A Robust Hybrid Video Watermarking Technique using Mosaicing

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Abstract- Video Watermarking is the technique by which some information is inserted in the video which can be extracted later. It provides protection against any kind of illegal manipulation by third party. In this paper, a non-blind watermarking scheme is proposed which is based on the combination of Discrete Wavelet Transform (DWT), Discrete Cosine Transform (DCT) and Singular Value Decomposition (SVD). The watermark is embedded in the mosaic formed from the frames of the video by modifying the DCT coefficients of LL1 (low frequency sub-band obtained by applying 1-level DWT on the mosaic) followed by diagonal based modification of singular value matrix which is obtained by SVD decomposition of LL2 (low frequency sub-band obtained by applying 2-level DWT on the modified LL1). The experimental values of PSNR, Correlation Factor show that the above proposed scheme is imperceptible, secure and robust against various types of attacks.

Keywords – Video Watermarking, Mosaic, DWT, DCT, SVD, PSNR.

I. INTRODUCTION

With advancement in technology and the explosive growth in the use of internet, it is now possible to create, share and transmit digital data such as audio, video, text which in turn has made the data prone to unauthorized use by the third party. To prevent the data from these kinds of attacks such as piracy, Digital Watermarking is applied to the copyrighted contents to counter their unauthorized distributions as well as to claim the ownership. The sudden increase of research interest in Watermarking is most likely due to the increase in concern over copyright protection of the content. The copyrighted contents are easily recorded and distributed due to prevalence of high capacity digital recording devices. By means of Digital Watermarking, some sort of signal is concealed in the original digital data which can be a RGB image, grayscale image, binary image or a pseudo random number. Video Watermarking [6] techniques are broadly classified as spatial domain technique [1] and frequency domain [5] [10] technique. In spatial domain technique, watermark is embedded in the lower level bit planes of the digital data which is transparent and visually pleasing but not robust to compression, whereas watermarking in frequency domain involves transformation of frequency coefficients of the digital data. The various transforms used are Discrete Wavelet Transform (DWT) [2] [9], Discrete Cosine Transform (DCT) [3] [7] [8] and Discrete Fourier Transform (DFT). In this paper, our approach is based on the combined use of Discrete Wavelet Transform, (DWT), Discrete Cosine Transform (DCT) and Singular Value Decomposition (SVD) [4], to get a robust watermarking technique which is imperceptible and secure enough to resist most of the attacks. The value of PSNR (Peak Signal to Noise Ratio) and Correlation Factor between the original and extracted watermark is the measure of the algorithm's robustness.

(1) VIDEO MOSAIC

Video Mosaicing is a process that stitches multiple arbitrary shaped overlapping frames of a video together in order to produce one large high resolution image which has indistinguishable boundaries between the original
To create the mosaic, the points of correspondence are selected between the related frames which make it possible to generate correspondence maps between them. These correspondence maps can then be further used to combine these frames into an aggregate structure. Figure 1 shows the concept of forming a mosaic.

(2) DISCRETE WAVELET TRANSFORM (DWT)

Discrete Wavelet Transform is a transformation technique in which the wavelets of the signal are discretely sampled. It captures both frequency and location (time) information of the signal. It decomposes the input signal into various frequency sub bands, i.e., LL, HL, LH, HH, where,

- LL represents low frequency band.
- HL represent vertical high frequency band.
- LH represent horizontal high frequency band.
- HH represent diagonal high frequency band.

The decomposition can take place at any level. In two level decomposition, the first level low frequency band is further decomposed into four above specified frequency sub bands, i.e., into LL₂, HL₂, LH₂, HH₂. Figure 2 below shows decomposition of an image up to two levels.
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(3) DISCRETE COSINE TRANSFORM (DCT)

Discrete Cosine Transform is a separable linear transformation technique that works upon the frequency coefficients of the input image. The two dimensional Discrete Cosine Transform is equivalent to a one dimensional Discrete Cosine Transform along a single dimension followed by a one dimensional Discrete Cosine Transform in the other dimension.

The two dimensional DCT for an input image A is given by

$$b_{pq} = \alpha_p \alpha_q \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} A_{mn} \cos \left( \frac{\pi (2m+1)}{2M} \right) \cos \left( \frac{\pi (2n+1)}{2N} \right)$$

Where,

$$\alpha_p = \begin{cases} \frac{1}{\sqrt{M}}, & p = 0 \\ \frac{2}{\sqrt{M}}, & 0 \leq p \leq M - 1 \end{cases}$$

And

$$\alpha_q = \begin{cases} \frac{1}{\sqrt{N}}, & q = 0 \\ \frac{2}{\sqrt{N}}, & 0 \leq q \leq N - 1 \end{cases}$$

M and N are the row and column size of A respectively.

(4) SINGULAR VALUE DECOMPOSITION (SVD)

Singular Value Decomposition of an input image ‘A’ of dimension MxN outputs three matrices, namely, U[MxM] and V[NxN] which are unitary matrices and S[MxN] which is a singular value matrix having non zero diagonal values only arranged in descending order. The luminance of the image is characterized by the singular values of ‘S’ matrix which are not altered significantly on account of any variation in the input image which shows its stability.

$$A = U^* S^* V^T$$

II. PROPOSED ALGORITHM

A. Watermark embedding algorithm –

The steps for embedding watermark algorithm are as follows:

1. Let ‘A’ be the input mosaic image obtained as discussed in section (I).

2. Let ‘W’ be the original grayscale watermark which is resized to half of the size of the input mosaic image.
3. Apply 2-D first level DWT to decompose 'A' and watermark into four frequency sub bands (LL1, HL1, LH1, HH1).

\[ A \rightarrow A_1(f \in [LL1, HL1, LH1, HH1]) \]

4. Apply DCT to low frequency components of input mosaic image \( A_{LL1} \) and arrange the resultant DCT coefficients in a row vector in descending order of magnitude.

5. Apply DCT to each frequency sub-band of watermark and arrange the resultant DCT coefficients together in a row vector in descending order of magnitude. A Key is generated here as per their position which is required during the extraction of the watermark.

6. Row vector (obtained in step 5) is multiplied by a scaling factor and added to the row vector (obtained in step 4).

7. The modified row vector of the input mosaic image is converted back to 2-D array and inverse DCT is applied on it.

8. The original watermark is resized again to one-fourth of the size of input mosaic image.

9. Apply 2-D second level DWT to the watermark.

10. Decompose all the second level frequency sub-bands using SVD.

\[
\begin{align*}
W_{LL2} &= U_1*S_1*V_1^t \\
W_{HL2} &= U_2*S_2*V_2^t \\
W_{LH2} &= U_3*S_3*V_3^t \\
W_{HH2} &= U_4*S_4*V_4^t
\end{align*}
\]

11. Apply DWT on the modified LL1 of the input mosaic image and decompose it using SVD

\[ A_{LL2} = U*S*V^t \]

12. The singular value matrices \( S_1, S_2, S_3, \text{and} S_4 \) are multiplied with some scaling constant and added to the singular value matrix obtained in previous step 2. Reconstruct \( A_{LL2} \) using modified singular value matrix.

13. Apply second level inverse DWT to obtain the watermarked image.

**B. Watermark extraction algorithm –**

The steps for extracting watermark algorithm are as follows.

Let \( W^* \) be the watermarked mosaic image.

1. Apply 2-D, second level DWT on \( W^* \) and obtain singular value matrix by decomposing its LL2 using SVD \( S_{w^*} \).

2. Second level DWT components of the watermark are obtained from \( S_{w^*} \) using the key.

3. Apply second level inverse DWT to extract the watermark.

The flowchart for both embedding and extraction of watermark is shown in Figure 3.
III. EXPERIMENTAL RESULTS

In the above proposed scheme, the watermark (Figure 3) is embedded in the mosaic (Figure 4) of size 512*512. PSNR and Correlation Factor were calculated under different attack to test the strength of extracted...
watermark with respect to the original watermark. The embedding strength (β) is varied over the range of 0.1 to 0.9 to verify the effect on the quality of watermarked image.

\[
\text{PSNR} = 10 \times \log \left( \frac{(256)^2}{\text{MSE}} \right)
\]  

(10)

\[
\text{Correlation Factor} = \frac{\sum_{i=1}^{MN} f_i f'_i}{\sqrt{\sum_{i=1}^{MN} f_i^2} \sqrt{\sum_{i=1}^{MN} f'_i^2}}
\]  

(11)

f- Represents original watermark
f'- Represents extracted watermark
M- Represents number of rows
N- Represents number of columns

The experiment was carried out by using MATLAB (7.14.0.739) and results of PSNR and Correlation factor are obtained for different values of embedding factor (β) in both the levels of watermarking. However the best results are found for β= 0.4. The results are shown in Table 1.

Table -1 Values of parameters between original and extracted watermark with and without attack
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<table>
<thead>
<tr>
<th>Scaling Factor $\beta=0.4$</th>
<th>PSNR (dB)</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without attack</td>
<td>49.961</td>
<td>0.9798</td>
</tr>
<tr>
<td>Gaussian Noise</td>
<td>33.575</td>
<td>0.8693</td>
</tr>
<tr>
<td>Speckle Noise</td>
<td>46.269</td>
<td>0.9690</td>
</tr>
<tr>
<td>Salt &amp; Pepper Noise</td>
<td>44.969</td>
<td>0.9608</td>
</tr>
<tr>
<td>Poisson Noise</td>
<td>47.591</td>
<td>0.9733</td>
</tr>
<tr>
<td>Rotation</td>
<td>48.246</td>
<td>0.9798</td>
</tr>
<tr>
<td>Cropping</td>
<td>27.418</td>
<td>0.9302</td>
</tr>
<tr>
<td>MPEG Compression</td>
<td>46.834</td>
<td>0.9367</td>
</tr>
<tr>
<td>Wiener Attack</td>
<td>45.960</td>
<td>0.9662</td>
</tr>
</tbody>
</table>

By applying this proposed method of watermarking it is found to be quite robust even for Wiener attack. It is a removal attack that removes much of the watermark energy as possible while minimizing the attack distortion. Most of the watermarking techniques fail miserably to resist Wiener attack. The proposed technique is able to resist Wiener attack because of embedding DCT coefficients of watermark into the DCT coefficients of mosaic image that are arranged in descending order of their magnitude, which is the characteristic of energy efficient watermarking scheme. Figure 6 shows extracted watermark and cover image under various attacks.
<table>
<thead>
<tr>
<th>Scaling Factor</th>
<th>Watermarked Image</th>
<th>Extracted Watermark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without Attack</td>
<td><img src="image1" alt="Watermarked Image" /></td>
<td><img src="image2" alt="Extracted Watermark" /></td>
</tr>
<tr>
<td>Gaussian Noise</td>
<td><img src="image3" alt="Watermarked Image" /></td>
<td><img src="image4" alt="Extracted Watermark" /></td>
</tr>
<tr>
<td>Speckle Noise</td>
<td><img src="image5" alt="Watermarked Image" /></td>
<td><img src="image6" alt="Extracted Watermark" /></td>
</tr>
<tr>
<td>Salt &amp; Pepper Noise</td>
<td><img src="image7" alt="Watermarked Image" /></td>
<td><img src="image8" alt="Extracted Watermark" /></td>
</tr>
<tr>
<td>Poisson Noise</td>
<td><img src="image9" alt="Watermarked Image" /></td>
<td><img src="image10" alt="Extracted Watermark" /></td>
</tr>
<tr>
<td>Rotation</td>
<td><img src="image11" alt="Watermarked Image" /></td>
<td><img src="image12" alt="Extracted Watermark" /></td>
</tr>
<tr>
<td>Cropping</td>
<td><img src="image13" alt="Watermarked Image" /></td>
<td><img src="image14" alt="Extracted Watermark" /></td>
</tr>
<tr>
<td>Weiner Attack</td>
<td><img src="image15" alt="Watermarked Image" /></td>
<td><img src="image16" alt="Extracted Watermark" /></td>
</tr>
</tbody>
</table>

Figure 6  Watermarked Mosic image obtained with different attack and Extracted Watermark
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IV. CONCLUSION

The technique proposed is non-blind in nature in which the best features of DWT-DCT-SVD are incorporated. The results demonstrate that the is immune against attempts to video modification and manipulation like compression, rotation, noise attacks (Gaussian noise, salt & pepper noise, Poisson noise, speckle noise) which are the measure of its robustness. The quality of the host image is not destroyed by the presence of watermark which shows its imperceptibility.

Further, the technique is quite robust for wiener attack also. This watermarking technique can be utilized for copyright protection and data authentication.

The proposed technique also results less pay load for watermarking of video as it takes the advantages of Video Mosaicing. Instead of watermarking each frame of video, a set of frames can be watermarked with the help of mosaicing. Hence this can be applied for real time video processing applications.

REFERENCE