Wavelet Packet Based Video Watermarking and Extraction Using Independent Component Analysis

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Abstract—**Due to the widespread use of digital media applications, multimedia refuge and the copyright protection has grown incredible important. Digital watermarking is a technology used for the copyright protection of digital application. Many literatures have reported about Discrete Wavelet Transform (DWT) based watermarking techniques for data security. However, DWT based watermarking schemes are found to be less robust against video processing attacks. Hence in this paper, an attempt is made to develop a video watermarking scheme based on Wavelet Packet Transform (WPT) and extraction using Independent Component Analysis (ICA). The real time multimedia video sequence is converted into video frames, each frame is decomposed into various sub-bands using WPT. The watermark is embedded in a particular wavelet packet sub-band based on the value of Peak Signal to Noise Ratio (PSNR) that is calculated between watermarked and original image. Embedding in WPT sub-bands enhanced the performance of the video watermarking technique than DWT. The proposed scheme generates high PSNR value even in the presence of salt & pepper noise and rotation. An intelligent blind technique namely, ICA is implemented for extracting the watermark. From the simulation results, it is revealed that wavelet packet transform performs better when compared to DWT.**

Index Terms—**video watermarking, wavelet transform, independent component analysis**

I. Introduction

The reputation of digital video based application is complemented by the necessity of copyright protection to prevent prohibited copying and the distribution of digital video. Copyright protection familiarizes authentication such as ownership info and logo in the digital media deprived of disturbing its perceptual quality. In case of any dispute, confirmations data is mined from the media and can be used as confident proof of verify the ownership [1]. Watermarking is the development that embeds information called a watermark or digital signature in to the multimedia substances such that watermark can be distinguished in future to make a declaration about the object. Object may be image or audio or video for the resolution of copyright protection. Copyright protection inserts authentication data such as ownership information and logo in the digital media without affecting its perceptual quality .Watermarking is one of the widespread techniques to authenticate a digital media. Watermarking is the process of inserting some owner’s authentication information in digital media without affects the visual impression of the original multimedia content. Imperceptibility and robustness nearby attacks are the basic concern in digital video watermarking techniques. Various digital watermarking systems have been projected for video because it has the distinguish characteristics for instance temporal and interference which involve the separate content for the video watermarking [2]. Video watermarking is implemented by two different fields one is spatial content of the video based and another one is frequency content of the video based. The spatial based video watermarking is an entire image pigments are used for watermarking procedures. It has the drawback of less robust against several attacks. So in this paper, we apply the working frequency version of the video content in some pixels level only to achieve the frequency version of the video content the mathematical transformation using Wavelet Packet Transform (WPT) and Independent Component Analysis (ICA). Wavelet Packet Transform (WPT) is another way of decomposing signal or image into various sub-bands with high resolution [3, 4]. It differs from DWT by decomposing the high pass filtered output along with the low pass filtered output, thereby providing more sub-bands for data hiding. The watermark is embedded in the perceptual model with stochastic approach. Inserting the watermark in low frequencies attained by wavelet packet decomposition enhances the robustness with respect to attacks. Besides, an intelligent detection technique based on ICA is implemented for extraction without the use of previous knowledge of the watermark and even the transformation process [5]-[7]. Robustness

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against various attacks like salt and pepper noise and rotation of the proposed scheme are demonstrated with simulation results. The rest of the paper is organized as follows: section II presents the proposed watermarking scheme. Section III introduces the experimental results and finally section IV concludes the paper.

II. Proposed System

In this paper it is proposed to implement WPT and then applying Independent Component analysis to it. To achieve more robustness watermark is embedded in the sub-bands of WPT.

A. *Discrete Wavelet Transform*

The Discrete Wavelet Transform (DWT) is used in a wide range of digital signal processing applications. DWT is a transform based on frequency domain. The Discrete Wavelet Transform(DWT) decomposes an image or a video frame into sub-images. 1 level discrete wavelet transform decomposes an image or a video frame into sub-images. DWT splits the frequency band of an image into a lower resolution approximation sub-band (LL) as well as horizontal (HL), vertical (LH) and diagonal (HH) detail components. 2-level DWT further splits the image into 16 sub-bands [8, 9].

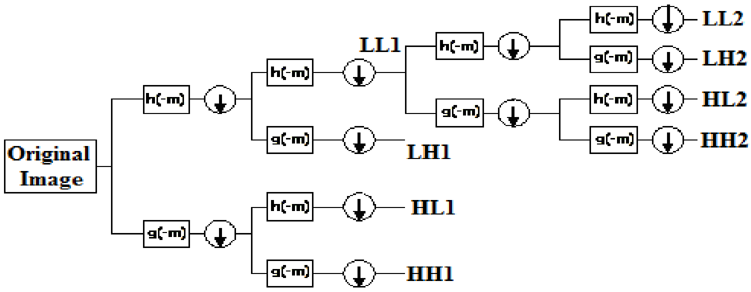

Figure 1. Two level decomposition using DWT.

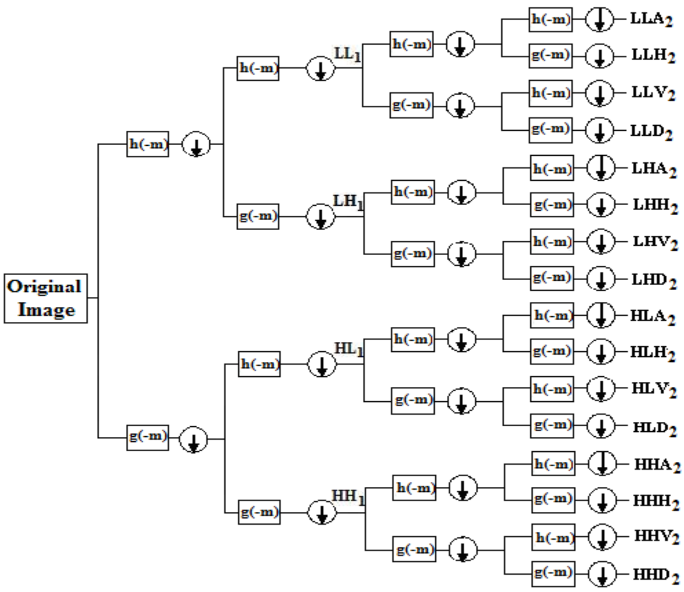

Figure 2. Two level decomposition using WPT

B. *Wavelet Packet Transform*

The wavelet packet transform is a generalization of the wavelet packet transforms. In the wavelet transform, only the low pass filter is iterated. It is assumed that lower frequencies contain more important than higher frequencies. This assumption is not true for many signals. The main difference between the wavelet packets transform and the wavelet transform is that, in the wavelet packets, the basic two-channel filter bank can be iterated either over the low-pass branch or the high-pass branch as shown in Fig. 2. This provides an arbitrary tree structure with each tree corresponding to a wavelet packet basis. Wavelet packet bases are designed by dividing the frequency axis in intervals of varying sizes. These bases are thus particularly well adapted to decomposing signals that have different behavior in different frequency intervals. Here, in the case of wavelet packets, the sub-band information represented by the approximation and detail co-efficients like LL1, LH1, HL1 and HH1 are decomposed further as shown in Fig. 2. The advantages of these further series of operations are that the time frequency plane is partitioned more precisely. A two level wavelet packet transform generates 16 sub-bands of coefficients comprising LLA2 through HHD2 as shown in Fig. 2. This sub-band decomposition provides more resolution in time and thereby increases the robustness and imperceptibility of the watermarking scheme. Hence, in this paper wavelet packet based video watermarking is proposed and implemented.

III. Independent Component Analysis

ICA is a statistical technique for obtaining independent sources S from their linear mixtures X, when neither the original sources nor the actual mixing A are known. The result of the separation process is a demixing matrix W, which can be used to obtain the estimated unknown sources, $\bar{S}$ from their mixtures. This process is described by

$$X = AS \qquad (1)$$

FastICA algorithm used in this paper work for watermark extraction is discussed below:

A. *FastICA Algorithm*

Aapo Hyvarinen and Erkki Oja have proposed an Fast ICA algorithm and it is based on a fixed-point iteration scheme [10]. The operation of FastICA algorithm is outlined as follows:

i) The mean of the mixed signal X is subtracted so as to make X as a zero mean signal as

$$X = X - E[X] \qquad (2)$$

where $E[X]$ is the mean of the signal.

ii) Then covariance matrix is

$$R = E[XX^T] \qquad (3)$$

Is obtained and eigen value decomposition is performed on it and is given by

$$R = EDE^T$$

where E is the orthonormal matrix of eigenvalues of R and D is the diagonal matrix of eigenvalues. Find the whitening matrix, P which transforms the covariance matrix into an identity matrix is given by

$$P = Inv\left(sqrt(D) \times E^T\right) \qquad (4)$$

iii) Choose an initial weight vector W, such that the projection $W^T X$ maximizes non gaussianity as

$$W^+ = E\left\{X * g\left(W^T X\right)\right\} - E\left\{g'\left(W^T\right)\right\}W \qquad (5)$$

where g is the derivative of the nonquadratric function. The variance of $W^{+T} X$ must be made unity. Since X is already whitened it is sufficient to constrain the norm of W^+ to be unity.

$$W = W^+ / \left\|W^+\right\| \qquad (6)$$

If W not converges means go back to step (iii).

iv) The demixing matrix is given by

$$W = W^T \times P \qquad (7)$$

And independent components are obtained by

$$\bar{S} = W \times X \qquad (8)$$

IV. Embedding Procedure

In our proposed work, binary watermark is embedded in the particular sub-band of the 2 level WPT.

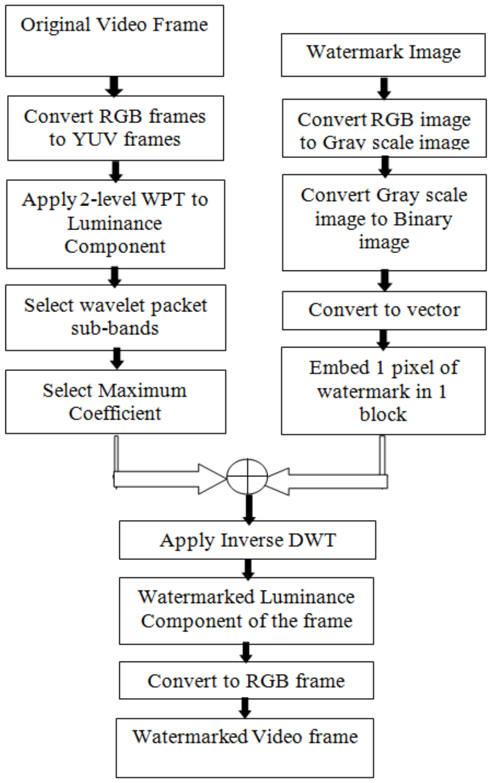

Figure 3. Watermark embedding procedure

V. Extraction Procedure

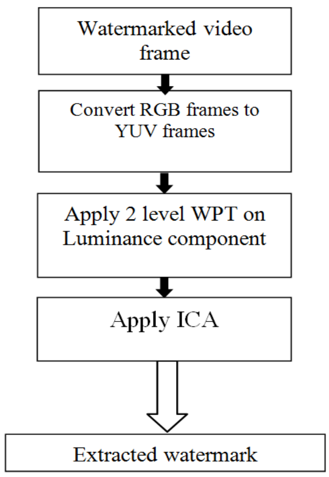

Figure 4. Watermark extraction procedure

VI. Experimental Results

A Color video is tested in our proposed technique and is shown in Fig. 5. The original video is converted into various frames of size 512 x 512 that is converted to 256X256 frame size by 1 level WPT and further modified to 128X128 frame size by taking 2 level WPT. The watermark is embedded using the equation (9) and PSNR value is calculated using the equation (10) in all frames. 15th frame is selected due to high PSNR value and is shown in Fig. 6. RGB frame is converted to YUV frame as in Fig. 7. A RGB original watermark (baby image) of size 128 x 128 is considered and is converted to grayscale and further to binary as shown in Figs. 8- 10 respectively. The watermark is embedded in the sub-band of two level WPT in the HLV2 sub- band as shown in Fig. 11. The robustness of the above watermarking scheme is validated against attacks like salt and pepper noise and rotation as shown in Figs. 12 and 13. The watermarked video of RGB frame is shown in Fig. 14. After applying FastICA watermark is extracted and Normalized Correlation (NC) is calculated using the equation (11) from the watermarked frame and is shown in Fig. 15.

$$I'HLV_2(i,j) = HLV_2(i,j) + \alpha .\ W(i,j) \qquad (9)$$

Figure 5. Original video

Figure 6. 15th frame of the original video

Figure 7. 15th frame of the original video in YUV

Figure 8.Original watermark

Figure 9. Grayscale watermark

Figure 10. Binary watermark

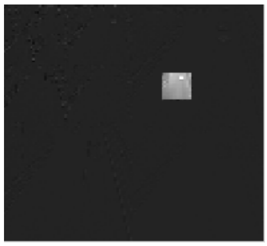

Figure 11.Two level WPT

Figure 12. Salt & pepper noise

Figure 13. Rotation

Figure 14. Watermarked video

Figure 15. Extracted watermark

$$PSNR = 10\log_{10}\frac{255^2}{MSE}(dB) \qquad (10)$$

$$\text{NC} = \frac{\sum_{m=0}^{M-1}\sum_{n=0}^{N-1} x(m,n)\ \hat{x}(m,n)}{\sum_{m=0}^{M-1}\sum_{n=0}^{N-1} x^2(m,n)} \qquad (11)$$

TABLE I. PERFORMANCE COMPARISON OF DWT AND WPT

Frames	Discrete Wavelet Transform		Wavelet Packet Transform	
	PSNR	NC	PSNR	NC
Watermarked	42.1367	0.8961	45.9783	0.9237
Salt & Pepper noise	32.3698	0.8718	36.7632	0.9184
Rotation	31.2045	0.8667	34.6392	0.9126

VII. CONCLUSION

In this paper, an attempt is made to implement wavelet packet based video watermarking and extraction using FastICA. The performance of Wavelet Packet is compared with Wavelet transform. From the results, it is proved that Wavelet Packet posses a high PSNR value compared to Wavelet transform. Its experimental consequence shows extraordinary imperceptibility where there is no obvious variance between the watermarked video frame and original video frame. Also in extraction, it is concluded that the performance of Wavelet Packet is superior to Wavelet transform. The robustness of the proposed scheme is also evaluated against common image processing attacks.

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