Robust Hybrid Video Watermarking Using SVD and DTCWT

T. Geetamma and J. Beatrice Seventline

Abstract Watermarking is one of the widely used applications to provide security for the content shared over internet. Internet is a place where the data is not of assured security to the fullest. DTCWT is widely used in all image processing applications over a decade. A novel imperceptible video watermarking scheme is proposed. This method is implemented with the use of Dual Tree Complex Wavelet Transform (DTCWT) and Singular value decomposition (SVD) which helps in proof of ownership. In this method Singular Value Decomposition is applied to the Dual Tree Complex Wavelet Transform (DTCWT) coefficients of both watermark and original image and the singular Eigen values are interchanged. Because of advantages, Shift invariance and Directionality we prefer DTCWT. As SVD decomposes the matrix into 3 matrices U, S, V, we need U, V at the time of extraction. So we use U, V as watermark in audio. Watermark extracted from the audio gives the U, V matrices which makes this method blind watermarking. In order to prove the robustness of the method the results are compared with similar algorithms proposed in this paper but with DWT.

Keywords SVD · Arnold encryption · DTCWT · Blind and non–blind video watermarking

1 Introduction

Over the past decade internet spread widely, not just geographically but in terms of applications, has reached every corner of the world providing faster means of transferring information or data. However this spread has been exploited to stealing

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of data to claim originality. In order to avoid theft of valuable data, security measures are employed, each method has its advantages. Watermarking is one of them, particularly suited for multimedia files. Watermarking can also be used for text files, but its wide use in Multimedia data made it a highly suited security measure. There are different types of watermarking methods; some are classified based on transform used and some on the type of watermark. Watermarking is a procedure in which a secrete file is embedded in a document (image, text, audio), as a precaution to save the document from attacks while transferring the data over a communication channel. File embedded is called *watermark*. Watermarking method employed in this paper uses DTCWT because of advantages like Shift invariance and Directionality which are not implemented in DWT. SVD is used for blind watermarking in this paper. Similar research in literature referred SVD watermarking implementation on images in [1] 2007 and in 2009 [2] were non blind. Simulation results are compared with DWT methods to analyse the performance DTCWT.

2 Proposed Method

This method uses Dual Tree Complex Wavelet Transform (DTCWT) [3], Singular Value Decomposition (SVD) [4] and Arnold encryption method [5]. In place of DTCWT we also have used DWT to compare the results. Whole process is divided into 4 steps they are:

1. Watermark pre-process
2. Video pre-process
3. Embedding
4. Extraction

2.1 Algorithm

Watermark Preprocess: In this process, Watermark is altered every second, considering 24 frames for a second, each of the 24 frames have similar watermark. A secret key K is used to modify each second, where $K \in \{1, -1\}$. K changes every second. w is an arary of 1's and −1's [6].

$$W = \begin{bmatrix} K(1) * w & K(2) * w \\ K(3) * w & K(4) * w \end{bmatrix}$$

Watermark Size is chosen based on the size of 2nd level DTCWT coefficient matrix of video frame [1], i.e. chrominance channel in YUV (4:2:0) representation of the video frame. Watermark is encrypted before embedding using Arnold encryption method.

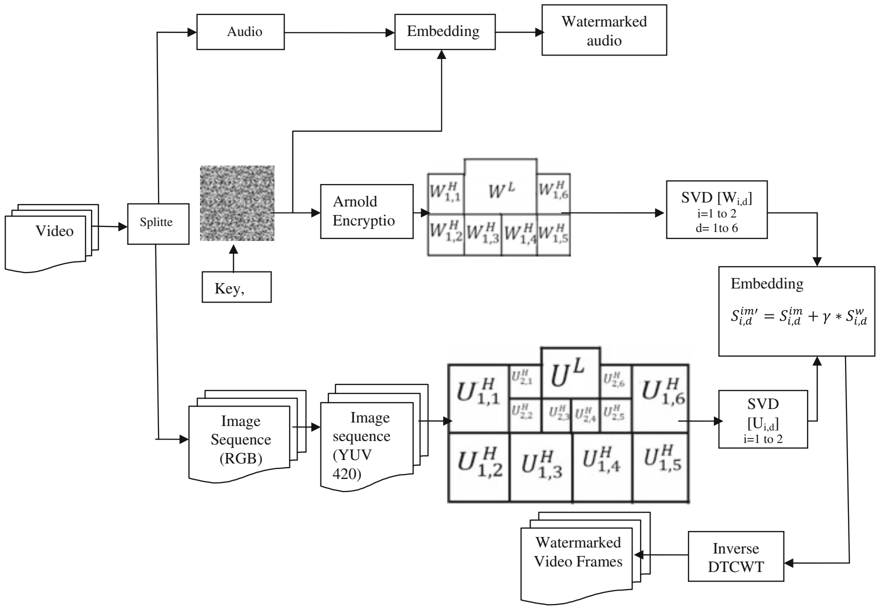


Fig. 1 Hybrid watermarking algorithm

$$[U^w, S^w, V^w] = SVD(W_{i,d})$$

Video preprocess: Video is mixture of both audio and images, we separate them using software (format factory). RGB video frame is converted to standard YUV (4:2:0) representation. 2-level DTCWT is applied on the YUV frame. On the higher band coefficients SVD is applied.

Embedding: DTCWT coefficients of watermark undergo SVD before embedding and S is embedded into coefficients of the Chrominance channel of video frame.

- Video frame is converted to YC_bC_r colour space (which was originally in RGB colour space) (Fig. 1).
- 2 level DTCWT is applied on blue Chrominance channel of video frame.
- SVD is applied on 2nd level coefficients which will give 3 matrices.

$$SVD(A_{i,d}) = [U^{im}, S^{im}, V^{im}]$$

- The singular values of $U_{i,d}$ are interchanged with the singular values of Watermark based on the following equation.

$$S_{i,d}^{im'} = S_{i,d}^{im} + \gamma * S_{i,d}^{w}$$

where $S^{w}_{i,d}$ is the singular vector of watermark and γ is the embedding strength

- In the last step, inverse SVD is applied on U^{i}, $S^{i'}$, V^{i} which finally generates watermarked frame.

$$ISVD\left[U^{im}, S^{im'}, V^{im}\right] = A^{w}_{i,d}$$

where $A^{w}_{i,d}$ is the watermarked coefficients.

Extraction: Extraction process follows reverse operation of embedding algorithm. First a watermarked frame is taken and 2-level DTCWT is applied. Later the matrix embedded is extracted by the following equation: $S^{w}_{i,d} = \left(S^{im''}_{i,d} - S^{im}_{i,d}\right)/\gamma$

Audio Watermarking: Watermark used for embedding is '*w*'. Embedding algorithm uses FFT, The FFT coefficients are framed as matrices and SVD is applied on the coefficients. By analyzing the coefficients a particular threshold level is chosen and embedding is done. The embedding procedure is that the every coefficient is checked with watermark and if the bit is 1, threshold is added to coefficient, and if watermark is 0, threshold is subtracted. Extraction follows a similar process which is the inverse of the embedding process.

Video watermark Extraction: In the extraction process first the singular vector of watermark is extracted, giving us $S^{w}_{i,d}$., after that we extract the watermark from audio signal which is 'w' (Fig. 2).

Consider an attack similar to extraction attempt from audio and video: the attacker will never be able to get the linkage between the two styles of audio and video relationship. Hence extracted watermark will not permit the true watermark that can prove ownership. We replace $S^{wa}_{i,d}$ with $S^{w}_{i,d}$ and perform inverse SVD that gives same watermark. In case of non blind watermarking, SVD matrices are considered directly.

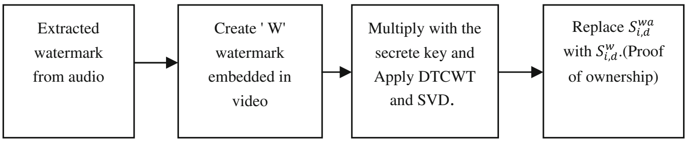
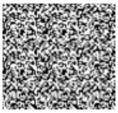
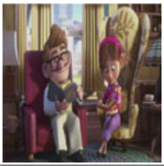
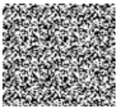
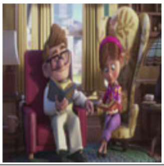
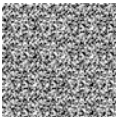
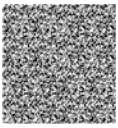
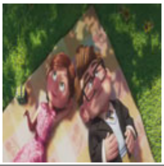


Fig. 2 Watermark extraction from video frame

Table 1 Non blind watermarking results

Frame number	Watermark (120 × 120)	Watermarked frame (480 × 480)	PSNR (dB)	Correlation factor
1			27.63	0.8739
30			27.6667	0.8749
60			27.65	0.8739
96			27.66	0.8741

3 Experimental Results

Both Blind and Non-Blind algorithms are implemented on a video with 480 × 480 resolution. "Watermark with the size of 120 × 120 is used. Watermarked results below are 4 frames (1, 30, 60, 96) each from a second re taken and the PSNR value of watermarked frame and original frame along with the correlation factor of extracted watermark". Same video is also considered for DWT approach (Table 1).

Embedding algorithm for blind watermarking is same as in Non blind. In case of audio watermarking we have (Table 2):

Table 2 Audio watermarking results

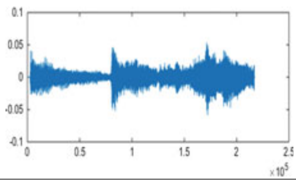
Number of samples present in the audio	Watermark (60 × 60)	Watermarked audio	PSNR (dB)	Correlation factor
Present: 217,728			103.6	1
Considered for watermarking: 215,681				

Table 3 Comparing the results DTCWT of blind and non blind watermarking

Frame number	Correlation (non-blind watermarking)	Correlation (blind watermarking)
1	0.8739	0.9630
30	0.8749	0.9627
60	0.8739	0.9624
96	0.8741	0.9625

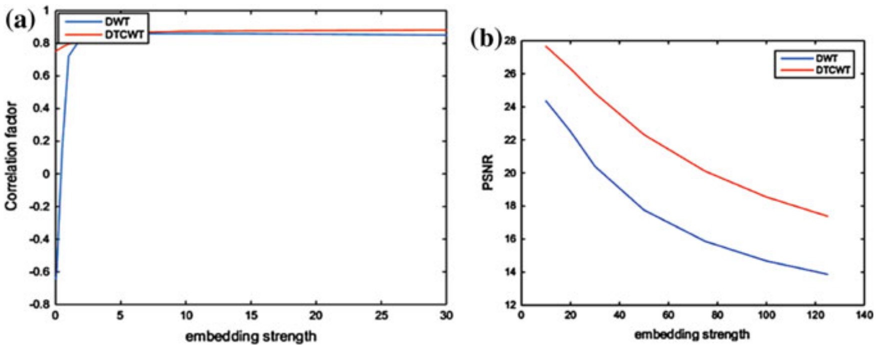


Fig. 3 Correlation and PSNR values for different embedding strength values for DWT and DTCWT

From the expected watermark from audio we generate watermark which is embedded in the video frames. 1-leve DTCWT is applied, followed by SVD that gives 6*3 matrices. Replace all the $S^{w}_{i,d}$ with the matrices extracted from the video frames. This is the process of embedding. Audio algorithm used is similar to both the methods one with DWT and another with DTCWT (Table 3).

In blind watermarking we have lower band coefficients of watermark, which increase the correlation factor. Now consider correlation factor for both DWT and DTCWT (Fig. 3).

Assume the video to be transmitted through a noisy channel. Comparison for DWT and DTCWT is as follows (Fig. 4).

In this method to face synchronisation attacks watermark is introduced in all of the video frames.

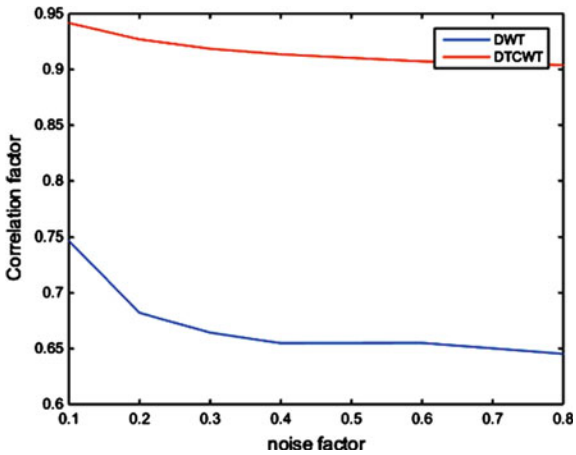


Fig. 4 Comparison between DWT and DTCWT for different noise factors

4 Conclusion

DTCWT is useful tool in signal processing applications. This method is secure compared to other pervious implemented methods of similar process. Results show improvement in performance to previous methods. This method can resist from any form of theft. The algorithm is better for noise induction, cropping, scaling but not so robust to geometrical distortions. Future work include increasing the robustness of audio watermarking algorithm and making the Video watermarking robust to all sorts of attacks present.

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