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Haar Wavelet Transform and Multiobjective Cost Function for Video Watermarking

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Abstract: Generally, Watermarking is the process of hiding the concealed message into multimedia sources, like image, video and audio. Video watermarking is mostly concentrated in the robustness of the system rather than other steganography. In this paper, the multiobjective cost function is proposed for video watermarking. At first, the cover image (video frame) is subjected into cost function computation. Subsequently, the cost function is recently proposed and modeled by various constraints, like energy, intensity, coverage, edge, as well as brightness. Then, the Haar Wavelet Transform is applied to the original frame, which attains a wavelet coefficient on the basis of the video frame. Concurrently, by exploiting the bit plane technique the concealed message is partitioned into binary images. In the embedding phase, the message bit is embedded into the wavelet coefficients according to the cost value. The concealed message is retrieved in the extraction phase. At last, the simulation results are examined, and performance is evaluated by exploiting metrics like Peak Signal Noise Ratio (PSNR) and correlation coefficients.

Keywords: Watermarking; Video Frame; Wavelet; Haar Wavelet; PSNR

Nomenclature

Abbreviations	Descriptions
AW	Approximate Weight
HSN	High-Speed Network
HPF	High-Pass Filters
HVS	Human Visual System
PN	Pseudo-Random
DD	Diagonal Direction
AWGN	Additive White Gaussian Noise
PCA	Principal Component Analysis
ML	Maximum Likelihood
HD	Horizontal Direction
SIFT	Scale Invariant Feature Transform
HWT	Haar Wavelet Transform
VD	Vertical Direction

1. Introduction

In society, the incessant advancements of network applications encompass maximized the rate of popularization for the smart devices. A growing number of digital media information is extensively and quickly dispersed by HSN exploiting smart devices. Because of the nearness of network transmission and the real-time communication of smart devices in processing information, people can expediently, rapidly, and professionally distribute, download, and exploit several digital media. Smart devices and HSN permit suitable and timely information transfer; however digital media information is at risk of accidental or deliberate destruction and tampering. Hence, the main research concern in information security is effectual copyright security for digital media information.

Generally, video watermarking indicates the adding of copyright information into video series to secure the owner's copyrights for the videos. To attain real-time performance, high transparency, and sturdiness in copyright form the video watermarking is necessary. Moreover, in recent years the consistent watermarking technique of video over geometric attacks is the main research subject. The geometric attack is represented as a particular synchronous attack that is applied a local or global projection or affine conversion to watermarked video or image frame [1]. While the video or image frame happen geometric attacks, in the attacked digital mechanism the watermarking signals are still stored. Nevertheless, the watermarking signals cannot be appropriately positioned from the preliminary place of the digital works, and the synchronization among the digital works and the watermarking signals may not be definite.

Even though video watermarking is an entrenched technology, the scalability is still considered as a problem. Commonly, conventional content-distribution frameworks are a client-server-based approach. Hence, common watermarking systems need the trusted server to set in the watermark, hence that the unwatermarked video is not at all revealed external to the server. Nevertheless, the computational complexity rises linearly with the number of users in such systems. In large-scale Distributed System, to stay the total computational complexity less, the watermarking process must possess less complexity. Consequently, watermarking technique, which functions in the compressed domain, was utilized [1].

A well-liked instance of this type is stabilizer embedding whereas the watermark is increased by means of a PN [6] series and after that increased to a series of successive host samples with a constant increase factor. The correlation decoder is best for extraction of watermark by presumptuous the host samples to obtain Gaussian distribution and the attack is restricted to AWGN [7].

In the previous scenario, as the increase of watermark authority happen additional confrontation over attacks, it is lucid to equal distinctiveness of the watermark to those of features of video. An ordinary technique in this manner is the multiplicative embedding whereas the watermark samples energy is proportional to those of features of video. Moreover, the multiplicative embedding techniques like better vigor over noise, and increase attacks while compared with the additive embedding techniques [8]. On the basis of the [9], multiplicative techniques are favored to preservative ones as the misrepresentation proportional to the strength of the signal is additionally tricky to recognize. Hence, multiplicative techniques tend to additional influential watermark embedding when the watermarked signal quality at a satisfactory stage remains. Furthermore, multiplicative techniques are extra secured than stabilizer ones as the watermark of host signal-dependent so, it is trickier. The ML detection was widespread for watermark extraction in multiplicative techniques [7]. Two multiplicative watermarking techniques were presented in [9], for watermark extraction, whereas ML recognition, and side information, was exploited. With ML detector a blind multiplicative watermarking technique was proposed in [10], which need no side information for the watermark extraction sake. In [11], the multiplicative watermarking rule in the LL subband of the WT was exploited for data embedding. Both extraction phases and data embedding were proposed on the basis of the PCA.

The major work of this article is to present the multiobjective cost function for both extraction and embedding phases. Using multiple objectives, the cost function is recently formulated, like edge, wavelet energy, pixel intensity, coverage, and brightness. Moreover, the cost function and Haar Wavelet Transforms are efficiently combined for recognizing the appropriate pixels in the presented video watermarking technique.

2. Literature Review

In 2018, Hannes Mareen et al. [1], developed a new video watermarking method in that merely a single encoder decision was evidently altered. Subsequently, the evident change robotically proliferates into a huge collection of implied distortions, which indicates the watermark. The implied distortions were similar to normal; encoder produced compression artifacts and therefore was invisible. In addition, they show to be robust over video manipulations. Moreover, the presented technique needs no alterations in conventional customer electronic devices.

In 2017, Md. Asikuzzaman and Mark R. Pickering [2], presented an evaluation of digital video watermarking approaches in that their confronts, technologies, and significant possessions, were conferred and classifies them on the basis of the domain in that they embed the watermark. It subsequently offers a summary of some rising inventive solutions by exploiting the watermarks. Securing a 3D video using watermarking was an increasing area of research.

In 2019, Konstantinos Pexaras et al [3], introduced computation optimizations of the proposed technique. It was exploited to remain the integer element of arithmetic operations at best size and, so, arithmetic units as minute as probable. Moreover, the additional evaluation was done to minimize quantization fault. Here, three various hardware-architecture variations were presented, 1 for video (pipelined) and 2 for image watermarking that reuse the previously miniature arithmetic units in various calculation steps, to additional minimize cost for implementation. The presented models were compared constructively to previously conventional implementations with respect to power, area, and performance.

In 2018, Hannes Mareen et al. [4], worked on a video watermarking, which was an entrenched technology to aid recognize digital pirates while they illegitimately reallocate multimedia contented. To give each client with an inimitable, watermarked video, conventional distribution frameworks independently encode every watermarked video. Nevertheless, as these encodings need a maximum number of calculation resources, such frameworks do not scale fine to a huge number of users. Hence, a novel architecture, which exploits speed encoders rather than conventional full encoders, was presented.

In 2018, Zhi Li et al [5], presented dual un-compressed video watermarking techniques on the basis of the HVS and SIFT in the domain of the contourlet. Initially, each frame was decomposed using contourlet transform to attain the minimum-frequency band and various maximum-frequency sub-bands in various directions. Moreover, the value of energy for each maximum-frequency sub-band was computed. Finally, the human visual disguising threshold on the basis of the contourlet domain was computed as the maximum embedding tolerance.

3 Proposed Methodology

3.1 Using Proposed Multi-Objective Cost Function and Haar Wavelet Transform for Video Watermarking

For video watermarking technique, the major objective of this paper is to model and develop the multi-objective cost function. Moreover, the main intention of this paper is to conceal the secret message into media source video. Fig. 1 demonstrates the schematic illustration of proposed methodology. In general, the video comprises a huge amount of frames in that the watermark needs to be embedded. The proposed technique comprises of 4 phases such as keyframe extraction, embedding process, cost function computation, and extraction process. At first, by exploiting equal intervals, the keyframes are extracted for the following steps. Subsequently, the 2-level decomposition of the WT is applied to each frame. The novel multi-objective cost function is presented for extraction and embedding. The proposed cost function is recently presented with the assist of multiple criterions like wavelet energy, pixel intensity, edge, coverage, and brightness. Subsequently, the bit plane technique is exploited to generate the binary image exploited for extraction and embedding. Formerly the cost value is computed; subsequently the message insertion bit into the wavelet coefficients for the original frame is performed. When in the extraction phase, the receiver retrieves the concealed data on the basis of the cost function value.

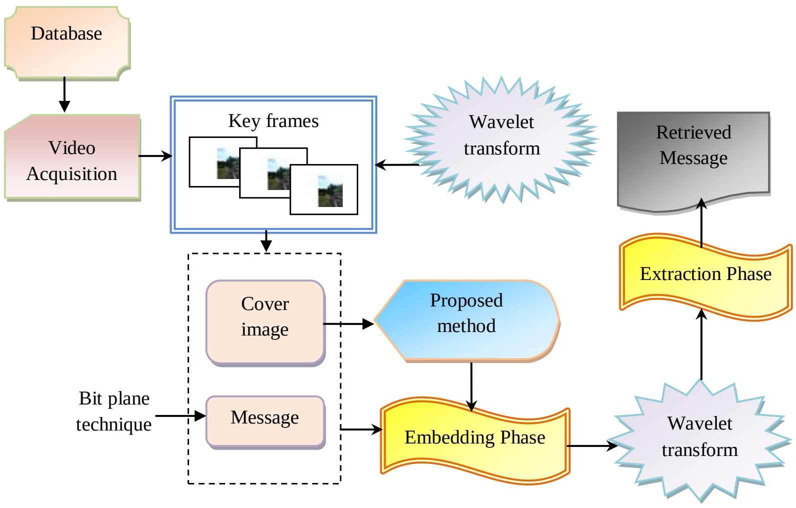

Fig. 1. *Architectural Model of the Proposed Algorithm*

3.2 Keyframe Extraction from Input Video

The video watermarking is the process of concealing the watermark image into the cover image i.e., video, which is exploited recently designed multi-objective cost function. The main aim of keyframe extraction is to maximize the sturdiness of the system as the video pretense a large number of frames. Let us assume I be the input database comprises of y number of videos that are stated by, $I = \{U_p;\ 1 \le p \le y\}$. Subsequently, each video comprises z count of frames that is stated as $U = \{FN;\ 1 \le n \le z\}$. In addition, the secret message is the main challenge, here; the message is indicated as P comprises c number of columns and r number of rows (i.e.,) indicated by $P = p_{rc}$. Among

z number of frames, important keyframe for extraction and embedding process is extracted. By the equal time interval, the keyframe is extracted, that is indicated by z/n whereas n represents the integer value. Hence, the extraction of keyframe from the video is indicated in eq. (1).

$$U = \{Y_h; \quad 1 \le h \le g\} \tag{1}$$

In eq. (1), Y indicate the original frame exploited to embed the secret message using the presented technique.

3.3 Using Bit Plane Technique for Message Partition

Let us consider P as the secret message which transmits to the receiver over the Internet. The concealed message size image is 36×44 and g represents the number of concealed messages for embedding phase as g count of keyframes as a video. The message is embedded into a video instead of other media sources, retrieves at the destination side to improve the security. Typically, the frame image comprises the grey value from 0 to 255 in the type of eight-bit value. To partition the original frame image into 8-bit planes fit into 8 different bit locations from MSB to LSB, the bit plane technique [12] is exploited. The benefit of this approach is to present the important connection of every bit takes place in each pixel. Moreover, the bit plane approach attains 8 binary images of the concealed message. The initial bit plane image is produced via the minimum important bits of each pixel. Likewise, the final bit plane binary image is carved using all the majority important bits of pixels and it is stated in eq. (2).

$$P = \{P_1, P_2, P_3, \ldots\ldots, P_8\} \tag{2}$$

In eq. (2), P_1 represent the first binary image and P_8 indicates the 8^{th} binary image of the concealed message.

3.4 Proposed Multi-Objective Cost Function

In this paper, a model for the cost function computation by exploiting multiple objectives is proposed. In the original frame, every pixel is subjected to cost value computation. The embedding phase is done once the cost function is determined. The notable feature of this model is to present the position whereas the message is to be embedded. The proposed multi-objective value of the cost is exploited to decide the value of the cost for each pixel. Moreover, the multiple objectives are exploited to calculate the cost function that is an edge, intensity, brightness, coverage, as well as energy. Fig. 3 indicates the diagrammatic representation of cost function model.

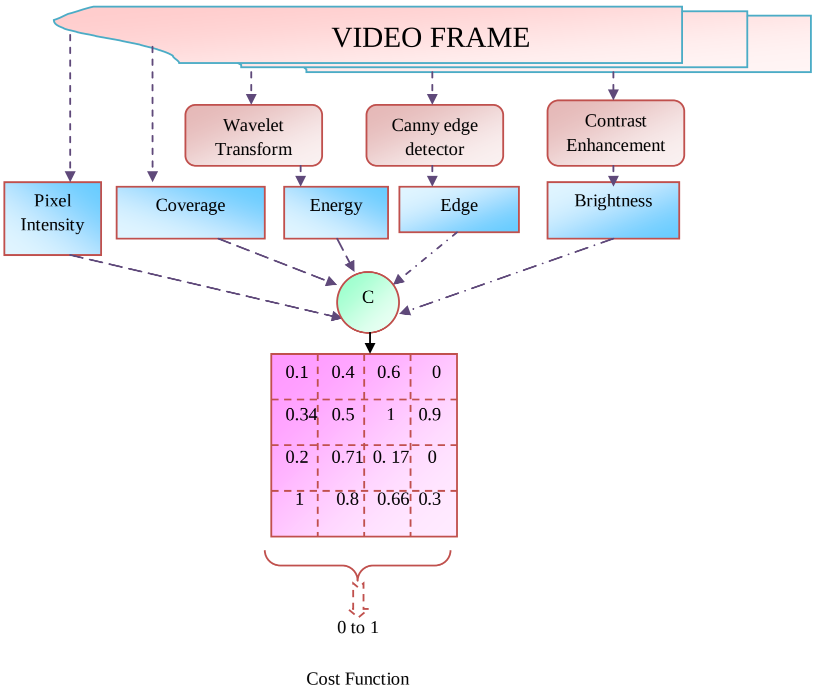

Fig. 2. *Diagrammatic representation of cost function model*

a) Pixel Intensity:

Every pixel is represented as the video frame example; classically provides a precise indication of the original image. The pixels varied from 0 to 255. In addition, every pixel of the frame executes the value of the intensity in the video frame. Consequently, the pixel intensity is the initial criterion to assess the value of the cost. The pixel intensity analysis helps using neighborhood pixels of the present value of the pixel. Usually, the original frame image size is 288×352. Additionally, the resizing operation is used to attain the original frame as 72×88 (i.e.,) Y_f. Hence, the pixel intensity is stated in eq. (3).

$$Y_f^s(i,j) = \frac{1}{255 * 8} \sum_{r=1}^{8} \left[Y_f(i,j) - Y_f^r(i,j) \right] \tag{3}$$

In eq. (3), $Y_f(i,j)$ denotes the present value of the pixel $Y_f^r(i,j)$ indicates the r^{th} neighbourhood pixel and r represents the count of neighbourhood pixels, which deviates from one to eight. Hence, the intensity-on the basis of the cost value is calculated for 8 subbands.

b) Edge:

By exploiting the canny edge detector, the cost value of edge-based is calculated [13]. Initially, to resize the frame image to attain the edge pixels the canny edge detector is used. It alleviates perceives the sharp edge lines and image blur efficiently. After that, obtained edge size is on the basis of the image frame is 72×88. To maximize the sturdiness and imperceptibility measure, the main aim is to embed a concealed message into edge pixels. The Canny edge detection algorithm steps are gradient searching, non-maximum suppression, double thresholding, smoothing and edge connecting. Hence, eq. (4) represents the edge detector.

$$EV = edge(Y_f) \tag{4}$$

In eq. (4) EV indicates the edge-based video frame and Y indicate the input frame. Hence, the edge-based cost value is exploited by eq. (5).

$$EV^s(i,j) = \frac{1}{8} \sum_{r=1}^{8} EV_r(i,j) \tag{5}$$

In eq. (5), $EV_r^x(i,j)$ represents the neighbourhood edge pixel and $EV^s(i,j)$ represents the cost value of edge. If the defined pixel is an edge, subsequently it is stated as $EV_r(i,j) = 1$.

c) Brightness:

In order to improve the image perception of the frame, the technique of contrast enhancement utilizing neighbourhood is exploited. Moreover, it is attained by enhancing the important features and alleviates the vagueness of the pixels. To modify the pixel intensity in the resized frame image Y_f, the contrast enhancement [14] approach is exploited, hence; presents a maximum count of bins. Subsequently, the contrast enhancement is attained by local maxima as well as minima of the pixel value. Hence, using eq. (6), the contrast enhancement of a frame image is computed.

$$Y_f^N(i,j) = \frac{Y_f(i,j) - L_1}{L_2 - L_1} \times L_a \tag{6}$$

In eq. (8), L_1 and L_2 represents the minima and maxima $X_r^N(i,j)$ represents the contrast improved frame image as well as L_a presents the utmost grayscale value that is 255. In addition, the obtained contrast improved image possesses 72×88 size. Subsequently, the contrast-enhanced image cost value is calculated aided using the neighborhood pixels of the image. Hence, it is calculated as eq. (7).

$$D^B(i,j) = \frac{1}{255 * 8} \sum_{r=1}^{8} \left[Y_f^N(i,j) - Y_{f(r)}^N(i,j) \right] \tag{7}$$

In eq. (7), $Y_f^N(i,j)$ and $Y_{f(r)}^N(i,j)$ represents the present and neighborhood pixel of the contrast-enhanced frame image. Hence, the brightness objective $D^B(i,j)$ cost value is attained.

d) Wavelet energy:

To estimate the pixel energy the frame is subsequently exploited. To estimate the energy, the existing WTs [15] is exploited for the extraction of the wavelet coefficients as it shows the scale features and its location. Basically, the WT is utilized to decompose the original frame image into four subbands that are LL, HL, HH, and LH. It is stated in eq. (8).

$$wt = DWT(Y) \tag{8}$$

By exploiting eq. (8), the frame image is decomposed into a horizontal, estimate, diagonal and vertical. The LL band is stated as an estimated band; it appears to be similar to original frame image. The subsequent level decomposition is exploited to attain the LL band in 72×88 size. Subsequently, the LL band is divided into nb amount of blocks whereas the energy is calculated. Subsequently, the obtained value of the energy is allocated to its equivalent pixels. Hence, the blocked energy of the wavelet coefficients is stated in eq. (9).

$$wt_B(nb) = -\sum_{i=1}^{N} \left[g_i \log(g_i) + 1 \right] \tag{9}$$

In eq. (9), N represents the total number of pixels in every block and g_i indicates the probability measure and it is represented in eq. (10).

$$D^{wt}(i,j) = \frac{1}{Z_{nb}} \left[wt_B(nb) \right]; \quad nb \in (i,j) \tag{10}$$

In eq. (10), Z_{nb} indicates the normalization factor to calculate the value of the cost deviates from 0 to 1. Hence, the value of the cost is allocated to every pixel in the wavelet coefficients.

e) Coverage:

The cost of coverage is computed by exploiting neighborhood pixels. Conversely, it is stated by the similar ratio of neighborhood pixels to the total count of pixels in the image frame N_l. Using eq. (11) the cost of the coverage is estimated for all the coefficients of wavelet.

$$D^l(i,j) = \frac{\text{Number of similar r neighbourhood pixels}}{N_l} \tag{11}$$

At last, the cost function is recently designed by wavelet energy, intensity, brightness edge, and coverage. Eq. (12) is used to compute the cost value.

$$L = \frac{(1 - D^s) + (1 - EV^s) + (1 - D^B) + D^{wt} + D^l}{4} \tag{12}$$

By eq. (12), the extraction and embedding process is done. Subsequently, the concealed message is well-established into the frame while the value of the cost for the pixel is 1. Hence, the cost matrix size is indicated 72×88.

3.5 Embedding process using Haar Wavelet Transform

Once the cost value for pixels is computed, after that it undergoes for the watermarking process. The watermarking or embedding process is utilized to cover the concealed message into media files, like image, video, and audio. Then, the bit plane method is utilized to attain eight binary images as the wavelet provides eight subbands. This paper uses WT for both the extraction and embedding process. During the embedding process, the input frame is decomposed into 8 subbands by 2-level decompositions. Hence, the secret message is well-established into the wavelet coefficient.

a) Binary cost value:

The presented cost function is exploited to estimate the value of the cost with the assistance of multiple criterions. This calculation provides position in that the message is embedded. Generally, the cost function value deviates from zero to one. Although, the watermarking algorithm is required to calculate the binary cost value in order to extract and embed the concealed message. At first, the cost function is 72×88 size that is the similar size of the cover image (wavelet bands of original frame). A high amount of cost values is stated as binary cost 1 that is equivalent to the secret message size. Subsequently, binary cost matrix is 36×44 size. Based on value of the cost, the message bit of each bit plane image is embedded into every wavelet coefficient.

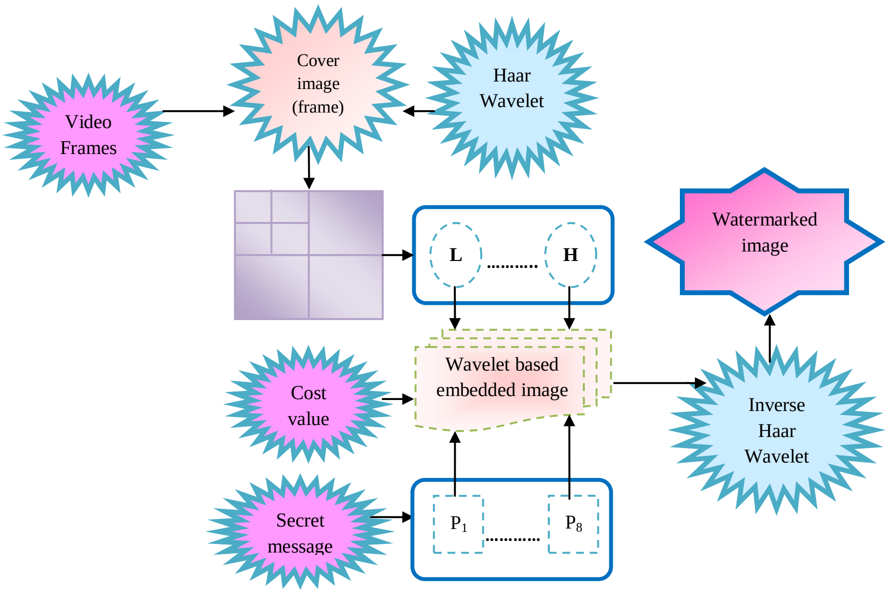

***Fig. 3.** Diagrammatic representation of embedding process*

b) Embedding process:

For the data embedding in the 288×352 size, the input video frame (cover image) is exploited. Since the video frame showed in color image, the YUV spacing method is exploited to change the image from the RGB color image. Conversely, RGB module, the indication of YUV image with respect to 1 luminance module, referred as Y, which is equal to grayscale image as well as 2 chrominance modules are V-red projection and U-blue projection. Hence, Y module of the frame is represented as an input for the presented technique.

In recent times, wavelet-based watermarking strategies have started to be a focus on significantly maximized concentration [18] [19]. The most important motivation for introducing watermarks in the wavelet domain is that it has high-quality space-frequency localization, minimum computational cost, and better HVS modeling. In the wavelet domain, a watermark is to be embedded; there are various wavelet bases to select. As the various bases have dissimilar features, the option of that base to embed the watermark is significant.

3.5 Proposed Haar Wavelet Transform

Let us consider $D(y,z)$ indicate a digital image is $2P \times 2Q$ size, if not, boundary continuation must be exploited to assure that the image size is dividable by two that is essential for HWT. Here, HPF represented as $p(n)$ and wavelet low-pass represented as $q(n)$ correspondingly. Subsequently, the image can be decomposed into its several resolutions on the basis of the AW and the detailed weights of the HD, the VD, and DD [17]. Eq. (13) is used for decomposition.

$$\begin{cases} AW(g,h) = \sum_{y,z} q(y-2g)q(y-2h)D(y,z) \\ VD(g,h) = \sum_{y,z} q(y-2g)p(y-2h)D(y,z) \\ HD(g,h) = \sum_{y,z} q(y-2g)p(y-2h)D(y,z) \\ DD(g,h) = \sum_{y,z} q(y-2g)p(y-2h)D(y,z) \end{cases} \tag{13}$$

In eq. (13), g,h, $N \in X^{+}$, $y,z \in X$, $-2N+1 \le y-2g \le 0$ and $-2N+1 \le z-2g \le 0$. Based on related decomposition process is evaluated on AW to obtain two or extra level of wavelet transformed image. The inverse transform of the wavelet decomposition is the wavelet image reconstruction and it is stated in eq. (14).

$$\begin{aligned} D(y,z) = & \sum_{g,h} q(y-2g)q(y-2g)AW(g,h) \\ & + \sum_{g,h} q(y-2g)p(y-2g)VD(g,h) \\ & + \sum_{g,h} p(y-2g)q(y-2g)HD(g,h) \\ & + \sum_{g,h} p(y-2g)p(y-2g)DD(g,h) \end{aligned} \tag{14}$$

In eq. (14) $,g,h,N \in X^+, y,z \in X, -2T+1 \le y-2g \le 0$ and $-2T+1 \le z-2g \le 0$. As for the Haar wavelet, the LPF $\left\{ \frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}} \right\}$ and HPF $\left\{ \frac{1}{\sqrt{2}}, -\frac{1}{\sqrt{2}} \right\}$ is so eq. (13) can be stated as eq. (15).

$$\begin{cases} D_{AW}(g,h) = \left[D(2g-1,2hj-1) + D(2g-1,2h) + D(2g,2h-1) + D(2g,2h)\right]/2 \\ D_{VD}(g,h) = \left[D(2g-1,2h-1) - D(2g-1,2h) + D(2g,2h-1) - D(2g,2h)\right]/2 \\ D_{HD}(g,h) = \left[D(2g-1,2h-1) + D(2g-1,2h) - D(2g,2h-1) - D(2g,2h)\right]/2 \\ D_{DD}(g,h) = \left[D(2g-1,2h-1) - D(2g-1,2h) - D(2g,2h-1) + D(2g,2h)\right]/2 \end{cases} \tag{15}$$

Where, $1 \le i \le P$ $1 \le i \le Q$

Hence, 1-level of decomposition over image outcomes in four sub-bands per module is performed. VD, HD, and DD comprise the uppermost frequency bands present in the image tile, while AW comprises the lowermost frequency band [15].

Subsequent to the embedded image is attained; it conveys against the communication channel to arrive at the destination. The fundamentals of the extraction process are the original frame image, watermarked image, as well as cost function.

4. Results and Discussions

4.1 Simulation Procedure

General simulation outcomes of presented video watermarking approach were it seems that intentional in this section. Subsequently, the performance was evaluated by exploiting correlation coefficient and PSNR. Because of the unavailability of benchmark datasets, the input videos are obtained from openly obtainable sources. For the simulation process, two input videos were exploited by public sources like YouTube. Moreover, video 1 and 2 are contemplated as two input videos in that the concealed message is embedded steadily.

4.2 Performance Analysis

Table 1 summarizes the performance analysis of the proposed and conventional algorithms are presented for video 1 and video 2. Here, the PSNR of the proposed and conventional methods have been computed. The analysis exhibited that the proposed techniques perform superior to the conventional algorithms for both video 1 and video 2. Here, the proposed method is 21% better than the Wavelet transform and 22% better than the Discrete Wavelet and 25% better than the LSB algorithm for video frame 1. For video frame 2, the proposed method is 12% better than the Wavelet transform and 15% better than the Discrete Wavelet and 16% better than the LSB algorithm.

Table 1. *Performance evaluation of the proposed and conventional techniques with respect to the PSNR*

Methods	**PSNR (dB)**	
	Frames	
	Video 1	Video 2
Wavelet	73.3	75.32
Discrete Wavelet	71.2	72.12
LSB	61.6	68.22
Proposed Method	76.7	99.22

Table 2 states the performance analysis of the proposed and conventional algorithms are presented for video 1 and video 2 regarding the correlation coefficient. Here, the correlation coefficients such as frames, noise, random noise, and histogram are computed. The overall analysis showed the proposed method is superior to the conventional algorithms for both the video 1 and video 2.

Table 2. *Performance analysis of the proposed and conventional methods with respect to the correlation coefficient*

Methods	Correlation coefficient							
	Frames		Noise		Random Noise		Histogram	
	Video 1	Video 2	Video 1	Video 2	Video 1	Video 2	Video 1	Video 2
Wavelet	0.86	0.89	0.56	0.56	0.51	0.71	0.65	0.54
LSB	0.55	0.59	0.59	0.69	0.65	0.76	0.66	0.62
Proposed	1.00	1.00	0.88	0.98	0.98	1.00	0.79	0.91

5. Conclusion

This article presents a video watermarking technique by exploiting the proposed multiobjective cost function. Moreover, the input for the proposed algorithm is the video frame. Previous to extraction and embedding, the original frame experiences the resolve of the presented cost function. Moreover, it is recently invented using various criterions, like energy, pixel intensity, brightness, edge, and coverage. As a result, the two-level decomposition of WT is exploited to the cover image (frame) that attained the wavelet coefficient for the extraction as well as embedding process. Moreover, the bit plane technique is exploited to attain the binary image of the secret message. At last, the simulation outcomes of the proposed technique were evaluated using evaluation metrics, like correlation coefficients and PSNR.

References

[1] H. Mareen, J. De Praeter, G. Van Wallendael and P. Lambert, "A novel video watermarking approach based on implicit distortions," 2018 IEEE International Conference on Consumer Electronics (ICCE), Las Vegas, NV, 2018, pp. 1-2.

[2] M. Asikuzzaman and M. R. Pickering, "An Overview of Digital Video Watermarking," IEEE Transactions on Circuits and Systems for Video Technology, vol. 28, no. 9, pp. 2131-2153, Sept. 2018.

[3] K. Pexaras, I. G. Karybali and E. Kalligeros, "Optimization and Hardware Implementation of Image and Video Watermarking for Low-Cost Applications," IEEE Transactions on Circuits and Systems I: Regular Papers, vol. 66, no. 6, pp. 2088-2101, June 2019.

[4] H. Mareen, J. De Praeter, G. Van Wallendael and P. Lambert, "A Scalable Architecture for Uncompressed-Domain Watermarked Videos," in IEEE Transactions on Information Forensics and Security, vol. 14, no. 6, pp. 1432-1444, June 2019.

[5] Z. Li, S. Q. Chen and X. Y. Cheng, "Dual Video Watermarking Algorithm Based on SIFT and HVS in the Contourlet Domain," in IEEE Access, vol. 7, pp. 84020-84032, 2019.

[6] Q. Cheng, T. Huang, An additive approach to transform-domain information hiding and optimum detection structure, IEEE Transactions on Multimedia 3 (3) (2001) 273–284.

[7] Q. Cheng, T. Huang, Robust optimum detection of transform domain multiplicative watermarks, IEEE Transactions on Signal Processing 51 (4) (2003) 906–924. doi:10.1109/TSP.2003.809374.

[8] M. Barni, F. Bartolini, Watermarking systems engineering: enabling digital assets security and other applications, CRC Press, 2004.

[9] H. Khalilian, I. Bajic, Multiplicative video watermarking with semi-blind maximum likelihood decoding for copyright protection, in: IEEE Pacific Rim Conference on Communications, Computers and Signal Processing (PacRim), 2011, pp. 125–130.

[10] S. M. E. Sahraeian, M. Akhaee, F. Marvasti, Information hiding with optimal detector for highly correlated signals, in: IEEE International Conference on Communications, ICC '09, 2009, pp. 1–5..

[11] H. Khalilian, I. Bajic, Video watermarking with empirical PCA-based decoding, IEEE Transactions on Image Processing 22 (12) (2013) 4825–4840.

[12] Priyanka Patiala and Chandrakant Biradar, "Robust Scheme of Digital Video Watermarking", International Journal of Science and Research (IJSR), vol. 4, no. 9, pp. 460-465, 2015.

[13] Youssef Bassil, "Image Steganography based on a Parameterized Canny Edge Detection Algorithm", International Journal of Computer Applications, vol. 60, no. 4, pp. 0975–8887, 2012.

[14] Ritika and Sandeep Kaur, "Contrast Enhancement Techniques for Images–A Visual Analysis", International Journal of Computer Applications, vol. 64, no. 17, pp. 975-8887, 2013.

[15] Rakesh Kumar and Savita Chaudhary, "Video Watermarking Using Wavelet Transformation", International Journal of Computer Trends and Technology (IJCTT), vol. 4, no. 5, pp. 1154-1157, 2013.

[16] A. K. Singh, M. Dave and A. Mohan, Multilevel encrypted text watermarking on medical images using spread-spectrum in DWT domain, Wireless Pers. Commun. 83 (2015), 2133–2150.
[17] Jian-Fei Wang, "Reproducing kernel of image space of Haar wavelet transform," 2008 International Conference on Wavelet Analysis and Pattern Recognition, Hong Kong, 2008, pp. 639-643.
[18] Vinolin V and Vinusha S,"Edge-based Image Steganography using Edge Least Significant Bit (ELSB) Technique",Multimedia Research, Volume 1, Issue 1, October 2018.
[19] Vinusha S,"Secret Image Sharing and Steganography Using Haar Wavelet Transform", Multimedia Research, Volume 2, Issue 2, April 2019.