Copyright Protection of Color Video Using Digital Watermarking

Majid Masoumi[1], Shervin Amiri[2]

[1] Electrical Engineering Department, Islamic Azad University Qazvin Branch, Qazvin, Iran

[2]Scientific Member of E.E. Department, Iranian Research Organization for Science and Technology (IROST), Tehran, Iran

Abstract

A huge amount of digital multimedia data is broadcasted daily over the internet. Since digital data can be easily duplicated, intellectual property right protection techniques have become an important issue. In this study, a robust algorithm based on DWT for video copyright protection is proposed. Firstly, the RGB video is converted into YUV color component video, then, in order to make the watermark imperceptible, the luminance layer is only used to embed the watermark and the chrominance layer is left unchanged. In this algorithm, DWT is performed on both watermark image and video I- frames. Using a multiplicative hiding method, watermark image is embedded in its corresponding frequency coefficients of DWT in video I-frames. Based on experimental results the presented method maintains the high transparency of video stream meanwhile resist the watermark against a variety of attacks like: noisy attacks, filtering attacks, blurring attack and compression attacks.

Keywords: *Video Watermarking, Discrete Wavelet Transform (DWT), Intra-Frame.*

1. Introduction

With dramatic growth of the Internet and multimedia systems in distributed environments, it is easier for digital data owners to transfer multimedia documents across the Internet. Therefore, there is an increase in concern over copyright protection of digital contents [1-4]. Traditionally, encryption and control access techniques were employed to protect the ownership of media. These techniques, however, do not protect against unauthorized copying after the media have been successfully transmitted and decrypted.

Recently, watermark techniques are utilized to maintain the copyright [4-7].Multimedia and network security issues are classically handled through cryptography, however, cryptography ensures confidentiality, authenticity, and integrity only when a message is transmitted through a public channel such as an open network. It does not protect against unauthorized copying after the message has been successfully transmitted. Digital watermarking is an effective way to protect copyright of multimedia data even after its transmission. Watermarking is a concept of embedding a special pattern, watermark, into a multimedia document so that a given piece of copyright information is permanently tied to the data. This information can later prove the ownership, identify a misappropriating person, trace the marked document's dissemination through the network, or simply inform users about the rights-holder or the permitted use of the data [6].

The purpose of a digital watermark is to embed auxiliary information into a digital signal by making small changes that are not perceptible to its intended recipient. For instance, in the case of multimedia watermarking, the hidden signal should not result in any visible or audible distortions. Because the embedded signals enable invisible tags to be attached to digital documents, watermarks are powerful tools that will play a significant role in solving the growing digital property identification problem [8].

Numerous inventive watermarking approaches have been proposed in these few years and most of them focus on digital image watermarking. A variety of watermarking techniques have been proposed to embed a robust watermark into digital images .These techniques can be divided into two main categories according to the embedding domain of the cover image: the spatial domain methods and the transform domain methods. The spatial domain methods are the earliest and simplest watermarking techniques but they have a low information hiding capacity, and the watermark can be easily erased by lossy compression. On the other hand, the transform domain approaches insert the watermark into the transform coefficients of the original image "cover", yielding more information embedding and more robustness against watermarking attacks. Recent popular transforms contain the discrete cosine transform (DCT) [4], the discrete wavelet transform (DWT) [5], and the discrete Fourier transform (DFT).

Image watermarking techniques can be extended easily to watermark video image sequences [6, 7]. For digital watermarking of video, different characteristics of the watermarking process as well as the watermark are desirable. These requirements are:

- ***Imperceptibility***: The digital watermark embedded into the video data should be invisible to the human observer.
- ***Robustness***: It should be impossible to manipulate the watermark by intentional or unintentional operations on the uncompressed or compressed video, at the same time, degrading the perceived quality of the digital video significantly thereby reducing its commercial value. Such operations are, for example, addition of signals, cropping, lossy compression, frame averaging, frame dropping and collusion.
- ***Capacity***: A watermarking system must allow for a useful amount of information to be embedded into a video. The amount of information that can be embedded in a watermarked video is called data payload. The data payload in video watermarking means the number of bits encoded with the video. The payload of the embedded watermark information must be sufficient to enable the envisioned application.

The use of digital video applications such as video-conferencing, digital television, digital cinema, distance learning, videophone, and video-on-demand has grown very rapidly over the last few years. Today it is much easier for the digital data owners to transfer multimedia data over the internet, and hence the data could be perfectly duplicated and rapidly redistributed on a large scale. Thus, the importance of copyright protection for multimedia data has become more critical [9].

Video watermarking introduces some issues which are not presented in image watermarking. As applying a fixed image watermark to each frame in the video leads to the problem of maintaining statistical and perceptual invisibility [10], our proposed scheme is formed based on employing independent watermarks in each I-frame.

Video watermarking techniques can be broadly classified in two categories. In the first category, the watermark is embedded into compressed video, and in the second category, the watermark is embedded into uncompressed video. Hsu and Wu [11] embed a pseudo random number sequence into both intra and inter frames using DCT with different residual masks in MPEG-1. Wang et al [12] uses the spatial domain for watermark embedding with much lower computation complexity in MPEG-2. Deguillaume et al [13] proposes a Discrete Fourier Transform (DFT) method for embedding the watermark into I-frames only. A none-blind video watermarking scheme proposed in Ref.[14], The idea is to embed a binary pattern in the form of a binary image as an invisible watermark in the four wavelet sub-bands of each intra-frame of the MPEG video. A spread spectrum approach to embed a digital watermark in both the uncompressed domain and the compressed MPEG-2 domain is presented in Ref.[15]. In Ref.[16], where a perceptual watermarking method, operating in the 2D-DCT domain on a frame based approach, for embedding the mark into MPEG-2 compressed video streams, has been presented. However, using a frame-by-frame watermarking strategy, several drawbacks occur when both non-hostile and hostile video processing operations such as video format conversion, temporal desynchronization, video editing, and video collusion are performed[17].

In this paper, a novel watermarking technique is applied to embed the watermark into its corresponding frequency coefficients of DWT in each video intra-frame. The experimental results show that the proposed scheme is robust against a variety of attacks including noisy attacks, filtering attacks, blurring attack and lots of compression attacks.

The rest of paper is organized as follows: Section 2 expresses an integral definition about discrete wavelet transform. Section 3 delivers a relationship between wavelet domain and its application in image. Section 4 presents our proposed watermarking algorithm. In section 5, the experimental results are illustrated. Finally, section 6 concludes the paper.

2. Discrete Wavelet Transform

The wavelet transform is a valuable tool for Multi-resolution analysis that has been widely used in image processing applications. The wavelet transform has a number of advantages over other transforms as it provides a multi-resolution description, it allows superior modeling of the human visual system (HVS), the high-resolution sub bands allow easy detection of features such as edges or textured areas in transform domain. In the transform coding of images, the image is projected onto a set of basic functions, and the resultant transform coefficients are encoded. Efficient coding requires that the transform compact the energy into a small number of coefficients.

2.1 One Dimensional Discrete Wavelet Transforms

A general 1-D discrete wavelet transform can be written as [18]:

$$W(j,k)=\frac{1}{\sqrt{M}}\sum_{x} f(x)2^{\frac{j}{2}}\psi(2^{j}x-k) \tag{1}$$

$$\psi = \begin{cases} 1 & 0 \le x \le 0.5 \\ -1 & 0.5 \le x \le 1 \\ 0 & \text{otherwise.} \end{cases} \quad (2)$$

Where W represents the wavelet coefficients function, j , k denote the dilation and translation parameters respectively, and M is the length of the sequence f .

2.2 Two Dimensional Discrete Wavelet Transform

The one-dimensional wavelet transform can easily extended to two-dimensional functions like images. In two dimensions, a two-dimensional scaling function, $\varphi(x,y)$ and three dimensional wavelets, $\psi^H(x,y)$, $\psi^V(x,y)$, $\psi^D(x,y)$ are required. Each is the product of a one-dimensional scaling function φ and corresponding wavelet ψ . Excluding products that produce one-dimensional results, like $\varphi(x)\psi(x)$, the four remaining products produce the separable scaling function:

$$\varphi(x,y) = \varphi(x)\varphi(y) \quad (3)$$

and separable, "directionally sensitive" wavelets :

$$\psi^H(x,y) = \psi(x)\varphi(y) \quad (4)$$

$$\psi^V(x,y) = \varphi(x)\psi(y) \quad (5)$$

$$\psi^D(x,y) = \psi(x)\psi(y) \quad (6)$$

Given separable two-dimensional scaling and wavelet functions, extension of the one-dimensional DWT to two dimensions is straightforward. The scaled and translated basis functions are:

$$\varphi_{j,m,n}(x,y) = 2^{\frac{j}{2}}\varphi(2^j x - m, 2^j y - n) \quad (7)$$

$$\psi^i_{j,m,n}(x,y) = 2^{\frac{j}{2}}\psi(2^j x - m, 2^j y - n) \quad \text{i=\{H,V,D\}} \quad (8)$$

Where index i identifies the directional wavelets in Eqs. (4) to (6). The discrete wavelet transform of function $f(x,y)$ of size $M \times N$ is then:

$$W_\varphi(j_0,m,n) = \frac{1}{\sqrt{MN}} \sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)\varphi_{j_0,m,n}(x_0) \quad (9)$$

$$W^i_\psi(j,m,n) = \frac{1}{\sqrt{MN}} \sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)\psi^i_{j,m,n}(x_0) \quad (10)$$

i={H,V,D}

As in the one-dimensional case, j_0 is an arbitrary starting scale and the $W_\varphi(j_0,m,n)$ coefficients define an approximation of $f(x,y)$ at scale j_0 . The $W^i_\psi(j,m,n)$ coefficients add horizontal, vertical, and diagonal details for scales $j \ge j_0$. Given the W_φ and W^i_ψ of Eqs. (9) and (10), $f(x,y)$ is obtained via the inverse discrete wavelet transform:

$$\text{f(x,y)=} \frac{1}{\sqrt{MN}} \sum_m \sum_n W_\varphi(j_0,m,n)\varphi_{j_0,m,n}(x,y) + \frac{1}{\sqrt{MN}} \sum_{i=H,V,D} \sum_{j=j_0}^{\infty} \sum_m \sum_n W^i_\psi(j,m,n)\psi^i_{j,m,n}(x,y) \quad (11)$$

It is proved theoretically that wavelet transform can be implemented by use of perfect reconstruction finite impulse response filter banks [19]. The analysis filter bank decomposes the input signal $f(x)$ into two sub-band signals, $L(n)$ and $H(n)$. The signal L represents the low frequency part of $f(x)$, while the signal H represents the high frequency part of $f(x)$. The analysis filter bank convolves $f(x)$ with a low-pass filter h_0 and a high-pass filter h_1 then down sample the resultant signals as shown Fig.(1) .

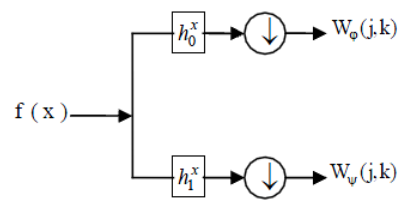


Fig. 1 1-D wavelet analysis filter bank

To use the wavelet transform for image processing a $2D$ version of the filter bank is used. In the $2D$ case, the $1D$ analysis filter bank is first applied to the columns of the image and then applied to the rows. If the image has M rows and N columns, then after applying the $1D$

analysis filter bank to each column there exists two sub-band images, each having $M/2$ rows and N columns. After applying the $1D$ analysis filter bank to each row of both of the two sub-band images, this results in four sub-band images, each having $M/2$ rows and $N/2$ columns. This is illustrated in Fig. (2).

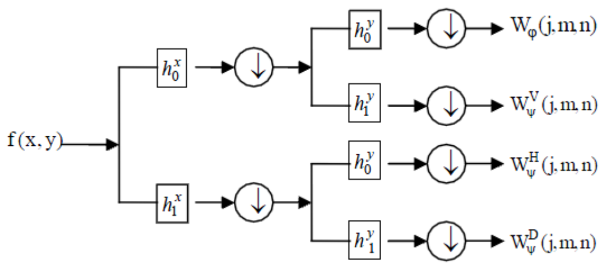


Fig. 2 One stage in multi-resolution wavelet decomposition of an image

3. DWT and image multi-resolution analysis

From human visual point of view, it is generally believed that watermark information should be embedded into the component which has the greatest impact on the human's vision. As the important components in vision are usually the main components of images, namely, these components get most of the energies in the image signal. If the image is so disturbed by noise that a certain degree of distortion is produced, generally it will not lead to a greater visual impact. It indicates that the image retains its major components, and also shows that the main components of the image have a strong anti-interference ability. Therefore, embedding watermark in this part, we can get a better robustness [20].

Layer by layer DWT can decompose a two-dimensional image into wavelet-like matrix C_{aj} and detail components including C_{hj}, C_{vj}, C_{dj}, which are in horizontal, vertical and diagonal directions respectively. We can see that after wavelet transform of the image, four sub-images, one-fourth the size of the image in size, can be got: horizontal, vertical and diagonal direction high-frequency and low frequency approximation sub-images. The low-frequency approximation sub-image can also be further broken down, in exactly the same way, into four smaller secondary sub-images. This process can be repeated indefinitely. In the analysis of multi-level decomposition for general images, we find that the approximation sub-images at the lowest level collect most energies of the image. They are an important part of vision, and they possess a great visual capacity. Therefore it is the proper place to embed digital watermark information. We can easily expand this idea for each frame of video instead of images.

In Ref. [21], the authors showed experimentally that embedding the watermark in the low and high frequency components of an image increases the robustness against attacks. More specifically, embedding the watermark in low-frequency components increases the robustness to the attacks that have low frequency characteristics such as filtering, lossy compression, and geometric distortions, whereas embedding the watermark in the middle and high frequency components is typically less robust against low pass filtering and small geometric deformations of the image.

4. Proposed video watermarking algorithm

4.1 Preprocessing of video

In MPEG stream, there are typically three kinds of coded images in each group of pictures: I (intra) frame compressed using only intra-frame coding, P (predicted) frame coded with motion compression using past I-frames or P-frames, and B (bidirectional) frame coded by motion compensation by either past or future I or P frames, In order to achieve a low complexity and improve the robustness, we only used the I-frames to embed the watermark.

So, for obtaining I-frames before embedding the watermark, initially, it is needed to video stream is split into I, B and P-frames. This process is shown in Fig. 3. Whereas we would like to put watermark into I-frames, in the second step RGB I-frames are converted to YUV color component (Y represents the luminance component i.e. the brightness, U and V represent the chrominance components i.e. color). In order to make the watermark imperceptible, we use the luminance layer to embed the watermark and we leave the chrominance layer unchanged.

4.2 Watermark embedding procedure

After Video decomposition and obtaining original frames (as mentioned in last section) the watermark embedding process is as follows:

1) Conducting first level of Haar wavelet transform for each original frame which is $M \times N$ in size. Haar wavelet is the simplest compactly supported orthogonal wavelet function which has features like simple computation and easy to use and so on. Different levels of wavelet decomposition applied in our method and

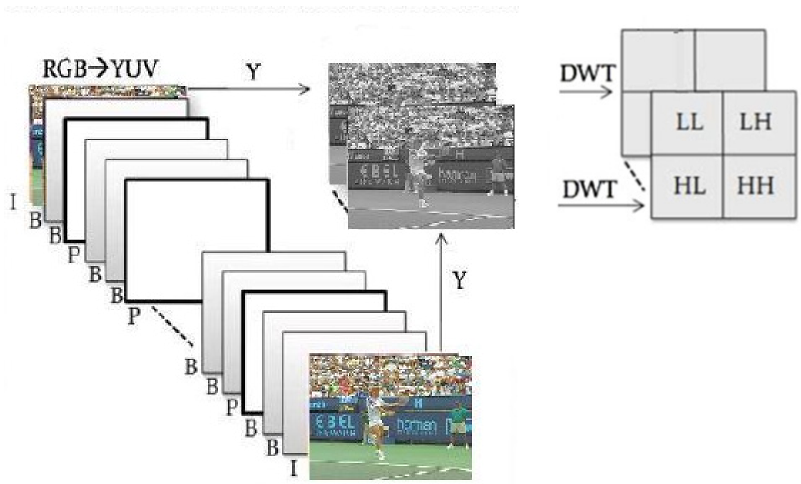


Fig. 3 Splitting video stream into I, B and P-frames and performing 2D-DWT on I-frames

we found that more than one level wavelet i.e. two, three,…, level wavelet will not have much impact on improving the watermark's robustness, indeed it reduces the quality of video with increasing in computing complexity, therefore it is appropriate to carry out only one level wavelet decomposition.

2) After the Haar wavelet transform, the original frame is decomposed into the four sub-images which have same size, namely ll_0 , approximate wavelet coefficient; hl_0 , horizontal detail coefficient; lh_0 , vertical detail coefficient; hh_0 , diagonal detail coefficient.

3) Conduct the first level Haar wavelet decomposition in the watermark image which has the same size with the original frames, then four sub-images, which are at different levels can be got, namely, ll_w , approximate wavelet coefficient; hl_w , horizontal detail coefficient; lh_w , vertical detail coefficient; hh_w , diagonal detail coefficient.

4) Taking into account the transparency of the embedded watermarks, ll_w is embedded into ll_0 ; taking into account the robustness of the embedded watermark, hl_0 , lh_0 , hh_0 are embedded into hl_w , lh_w , hh_w respectively. Watermark embedding algorithm adopts multiplicative hiding method [22]:

$$\left.\begin{aligned} C_a &= (1+\alpha_1.ll_w).ll_0 \\ C_h &= (1+\alpha_2.hl_w).hl_0 \\ C_v &= (1+\alpha_3.lh_w).lh_0 \\ C_d &= (1+\alpha_4.hh_w).hh_0 \end{aligned}\right\} \qquad (12)$$

Where α_1, α_2, α_3, α_4 are power factors which are used to control the features of the embedded watermark. If they get larger values, the watermark will have a good robustness ability, but its transparency will be poor; if they get smaller values, the watermark will have a poor robustness ability, and its transparency will be good. Obviously, robustness and transparency should be taken into account in the watermark embedding in video frames. In addition, experiments show that the power factor values vary in different videos. Commonly, the above power factors should be within the range of 0.01 and 0.09. C_a, C_h, C_v , C_d are the decomposed sub-images of the watermarked frame. Between these sub-images (coefficients) the main influence on watermark is related to C_a, because it has the most energy respect to other sub-images.

5) Performing IDWT on earned coefficients i.e. C_a , C_h , C_v , C_d , gives the watermarked frame.

4.3 Watermark extraction procedure

This section is followed like embedding process

1) First decomposing of video stream to get original frames.

2) Conducting first level of Haar wavelet transform on the original frames and the watermark image respectively. detail sub-images and two low-frequency approximation sub-images i.e. C_{a1} and C_{a2} can be got.

3) By using the low-frequency approximation sub-images i.e. C_{a1} and C_{a2} , and performing the inverse operation of embedding watermark algorithm ,and finally by defining a threshold the watermark image can be clearly detected .it means:

IJCSI International Journal of Computer Science Issues, Vol. 9, Issue 4, No 2, July 2012
ISSN (Online): 1694-0814
www.IJCSI.org

If *Obtained watermark* $\leq$ *Th*
Then *watermark is detectable*
End

In the proposed scheme in order to resist system against all kind of attacks Th is considered as 0.9.

5. Experimental results

Generally, the accurate measurement of the imperceptibility as perceived by a human observer is a great challenge in image/video processing. The reason is that the amount and visibility of distortions introduced by the watermarking attacks strongly depend on the actual image/video content [23]. To measure the perceptual quality, we calculate the peak to signal-to-noise ratio (PSNR) that is used to estimate the quality of the watermarked frames in comparison with the original ones. The PSNR [24] is defined as follows

$$PSNR = 20\log_{10}\left(\frac{\max_i}{\sqrt{MSE}}\right) \qquad (13)$$

Where $\max_i = \max\left\{\hat{F}_{ij}, 1 \leq i, j \leq m\right\}$ and the MSE is the mean squared error between the cover frame F and the watermarked frame $\hat{F}$:

$$MSE = \frac{1}{m^2}\sum_{i=1}^{m}\sum_{j=1}^{m}\left\|F_{ij} - \hat{F}_{ij}\right\|^2 \qquad (14)$$

The proposed watermarking scheme is performed on several different color video sequences including: akiyo, bus, stefan and suzie sequences with size of 352×288. These sequences are 30 fps and in a period of 10 seconds. A binary image (butterfly) with the same size of video frame is considered as watermark (fig.4).

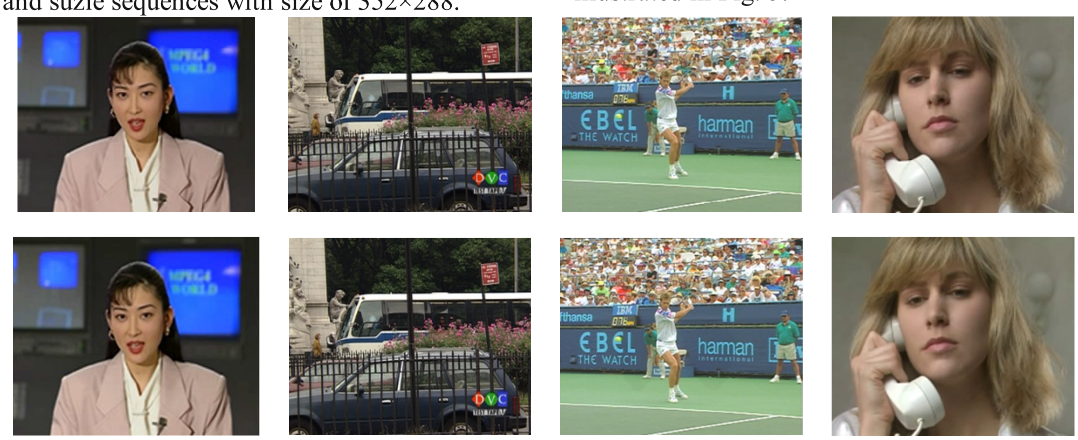
For imperceptibility purpose PSNR is used, also in order to evaluate robustness of system we have used correlation coefficient between original watermark and obtained watermark.

Fig. 4. watermark image

There are several attacks which are performed on our watermarking method; these attacks contain: pepper and salt attack, Gaussian noise attack, speckle noise, MJPEG compression, median filtering, low pass filtering, blurring, JPEG compression, MPEG compression, H.264 compression.

As mentioned before the value of α_i can vary in different video sequences. It should be noted that α_2, α_3 and α_4 have very insignificant influence on transparency of video sequences meanwhile α_1 has the main effect on transparency. So for implementing a good trade-off between robustness and imperceptibility, α_1 is considered as 0.01565 in our method. Also in order to detect watermark after facing all attacks the threshold is considered as 0.9.

A comparison between original and watermarked video sequences can show that the watermark invisibility achieved by this method is very effective. This comparison illustrated in Fig. 5.



Akiyo Bus Stefan Suzie

Fig.5 Comparison between the original and watermarked frames; first row shows the original video frames and second row are the watermarked video frames

Fig. 6. (a) Watermarked frame (b) Extracted watermark

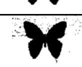
As seen, approximately there is no different between the original and watermarked video frames which show the high transparency of watermarked scheme.

The extraction process shows that the size of obtained watermark is changed, because the watermark image is extracted from the low-frequency part of original frames, so the size of the extracted information is 1/4 of the original frames size, that is, the extracted watermark stays at the position where it is embedded in the original frames. Fig. 6 shows this matter.

So this algorithm can help us to observe the specific location of the watermark embedded frames. In short, this algorithm provide a new approach for digital video watermarking research and practice, therefore it is of great practical significance

In Table 1 a good comparison between the PSNR and correlation for all video sequences, also extracted watermark are depicted. These results obtained when there are no attacks over video sequences.

Table 1: Comparison between PSNR and correlation coefficient for different video sequences.

Video sequence (No attack)	***PSNR (db)***	***Correlation coefficient***	***Extracted watermark***
Akiyo	38.12	0.9924	
Bus	40.09	0.9836	
Stefan	36.01	0.9754	
Suzie	38.00	0.9910	

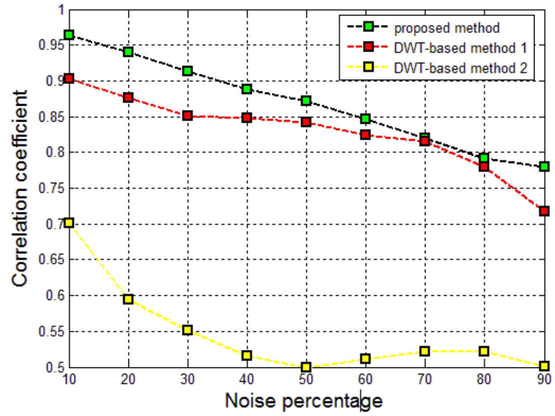


Fig .7 Performance under noisy attack

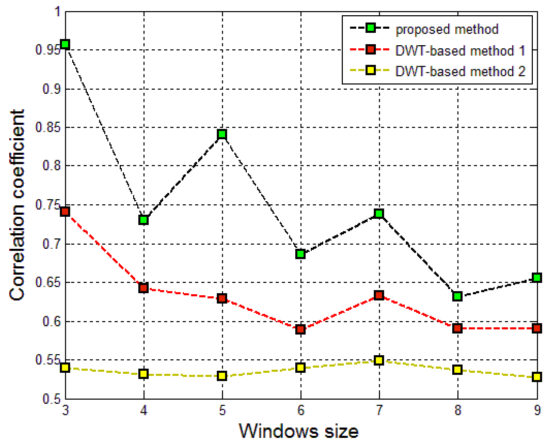


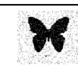
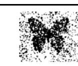
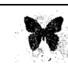
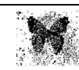
Fig.8 Performance under median filtering

In order to demonstrate the robustness of the proposed scheme 10 various attacks are applied on watermarked video. The experimental results show the high robustness of our method based on correlation coefficient. Table 2 shows the fidelity of our claim.

At the end, for showing the preference of our scheme over other schemes, the results of two different methods are compared with our method. Method 1 is a DWT-based watermarking scheme [25] which embeds the watermark in successive frames; these frames are selected based on scene change detection. Method 2 is another DWT-based watermarking scheme [26] which embeds an identical watermark in all frames .The selected attacks for comparing these 3 schemes are noisy attack and median filtering attack.

As Fig.7 and Fig.8 show, the proposed video watermarking algorithm has the best performance over the robustness.

Table 2: Influence of various attacks on proposed video watermarking algorithm

Attacks	*correlation coefficient*	*extracted watermark*
Motion blurring	0.9049	
Median filtering(windows size= [3 3])	0.9561	
Low-pass filtering(windows size= [3 3])	0.9112	
Salt & pepper noise (density=0.025)	0.8724	
Gaussian noise (mean=0, variance=0.001)	0.6048	
Speckle noise (variance=0.004)	0.6562	
JPEG compression (quality factor=70)	0.8938	
MJPEG compression (quality factor=80)	0.7346	
MPEG compression (quality factor=85)	0.6042	
H.264 compression (quality factor=80)	0.6505	

6. Conclusion

In this paper a robust watermarking algorithm for video is delivered. The proposed scheme is based on DWT. DWT is performed on both watermark image and video I-frames. Also, in order to make the watermark imperceptible, luminance layer has been chosen for embedding process. Then watermark image is embedded in its corresponding frequency coefficients of DWT in video I-frames. This algorithm, besides maintaining the high transparency of video stream leads to resist the watermark against a variety of attacks. Lots of attacks are applied for showing the robustness of the proposed method. These attacks contain: noisy attacks, filtering attacks, blurring attack and compression attacks. The experimental result showed the proposed algorithm has high degree of robustness against a wide range of attacks.

References

[1] A. Piva, F. Bartolini and M. Barni, "Managing copyright in open networks", IEEE Transactions on Internet Computing,Vol. 6, Issue. 3, pp. 18-26, May-June 2002.

[2] C. Lu, H. Yuan and M. Liao, "Multi- purpose Watermarking for Image Authentication and Protection", IEEE Transactions on Image Processing, Vol. 10, Issue. 10, pp. 1579-1592,Oct. 2001.

[3] C. Lu, S. Huang, C. Sze and H.Y.M. Liao, "Cocktail watermarking for digital image protection", IEEE Transactions on Multimedia, Vol. 2, pp. 209-224, Dec. 2000.

[4] J. Lee and S. Jung, "A survey of watermarking techniques applied to multimedia", Proceedings 2001 IEEE International Symposium on Industrial Electronics (ISIE2001), Vol. 1, pp. 272-277, 2001.

[5] M. Barni, F. Bartolini, R. Caldelli, A. D. Rosa and A. Piva, "A Robust Watermarking Approach for Raw Video", Proceedings 10th International Packet Video Workshop PV2000, Cagliari, Italy, May 1-2, 2000.

[6] F. Petitcolas (Eds), Information hiding techniques for steganography and digital watermarking Stefan Katzenbeisser, Artech House Books, Dec. 1999, ISBN 1-58053- 035-4.

[7] A. Eskicioglu and E. Delp, "An overview of multimedia content protection in consumer electronics devices", Proceedings Signal Processing Image Communication Vol. 16, pp. 681-699, 2001.

[8] K. Su, D. Kundur and D. Hatzinakos, "Spatially Localized Image-dependent Watermarking for Statistical Invisibility and Collusion Resistance", IEEE Transactions on Multimedia, 2004.

[9] I.J. Cox, M.L. Miller and J.A. Bloom, Digital Watermarking, Morgan Kaufmann, San Francisco, 2001.

[10] N. Checcacci, M. Barni, F. Bartolini and S. Basagni, "Robust video watermarking for wireless multimedia communications", Proceedings 2000 IEEE Wireless Communications and Networking Conference (WCNC 2000), Vol. 3, pp. 1530-1535, 2000.

[11] C.-T. Hsu and J.-L. Wu, "DCT-Based Watermarking for Video", IEEE Transaction on Consumer Electronics, Vol. 44, No.1, , pp. 206-216, February 1998.

[12] H. Wang, Z. Lu, J. Pan and S. Sun, "Robust Blind Video Watermarking with Adaptive Embedding Mechanism", International Journal of Innovative Computing, Information and Control, Vol. 1, No. 2, June 2005.

[13] F. Deguillaume, G. Csurka, J. O'Ruanaidh and T. Pun, "Robust 3D DFT Video Watermarking", Proceedings of SPIE Security Watermarking Multimedia Contents I, Vol. 3657, January 25-27, pp. 113-124. Trakya, 1999.

[14] E. Elbasia and A.M.M. Eskicioglu, "MPEG-1 video semi-blind watermarking algorithm in the DWT domain". In: Proceedings of the IEEE International Symposium on Broadband Multimedia Systems and Broadcasting, pp. 87–90. Las Vegas ,2006.

[15] C.I.Podilchuk, , W.J.Zeng, "Image-adaptive watermarking using visual models", IEEE J. Sel. Areas Commun. Vol. 16, No. 4, pp. 525–539, 1998.

[16] A.D.Gwenael, , J.L.Dugelay, "A guide tour of video watermarking", Signal Process Image Commun, Vol. 18, No.4, pp. 263–282, 2003.

[17] Y.Wang, A.Pearmain, "Blind MPEG-2 video watermarking robust against geometric attacks: a set of approaches in DCT domain", IEEE Trans. Image Process, Vol.15, No.6, pp. 1536–1543, 2006.

[18] J. Foote and J. Adcock, "Time base modulation: a new approach to watermarking audio and images", Proc, ICME, 2002.

[19] A. Bilgin, G. Zweig and M.W. Marcellin , "Three-dimensional image compression with integer wavelet transforms", Vol. 39, No. 11, Applied Optics, 2000.

[20] X. Peng, L. Lipeng and Z. Gengzhong, "Digital image watermarking based on wavelet packet with best tree", Journal of Shihezi University: Natural Science, Vol. 23, No.5, pp. 647–649 (in Chinese), 2005.

[21] E. Ganic and A.M. Eskicioglu, "Robust DWT-SVD domain image watermarking: embedding data in all frequencies", In: Proceedings of the ACM Multimedia and SecurityWorkshop, pp. 166–174, 2004.

[22] L. Zhenpeng, X. Huayong, Z. Kun and et al, "A meaningful watermarking algorithm based on wavelet transform", Journal of Jiamusi University: Natural Sciences, Vol. 23, No. 4, pp. 525–529 (in Chinese), 2005.

[23] S. Winkler, E.D. Gelasca and T. Ebrahimi, "Toward perceptual metrics for video watermark evaluation", Proc. SPIE Appl. Digit. Image Process. 5203, 371–378, 2003.

[24]A.N. Netravali and B.G. Haskell: Digital Pictures: Representation, Compression, and Standards. Plenum, New York , 1995.

[25] K.R. Chetan and K. Raghavendra , "DWT Based Blind Digital Video Watermarking Scheme for Video Authentication", International Journal of Computer Applications (0975 – 8887) Vol. 4, No.10, August 2010.

[26] M. Ejima andA. Miyazaki, "A wavelet-based watermarking for digital images and video", International Conference on Image Processing, ICIP 00, Vol. 3, pp. 678-681, 2000.

Majid Masoumi was born in Lahijan, Iran, in 1986. He is a Master student in electrical engineering at Azad University of Qazvin. He received his B.Sc. degree in electrical engineering in 2008. His previously researches include audio watermarking, opto-electronics and photonic crystals. He is currently interested in watermarking, image & video processing, cryptography, optimization, and communication systems. Specially using spread spectrum for making secure the networks against attacks and jammers. He is presently working at Iranian Research Organization for Science and Technology (IROST) as a researcher.

Shervin Amiri was born in Tehran, Iran, in 1966. He received his B.Sc., M.Sc. and Ph.D. from Iran University of Science & Technology (IUST) in communication systems. Now he is a Scientific Member of Electrical Engineering Department in Iranian Research Organization for Science and Technology (IROST).He is supervisor of many PhD and MSc students in the fields of communication system and subsystem.