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BLUE COLOR FRAMES BASED ROBUST DIGITAL VIDEO WATERMARKING USING WAVELETS AND SVD

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Abstract: In recent years, video piracy becomes a major challenge for multimedia world. For preserving copyrights of information like videos watermarking is the best solution. In watermarking process fundamentally owner embed some hidden signature into the original video that can be used to check the originality of the information. In this paper, we propose an effective watermarking technique which utilizes Blue channel video frames as this color is less sensitive to our eyes and also less sensitive to noise such as Gaussian, Salt & Pepper etc. Further, Discrete Wavelet Transform (DWT) and Singular Value Decomposition (SVD) methods are used for embedding watermark signatures into original information using Alpha Blending Technique. In this work, we proceed with Blind watermarking methodology in which original video is not required at the time of extraction. For security reasons, the system is secured by secret key mechanism through which only authenticate persons can extract watermark. To prove robustness of the proposed system original watermark signature is compared with extracted signature in the presence of noise such as Gaussian, Salt & Pepper, Rotation and Cropping effects by considering the parameters such as Peak Signal to Noise ratio (PSNR) and Normalized Correlation (NC).
Keywords: Discrete Wavelet Transform (DWT), Normalized Correlation (NC), Noise, Peak Signal to Noise Ratio (PSNR), Singular Value Decomposition (SVD), Video Watermarking, Watermark

I. INTRODUCTION

Now days, protecting copyrights of multimedia contents become a major challenge for researchers as most of the multimedia information is available on internet. Numbers of ways are available through which intellectual property of information can be shield. Watermarking is one of these way in which copyright data considered as watermark will embed into original content using various algorithms without affecting the fundamental nature and quality of the information [1]. The embedded watermark information can be used for copyright protection in the way that, this watermark can be extracted to claim copyright. While developing any watermarking scheme the major challenges that a researcher has to face are Quality and Robustness of the system. By quality, here we fundamentally focused on the Peak Signal to Noise Ratio (PSNR) between original and watermarked contents. Objectives are not to distorted or change the perceptual quality of information after embedding some secret information within it [4]. While on the other side of the coin, a robust watermarking scheme is always preferable as it shows the strength of the algorithm when some unauthorized person wants to abolish copyright information. This can be tested in the presence of various attacks such as Gaussian, Salt & Pepper noise, rotation and cropping effects. From above discussion it can be concluded that, these two factors are anti-parallel. Embedding of watermark can be done using two approaches – Spatial and Frequency domain. Spatial domain is also know time domain in which watermark is directly embedded at pixel level of information content without changing their original form. For example, Least Significant Bit (LSB) method [5]. While in frequency domain approach the embedding is performed in frequency domain and for converting content in frequency domain any transform is used such as Discrete Fourier Transform (DFT), Discrete Cosine Transform (DCT) and Discrete Wavelet Transform [1]. For achieving higher robustness of the system DWT is the best option. In this work, a highly robust system has proposed using blue channel based video watermarking using SVD and DWT approaches. As, blue channel of color video is having more robust nature against noises as compared to red and green channels. Remaining paper is structured as follows. Section II includes the key researches related to foundation of this article. Section III briefly introduced the mathematical analysis of DWT and SVD has been discussed followed by proposed watermarking scheme. Section IV demonstrates the simulation of proposed video watermarking algorithm using MATLAB. Finally, Section V concludes this paper.

II. RELATED WORK

From the last decade, the video watermarking has attained the immense place in the ground of research. It attains the consideration because it is offered as the solution for avoiding the copyrights violation of multimedia information in unrestrained environment such as Internet. The major work done by researchers related to this work is discussed in this section.

S. Kadu et. al [2] proposed Discrete Wavelet Transform (DWT) based video watermarking technique in which low frequency components are used to generate a key from watermark image during embedding process and the same key will be used at the time of extraction. This is blind watermarking scheme because at the time of extraction original video is not required. To justify the robustness of the technique extracted watermark is compared with original embedded watermark image in the presence of attacks such as Gaussian noise and Salt & Pepper noise. To analyze the performance measurement parameters such as Peak Signal to Noise Ration (PSNR) and Correlation Coefficient (CC) were used. Results were tested on some videos from MATLAB‟s database and some from YouTube. Although this methodology shows high robustness in the presence of noise but the quality of the watermarked video is too poor as PSNR in the presence of noise is below 25 dB. As the extension of this work SVD-DWT can be used for embedding the watermark and results should be tested against geometric effects such as rotation, cropping etc. which are missing in this methodology.

S. Bajracharya et. al [3] proposed DWT-SVD based digital image watermarking scheme in which watermarking process is only applied on still image and indicates that using DWT-SVD approaches for watermarking improves the PSNR and Normalized Correlation as well. This method is non-blind in nature that means cover image is required at the time of extraction.

S. Batra et. al [7] demonstrate a blind video watermarking method using SVD and multilevel DWT. In this work, key is generated using orthogonal decomposed values of watermark and embedding had executed on low frequency component of 4-Level DWT with cascading of SVD.

S. Kumar et. al [6] proposed RGB image watermarking on video frames using DWT. In this work colored video frames and watermarked image is first converted into RGB frames individually. After that 3-Level DWT is applied on each still images and get embed using Alpha Blending technique. At the time of extraction reverse process of embedding algorithm applied. For performance measurement PSNR, Mean Square Error (MSE) and NC calculated.

III. MATHMATICAL MODEL

A. Discrete Wavelet Transform (DWT)

The most popular application of wavelets is Discrete Wavelet Transform (DWT). DWT is used to decompose a two dimensional images into different frequency wavelets. As compare to Fourier Transform DWT has additional feature of multi-scale representation i.e frequency and location information. DWT decompose an image into LL, LH, HL and HH sub-bands. Out of these LL represents low frequency, LH and HL represents middle frequency and HH represent high frequency components. The 1-Level DWT of an image is shown in Fig. 1.

DWT Components

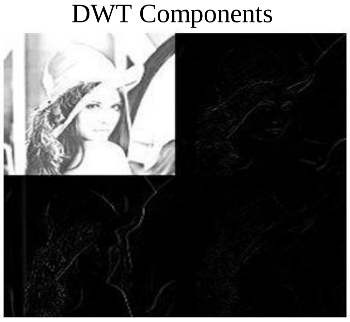


Fig. 1. 1-Level DWT

An image is decompose into 4 sub-bands as shown in Fig. 2 denoted LL, LH, HL, and HH at level 1 in the DWT domain, where LH, HL, and HH represent the premium level wavelet coefficients and LL stands for the coarse-level coefficients. The LL sub-band can further be decomposed to obtain another level of decomposition. The decomposition process continues on the LL sub-band until the desired number of levels determined by the application is reached.

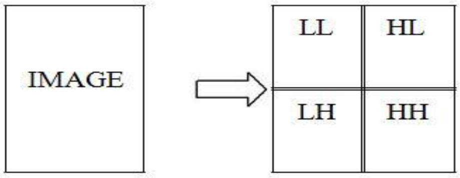


Fig. 2. DWT decomposition

B. Singular Value Decomposition (SVD)

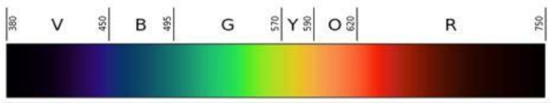
Singular Value Decomposition is a mathematical tool used for minimization of complexity of two dimensional matrixes. In this method digital image is segmented into a matrix which is not negative. Singular value decomposition is a numerical analysis technique specially utilized for diagonal matrix in which all non diagonal elements are zero. In many application areas Singular Value Decomposition (SVD) is used as an algorithm [9]. In the field of image processing SVD had the advantage that if pixel values of any image get disturbed by noise then singular values of an image does not get changed too much that preserve the perceptibility of the image. Basically, the feature of not getting disturbed by attacks on image is used to improve the robustness of the system. SVD of an image „WI" is given by (3.1)

$$WI = U \Sigma V^T \tag{3.1}$$

where U is pxp matrix, V is qxq matrix and both these matrices are orthogonal matrices (Matrix WI is orthogonal if $WI*WI^T=I$). $\Sigma = \text{diag}(\sigma1, \sigma2,\ldots,\sigma p)$ is pxq diagonal matrix with $(\sigma1, \sigma2, \ldots \sigma p \geq 0)$. σi are called singular values of W and they are positive square root of the eigenvalues of $WI*WI^T$. The columns of U (orthogonal eigenvector of $WI*WI^T$) are called left singular vectors of W while columns of V (orthogonal eigenvector of $WI^{T*}WI$) are called right singular vectors of W.

C. Proposed Watermarking Methodology

In this work, we proposed a video watermarking technique using blue color frames as the frequency of blue color as compare to red and green color is more. As the frequency is going higher the effect of noise on signal get decreases [8]. For the verification of frequency of blue color Fig. 3 is shown which is taken from Wikipedia. The complete watermarking scheme is divided into two phases – embedding and extraction phase. The algorithm for each phase will be provided separately.



Color	Wavelength	Frequency
violet	380–450 nm	668–789 THz
blue	450–495 nm	606–668 THz
green	495–570 nm	526–606 THz
yellow	570–590 nm	508–526 THz
orange	590–620 nm	484–508 THz
red	620–750 nm	400–484 THz

Fig. 3. Color spectrum [8]

D. Embedding Phase - Algorithm
The algorithm for the embedding phase of proposed watermarking scheme is discussed in this section.

Input: CV = Cover Video, WI = Watermark Image, n = total number of frames in cover video.

Step 1: After selecting CV extract all the individual frames of the video and also convert these RGB frames into independent Red, Green and Blue frames.

Step 2: Enter the secret key, it may consist of numerals, characters or any special symbol and the same entered key will be required at the time of extraction.

Step 3: Apply 2 Level DWT on each Blue Frame after converting into grayscale format and decompose as given below

for i = 1 to n
[LL, LH, HL, HH] = dwt2(i)
[LL1, LH1, HL1, HH1] = dwt2(LL) end

Step 4: Apply SVD on LL1 and decompose into following components as

for i = 1 to n
[U, S, V] = svd(LL1) end

Step 5: Repeat Step 3 and Step 4 for WI as given below

[LL_W, LH_W, HL_W, HH_W] = dwt2(WI)
[LL_W1, LH_W1, HL_W1, HH_W1] = dwt2(LL_W) [U_W, S_W, V_W] = svd(LL_W1)

*S*tep 6: Embed watermark low frequency component into low frequency component of blue frames of cover video using Alpha Blending Technique.

for i = 1 to n
*WV = S + α*LL_W1 end*

Step 7: Apply inverse DWT for converting back wavelets components to spatial components to create watermarked video.

for i = 1 to n
WVI = idwt2(WV, LH1, HL1, HH1)
WVI_final = idwt2(WVI, LH, HL, HH) end

Step 8: Merge watermarked frame with grayscale converted frames of red and green color to prepare the final watermarked video.

E. Extraction Phase - Algorithm
The algorithm for the extraction phase of proposed watermarking scheme is discussed in this section.

Input: WVI = Watermarked Video, secret key, m = total number of watermarked frames. Load U_W, V_W, S from extraction algorithm

Step 1: Extract all Blue frames from watermarked video and check for secret key. Apply 2 - Level DWT on each Watermarked Blue Frame and decompose as given below

if(entered key == secret key) for j = 1 to m
[A, B, C, D] = dwt2(j)
[A_LL, A_LH, A_HL, A_HH] = dwt2(A) end
el
se
ex
it

Step 2: Apply SVD on LL1 and decompose into following components as

for j = 1 to m
[U_WI, S_WI, V_WI] = svd(A_LL) end

Step 3: Prepare a matrix including orthogonal components of watermark image and singular component obtained from Step 2.

for j =1 to m
*M(j) = U_W * S_WI * V_W^T end*

Step 4: Recover watermark low frequency component using inverse alpha blending technique

for j =1 to m
r_LL(j) = (M(j) – S) / α end

IV. SIMULATION RESULTS

In this section, we demonstrate the simulation and comparative analysis of the results of proposed Blue color based watermarking algorithm with DWT have been demonstrated.

A. Simulation Parameters
The simulation of proposed watermarking algorithm had conducted using MATLAB version R2013a (8.1.0.604). For the evaluation of algorithm the parameters used are Peak Signal to Noise Ratio (PSNR) for measuring the perceptibility of watermarked video contents. The formula used for PSNR calculation is given in (4.1)

$$PSNR\,(dB) = 10\log_{10}\frac{255^2}{MSE} \quad (4.1)$$

where MSE is the mean squared difference between the cover frame and watermarked frame. The mathematical formula for MSE is given by (4.2)

$$MSE = \left(\frac{1}{X*Y}\right)\sum_{i=1}^{X}\sum_{j=1}^{Y}(P_{ij} - Q_{ij})^2 \quad (4.2)$$

In Equation (4.2), Pij means the pixel value at position (i, j) in the cover-frame and Qij means the pixel value at the same position in the corresponding watermarked image. The calculated PSNR usually adopts dB value for quality judgment. The larger the PSNR, the higher is the image quality. On the contrary, a small dB value of PSNR indicates that there is a great deformation between the cover-frame and the watermarked image. The other parameter used for evaluation is Normalized Correlation Coefficient (NCC) used for robustness measurement which is given by (4.3)

$$NCC = \frac{\sum_{m}\sum_{n}(X_{mn} - X')(Y_{mn} - Y')}{\sqrt{(\sum_{m}\sum_{n}(X_{mn} - X')^2)(\sum_{m}\sum_{n}(Y_{mn} - Y')^2)}} \quad (4.3)$$

where X` is the average value of the original image, X and Y‟ is the average value of the modified image, Y. A robust watermark must be invariant to possible attacks and remains detectable after attacks are applied. However, it is probably impossible, up to now, for a watermark to resist all kind of attacks, in addition, it is unnecessary and extreme.

The details of test videos used for the simulation of proposed watermarking algorithm is provided in Table I.

TABLE I
TEST VIDEOS DATABASE

Video Name	Frame Size (H x W)	No. of Frames	Duration (in sec.)	Source
viptraffic.avi	120x160	120	08	MATLAB
shaky_car.avi	240x320	132	04	MATLAB
scenevideoclip.avi	120x160	92	06	MATLAB
game.mp4	360x640	121	04	YouTube
funny_rabit.mp4	176x320	250	10	YouTube

The original watermark image used is shown in Fig. 4 which has been taken from MATLAB standard database i.e testpat1.png.

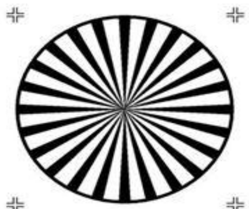


Fig. 4. Original watermark image

B. Fidelity

Fidelity indicates the perceptual quality of the video after watermarking process. Ideally the watermarked video must be similar as original one. This parameter can be evaluated using PSNR calculation. Table II shows values of PSNR shows for all test videos considering the effect of noises as well.

TABLE II
PSNR(IN DB) FOR ALL TEST VIDEOS

Video Name	PSNR (without noise)	Gaussian Noise (variance = 0.01)	Salt & Pepper Noise (Density =0.01)	Rotation (60 Degree)	Cropping
viptraffic.avi	41.07	27.05	27.04	24.8	25.77
shaky_car.avi	46.47	26.5	25.88	25.04	26.24
scenevideoclip .avi	36.41	26.45	27.10	25.18	25.94
game.mp4	39.65	27.15	27.61	25.26	27.16
funny_rabit.m p4	54.11	25.95	25.08	24.92	26.40

From Table II it is clearly indicated that the quality of video after watermarking is good as it is higher than 30 dB in each case. Even in the presence of higher value of noises the PSNR does not affected too much. Now for reference we display the frame number 36 of video „viptraffic.avi‟ and it‟s corresponding watermarked frame in Fig. 5.

Fig. 5. Original and watermarked frame number 36 of „viptraffic.avi‟

The PSNR for each frame of reference video „viptraffic.avi‟ is shown in Fig. 6.

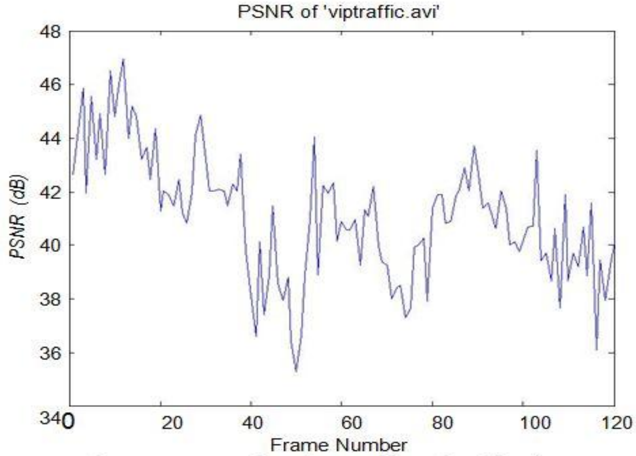


Fig. 6. PSNR curve for reference video „viptraffic.avi‟

C. Robustness

Robustness indicates comparison of the extracted watermark with the original watermark. Higher the robustness of the system lesser is the chances of decreasing the quality of watermark during extraction process. Majorly robustness is analyzed in the presence of noise attacks. In this proposed methodology blue color frames are utilized for watermarking process as the frequency of blue color as compared to red and green color is higher and at higher frequencies the effect of noises is the minimum. In Fig. 7 red, green and blue frames of reference video „scenevideoclip.avi‟ (frame number 60) is displayed.

Fig. 7 (a). Red frame

Fig. 7 (b) Green frame

Fig. 7 (c). Blue frame

Table III, shows the various values of Normalized Correlation Coefficient (NCC) used for robustness measurement. This can be implemented by finding the cross correlation between two matrices in MATLAB which is used to calculated degree of similarity in two independent matrices.

TABLE III
NCC FOR ALL TEST VIDEOS

Video Name	NCC (without noise)	Gaussian Noise (variance = 0.01)	Salt & Pepper Noise (Density =0.01)	Rotation (60 Degree)	Cropping
viptraffic.avi	0.92	0.86	0.85	0.69	0.79
shaky_car.avi	0.92	0.82	0.80	0.72	0.76
scenevideoclip.avi	0.91	0.82	0.82	0.79	0.83
game.mp4	0.92	0.81	0.81	0.80	0.79
funny_rabit.mp4	0.92	0.84	0.82	0.80	0.79

From Table III it is concluded that the robustness of the system is very good as even a large value of noise attacks are considered in Table III, the Normalized Correlation Coefficient (NCC) value is still greater than 0.70 in each case which indicates the system is robust. Now in Fig. 8 we displayed the extracted watermarks in different scenario i.e without noise, considering noise effect including geometrical as well.

Fig. 8 (a) Extracted watermark without noise

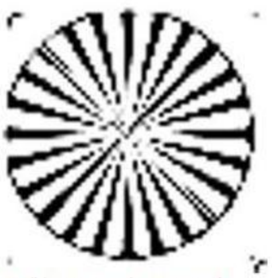


Fig. 8 (b) Extracted watermark with gaussian noise

Fig. 8 (c) Extracted watermark with salt & pepper noise

Fig. 8 (d) Extracted watermark with rotation effect

Fig. 8 (e) Extracted watermark with cropping effect

D. Comparison with DWT

Now, in this section we compare proposed watermarking algorithm with Discrete Wavelet Transform (DWT) on the basis of fidelity and robustness. For that purpose here we consider only one reference video „scenevideoclip.avi". The comparison of fidelity is done using the measurement of PSNR as shown in Fig. 9 for both proposed algorithm and DWT based algorithm.

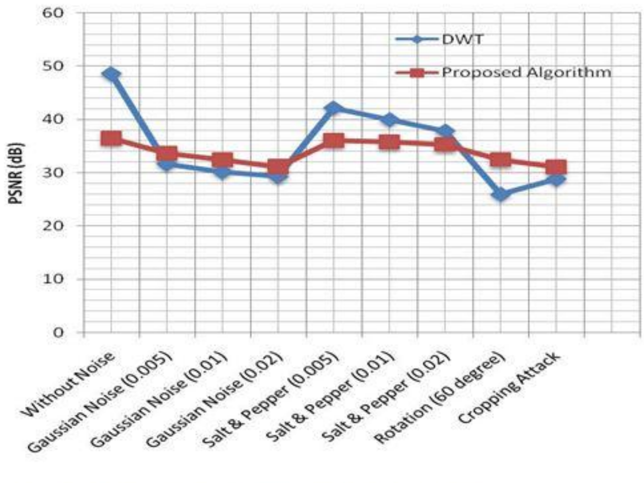


Fig. 9. PSNR comparison of proposed algorithm with DWT

Fig. 9 shows that the perceptual quality of proposed approach with Gaussian noise and geometrical attacks is better as compared to DWT approach. In Fig. 10 robustness of the proposed algorithm is compared with DWT approach. For that purpose here we consider only one reference video „scenevideoclip.avi".

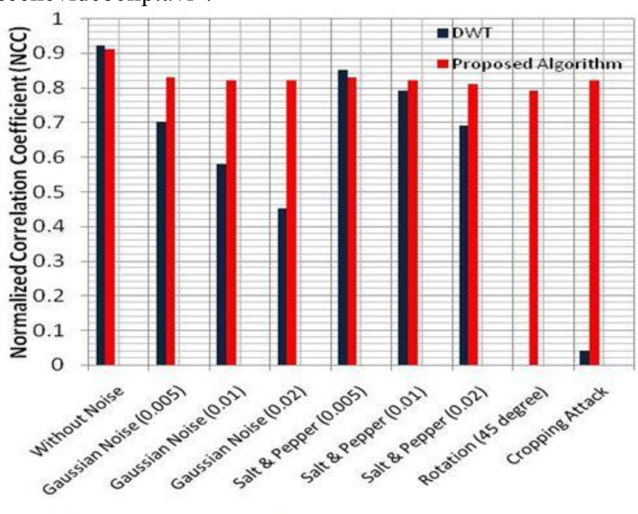


Fig. 10. Robustness comparison of proposed algorithm with DWT

Fig. 10 clearly shows that the proposed watermarking algorithm is more robust especially against geometrical attacks such as rotation and cropping.

V. CONCLUSION

In this paper, Blue frame based robust digital video watermarking using wavelets and Singular Value Decomposition (SVD) had proposed which utilize the concept of decreasing the effect of noise over signals as the frequency of the signal increases. In addition to this, SVD is used for further increasing the robustness of the system. This work can be extended for making an intelligent watermarking algorithm in which value of scaling factor is based on the intensity value of pixels of the frames.

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