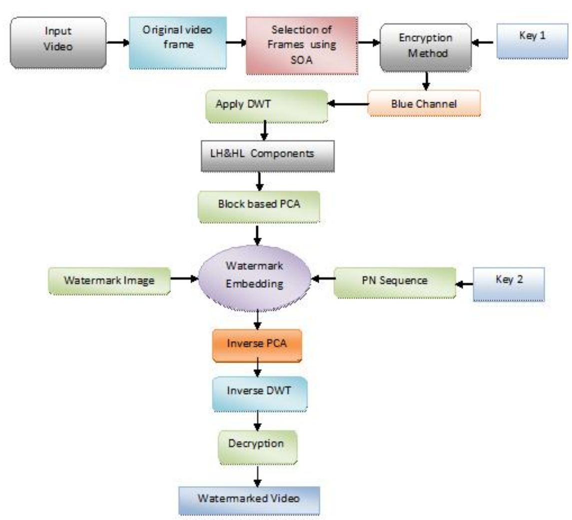

Fig-3 Block diagram of Embedding Process

(v) Watermark extraction steps

The specified procedure of watermark extraction is described beneath. Watermark extraction step is the

ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
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opposite process of watermark embedding process. No necessitate for the original video in watermark extraction process. For extraction steps only the watermark video and location of the embedding process are necessary

Input: Watermark video sequence

Output: extract watermark image

- Find high intensity value of all embed frames.
- Then compare intensity value with the motion frames.
- After that extract the watermark image from each embed frames.
- Use Inverse 1D level DWT.
- To bring back the watermark im To bring back the watermark image.

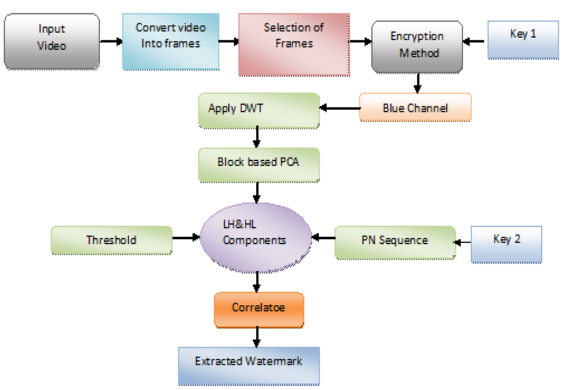


Fig 4: Watermark Extraction Process

V. EXPERIMENTAL RESULTS

The experimental result of the proposed video watermarking using hybrid DWT-PCA is explained below. In this paper efficiently embedded the watermark image into input video sequence and extract back from the watermark video sequence. The output of the proposed video watermarking has been calculated by PSNR and NC (Normalized cross Correlation). The visual quality is evaluated by the PSNR criterion for watermarked video. The extracting fidelity is computed by the NC value between the original watermark image and the extracted watermark image. The performance of the proposed watermarking method is evaluated by using two video sample sequences namely Akiyo and Hall. The result of the Akiyo video sequence of the watermark image is shown in Fig.5.

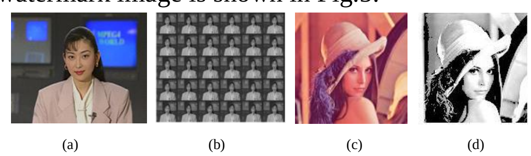


Fig.6 (a) input Akiyo video sequence (b) watermark video sequence (c) watermark image (d) extracted watermark image.

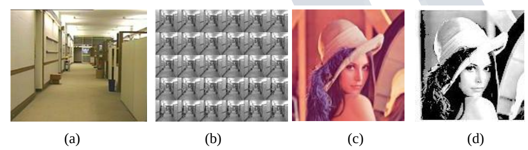


Fig.7 (a) input Hall video sequence (b) watermark video sequence (c) watermark image (d) extracted watermark image.

A. *Evaluation Metrics*

The quality of the system is evaluated using the quality metrics. The quality metrics calculated in our proposed methodology are:

- PSNR
- NC

(i) *PSNR (Peak Signal to Noise Ratio)*

PSNR is the logarithmic value of ratio between signal and noise. It is expressed in decibels. The PSNR value is calculated using the following equation. It's shown in below,

$$PSNR = 20\log_{10}\left(\frac{MAX_i}{\sqrt{MSE}}\right) \tag{3}$$

Where,

MSE = Mean square error

MAX_i is the maximum possible pixel value of the image.

Table 1 and Table 2 represent the PSNR values of the both input Akiyo and hall video sequence with and without optimization.

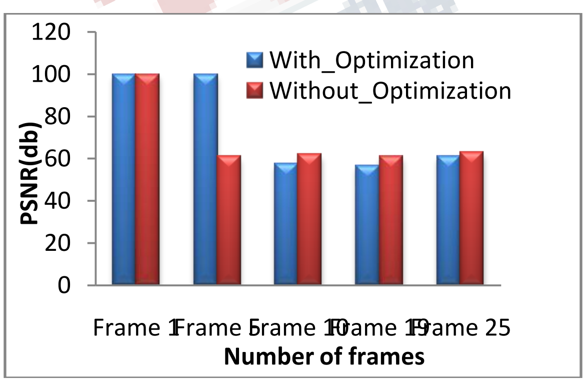
Table 1: PSNR values for Akiyo with and without optimization

Frames	PSNR Values for Akiyo video	
	With optimization	Without optimization
Frame 1	100	100
Frame 5	100	60.9257
Frame 10	57.5092	61.9039
Frame 19	56.7744	61.2754
Frame 25	61.0648	62.9404

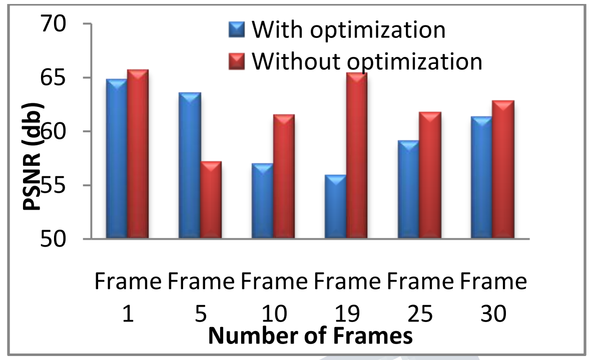
Table 2: PSNR values for Hall with and without optimization

Frames	PSNR Values for Akiyo video	
	With optimization	Without optimization
Frame 1	64.7276	65.6764
Frame 5	63.4782	57.0972
Frame 10	56.9368	61.4367
Frame 19	55.8458	65.3611
Frame 25	59.0570	61.7698

Graph 1 and Graph 2 represent the PSNR values by varying the frame number for both Akiyo and Hall video sequence. It's shown in below,



Graph 1: PSNR values by varying the frame number for Akiyo



Graph 2: PSNR values by varying the frame number for Hall

(ii) *NC (Normalized cross Correlation)*

The Normalized Cross-Correlation (NC) is calculated using the following equation. It's shown in below

$$NC = \frac{\sum_{i=1}^{i=n-1}\sum_{j=1}^{j=n-1} W(i,j).W^{'}(i,j)}{\sqrt{\sum_{i=1}^{i=n-1}\sum_{j=1}^{j=n-1}(W(i,j))^2}.\sqrt{\sum_{i=1}^{i=n-1}\sum_{j=1}^{j=n-1}(W^{'}(i,j))^2}} \quad (4)$$

Where,

W (i,j) = Pixel values of the original watermark

$W^{'}$ (i,j) = Pixel values of the detected watermark

Table 2 and Table 3 represent the NC values of the both input Akiyo and hall video sequence with and without optimization.

Table 3: NC values for Akiyo with and without optimization

Frames	PSNR Values for Akiyo video	
	With optimization	Without optimization
Frame 1	1.0000	1.0000
Frame 5	1.0000	0.9198
Frame 10	0.9958	0.9769
Frame 19	1.0000	0.9707
Frame 25	0.9949	0.9664

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ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
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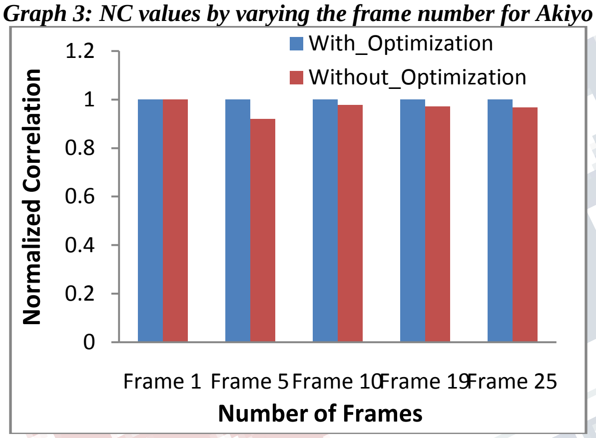
Table 4: NC values for Hall with and without optimization

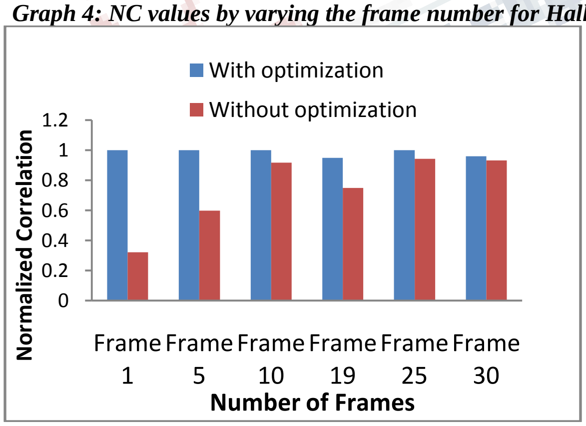
Frames	PSNR Values for Hall video	
	With optimization	Without optimization
Frame 1	1.0000	0.3211
Frame 5	1.0000	0.5977
Frame 10	1.0000	0.9171
Frame 19	0.9481	0.7488
Frame 25	1.0000	0.9428
Frame 30	0.9604	0.9317

Graph 3 and Graph 4 represent the NC values by varying the frame number for both Akiyo and Hall video sequence. It's shown in below,

Graph 3: NC values by varying the frame number for Akiyo



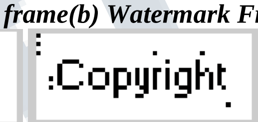
Graph 4: NC values by varying the frame number for Hall



Some other experimental results of watermarking and scan based encryption method in DWT-PCA domain are shown in table. The algorithm is implemented in Matlab version (R2013a) with the standard rhinos.avi video. The original video sample consists of about 300 frames of size 262x262. Fig. 8(a) and 8(b) show the original and the watermarked video frames respectively. Fig. 9 is the recovered watermark.

(a) (b)

Fig 8 (a) Original video frame(b) Watermark Frame



(1) Orthogonal output PSNR= 56.4782 dB

(2) Diagonal Output PSNR=56.3569dB

(3) Raster Output PSNR= 56.3549 dB

(4) Spiral Output PSNR=56.3539 dB

Fig 9 Different Extracted watermark for different scan pattern with different PSNR values

Table 5: Comparison during attacks for Rhinos Video

Attacks	Proposed method		Existing Method [18]	
	PSNR	NC	PSNR	NC
Extracted Image	62.6689	0.9882	37.7389	0.9543
Salt & Pepper	55.5577	1.0000	32.3132	0.9904
Speckle noise	54.6313	0.9843	35.9578	0.9732
Gaussian noise	49.7052	0.9137	33.2908	0.9956
Poisson noise	62.9288	0.8823	35.6241	0.9742
Blur	53.4539	0.9987	36.8717	0.9940
Frame averaging	56.4782	0.9997	38.5889	0.9946
Frame Dropping	56.9827	0.9279	37.9989	0.8926
Frame Swapping	56.9462	0.9389	38.5436	0.9728
Rotation	51.9835	1.0000	38.2881	0.9955
Cropping	59.7829	0.9978	41.2539	0.8927

Graph 5: PSNR value for watermark image applying different types of attacks

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ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
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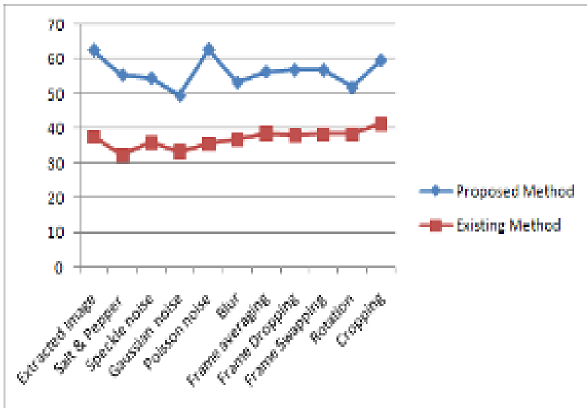
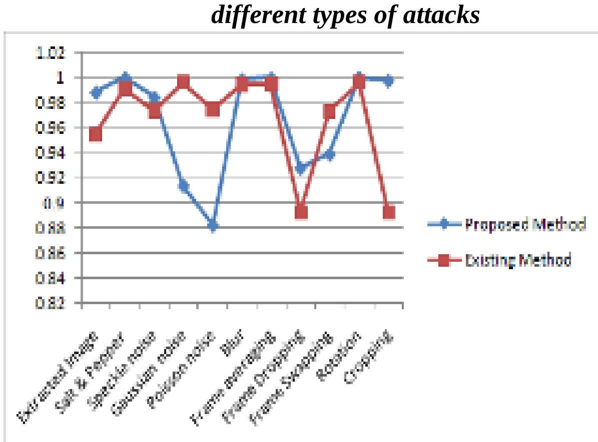


Graph 6: NC value for watermark image applying different types of attacks



Here in Table 5 the proposed methodology performance is compared with the existing method [18]. The robustness of the watermarking scheme is analyzed based on two different attacks such as Salt and Pepper noise attack and Intensity attack. In this table Salt and pepper noise attack of Rhinos video is compared with existing technique [18]. Our proposed method gave better robustness when compared to the existing method.

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