Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 12, No.3, December : 2024

HYBRID STRUCTURE OF DWT – SVD BASED VIDEO WATERMARKING FOR COPYRIGHT PROTECTION USING BACTERIAL FORAGING OPTIMIZATION ALGORITHM

Dr. S. Anjaneyulu, Assistant Professor, Dept. of ECE, SKU College of Engineering and Technology, S.K. University, Anantapuramu-515003, A.P, E-Mail: anjaneyulu0607@gmail.com
Dr. P. Thimmaiah, Assistant Professor, Dept. of Electronics, S.K.University, Anantapuramu-515003, A.P, E-Mail: drptm2008@gmail.com

ABSTRACT
The Watermarking is a component of inserting data into the multimedia, for example, image, audio, video and text. This paper propose a method for video watermarking using hybrid structure DWT-SVD to protect the copy right of images. In order to improve the efficiency of video watermarking two main processes are used namely 1) watermark embedding process and 2) watermark extraction process. Before embedding process the input video sequence convert into number of frames. Here using singular value decomposition (SVD) transforms and Discrete wavelet Transform (DWT) is applied in watermark image. The Bacterial Foraging 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. The 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.

Keywords:
Watermarking, Singular value decomposition, discrete wavelet transform, Bacterial Foraging Optimization, Embedding, Extraction.

1. Introduction
The rapid growth of multimedia content in digital watermark 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 initiation of image processing tools has increased the vulnerability for illicit copying, modifications, and diffusion 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 part 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, endure 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 gloss, 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 classify 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 illicit 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 dropping 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 continue 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 better 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 maximum temporal frequencies which they have selected with broad 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 own 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 untidy mixing method to improve 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.

K. Ait Saadi *et al*. [24] have proposed a grey-scale pre-processing and robust video watermarking algorithm for the copyright protection application in the emerging video coding standard H.264/AVC. The watermark was first transformed by a Hadamard transform and modified to accommodate the H.264/ AVC computational constraints before it were inserted into video data in the compressed domain. The approach leads to good robustness and high capacity of embedding by maintaining good visual quality of the watermarked sequences. The experimental results proved the capability to embed the watermark in short video sequences and the effectiveness of the algorithm against some attacks such as re-compression by the H.264 codec, transcoding, and some common processing.

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.

Xinghao Jiang *et al.* [28] have presented 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 proposed 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). Experimental results showed that it can be implemented in real time with better visual quality.

Zhaowan Sun *et al.* [29] have proposed a video watermarking scheme based on motion location. In the scheme, independent component analysis was used to extract a dynamic frame from two successive frames of original video, and the motion is located by using the variance of 8 × 8 block in the extracted dynamic frame. According to the located motion, they choose a corresponding region in the former frame of the two successive frames, where watermark is embedded by using the quantization index modulation algorithm. The procedure above was repeated until each frame of the video (excluding the last one) was watermarked. The simulations showed that the proposed scheme has a good performance to resist Gaussian noising, MPEG2 compression, frame dropping, frame cropping and more.

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,

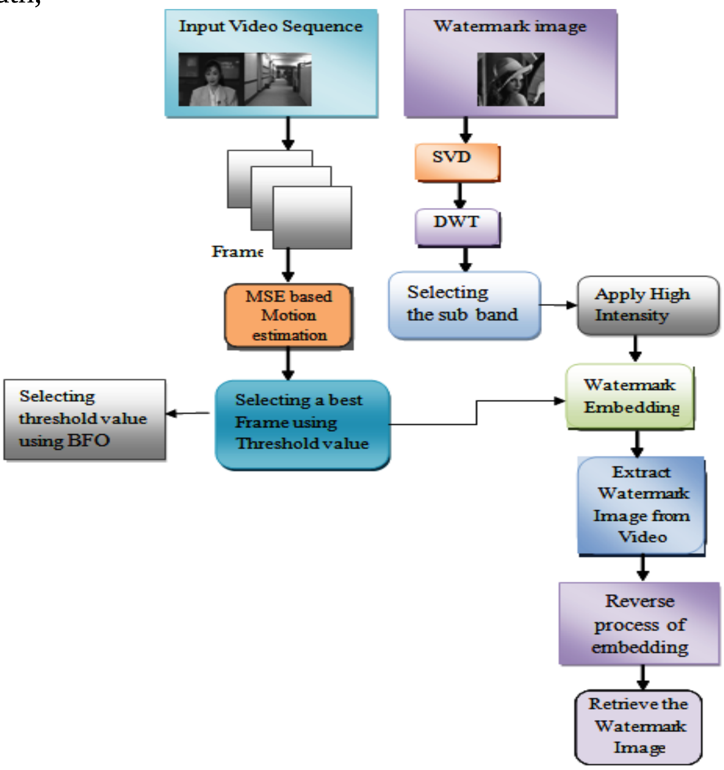


Figure.1 Block diagram of proposed method

4.1 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,

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 12, No.3, December : 2024

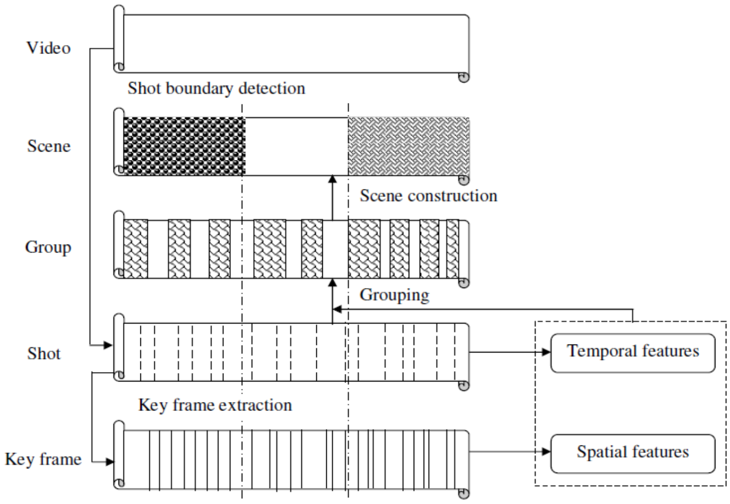


Figure.2 Shot segmentation

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.

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.

4.2.1 Bacterial Foraging Optimization Algorithm

BFO algorithm is a metaheuristic optimization algorithm. The BFO technique is a calculation method to solve complex engineering problems by modeling the E. coli bacteria foraging behavior. Bacteria are a lot simpler than other species which are in complex life forms. They need to perform nutritional activities expending energy at the optimum level by using their limited perception and movement abilities. They are easier to model than other life forms. E. coli bacteria, which is one of such creatures, is one of the microorganisms whose composition and working style are best understood. E. Coli bacteria releases a chemical substance which stimulates other bacteria when it finds the nutrient. With the effect of this chemical substance, E. coli bacteria move towards the location of nutrient. If the nutrient density is too high, the bacteria can move as a group by clamping down. When E. coli bacterial cells search for nutrient, they perform chemotaxis (swimming and rolling), swarming, reproduction, elimination and dispersal activities. While the flagella and the base of the flagellum rotate counterclockwise, Chemotaxis is a left-handed helix structured to generate force beside the bacteria and repel the cell. Otherwise, each flagellum moves independently and rolls clockwise (Figure 5) [25, 26, 30]. BFO algorithm consists of four stages [25, 30];

1.Chemotaxis: At this stage, the foraging movement of an E. coli cell is modeled. The E. coli cell foraging with swimming and rolling movement by using its flagella. It can roll or swim in the reverse direction. It moves with these two actions throughout its life. Bacteria rolling more frequently in areas where food is poorer while they swim in areas where food is more abundant. Figure 5 shows how a bacterium moves clockwise and counterclockwise in a nutrient solution [26, 30].

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 12, No.3, December : 2024

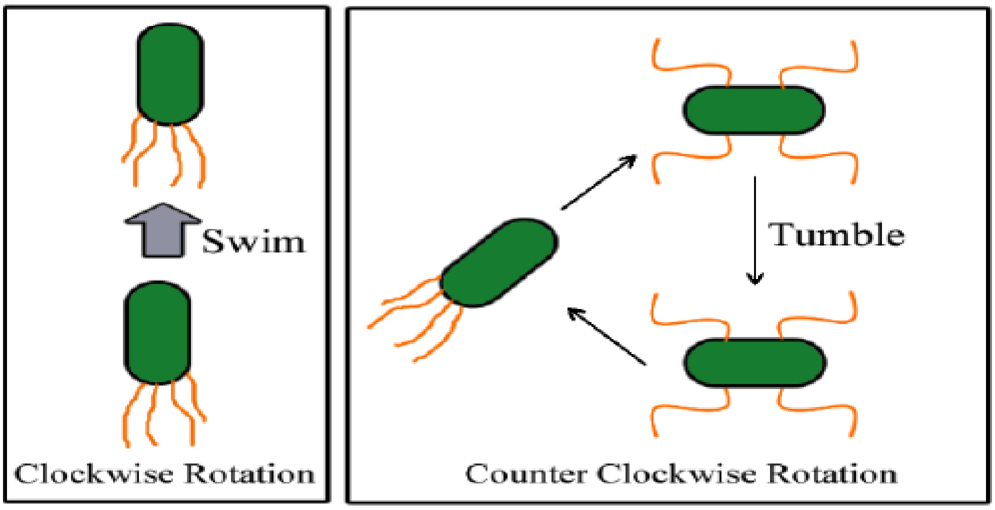


Figure. 3- Swimming and rolling of E. coli bacterium

2- **Swarming:** E. coli bacteria exhibit a movement behavior among the bacteria for searching food during the chemotaxis stage. There is both pushing and pulling behavior among bacteria. E. coli bacteria produce movement information by secreting an aspartate to allow individual bacteria to travel to the center of the population and assemble them. At the same time, bacteria are kept at a certain distance according to the relevant pushing and pulling information. [20, 21].

3- **Reproduction:** After a while, bacteria with poor foraging ability are eliminated. Healthier bacteria with strong foraging ability will split in half producing offspring to maintain the population's size. Thus, the bacterial population is kept constant [20, 21].

4- **Elimination-**Dispersal: During the forging process, sudden or gradual environmental changes can occur. With these changes, some group of bacteria dies, while others migrate to new areas. The unexpected situations such as the death of bacteria or migration to new areas cannot be ruled out. The elimination-dispersal process has been proposed to control these situations. In this case, bacteria that die or migrate are replaced by randomly produced new substitute bacteria. [20, 21].

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 singular value decomposition (SVD) and discrete wavelet transform (DWT). It contains the subsequent steps the detailed procedure is elucidated below,

- singular value decomposition (SVD) and discrete wavelet transform (DWT)

4.3.1 Singular Value Decomposition

In order to improve the robustness, Singular Value Decomposition (SVD) has been employed in watermark methods. This method decays a matrix in three matrices P, Q, R. The equation of the matrices shown in below,

$$X = PQR^T \qquad (5)$$

Where X is the original matrix, Q is the diagonal matrix of the eigenvalues of X. These diagonal values are as well called as singular values. P is orthogonal matrices and the transpose of an orthogonal matrix R. P columns are called left singular vector and the Q columns are called right singular vectors of X. The basic design behind SVD technique of watermarking is to find out the SVD of image and the differing singular values to implant 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 id biorthogonal filter. The subband is separated by using this filter. This change can be replicated on the sub bands.

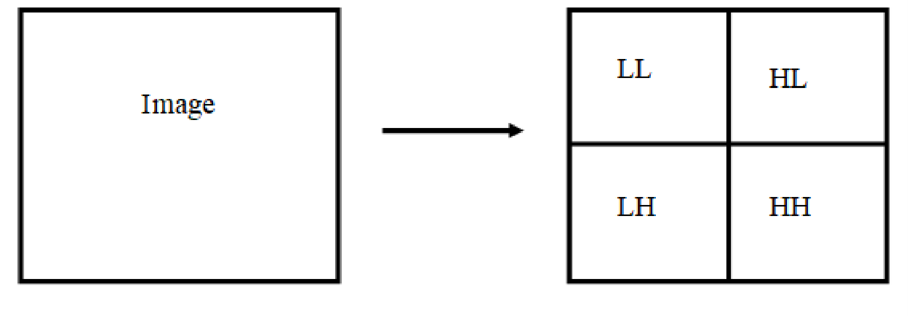


Fig.4 DWT levelFi

Figure.4 shown in beneath,

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 ($V_i|i=1,2,\ldots n$) 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.
- The threshold value is optimized by using Bacterial Foraging Optimization Algorithm After that choose the watermark image.
- After choosing the watermark image use singular value decomposition 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

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 12, No.3, December : 2024

The experimental result of the proposed video watermarking using hybrid DWT-SVD is explained beneath. In this paper ably 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.

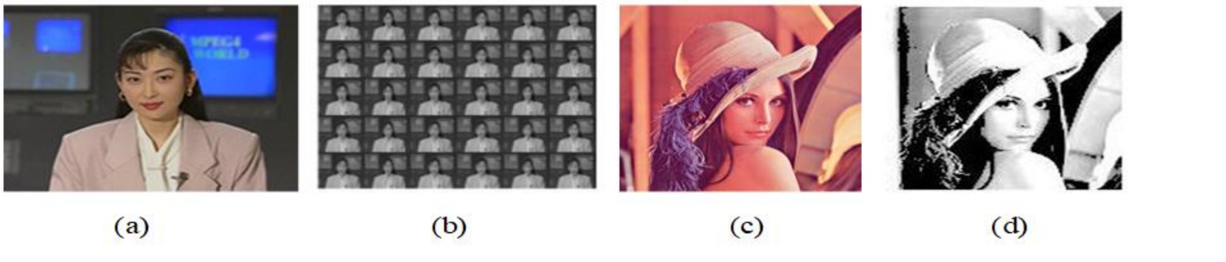


Figure.5 (a) input Akiyo video sequence (b) watermark video sequence (c) watermark image (d) extracted watermark image.

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

Figure.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 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,

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

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.

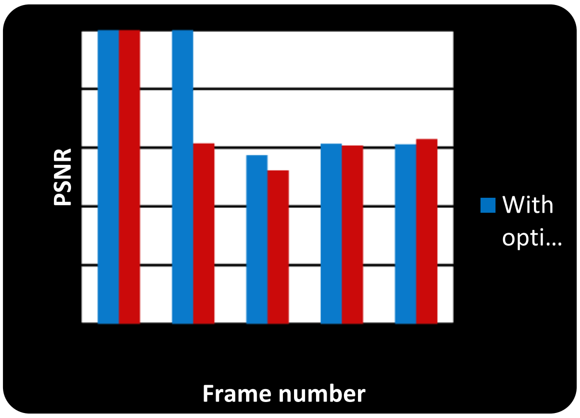
Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 12, No.3, December : 2024

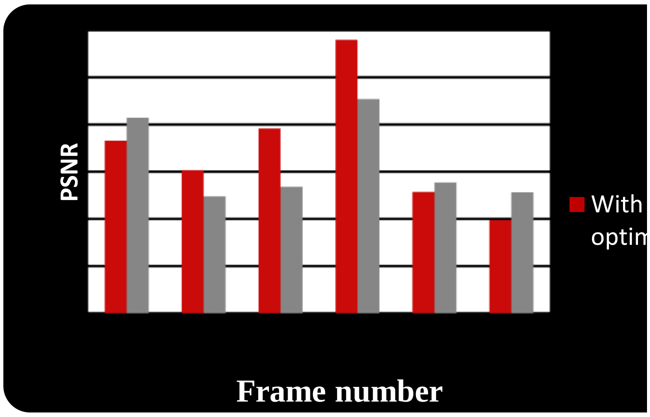
Table 1 &2: PSNR values for Akiyo and Hall with and without optimization

Frames	PSNR Values for Akiyo video	
	With optimization	Without optimization
Frame 1	100	100
Frame 5	100	61.7271
Frame 10	59.7658	63.5539
Frame 19	58.8767	62.8454
Frame 25	63.5694	63.8498

Frames	PSNR Values for Hall video	
	With optimization	Without optimization
Frame 1	66.7225	65.9986
Frame 5	64.8256	58.7252
Frame 10	59.9877	61.4385
Frame 19	56.9458	67.5668
Frame 25	59.6574	63.7672

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,





5.1.2 NC (Normalized cross Correlation)

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

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

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

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

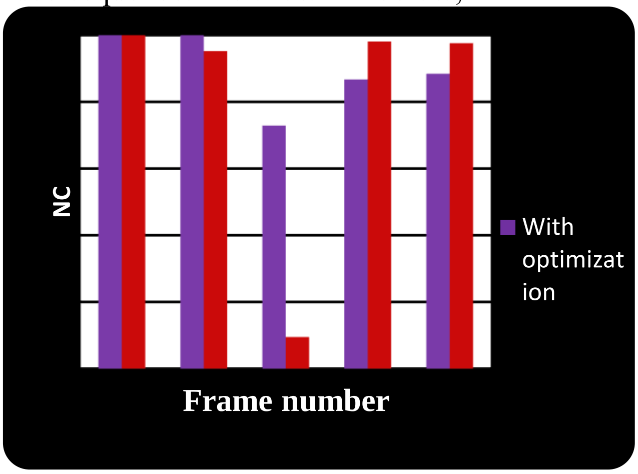
Table 3 &4: NC values for Akiyo and Hall with and without optimization

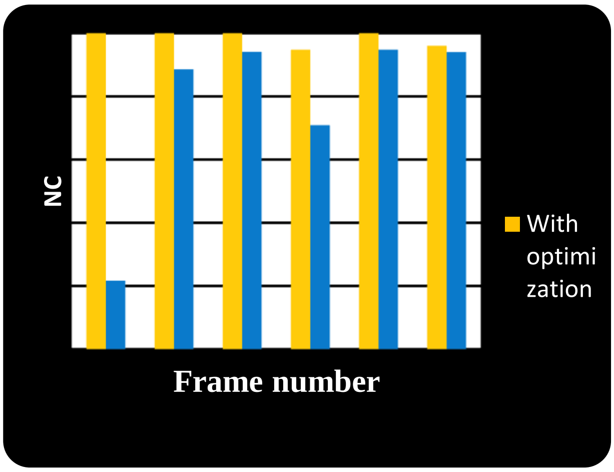
Frames	NC Values for Akiyo video	
	With optimization	Without optimization
Frame 1	1	1
Frame 5	0.9825	1
Frame 10	0.0969	0.7245
Frame 19	0.9916	0.9267
Frame 25	0.9784	0.8968

Frames	NC Values for Hall video	
	With optimization	Without optimization
Frame 1	0.2198	1
Frame 5	0.8953	1
Frame 10	0.9817	1
Frame 19	0.7098	0.9586
Frame 25	0.9499	1

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 12, No.3, December : 2024

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,





5.4 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*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.

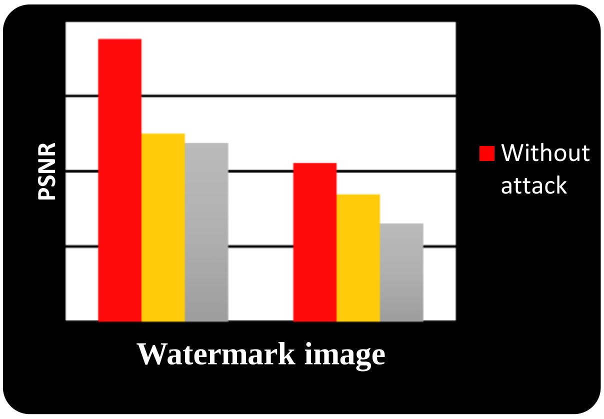
For examine the criteria firstly assault the image with all of these attack. From then on recover the actual watermark details from attacked image. Compare the excellent of watermark image recovered by non-attacked along with recovered by attacked image. Thus anyone can examine the robustness of criteria 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 and 6: Performance metrics with and without applying different types of attacks for Akiyo

Performance Metrics	**Without attack**	**Intensity Attack**	**Salt and pepper noise Attack**
Mean PSNR	44.5134	41.9972	40.9516
Mean NC	0.9017	0.8935	0.9135

Performance Metrics	**Without attack**	**Intensity Attack**	**Salt and pepper noise Attack**
Mean PSNR	40.9197	39.5849	39.6153
Mean NC	0.8915	0.8619	0.8842

Graph 5 and Graph 6 represent the PSNR and NC value for watermark image with and without applying different types of attacks both Akiyo and Hall video sequence**.**



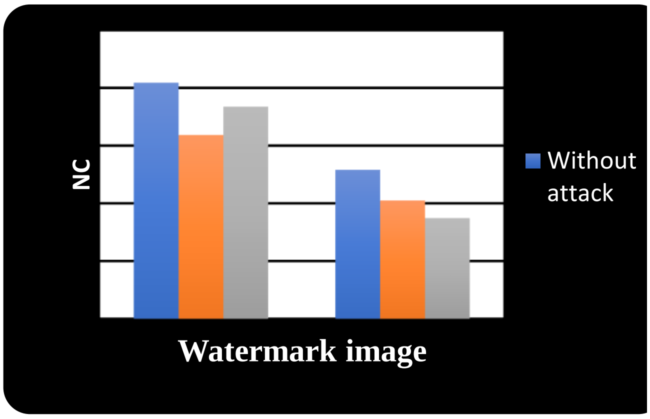


Table 7: Comparison during attacks for Akiyo Video

Attacks	Proposed method with attack		Existing Method [33]	
	NC	**PSNR**	**NC**	**PSNR**
Salt and Pepper Noise attack	0.9135	41.7512	0.6548	23.459
Rotation	0.9418	42.765	0.6510	27.825
Geometric Transform	0.9312	44.199	0.5313	40.0710
Intensity attack	0.8938	40.929	Not given	Not given

Here in Table 7 the proposed methodology performance is compared with the existing method [33]. 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 Akiyo video is compared with existing technique [33]. Our proposed method gave better robustness when compared to the existing method.

6. Conclusion

In this paper modified Bacterial Foraging Optimization Algorithm 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 singular value decomposition is applied. The Bacterial Foraging 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.

References

[1] A. Piva, F. Bartolini, and M. Barni, “Managing copyright in open networks,” IEEE Trans. Internet Computing, vol. 6, no. 3, pp. 18–26, May–Jun. 2002.
[2] C. Lu, H. Yuan, and M. Liao, “Multipurpose watermarking for image authentication and protection,” IEEE Trans. Image Process., vol. 10, No.10, pp. 1579–1592, Oct. 2001.
[3] Tosihiro Akiyama, Fumiaki Motoyoshi, Osamu Uchida and Shohachiro Nakanishi, "Hybrid Digital Watermarking For Color Images Based On Wavelet Transform", IADIS International Conference Applied Computing, pp. 548 - 551, ISBN: 972-8924-09-7, 2006.
[4] Memon, N. and Wong, P., Protecting Digital Media Content. In: Communications of ACM, pp. 35-43, Vol. 41, No. 7, July 1998.
[5] G. Voyatzis and I. Pitas, “The use of watermarks in the protection of digital multimedia products," IEEE Proceedings, vol. 87, No. 7, pp 1197-1207, July 1999.

[6] Xiang-Yang Wang and Hong Zhao, "A Novel Synchronization Invariant Audio Watermarking Scheme Based on DWT and DCT", IEEE Transactions On Signal Processing, Vol. 54, No. 12, December 2006.
[7] Pei-chun chen, Yung-sheng Chen and Wen-Hsing Hsu, "A Digital Image Watermarking System: Modeling, Peformance Analysis, and Application", in Proc. of 12th IPPR Conference on Computer Vision, Graphics and Image Processing, pp. 199-206, 1999.
[8] Dominik Birk, Sean Gaines, and Christoph Wegener, "A Framework for Digital Watermarking Next Generation Media Broadcasts", IAENG International Journal of Computer Science, Vol. 35, No. 4, 2008.
[9] Mohanty, S.P., K.R., Ramakrishnan, and M.S., Kankanhalli, “A DCT domain visible watermarking technique for images”, Tech. Rep., University of South Florida, USA, 1999.
[10] Chae, J.J., and B.S., Manjunath, “A robust embedded data from wavelet coefficients”, Tech. Rep., University of California, CA, 1997.
[11] Yeung, M. & Minzter, F. “An Invisible Watermarking technique for image verification”, In Proceedings of the IEEE International Conference on Image Processing, pp: 680-683, 1997.
[12] Cox I. J., Miller, M. L. and Bloom J. A., “Digital Watermarking”, Morgan Kaufmann Publishers, USA, 2002.
[13] Miller, M.; Cox, I.J.; Linnartz, J.P.M.G.; Kalker, T., “A review of watermarking principles and practices,” In Digital Signal Processing in Multimedia Systems, Edit. K. K. Parhi and T. Nishitani, Marcell Dekker Inc., pp. 461-485, 1999.
[14] Shelby Pereia and Thierry Pun, "Fast Robust Template Matching for Affine Resistant Image Watermarks," Proceedings of the Third International Workshop on Information Hiding, Lecture Notes in Computer Science (LNCS), Vol. 1768, pp. 199 - 210, 1999.
[15] R. B. Wolfgang, C. I. Pdilchuk, and E. J. Delp, “Perceptual watermarks for digital images and video”. Proc. of the IEEE, Vol. 87, No. 7, pp: 1108-1126, 1999.
[16] Neeta Deshpande, Archana Rajurkar, R Manthalkar, "Review of Robust Video Watermarking Algorithms", IJCSIS, Vol. 7 No. 3, pp: 237-246, 2010.
[17] Ji-Young Moon and Yo-Sung Ho, "A Video Watermarking Algorithm Based on the Human Visual System Properties", Computer and Information Sciences -Lecture Notes in Computer Science, Vol: 2869, pp: 699-706, 2003.
[18] Bhattacharya, S. Chattopadhyay, T. Arpan Pal, "A Survey on Different Video Watermarking Techniques and Comparative Analysis with Reference to H.264/AVC", in proceedings of the IEEE Tenth International Symposium on Consumer Electronics, pp: 1 - 6, Petersburg, 2006.
[19] Vivek Kumar Agrawal, "Perceptual Watermarking of Digital Video using the Variable Temporal Length 3d-DCT", Master thesis, Indian Institute of Technology, Kanpur, 2007.
[20] Bijan G. Mobasseri, Michael P. Marcinak, "Watermarking of MPEG-2 Video in Compressed Domain Using VLC Mapping", ACM Multimedia and Security Workshop, NY, 2005.
[21]Yan Liua and Jiying Zhao ," A new video watermarking algorithm based on 1D DFT and Radon transform ",Signal Processing, Vol. 90, No. 2, pp. 626-639, 2010.
[22] Reyes R., Cruz C., Nakano-Miyatake M. and Perez-Meana H.,"Digital Video Watermarking in DWT Domain Using Chaotic Mixtures”, IEEE Latin America Transactions, Vol. 8, No.3, pp. 304 - 310, 2010.
[23] Kareem Ahmed, Ibrahim El-Henawy and Ahmed Atwan, "Novel DWT video watermarking schema ", Machine Graphics & Vision International Journal archive, Vol. 18, No. 3, pp. 363-380, 2009.
[24] K. Ait Saadi, A. Guessoum, A. Bouridane, "Efficient pre-processing watermark for robust video watermarking of H.264/AVC", International Journal of Advanced Media and Communication, Vol: 4, No: 3, PP: 219-234, 2010.

[25] Bakwad K. M., Pattnaik S.S., Sohi B. S., Devi S., Panigrahi B. K. , Gollapudi S. V. R. S., "Bacterial Foraging Optimization Technique Cascaded with Adaptive Filter to Enhance Peak Signal to Noise Ratio from Single Image", IETE Journal of Research, 55:4, 173-179,(2009).

[26] Zhang Q., Chen, H., Luo J., Xu Y., Wu C., Li C., "Chaos Enhanced Bacterial Foraging Optimization for Global Optimization", in IEEE Access, vol. 6, pp. 64905-64919, 2018.

[27] Yun Ye, Xinghao Jiang, Tanfeng Sun and Jianhua Li, "An Efficient Video Watermarking Scheme with Luminance Differential DC Coefficient Modification", Advances in Multimedia Information Processing – PCM, Lecture Notes in Computer Science, Vol: 4810, pp: 437-440, 2007.

[28] Xinghao Jiang, Tanfeng Sun, Jianhua Li and Ye Yun, "A Novel Real-Time MPEG-2 Video Watermarking Scheme in Copyright Protection", Digital Watermarking, Lecture Notes in Computer Science, Vol: 5450, pp:45-51, 2009.

[29] Zhaowan Sun, Ju Liu, Jiande Sun, Xinghua Sun and Jie Ling, "A motion location based video watermarking scheme using ICA to extract dynamic frames", Neural Computing & Applications, Vol:18, No: 5, pp: 507-514, 2009.

[30] Das, S., Biswas, A., Dasgupta, S., Abraham, A., "Bacterial Foraging Optimization Algorithm: Theoretical Foundations, Analysis, and Applications", Foundations of Computational Intelligence, Volume 3, pp 23–55, (2009).

[31] Mahesh R. Sanghavi , Dr. Mrs. Archana M. Rajurkar, Prof. Dr. Rajeev Mathur, Kainjan S. Kotecha ,"A Robust Scheme for Digital Video Watermarking based on Scrambling of Watermark," *International Journal of Computer Applications* (0975 – 8887), Vol.35, No.2, December 2011.

[32] Anjaneyulu Sake and Ramashri Tirumala "Hybrid DWT – SVD Based Video Watermarking For Copyright Protection Using Improved Artificial Bee Colony Optimization algorithm"Maxwell Scientific Organization, Research Journal of Applied Science ,Engg&Tech 2015

.[33] Phadtare Saurabh, Dhebe Pooja, Bobade Sharayu and Jawalkar Nishigandha, "Video Watermarking Scheme Based on DWT and PCA for Copyright Protection", IOSR Journal of Computer Engineering (IOSR-JCE), Vol. 9, No. 4,pp. 18-24, 2013.