Research Paper

AN EFFICIENT HYBRID VIDEO WATERMARKING SCHEME USING DISCRETE WAVELET TRANSFORM"

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ABSTRACT:
In rapid growth of network distributions of images and video, there is an imperative need for copyright protection, besides pirating. Different digital image and video watermarking schemes have been proposed to deal with this matter of ownership identification. The video watermarking schemes using discrete wavelet are transformed to keep the copyright of digital videos. The input video sequence is segmented into shots with known shots of segmentation technique. The segmented video shots are partitioned into quantity of frames considered for the embedding process. The proposed method provides the exploitation of the grayscale image as a watermark to embed into the video sequence. In this process the PSNR value calculated for each frames and select the best frame by using CS algorithm. In watermarking embedding process, segmented video data is given to the discrete wavelet transform and the encrypted image watermark data is embedded based on optimal location analysis that is carried out using ABC algorithm. The grayscale image is sliced into bit planes for analyzing each bit of the image. Afterwards, the sliced bit plane images are permuted to the watermark images which are embedded into every frame of the segmented shots with the support of the watermark embedding process. Finally, the recovery of the watermark is achieved through the aid of the watermark extraction process. The experimentation results showing the proposed video watermarking scheme provide superior results with higher accuracy.

KEYWORDS: Cuckoo Search (CS) Algorithm, Artificial Bee Colony (ABC) Algorithm, Optimal Location, Hybrid Video Watermarking.

I. INTRODUCTION

Multimedia watermarking is a method of robustly embedding information into media, which remainder together even after digital to analog and further signal conversions. This is achieved by embedding information imperceptibly into the media content itself, rather than relying on a file description or other techniques to communicate information [1]. A watermark embedding technique is supplied with an unwatermarked video sequence, a secret key and a binary message to embed in order to acquire a watermarked video sequence. This message can then be extracted using the appropriate watermark extraction technique and secret key [2].

K. Ait Saadi *et al.* [3] have proposed a grey-scale pre-processing as well as robust video watermarking algorithm in the emerging video coding standard H.264/AVC for copyright protection application. Yan Liua and Jiying Zhao [4] proposed a 1D DFT (one-dimensional discrete Fourier transform) with 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. Jing Zhang *et al.* [5] have proposed a video watermarking method of the modern video coding standard H.264/AVC. For copyright protection, 2-D 8-bit watermarks like precise company trademarks or logos can be utilized as inconvertible watermark. Patrizio Campisi *et al.* [6] have proposed a video watermarking method working in the three-dimensional discrete wavelet transform (3D DWT) based on the use of an innovative video perceptual mask, employed in the 3D DWT domain. A robust scheme for digital video watermarking based on scrambling and then embedding the watermark into different parts of the source video according to its scene change was proposed by Mahesh R. Sanghavi *et al.* [7]. A.Essaouabi *et al.* [8] novel video watermarking systems operating in the three-dimensional wavelet transform is here presented. Specifically, the video sequence is partitioned into spatio-temporal units and the single shots are projected onto the 3D wavelet domain. A public video watermarking algorithm, the robustness of which relies on the embedding energy WAS presented by Reyes R. *et al.* [9]. A visibly identifiable binary pattern, such as owner's logotype has been embedded by their proposed algorithm. The fundamental idea of the wavelet transform is to signify several subjective function as a superposition of wavelets or basis functions was proposed by A.Essaouabi *et al.* [10]. A novel video watermarking scheme using discrete wavelet transform to protect the copyright of digital images was proposed by M.Sundararajan *et al.* [11] and [12].

II. ABC AND CS BASED PROPOSED VIDEO WATERMARKING SCHEME

In the hybrid video watermarking scheme (DWT+ABC+CS), ABC is used for selecting the best location whereas the CS is used for selecting the best frame is discussed. The scheme consists of four modules namely shot segmentation module, frame and location module, embedding module and extraction module. Shots are detected and segmented in the shot segmentation module. Subsequently frame and location is identified using ABC algorithm in frame and location module. Once best frame and locations are identified, the embedding and extraction procedure is carried out in the subsequent modules.

2.1 Frame and Location Module using CS and ABC Algorithm

In this section, the frame and location based video watermarking technique using CS –ABC algorithm is presented. The scheme consists of four modules namely shot segmentation module, frame and location module, embedding module and extraction module. Shots are detected and segmented in the shot segmentation module. Firstly, the shots converted into frames, the best frame are identified by using CS algorithm. Subsequently location is identified using ABC algorithm. The embedding and extraction procedure is carried out in the subsequent modules. The structural design of the Hybrid Color Video Watermarking is shown in figure 1.

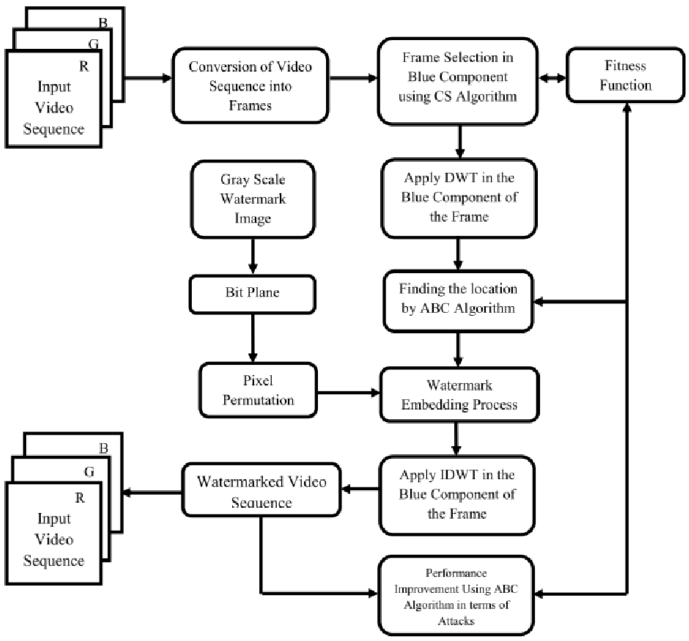

Figure1. Structural Design of Hybrid Video Watermarking

III. WATERMARKING EMBEDING AND EXTRACTION PROCESS

3.1 Watermarking Embedding Module

Step 1: The video sequence divided into number shots using shot segmentation technique. It identifies the number of frames involved in each segmented shots for embedding.

Step2: Slice the grayscale watermark image into 8 bit planes using bit plane slicing.

Step3: Modifying the sliced images using pixel permutation technique to obtain the altered grayscale image.

Step4: The blue components of all the partitioned frames for embedding the each sliced image into the blue components of each frame using ABC or CS algorithm.

Step5: Decay the blue components of each partitioned frame into four sub-bands such as the DWT to achieve the transformed frames.

Step6: Determine the frequency of sub-bands (HL, LH) from the transformed frames to embed the altered grayscale image.

Step7: Find the coincidence matrix of the altered image to embed into the choosing sub-bands. The upper part of the coincidence matrix is embedded into the HL sub-band and the lower part of the coincidence matrix into the LH sub-band.

Step8: Calculate the fitness function of each possible location from the employed bee in the ABC Algorithm that is composed of the PSNR values. Calculate the new food source and find the best food source.

$$Fitness = PSNR + NC$$

Step9: Find the probability of selected food source and find the fitness value.

Step10: Choosing the maximum value of PSNR in corresponding locations and embedding the same.

Step11: Embed the watermark bits with '0' or '1' in a zig-zag manner in the chosen embedding part, since the watermark is the gray scale image.

Case 1: the watermark embedding bit is '1'

if $Y_{p(i)} > 1$ then $Y_p[j,k] << Abs\ [Y_{p(i)}]$

else $Y_p[j,k] << Y_{p(i)} + \max(Y_p)$.

Case 2: the watermark embedding bit is '0'.

if $Y_{p(i)} < 0$ then $Y_p[j,k] << Abs\ [Y_{p(i)}]$ z

Step12: In onlooker bee, find the neighboring locations and apply the fitness function to have the maximum PSNR values in those locations.

Step13: Find the worst employed bees by memorizing the most excellent solution so far and replace them with the scout bees if the scout bees are better

Step14: Update the scout bee to get optimal solution

Step15: Similarly, the lower part of the similitude matrix is embedded into the LH sub-band. Also, each gray scale image is embedded into every frame of the every shot.

Step16: Divide all the embedded frames by means of the embedding strength to improve the quality of the image.

Step17: Map the modified sub-bands into its original position and relate the inverse discrete wavelet transform to accomplish the watermarked video sequence.

3.2 Watermark Extraction Module

The extraction of the embedded watermark image is carried out without affecting the original video and is explained in this module. Here, the input is the watermarked video sequence represented by and also the size of the watermark image. The output is the recovered watermark image represented by. Initially, it is necessary to segment the watermarked video sequence into a quantity of non-overlapping shot using the injection segmentation technique. To identify the number of frames involved in each segmented shots for the extraction process; find the optimal frame and location for extracting the watermark pixel using ABC; decompose the optimal frame with the aid of the discrete wavelet transform into four sub-bands HH, HL, LH and LL; Select the low frequency sub-bands (HL, LH) from the transformed frames to extract the watermark grayscale image. Extract the watermark pixels from the embedding part in a zig-zag manner from the HL and the LH sub-bands with the support of the subsequent steps. But the embedded pixel value is greater than the mean pixel value, and then the extracted pixel value is one. If it is less significant, then the extracted pixel is zero.

$$W_I[i',j'] = \begin{cases} 1, & Y_p(i) > mean\ (Y_p), \quad where \quad 0 < i < n \\ 0, & otherwise \end{cases}$$

Form the matrix with the size of the watermark image and the extracted pixels are located in it to attain the watermark image. Obtain the watermark image by applying the repeal progression of incarnation and bit plane slicing.

IV. SIMULATION RESULTS

The experimental results of our proposed digital video watermarking technique using ABC algorithm are presented in this section. The experimental results are carried out with different video sequences and the grayscale image as the hiding information. The proposed scheme effectively embeds the watermark image pixels into the video sequence and extracted it reverse from the watermarked video sequence.

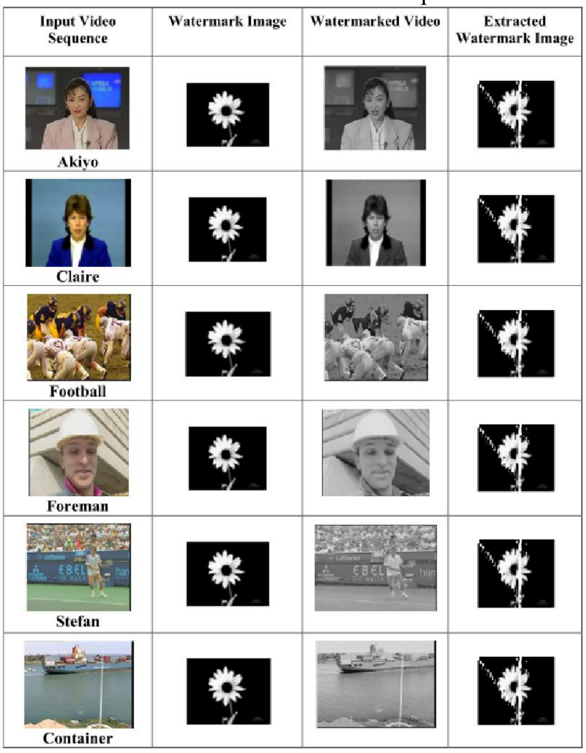

Figure2. Samples of Video Sequences

The watermarked video sequences possess superior Peak Signal to Noise Ratio and visual quality for grayscale watermark images. The outputs, obtained from the proposed video watermarking techniques, are compared based on the evaluation metrics, PSNR and NC. The visual quality is evaluated by the PSNR norm between the original video sequences and the watermarked video and the extracting fidelity is compared by the NC value between the original watermark image and the extracted watermark image The results demonstrated that the competence of the proposed approach. Figure 2 depicts eight samples of video sequences such as Akiyo, Claire, Football, Foreman, Stefan, Container, Rhino, Coast Guard and its extracted watermarks.

5.1 Performance Evaluation

To prove the efficacy of the proposed schemes, the results are compared with the existing methods [8] and [10]. Table 1 shows the PSNR values with different video sequence. Table 2 shows the NC values with different video sequence. The results of the comparative data clearly demonstrate the efficacy of the present methodology as evidenced from the PSNR and NC value.

Table 1. Performance Evaluation of PSNR (dB)

Video Sequence	[8]	[10]	[11] & [12]	Proposed Schemes (DWT+ABC+CS)
Akiyo	30.96	---	40.12	51.32
Claire	31.30	---	34.81	51.54
Football	33.21	---	37.19	52.76
Foremen	---	36.82	38.23	51.23
Stefan	---	35.43	39.78	51.05

Table 2. Performance Evaluation of NC

Video Sequence	[8]	[10]	Proposed Scheme DWT+ABC+CS
Akiyo	0.9981	---	0.9921
Claire	0.9345	---	0.9942
Football	0.9551	---	0.9973
Stefan	---	0.9587	0.9902
Foremen	---	0.9736	0.9896

5.2 Robustness Evaluation

A video watermarking scheme based on wavelet decomposition in which the watermark is embedded in the randomly selected frames is presented in [13]. Blue channel of the frames has been chosen for embedding. Watermark is embedded in mid-frequency component in order to make it robust against the low-frequency attack. On comparing the performance evaluation of the PSNR and the NC of the proposed scheme with existing method [13], the proposed scheme outperforms the existing method. The results are tabulated in table 3.

Table 3. Performance Evaluation of PSNR and NC

Video Sequence	PSNR (dB)		NC	
	[13]	DWT + ABC + CS	[13]	DWT + ABC + CS
Rhino	39.7596	47.98	0.9888	0.9934
Akiyo	39.9675	48.92	0.9999	0.9954
Coast Guard	39.5734	48.23	0.9999	0.9976

Mahesh R.Sanghavi [14] presented a Fibonacci series based embedding of a watermark in frames of the video. Fibonacci series based watermarking method proves to be the most suitable alternative for key-frame based watermarking scheme. To prove the robustness of our proposed scheme the experimental results are conducted with various attacks for the Akiyo video sequence and the NC values are compared with existing method [14]. Table 4 shows the comparison of NC values for different attacks.

Table 4. Performance evaluation (NC)

Attacks	(if all frames attacked)		(if selected frames attacked)	
	[14]	DWT+ABC+CS	[14]	DWT +ABC +CS
JPEG Lossy compression	0.72	0.9256	1	1
Noise Addition	0.69	0.9743	1	1
Median Filter	0.52	0.8589	1	1
Cropping	0.70	0.9476	1	1
Rescale	0.61	0.9574	1	1
Rotation	0.67	0.9743	1	1
Frame Dropping	0.92	0.9837	1	1
Frame colluding	0.85	0.9645	1	1
Frame swapping	1.0	0.9943	1	1
Frame Averaging	0.7	0.8976	1	1

5.3 Video Specific Attacks

Video Specific attacks are additional to image processing attacks and they are only applicable to video stream data: This category includes two types of attacks: friendly and Non-friendly attacks. All the friendly attacks never aim to destroy the embedded watermark intentionally like *frame insertion* attack; for example, suppose some commercial break is to insert into the video. Since the watermarked video has changed unintentionally, due to newly inserted frame, the watermark may be collapsed.

Another attack is frame deletion attacks; this may require when sensor cut down some shots or scene due to some bad message pass to the society i.e. technically, the frames deletion requires from the original video which may also unintentionally alter or destroy the watermark. Another category is *non-friendly attacks*: *Frame averaging* is one of them; it is supposed to replace the frame with the averaging of all neighboring frames. For example, 10thframe can be replace with the (9th frame+10th frame+11th frame)/3. On the other hand, one more non-friendly attack is frame swapping; for example 10th and 11th frame can be interchange, which may also harm the watermark embedded into the video bit stream. A special attention towards video specific attacks must be taken while designing the video watermarking [15].

To prove the robustness of the proposed scheme, the experimental results are carried out with various video specific attacks for the Akiyo and Foremen video sequence. Frame dropping attack is a little change between frames in shot which a few frames are removed from the video shot and replaced by corresponding original frames is used as an effective video watermark attack. The NC values of the proposed method are compared with the existing technique for frame dropping attack. Table 5 shows the NC values for frame dropping attacks for foremen and akiyo video sequence. The results shown in the current method displays the better result for frame dropping attack compared to existing method [8]. The results encourage the evaluation of proposed method rather than the existing method [8] and [10].

5.3.1 Frame Averaging Attack:

The proposed scheme uses the average of current frame and its two nearest neighbors to replace the current frame. For frame averaging attack, the Foremen and Akiyo video sequence is used in the proposed scheme is compared with the existing technique [8] and [10]. The results are shown in table 6.

5.3.2 Frame Swapping Attack:

It can also destroy some dynamic composition of the video watermark [8]. We define the following swapping mode by $F_K(i,j)= F_{k-1}(i,j)$ k=1,3,5…….n-1 the corresponding results are presented in Table 7. The NC values of the proposed scheme are performed fine in compared to existing methods.

Table 5. NC for Frame Dropping Attack

Frame Numbers	Normalized Correlation					
		Foreman Video Sequence		Akiyo Video Sequence		
		Proposed Scheme		Proposed Scheme		
	[8]	[11]	DWT+ABC+CS	[10]	[11]	DWT+ABC+CS
1	0.9012	0.8972	0.9875	0.9012	0.9013	0.9876
2	0.9070	0.8836	0.9732	0.9070	0.9160	0.9765
3	0.8976	0.8745	0.9689	0.8976	0.9213	0.9714
4	0.8482	0.8653	0.9578	0.8482	0.8943	0.9634
5	0.8142	0.8543	0.9498	0.8142	0.9360	0.9602
6	0.7654	0.8454	0.9386	0.7801	0.9290	0.9587
7	0.6973	0.7962	0.9324	0.6854	0.9270	0.9501
8	0.5943	0.7454	0.9316	0.5923	0.9380	0.9498

Table 6. NC for Frame Averaging for Video Sequence

Frame Numbers	Normalized Correlation					
		Foreman Video Sequence		Akiyo Video Sequence		
		Proposed Scheme		Proposed Scheme		
	[8]	[11]	DWT+ABC+CS	[10]	[11]	DWT+ABC+CS
1	0.8943	0.9102	0.9878	0.9430	0.9567	
2	0.8745	0.9010	0.9845	0.9360	0.9434	0.9786
3	0.8721	0.8923	0.9812	0.9240	0.9260	0.9753
4	0.8697	0.8210	0.9787	0.8765	0.8865	0.9723
5	0.8658	0.8120	0.9732	0.8543	0.8656	0.9686
6	0.8579	0.8010	0.9702	0.8210	0.8770	0.9665
7	0.8537	0.8023	0.9658	0.8010	0.8340	0.9623
8	0.8476	0.7912	0.9623	0.7912	0.8210	0.9578

Table 7 NC for Frame swapping Attack

Frame Number	Normalized Correlation		
	Foreman Video Sequence		Akiyo Video Sequence	
	[8]	Proposed Scheme DWT+ABC+CS	[10]	Proposed Scheme DWT+ABC+CS
1	0.9012	0.9874	0.8911	0.9897
2	0.9070	0.9852	0.8448	0.9832
3	0.8976	0.9825	0.7821	0.9786
4	0.8482	0.9764	0.6974	0.9741
5	0.8142	0.9732	0.6784	0.9705
6	0.8012	0.9712	0.6523	0.9656
7	0.7020	0.9687	0.6411	0.9632
8	0.6987	0.9658	0.62	0.9603

5.4 Effect of Gain factor (α)

Different gain factors are being used during embedding to see the effect on the visual quality of the watermarked image and the extracted watermark. PSNR is used as the performance indicator. Simulations are carried out for the four Video sequences such as Akiyo, Hall, Claire and Football .Table 8 shows the PSNR value for the four video sequences with different frame numbers and embedding strength. The simulation results show that decrease in gain factor increases the PSNR value. Gain factor can be chosen as small as possible so that it will give a high PSNR which means that the visual quality of the watermarked image is good.

Table 8. PSNR values with different Frame Numbers and Embedding strength

Video Sequences	Frames	PSNR (dB)					
		α=1		α=5		α=10	
		DWT	DWT+ ABC+CS	DWT	DWT+ ABC+CS	DWT	DWT+ ABC+CS
Akiyo	50	36.58	52.58	37.74	47.74	36.11	46.11
	100	39.63	51.63	39.86	49.86	37.63	47.63
	150	36.63	50.63	38.57	48.57	35.92	45.92
	200	35.79	49.79	37.85	47.85	35.93	45.93
	250	35.47	49.47	36.61	46.61	34.86	44.86
	300	36.74	49.74	36.34	46.34	34.33	44.33
Hall	50	26.45	46.45	25.19	45.19	24.27	44.27
	100	27.17	47.17	25.82	45.82	24.89	44.89
	150	26.22	46.22	25.66	45.66	24.73	44.73
	200	26.56	46.56	25.47	45.47	24.55	44.55
	250	25.68	45.68	25.34	45.34	24.42	44.42
	300	27.45	47.45	25.82	45.82	24.90	44.90
Football	50	28.53	48.53	24.16	44.16	23.26	43.26
	100	30.51	50.51	24.67	44.67	24.01	44.01
	150	34.09	44.09	37.19	47.19	36.37	46.37
	200	26.24	46.24	27.12	47.12	26.13	46.13
	250	29.66	49.66	27.63	47.63	26.65	46.65
	300	29.14	49.14	27.56	47.56	26.32	46.32
Claire	50	28.68	48.68	27.31	47.31	23.99	43.99
	100	28.05	48.05	25.37	45.37	24.45	44.45
	150	30.26	50.26	27.67	47.67	26.80	46.80
	200	30.97	50.97	26.15	46.15	25.08	45.08
	250	30.27	50.27	26.98	46.98	26.11	46.11
	300	30.14	50.14	26.32	46.32	26.04	46.04

VI. CONCLUSION

In this investigation, an efficient intelligent and hybrid video watermarking scheme using the DWT to protect the copyright of digital video sequence is also demonstrated. This is possible with the attainment of watermark embedding and watermark extraction process. From the computed value it is evident that this scheme is able to embed the watermark without any appreciable degrading in the video. The quality of the extracted watermark is also same as that of the original one. Experimental results proved that the proposed scheme is efficient by means of imperceptibility and robustness against attacks such as frame dropping and frame averaging.

Following are some of the observations made after successfully implemented both embedding and extracting algorithm using intelligent video watermarking scheme.

- Perceptibility in this method decreases with the increase in embedding strength.
- Robustness decreases with the increase in Embedding strength.
- The frames looks visibly fine if the resultant PSNR is above 30 dB. The message seems visibly identifiable if the resultant correlation is greater than 0.60.
- This method is fully robust against all kind of attacks.

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