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# Digital Video Watermarking Techniques for Secure Multimedia Creation and Delivery

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## Abstract

**Due to the extensive use of digital media applications, multimedia security and the copyright protection has gained tremendous important. Digital watermarking is a technology used for the copyright protection of digital application. In this paper we have compressive approach for digital video watermarking is introduced,were watermark image is embedded in to the video frame each video frame is decomposed in to sub images using 2 level Discrete Wavelet Transform (DWT) and Principal Component Analysis (PCA) Transform is applied for each block in the two bands LL & HH.[1,2]combining the two transform improved the performance of the watermark algorithm. The scheme is tested by various attacks. Experimental result shows no visible difference between watermark frame and original video frame, it shows the robustness against a wide range of attack such as Gaussion noise, salt & pepper Noise ,median filtering , rotation, cropping etc. The Proposed scheme is tested using number of video sequences .its experimental result shows high imperceptibility where there is no noticeable difference between the watermark video frame and original video frame. Without attacking any noise on to the watermark video frame the computed normalized correlation (NC) is 1 and Peak Signal to Noise Ratio (PSNR) having high Score which is 44.097.**

**Keywords:** Digital Video Watermarking, Discrete Wavelet Transform, Principal Component Analysis, Image Watermark.

## I. Introduction

The popularity of digital video based application is accompanied by the need of copyright protection to prevent illicit copying and the distribution of digital video. Copyright protection inserts authentication such as ownership information and logo in the digital media without affecting its perceptual quality. In case of any dispute, authentications data is extracted from the media and can be used as authoritative proof of prove the ownership. Watermarking is the process that embeds data called a watermark or digital signature in to the multimedia objects such that watermark can be detected or extracted later to make an assertion about the object. Object may be image or audio or video for the purpose of copyright protection. Digital watermarking techniques must meet the criteria of imperceptibility as well as robustness against all attacks for removal of watermark[3,4].

In this paper we proposed an imperceptibility and robust video watermarking algorithm based on Discrete Wavelet Transform(DWT) and Principal Component Analysis(PCA). DWT is more computationally efficient than other transform methods like DFT and DCT. Due to its excellent sptio-frequency localization properties ,DWT is very suitable to identify areas in the host video frames where watermark can be embedded imperceptibility. It is known that even after decomposition of video frame using the wavelet transformation there exist some amount of correlation between wavelet coefficients.
PCA is basically used to hybridize the algorithm as it has inherent property of removing the correlation among the data. i.e. wavelet coefficient and it helps in distributing the watermark bits over the subbands used for embedding thus result in more robust watermarking scheme that is resistant to almost all attacks .watermark is embedded in to the luminance component of extracted System(HVS).
Paper is organized as follows Section 2 contains Proposed Watermarking Scheme, Section 3 contains different experimental result in the watermarking scheme, section 4 contain Attack Scenarios, section 5 contain attack analysis and Finally Section 4 gives the conclusion.

## II. Proposed Watermark Scheme

The proposed watermark scheme is based on combining two transform ,the DWT and the PCA. block diagram of embedding and extraction algorithm are as shown in fig.1 and Fig.2. In our method video frames are taken as input and watermark is embedded in each frames by altering the wavelet coefficient of frame by altering the wavelet coefficient of selected DWT subbands followed by performing the PCA transformation on selected subbands.

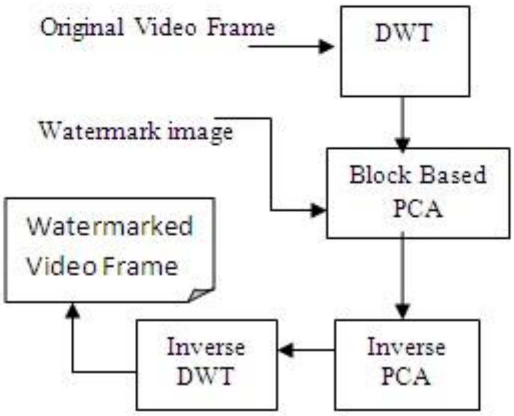


Fig.1 Watermark Embedding Algorithm

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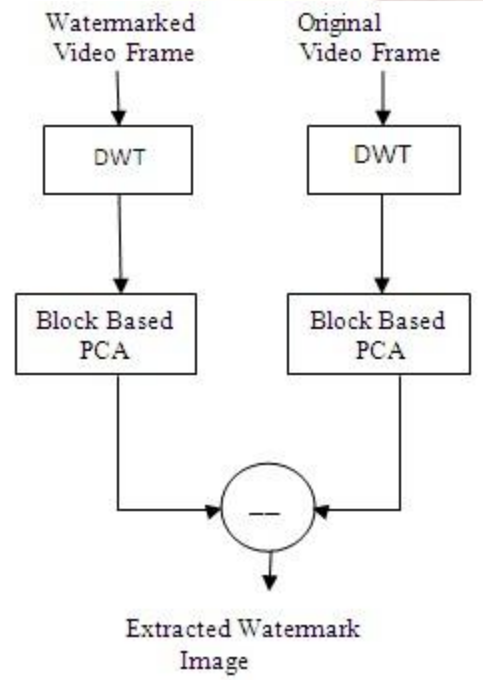


Fig.2 Watermark Extraction algorithm

### 2.1 Discrete Wavelet Transform

The DWT is more popular in signal processing applications. 2D Discrete Wavelet Transform (DWT) decomposes an video frames in to sub images,3 details and 1 approximation. The approximation sub images is lower resolution approximation image(LL) however the details sub images are horizontal (HL), vertical(LH) and diagonal (HH) detail components. The main advantage of wavelet transform is its compatibility with model aspect of the Human Visual System(HVS) as compared to FFT or DCT. In the proposed algorithm sub bands LL and HH from resolution level 2 of wavelet transform of the frame are chosen for embedding process. The following figure shows the selected DWT bands which used in our proposed algorithm. Embedding the watermark in low frequencies obtained by wavelet decomposition increases the robustness against attacks like filtering, lossy compression, and geometric distortion while making scheme more sensitive to contrast adjustment, gamma correction and histogram equalization. embedding the watermark in high frequency sub bands makes the watermark more imperceptible while embedding in low frequencies makes it more robust against variety of attacks.

## III. Principal Component Analysis

Principal Component Analysis(PCA) is a mathematical procedure that uses the orthogonal transformation to convert a set of observations of possible correlated variables in to set of values of uncorrelated variables called Principal Component. The number of principal component is less than or equal to the number of the original variables. PCA is a method of identifying patterns in data, and expressing the data in such a way that so as to highlight their similarities and differences .PCA is a powerful tool for analyzing data and other main advantages of PCA is that once these pattern in data have been identified , the data can be compressed by reducing the number of dimensions ,without much loss of information[7,8].

## IV. Watermark Embedding

The proposed watermark embedding process as shown in fig.1 is briefly describe in the following.

Steps1: Divide the video frame and convert 2N x 2N RGB frames in to YUV components.

Steps2: For each frame ,choose the luminance Y component and apply DWT to decompose the Y frames in to four multiresolution sub bands NxN: LL,HL,LH,HH.

Step3: Divide the two sub bands LL and HH in to n x n non overlapping blocks.

Step4: Apply PCA to each block in the chosen subbands LL and HH.

Step5: Convert the 50x50 watermark logo in a vector $W=\{w_1,w_2 \ldots\ldots w_{50x50}\}$ for 0 & 1.

Step6:Embed the logo in to LL and HH bands with the help of DWT and PCA for HH band,the watermark bits are embedded.

Step7: for HH band use embedded the watermark bit W.

Step8: Apply inverse PCA on the modified PCA component of the two-bands to obtain modified wavelet coefficient.

Step9: Apply inverse DWT to produce the watermarked luminance component of the frame then the reconstruct the watermarked frame.

## V. Watermark Extraction:

Watermark extraction process as shown in fig.2 is the inverse procedure of the watermark embedding process .The proposed algorithm is non blind

algorithm so original video sequence and watermark is nothing but the user secrete key are required .
The watermark extraction process as follows:

Step1: Convert the watermark (and may be attack) video in to frames and convert the 2Nx2N RGB frames in to YUV components.

Step2: For each frame, choose luminance Y component and apply the DWT to decompose the Y frames in to four multiresolution subbands NxN.

Step3: Divide the subbands LL and HH in to nxn nonoverlaping blocks.

Step4: Apply PCA to each block in chosen subbands LL and HH.

Step5: Convert 50x50 watermark logo in to a vector $W=\{w_1,w_2\ldots\ldots\ldots\ldots w_{50x50}\}$ for 0 & 1.
Step6: watermark is extracted by following way as

$$Wx = \frac{(V - V')}{\alpha} \qquad (1)$$

where
V = Original Video Frame after applying DWT and PCA.
V' = Watermark Video Frame after applying DWT and PCA.
α = Watermark strength.
Step7: After extracting the watermark frame LL and HH bands, similarly measurement of extracted watermark $W'_E$ and reference watermark $W_R$ are used for the objective judgment of the extraction fidelity NC which is given by

$$NC = \frac{\sum_i \sum_j w(i,j)\, w'(i,j)}{\sqrt{\sum_i \sum_j W(i,j) \sum_i \sum_j W(i,j)}} \qquad (2)$$

Where NC is normalized correlation whose peak value is 1.
i.e NC value is 1 when original watermark and extracted watermark are identical and zero if the original watermark and extracted watermark are different from each other.

## VI. Experimental results

The proposed algorithm is applied to a sample video sequence 'foreman.qcif' using watermark logo 'M8.bmp' whose size is 50x50.here we have taken gray scale logo a below figure shows the original watermark and the extracted watermark , in fig.4(a) and 4(b) respectively. Fig.5(a) and 5(b) shows original video frame as well as watermarked video frame respectively

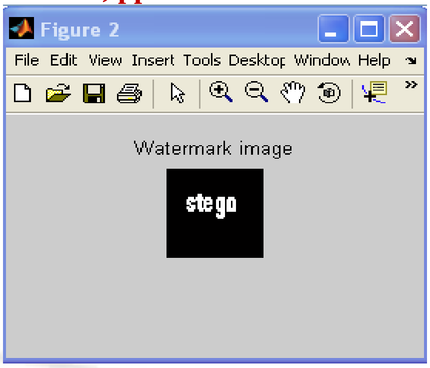

Fig.4(a) Original Watermark

Fig.4(b) Extracted Watermark
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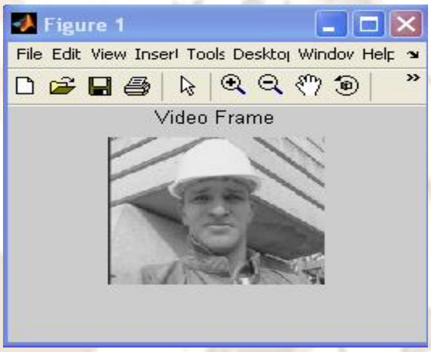


Fig.5(a) Original Video Frame

Fig.5(b) Watermarked Video Frame

The performance of the algorithm has been measured in terms of its imperceptibility and against possible attacks like noise addition, filtering, and geometric attack etc.
A number of video sequence are used for testing the proposed scheme. for example foreman video sequence for evaluating the performance of any

watermarking system, Peak Signal to Noise Ratio(PSNR) is common Measure of visual quality of watermarking system. To calculate the PSNR, first the Mean Square Error (MSE) between the original and watermarked video frame is computed as follows.

$$MSE = \sum_{i=1}^{M}\sum_{j=1}^{N}[\, I(i,j) - I'(i,j)]^2 \quad (3)$$

Where M,N are the size of the frame and I( i , j), I'( i , j) are the pixel value at location ( i ,j) of the original and watermarked video frame. Then Peak Signal to Noise Ratio is define as:

$$PSNR = 10\ log \frac{255^{\ 2}}{MSE} \quad (4)$$

The Luminance component of the first 115 frames of the Foreman Video Sequences are watermarked ,the watermarked frame size is 176x144. The watermark image with size 50x50.

The original sample frame and its corresponding watermarked frame are shown in fig.5(a) and 5(b). The measured PSNR is 44.21db and the watermarked frame appears identical to the original. The value of PSNR is constant over all tested frame which means that the error between the original and watermarked frame is very low so high visual quality is obtained. Fig.4(a) and Fig.4(b) shows that original embedding watermark and the extracted watermark from LL band HH band were no attacks were applied. The measured value of NC is 1 for both LL and HH band i.e. extracted watermark is identical to the original and exact extraction is obtained.

Fig.6 and Fig.7 shows the watermarked video frame after addition of ‘salt and pepper noise’ ‘Gaussian’ noise respectively

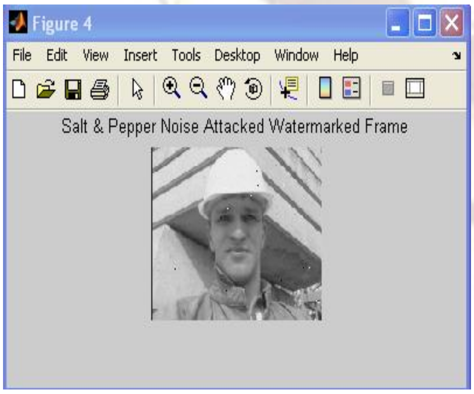



Figure 6. Video Frame after addition of ‘salt and pepper’ Noise


Figure 7. Video Frame after addition of gaussian Noise

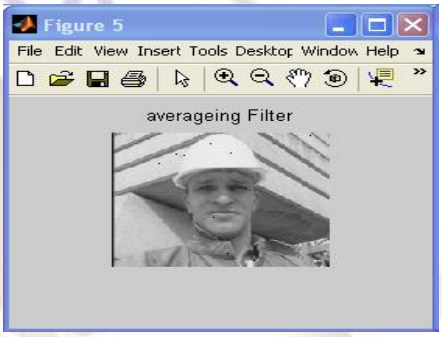



Figure 8. Video Frame after Median Filtering

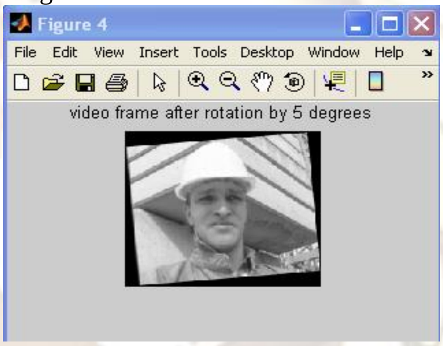



Figure 9.Video Frame after rotation by 5 degrees.


Figure 10.Video Frame after Cropping

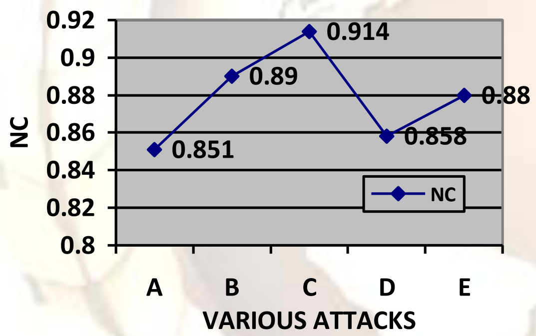
Fig. 8 shows the effect of the effect of the median filtering. Fig.9 shows the effect of carrying out video frame rotation by 5 degrees. Fig. 10 shows the cropped video frame. In case of geometric attack we test the scheme against frame rotation ,and frame cropping. The result shows that the watermark is totally recovered in the same way rotate and cropping of the frame gives the result. From the result ,the scheme is not robust against frame rotation and frame cropping which will be investigated in future.

In our proposed scheme we have embedding the watermark in to the original frame and to obtain the watermarked video frame without any noise and other hand we have extract the watermark to measure its imperceptibility property(PSNR) & Robustness (NC). Bellowing Table.1 shows NC of the Video Frame without embedding the watermark and watermark embedding video frame.

Table.1 NC of video Frame and watermarked video frame.

| Parameter | PSNR(dB) | NC |
|---|---|---|
| Video Frame | 44.21 | 1 |
| Watermarked Video Frame | 19.83 | 0.914 |

**Fig.12 Result Analysis of Various attacks on Watermarked Video Frame**




The Following Table.2 shows the value of the data collected from the watermark video after performing the various attacks as shown previously

**Table.2 Result Analysis**

| **Attacks** | **Extracted Watermark** | |
|---|---|---|
| | **PSNR(dB)** | **NC** |
| **Salt & Pepper Noise** | **34.59** | **0.851** |
| **Gaussian Noise** | **43.32** | **0.890** |
| **Median Filtering** | **44.21** | **0.914** |
| **Rotation** | **17.75** | **0.858** |
| **cropping** | **18.42** | **0.880** |

From the Fig.12 notations A as salt and pepper noise, B as Gaussian noise , C as Median Filtering, D as Rotation and Finally E as Cropping noise respectively.

## VII. Attack Scenarios

DWT and PCA inherit many advantages in resisting the attacks on the watermarked frames. It achieves perceptual invisibility and can resist attacks by image processing techniques. To test the robustness of watermark , different attacks were mounted on watermarked video. The embedded watermark was retrieved using proposed algorithm and NC value of recovered watermark was recorded for different attacks scenarios. With reference to above graph Fig.12 NC values for all attacks scenarios are well above 0.6 and guarantees the robustness of the proposed scheme.

## VIII. Attack Analysis

The Video watermarking scheme is robust against the video specific attacks like salt and pepper noise, Gaussian noise,median filtering ,rotation, cropping,median filtering. To analysis the performance the various attacks with the help of the following graph which shows that the result analysis of various attacks on watermark video frame. It was observed that the proposed scheme shows great robustness than the earlier DWT based scheme. Table 3 shows Attack Analysis of the proposed Scheme compare with earlier method so we clear here our system is more robust video watermarking scheme on various attacks.

It was observed that the proposed scheme shows great robustness than the previous scheme. The algorithm ability to make the watermark resistant to these attacks was analyzed and better results were inferred from the graph.

**Table.3 Attack Analysis**

| **Attacks** | **Extracted Watermark** | |
|---|---|---|
| | **NC(Proposed)** | **NC(Previous)** |
| **Salt & Pepper Noise** | **0.851** | **0.6548** |
| **Gaussian Noise** | **0.890** | **0.6861** |
| **Median Filtering** | **0.914** | **0.5771** |
| **Rotation** | **0.858** | **0.6510** |
| **Cropping** | **0.880** | **0.6801** |

## IX. Conclusion

The algorithm implemented using DWT-PCA is robust and imperceptible in nature and embedding the watermark in LL sub band helps in increasing the robustness of embedding procedure without much degradation in the video quality.

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