Analytical approach of Robust Singular Value Decomposition based video watermarking

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Abstract— In this Paper, We propose a video watermarking technique based on very popular mathematical tool namely singular value decomposition. Here we made use of singular values of frames of the video for the embedding purpose. At the end we achieved a video watermarking system which is resist to low pass filtering, filtering, edge filter, noise attacks, rotation, cropping and lossy compression attacks.

Keywords — Attacks, Copyright Protection, Digital Video Watermarking, Singular Value Decomposition, Visual Quality Parameters

I. INTRODUCTION

Today majority of the data transfer over the internet is in the form of the video and image and that is why there is a question of copyright protection and the proof of ownership comes into the picture every now and then. Both the task can be completed by a concept called digital watermarking which includes a number of techniques that are used to imperceptibly convey information by embedding it into the cover data [1]. In our paper we have taken video sequence as our cover data watermarking is thus called the Video Watermarking. The major factors that increases the demands of the Video watermarking [1, 2] are stated as below.

• Privacy of the digital data is required and because the copying of a video is comparatively very easy.
• Fighting against the “Intellectual property rights breach”
• Tempering of the digital video must be concealed.
• Copyright protection must not be eroded.

In this paper we made use of the mathematical linear algebra rule called singular value decomposition to achieve a better resistance against various kinds of attacks. This paper is organized in six sections. The subsequent section shows the general idea of implementation of the embedding and extracting process for a video watermarking system. Section 3 explains the concepts of singular value decomposition followed by the general properties of the singular value decomposition. Section 4 explains about the PSNR and MSE visual quality matrices with the help of which we can evaluate the scheme. Section 5 explains the proposed algorithm. Section 6 gives the performance analysis of the proposed scheme and graphical and tabular format of the results.

II. IMPLEMENTATION

The figure 1 shows the idea of the video watermarking at the sending end. Here first of all frames is extracted from the video sequence. The next step is to perform a color space conversion from RGB to YCbCr plane and divide frames into their Y, Cb and Cr parts. Out of them the Y - luminance part is then individually given to the embedding algorithm block where the other input is a watermark to be embedded. After Y part is watermarked the next frame is taken and the procedure is repeated until the last frame. After the watermark is embedded in every frame, all frames are mixed to make the watermarked video which is then transmitted in the channel.

The figure 2 shows the idea of the video watermarking at the receiver end. Here watermarked video is divided into the frames. Color space conversion is performed to have y, Cb and Cr parts from which Y part is selected and the watermark is extracted. This Procedure is repeated for all frames so as to recover all watermarks.
apply SVD to an Image A of size MxN, we find three matrices, namely U, V and S whose properties are:
- We can represent $A = USV^T$.
- U and V matrices are called Unitary matrices having size MxM and NxN respectively.
- S matrix is called diagonal matrix having size MxN.
- The columns of the U matrix are called the left singular vectors while the columns of the V matrix are called the right singular vectors of A.
- The diagonal entries of S are called the singular values of A and are arranged in decreasing order.
- The singular values (SVs) of an image have very good stability, i.e., when a small perturbation is added to an image, its SVs do not change significantly.
- SVD [11,12] is able to efficiently represent the intrinsic algebraic properties of an image, where singular values correspond to the brightness of the image and singular vectors reflect geometry characteristics of the image.
- An image matrix has many small singular values compared with the first singular value. Even ignoring these small singular values in the reconstruction of the image does not affect the quality of the reconstructed image [12].

An Example of the Singular Value decomposition is given as shown in figure 3.

IV. VISUAL QUALITY PARAMETERS
We have mainly used the following visual quality matrices [13] for the sake of comparison of degradation after the watermark is added to video.

$$MSE = \frac{1}{MN} \sum_{x=1}^{M} \sum_{y=1}^{N} (f(x,y) - f'(x,y))^2$$  \hspace{1cm} (1)

$$PSNR = 10 \times \log_{10} \frac{255^2}{MSE}$$  \hspace{1cm} (2)

Here MSE – Mean Square Error
PSNR – Peak Signal to noise Ratio
$f(x,y)$ – Original Frame of the video
$f'(x,y)$ – Watermarked Frame of the Video.

The phrase peak signal-to-noise ratio [14], often abbreviated PSNR, is used to measure the similarity between two signals where in one is original and the other is altered version of the same. PSNR can be defined via the Mean Square Error.
Square Error (MSE) which gives us the idea of difference between the original and the altered signal. PSNR is measured in the logarithmic scale and MSE is measured in the general scale.

At the receiver end we extracted the watermark and measured the correlation [12] of the recovered watermark and original watermark for the sake of checking the robustness.

V. PROPOSED ALGORITHM

In our proposed algorithm we have taken the video as shown in the figure 4 and we have taken the message to be embedded as shown in the figure 5.

A. Embedding Algorithm

Following is the stepwise representation of what we have done for the video watermarking using the proposed algorithm.

1. First of all the video is decomposed into the no. of frames.
2. A frame is taken and Colorspace conversion is applied to convert RGB frame into YCbCr frame.
3. Select Y frame for the embedding purpose.
4. Singular value decomposition is applied on the selected frame;
5. Watermark is rescaled to the size of the Singular Component i.e. S
6. Singular component is modified as $S = S + K \cdot W$ where W is the watermark and K is the gain factor.
7. Again SVD is applied on the modified Singular Component.
8. Selected sub-band is modified as New_Value = $U \cdot Modified_S \cdot VT$
9. Inverse colorspace conversion is applied.
10. Steps 2 to 9 are executed until the end of all frames.
11. All watermarked frames are combined to have watermarked video.

After the execution of the above algorithm we achieved the figure 6 which is a watermarked video.

B. Extraction Algorithm

Following is the stepwise representation of what we have done to extract the message at the receiver end from the video using the proposed algorithm

1. First of all the video is decomposed into the no. of frames.
2. A frame is taken and Colorspace conversion is applied to convert RGB frame into YCbCr frame.
3. Select any sub-band of the four for the further processing. Horizontal or Vertical sub-band is suggested to be selected for the better performance.
4. Singular value decomposition is applied on the selected sub-band;
5. Singular part is resized to have the size same as the message.
6. We achieve $D = U \cdot S \cdot VT$
7. Watermark is generated by applying $(D - S) / K$;
8. The process is repeated for every frame.

Here Figure 7 shows the watermark extracted when value of K is 100 and 10 respectively with Horizontal sub-band chosen for the embedding.

VI. RESULTS & DISCUSSIONS

Figures 8 to 10 show the graphical results of the proposed scheme.
achieving the same. various attacks and we concluded that we were successful in achieving the same.

![MSE graph](image)

![Correlation graph](image)

**Table 1** shows some of the results that we got against various attacks and we concluded that we were successful in achieving the same.

<table>
<thead>
<tr>
<th>TABLE I</th>
<th>PSNR, MSE AND CORRELATION RESULTS UNDER VARIOUS ATTACKS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PSNR (dB)</td>
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<tr>
<td><strong>Compression</strong></td>
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<td>cq=95</td>
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<td><strong>Guassian LPF</strong></td>
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<tr>
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<tr>
<td>var=0.4</td>
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</tr>
</tbody>
</table>

**VII. CONCLUSIONS**

From the Experiments performed we have seen that the proposed method is robust against almost all possible attacks and gives a good perceptible watermark extraction.

**REFERENCES**


