DWT AND PCA BASED DIGITAL VIDEO WATERMARKING

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Due to the extensive use of digital media applications, multimedia security and copyright protection has gained tremendous importance. Digital Watermarking is a technology used for the copyright protection of digital applications. In this project, a comprehensive approach for watermarking digital video is introduced. We propose a hybrid digital video watermarking scheme based on Discrete Wavelet Transform (DWT) and Principal Component Analysis (PCA). 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. The imperceptible high bit rate watermark embedded is robust against various attacks that can be carried out on the watermarked video, such as filtering, contrast adjustment, noise addition and geometric attacks.

I. INTRODUCTION

The watermarking algorithm basically utilizes two mathematical techniques: DWT and PCA. The significance of using these techniques in watermarking has been explained first.

1.1 Discrete Wavelet Transform:

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 (Fig. 1) 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.

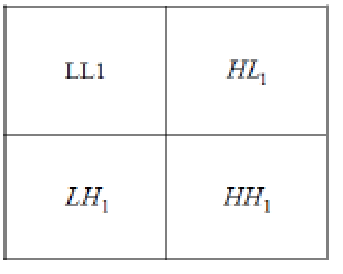


Figure 1: DWT sub-bands

1.2 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. 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 following block diagram shows the embedding and extraction procedure of the watermark. 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.

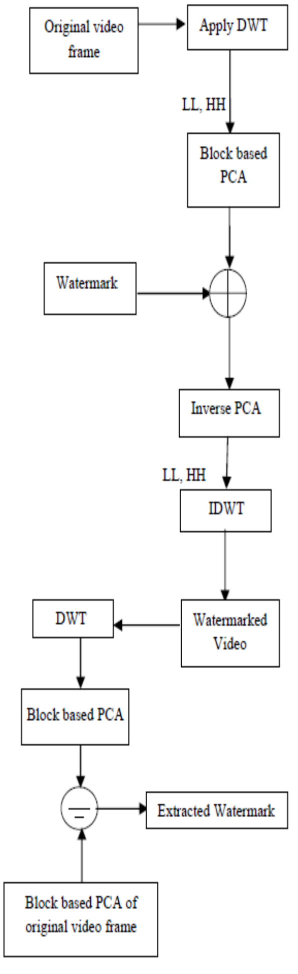


Figure2: Diagram of Watermarking

II. ALGORITHMS FOR WATERMARKING

2.1 Algorithm 1:

(a)Embedding Procedure

Step 1: Convert the n × n binary watermark logo into a 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 color 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

$$score_i^{'} = score_i + \alpha W \qquad (1)$$

Where i score 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 non 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-block as in equation 2.

2.2 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.

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

Here Z_i represents a centered, scaled version of, of the same size as that of D_i.
Step 4: Carry out principal component analysis on Z_i (size 1 x n2) to obtain the principal component coefficient matrix coeffi (size n2 × n2).
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 ith sub-block.

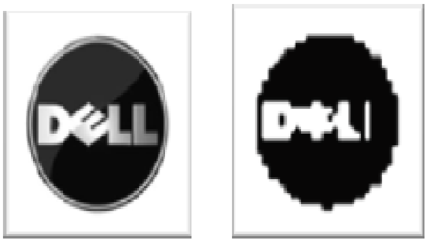
III. EXPERIMENTAL RESULTS

(a)

Figure: 3(a) Original Video frame

(b)

Figure: 3 (b) Watermarked video



(a) (b)

Figure: 4 (a) Original watermark (b) Extracted binary watermark

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:

$$PSNR = 10Log_{10}(255^2 / MSE) \quad (5)$$

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

$$MSE = (1/mn)\sum_{i=1}^{m}\sum_{j=1}^{n}[I(i,j) - I'(i,j)] \quad (6)$$

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.

$$NC = \frac{\sum_i\sum_j W(i,j)\cdot W'(i,j)}{\sqrt{\sum_i\sum_j W(i,j)}\sqrt{\sum_i\sum_j W'(i,j)}} \quad (7)$$

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 table shows the value of the data collected from the watermarked video after performing the various attacks as shown previously

TABLE :RESULT ANALYSIS

Attack	PSNR	NC
GAUSSIAN NOISE	31.1564	0.6861
SALT & PEPPER NOISE	24.4592	0.6548
CROPPING	28.3373	0.6801
ROTATION	28.8256	0.6510
RESIZING	41.4628	0.6068
MEDIAN FILTERING	39.1676	0.5771
GAMMA CORRECTION	24.0749	0.5913
SHARPENING FILTER	40.0710	0.5313
CONTRAST ADJUSTMENT	32.4420	0.5192
AUTOMATIC EQUALIZATION ATTACK	46.4597	0.6540

IV. REFERENCES

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