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Hybrid Digital Video Watermarking based on DWT-PCA

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Abstract: The digital multimedia content authentication and copyright protection has become an important issue in the recent years. Digital image watermarking techniques can be classified into spatial or transform domains. The spatial domain methods are the simplest watermarking techniques but have low robustness against different attacks, unlike the transform domains watermarking methods are more complex and have high robustness against various attacks. Most commonly used methods of watermarking are discrete cosine transform (DCT), discrete wavelet transform (DWT).A hybrid digital video watermarking scheme based on Discrete Wavelet Transform (DWT) and Principal Component Analysis (PCA). These transform domain technique always give more robust output than DCT and DWT The video frames are first decomposed using DWT and the binary watermark is embedded in the principal components of the low frequency wavelet coefficients Experimental result shows no visible difference between the watermarked frames and original frame. It shows robustness on the watermarked video against various attacks. Peak signal to noise ratio (PSNR) is calculated to measure efficiency of this all methods.NC (Normalization Correlation)is calculated to define correlation between embedded watermark and extracted watermark.

I. INTRODUCTION

Rapid growth of the internet and digital technologies, copyright protection plays an essential role in economical multimedia distribution. Image watermarking emerged as a solution for protecting images and ownership proof. It is process of embedding some digitized information such as logo, text, pseudo random bits, into the host image. For copyright protection, the watermark needs to be detectable even after encountering different attacks. The transparency of the watermarked image is another important issue in digital image watermarking and the watermarked image should not be visually identical to the original one. The blindness is another important issue where it is difficult to obtain the original image. In the recent years, a hybrid digital video watermarking scheme based on Discrete Wavelet Transform (DWT) and Principal Component Analysis (PCA) is used. These transform domain technique always give more robust output than DCT and DWT [1]. PCA helps in reducing correlation among the wavelet coefficients obtained from wavelet decomposition of each video frame thereby dispersing the watermark bits into the uncorrelated coefficients. The video frames are first decomposed using DWT and the binary watermark is embedded in the principal components of the low frequency wavelet coefficients.

II. PRESENT TECHNIQUES

Techniques used for Video Watermarking

Video watermarking involves embedding information into the frames of the video. It is an extension of image watermarking and hence the techniques used for image watermarking can be applied to watermark video content as well. Video watermarking can be done on spatial domain; frequency domain. Spatial domain video watermarking is much simpler than frequency domain video watermarking however frequency domain watermarking is comparatively more robust and can withstand most of the unintentional attacks. Widely used frequency transforms are DFT (Discrete Fourier Transform), FFT (Fast Fourier Transform), DCT (Discrete Cosine Transform) and DWT (Discrete Wavelet Transform).

Domain

Different digital video watermarking algorithms have been proposed. Video watermarking techniques are classified according to their working domain .Some techniques embed watermark in the spatial domain by modifying the pixel values in each frame extracted from the video. These methods are not robust to attacks and common signal distortions. In contrast, other techniques embed the watermark in the frequency domain, which are comparatively more robust to distortions.

A. Spatial Domain Watermarking

The spatial domain watermarking techniques embed the watermark by modifying the pixel values of the host image or video directly. In case of attacks destroying data, a single surviving watermark can be considered a success. Although they are robust to attacks like cropping, noise, lossy compression, etc, an attack that is set on a pixel to pixel basis can fully uncover the watermark, which is the major drawback of the system. The major advantages of pixel based methods are that they are conceptually simple and have very low computational complexities. Therefore they are widely used in video watermarking.

B. Frequency Domain Watermarking

In frequency domain techniques, the watermark is embedded by modifying the transform coefficients of the frames of the video sequence. The most commonly used transforms are the Discrete Fourier Transform (DFT), the Discrete Cosine Transform (DCT), and the Discrete Wavelet Transform (DWT).The watermark is embedded distributive in overall domain of an original data. Here, the host image/video is first converted into frequency domain by transformation techniques. The transformed domain coefficients are then altered to store the watermark information. The watermarked image/video is finally obtained by applying the inverse transform. Several researches concentrated on using DWT because of its multi resolution characteristics, it provides both spatial and frequency domain characteristics so it is compatible with the Human Visual System (HVS). Also the recent trend is to combine the DWT with other algorithms to increase robustness and invisibility.

Discrete Cosine Transform (DCT):

Discrete Cosine Transform (DCT) is an important method for video watermarking. A lot of digital video watermarking algorithms embed the watermark into this domain. The usability of this transform is because that most of the video compression standards are based on DCT and some other related transforms. In this domain some DCT coefficients of the video are selected and divided into frequency bands, and then the watermark bits are embedded by doing adjustment in each frequency bands.

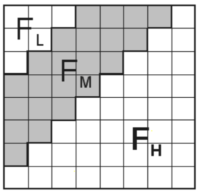


Fig 1 : DCT Region

Discrete Wavelet Transform (DWT):

The Discrete Wavelet Transform (DWT) is used in a wide variety of signal processing applications. 2-D discrete wavelet transform (DWT) decomposes an image or a video frame into sub-images, 3 details and 1 approximation. The approximation sub-image resembles the original on 1/4 the scale of the original. The 2-D DWT is an application of the 1-D DWT in both the horizontal and the vertical directions. DWT separates the frequency band of an image into a lower resolution approximation sub-band (LL) as well as horizontal (HL), vertical (LH) and diagonal (HH) detail components. Embedding the watermark in low frequencies obtained by wavelet decomposition increases the robustness with respect to attacks that have low pass characteristics like filtering, lossy compression and geometric distortions while making the scheme more sensitive to contrast adjustment, gamma correction, and histogram equalization. Since the HVS is less sensitive to high frequencies, embedding the watermark in high frequency sub-bands makes the watermark more imperceptible while embedding in low frequencies makes it more robust against a variety of attacks [1].

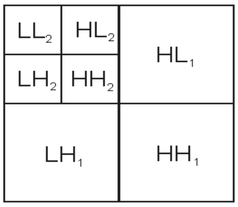


Fig 2 .DWT Subband

III. PROPOSED METHOD

<u>The watermarking algorithm basically utilizes two mathematical techniques: DWT and PCA.</u>

Discrete Wavelet Transform

The most advanced and useful transform domain watermarking technique is Discrete Wavelet Transform (DWT). DWT is a hierarchical transform. DWT offers multi resolution analysis i.e. it has the capabilities to study or analyze a signal at different levels [4]. DWT is used in a wide variety of signal processing applications. 2-D discrete wavelet transform (DWT) decomposes an image or a video frame into sub-images, 3 details and 1 approximation. The approximation sub-image resembles the original on 1/4 the scale of the original. The 1-D DWT is an application of the 2-D DWT in both the horizontal and the vertical directions. DWT separates the frequency band of an image into a lower resolution approximation sub-band (LL) as well as horizontal (HL), vertical (LH) and diagonal (HH) detail components. Embedding the watermark in low frequencies obtained by wavelet decomposition increases the robustness with respect to attacks that have low pass characteristics like filtering, lossy compression and geometric distortions while making the scheme more sensitive to contrast adjustment, gamma correction, and histogram equalization. Since the HVS is less sensitive to high frequencies, embedding the watermark in high frequency sub-bands makes the watermark more imperceptible while embedding in low frequencies makes it more robust against a variety of attacks.

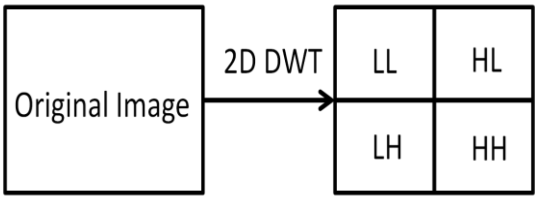


Fig 3: 2D DWT subbands

Principal Component Analysis

Principal component analysis (PCA) is a mathematical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of uncorrelated variables called principal components [2]. The number of principal components is less than or equal to the number of original variables. PCA is a method of identifying patterns in data, and expressing the data in such a way so as to highlight their similarities and differences. Since patterns in data can be hard to find in data of high dimension, where the advantage of graphical representation is not available, PCA is a powerful tool for analyzing data. The other main advantage of PCA is that once these patterns in the data have been identified, the data can be compressed by reducing the number of dimensions, without much loss of information. It plots the data into a new coordinate system where the data with maximum covariance are plotted together and is known as the first principal component. Similarly, there are the second and third principal components and so on. The maximum energy concentration lies in the first principal component [3].The following block diagram (Fig.4) shows the embedding and the extraction procedure of the watermark.

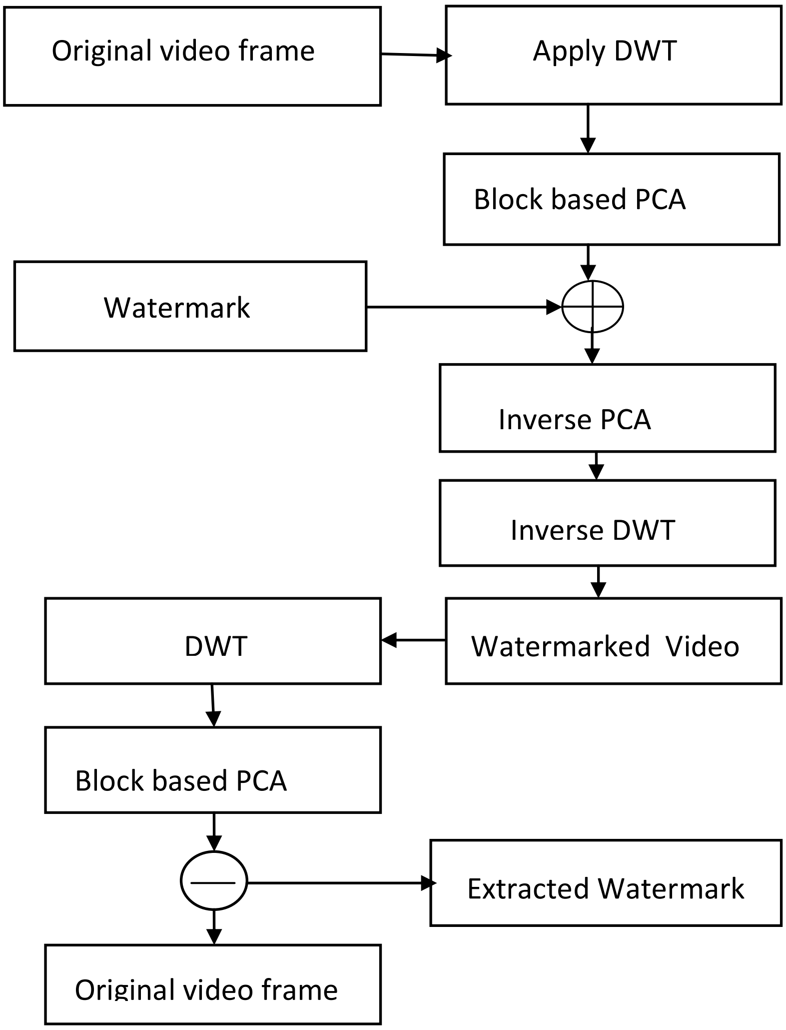


Fig 4 : Block diagram of watermarking

In the proposed method the binary watermark is embedded into each of the video frames by the decomposition of the frames into DWT sub bands followed by the application of block based PCA on the sub-blocks of the low frequency sub-band. The watermark is embedded into the principal components of the sub-blocks. The extracted watermark is obtained through a similar procedure.

Algorithms for Watermarking Using DWT and PCA

Algorithm 1:

Embedding Procedure

Step 1: Convert the n × n binary watermark logo into vector W ={ w1, w2 , ……, wn × n} of '0's and '1's.

Step 2: Divide the video (2N × 2N) into distinct frames.

Step 3: Convert each frame from RGB to YUV colour format.

Step 4: Apply 1-level DWT to the luminance(Y component) of each video frame to obtain four sub-bands LL, LH , HL and HH of size N x N .

Step 5: Divide the LL sub-band into k non-overlapping sub-blocks each of dimension n × n (of the same size as the watermark logo).

Step 6: The watermark bits are embedded with strength into each sub-block by first obtaining the principal component scores by Algorithm 2.

$$Score'_i = Score_i + \alpha W \quad (1)$$

Where $Score_i$ represents the principal component matrix of the ith sub-block.

Step 7: Apply inverse PCA on the modified PCA component of the sub-blocks of the LL sub-band to obtain the modified wavelet coefficients.

Step 8: Apply inverse DWT to obtain the watermarked luminance component of the frame. Then convert the video frame back to its RGB components.

Extraction Procedure

Step 1: Divide the watermarked (and possibly attacked) video into distinct frames and convert them from RGB to YUV format.

Step 2: Choose the luminance (Y) component of a frame and apply the DWT to decompose the Y component into the four sub-bands LL , HL , LH , and HH of size N×N.

Step 3: Divide the LL sub-band into n × n no overlapping sub-blocks.

Step 4: Apply PCA to each block in the chosen subband LL by using Algorithm 2.

Step 5: From the LL sub-band, the watermark bits are extracted from the principal components of each sub-blockas

$$W'_i = \frac{(Score'_i - Score_i)}{\alpha} \quad (2)$$

Where W'_i is the watermark extracted from the i^{th} subblock

Algorithm 2:

The LL sub-band coefficients are transformed into a new coordinate set by calculating the principal components of each sub-block (size n x n).

Step 1: Each sub-block is converted into a row vector D_i with n2 elements (i=1,2…k).

Step 2: Compute the mean μ_i and standard deviation σ_i of the elements of vector D_i

Step 3: Compute a Z_i according to the following equation

$$Z_i = \frac{(D_i - \mu_i)}{\sigma_i} \quad (3)$$

Here Z_i represents a cantered, scaled version of D_i of the same size as that of D_i.

Step 4: Carry out principal component analysis on Z_i to obtain the principal component coefficient matrix coefficient.

Step 5: Calculate vector $Score_i$ as

$$Score_i = Z_i \times coeff_i \quad (4)$$

Where $Score_i$ represents the principal component scores of the i^{th} sub-block

IV. RESULTS

A 400 300 colour image is taken from video sequences as the cover image and watermark of size100 100 is embedded in to the cover image using, Hybrid DWT-PCA technique. The watermark bits are embedded with strength in to each sub band frequency. In which strength is varied in between two level i.e. minimum LEVEL (=10), maximum level (=170). The performance of the algorithm has been measured in terms of its imperceptibility and robustness against the possible attacks like Gaussian noise addition, Salt pepper noise, Cropping noise, Rotate Noise, Median filtering Noise, Contrast Adjustment Noise, Histogram equalisation etc.

Result of Proposed Watermarking Scheme

Hybrid DWT-PCA α =10

Fig5: Watermarked Frame

Fig6:Watermarked Video

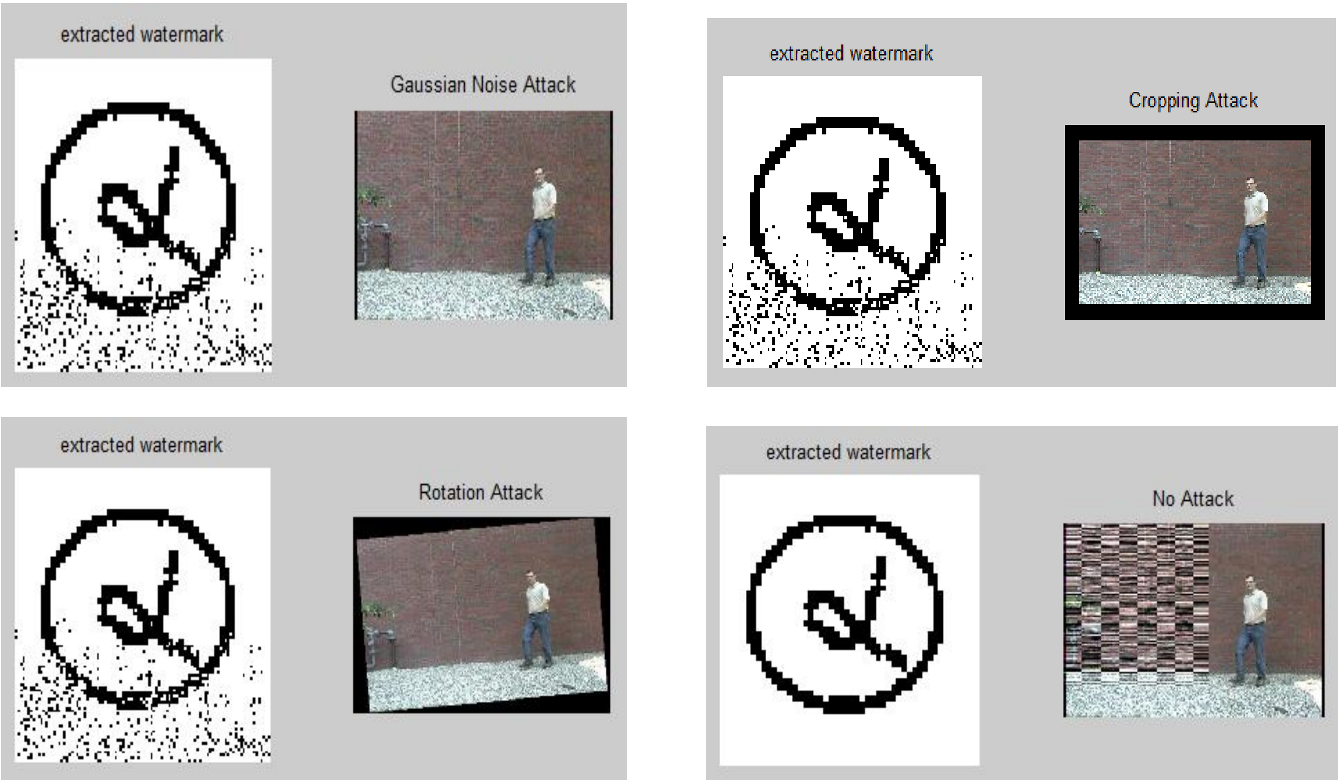


Fig 7: Video Frame after addition different Noise and Extracted watermark from watermarked frame

Hybrid DWT-PCA α =170

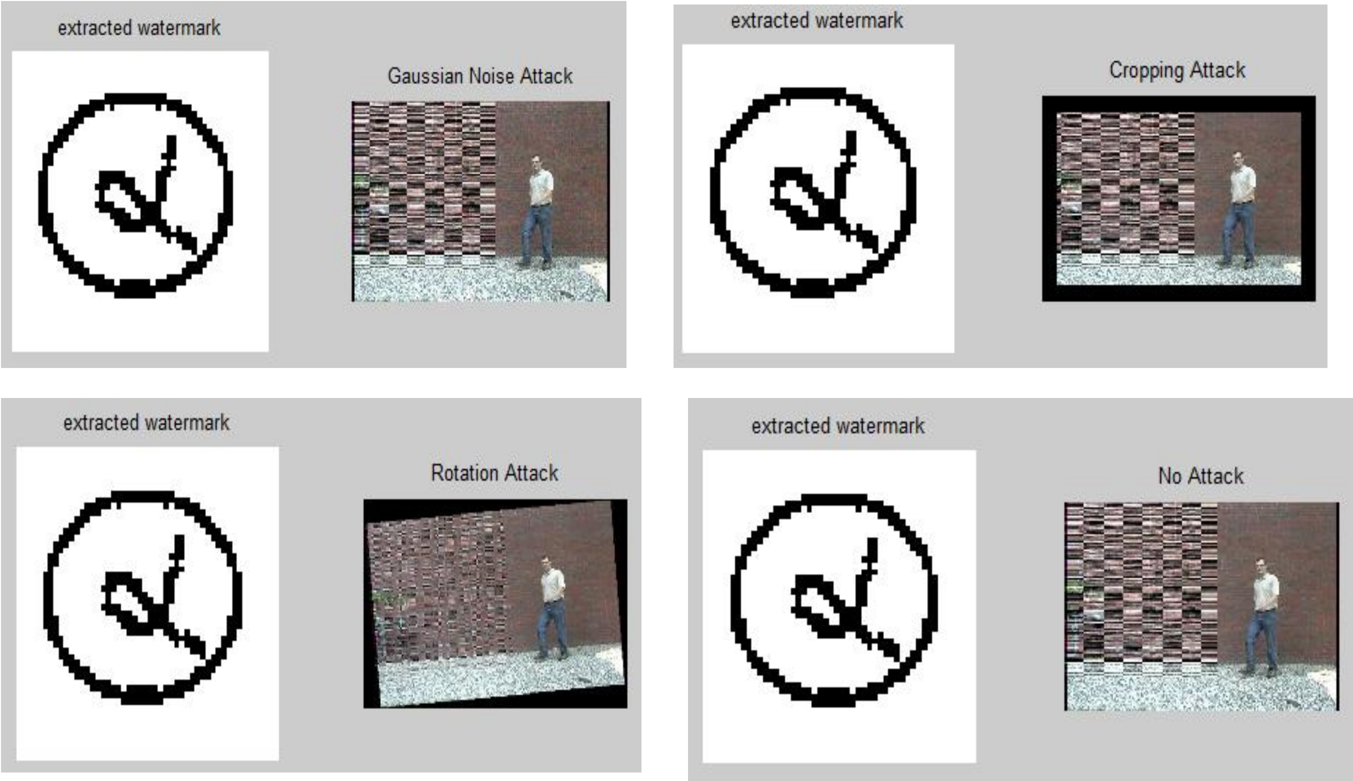
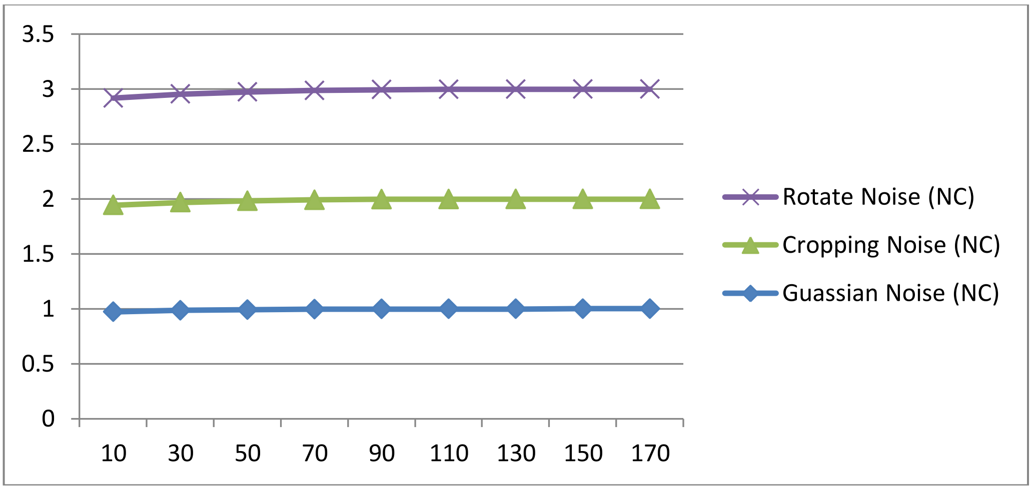


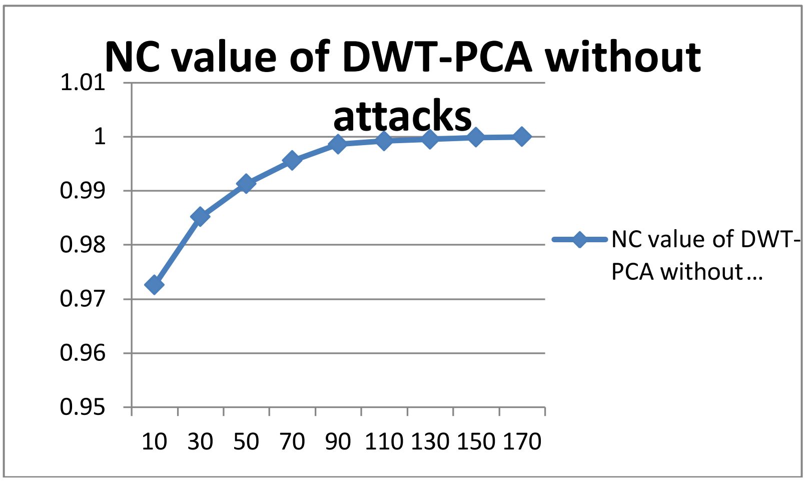
Fig 8: Video Frame after addition different Noise and Extracted watermark from watermarked frame

Table 1:NC Value of Hybrid PCA- DWT with and without different attacks

Alpha	Guassian Noise (NC) With Attack	Cropping Noise (NC) With Attack	Rotate Noise (NC) With Attack	NC value of DWT-PCA without attacks
10	0.9727	0.9726	0.9726	0.9726
30	0.9852	0.9852	0.9853	0.9852
50	0.9913	0.9913	0.9914	0.9913
70	0.9956	0.9956	0.9957	0.9956
90	0.9986	0.9986	0.9987	0.9986
110	0.9992	0.9992	0.9992	0.9992
130	0.9996	0.9996	0.9996	0.9995
150	0.9999	0.9999	1	0.9999
170	1	1	1	1



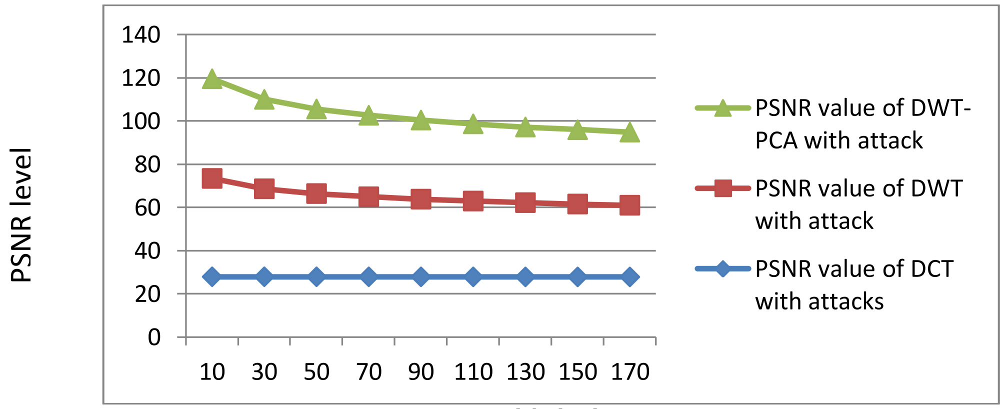
Alpha level
Fig 9: NC value of Hybrid PCA- DWT after applying different attacks.



Alpha level
Fig 10: NC value of Hybrid DWT-PCA without attacks

Table 2:PSNR value of all transforms with attacks

Alpha	PSNR value of DCT with attacks	PSNR value of DWT with attack	PSNR value of DWT-PCA with attack
10	27.9555	45.5097	46.1594
30	27.9501	40.7385	41.3811
50	27.9421	38.52	39.1695
70	27.9324	37.0588	37.7082
90	27.9211	35.9673	36.6168
110	27.9084	35.0958	35.7453
130	27.8946	34.3703	35.0198
150	27.8798	33.7488	34.3983
170	27.8642	33.2053	33.8547



Alpha level
Fig 11: PSNR value all transforms after applying different attacks.

Table 3: PSNR value of all transforms without attacks

Alpha	PSNR value of DCT Without Attacks	PSNR value of DWT Without Attacks	PSNR value of DWT-PCA Without Attacks
10	31.0693	32.7907	32.7775
30	31.061	32.9672	32.9511
50	31.0494	33.2905	33.2254
70	31.0336	33.7039	33.5668
90	31.015	34.1804	33.9334
110	30.972	34.7574	34.3225
130	30.9257	35.3976	34.7151
150	30.9003	36.15	35.0377
170	30.8743	36.9846	35.2837

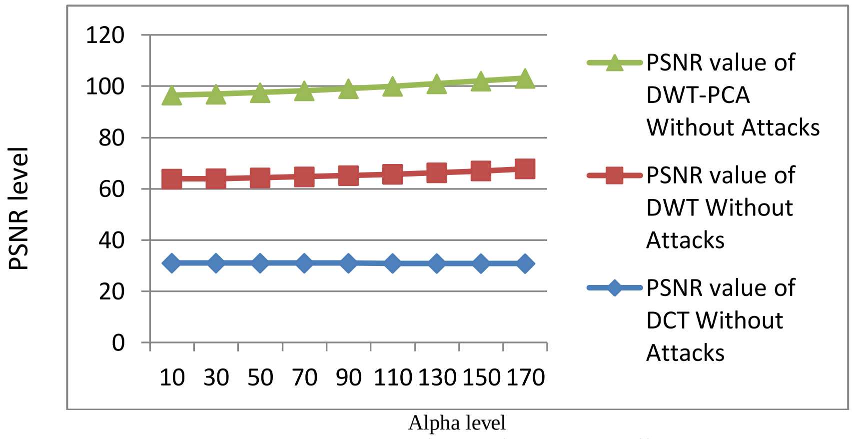


Figure 10: PSNR value all transforms before applying different attacks.

V. Conclusion

- Experimental Results shows no visible different between the watermarked video and original video. It shows robustness of the watermarked video against various attacks.
- It also shows that video watermarking can be done using three frequency transforms methods such that DCT, DWT, Hybrid DWT-PCA.
- In DCT, DWT transform technique PSNR value decreases at higher value of embedding strength, and in Hybrid DWT-PCA transform technique, there is not much decrease in PSNR value at higher value of embedding strength. NC (Normalized Correlation) value of proposed method is almost equal to one.

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