Hybrid LWT-PCA Based Video Watermarking for Copyright Protection Using Optimization Techniques

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***Abstract*-**Image and Video Watermarking is a component of inserting data into the multimedia. This paper propose a method for video watermarking using hybrid LWT-PCA to protect the copy right of images. In order to improve the efficiency of video watermarking the main processes are used namely watermark embedding and watermark extraction process. In this research work, a blind method with entropy, LWT–PCA and Improved Artificial Bee Colony (ABC) optimization algorithm is proposed to embed and extraction process. The embedding and extraction steps of the method are done in the low frequency bands of LWT. Here principal component analysis (PCA) transforms and LWT is applied in watermark image. The improved artificial bee colony algorithm is proposed for generating random frame for the embedding process. The experimental results show the effectiveness of the proposed method. Peak signal to noise ratio, normalized correlation and bit error rate are preferred to interpret the success of the method. The proposed method is implemented in MATLAB.

Keywords-*Video* Watermarking, Principal Component Analysis, Lifting Wavelet Transform, artificial bee colony, Embedding, Extraction.

I. INTRODUCTION

The explosive 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. In order to improve the effective utilization of the network information, the copyright protection is becoming particularly important.

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 [6].

The most of the algorithms in this field are used discrete wavelet transform (DWT) and wavelet packet decomposition (WPD). Most of recent papers focus on wavelet-based transformations because of being quick and more efficient than the other transforms. Lower bands are usually used to embed data on wavelet-based transformations [7]–[10]. Like the Lifting Wavelet Transform (LWT) is a version of wavelet transform, widely used in digital watermarking. The reason LWT is preferred is that it is easier, fast and has less complexity.

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. 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 [11]. 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 [12].

The basic concept of digital watermarking technique is to hide digital data (watermark) into digital images (host image). The basic requirements of a watermark are capacity (data payload), robustness, imperceptibly and security for different watermarking applications such as copyright protection, authentication, owner identification, copy control and data hiding. For host images, a watermarking method is generally considered depending on the application structure satisfying different requirements.

Capacity: The amount of data or information that can be embedded.

Robustness: Withstanding capacity of watermark to various attacks.

Imperceptibility: Non-visibility of a watermark

Security: Based on secret knowledge of watermark content access (usually a secret key).

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.

Cox, I.J. et al [13] expressed that digital watermarking 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 . 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 numerously 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. 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.

Seyma Yucel Altay and Guzin Ulutas [14] In digital watermarking, imperceptibility and robustness restrict eachother. As imperceptibility increases, robustness decreases or vice versa. In this study, it is benefited from artificial bee colony Algorithm (ABC) that is an optimization algorithm to keep these two values optimal and to ensure trade-off between robustness and imperceptibility. By using ABC in conjunction with LWT algorithm and entropy concept, it is aimed that the most suitable blocks that watermark will be embedded are selected. Embedding and extraction process of watermarking are implemented in LWT domain. A LWT-ABC Algorithm Based Approach for Smooth Image and video Watermarking.

Sweldens W [15] over the past decade, has used in different types of applications. LWT is quick and more effective than traditional wavelet transform because it can simultaneously and effectively analyze both time and frequency parameters of a given signal. Unlike the first-generation wavelet, the lifting scheme designs a new wavelet with better attributes without any necessity for Fourier analysis. LWT consists of 3 steps: splitting, prediction, and updating.

Reyes R. *et al.* [16] 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.

Based on the observation that low-frequency DCT coefficients of an image are less affected by geometric processing, Dooseop Choia *et al.* [17] have proposed a blind MPEG-2 video watermarking algorithm robust to camcorder recording. The mean of the low-frequency DCT coefficients of the video was temporally modulated according to the information bits. To avoid watermark's drift into other frames, they embed watermarks only in the B-frames of MPEG-2 videos, which also allows minimal partial decoding and achieves efficiency. Experimental results showed that the proposed scheme achieves high video quality and robustness to camcorder recording and other attacks.

Shankar *et al.* [18] the study on nature has inspired many researchers in many ways. Now-a-days, most of the new schemes are nature-inspired honey bees because they have been developed by drawing inspiration from nature. Even with the emphasis on the source of inspiration, there can still be different levels of classifications. The study on video watermarking technique to embed audio watermark based on ABC and CS algorithm is presented. The proposed approach is robust against wide spread geometrical attacks. This proposed watermarking scheme can further be associated with diverse applications to achieve a refined system and the fidelity can be improved by applying CS and ABC algorithm. The scheme can be improved by making use of the information from the video, such as instant information, to enhance the robustness of the watermark. The original audio data is extracted from the watermarked video. The performance of video watermarking is analyzed in terms of various attacks salt and pepper, Gaussian, cropping, rotation etc. [19].

III. PROBLEM DEFINITION

The main objective of the proposed research work is to develop a robust image and video watermarking algorithms by using artificial bee colony optimization technique. In the previous section different watermarking applications of image and video have been discussed, where it has been pointed out that all the watermarking schemes have some common requirements and some special criteria are required depending on the type of application these schemes are developed for. The main aims of the proposed research work are:

- To investigate multiple watermarking techniques for copyright protection, copy control, owner identification internet and secure communication.
- To design, implement and analyze images and video watermarking algorithms meeting the requirements of perceptual transparency and robustness.
- To solve the security problem with image and video watermarking schemes with the objective of increasing the image/video quality and the watermarking of the image against various attacks.
- To optimize the conflicting requirements of an image and video watermarking algorithms such as data payload, imperceptibility and robustness.
- To increase the overall robustness of the developed image and video watermarking systems for different attacks using different optimization techniques.

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. Shot segmentation:

Let as consider the input database contain i num of video sequence $V_i|i=1,2,\ldots n$. At initial step, the input video sequence is divided into shots then the segmented shots are divided into j number of frames. It's demonstrated in beneath,

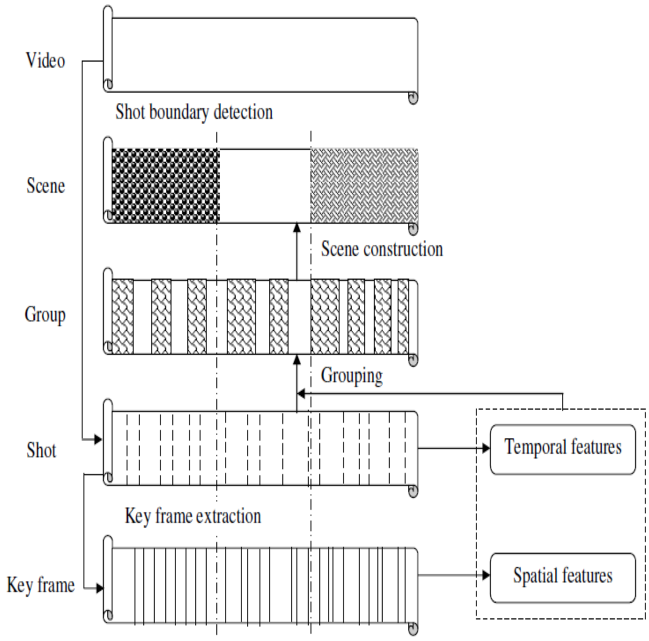


Figure.1 Shot Segmentation

B. 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 Improved Artificial Bee Colony Algorithm.

1) Improved Artificial Bee Colony

Artificial Bee Colony (ABC) is motivated by the intelligent behavior of honey bees. It contains three components namely, employed bees, onlooker bees and scout bees. In ABC system, artificial bees fly around in a multidimensional search space and some (employed and onlooker bees) select food sources depending on the experience of themselves and their nest mates, and fine-tune their positions. A few (scouts) fly and select the food sources arbitrarily without by means of experience. If the nectar amount of a novel source is higher than that of the earlier one in their memory, they memorize the novel position and forget the earlier one. In Fig.4, the flowchart for the Improved Artificial Bee Colony is illustrated.

a).Preliminary step:

Initially, produce the initial food source S_i (i=1,2,3..N) where N indicates the number of food source. This procedure is called initialization process. Using fitness function, the fitness value of the food source is computed to find the best food source. It's demonstrated in beneath,

$$Fitness\text{-}MSE \qquad (2)$$

Where, f_i is an objective function for the particular problem. The iteration is set to 1 after finding the fitness value. Next the employed bee phase is performed.

b).Employed bee phase

Using the subsequent equation the novel food source are produced in the employed bee phase,

$$S_{ij}^{new} = S_{ij} + \gamma (S_{ij} - S_{kj}) \qquad (3)$$

Where S_{ij} is the j[th] parameter of the i[th] employed bee; S_{ij}^{new} is a novel solution for S_{ij} in the j[th] dimension; S_{kj} is the neighbor bee of S_{ij} in employed bee population; γ is a number arbitrarily chosen in the range of [-1,1]; Next the fitness value is found for every novel food source and choose the best food source. After choosing the best food source next use greedy selection process. Using the equation (3), find the possibility of the chosen food source is calculated.

$$P_i = \frac{fitness_i}{\sum_{n=1}^{SN} fitness_n} \qquad (4)$$

Where, fit_i is a fitness value of i[th] employed bee

C. 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 Principal Component Analysis (PCA) and lifting wavelet transform (DWT). It contains the subsequent steps the detailed procedure is elucidated below,

- Principal Component Analysis (PCA)
- Lifting Wavelet Transform (DWT)

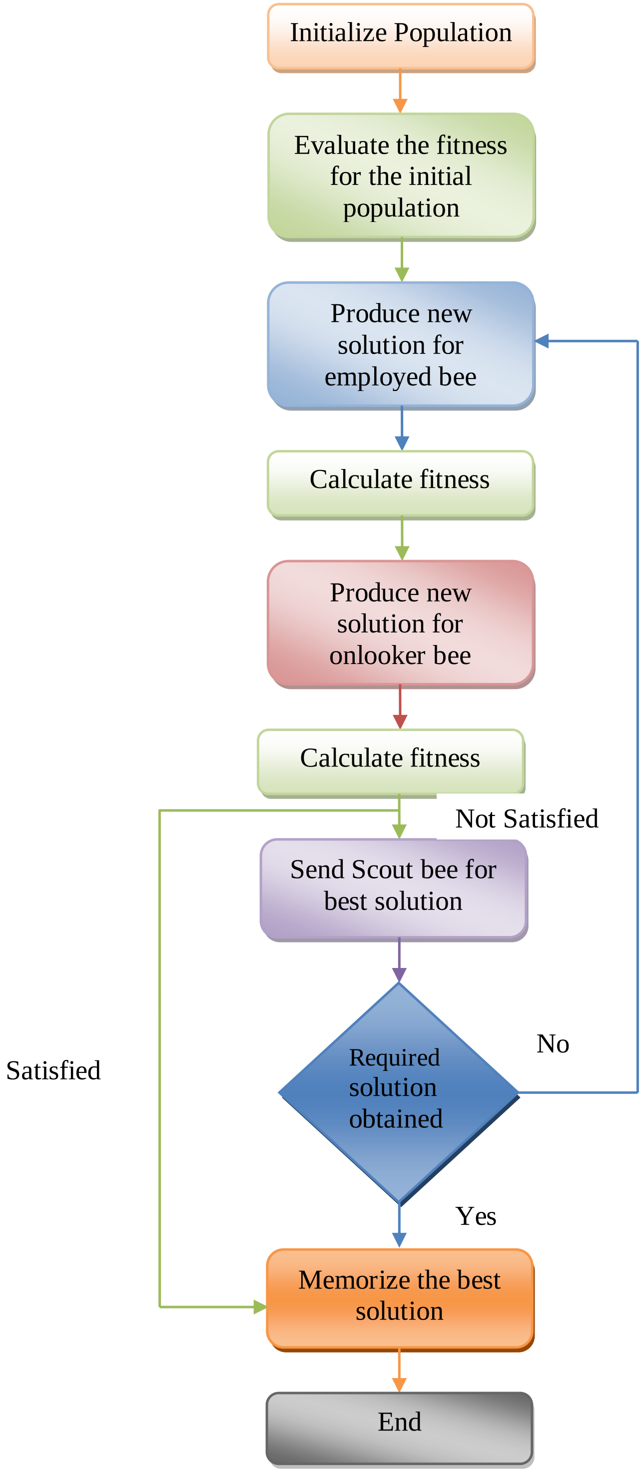


Figure.2 The flowchart for Improved Artificial Bee Colony

1) 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.

2). Lifting Wavelet Transform

Lifting Wavelet Transform (LWT) decays the image into four sub bands (LL, LH, HL, HH) with similar bandwidth. LWT is an alternative approach for DWT to transform image into frequency domain [11] for real time applications. Lifting wavelet is the second generation and fast wavelet transform. In this, translation and dilation are not fundamental to obtain lifting wavelets. In lifting wavelet transformation, up and down sampling is replaced simply by split and merge in each of the level. The subband is separated by using this filter. This change can be replicated on the sub bands. Fig 3 shown in beneath, In comparison with general wavelets, reconstruction of image by lifting wavelet is good performance because; it increases smoothness and reduces aliasing effects [13]. Employing LWT reduces loss in information, increases intactness of embedded watermark in the image and helps to achieve the reversibility of watermark.

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. 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. LWT based watermark, the chosen band can develop the watermark robustness.

D. Watermark embedding steps

Watermark embedding process is explained using 5 steps as follows. The block diagram for embedding watermark information is as shown in Figure 3.

STEP1**:** Segregate color video sequence into frames.

STEP2: Best frame is selected by using PSO. Best frame is separated into R, G and B frames. Select “B” layer to which LWT is applied. LH and HL sub bands are considered for watermark embedding.

STEP3: To LH & HL sub-images PCA is applied and the watermark bits are embedded with strength 'k' into each principal component coefficients. The embedding is carried out as

$$Sy = Sx + k\,w \qquad (5)$$

Where 'k' is the watermark strength or control factor that maintains the trade-off among the parameters imperceptibility and robustness of the watermarking scheme. This parameter can be used as single scaling factor.

STEP4**:** Apply inverse PCA on the modified PCA components of the sub-images (LH & HL sub-bands of B frame) to obtain the modified wavelet coefficients.

STEP5: Fuse RGB layers. Apply inverse DWT to obtain the watermarked frame. Then convert the watermarked video frame back to its watermarked video sequence.

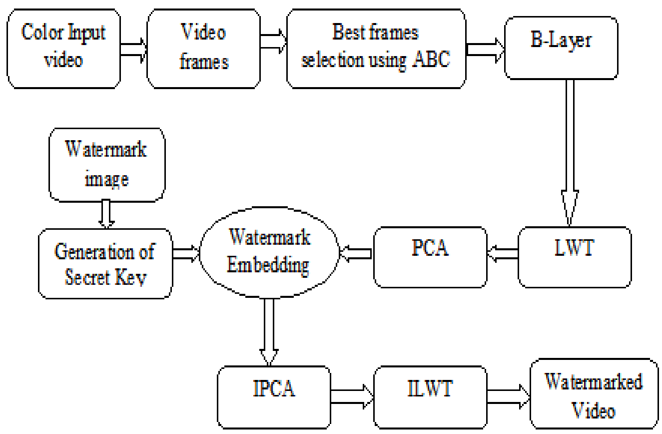


Figure 3: Block diagram for watermark embedding process

E). Watermark extraction steps

In order to recover the watermark, the PSO optimization technique, scaling factor k and transforms DWT & PCA are used to extract the watermark image. The watermark extraction process is explained using 5 steps as follows. The block diagram for extraction of watermark information is shown in Figure 4.

STEP1: Divide the watermarked video into distinct frames.
STEP2: Select the watermarked frame through PSO technique, separate it into RGB layers.
STEP3: As watermark information is embedded in B-layer, DWT is applied to B layer, resulting sub-bands LL, HL, LH and HH. Select LH & HL sub images.
STEP4: Apply PCA to LH and HL sub-images From the LH & HL sub-bands. The watermark bits are extracted from the modified principal components using watermark strength k.
STEP5: To know the performance evaluation of developed LWT-PCA-ABC, PSNR and NC are computed.

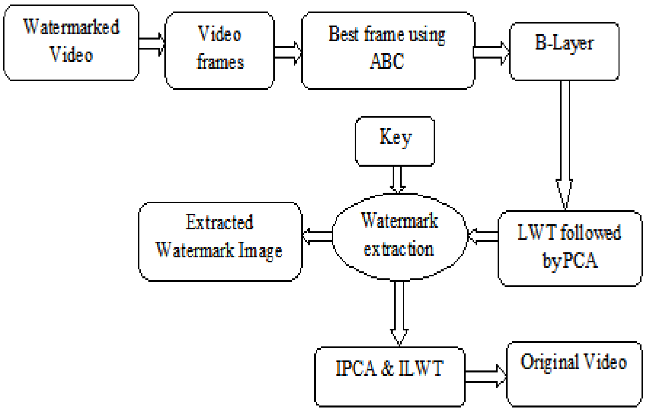


Figure 4: Block diagram of watermark extraction process

V. EXPERIMENTAL RESULTS

It is observed from the results that the PSNR and NC are much better for proposed algorithm in comparison with existing algorithm. 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 experimental results of the Akiyo video sequence for without and with optimization techniques are shown in Figures 5 and 6.

(i) Without Optimization Technique

			
(a) Akiyo video.avi	(b)Watermark video sequence	(c)Watermark Image PSNR=39.59	(d) Extracted Watermark Image NC=0.86

Figure 5: Input Akiyo video and Watermark image

(ii) With Optimization Technique

			
(a) Akiyo video.avi	(b)Watermark video sequence	(c)Watermark Image PSNR=43.55	(d) Extracted Watermark Image NC=1.00

Figure 6: Input Akiyo video and Watermark image

5.1 Evaluation Metrics

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

- PSNR
- NC

5.1.1 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,

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

Where,
MSE = Mean square error
MAX_i is the maximum possible pixel value of the image.
Comparative Analysis of PSNR and NC of different frames for Akiyo and Hall video sequences is as shown in Table 1 and 2 for different frames. From Table 1 & 2 it is observed from the tabulated results that with optimization techniques the PSNR and NC values are very high in comparison with and without optimization technique.

TABLE 1: PSNR values for Akiyo with and without optimization

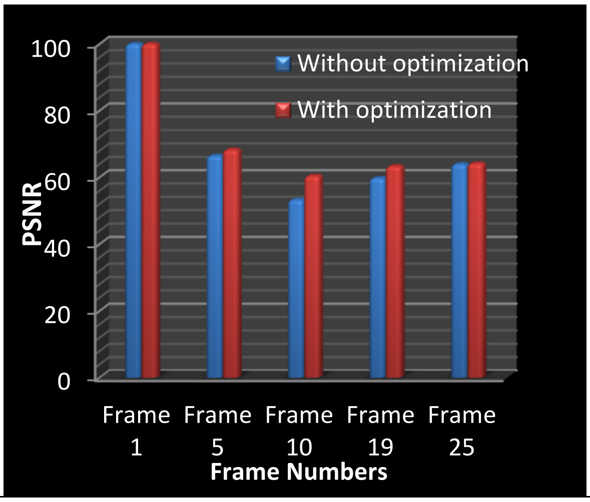
Images	**PSNR Values for Akiyo**	
	Without optimization using IABC	***With optimization using IABC***
Frame 1	100	100
Frame 5	66.4639	68.2851
Frame 10	53.2662	60.4326
Frame 19	59.7388	63.3277
Frame 25	63.9451	64.1409

TABLE 2: PSNR values for Hall with and without optimization

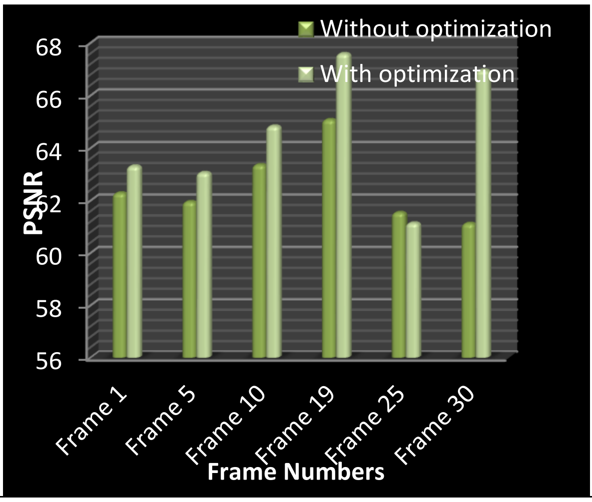
Images	**PSNR Values for Hall**	
	Without optimization using IABC	***With optimization using IABC***
Frame 1	62.2878	63.3144
Frame 5	61.9553	63.0669
Frame 10	63.3617	64.8342
Frame 19	65.0785	67.5912
Frame 25	61.5432	61.1428
Frame 30	61.1269	66.9599

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,

PSNR values by varying the frame number



Graph 1: Akiyo video sequence



Graph 2: Hall video sequence

5.1.2 NC (Normalized cross Correlation)

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

$$NC = \frac{\sum_{i=1}^{i=n-1}\sum_{j=1}^{j=n-1} W(i,j)\,W'(i,j)}{\sqrt{\sum_{i=1}^{i=n-1}\sum_{j=1}^{j=n-1}\left(W(i,j)\right)^2}\cdot\sqrt{\sum_{i=1}^{i=n-1}\sum_{j=1}^{j=n-1}\left(W'(i,j)\right)^2}}$$

Where,

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

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

Table 3 and 4 represent the NC values of the both input Akiyo and hall video sequence with and without optimization.

TABLE 3: PSNR values for Akiyo with and without optimization

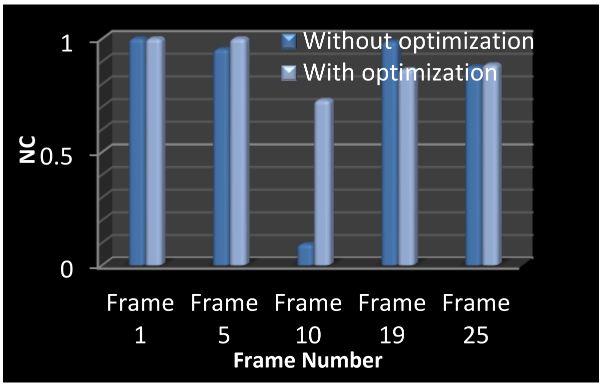
Images	NC Values for Akiyo	
	Without optimization using IABC	*With optimization using IABC*
Frame 1	1	1
Frame 5	0.95255	1
Frame 10	0.0928	0.7283
Frame 19	0.9859	0.8638
Frame 25	0.8765	0.8848

.TABLE 4: PSNR values for Hall with and without optimization

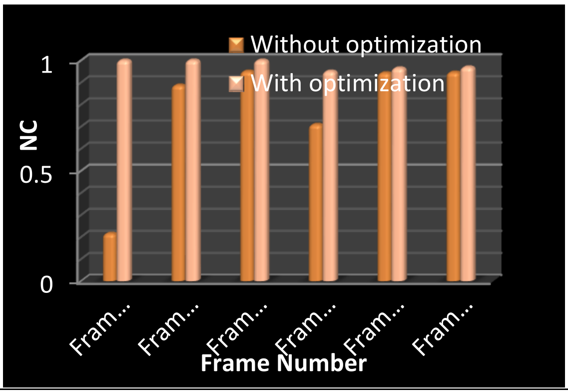
Images	NC Values for Hall	
	Without optimization using IABC	*With optimization using IABC*
Frame 1	0.2153	1
Frame 5	0.8867	1
Frame 10	0.9498	1
Frame 19	0.7088	0.9499
Frame 25	0.9426	0.9645
Frame 30	0.9455	0.9689

Graphs 3 and 4 represent the NC values by varying the frame numbers for both Akiyo and Hall video sequence. From the graphs it is observed that the NC value differ from frame to frame because of variation in the intensity value of the pixels.

NC values by varying the frame number



Graph 3: Akiyo video sequence



Graph 4: Hall video sequence

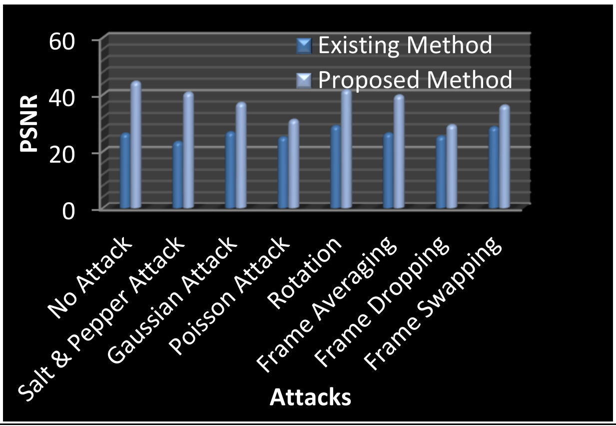
The experimental results of proposed video watermarking LWT-PCA-ABC algorithm are tested for different video sequences, various watermark images and varies attacks. The proposed algorithm is tested for . Salt & Pepper noise, Poison noise, Gaussian noise, intensity, rotation, Frame averaging, Frame dropping, Frame swapping attacks. The experimental results are tabulated in the Table 5

TABLE 5: Performance results of developed DWT-SVD-ABC algorithm (Akiyo Video Sequence)

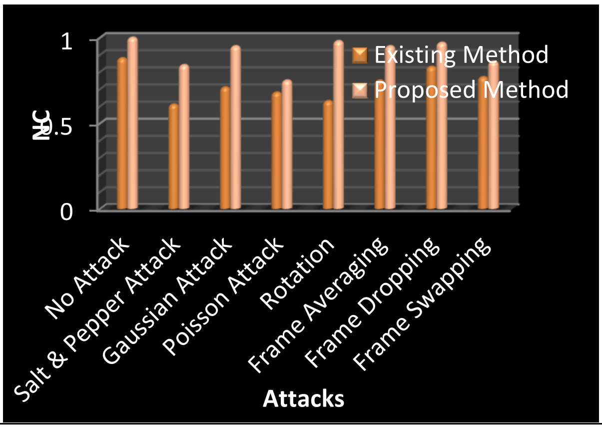
Attacks	**Existing Watermarking Algorithm**		**DWT-SVD-ABC algorithm**	
	PSNR in dB	***NC***	***PSNR in dB***	***NC***
No Attack	26.38	0.88	44.58	1.00
Salt & Pepper Attack	23.45	0.61	40.75	0.84
Gaussian Attack	26.86	0.71	37.15	0.95
Poisson Attack	25.13	0.68	31.23	0.75
Rotation	29.08	0.63	41.69	0.98
Frame Averaging	26.45	0.75	39.78	0.95
Frame Dropping	25.43	0.83	29.35	0.97
Frame Swapping	28.66	0.77	36.24	0.86

Graphs 5 and6 represent comparison results of PSNR and NC for existing and proposed methods with various attacks. From Table 5 it is noticed that PSNR and NC are very high for proposed algorithm in comparison with existing algorithm, thus robustness of developed DWT-PCA-PSO video watermarking algorithm is good.

Comparison results of PSNR and NC
for existing and proposed methods with various attacks (Akiyo video)



Graph 5: PSNR with various attacks



Graph 6: NC with various attacks

VI. CONCLUSION

- The watermark is embedded into the maximum coefficient of the PCA block of the two bands. The PCA helps in reducing correlation among the wavelet coefficients obtained from wavelet decomposition of each video frame there by dispersing the watermark bits into the uncorrelated coefficients.
- From experimental results, the high PSNR indicates high imperceptibility where there is no noticeable difference between the watermarked video frames and the original frames.
- High NC indicates that the imperceptible high bit rate watermark embedded is robust against various attacks that can be carried out on the watermarked video, such as filtering, contrast adjustment, noise addition and geometric attacks.

Finally, it is concluded that the blind video watermarking algorithm by using PSO is more robust in comparison with many existing watermarking algorithms. From the results, it is concluded that the watermark image is efficiently extracted under different attacks. Hence, the developed algorithm is quite suitable for copyright Protection, owner identification and copy control applications.

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