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Watermarking for Video using single channel block based schur decomposition

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Abstract

The fast evolution of cyber world has compiled many research scholars to develop different ways of securing the transmission of digital multimedia documents like text, images, audio, and video as it can be easily accessed manipulated or tampered. Different domains and methods to achieve watermarking are spatial like LSB and transform like DCT, FFT, WFT and SVD. Existing image watermarking techniques can be extended to perform watermarking on video.

This paper presents a digital watermarking scheme for color media using block based SVD approach. The proposed algorithm for watermarking handles the problem of false-positive detection and can be used for color videos. Watermarking using SVD can be done more efficiently if watermark is embedded in the blue component of the host frame of the video, instead of embedding it in the frame without separating the color component. Analysis and results shows that the proposed algorithm is robust secure and more efficient compared to our earlier scheme where embedding is done without separating the color components of the image to be watermarked.

AMS subject classification:
Keywords: Watermarking Singular value decomposition, Digital video watermarking, RGB, Single Channel watermarking.

1. Introduction

The technique of digital watermarking is considered one of the most powerful security measures in the transmission of multimedia digital documents. It can be effectively used by media owners use to insert watermark information into their document for the purpose of copyright protection. This paper presents an improved version of the earlier discussed block based SVD watermarking technique [14] for protecting rightful ownership. Results show that in this scheme the efficiency of watermarking in terms of MSE and PSNR values and payload is improved by embedding the watermark image in the blue component [15] from the [R,G,B] panel of the video frames.

2. Rightful Ownership and Robustness

Extracting the watermark from a watermarked image is not enough to prove ownership of the watermarked media. Zhang and Li (2005), said that by taking recourse to the reference matrices of the watermark, the watermark can be extracted from a possibly distorted watermarked image. The authors pointed out the fact that SVD subspace can preserve major information of an image, leads to a flaw; in which any reference watermark that is being searched for in an arbitrary image can be found. Chirag Jain and Siddhart Arora [2] have also proposed an algorithm which eliminated this flaw making watermarking with SVD more reliable. If embedding is done block-wise, larger watermark can be hidden in the host video, compared with the diagonal wise embedding or non block based approach [12].

3. SVD: Singular value decomposition

SVD is an algebraic technique for image watermarking on any digital signal. A digital image X of size MXN, with $M >= N$, is considered as a 2-D Matrix. SVD of X is defined as $X = USVH$

$$\sum Ui * Si * Vi$$

Where $U = MXM$ orthogonal matrix and $V = NXN$ are orthogonal matrix
and $S = MXN$ is a matrix with the diagonal elements representing the singular values.
U: XXH's eigenvector (left singular vector)
V: XHX's eigenvector (right singular vector)
Sii = is a nonnegative real number and is X's singular value
Main properties of SVD
Have very good stability
Represent image properties
Can process non-square matrix
Mapping of matrix X to S is many-to-one and nonlinear

$$X ==> USVH$$

$$X ==> US'VH$$

If $U! = U$ and/or $V! = V$ then $X! = X$. If we change S by small amount, it doesn't affect the image, provided U and V are not altered [7].

3.1. Schur Decomposition

Schur decomposition of a real matrix A results in two matrices U and D such that

$$A = UxDxU'$$

Heres D is an upper triangular matrix. U is a unitary matrix. U' indicates transpose of U. D has the real eigenvalues on the diagonal and the complex eigenvalues in 2-by-2 blocks on the diagonal. Schur decomposition requires about

$$8/3N^3$$

flops. This is less than one third the number of computations required for SVD decompositions that require about 11N3flops. In Schur decomposition, the matrix U has one interesting property, i.e. all its first two column elements are of same sign and their values are very close. This property can be explored for image watermarking.

3.2. Watermarking Done in Color Component

An efficient watermarking scheme has been proposed by us earlier [14]. To further increase the robustness of the watermark, watermarking is done in the blue color channel using SVD. Blue color channel is chosen as it has shows greater efficiency [15]. Results obtained shows that the efficiency of watermarking is increased using this new scheme in terms of the MSE and PSNR values.

4. The proposed algorithm

Watermark Embedding steps
Input: Video Clip
Output: Watermarked Video Clip

1. Convert input into its constituent frames
2. Select a frame A, Divide A into blocks.
3. Take a block BA
4. Divide the original image into the three color channels (RBG) and let the blue channel of original image be stored in BAb.
5. Perform Schur on BAb, we will get U, and D matrices.
6. Now let W be a watermark image.

7. Divide W into blocks and take block BW
8. Perform Schur on BW, it will give Uw and Dw matrices
9. Add this Dw to the D matrix of original frame to get new Dn

$$Dn = D + Dw$$

10. Performing reverse Schur, we will get watermarked frame BAwb.

$$BAwb = U * Dn * U'$$

11. Add previously stored green and red color components to BAwg
12. Repeat steps 4-11 for all blocks in each frame.
13. Combine all the frames, it will give watermarked video.

Watermark Extraction steps
Input: Watermarked Video Clip, Original Watermark image
Output: Extracted Watermark

1. Convert input into its constituent frames
2. Select a frame A, Divide A into blocks.
3. Take a block BA
4. Divide the original image into the three color channels (RBG) and let the blue channel of original image be stored in BA.
5. Now let W be a watermark image.
6. Divide W into blocks and take block BW
7. Get a difference between both the blocks BPE

$$BPE = BAw - BA$$

8. Use this difference to Get new Block BPn

$$BPn = inv(U) * BPE * inv(U');$$

9. Where U is original frame's Schur components.
10. We get Extracted Watermark by

$$WE = Uw * BPn * Uw'$$

11. Repeat steps 4-9 for all blocks in each frame.
12. It will give extracted Watermark

5. Experimental Results

The algorithm shows good performance and is illustrated in table 1. Table 2 shows that watermarks are successfully extracted even if watermarked image is cropped, rotated, scaled, translated, compressed using jpeg compression or noise is added. Also false detection is not possible. This shows that the proposed algorithm sustains attacks is robust and secure. Any image file (*.tiff, *.gif,*.jpeg,*.bmp,) whose size is less than the frame of the constituent video can be chosen as watermark. Table 1 depicts the comparison of Peak Signal to noise ratio (PSNR) and Mean square Error (MSE) values of our previous algorithm [14] and the one presented in this paper. From Table 1 it can be clearly incurred that the algorithm presented in this paper is more efficient. The algorithm is tested on 3 video samples and the comparative result is depicted in table 1 and is obtained by testing on intermediate frames of each video. Figure 1, figure 2 and figure 3 are intermediate frames from three different videos used as host frames. Figures 4,5,6 are frames on which watermark has been embedded. Figure 7 and figure 8 are watermark images that are embedded and figure 9, 10 are the respective extracted watermarks. Figure 11 shows that false detection is not possible if watermark other than the one used for embedding is used as reference for extraction which ensures rightful ownership.

Table 1: Result Analysis

Input		Previous algorithm		New algorithm
	MSE	PSNR	MSE	PSNR
Video1 Watermark1	6.06217	40.3045	1.18459	47.3951
Video1 Watermark2	6.327	40.1162	1.23312	47.2207
Video2 Watermark1	6.32894	40.1175	1.20218	47.3311
Video2 Watermark2	6.0621	40.3046	1.23718	47.2065
Video3 Watermark1	6.32898	40.1175	1.21521	47.2843
Video3 Watermark2	6.06217	40.3045	1.6232	47.4775

Figure 1: Intermediate frame from Video 1.

Figure 2: Intermediate frame from Video 2

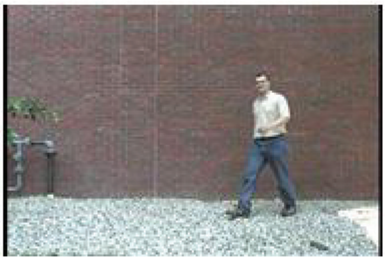

Figure 3: Intermediate frame from Video 3

Figure 4: Watermarked frame from Video 1

Figure 5: Watermarked frame from Video 2

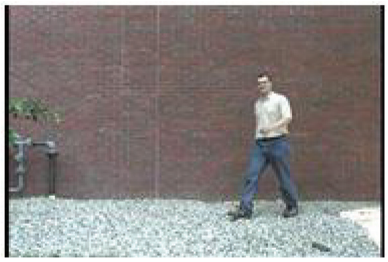

Figure 6: Watermarked frame from Video 3

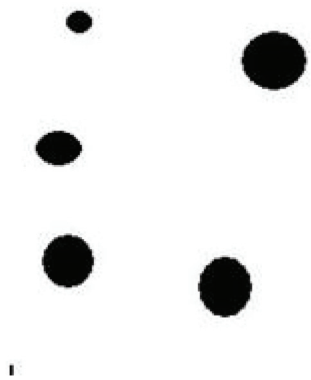

Figure 7: Watermark 1

Figure 8: Watermark 2

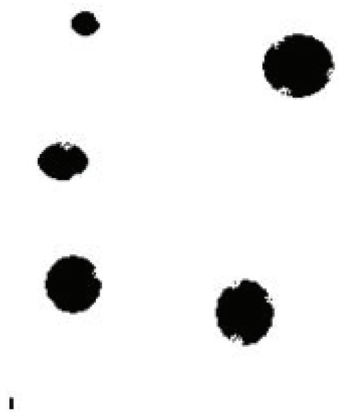

Figure 9: Extracted Watermark 1

Figure 10: Extracted Watermark 2

Figure 11: Extracted Watermark in false detection

Robustness Analysis:
Type of attack

1. Cropping

Figure 12: Cropping

2. Rotation
3. Addition of Noise
4. Translation
5. Scaling
6. JPEG compression

Figure 13: Rotation

Figure 14: Noise

Figure 15: Translation

Figure 16: Scaling

Figure 17: JPEG Compression

6. Conclusion

The above results are obtained using Matlab 7.5 and have shown satisfactory results. The results verify the efficiency of the proposed algorithm in terms of transparency, robustness and trustworthiness. The constraint on size of watermark is removed as bigger watermarks can be embedded in color images using block based approach as compared to the approach of embedding the watermark diagonally in D matrix of the Schur of the host frame. Also more watermark information can be added in the green and red channel of the host image. This algorithm can thus be used for digital watermarking in applications like fingerprinting, copy control, broadcast monitoring, video authentication and copyright protection.

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