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Video Authentication by Visible Watermarking

Abstract

Video security covers many subjects as authentication and copyright protection for multimedia products and thus the video watermarking technique is necessary, but the main problem in video is its big size, since video includes a lot of redundant information so that compressing it helps to reduce the size and saves the transmission bandwidth and storage space.

In this paper a visible watermarking algorithm for digital video based on Haar Discrete Wavelet Transform (HDWT) was proposed. The video is first compressed using Haar discrete wavelet transform in order to reduce it size and then the visible watermark image is embedded into the resulting compressed video using again Haar discrete wavelet transform to improve the video authentication. In order to increase the protection of manipulation video, the embedded process is done selectively by the authorized user, so the user can select the choice of the region to embed the watermark (the upper left corner, the upper-right corner, the lower left corner, the lower-right corner) or the watermark can appear randomly in any region in the video.

The proposed algorithm is applied on many color videos for format (.AVI) with many color watermark images for format (. JPEG), and the experimental results are evaluated by Peak Signal to Noise Ratio (PSNR) and Normalized Cross Correlation (NCC) and it is show high imperceptibility where there is no noticeable difference between the original video and the watermarked compress video. Finally, the robustness of the proposed algorithm is achieved against various attacks like Gaussian noise, Salt & Pepper noise, rotation and resizing.

تخويل الفديو بأستخدام العلامه المائيه المرئيه

الخلاصة

امن الفديو يغطي مفاهيم متعدده كالتخويل وحماية حقوق النشر للوسائط الماديه وبالتالي فأن تقنيه العلامه المائيه اصبحت ضروريه، لكن المشكله الرئيسية بالفديو هي حجه الكبير، حيث يحتوي على الكثير من المعلومات المكررة لذلك فأن عملية الضغط تساعد على تقليل الحجم وبالتالي تسهل من عملية نقل الفديو وخزنه.

في هذا البحث تم اقتراح خوارزميه للعلامه المائيه الظاهرة للفديو والتي تعتمد على التحويل المويجي المنفصل (HDWT). حيث تم ضغط الفديو في البدايه لغرض تقليل حجمه، ومن ثم تضمين صوره العلامه المائيه المرئيه الى الفديو المضغوط بأستخدام HDWT لغرض تحسين توثيق الفديو. بهدف زيادة حماية الفديو من التلاعب، تم تنفيذ عملية التضمين بشكل انتقائي من قبل الشخص المخول، حيث يتمكن الشخص إما اختيار المنطقة لتضمين العلامة المائية (الزاوية اليسرى العليا، الزاوية اليمنى العليا، الزاوية اليسرى السفلى، الزاوية اليمنى السفلى) أو تظهر العلامة المائية بشكل عشوائي في اي مكان داخل الفديو.

تم تطبيق الخوارزمية المقترحة في العديد من الفديو الملون نوع (AVI.) مع صور ملونه متعددة للعلامة المائية من نوع (JPEG.)، وتم تقييم النتائج التجريبية من خلال نسبة الـ (PSNR) والـ (NCC)، والتي اظهرت شفافية عالية حيث لايوجد اختلاف ملحوظ بين صور الفديو الاصلية وصور الفديو المضغوط ذو العلامة المائية. اخيرا، تم التحقق من متانة الخوارزمية المقترحة ضد هجمات مختلفة مثل ضوضاء كاوس، وضوضاء الملح والفلفل، والتدوير وتغيير الحجم.

Keywords

Video watermarking, Haar Discrete Wavelet Transform (HDWT), Peak Signal to Noise Ratio (PSNR) and Normalized Cross Correlation (NCC).

Introduction

In recent times, using of digital video has dramatically grown and distributed it over a network can be easily reproduced without any error. Furthermore, it is concerned with many applications such as video conferencing, digital TV, digital cinema, distance learning program, monitoring and announcement; therefore, their owner put at a risk since they are concerned about illegal copying of their products. As a result, copyright protection is becoming important issue in multi-media applications [1, 2].

Digital video contains a flow of images that are captured at uniform time period, which represented as digitized samples, including color information and intensity information at each spatial and temporal position. For each sample, this information may be represented by the values of three basic color components (Red, Green and Blue) RGB [3].

The massive amount of video data effects highly on its transmission speed on the Web. So, the compression of video is very importance in video information processing. The final purpose of video compression is to obtain higher-quality video to satisfy the band-width of a multimedia information system Video compression technology is very important to HDTV, DVD and Video conference. Wavelet transforms suitable to use in video compression because it's features of multi-resolution, time/frequency localization and lower time complexity [4].

Watermarking is used for securing the copyright protection of video by embedding information in the host digital signal imperceptibly and robustly. The visual patterns in visible watermarking like logo seem in the video frames being completely visible or partially visible, but the information in invisible watermarking should not appear in the video; it must be perceptually invisible [5, 6].

At last, this paper concentrates on a technique for embedding a visible watermark image into the video after compress it in order to protect a video from illegal access. Haar Discrete wavelet transform is used to compress the original video, and then used to embed the watermark image visibly into the compressed video frames in random regions or depending on the user's selection. The performance of the proposed algorithm is measured by the standard metrics such as Peak Signal to Noise Ratio (PSNR) and Normalized Cross Correlation (NCC). It is more robust and protects against some common attacks such as Gaussian noise, Salt & Pepper noise, rotation and resizing.

Video Watermarking and Compression Using Haar Wavelet

Video watermarking require specific approaches not existing in the image watermarking because the video sequences have some differentiate features such as the temporal and inter-frame features. Depending on the domain that used for hiding the watermark bits in the host video, video watermarking can be categorized into two major classes. The first one is the spatial or time domain, where embedding and detection of the watermark are performed by immediately manipulating the pixel intensity values of the video frame. While the second class is the transform domain since the watermark is embedded by changing the frequency components. Discrete Fourier Transform (DFT), Discrete Cosine Transform (DCT), and the Discrete Wavelet Transform (DWT) are the commonly used transform domain techniques. The frequency domain watermarking schemes are comparatively further robust than the spatial domain watermarking schemes, especially in lossy compression, noise addition, rotation and cropping [7, 8].

In watermarking process, there are some most important properties required for digital video watermark such as robustness (the watermark should be unattainable to remove from watermarked video without the enough knowledge of an embedding process), imperceptibility (the watermark embedded into the digital video sequence should be invisible to Human Vision System), unambiguous (The extracted watermark should be unique identify the original owner of the video), computational cost (The both embedding and detecting process should be completely fast with low computational complexity), and finally random detection (The detection of the watermark can be done in any position of video) [9].

Video compression is a technique used to reduce and removing the number of pixels in each frame of the video by preventing the redundant information so that it can be effectively sent and stored without influencing the quality of the video. But anyway, its quality can be affected if the size of the file is too minimizing by raising the compression level for the presented compression technique [10].

The goal of the video compression process is to reduce the color resolution and the color small difference in the frame, prevent the invisible parts of the frame and compare the neighboring frames and remove the unchanged details between two frames. The compression technique can be classified into two categories, Lossy and Lossless compression. In lossy compression, the size of the video is extremely reduced. It is compress the real data from the video frame and exchange them with an approximation, while in the lossless compression; the real qualities of the video frames are maintained even after the compression process. Transforms are one of the compression techniques which are widely used in video compression [11, 8].

Haar wavelet is one kind of wavelet transform; it is related to a mathematical operation called the Haar transform. Haar Wavelet Transform (HWT) is one of the main transformations from the space domain to a frequency domain. It is so fast transform because it is real and orthogonal. Since the original signal is divided into two frequency part a low and a high and filters enabling the divided without repeat the information which are said to be orthogonal. The (HWT) has a number of characteristic such as it is memory active, since it can be calculated in place without a temporary array, it is precisely reversible without the edge effects which to be a problem with other wavelet transforms and it provides a high compression ratio and a high PSNR value. The Haar transform decomposes a discrete signal into two sub signals, one is called approximation and the other one is called detail [12, 13]. Haar wavelet has two functions; the mother wavelet function ψ (t) which described as:

$$\Psi(t) = \begin{cases} 1 & 0 \le t < 1/2 \\ -1 & 1/2 \le t < 1 \\ 0 & otherwise \end{cases} \quad \ldots\ldots\ldots 1$$

and its scaling function φ (t) described as:

$$\varphi(t) = \begin{cases} 1 & 0 \le t < 1 \\ 0 & otherwise \end{cases} \quad \ldots\ldots\ldots 2$$

Haar wavelet transformation contains of a sequence of low-pass and high-pass filters, known as a filter bank. Since the low pass filter implement an averaging/blurring operation that is expressed as in equation 3.

$$L = \frac{1}{\sqrt{2}}(1 \ldots 1) \quad \ldots\ldots\ldots 3$$

whill the high-pass filter implement a differencing operation and can be expressed as in equation 4.

$$H = \frac{1}{2}(1 - 1) \quad \ldots\ldots\ldots 4$$

The low and high filter's equations above can be formulated simultaneously through four filters (LL, HL, LH, and HH) [14].

The Proposed Algorithm

This paper suggests an algorithm for video authentication by using visible watermarking, which it consists of two parts, embedding and extraction. For each of the video frames, the Haar Discrete Wavelet Transform (HDWT) is applied and the visible watermark image is embedded. The watermark image is embedded in the transformed coefficients of the video frames and the user either gives the choice of the region for embedding the watermark or the watermark can appear randomly in the video frames, also the extraction process will be done for extract the visible watermark. Finally the PSNR and NCC will be calculated to prove the efficiency of this suggested algorithm.

Embedding Visible Watermarking Algorithm

In this part the original color digital video is first compressed in order to reduce it size by using HDWT, then the original visible watermark image is embedded in the resulted compressed color digital video after transformed them again using HDWT, and this is down by added the low frequencies (LL) of each pixel in the original watermark image to the low frequencies pixels of the compressed video. This algorithm is illustrated in an algorithm (1):

Algorithm (1): Embedded Visible Watermarking

Input: Original color digital video, original watermark image and transparency value (t).

Output: Watermarked compressed digital video.

Step 1: Read the original color digital video with (.AVI) format.

Step 2: Divide the video in to the distinct frames.

Step 3: Read each frame respectively and apply the single level two dimensional HDWT in order to convert the domain of the video from the time domain to the frequency domain to decompose the frame in to the approximation coefficients and details coefficients (horizontal, vertical and diagonal), then compress it using the HDWT.

Step4: Apply the inverse HDWT for each of the modified frames respectively in order to convert the domain of the compressed video from the frequency domain to the time domain to reconstruct the compressed video frames.

Step 5: Combine the compressed video frames and save it.

Step 6: Read the original watermark image and resize it.

Step 7: Read the resulting of the compressed video and divide it in to the distinct frames.

Step 8: Read each frame of the compressed video respectively and again apply the single level two dimensional HDWT to each of the compressed video frames and to original watermark image, obtain 4-subbands (LL, LH, HL and HH).

Step 9: Embed the original watermark image data by adding the low frequency coefficient of each pixel of it's to the low frequency coefficient pixels of the compressed video frames, multiply with the transparency value (t) as in the following equation.

$$LL(\bar{v}) = LL(v) + (LL(w) \times t) \quad \ldots..(5)$$

Where: LL ($\bar{v}$) are the low coefficients of the resulting watermarked compressed video frames, LL (v) are the low coefficients of the compressed video frames, LL (w) are the low coefficients of the original watermark image and (t) is the transparency value that used to minimize the contrast amount.

Here the user can select the visible watermarking area as follows:

a. Compute the size of the frame (W, H). Where (W), is the width and (H) is the high of the frame.

b. Compute the size of the watermark (W^-, H^-). Where (W^-), is the width and (H^-) is the high of the watermark image.

c. If the upper left corner selected, then the embedding process in the video is begin from the position (0, 0).

d. If the upper right corner selected, then the embedding process in the video is begin from the position (0, W- W^-).

e. If the lower left corner selected, then the embedding process in the video is begin from the position (H- H^-, 0).

f. If the lower right corner selected, then the embedding process in the video is begin from the position (H- H^-, W- W^-).

g. If randomly position in the video was selected, then choosing a random number not exceed the limits of video.

Step 10: Apply the inverse HDWT for each of the modified compressed video frames respectively to reconstruct the modified watermarked compressed video frames.

Step 11: Combine the resulting of the modified watermarked compressed video frames and save it.

Step 12: Play the resulting of the visible modified watermarked compressed video and compute the PSNR value to determine its watermarking imperceptibility.

Step 13: End.

Extraction Visible Watermarking Algorithm

In this part, an original watermark image is extracted from the watermarked compressed video, and this is done by applying the reverse operation which is used in the embedding process. The extraction process is done after the watermarked compressed video and the compressed video are transformed them using HDWT and then subtract each pixel in the compressed video from the pixels in the watermarked compressed video. This algorithm is illustrated in algorithm (2):

Algorithm (2): Extracted Visible Watermarking

Input: watermarked compressed digital video, compressed video and transparency value (t).

Output: watermark image.

Step 1: Read the watermarked compressed digital video.

Step 2: Divide the watermarked compressed video in to the distinct frames.

Step 3: Read only the first frame from the watermarked compressed video and apply the single level two dimensional HDWT to this frame, obtain 4-subbands (LL, LH, HL and HH).

Step 4: Extracted the embedded watermark image from the first frame of the watermarked compressed video by applying the reverse operation of the embedding process as in the following equation.

$$LL\ (w) = (LL\ (v^{-}) - LL\ (v))\ /\ t \qquad \text{.....(6)}$$

Step 5: Apply the inverse HDWT for the modified watermark image to obtain the extracted watermark image.

Step 6: End.

Experiment Results and Discussion

In this research, an efficient visible watermarking algorithm for digital video authentication based on Haar Discrete Wavelet Transform (HDWT) is proposed and developed. This proposed algorithm has been implemented and tested its performance using the software MATLAB 2015. It is applied on samples videos and samples watermark images. Here the tested on to the two samples of digital color videos "traffic.avi" and "al'ahwar.avi" with two of the digital color watermark logo images "no waiting" and "Iraqi flag" are given. The watermark image is visibly embedded after the digital color video has been compressed. Figure (1) and figure (2) show one frame taken from the first original video, the "traffic.avi" video and the first original watermark image "no waiting.jpg" respectively.

Figure (1): Original video frame "traffic"

Figure (2): original watermark image "no waiting"

When applying the embedding process, the visible watermark image is embedded in the same region for all the frames of the compressed video. Figure (3) shows the watermaked compressed video frame with variance transparency value and with watermark size (40*40). After applying the embedded process for more than one try, then the visible watermark image is appear at different positions for the same frame of all the video frames depending on the user's selection (four corners region) or randomly.

a) Transparency value= 0.5

b) Transparency value= 0.2

Figure (3): watermaked compressed video frames "traffic" with variance transparency

Also in this proposed algorithm the watermark image can be resized before perform the embedded process as shown in figure (4).

Figure (4): watermaked compressed video frame "traffic" with watermark size (60 * 60)

Figure (5) and figure (6) show one frame taken from the second original video, the "al'ahwar" video and the second original watermark image "Iraqi flag" respectively as well as figure (7) shows the watermaked compressed video frame.

Figure (5): Original video frame "al'ahwar"

Figure (6): original watermark image "Iraqi flag"

a) Transparency value= 0.5

b) Transparency value= 0.2

Figure (7): watermaked compressed video frames "with variance transparency value

Figure (8): watermaked compressed video frame "traffic" with watermark size (60 * 60)

Generally, the performance of this proposed algorithm has been evaluated by measuring its imperceptibility and robustness versus the different possible attacks such as adding the Gaussian, Salt & Pepper noises, rotation and resizing. PSNR is applied to measure the imperceptibility between the original video and the watermarked video (expressed in decibels (dB)) that it is defined by the equation 7 [7].

$$PSNR = 10\log_{10}\frac{255^2}{MN \times \sum_{i=1}^{M}\sum_{j=1}^{N}\left[I\ (i,j) - I'(i,j)\right]^2} \qquad \text{............................. 7}$$

The higher value of the PSNR refers to an acceptable imperceptibility of watermarking process, with better quality of the video frames. Where M, N are the size of the frame, and I (i, j), I'(i, j) are the pixel values at location (i, j) of the original and watermarked frames.

After attacks have been carried on, the samples images in figure (9) and figure (10) represent images taken from the first watermarked compressed video after the addition of ' Gaussian ' and ' Salt & Pepper ' noise respectively with random watermark regions and with varity noise density, figure (11) shows the effect of carrying out the video frame rotation by an angle of (7 degrees, 12 degrees and 20 degrees) with random watermark regions and finally, figure (12) shows the watermarked video frame after resizing first by a factor of half followed by a factor to 2 also with random watermark regions.

a) Noise density = 0.12 b) Noise density = 0.09 c) Noise density = 0.05

Figure (9): watermaked compressed video frames with addition of Gaussian noise

a) Noise density = 0.12 b) Noise density = 0.09 c) Noise density = 0.05

Figure (10): watermaked compressed video frames with addition of salt and pepper

Figure (11): watermaked compressed video frames with rotation in a varity angles and watermark regions

Figure (12): watermaked compressed video frames after resizing in a varity watermark regions

Also, the samples images in figure (13) and figure (14) represent images taken from the second watermarked compressed video after the addition of ' Gaussian ' and ' Salt & Pepper ' noise respectively with random watermark regions and with varity noise density, figure (15) shows the effect of carrying out the video frame rotation by an angle of (7 degrees, 12 degrees and 20 degrees) with random watermark regions and finally, figure (16) shows the watermarked video frame after resizing first by a factor of half followed by a factor to 2 also with random watermark regions.

a) Noise density = 0.12 b) Noise density = 0.09 c) Noise density = 0.05

Figure (13): watermaked compressed video frames with addition of Gaussian noise

a) Noise density = 0.12 b) Noise density = 0.09 c) Noise density = 0.05

Figure (14): watermaked compressed video frames with addition of salt and pepper noise

Figure (15): watermaked compressed video frames with rotation in a varity angles and watermark regions

Figure (16): watermaked compressed video frames after resizing in a varity watermark regions

The similarity between the original and the extracted watermark image is used to represent how the algorithm is robust versus attacks and it is calculated by NCC value, which it is defined by the equation 8.

$$NC = \frac{\sum_i \sum_j W(i, j).w'(i, j)}{\sum_i \sum_j W(i, j)^2} \qquad \text{..............................} \; 8$$

Its peak value is 1 when both the original and the extracted watermark are similar and its value is zero if they are unlike from each other [7].

The following samples images represent the extracted watermark image before and after the different types of attacks have been carried on, which it has been taken from the first and the second watermarked compressed video as shown in figure (17) and figure (18). The image (a) represents the extracted watermark image without any attack, (b, c, d) represent the extracted watermark image after adding the Gaussian noise with density 0.12, 0.09 ,0.05 respectively, (e, f, g) adding the Salt & Pepper noise again with density 0.12, 0.09 ,0.05 respectively, (h, I, j) rotation with the degree (7, 12, 20), (k, l) resizing first by a factor of half followed by a factor to 2.

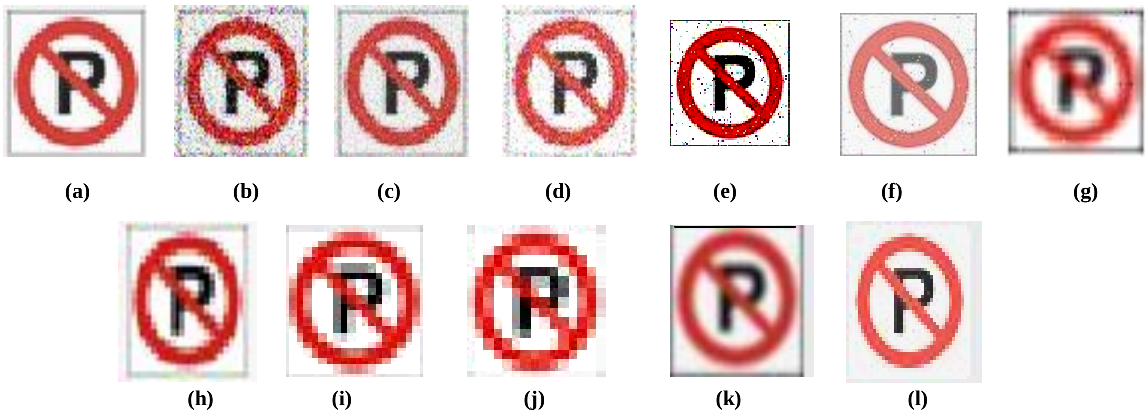

Figure (17): Extracted the first watermark image from the attacked video frame

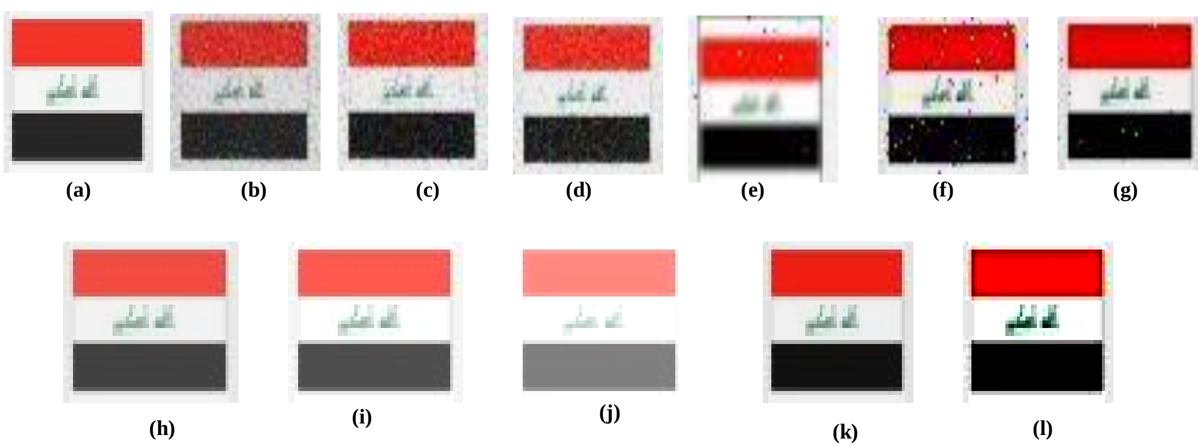

Figure (18): Extracted the second watermark image from the attacked video frame

Finally, table (1) shows the size of the video before and after compression it by using HDWT. Table (2) shows the values of the data that are collected from the video in the form of PSNR, since for a video the PSNR is calculated by taking the summation of the PSNRs values through all of the video frames, then will be divided by the total number of frames to take out the average value of PSNR. Also, table (3) shows the values of the data which are composed from the extracted watermark image in the form of NCC after carrying out the various kinds of attacks.

Table (1): Size of the video before and after compression using HDWT

Video Name	Size of video before compression	Size of video after compression
Traffic.avi	204 KB	159 KB
al'ahwar.avi	278KB	187KB

Table (2): The PSNR values of the watermarked compressed video

Compressed watermarked video name	Transparency value for watermark size (40 * 40)	PSNR value
Traffic.avi	0.2	41.481
	0.5	40.225
al'ahwar.avi	0.2	40.832
	0. 5	39.682
Compressed watermarked video name	**Transparency value for watermark size (60 * 60)**	**PSNR value**
Traffic.avi	0.2	39.127
	0.5	38.565
al'ahwar.avi	0.2	38.792
	0. 5	37.755

Table (3): The NCC Values of the Watermarked Compressed Videos

Video Name	Attack Transparency value is 0.5 and the watermark size is (40 * 40)	NCC value
Traffic.avi	Gaussian noise Density 0.12, 0.09, 0.05	0.783, 0.833, 0.931
	Salt & Pepper noise Density 0.12, 0.09, 0.05	0.796, 0.873, 0.905
	Rotation Degree 7^O, 12^O, 20^O	0.975, 0.923, 0.853
	Resizing 512 * 512, 128 * 128	0.913, 0.97
al'ahwar.avi	Gaussian noise Density 0.12, 0.09, 0.05	0.731, 0.814, 0.927
	Salt & Pepper noise Density 0.12, 0.09, 0.05	0.794, 0.843, 0.905
	Rotation Degree 7^O, 12^O, 20^O	0.921, 0.903, 0.811
	Resizing 512 * 512, 128 * 128	0.902, 0.961

Conclusions and Future Works

A visible watermarking algorithm for video authentication has been proposed in this paper, since the visible watermark color image has been embedded into lower bands of level one based on HDWT and before embedding, the original video has been compressed to reduce its size using HDWT.

In order to provide an effective data transfer and servicing of data security, the video compression and embedding techniques are used during the transmission of data. This proposed algorithm is capable of choosing any position in the frame to embed the watermark with different transparency rate. Also, this proposed algorithm applied on the color video (.avi) format, and after compressed the video, no visible degradation of video frames quality is appeared. Since, the output of the compressed video is in a good quality and good performance in spite of reducing its size.

The experimental results of this proposed algorithm are validated using the metrics PSNR and NCC. They show that this watermarking algorithm is robust and imperceptible in nature because it is not only preserve the video quality well, but it is also robust against several attacks; such as adding Gaussian , Salt & Pepper noise, rotation and resizing. Furthermore, the value of the transparency or the size of the watermark image is affected more into the watermarking process; where the PSNR values were decreased if the transparency value or the size of the watermark image were increased and vice versa.

As a future work, hybrid transformations could be used for embedding process to enhancement the performance of the proposed algorithm. Also, embedding the watermark into the different positions in each frame of the video using the time can be suggested.

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