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Video Watermarking Using Hybrid SVD-DWT

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Abstract – Developing a robust method for watermarking is one of the sought after research problems in today's scenario of the sought after research problems in today's scenario,due to extensive violations in copyright protection and exponential change in multimedia .So to solve this problem I present a semi-blind video watermarking technique which uses two images, fused using stationary wavelet transform (SWT) for watermarking. Then I use two level Discrete Wavelet Transform (DWT) to transform the fused watermark and cover video frames Singular Value Decomposition (SVD) is used to decompose the cover frames of the video where watermark is embedded using lower and middle bands of cover video and the lower sub-bands of fused watermark. The whole watermark isn't required during extraction on the receiving end. This methodology has been implemented on MATLAB prototype. The technique is evaluated with the help of PSNR (peak signal to noise ratio) and CC (correlation coefficient), results show that it outperforms some earlier used techniques.

Index Terms – Coefficient(CC), Peak signal to noise ratio (PSNR),Discrete Wavelet Transform (DWT), Singular Value Decomposition (SVD), Stationary wavelet transform (SWT), MATLAB

1. INTRODUCTION

In today's world, because of immense developments in multimedia technology that includes audio, images and video have found widespread applications. One amongst the efficient solutions is to avoid illegal copying, modifying and redistributing multimedia data is using the approach of digital watermarking [2]. This scheme has gained popularity because of its wide range of applications which include copy right protection,finger printing, E-voting , authentication of the content,broadcast monitoring,indexing military applications and medical applications.Due to its efficient and reliable aspects security concerns have reduced ,which includes transfer of any multimedia which is one amongst the prime concerns. Watermarking is basically a process of embedding some form of data into the original multimedia content in such a manner , that it can be extracted any time when the need arises, e.g. in the cases of copyright protection [3] .While realizing the concept of watermarking there are some requirements which have to be taken care of. They are as follows [4][5][6].

- Unobtrusive: The watermark should be embedded in such a manner that the original content should faithfully match the watermarked content to some extent in terms of perception .i.e. quality should not be degraded.
- Robustness: It is defined as the ability of the system to extract the watermark back inspite of many deliberate or unintentional noise attacks. Watermark should be able to be resistant to attacks like compression processes, geometric distortions, signal operations, noise, rewatermarking subterfuge attacks e.t.c.
- Computational cost: Embedding and extraction should be fast so as to relate with real time processing and should be less complex.
- Capacity: It gives us the measure of the number of bits that can be embedded in the original cover video. It is also called as payload.
- Security: it should be secure to such an extent that only the authorizer should detect and extract it.
- Watermark should be unambiguous and unique to the owner.
- Watermark should be detected without the requirement of unaltered original signal.
- Watermarking process should be universally used for all types of media.

The work done in the field of watermarking is mainly done pertaining to audio and images, but the work done in the field of image processing, has some specific issues that do not relate with the process of video watermarking. Present video watermarking techniques, come with compromises on many basic requirements. There are several problems in video watermarking e.g. during watermarking we have to keep in consideration the impact of embedding on different motion vectors which affect the degradation of video. So digital video watermarking has become one of the attractive issues to work on for research purpose in today's era [7].

Watermarking techniques are of different types.

- Based on multimedia content: text watermarking, image watermarking, audio watermarking and video watermarking.
- Based on human perception: visible watermarking, invisible watermarking and dual watermarking.
- Based on working domain: spatial domain watermarking and frequency domain watermarking.

- Based on watermarking extraction: blind watermarking, semi blind watermarking and non-blind watermarking.
- Based on application: fragile watermarking, semi fragile watermarking and robust watermarking.

2. RELATED WORK

A lot of work has been done in the field of video watermarking which include spatial and frequency domain approaches in visible and invisible approach. Some important work has been discussed as below.

Hemdan[8] et al., proposed an image watermarking technique which used Discrete Wavelet Transform (DWT) and Singular Value Decomposition (SVD) by using multiple fused watermarks. In this work cover image is transformed into wavelet components using DWT, and in parallel watermark images are fused which form a single watermark matrix. Then SVD is applied on frequency components obtained. The diagonal components have been utilized for adding watermark matrix to obtain the new modified matrix. Again SVD is applied on new matrix to obtain the watermarked image by using the inverse DWT (IDWT) of the multiplication of orthogonal components of original image and diagonal component of modified matrix. For extraction of watermark the reverse process was applied. The results were estimated by applying the noise attacks. Madhesiya [9] et al., proposed an advanced digital watermarking technique which is based on Singular Value Decomposition (SVD), Discrete Wavelet Transform (DWT), Discrete Cosine Transform (DCT) and Arnold transform. In this work the compression property of DCT, scalability of DWT, resiliency of SVD and robustness of Arnold transform is utilized. Khan [10] et al., proposed watermarking system which combined DCT, DWT and SVD. After this, SVD was applied on zigzag DCT coefficients. For extracting reverse process was applied.

A hybrid video watermarking technique which used both DWT and SVD has been reported by Rathod [11] et al. First the movie clip is converted into still video frames, then two-dimensional DWT is applied on the frames, and then SVD is used for embedding of the watermark. Still frames were then converted into .avi format movie.For extraction purpose watermarked video is converted into still frames again and then DWT is applied. Then SVD is applied. Saxena [12] et al., proposed DWT-SVD based on semi blind image watermarking technique which used high frequency bands of DWT. In semi-blind watermarking secret key and the watermark bit sequence should be known so as to extract the watermark.

Agarwal [13] et al., proposed a hybrid digital video watermarking technique based on discrete wavelet transform (DWT) and singular value decomposition (SVD). Instead of using binary image as a watermark as in popular in past papers, use of grayscale images as a watermark has been implemented. The video frames are converted into YCbCr color space and then the luminance part (Y component) is decomposed into four sub bands using DWT,then SVD is applied on low frequency i.e. LL band for embedding of watermark image. Hartung [19] et al., reported a scheme for embedding watermarks in uncompressed and compressed videos. The concept of spread spectrum communications was used. The use of DCT with a constant bit rate is used for embedding the watermark. It has advantages in decreasing complexity of the process.

Haweez [20] et al., proposed a robust watermarking scheme using the properties of SVD and DWT for video watermarking, which utilized the low and middle bands of both , fused watermark and cover video. The results were proved better after testing the video for various attacks like cropping ,rotation, salt and pepper and gaussian attacks.

3. PORPOSED MODELLING

The proposed system has been developed around the concepts of DWT [15] and SVD[14]. The process is divided into two parts i.e. embedding and extraction.

A. Wavelet based Image Fusion:

First the watermarks are fused together so that fused watermark can be embedded in the cover video. In this work, 2 dimensional Discrete Stationary Wavelet Transform (SWT) has been used to obtain the fusion of watermark images. One of the ways so as to restore the translation invariance is to average some little different DWT, called un-decimated DWT, to define the stationary wavelet transform (SWT). In this case the four images formed (one the approximation one and three detailed images) are at half of the resolution as compared to original. They are of the same size as that of the original image[17]. Let x (m,n) and y (m,n) be the images which are to be fused, the decomposed low frequency sub-images of x (m,n) and y (m,n) are l_x (m,n) and l_y (m,n) respectively. The equation to derive fused low frequency sub-image Fz (m,n) is given by equation below.

$$Fz(m,n) = a_0 * l\_x(m,n) + a_1 * l\_y(m,n)$$

where a_0 and a_1 are scaling constants.

Taking the absolute values of horizontal details of the given image and subtracting the second part of the image from the first part.

$$D = (abs(H1L1)-abs(H2L1))>=0$$

Element wise multiplication of D is made for fused horizontal part and horizontal detail of first image and then subtract another horizontal detail of second image which is multiplied by logical not of D from first one. Finding D for vertical and diagonal parts and then obtaining the fused vertical details of the image. The process is repeated for fusion at the first level.

Fused image is obtained by making use of inverse stationary wavelet transform [18].

B. Embedding Phase of Proposed Algorithm :

The embedding phase of watermark into video takes flowing steps in the proposed algorithm.

1. Extract the frames out of cover video and enter a secret key to make the mechanism more secure.
2. Fuse the 2 images used for watermark to get fused watermark using stationary wavelet transform.
3. After selecting the cover medium 2-Level DWT is applied on each of the frames and fused watermark. Let the cover frame denoted by a(x,y) and fused watermark is b(x,y). The 1-Level DWT decomposes a(x,y) and b (x,y) into

$$a(x,y) = [ll, lh, hl, hh] \quad (1)$$

$$b(x,y) = [l\_l, l\_h, h\_l, h\_h] \quad (2)$$

We have used "haar"in the process as it is extensively used and is the simplest of all wavelet types which acts as a prototype for all other wavelet transforms.

4. Again apply DWT on low and middle frequency bands i.e ll, lh, hl, bands of cover image and low frequency bands i.e l_l band of fused watermark (as shown in fig.3.1 and 3.2).

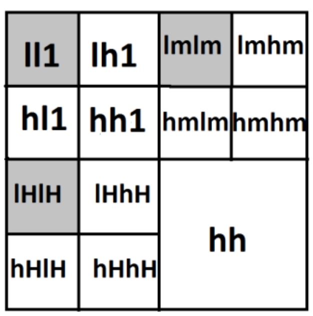

Fig. 3.1 : Low and Middle Frequency Decomposition of Cover Frame

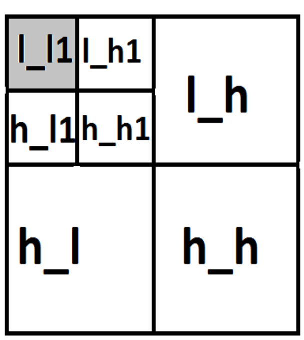

Fig. 3.2: Low Frequency Decomposition of Watermark Image

5. Apply SVD on low and middle frames of the cover image.

$$[U,S,V]=svd(ll1) \quad (3)$$

$$[Um,Sm,Vm]=svd(lmlm) \quad (4)$$

$$[Uh,Sh,Vh]=svd(lHlH) \quad (5)$$

6. Embedding the fused watermark image content with the singular value of low and middle frequency bands with a scaling coefficient (β) given by (7), (8), and (9).

$$N = S + \beta * l\_l1 \quad (7)$$

$$Nm = Sm + \beta * l\_l1 \quad (8)$$

$$Nh = Sh + \beta * l\_l1 \quad (9)$$

where β is a scaling coefficient and its value can be varied in-between 0 and 1.In this work its value has been considered as 0.05. l_l1 is the low frequency band obtained of that of watermark image.

7. Now again applying SVD on N, Nm and Nh we obtain the orthogonal (U,V)and singular components(S) of watermarked frames.

$$[Uw1, Sw1, Vw1] = svd (N) \quad (10)$$

$$[Uw2, Sw2, Vw2] = svd (Nm) \quad (11)$$

$$[Uw3, Sw3, Vw3] = svd (Nh) \quad (12)$$

8. Finally, the watermarked low and middle frequency components can be obtained by using (13), (14) and (15).

$$aw = U*Sw1*V^T \quad (13)$$

$$bw = Um*Sw2*Vm^T \quad (14)$$

$$cw = Uh*Sw3*Vh^T \quad (15)$$

9. Now, apply on bands 2level Inverse Discrete Wavelet Transform to get the watermarked frames, and finally the watermarked frames.

$$Wi\_ll = idwt2(aw, lh1, hl1, hh1) \quad (16)$$

$$Wi\_hl = idwt2(bw, lmhm, hmlm, hmhm) \quad (17)$$

$$Wi\_lh = idwt2(cw, lHhH, hHlH, hHhH) \quad (18)$$

$$Wi\_final = idwt2 (Wi\_ll, Wi\_lh, Wi\_hl, hh,) \quad (19)$$

4. EXTRACTION PHASE OF PROPOSED ALGORITHM

The exctaction process follows as :

1.First the secret key is entered , if it matches the original key entered during embedding ,we proceed further.

2.In the received watermarked video frames are extracted.

3. Apply 1-Level DWT on each recieved frame. Let z(x,y) be a given watermarked frame so, z(x,y) = [llr lhr hlr hhr].

4.Using low and middle frequency components as for further decomposition given by (20), (21) and (22).

[llr1 lhr1 hlr1 hhr1] = dwt2 (llr) (20)

[llmr lhmr hlmr hhmr] = dwt2 (lhr) (21)

[lhhr lhhr hlhr hhhr] =dwt2 (hlr) (22)

5.Now appling SVD on low and middle frequency components as given by (23), (24) and (25).

[U S V] = svd (llwa1) (23)

[U1 S1 V1] = svd (llmr) (24)

[U2 S2 V2] = svd (lhhr) (25)

6. Matrices are obtained corresponding to low and middle frequency components that include fused watermark image using orthogonal components (26), (27) and (28).

$x= Uw1*S*Vw1^T$ (26)

$y = Uw2*S1*Vw2^T$ (27)

$z = Uw3*S2*Vw3^T$ (28)

7. The fused watermark can be obtained by subtracting x,y,z from singular components and dividing each by scaling factor β .

8.Now, anti-fusion can be applied to separate the individual watermark images.

5. RESULTS AND DISCUSSIONS

In this section we present the results of simulation of our proposed watermarking algorithm in comparison with SVD-DWT hybrid approach [8].

Fig.4.1: Watermarking Images

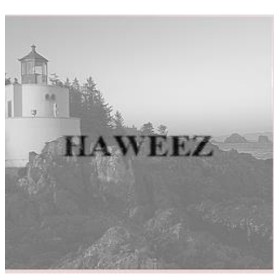

Fig. 4.2: Fused Watermark

Fig 4.3 Extracted fused watermark

Parameters used to acess the performance are:

- Peak Signal to Noise Ratio (PSNR) for measurement of fidelity.
- Correlation Coefficient (CC) for measurement robustness.

C. Fidelity Comparison

The comparison of proposed algorithm in terms of fidelity with a SVD-DWT based scheme reported by [8]is shown in Fig. 5.4 and Fig. 5.5 for Test Video-1st and Test Video-2nd respectively. The comparison has been done by adding various noise attacks such as Gaussian, Salt & Pepper, and Cropping attacks. From Fig. 5.4 and Fig. 5.5 it can be concluded that the proposed approach provides good quality of video after embedding watermark images.

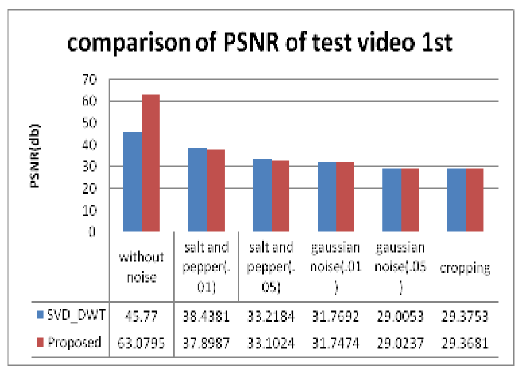

Fig. 5.4: PSNR Comparison for Test Video-1

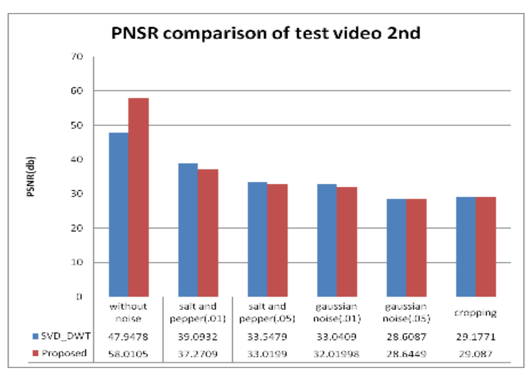

Fig. 5.5: PSNR Comparison for Test Video- 2

B. Robustness Comparison

The comparison of proposed algorithm in terms of robustness with that proposed by[8]is shown in Fig. 5.6 and Fig. 5.7 for Test Video-1st and Test Video-2nd respectively. The comparison has been done after adding of various noise attacks such as Gaussian, Salt & Pepper and Cropping attacks. From Fig. 5.6 and Fig. 5.7. it can be concluded that the proposed approach provides high robustness in each case.

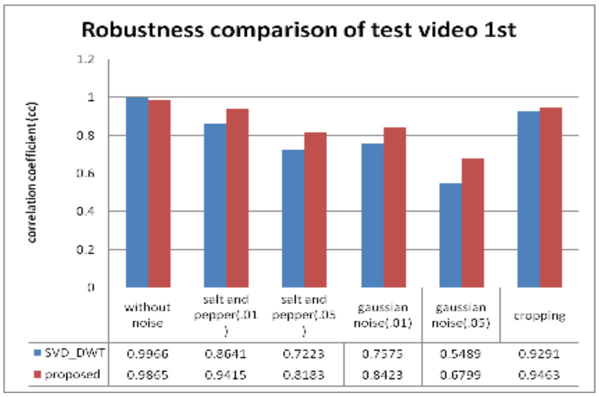

Fig. 5.5: Robustness Comparison for Test Video-1

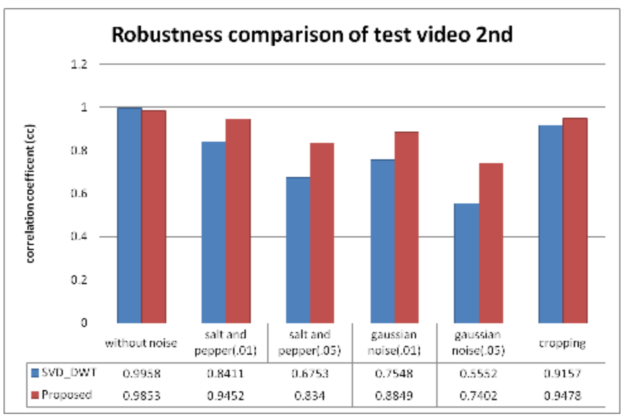

Fig. 5.6: Robustness Comparison for Test Video-2

6. CONCLUSION

A robust video watermarking technique has been reported. It uses the concept of SVD-DWT and image fusion. The comparison results show that the proposed system is capable of providing high quality watermarked videos. Besides the robustness of the scheme to various images processing attacks has been found better.

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