

Hybrid Discrete Wavelet Transform -Methods of Principal Components Based Video Watermarking For Copyright Protection Using Ant Colony Optimization Techniques

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Abstract

Watermarking is a component of inserting data into the multimedia, for example, image, audio or video. This paper propose a method for video watermarking using hybrid DWT-PCA 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 Analysis (PCA) transforms and DWT is applied in watermark image. The Ant Colony Optimization algorithm is proposed for generating random frame 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 proposed method is implemented in MATLAB.

Keywords: Watermarking, Principal Component Analysis, discrete wavelet transform, Ant Colony Optimization Technique, Motion Estimation

1. 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.

For digital watermarking of video, different characteristics of the watermarking process as well as the watermark are desirable [16 -20]. These requirements are:

- **Invisibility:** The digital watermark embedded into the video data should be invisible to the human observer.

- **Robustness:** It should be impossible to manipulate the watermark by intentional or unintentional operations on the uncompressed or compressed video, at the same time, degrading the perceived quality of the digital video significantly thereby reducing its commercial value. Such operations are, for example, addition of signals, cropping, lossy compression, frame averaging, frame dropping and collusion.

- **Fidelity:** A watermark is said to have high fidelity if the degradation it causes is very difficult for a viewer to perceive. However, it only needs to be imperceptible at the time that the media is viewed. If we are certain that the media will be seriously degraded due to other means such as transmission before being viewed, we can rely on that degradation to help mask the watermark.

- **Interoperability:** Even though many applications call for watermarking in the compressed video, it would be a desirable property if uncompressed video could compatibly be watermarked without having to encode it first. Also, the watermark should sustain the compression and decompression operations.

- **Constant Bit Rate:** Watermarking in the bit stream domain should not increase the bit rate, at least for constant bit rate applications where transmission channel bandwidth has to be obeyed.

2. 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.

E. Yavuz, Z. Telatar [34] In this paper, the advance use of Discrete Wavelet transform & Principle Component Analysis [34] in Digital Video Watermarking. There are different types of transforms which are DFT, DCT, DWT etc. The DWT is more fast & computationally more efficient than other transforms. DWT has excellent spatio-frequency properties hence it is used to identify the areas to which the watermark can be embedded imperceptibly. The watermark is embedded into the luminance component of the extracted frames as it is less sensitive to the human visual system (HVS).

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 the security of their proposed method. The watermark has been proved to be invisible and robust to several attacks by means of simulation results.

Jing Zhang *et al.* [25] have proposed a robust video watermarking scheme of the state-of-the-art video coding standard H.264/AVC. 2-D 8-bit watermarks such as detailed company trademarks or logos can be used as inconvertible watermark for copyright protection. A grayscale watermark pattern was first modified to accommodate the H.264/AVC computational constraints, and then embedded into video data in the compressed domain. With the proposed method, the video watermarking scheme can achieve high robustness and good visual quality without increasing the overall bit-rate. Experimental results showed that the algorithm can robustly survive transcoding process and strong common signal processing attacks, such as bit-rate reduction, Gaussian filtering and contrast enhancement.

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.

Yan Liua and Jiying Zhao [30] proposed a video watermarking algorithm based on the 1D DFT (one-dimensional discrete Fourier transform) and Radon transform. The 1D DFT for a video sequence generates an ideal domain, in which the spatial information is still kept and the temporal information was obtained. With detailed analysis and calculation, they have chosen the frames with highest temporal frequencies to embed the fence-shaped watermark pattern in the Radon transform domain of the selected frames. The adaptive embedding strength for different locations keeps the fidelity of the watermarked video. The performance of the proposed algorithm was evaluated by video compression standard H.264 with three different bit rates; geometric attacks such as rotation, translation, and aspect-ratio changes; and other attacks like frame drop, frame swap, spatial filtering, noise addition, lighting change, and histogram equalization. They conclude the introduction of the 1D DFT along temporal direction for watermarking that enables the robustness against video compression, and the Radon transform-based watermark embedding and extraction that produces the robustness against geometric transformations.

3. 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.

4. 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,

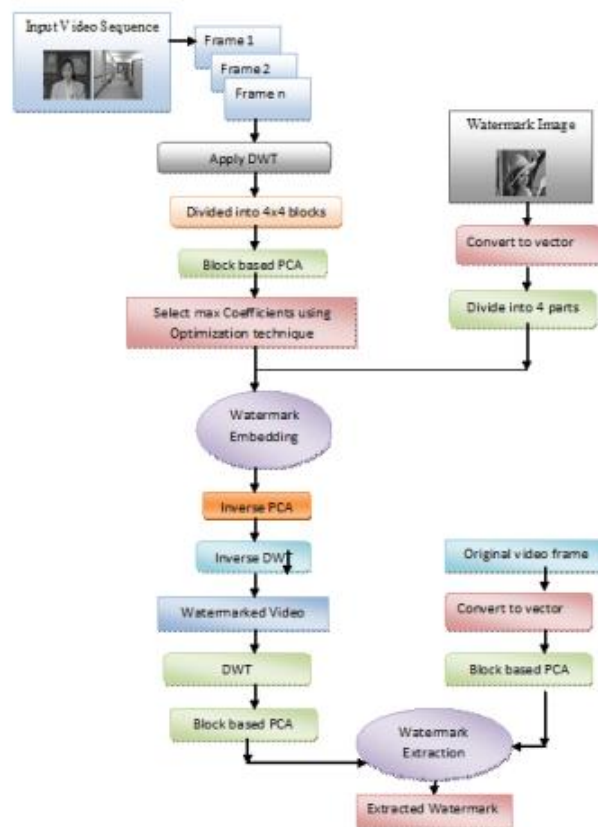


Fig.1 Block diagram of proposed method

4.1 Shot segmentation

Let us consider the input database contain i num of video sequence $V_i | i=1,2,\dots,n$. 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,

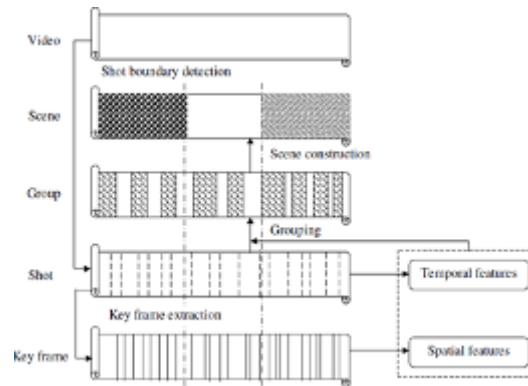


Fig.2 Shot segmentation

4.2 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.

$$\text{MSE} = \text{Distance between two frames} \quad (1)$$

If $\text{MSE} > \text{threshold}$, then select that frame as the best frame for embedding process. Here the threshold value is optimized using Improved Artificial Bee Colony Algorithm.

4.2.1 Ant Colony Optimization Algorithm

The ant colony optimization (ACO) was introduced by Dorigo as solution for hard optimization problems. It is inspired by observation of real ant colonies. Ants explore randomly the area surrounding their nest in order to find food. If an ant finds a food source, it evaluates and carries some food to the nest. During the return travels the ant deposits on the ground a chemical substance called pheromone trail. Other ants can smell the pheromone and follow it with some probability. This way, ants can communicate via pheromone and find the optimal path between the food source and the nest. This capability of real ant colony to find optimal paths has led to the definition of artificial ant colonies that can find the optimal solution for hard optimization problems such as the traveling salesman problem. The first point to take into account in ant colony optimization is how the colony is represented. For continuous variables, a colony of m ants is represented as $m \times n$ matrix C ,

$$\text{Where } C = [x_1 \ x_2 \ \dots \ x_m]^T \text{ such that } x = [x_1 \ x_2 \ \dots \ x_n] \quad (1)$$

is a vector of n design variables that corresponds to a single ant. The second point to consider is how to model the pheromone communication scheme. Socha and Dorigo suggest to use a normal distribution for a continuous model implementation:

$$f_{\text{pheromone}}(\mathbf{x}) = e^{-\frac{(\mathbf{x} - \mathbf{x}_{\min})^2}{2\sigma^2}} \quad (2)$$

where \mathbf{x}_{\min} is the optimal point found within the design space and the standard deviation σ as an index of the ants aggregation around the current minimum. To initialize the algorithm, \mathbf{x}_{\min} is randomly chosen in the design space, using a uniform distribution, and σ is taken at least three times greater than the length of the design space, to uniformly locate the ants within it. At each iteration, the ACO algorithm updates the values of each design variable, and this is for all the ants of the colony; that is, at each iteration each ant sets the values for the trial solution as per the distribution in (1). At the end, the pheromone distribution over the design space is updated by collecting the information acquired throughout the optimization steps. Since the pheromone is modeled by (1), it is necessary only to

update \mathbf{x}_{\min} and σ as

$$\sigma = \text{std}(\text{colony}) \quad (3)$$

where $\text{std}(\text{colony})$ makes use of the colony of ants (candidate solution) to return a vector containing the standard deviation for each design variable [23]. The accumulation of pheromone increases in the vicinity of the candidate towards the optimum solution. However, to avoid premature convergence, negative update procedures are not discarded: for this, a simple method is used, which consists in dissolving the pheromone. The principle is to spread the amount of pheromone by changing the current standard deviation (for each variable) according to

$$\sigma_{\text{new}} = \gamma \cdot \sigma_{\text{old}} \quad (4)$$

where $\gamma > 1$ is the dissolving rate.

4.3 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 discrete wavelet transform (DWT). It contains the subsequent steps the detailed procedure is elucidated below,

- Principal Component Analysis (PCA)
- discrete wavelet transform (DWT)

4.3.1 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.

4.3.2 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,

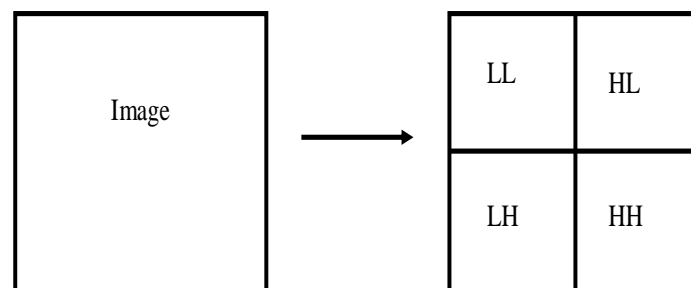


Fig.3 DWT level

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. 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.

4.4 Watermark embedding steps

Input: input video sequence and watermark image

Output: watermark video sequence

- Divide the input video sequence ($V_i | i=1,2,\dots,n$) into number of shots next the segmented shots are divided into j number of frames.
- Mean square error is found out in motion estimation by comparing the each nearest frames. If the MSE value is greater than the threshold values choose that frame as the best frame for watermark embedding.
- Take luminance component of one frame and apply DWT we obtain four sub bands as shown in above diagram.
- Transform each block into PCA components by calculating the eigenvectors corresponding to eigenvalues of the covariance matrix:
-
- The threshold value is optimized by using Ant Colony Optimization Algorithm.
- After that choose the watermark image.
- After choosing the watermark image use Principal Component Analysis to the chosen watermark image.
- After that use 1D-DWT to the original watermark image. Four sub bands attained in the DWT level. The four sub bands are symbolizing as LL, LH, HL, and HH.
- Select the LL sub band and find the high intensity value.
- Attain watermark video sequence.

4.5 Watermark extraction steps

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

5. EXPERIMENTAL RESULTS

The experimental result of the proposed video watermarking using hybrid DWT-SVD 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.

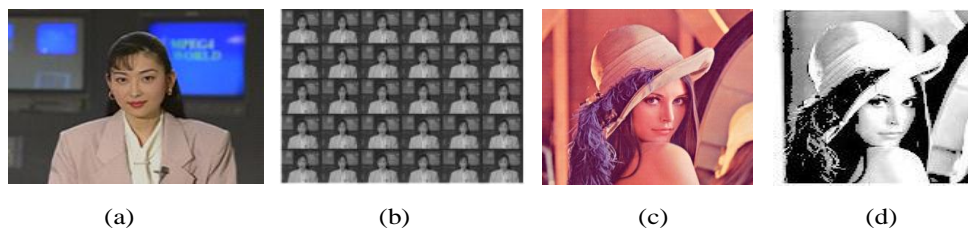


Fig. 4 (a) input Akiyo video sequence (b) watermark video sequence (c) watermark image (d) extracted watermark image.

The result of the Hall video sequence of the watermark image is shown in Fig.6.

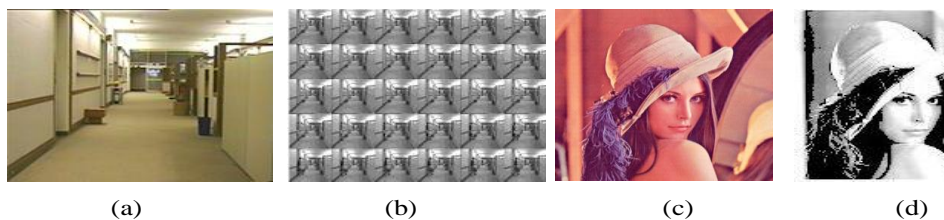


Fig.6 (a) input Hall video sequence (b) watermark video sequence (c) watermark image (d) extracted watermark image.

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. Peak Signal to Noise Ratio (PSNR)

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,

$$PSNR = 20 \log_{10} \left(\frac{MAX_i}{\sqrt{MSE}} \right) \quad (6)$$

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.

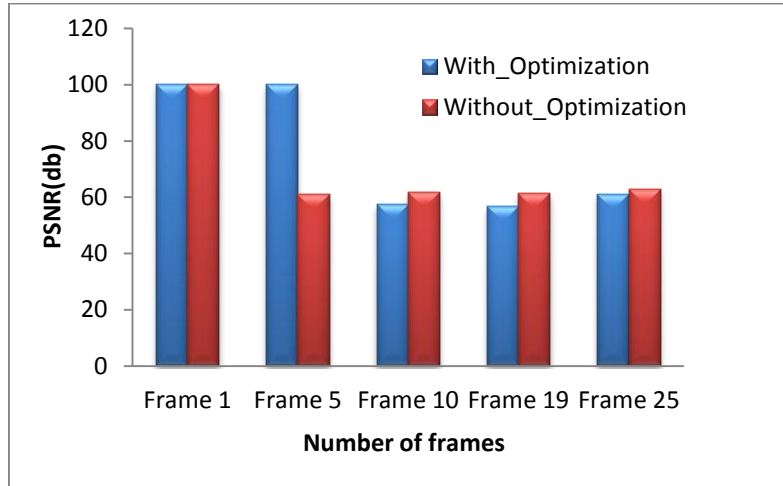
Table 1: PSNR values for Akiyo with and without optimization

Frames	PSNR Values for Akiyo video	
	With optimization using ACO	Without optimization using ACO
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

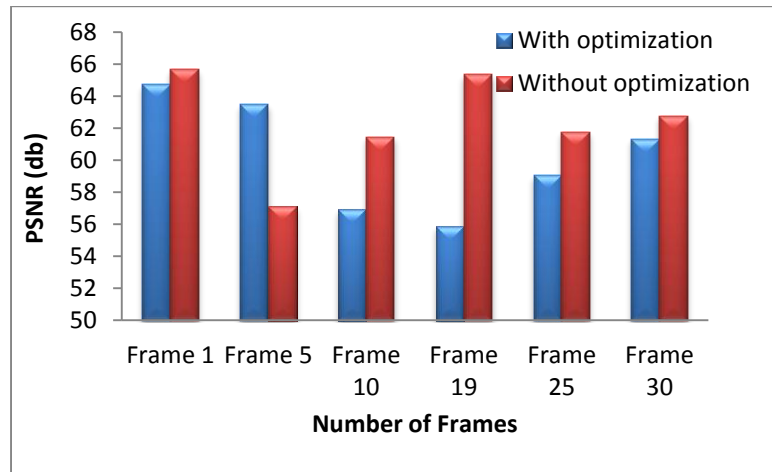
Table 2: PSNR values for Hall with and without optimization

Frames	PSNR Values for Hall video	
	With optimization using ACO	Without optimization using ACO
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

5.1.2 Normalized cross Correlation (NC)

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

$$NC = \frac{\sum_{i=1}^{i=n-1} \sum_{j=1}^{j=n-1} W(i, j) \cdot W'(i, j)}{\sqrt{\sum_{i=1}^{i=n-1} \sum_{j=1}^{j=n-1} (W(i, j))^2} \cdot \sqrt{\sum_{i=1}^{i=n-1} \sum_{j=1}^{j=n-1} (W'(i, j))^2}} \quad (7)$$

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.

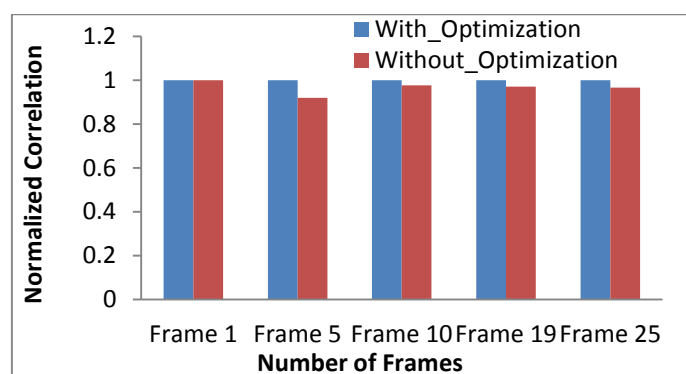
Table 3: NC values for Akiyo with and without optimization

Frames	PSNR Values for Akiyo video	
	With optimization using ACO	Without optimization using ACO
Frame 1	1.000	1.000
Frame 5	1.000	0.9198
Frame 10	1.000	0.9769
Frame 19	1.000	0.9707
Frame 25	1.000	0.9664

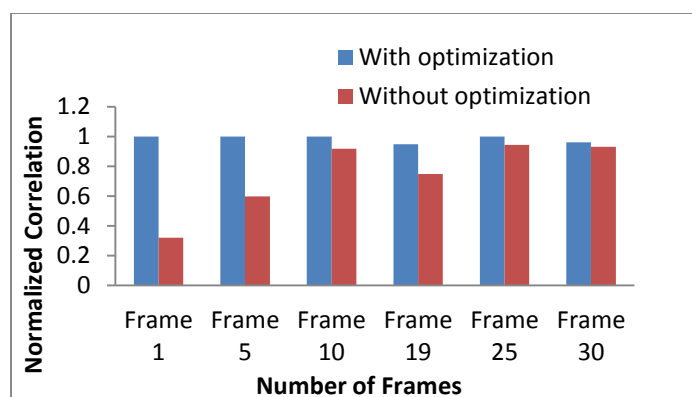
Table 4: NC values for Hall with and without optimization

Frames	PSNR Values for Hall video	
	With optimization using ACO	Without optimization using ACO
Frame 1	1.000	0.3211
Frame 5	1.000	0.597
Frame 10	1.000	0.9171
Frame 19	0.9481	0.7488
Frame 25	1.000	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

5.2 Robustness Evaluation

To verify the robustness of the proposed video watermarking scheme, the experimental results are conducted with various attacks for the watermark image.

Intensity attack

It's a type connected with attack by which attacker transform the intensity on the watermarked picture to weaken the watermark data.

- ✓ photographic negative (using imcomplement function)
- ✓ gamma transformation (using imadjust)
- ✓ logarithmic transformations (using $c \cdot \log(1+f)$)
- ✓ contrast-stretching transformations (using $1./(1+(m./(double(f)+eps)).^E)$)

Salt and pepper noise attack

Here we use the salt and pepper noise for the noise attack. The salt and pepper noise is added to the watermark image. After applying the salt and pepper noise, the noise attacked image is extracted from the watermark image.

Outside of all above we will find so various attacks including resizing, popping, scaling, sharpening, JPEG compression etc. which affects the quality of watermark photograph and watermark far too.

For examine the criteria firstly assault the image with all of these attack. From then on recover the actual watermark details from attacked image. Compare the excellent of watermark image recovered by non-attacked along with recovered by attacked image. Thus anyone can examine the robustness of criteria against these attacks. Table 5 and Table 6 represent the performance metrics with and without applying different types of attacks for watermark image both Akiyo and Hall video sequence.

Table 5: Comparison during attacks for Akiyo Video

Attacks	Proposed method		Existing Method [35]	
	PSNR	NC	PSNR	NC
Extracted Image	59.0072	0.9137	----	-----
Salt & Pepper	47.9288	0.9085	28.8216	0.6246
Speckle noise	50.2290	0.9063	29.1459	0.7134
Gaussian noise	42.3175	0.8992	29.1268	0.6551
Poisson noise	59.1075	0.9895	-----	-----
Median	38.6239	0.6278	29.2262	0.4968
Histogram Equalization	46.7289	0.9949	29.1297	0.9283

Here in Table 5 the proposed methodology performance is compared with the existing method [35]. The robustness of the watermarking scheme is analyzed based on different attacks such as Salt and Pepper noise attack speckle, Gaussian attack etc. In this table Salt and pepper noise attack of Akiyo video is compared with existing technique [35]. Our proposed method gave better robustness when compared to the existing method.

IV CONCLUSION

In this paper modified Ant Colony Optimization techniques is proposed. Watermark embedding and watermark extraction are the two main process implemented in the work in order to improve the efficiency. The input video sequence converted into number of frames before the embedding process. In watermark image principal component analysis is applied. The improved ant colony optimization algorithm is proposed for generating random frame for the embedding process. The result obtain from the embedding process is watermark video sequence. Watermark extraction is the reverse process of embedding, it extract the watermark image from the watermark video sequence.

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