High Capacity Video Watermarking based on DWT-DCT-SVD

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Abstract – **In this paper, a new non-blind high capacity video watermarking algorithm based on DWT, DCT and SVD has been proposed. In this method, the watermarking data can be embedded in singular values of DCT coefficients of middle and high frequency subbands (LH, HL, HH) in DWT domain of selected group of frames. The embedded watermarks are extracted with inverse process of embedding. The amount of watermark insertion is controlled by the Peak Signal to Noise Ratio and Mean square error of the watermarked frame with original frame. Experimental results show that the watermarked video is indistinguishable from original video and also state that the proposed algorithm is imperceptible with a good watermark capacity at various scaling factors. From the results, the effect of scaling factor on video quality is clearly observed. The similarity between inserted and extracted watermark is estimated by correlation factor. The further extension of selected method was presented in conclusion.**

Index Terms **– DCT, DWT, SVD, *W*atermark**

I. INTRODUCTION

These days, with the advent of digital television, the usage of DVDs and the transfer of video files show the importance of digital video. Since digital video can be rapidly manipulated, reproduced and distributed over information networks, necessary techniques are required for copyright protection. Technical solutions for copyright protection of multimedia data are being pursued. Digital watermarking has been identified as a means to identify the owner and distribution path of digital data. The watermark is embedded and extracted as per the requirement. Digital video is a sequence or collection of consecutive still images. The amount of information that can be embedded in the video sequence is called payload. In reality, video watermarking techniques need to meet other challenges than that in image watermarking schemes such as large volume of inherently repeated sequence of data between frames.

The watermarking can be done either in spatial domain or transform domain [1]. Spatial domain technique embeds the watermark by directly modifying the pixel values of the original data. In transform domain technique, the watermark will be embedded by modifying the transform coefficients of the host data. In the transform domain the manipulation of watermark is more difficult than in spatial domain. This is due to the fact that when image is inverse transformed watermark is distributed irregularly over the host image which makes the attacker difficult to read and modify. All the watermarking techniques should satisfy the basic requirements as watermark perceptual invisibility and watermark robustness against various modifications while preserving the desired image quality [2]. The applications of video watermarking are copyright protection, Broadcast monitoring, Video authentication, Finger printing and copy control.

The most universally used transform domain techniques are Discrete Wavelet Transform (DWT), Discrete Cosine Transform (DCT), Discrete Fourier Transform (DFT) and Singular Value Decomposition (SVD). DWT technique separates the image into multi resolution approximation and detail bands like low resolution approximations (LL), horizontal (HL), vertical (LH), diagonal (HH) detail components. This process can be repeated to compute multiple scale wavelet decomposition. The advantage of DWT is that higher energy watermarks can be embedded in high resolution regions (HL, LH, HH) to which HVS is less sensitive [3] – [5]. In DCT domain, few coefficients are used for excellent signal approximations. We can easily select the regions for embedding, as frequency components are arranged in a sequence from low frequency, mid frequency and high frequency [6]. SVD is a powerful numeric analysis tool for matrices which gives minimum least square truncation error [7]. The main characteristics of SVD are singular values of an image have good stability and Singular values represent intrinsic algebraic image properties.

In this paper, we focused on hybrid frequency domain invisible watermarking method using all merits of DWT, DCT and SVD techniques.

II. PROCEDURE FOR EMBEDDING AND EXTRACTION

This section elaborates the embedding of watermark into original video and extraction of embedding data from watermarked video.

A. Watermark embedding

The steps for Embedding procedure are as follows:

1. The original video is partitioned into groups of P frames
2. R, G, B planes are isolated from each frame of the original video.
3. Each plane of the frame is decomposed using DWT into bands of different frequencies.
4. The DCT is performed on selected high and middle frequency bands to get DCT transformed coefficients.
5. Singular values are obtained by applying SVD to DCT coefficients.
6. R, G, B planes of individual watermarks also separated.
7. DWT is applied on each plane of the individual watermarks to decompose into different frequency bands.
8. DCT is applied on middle and high frequency bands.
9. SVD is performed on DCT coefficients to obtain singular values.

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10. Now the singular values of R, G, B planes of each frame in video are modified with singular values of R, G, B planes of individual watermarks at chosen scaling factor. Watermarked frame is obtained by using the following :
    $M(i, j) = S_o(i, j) + \alpha * S_w(i, j)$

11. Inverse SVD is applied to get modified matrix using orthogonal matrices.
12. Inverse DCT is performed on modified SVD matrices.
13. Watermarked frame is attained by applying Inverse DWT to coefficients obtained in step 12.
14. These steps are repeated for embedding the individual watermarks in each group of P frames.
15. PSNR values are estimated between watermarked and original video frames.

With this algorithm, we are able to embed the maximum capacity of watermark without degrading the quality of watermarked video.

B. Watermark detection

The extraction process requires the original data to detect the watermark. The extraction steps are as follows:

1. The watermarked video is divided into groups of P frames.
2. R, G, B planes are separated from watermarked frame of video.
3. DWT is applied to R, G, B planes of each video frame to get decomposed frequency bands.
4. High energy compaction coefficients are acquired by performing DCT on selected frequency bands.
5. Modified singular values are secured by applying SVD on DCT coefficients.
6. Singular values of watermark is obtained by using the following :
   $S_w(i, j) = (M(i, j) – S_0(i, j)) / \alpha$

7. Inverse SVD is applied by using orthogonal matrices of original watermarks.
8. Inverse DCT is performed.
9. Watermark is extracted by applying inverse DWT on all approximation and transformed detailed coefficients.
10. The above steps are repeated for each group of frames to extract different individual watermarks.
11. Correlation factors are estimated between extracted and embedded watermarks.

III. RESULTS AND DISCUSSIONS

Simulations are performed to evaluate the performance of algorithms. The short video of 120 frames long and 256X256 pixels per frame in avi format as shown in Fig.1 were used in our research. The embedding watermark images of size 256X256 which we used in our experimentation are shown in Fig. 2. Watermarked videos are exposed in Fig. 3 and Fig. 4 at scaling factors α = 0.01and 1. The degradation of watermarked video at scaling factor 1 is observed in Fig. 4. The extracted watermarks are displayed in Fig. 5.

The effectiveness of proposed algorithm is illustrated in Table 1 at various scaling factors for short video frames with individual watermarks. These research results narrate that the imperceptibility of proposed algorithm is effective over the specified range of scaling factor.

The imperceptibility of watermark video is evaluated by calculating peak signal to noise ratio (PSNR) between watermarked and original frames of selected video.

$$PSNR = 20\log\left(\frac{255}{\sqrt{MSE}}\right) \quad (1)$$

$$MSE = \frac{1}{MN}\sum_i\sum_j (X(i,j) - X(i,j))^2 \quad (2)$$

And the similarity measurement between extracted and original watermarks is used for objective judgment of the extraction fidelity and it is defined as correlation factor (CF).

$$CF = \frac{\sum_i\sum_j W(i,j)W^l(i,j)}{\sum_i\sum_j (W(i,j))^2} \quad (3)$$

The correlation factors obtained for various logo images are shown in Table 2 and the embedded and extracted logo images in each set of frames are shown in Fig. 6 (a - j).

Table 1. MSE and PSNR values for watermarked short video with high energy watermarks

Watermark images	α = 0.01		α = 0.05		α = 0.1		α = 0.5		α = 1	
	MSE	PSNR	MSE	PSNR	MSE	PSNR	MSE	PSNR	MSE	PSNR
baboon	0.0190	65.3348	0.4759	51.3554	1.9037	45.3348	47.5922	31.3554	190.368	25.3348
barbara	0.0109	67.7499	0.2729	53.7705	1.0917	47.7499	27.2916	33.7705	109.166	27.7499
squirrel	0.0145	66.2820	0.3627	52.5352	1.4508	46.5146	36.2710	32.5352	145.084	26.5146
lena	0.0077	69.2820	0.1918	55.3026	0.7672	49.2820	19.1790	35.3026	076.715	29.2820
svu logo	0.0412	61.9828	1.0298	48.0034	4.1191	41.9828	102.977	28.0034	411.911	21.9828
mahal	0.0415	66.5169	0.3625	52.5375	1.4501	46.5169	36.2516	32.5375	145.006	26.5169
moon	0.0036	72.5876	0.0896	58.6082	0.3548	52.5876	08.9589	38.6082	035.835	32.5876
snist logo	0.0907	58.5538	2.2680	44.5744	9.0720	38.5538	226.800	24.5744	907.201	18.5538
peppers	0.0098	68.2325	0.2442	54.2531	0.9769	48.2325	24.4217	34.2531	097.686	28.2325
jntu logo	0.0193	65.2829	0.4817	51.3035	1.9266	45.2829	48.1651	31.3035	192.660	25.2829

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Fig. 1 Original video (short video.avi)

Fig. 2 Embedding watermark images (logos)

Fig. 3 Watermarked video (α = 0.01)

Fig. 4 Watermarked video (α = 1)

Fig. 5 Extracted watermark images (logos)

Table 2. CF values between embedded and extracted watermarks

Watermark images	CF
baboon	0.9320
barbara	0.9801
squirrel	0.9806
lena	0.9838
svu logo	0.9687
mahal	0.9468
moon	0.9971
snist logo	0.9674
peppers	0.9827
jntu logo	0.9906

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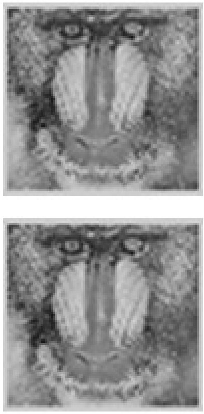
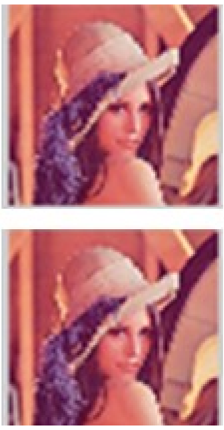


(a) CF = 0.9320

(b) CF = 0.9801

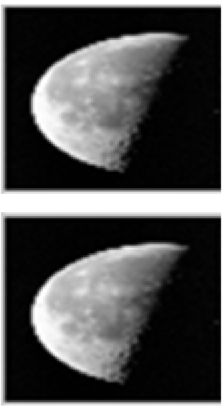
(c) CF = 0.9806



(d) CF = 0.9838

(e) CF = 0.9687

(f) CF = 0.9468



(g) CF = 0.9971

(h) CF = 0.9674

(i) CF = 0.9827

(j) CF = 0.9906

Fig. 6 Embedded and extracted watermark images(logos) from 1 - 12 frames (a), 13 – 24 frames (b), 25 – 36 frames (c), 37 – 48 frames (d), 49 – 60 frames (e), 61 – 72 frames (f), 73 – 84 frames (g), 85 – 96 frames (h), 97 – 108 frames (i), 109 – 120 frames (j)

It is observed that maximum correlation has been achieved between embedded and extracted watermarks with the proposed hybrid video watermarking technique. These results signify the robustness of our algorithm for specified range of scaling factors.

IV. CONCLUSION

In this paper, a novel high capacity non blind video watermarking algorithm is proposed. This hybrid algorithm which is a combination of SVD, DCT, DWT is implemented using MATLAB. The MSE and PSNR values attained in this algorithm are found to be good to estimate the imperceptibility of the proposed algorithm. Results demonstrate the effect of scaling factor on the quality of watermarked video. In future, we will improve the algorithm to gain better performance against various video processing attacks like frame averaging, frame dropping and compression.

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