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ADVANCED DIGITALVIDEO WATERMARKING USING DWT WITH PCA

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Abstract: **This paper presents a technique for embedding watermark into video frames. The proposed scheme is an imperceptible and a robust hybrid video watermarking scheme. PCA is applied to each block of the two bands (LL – HH) which result from Discrete Wavelet transform of every video frame. The watermark is embedded into the principal components of the LL blocks and HH blocks in different ways. Combining the two transforms improved the performance of the watermark algorithm. The scheme is tested by applying various attacks. Experimental results show no visible difference between the watermarked frames and the original frames and show the robustness against a attacks.**

Key words- Discrete Wavelet Transform, LL-HH, Pricipal Components Analysis,Video watermarking.

1. INTRODUCTION

The popularity of digital video based applications [1] is accompanied by the need for **copyright protection** to prevent illicit copying and distribution of digital video. Copyright protection inserts authentication data such as ownership information and logo in the digital media without affecting its perceptual quality. In case of any dispute, authentication data is extracted from the media and can be used as an authoritative proof to prove the ownership. As a method of copyright protection, digital video watermarking [2, 3] has recently emerged as a significant field of interest and a very active area of research. Watermarking is the process that embeds data called a watermark or digital signature into a multimedia object such that watermark can be detected or extracted later to make an assertion about the object. The object may be an 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 [4-6] for removal of the watermark.

Many digital watermarking schemes have been proposed for still images and videos [7]. Most of them operate on uncompressed videos [8-10], while others embed watermarks directly into compressed videos [8, 11]. The work on video specific watermarking can be further found in [12-15]. Video watermarking introduces a number of issues not present in image watermarking. Due to inherent redundancy between video frames, video signals are highly susceptible to attacks such as frame averaging, frame dropping, frame swapping and statistical analysis.

Video watermarking approaches can be classified into two main categories based on the method of hiding watermark bits in the host video. The two categories are:

Spatial domain watermarking where embedding and detection of watermark are performed by directly manipulating the pixel intensity values of the video frame. Transform domain [16-18] techniques, on the other hand,alter spatial pixel values of the host video according to a pre-determined transform and are more robust than spatial domain techniques since they disperse the watermark in the spatial domain of the video frame making it difficult to remove the watermark through malicious attacks like cropping, scaling, rotations and geometrical attacks. The commonly used transform domain techniques are Discrete Fourier Transform (DFT), the Discrete Cosine Transform (DCT), and the Discrete Wavelet Transform (DWT).

In this paper, we propose an imperceptible and robust video watermarking algorithm based on Discrete Wavelet Transform (DWT) [19-25] and Principal Component Analysis (PCA) [26-27]. DWT is more computationally efficient than other transform methods like DFT and DCT. Due to its excellent spatio-frequency localization properties, the DWT is very suitable to identify areas in the host video frame where a watermark can be embedded imperceptibly. It is known that even after the decomposition of the video frame using the wavelet transformation there exist some amount of correlation between the wavelet coefficients. PCA is basically used to hybridize the algorithm as it has the inherent property of removing the correlation amongst the data i.e. the wavelet coefficients and it helps in distributing the watermark bits over the sub-band used for embedding thus resulting in a more robust watermarking scheme that is resistant to almost all possible attacks. The watermark is embedded into the luminance component of the extracted frames as it is less sensitive to the human visual system (HVS).

2. Proposed Watermarking Scheme

The proposed hybrid watermarking scheme is based on the combination of DWT and PCA.

2.1 Discrete Wavelet Transform

The DWT is used in a wide variety of signal processing applications [23]. 2-D discrete wavelet transform (DWT) decomposes an image or a video frame into subimages, 3 details and 1 pproximation. The approximation sub image is lower resolution approximation image (LL) however the details sub images are horizontal (HL), vertical (LH) and diagonal (HH) detail components. The process can then be repeated to compute multiple "scale" Wavelet decomposition. The main advantage of the wavelet transform is its compatibility with a model aspect of the HVS as compared to the FFT or DCT. This allows us to use higher energy watermarks in regions that the HVS is known to be less sensitive, such as the high resolution detail bands. Embedding watermarks in these regions allow us to increase the robustness of our watermark without any visible impact on the image quality. In the proposed algorithm, sub-bands LL and HH from resolution level 2 of the wavelet transform of the frame are chosen for the embedding process. The following figure shows the selected DWT bands which used in our proposed algorithm.

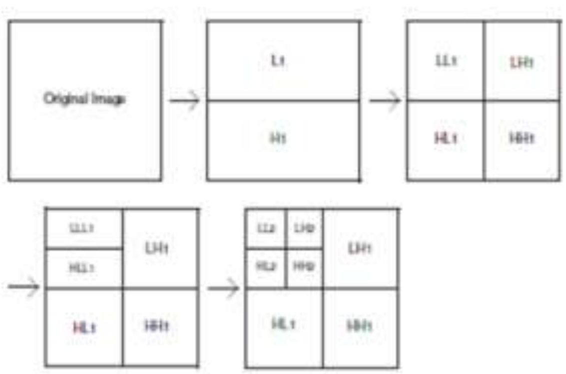

Fig 1. Scheme of decomposition up to the second level

2.2 Principal Component Analysis

Principal component analysis (PCA) is a mathematical procedure that uses an orthogonal transformation to convert a set of observations of correlated variables into a set of values of uncorrelated variables called principal components. PCA 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 first principal component has the maximum energy concentration [24].The diagram in Fig. 2 shows the embedding and extraction process of the watermark. In the proposed scheme, a binary image is embedded in the LL DWT sub-bands of level 2 of each decomposed frame in the video. Also, the same binary image is embedded in the HH DWT sub-band of level 2 of each decomposed frame. Embedding the watermark in both LL and HH makes the scheme robust to a variety of low and high frequency characteristic attacks. The extraction procedure of the watermark is similar to the embedding one.

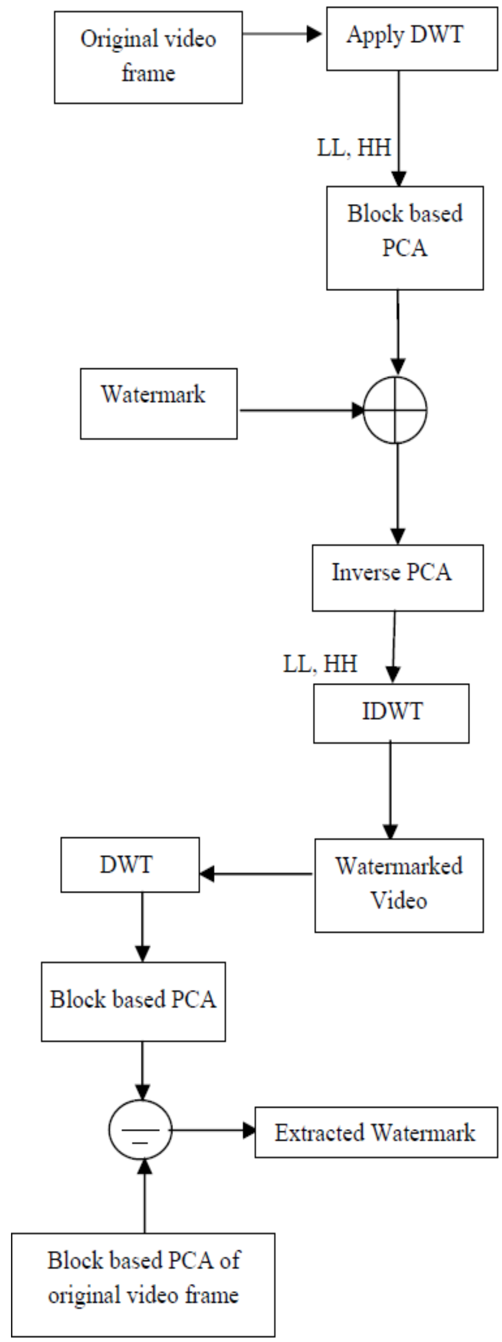

Fig. 2 Watermark embedding and extraction algorithm.

2.3 Algorithms for watermarking using DWT AND PCA

Algorithm 1:

a) Embedding Procedure

Step 1: Convert the n × n binary watermark logo into a vector W = { w1, w2 , w3…………, 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 α into each sub-block by first obtaining the principal component scores by Algorithm 2. The embedding is carried out as equation 1.

$$score_i' = score_i + \alpha W \quad (1)$$

where $score_i$ represents the principal component matrix of the ith sub-block.

Step 7: Apply inverse PCA on the modified PCA components 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.

b) 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 nonoverlapping 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-block as in equation 2.

$$W_i' = \frac{(score_i' - score_i)}{\alpha}$$

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 Z_i according to the following equation

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

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

Step 4: Carry out principal component analysis on z_i (size 1 x n^2) to obtain the principal component coefficient matrix coeffi (size $n^2 \times n^2$).

Step 5: Calculate vector i score as

$$score_i = Z_i \times coeff_i$$

where $score_i$ represents the principal component scores of the ith sub-block.

3. EXPERIMENTAL RESULTS

The proposed algorithm is applied to a sample video sequence using a 32 × 32 watermark logo.

PSNR : The Peak-Signal-To-Noise Ratio (PSNR) is used to deviation of the watermarked and attacked frames from the original video frames and is defined as:

$$PSNR = 10Log_{10}(255^2 / MSE)$$

where **MSE** (mean squared error) between the original and distorted frames (size m x n) is defined as:

$$MSE = (1/mn)\sum_{i=1}^{m}\sum_{i=1}^{n}[I(i,j) - I'(i,j)]$$

where I and I′ are the pixel values at location (i, j) of the original and the distorted frame respectively. Higher values of PSNR indicate more imperceptibility of watermarking. It is expressed in decibels (dB).

NC : The normalized coefficient (NC) gives a measure of the robustness of watermarking and its peak value is 1.

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

where W and W′ represent the original and extracted watermark respectively. After extracting and refining the watermark, a similarity measurement of the extracted and the referenced watermarks is used for objective judgment of the extraction fidelity. The following images represent stills taken from the watermarked video in after attacks have been carried on it.

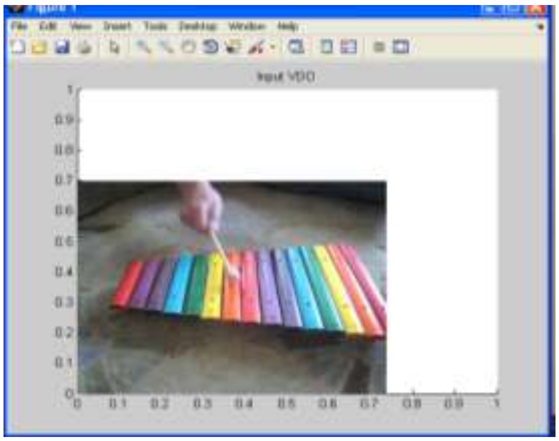

Fig 3.1 Input Video

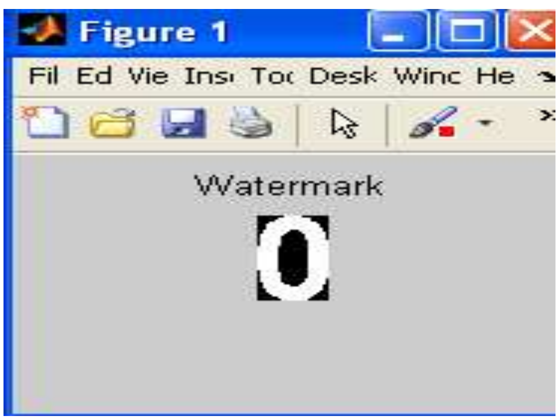

Fig 3.2 Insert Watermark

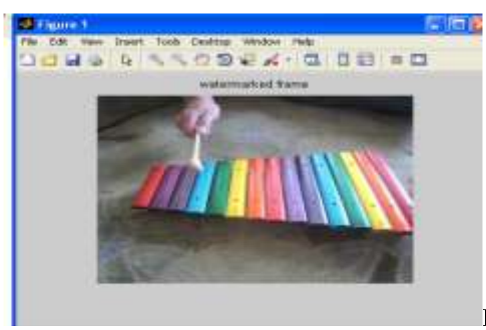

Fig 3.3 Watermarked Frame

Fig 3.4 Extracted Watermark

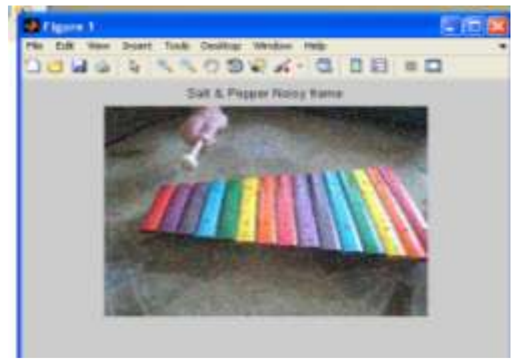

Fig 3.5 Video Frame After Addition Of Noise ‘Salt And Pepper’ Noise

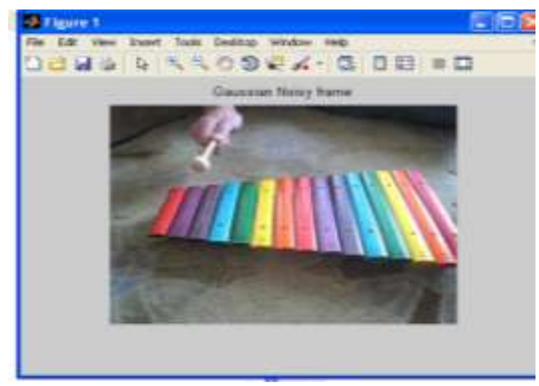

Fig 3.6video Frame After Addition Of Gaussian Noise

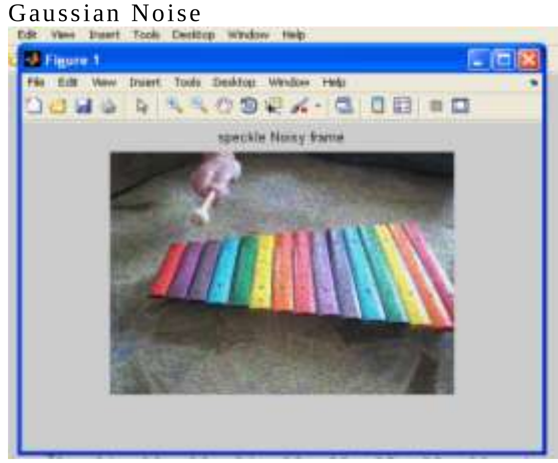

Fig 3.7 Video Frame After Addition Of Speckle Noise

Result Analysis

1) DWT AND DWT WITH PCA

	MSE	PSNR	NC
DWT WITH PCA	1.5090	46.3439	1.0000

2) ATTACK OF NOISE ON VIDEO

DWT With PCA	MSE	PSNR	NC
Normal Video	1.5090	46.3439	1.0000
Gaussian Noise	3.8807	42.2417	0.9934

IV. CONCLUSION

The algorithm implemented using DWT-PCA is robust and imperceptible in nature and embedding the binary watermark in the low LL sub band helps in increasing the robustness of the embedding procedure without much degradation in the video quality. As a future work thevideo frames can be subject to scene change analysis to embed an independent watermark in the sequence of frames forming a scene, and repeating this procedure for all the scenes within a video.

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