Contents lists available at Science-Gate

International Journal of Advanced and Applied Sciences

Journal homepage: http://www.science-gate.com/IJAAS.html

A new approach for scene-based digital video watermarking using discrete wavelet transforms

Dolley Shukla *, Manisha Sharma

Department of Electronics and Telecommunication Engineering, Chhattisgarh Swami Vivekanand Technical University, Bhilai, India

ARTICLE INFO

Article history:
Received 29 March 2017
Received in revised form
20 December 2017
Accepted 25 December 2017

Keywords:
Video
Video watermarking
Estimation of statistical measure
Sub-bands
Scene change detector

ABSTRACT

This paper presents a scene based video watermarking technique using discrete wavelet transform in the application of video copyright protection. The proposed technique combines the successive estimation of statistical measure (SESAME) technique with video watermarking. In this proposed technique, first level decomposition using 2D-discrete wavelet transform (DWT) of LL sub-band of the cover video frames is considered for embedding. To reduce the computational time, watermark image is inserted only in the scene change frames. To detect the scene changed frame, successive estimation of the statistical measure and HiBiSLI algorithm based scene change detector is designed, which is the most novel-part of the work. In the case of watermarking, the correlation between successive frames is an ideal measure for identifying scene change. The performance shows overall improvement in the measured value of metrics like mean square error, peak signal to noise ratio, normalized correlation, and structural similarity index and bit error rate for embedding using level 1 decomposition. The proposed system achieves robustness against image processing attacks, geometrical attacks, jpeg compression and different video attacks. Further performance enhancements have achieved by embedding at level-2 decomposition. The empirical result suggests that increasing number of levels can improve the performance of the system. Improvement in the robustness and transparency is calculated in terms of bit error rate, normalized correlation and SSIM. Finally, the results are discussed in light of some recently reported studies and have proven a non-blind, robust and imperceptible watermarking system.

1. Introduction

The widespread use of digital multimedia technology and the internet, has enabled people to process, deliver and store digital content more easily, but also have the capability of copying it rapidly and perfectly with no limitations on the number of copies, illegally redistributed without authorization. Therefore the issue arises is how to protect copyright ownership and copying of digital content. Traditionally, encryption and control access techniques were employed to protect the ownership of media. Cryptography -a classical protection- is not a solution because techniques do not protect against unauthorized copying after the media have been successfully transmitted and decrypted. The solution to this problem is to integrate some security information directly into the content of the digital data. The security information must be in inseparable form during its useful lifespan. The digital watermarking is such an effective way to protect the copyright of the digital multimedia data even after its transmission (Singh et al., 2013). Watermarking is the process of embedding some special pattern like labels, Marks into multimedia documents without degrading the quality of the data. The given information is tightly tied to the data. Later, this information is detected or extracted to prove the ownership of the data (Sequeira and Kundur, 2001).

There are various applications of watermarking such as transaction tracking, copyright protection, ownership identification, authentication, copy control, forensic analysis, database linking, and playback screening etc. (Cox and Miller, 2002). The process of proving the intellectual property rights in a court of law against the unauthorized transformation, reproduction, processing or

* Corresponding Author.
Email Address: dolley020375@gmail.com (D. Shukla)
https://doi.org/10.21833/ijaas.2018.02.022
2313-626X/

broadcasting of digital data is known as copyright protection. There is a unique watermark for each digital object. The embedded watermark must be robust against various kinds of attacks so that the embedded data still is valuable in terms of perceptual quality (Hussein and Mohammed, 2009; Masoumi and Amiri, 2012). Due to the large volume of inherently redundant data between video frames, video watermarking is more complicated as compared to image watermarking. The main problem associated with practical video watermarking systems is that existing algorithm does not provide the robustness against geometrical attacks such as blurring, sharpening, scaling, cropping, JPEG compression.

The rest of this paper is organized as follows. A review of related work is presented in section 2. Section 3 describes the novel watermarking technique, i.e., embedding and extraction part. Section 4 describes the parameters used. Results and analysis of watermarking with single level decomposition are presented in section 5. Section 6 gives the analysis of watermarking with level 2 decomposition. The comparative analysis of already existing schemes followed by the conclusion in section 7 and 8.

2. Literature survey

Video watermarking is a technique used for protecting the intellectual property rights of a digital media by embedding a watermark into the video. It is the recently developed area, motivates the researchers. The video watermarking still remains a challenging problem since the original video is often unavailable due to the size of the videos. The video watermarking schemes are based on the techniques of the Image watermarking and are applied to raw video in the uncompressed domain or the compressed video which is domain specific (Esen and Alatan, 2011; Yang et al., 2011).

There are two domains of video watermarking techniques, i.e., spatial domain watermarking and frequency domain watermarking. Spatial domain watermarking is used for providing integrity of data and are less robust as comparable to frequency domain techniques. Discrete cosine transform (DCT), Fast Fourier transforms (FFT), Discrete wavelet transform (DWT), Walsh transform (WT), S-transform (a modified Haar wavelet), Contourlet transform (CT), Discrete multiwavelet transform are frequency domain transforms. Although video watermarking is associated with the most sophisticated technologies, further research in the transform domain is required.

The simplest watermarking in the spatial domain is to spin the least significant bit (LSB) of the chosen pixels in the image (Langelaar et al., 2000) discussed the watermarking in the spatial domain. In the next step superimposed a watermark over an area of the image. With the use of pseudo-random number generator, results were improved, survived cropping attack. Correlation properties of additive pseudo-random noise patterns are applied (Chandramouli and Memon, 2001).

Transform domain technique removes the drawback of the spatial domain technique by using some additional features. In various literature (Asikuzzaman et al., 2012; El Allali et al., 2012; Kothari and Dwivedi, 2012), the authors have discussed watermark embedding in every frame of video. It withstands different image processing attacks but not the averaging and collusion attacks. The discrete cosine transforms based watermarking scheme is more robust to lossy compression (Duan et al., 1998). Template matching Discrete Fourier transform (Pereira and Pun, 2000) watermarking can resist sharing, rotation, and removal attacks. Discrete wavelet transforms based watermarking is the most robust to noise edition (Hong et al., 2001). Video watermarking contains a number of issues such as embedding a large amount of data, the redundancy between frames, and robustness against temporal attacks (Doerr and Dugelay, 2003) that image-based algorithms could not solve these problems. The collusion may be either inter-video or intra-video collusion (Singh et al., 2013). Embedding identical watermark to each frame of the video leads to the problem of maintaining the statistical perceptual invisibility. The collusion can estimate the watermark from each watermarked frame and obtain a refined estimate of the watermark by linear combination. The non-watermarked frame can be obtained by subtracting from the watermarked one (Hartung and Girod, 1996). On the other hand, applying independent watermarks to each frame poses a problem if regions in each frame remain small or if there is no motion between the consecutive frames (Zhang et al., 2000). Two types of watermarks (identical and independent) are used for embedding in motionless and motion regions of video respectively. Embedding watermarks in the detail bands of the discrete wavelet transform improves the robustness of the watermark (Langelaar et al., 2000). Niu and Sun (2000) proposed a wavelet based watermarking method that embeds decomposed watermark at a different resolution in the corresponding resolution of the decomposed video by means of multiresolution signal decomposition (Niu and Sun, 2000). Serdean et al. (2002) proposed a blind video watermarking scheme that is invariant to geometrical attacks such as shift, rotation, scaling, and cropping. This method employed image registration technique to invert the attack and watermark is embedded in the wavelet domain according to a human visual system (HVS) model.

Few researches such as Liu and Zhao (2010), Junxiao et al. (2011), Lee and Jung (2001) have used video watermarking based on scene changes. For this purpose different parts of the watermark are embedded in different scenes. The scheme was so robust and can withstand many attacks like frame averaging, frame dropping, etc., but the higher time complexity was a major limitation. As a solution, Xiaona et al. (2010) and Saez et al. (2004) presented key frame-based watermarking scheme. Where key-frames were identified first and embedding process performed on identified frames knows as key-frames. The scheme was a pioneer and worked well for many video attacks like collusion, frame dropping and frame averaging, etc. The scheme was solely depended on identifying the key-frames in the video. Limitation of the scheme was that it needed a separate algorithm to detect the key-frames.

Seong et al. (2004) proposed a watermarking method based on scene segmentation for copy protection on the Hard disk drive embedded digital broadcast receivers. In the first step, a video sequence, segmented as scenes, using the Macroblock type of B-picture in the MPEG compressed domain. In second step, for each scene, a different embedding parameters were determined based on the image complexity and the motion vector amplitude. Different watermark embedding strengths based on these parameters has been used. This method can reduce the computation for parameter determination. Using this method, a reasonable detection Ratio and invisibility were obtained. The system was robust against Gaussian noise, low pass filtering, histogram equalization, median filtering, and resize attack.

Among all the above-discussed techniques, the discrete wavelet transform (DWT) is more popular because of its excellent spatial localization, frequency spreading and multi resolution characteristics. DWT is more computationally efficient than other techniques. Its speed is faster than DCT & DFT because only the sum of difference in pixel has to be used for calculation.

The existing methods use the watermarking process, in successive frames, which were attained by scene change detection. The watermarking process dependent on the scene change frame. Detection of Scene change frame is very difficult. There could be few similar frames that may not be detected correctly.

However, in the proposed method, a new algorithm, for detecting the scene-changed frame of video, is suggested. Consider the frame of video, which shows an abrupt change in the scenes, on embedding the watermark. Embedding the watermark information in the abrupt scene change of video can resist the algorithm against lossy compressions. Therefore inserting the watermark in the scene change frame highly improves the robustness and transparency of the proposed scheme.

Major contribution of this paper is to develop an algorithm for video watermarking that reduces the computational time and improve the performance. To detect correct scene change frame, a scene change detector is designed based on SESAME and HiBisLI method. Daubechies wavelet has been used for decomposition illustrated in Fig. 1. In order to further improve the results, a second level decomposition in the LL sub band for embedding has been proposed and evaluated.

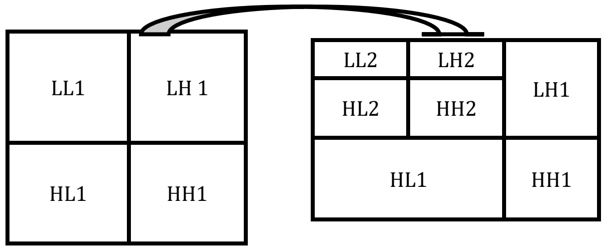


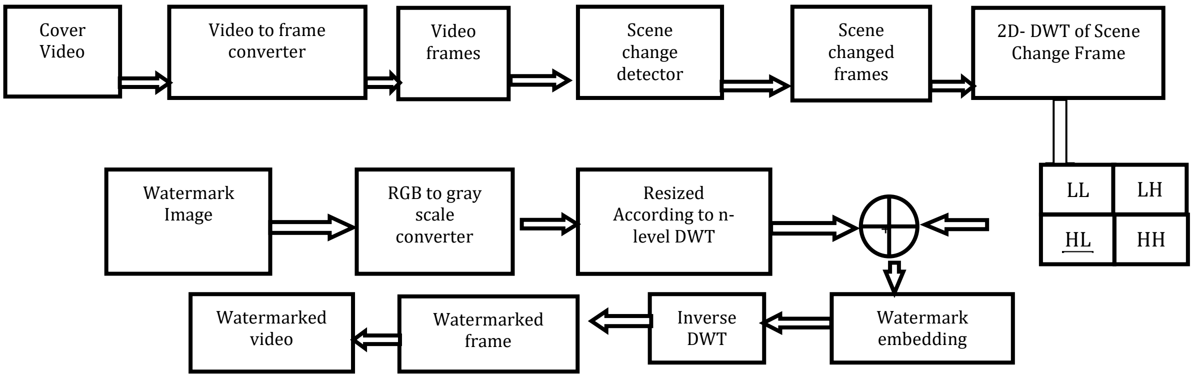
Fig. 1: Decomposition using discrete wavelet transforms [level 1 and 2]

3. Proposed methodology

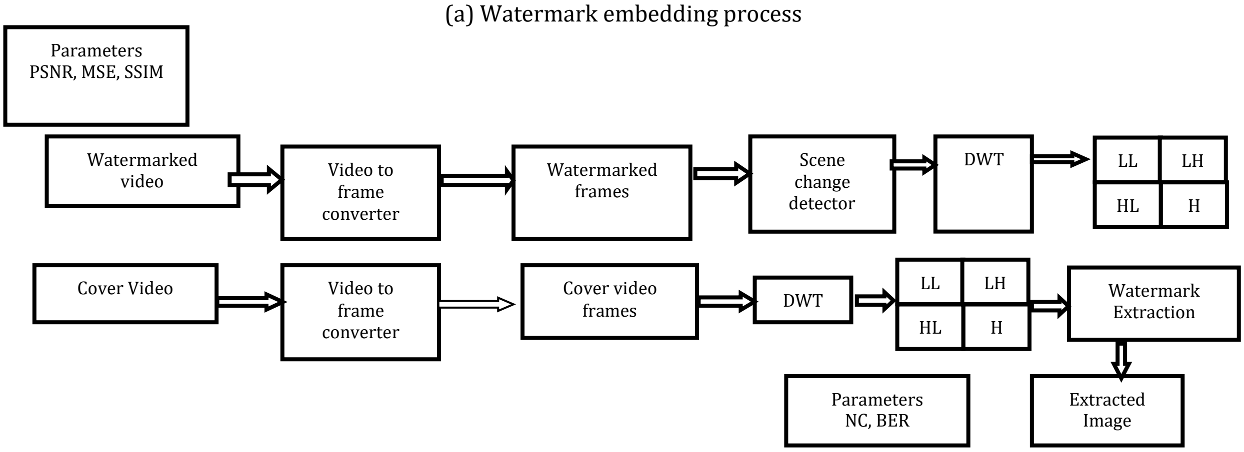
A new technique was proposed at EPFL called wavelets, has led to a flurry of activities centered on wavelets in the signal analysis and processing domain. Discrete Wavelet Transformation (DWT) gives digital signal more information about time, space and frequency domains. This work outlines a unique scene based watermarking in the LL sub-band of discrete wavelet transform coefficients. The suggested methodology involves two steps, scene change frames, which is to be extracted using scene change detector based on SESAME & HiBiSLi and watermark embedding and extraction process given in Fig. 2.Correlation based SESAME detects accurate abrupt scene changes and an image as a watermark is embedded in the LL sub-band of the scene changed frame of cover video using discrete wavelet transform (DWT). Daubechies wavelets are used for decomposition. Daubechies wavelets are a family of orthogonal, symmetric and regular wavelets with a higher number of vanishing moments of given support width, this results in better-watermarked image quality but poorly extracted watermark quality due to smoothness factor. The current scenario is compatible only with .avi video & .jpg images. Robustness of the scheme is tested under various image processing, filtering, geometrical and video frame attacks. One of the novel approaches of this project is that in order to improve the performance, the watermark is embedded only in frames where abrupt scene change occurs, using one and two level decomposition.

3.1. Video preprocess -scene change detector

The first and foremost work in this project was to design a scene change detector whose functionality is to detect abrupt scene changes from raw video. The Scene Change Detector detects the abrupt scene changes using a successive estimation of statistical measure i.e. correlation between the frames. For further refinement, the method is applied up to 4-levels. To remove the similar frames, a filtering method is used in the initial stage that filters out the similar frames in the early stage. In the initial stages, to sieve the same frames, the filtering method uses of the histogram, binary search, and linear Interpolation.



(a) Watermark embedding process



(b) Watermark extraction process

Fig. 2: Watermark embedding and extraction process

3.1.1. Histogram

Histogram collects similar scene values in the same bin and tries to find out the range of cut-off with maximum number of elements.

3.1.2. Binary search algorithm

With the binary search method an approximate/rough cutoff value is calculated. Binary search works on sorting arrays. A binary search starts with comparing the center element of the array with a target value. As a result, the search shifts to the upper or lower half of the array.

3.1.3. Linear interpolation

Linear interpolation is often used to approximate a value of some function using two known values of that function at other points. The error of this approximation is given as

$$R_x = (f_x - p_x) \quad (1)$$

where p denotes the linear interpolation polynomial defined below:

$$P(X) = f(x_0) + \frac{f_{x_1} - f_{x_0}}{x_1 - x_0} (x - x_0) \quad (2)$$

3.2. Watermark construction

An efficient watermarking system requires a well-designed watermark that most easily adapts the cover data & gives better robustness under the degradation of perceptual quality. In the proposed watermarking system, the color image is used for watermarking. It is then converted into a grayscale image of size N*N i.e. 256x256.

3.3. Watermark embedding algorithm

For embedding process, video data is divided into frames. Discrete wavelet transforms using Daubechies wavelet is applied in that frame where a scene change occurs. Discrete wavelet transform separates the image into four components, a lower resolution approximation (LL), a vertical (LH), a horizontal (HL) and a diagonal (HH).The proposed algorithm embeds the watermark image into LL sub-band. After resizing, the original watermark image is embedded into the LL sub-band. The process is explained in detail in Fig. 3.

The algorithm also works for 2-level embedding and extraction. For level 2 LL sub-band further divided into 4 sub-bands i.e., LL2, LH2, HL2 and HH2. Now, embedding process is performed by resizing the watermark image by 64*64. The extraction algorithm was same for all the levels.

3.4. Watermark detection and extraction algorithm

The detection and extraction process performs the reverse of embedding. It involves (i) watermarked video preprocessing and detection (ii) Extraction (iii) Watermarked video post processing. It performs the conversion of watermarked video into frames and then it checks for the scene changed frames. With the verification of the scene changed the frame, it detects the presence of a watermark. If there is a scene changed the frame, then it shows that the "watermark is present". Extraction: An extraction is the inverse operation of embedding. For extraction, the subtraction operation is performed between the LL sub-band of Watermarked video frame and cover video frame.

Input: Cover video with frame size M*M and watermark image of size N*N.
Output: Watermarked video

Step 1: Choose an appropriate watermark Image of size N*N and a video as a cover video.
Step 2: Apply preprocessing step on watermark image and convert the watermark image to gray image using RGB to Gray converter.
Step 3: Resize the watermark image into 128 X 128.
Step 4: Apply preprocessing on cover video and convert into the frame using video to frame converter.
Step5: Apply Scene Change detector algorithm using a Successive estimation of statistical measure i.e., correlation and HiBiSLi.
Step 6: Convert the scene changed frame into a gray level by applying RGB to the gray converter.
Step 7: Resize the scene changed cover video frames into 256 x 256 size.
Step 8: Decompose frames, where scene change occurs, by applying 1-level 2D- DWT on that scene changed Frames.Frame converted into four sub-bands (LL,LH, HL and HH)of size M/2 * M/2 i.e. (128 x 128 size), 3 details and 1 approximation.
LL - The approximation looks just like the original. All the energy contained in the LL Sub-band.
LH, HL, and HH - It allow us to use more accurately
HH - The high-frequency components are usually used for watermarking since the human eye is less sensitive to changes in edges.
Step 9: Then technique alpha-blending is used to insert the watermark in that frames of cover video where scene changes detected. In this technique, the decomposed components of the cover video frame where scene change detected and the watermark are multiplied by a scaling factor and are added. We have taken alpha = 0.05
For embedding -
ELL = VLL + alpha * img_resized_to_vll;
ELH = VLH;
EHL = VHL;
EHH = VHH;
Where
VLL – Low freq approximation
VLH,VHL,VHH - High freq approximation of cover video.
alpha – The embedding factor.
Step 10: Inverse DWT is applied to the watermarked video frames to generate the final secure watermarked video.

Fig. 3: Watermark embedding algorithm

Post processing is to prove the ownership or copyright protection, if watermark image is extracted from a particular scene changed watermarked frame, then the extracted image is recovered by resizing and converting the image into unsigned 8-byte wide integer. This process is explained in detail in Fig. 4.

Input: Watermarked video
Output: Extracted Image

Step 1: Consider watermarked video.
Step 2: Apply preprocessing on cover video and convert into the frame using video to frame converter.
Step3: Apply Scene Change detector algorithm using a Successive estimation of statistical measure i.e. correlation and HiBiSLi.
Step 6: Convert the scene changed frame into a gray level by applying RGB to the gray converter.
Step 7: Resize the scene changed watermarked video frames into 256 x 256 size.
Step 8: Apply DWT on scene changed watermarked video frame Which decomposed the image in four sub-bands.
Step 9: Apply alpha blending on LL frequency components which are used for embedding process.
ILL = (ELL - CLL)/alpha;
Where,
ILL - Extracted/ Recovered watermark image from Low-frequency approximation of embedded video
ELL-Low-frequency approximation of Embedded watermarked video frame.

CLL-Low-frequency approximation of the Cover video frame
Step10: Extracted image is resized and converted into the normal form using uint8.

Fig. 4: Extraction algorithm

4. Quality metrics

Proposed algorithm provides i) Imperceptibility ii) Robustness and iii) payload/embedding Capacity. For imperceptibility, the metric used is peak signal to noise ratio, mean square error and similarity index. For the second term, the metric used are normalized correlation and bit error rate. And the third term is based on the maximum no of pixels used to embed the cover video without destroying the cover video quality.

4.1. Imperceptibility

To evaluate the degradation caused by various attacks, peak signal to noise ratio, mean square error and structural similarity index measure are used. PSNR is defined as:

$$\mathrm{PSNR} = 10 \log_{10} \left(\frac{255^2}{\mathrm{MSE}} \right) \tag{3}$$

where mean-square error (MSE) is defined as:

$$\mathrm{MSE} = \frac{1}{m*n} \sum_{i=1}^{m} \sum_{j=1}^{n} (W(i,j) - W'(i,j)) \tag{4}$$

where $W(i,j)$ and $W'(i,j)$ are the gray levels of pixels in the cover video and watermarked video frame, respectively. The image quality is increased with increasing PSNR.

The SSIM of two video frame's cover video frame W(i, j) and the attacked watermarked video frame W'(i, j) is defined as

$$SSIM(X,Y) = \frac{(2\mu_X\mu_Y + C_1)\ (2\sigma_{XY} + C_2)}{(\mu_X^2 + \mu_Y^2 + C_1)\ (\sigma_X^2 + \sigma_Y^2 + C_2)} \quad (5)$$

where μ_x and μ_Y are the average of Xand Y respectively. σ_{XY} is the covariance of X and Y; μ_X^2 *and* μ_Y^2 are the variance of X and Y; C_1 and C_2 are two variables.

4.2. Robustness

To measure the robustness of the proposed scheme under various attacks, Normalized Correlation (NC), and Bit Error Rate (BER) metrics are used. The acceptable value of both metrics is between 0 and 1.

4.2.1. Normalized correlation (NC)

Normalized Correlation is used to compare the original watermark and extracted/ recovered watermark from watermarked video. If two images are uncorrelated, then its value will be close to 0.NC can be derived using mathematical representation given below:

$$\frac{\sum_{i=0}^{M-1} \sum_{j=0}^{N-1} [W(i,j) * W'(i,j)}{sqrt[\ \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} [W(i,j)^2\ ]\ \ sqrt[sqrt\{\ \sum_{j=0}^{N-1} \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} (W(i,j)^2)\ \}\ ]} \quad (6)$$

where, M and N represent the Width and height of watermark image; W (i, j)=Pixel intensity value at coordinate i, j of original watermark Image; W' (i, j)=Pixel intensity value at coordinate i, j of Extracted/ recovered watermark Image

4.2.2. Bit error rate (BER)

It is the ratio of wrongly extracted watermark bits to the total number of watermark bits embedded. If there is no error in the received message then the bit error rate value will be 0, otherwise close to 1. It can be computed using the equation as:

$$\text{error rate} = \frac{\sum_{i=0}^{M-1} |\ W\ i\ - W'i\ |}{m} = \frac{\text{No of error bits}}{\text{Total no.of embedded watermark bits}} \quad (7)$$

where, W_i =Intensity of i[th] pixel in original watermark image; W'_i= Intensity of i[th] pixel in extracted watermark image; m =Total no. of embedded watermark bits

4.3. Payload /Embedding capacity

In the proposed algorithm, watermark image of any size which is resized by 128x128 is considered and applied into LL Sub-band of decomposed frame of size 256x256. For 'N' number of frames in the given cover video, one can embed a maximum of

$$\frac{N'.\text{Watermark image size}}{N\ .\text{Cover Frame image Size}} \quad (8)$$

where N' is the no of scene change frames and N is the total no. of frames in the video. For level 1 payload = ½*2 = 0.25*(N'/ N); level 2 payload = N'.64x64 / N. 256x256 = 0.0625*(N'/N)

5. Experimental result

The entire system was developed in Matlab 2015 and ran on a dell laptop housing an i5 processor. Proposed method's performance is measured in terms of imperceptibility, robustness, channel capacity and computational time. Five sample videos of different frame size and frame rates as cover video and five different images of the same size has been taken to evaluate the performance. The sample videos are documentary.avi, NEWS.avi, Ad.avi, Sports .avi and children .avi. The result showed over watermark image, i.e., pepper .jpg.

5.1. Scene change detector output

Scene change frames with frame number displayed in the Fig. 5.

The experimental result of Table 1 and Table 2 shows that the successive estimation of statistical measure with correlation method requires 25.094 s computational times which is less for video scene detection as compare to histogram different method with 100% Precision and 85% Recall values. Table 3 compared the result with already existing technique.

5.2. Watermarking with Level -1 LL sub band

5.2.1. Encoder output

Perceptibility indicates the amount of distortion caused by watermark embed or the invisibility of the watermark. It is measured in terms of peak signal-to noise ratio (PSNR). Table 4 shows performance evaluation.

Best result: Ad .avi cover video with Cameraman.jpg watermark image video with pepper .jpg watermark image gives best MSE 0.0096512, PSNR value 68.2849.To check the similarity between embedded video and original video, Similarity index (SSIM) is calculated. Table 5a and Table 5b represent performance of encoder with different images and same image as a watermark.

Best result is Documentary.avi cover video with Pepper.jpg watermark image.

Table 1: Scene change detector output in terms of computational time

S. No.	Video Category	Method	No. of Scenes detected	Computational Time
1.	Documentary.mp4	Correlation	17	25.0094 Sec
2.	Documentary.mp4	Histogram Difference	7	25.3122 Sec

Table 2: Performance evaluation of Scene change detector parameters

Type of video	Method Used	No. of scenes detected	No. of Actual scenes detected	No. of missed scenes	No. of False scenes	Precision	Recall	F-measure
Documentry.avi	Correlation	17	17	03	00	100%	85%	0.9189

Table 3: Comparative analysis of SESAME and HiBisLI based scene change detector with existing technique

S. No.	Method	Description	Precision	Recall
1.	Colour Histogram with scaling of histogram metric	Histogram scaling method with scaling	90.47%	88.37%
2.	Proposed Technique [LL Sub-band Level 1]	SESAME and HiBiSLI	100%	85%

5.2.2. Decoder performance

In order to prove the robustness different attacks on the sample videos have been applied. Performance measuring parameters are normalized correlation and bit error rate.

The applied attacks are (i) No attack (ii) Image processing attacks (iii) Geometric attacks (iv) JPEG Compression (v) Video attacks

Table 4: Performance evaluation [different video with the same image]

Watermark image – pepper.jpg				
Cover video	Frame Size	MSE	PSNR	SSIM
Documentary.avi.	640x320	0.01074	67.820	1.000
AD.avi	620x620	0.01662	65.92435	1.000
Sports.avi	720x620	0.00965	68.2849	1.000

Fig. 5: Scene change frames

Table 5a: Performance evaluation of encoder [Ad.avi video with different images]

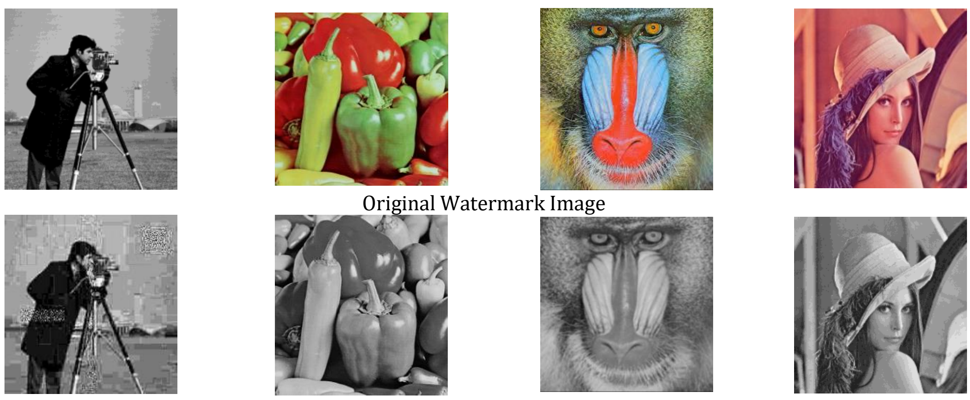
CoCover Video - Ad.avi					
S.No.	Watermark Image	MSE	PSNR	NC	SSIM
1.	Cameraman.jpg	0.001338	76.8693	0.900442	1.000
2.	lena.jpg	0.143956	56.54852	0.867168	1.000
3.	Mandril.jpg	0062401	0.178914	0.744767	1.000
4.	Pepper	0.016620	65.92435	0.909116	1.000

Table 5b: Performance evaluation of encoder [Documentry.avi video with the different images]

S. No.	Cover video and watermark image	MSE	PSNR	SSIM
1.	Documentary.avi and Pepper.jpg	0.01074	67.8203	1.00
2.	Documentary.avi and Baboon.jpg	0.01662	65.9243	1.00

5.2.2.1. No attack

Transparency and robustness are the terms that decide how effectively the watermark is embedded into the cover video. MSE-0.01336, PSNR-66.8713 dB value proved the transparency of the system and robustness under no attack has been evaluated by NC value. From Fig. 6 and Fig. 7 NC -0.9130 (approximately 1) and BER remains 0 for all the sample videos.



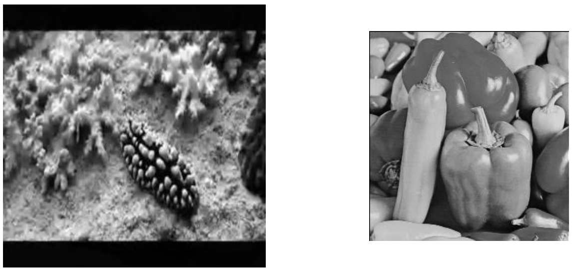
NC= 0.9004428 (a) Ad .avi and Cameraman .jpg

NC = 0.93288 (b) Ad.avi and Pepper

(c) Documentary.avi and Mandril.jpg

NC=0.867168 (d) Ad.avi and lena.jpg

Fig. 6: Original and extracted watermark images



MSE- 0.0107402
PSNR-66.8713
SSIM-0.931173

NC- 0.9130
BER – 0.0000

a) Cover Video frame b) Watermark Image (without attack) No Attack c) Parameter d) Parameter

Fig. 7: Cover video and extracted watermark images

5.3. Watermarking with level -2 decomposition

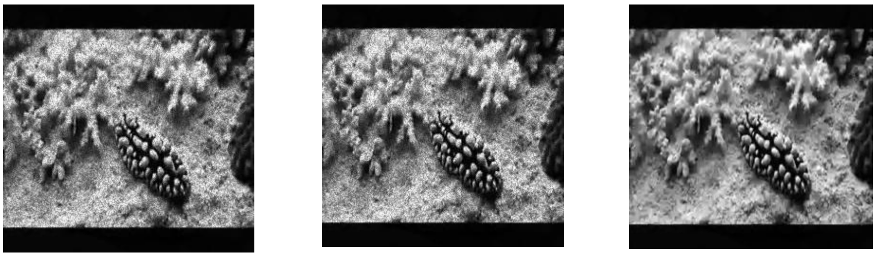
5.3.1. Encoder/Decoder output

The Performance evaluation of encoder with level 2 decomposition using parameters MSE, PSNR and SSI M is represented in Table 6 and the output is displayed in Fig. 8.

The performance of decoder with level -2 decomposition is evaluated using NC and BER depicted in Table 7. The extracted image displayed in Fig. 9.

Table 6: Documentry.avi and Pepper.jpg watermark image in different level of DWT

Wavelet – Daubechies					
Level	Cover Video	Watermark image	MSE	PSNR	SSIM
Level -1	Docentary.avi	Pepper.jpg(128*128)	0.013364	66.871332	1.000000
Level -2	Docentary.avi	Pepper.jpg(64x64)	0.013250	67.97589	1.000000



Cover Video Frame (a) Level 1 DWT (b) Level 2 DWT

Fig. 8: Watermarked video frame of level 1 and 2

Table 7: Documentry.avi and Pepper.jpg watermark image in different level of DWT (Decoder)

Wavelet - Daubechies				
Level	Cover Video	Watermark image	NC	BER
Level -1	Docentary.avi	Pepper.jpg (128*128)	0.932898	0.000000
Level -2	Docentary.avi	Pepper.jpg (64x64)	67.97589	0.000000

The reduction in the value of MSE by 0.8% and 1.65% improvement in the PSNR value, by increasing the number of decomposition levels from level 1 to level-2, shows improvement in the imperceptibility as depicted in the Figs. 10a and 10b. Robustness improvement in terms of normalized correlation with decomposition level 1 and level 2 shown in Fig. 10c. The result is enhanced by 1.82% in terms of NC.

Original watermark (b) Level -1 (c) Level -2

Fig. 9: Extracted outputs using Level 1 and level 2 DWT

6. Performance analysis

6.1. Imperceptibility assessment

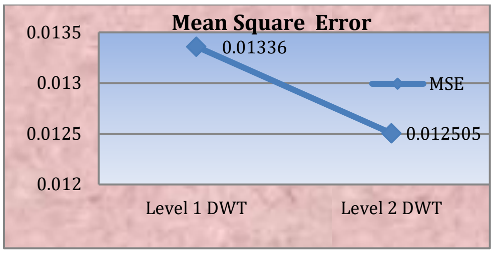
SSIM values under different category of attacks for level 1 and level 2 decomposition of LL sub-band is depicted in Table 8. Figs. 11a, 11b, 11c, and 11d show the improvement in the imperceptibility with increasing number of decomposition level by one in terms of SSIM.

Highest SSIM value is obtained as 1.000 against resizing, stretching and video attacks.

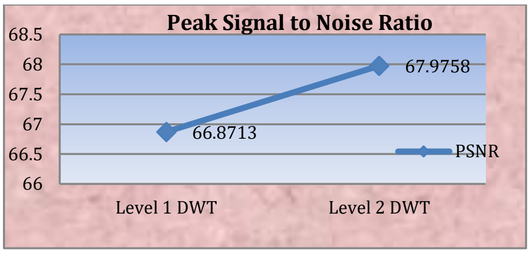
6.2. Robustness assessment (In terms of normalized correlation)

Robustness of the proposed algorithm is tested under different attacks. Table 9 represents the NC values for different levels under four categories of attacks i.e. image processing attacks, Gaussian Noise, JPEG compression and Noise Attacks. Highest NC value is 1.000 against frame swapping.

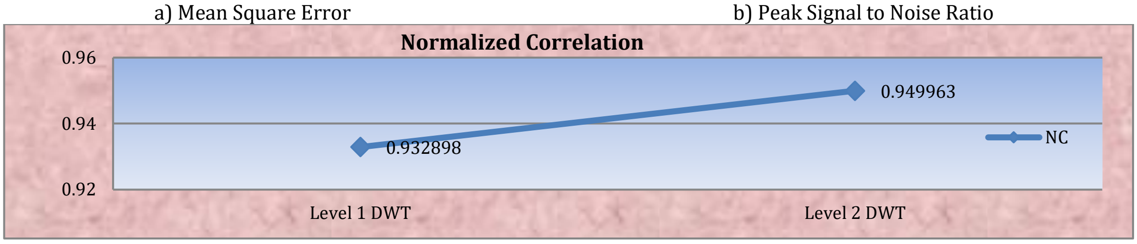
Graphical representation of improvement in the robustness with number of levels shifted from level 1 to level 2 for embedding in terms of normalized correlation is clearly shown in Figs. 12 a, 12b, 12c, and 12d under different attacks. Decoder performance is also evaluated using BER at different types of attacks shown in Table 10.



a) Mean Square Error



b) Peak Signal to Noise Ratio

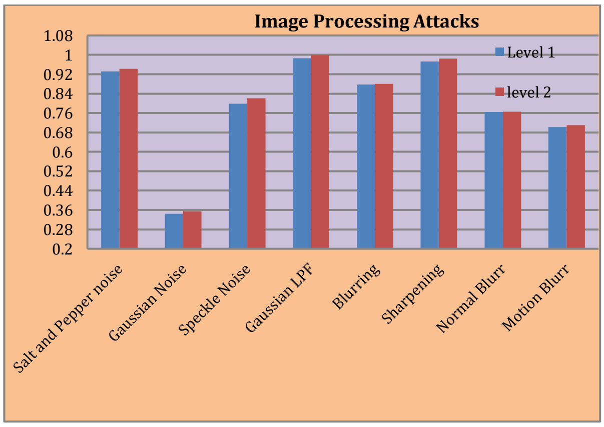


c) Normalized Correlation

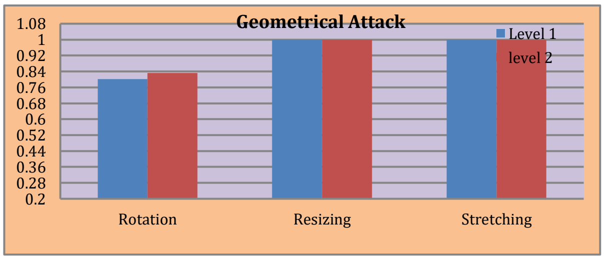
Fig. 10: Graphical representation (Documentary and pepper) using different level of decomposition

Table 8: Comparative performance analysis [Imperceptibility assessment]

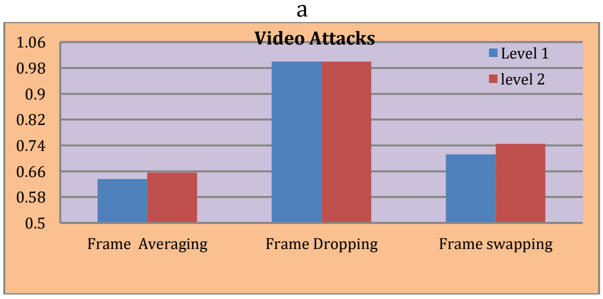
S. No.	Attack Category	Attacks	SSIM	
			Level 1	Level 2
1.		None	1.00000	1.00000
2.		Salt and Pepper noise	0.931173	0.94289
3.		Gaussian Noise	0.344853	0.35449
4.		Speckle Noise	0.798355	0.820909
5.	Image Processing Attacks	Gaussian LPF	0.986326	0.999328
6.		Blurring	0.877609	0.88078
7.		Sharpening	0.972952	0.98429
8.		Normal Blur	0.7645425	0.765468
9.		Motion Blur	0.701457	0.710335
10.	JPEG Compression	JPEG Compression	0.824305	0.844313
11.		Rotation	0.802009	0.832245
12.	Geometrical Attacks	Resizing	1.000000	1.000000
13.		Stretching	1.000000	1.000000
14.		Frame Averaging	0.656216	0.656179
15.	Video Attacks	Frame Dropping	1.00000	1.000000
16.		Frame swapping	0.7123278	0.7452644



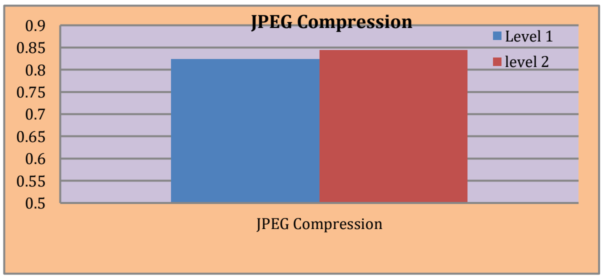
a



b



c



d

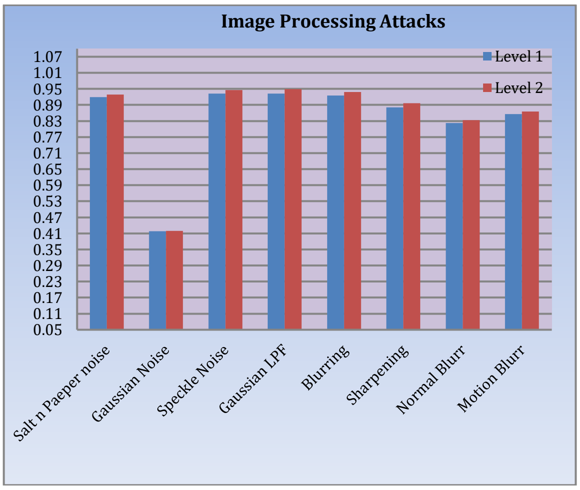
Fig. 11: Graphical representation of imperceptibility [SSIM]

Graphical representation of Fig. 13 illustrates the slight reduction in the BER with increasing no. of decomposed levels from level -1 to level-2. Watermarking in the LL2 sub-band i.e., level 2 decomposition proves more robustness. Since the proposed technique sustains different geometrical attacks like resizing, stretching and rotation attacks effectively, the technique can be used for copy protection application.

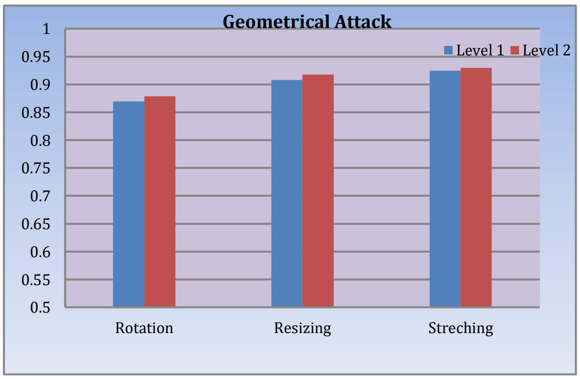
For assessing robustness in terms of bit error rate we found that scene based watermarking with level-2 decomposition requires less computational time as shown in Table 11.

Table 9: Comparative analysis using different level of DWT for watermark [Normalized correlation]

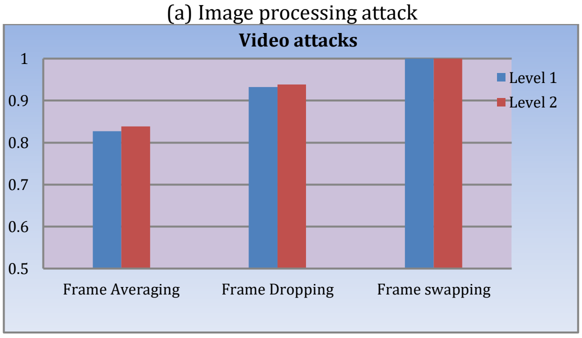
		Normalized correlation		
S. No.	Attack Category	Attacks	Level 1	Level 2
1.		None	0.932898	0.949963
2.		Salt and Pepper noise	0.91886	0.9291189
3.		Gaussian Noise	0.4177099	0.4194353
4.		Speckle Noise	0.932622	0.944884
5.	Image Processing Attacks	Gaussian LPF	0.932622	0.948634
6.		Blurring	0.925224	0.9383265
7.		Sharpening	0.881412	0.896202
8.		Normal Blurr	0.821663	0.833045
9.		Motion Blurr	0.855255	0.865491
10.	JPEG Compression	JPEG Compression	0.925226	0.9363326
11.		Rotation	0.86952	0.87867
12.	Geometrical Attacks	Resizing	0.907712	0.917805
13.		Streching	0.924457	0.929783
14.		Frame Averaging	0.827381	0.838669
15.	Video Attacks	Frame Dropping	0.932622	0.93860
16.		Frame swapping	1.00000	1.00000



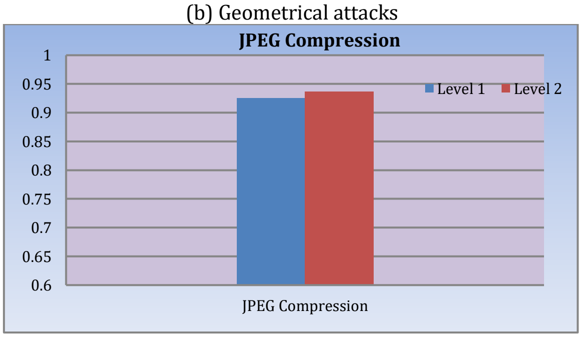
(a) Image processing attack



(b) Geometrical attacks



(c) Video attacks



(d) JPEG Compression

Fig. 12: Robustness in terms of normalized correlation

7. Comparative analysis

In order to prove the performance of the proposed algorithm, comparison with the other algorithm has been done. Comparative analysis of Table 12 shows that the proposed algorithm survives different image processing attacks, geometrical attacks, JPEG compression and video attacks.

It has been proven from the Table 13, that PSNR for the proposed work is higher than that of other. The NC value is 1 and the bit error rate is 0.00. While other algorithm attained lower PSNR and NC.

Table 14 represents the computational time required by encoder, decoder and the system to perform the watermarking operation. Comparative analysis in terms of computational time proves that the proposed scene based watermarking technique is much faster than conventional video watermarking technique.

Table 10: Comparative analysis using different level of DWT for watermark [Bit error rate]

S. No.	Attack Category	Attacks	Level 1	Level 2
1.	Image Processing Attacks	None	0.00000	0.00000
2.		Salt and Pepper noise	0.337647	0.32745
3.		Gaussian Noise	0.401243	0.40007
4.		Speckle Noise	0.301746	0.30045
5.		Gaussian LPF	0.082675	0.08003
6.		Blurring	0.238021	0.23689
7.		Sharpening	0.211516	0.21027
8.		Normal Blurr	0.167261	0.16209
9.		Motion Blurr	0.00000	0.0000
10.	JPEG Compression	JPEG Compression	0.458204	0.45690
11.	Geometrical Attacks	Rotation	0.302816	0.30100
12.		Resizing	0.287521	0.28471
13.		Streching	0.00000	0.00000
14.	Video Attacks	Frame Averaging	0.403713	0.40202
15.		Frame Dropping	0.00000	0.00000
16.		Frame swapping	0.341324	0.34101

Table 11: Performance evaluation of computational time

Level	Embedding time	Extraction Time	Total Computational time
Level 1	45.694036	3.19843	48.892466
Level 2	45.620552	3.713967	48.760222

Table 12: Comparison between proposed algorithm and previous work [Based on attack]

	Already Existing Scheme				Proposed Algorithm
Attacks used	Agilandeeswari and Ganesan (2016)	Thanh et al. (2014)	Ghosh et al. (2012)	Masoumi and Amiri (2012)	LL Sub-band
None	√	√	√	√	√
Salt and Pepper noise	√	√	√	√	√
Gaussian Noise	√	√	√	√	√
Speckle Noise	–	–	–	–	√
Gaussian LPF	–	–	–	–	√
Rotation	–	–	–	–	√
Blurring	–	–	–	–	√
Sharpening	–	–	–	–	√
Resizing	–	–	–	–	√
JPEG Compression	–	–	–	–	√
Normal Blurr	–	–	–	–	√
Motion Blurr	–	–	–	–	√
Stretching	–	–	–	–	√
Frame Averaging	√	√	–	√	√
Frame Dropping	√	√	–	√	√
Frame Swapping	√	√	–	√	√
Total Attacks	5	5	2	5	15

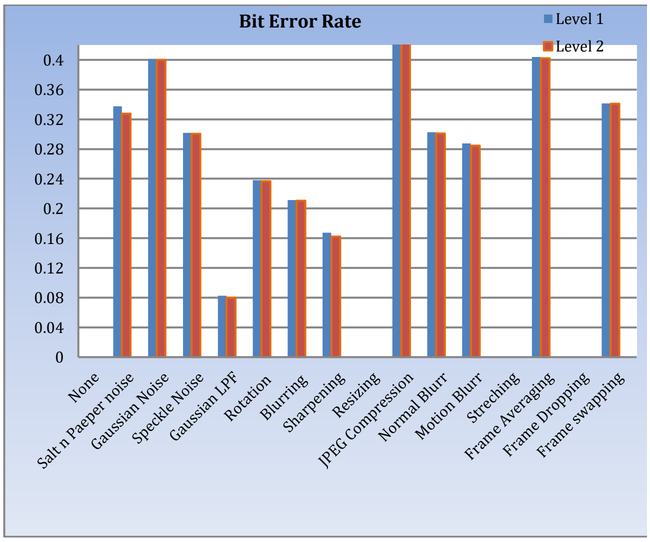


Fig. 13: Graphical representation [Robustness in terms of BER]

8. Conclusion and outlook

This paper presented a novel and robust video watermarking technique based on 2D-disrete wavelet transform. Daubechies wavelets are used to decompose the video frames into different frequency sub-bands. The watermarking process has utilized low-frequency coefficients of wavelet i.e., LL sub-band for embedding of the watermark image using 1st level decomposition. The key idea of the proposed scheme is applying a novel SESAME and HiBisLI based scene change detection method that detects the frames where scene change occurs. To reduce the computational and processing time, watermark is embedded only into the frame where scene change occurred. Imperceptibility in terms of PSNR and SSIM has been presented. Robustness of this method is carried out by a variety of attacks. The proposed method can effectively sustain Image processing attacks, geometrical attacks, JPEG compression and video attacks and can maintain a good performance in robustness, transparency, embedding capacity and reduced computational time. The proposed algorithm facilitate the protection of the copyright and copy protection of videos.

As a further enhancement of the methodology, a second level decomposition in LL sub-band for embedding and extraction has been proposed. The empirical result of the comparative analysis of watermarking with level 1 and level 2 shows that as the act of decomposition increases, the result becomes better. Improvement in the robustness and transparency in terms of different parameters proves the effectiveness of the scheme. It has been observed that the proposed scheme shows better robustness against fifteen different attacks, high imperceptibility, reduced computational time and good channel capacity, as compared to existing approaches.

9. Future work

1. The aim is to improve the performance of proposed technique in terms of robustness, imperceptibility, and channel capacity with 3rd level decomposition of DWT for embedding.
2. This study concentrated on correlation based scene change detection method; Future study can be focused on pixel differences based method for scene-based watermarking.
3. The future work will focus on developing a secure technique providing copy protection to the embedded video.

Table 13: Comparative analysis based on parameters

Method	Technique used	PSNR	MSE	NC	SSIM	BER	No. of attacks
(Leelavathy et al., 2012)	Histogram difference method [Discrete Multiwavelet Domain]	50.6419	----	0.3360	_	_	Withstand seven attacks-Salt and Pepper Noise, Gaussian Noise, Speckle Noise, Poisson"s Noise, Wiener filter, Cropping
(Masoumi and Amiri, 2012)	Scene based watermarking [DCT domain]	37.141	-----	1	----	0.030	Tolerate geometrical attacks, low robustness under scaling, frame dropping and frame insertion
(Shukla and Sharma, 2016)	DWT [embedding in each frame] [LL Sub-band].	55.011	0.2052	0.87802	_	_	No Attack Analysis
Proposed Method	LL ubband [SESAME]	67.9758	0.01325	0.94996	1.00	0.000	Fifteen different types of attacks like image processing attacks geometrical, video, noise attack, filtering.

Table 14: Comparative analysis [Computational time]

S. No.	Method	Computational Time (Encoder)	Computational Time (Decoder)	Computational Time (Total)
1.	When watermark embedded into all frames	67.838098 Sec.	68.122820 Sec.	135.960918 Sec.
2.	When watermark embedded only into scene changed frames (Proposed Method (Level-2))	45.620552 Sec	3.713967 Sec	48.760222 Sec

Acknowledgment

The author would like to thank Electronics and Telecommunication Engineering department, Bhilai Institute of Technology, Durg (C.G), India for providing facilities to carry out this work. We would also like to thank the editor and the anonymous reviewers for their valuable suggestions.

References

Agilandeeswari L and Ganesan K (2016). A robust color video watermarking scheme based on hybrid embedding techniques. Multimedia Tools and Applications, 75(14): 8745-8780.

Asikuzzaman M, Alam MJ, Lambert AJ, and Pickering MR (2012). A blind digital video watermarking scheme with enhanced robustness to geometric distortion. In the International Conference on Digital Image Computing Techniques and Applications, IEEE, Fremantle, Australia: 1-8. https://doi.org/10.1109/DICTA.2012.6411696

Chandramouli R and Memon N (2001). Analysis of LSB based image steganography techniques. In the International Conference on Image Processing, IEEE, Thessaloniki, Greece, 3: 1019-1022. https://doi.org/10.1109/ICIP.2001.958299

Cox IJ and Miller ML (2002). The first 50 years of electronic watermarking. EURASIP Journal on Advances in Signal Processing, 2002(2): 126-132.

Doerr G and Dugelay JL (2003). A guide tour of video watermarking. Signal processing: Image communication, 18(4): 263-282.

Duan FY, King I, Chan LW, and Xu L (1998). Intra-block algorithm for digital watermarking. In the Fourteenth International Conference on Pattern Recognition, IEEE, Brisbane, Queensland, Australia, 2: 1589-1591. https://doi.org/10.1109/ICPR.1998.712016

El Allali A, Elabbadi J, and Elahaj EI (2012). Video object watermarking using 3d-walsh hadamard transform and arnold transform. In the International Conference on Multimedia Computing and Systems, IEEE, Tangier, Morocco: 119-124. https://doi.org/10.1109/ICMCS.2012.6320214

Esen E and Alatan AA (2011). Robust video data hiding using forbidden zone data hiding and selective embedding. IEEE Transactions on Circuits and Systems for Video Technology, 21(8): 1130-1138.

Ghosh P, Ghosh R, Sinha S, Mukhopadhyay U, Kole DK, and Chakroborty A (2012). A novel digital watermarking technique for video copyright protection. In the In: International Conference of Advanced Computer Science & Information Technology, Pune, Maharashtra, India. https://doi.org/10.5121/csit.2012.2360

Hartung F and Girod B (1996). Digital watermarking of raw and compressed video. In the European EOS/SPIE Conference on Advanced Imaging and Network Technologies, Digital Compression Technologies and Systems for Video Communication, Berlin, Germany, 2952: 205-213. http://doi.org/10.1117/12.251278

Hong I, Kim I, and Han SS (2001). A blind watermarking technique using wavelet transform. In the IEEE International Conference on Industrial Electronics, IEEE, Pusan, South Korea, 3: 1946-1950. https://doi.org/10.1109/ISIE.2001.932010

Hussein J and Mohammed A (2009). Robust video watermarking using multi-band wavelet transform. International Journal of Computer Science Issues, 6(1):44-49.

Junxiao X, Qingbin L, and Zhiyong L (2011). A novel digital video watermarking algorithm. Procedia Engineering, 24: 90-94.

Kothari AM and Dwivedi VV (2012). Transform domain video watermarking: Design, implementation and performance analysis. In the International Conference on Communication Systems and Network Technologies (CSNT), IEEE, Rajkot, India: 133-137. https://doi.org/10.1109/CSNT.2012.38

Langelaar GC, Setyawan I, and Lagendijk RL (2000). Watermarking digital image and video data. A state-of-the-art overview. IEEE Signal Processing Magazine, 17(5): 20-46.

Lee SJ and Jung SH (2001). A survey of watermarking techniques applied to multimedia. In the IEEE International Conference on Industrial Electronics, IEEE, Pusan, South Korea, 1: 272-277. https://doi.org/10.1109/ISIE.2001.931796

Leelavathy N, Prasad EV, and Kumar SS (2012). A scene based video watermarking in discrete multiwavelet domain. International Journal of Multidisciplinary Sciences and Engineering, 3(7): 12-16.

Liu Y and Zhao J (2010). A new video watermarking algorithm based on 1D DFT and radon transform. Signal Processing, 90(2): 626-639.

Masoumi M and Amiri S (2012). A high capacity digital watermarking scheme for copyright protection of video data based on YCbCr color channels invariant to geometric and non-geometric attacks. International Journal of Computer Applications, 51(13): 13-20.

Niu X and Sun S (2000). A new wavelet-based digital watermarking for video. In the 9th IEEE Digital Signal Processing Workshop, IEEE, Texas, USA: 1-6.

Pereira S and Pun T (2000). Robust template matching for affine resistant image watermarks. IEEE Transactions on Image Processing, 9(6): 1123-1129.

Saez E, Benavides JI, and Guil N (2004). Reliable real time scene change detection in MPEG compressed video. In the IEEE International Conference on Multimedia and Expo, IEEE, Taipei, Taiwan, 1: 567-570. https://doi.org/10.1109/ICME.2004.1394255

Seong YK, Choi YH, and Choi TS (2004). Scene-based watermarking method for copy protection using image complexity and motion vector amplitude. In the IEEE International Conference on Acoustics, Speech, and Signal Processing, IEEE, Montreal, Que., Canada, 3: 403-409. https://doi.org/10.1109/ICASSP.2004.1326568

Sequeira A and Kundur D (2001). Communication and information theory in watermarking: A survey. Multimedia Systems and Applications IV, 4518: 216-227.

Serdean CV, Ambroze MA, Tomlinson M, and Wade G (2002). Combating geometrical attacks in a dwt based blind video watermarking system. In the 4th EURASIP-IEEE Region 8 International Conference on Video/Image Processing and Multimedia Communications, IEEE, Zadar, Croatia: 263-266. https://doi.org/10.1109/VIPROM.2002.1026666

Shukla D and Sharma M (2016). Video watermarking using dyadic filter and discrete wavelet transform. In the International Conference on Wireless Communications, Signal Processing and Networking, IEEE, Chennai, India: 1647-1650. https://doi.org/10.1109/WiSPNET.2016.7566419

Singh TR, Singh KM, and Roy S (2013). Video watermarking scheme based on visual cryptography and scene change detection. AEU-International Journal of Electronics and Communications, 67(8): 645-651.

Thanh TM, Hiep PT, Tam TM, and Tanaka K (2014). Robust semi-blind video watermarking based on frame-patch matching. AEU-International Journal of Electronics and Communications, 68(10): 1007-1015.

Xiaona Z, Guoqing Q, Qiang W, and Tao Z (2010). An improved approach of scene change detection in archived films. In the IEEE 10th International Conference on Signal Processing, IEEE, Beijing, China: 825-828. https://doi.org/10.1109/ICOSP.2010.5655938

Yang G, Li J, He Y, and Kang Z (2011). An information hiding algorithm based on intra-prediction modes and matrix coding for H. 264/AVC video stream. AEU-International Journal of Electronics and Communications, 65(4): 331-337.

Zhang L, Cao Z, and Gao C (2000). Application of RS-coded MPSK modulation scenarios to compressed image communication in mobile fading channel. In the 52nd IEEE-VTS Fall VTC Vehicular Technology Conference, IEEE, Boston, MA, USA, 3: 1198-1203. https://doi.org/10.1109/VETECF.2000.886291