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A Digital Video Watermarking Technique Based on Frame Extraction in 6-Level DWT

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Abstracts

Digital video watermarking was introduced at the end of the last century to provide means of enforcing video copyright protection. Video watermarking involves embedding secret information in the video. In this paper, we proposed a digital video watermarking technique based on identical frame extraction in 6-Level Discrete Wavelet Transform (DWT). In the proposed method, first the host video is divided into video frames. Then from each video frames one video frame called identical frame is selected for watermark embedding. Each identical frame is decomposed into 6-level DWT, and then select the higher Subband coefficients to embed the watermark and the watermark are adaptively embedded to these coefficients and thus guarantee the perceptual invisibility of the watermark. For watermark detection, the correlation between the watermark signal and the watermarked video is compared with a threshold value obtained from embedded watermark signal. The experimental results demonstrate that the watermarking method has strong robustness against some common attacks such as Gaussian noise adding, Salt & pepper noise adding, frame dropping.

Keywords: Video Watermarking, Discrete Wavelet Trans-form, Video frames.

Introduction

Video piracy has become an increasing problem particularly with the proliferation of media sharing through the advancement of Internet services and various storage technologies. Thus, research in copyright protection mechanisms, where one of which includes digital watermarking has been receiving an increasing interest from scientists especially in designing a seamless algorithm for effective implementation. Digital video watermarking involves embedding secret symbols known as watermarks within video which can be used later for copyright detection purposes.

There are three factors (robustness, security, perceptual fidelity) which are necessary for video watermarking system. The watermark can be visible or invisible. In visible watermarking, the information is visible in the video while in invisible watermarking, information is not visible. It can be detected only by the owner. Another classification of is based on domain which the watermark is applied i.e., the spatial or the frequency domain. The easiest way to watermark a video is to change directly the values of the pixels, in the spatial domain. A more advanced way to do it is to insert the watermark in the frequency domain. In this paper we propose an invisible video watermarking technique based on 6-Level DWT.

Many researchers around the world are working on digital watermarking for designing and implementing robust image or video watermarking technique. Some of those works are based on Discrete Wavelet Transform (DWT). A notable work is, in which the authors resize the host video to 256x256 size blocks and apply DWT on watermark video. To extract watermark they follow just inverse of embedding process. One of the major limitations of this method is that the host video must be square in size. Image which is used as a watermark must be in square size. Moreover the quality of watermarked video is bit degraded from the original host video.

Tian Hu et al. [13] proposed a watermarking technique in 1D-DWT where the author applied 1D-DWT to the luminance of two consecutive frames to obtain low frequency image. Low frequency image is partitioned into equal sized sub image. Calculate average pixel in each block. Embed watermark in these blocks according to interval where the average pixel value is. In order to detect the watermark the author used 1D-DWT to the luminance of two consecutive frames to obtain low frequency image. Compute average pixel value of each block. Determined interval where each average value belongs. The main limitation of this work is that their system only support binary image as

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the watermark.

In video watermarking blind watermarking scheme is also popular. One of the notable works is [14] where the author presented a new blind watermarking scheme in which a watermark is embedded into the one level DCT. The method uses the Human Visual System (HVS) model, and neural network. The neural network is implemented while embedding and extracting watermark. The HVS model is used to determine the watermark insertion strength. The inserted watermark is a random sequence. The secret key determines the beginning position of the image where the watermark is embedded. An-other novel blind video watermarking scheme is [10] which is based on pseudo-3D DCT. In this work they converted several scenes into video segment, and the frames in each scene are transformed in the 2D-DCT. Then the resulting Direct Current (DC) components are transformed along the temporal dimension. Afterwards, the normally distributed watermark is embedded into the pseudo-3D DCT Alternating Current (AC) coefficients. In the proposed method (i) original video need not to be squared i.e. any video can be used as original video (ii) the watermark signal can be of any size (iii) for watermark detection no original video is required and (iv) perceptually invisible robust watermarking is achieved.

The remainder of this paper is organized as the following. At first, in Section II we illustrate the various components of our proposed technique to embed and detect watermark from video content. Further, in Section III we present some key experimental results and evaluate the performance of the proposed system. At the end we provide conclusion of the paper in Section IV and state some possible future work directions.

Proposed watermarking technique

This section illustrates the overall technique of our proposed digital video watermarking technique based on 6-level DWT. At first, the formation of 6-Level DWT is presented. Then the proposed watermark embedding process, including identical frame extraction technique is discussed in detail. Finally, the watermark detection process and its different steps are discussed in detail.

A. 6-Level-DWT

Discrete wavelet transform (DWT) is a mathematical tool for hierarchically decomposing an image. DWT is the multi-resolution description of an image. The decoding can be processed sequentially from a low resolution to the higher resolution. The DWT splits the signal into high and low frequency parts. The high frequency part contains information about the edge components, while the low frequency part is split again into high and low frequency parts. The high frequency components are usually used for watermarking since the human eye is less sensitive to changes in edges. After the first level of decomposition, there are 4 sub-bands: LL1, LH1, HL1, and HH1. For each successive level of decomposition, the LL sub-band of the previous level is used as the input. To perform second level decomposition, the DWT is applied to LL1 band which decomposes the LL1 band into the four sub bands LL2, LH2, HL2, and HH2. To perform third level decomposition, the DWT is applied to LL2 band which decompose this band into the four sub-bands: LL3, LH3, HL3, and HH3. LL3 band which decompose this band into the four sub-bands: LL4, LH4, HL4, and HH4. LL4 band which decompose this band into the four sub-bands: LL5, LH5, HL5, and HH5. LL5 band which decompose this band into the four sub-bands: LL6, LH6, HL6, and HH6.

B. Watermark embedding

In a video, sometimes different video frames are almost identical. A continuous identical video frames is called a video frames. In order to increase the performance of watermark embedding process the proposed system will separate the video into video frames. Each video shot has one or more video frames that are almost identical. In order to determine whether two video frames are identical we compare the two image pixels. Moreover we also consider on global characteristics of the frames, which is intensity histogram. According to video standard, the intensity for a RGB frame can be calculated as,

$$I = 0{:}299R + 0{:}587G + 0{:}114B \qquad (1)$$

Where R, G and B are Red, Green and Blue value of the pixel. Generally, the human visual system is least sensitive to the range of high frequency [18]. Among three channels of the RGB image, the blue channel has characteristic of the highest frequency range. So, for the high performance the blue channel is transformed into DWT and the watermark is embedded from HL4 sub-band of the blue channel of the host video frame. If the HL4 sub-band is fill-up then the remaining watermark signal is embedded in LH4sub-band. Again, if the LH4 sub-band is over then HH4. If HH4 is over then the next upper level is used that is HL3, LH3, HH3 is used. In this way all the watermark is

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embedded into the video frame (see Figure 1). This process has the benefit of larger watermark can be embedded into the video. As we are placing the watermark into the high frequency part of the blue channel, so the greater invisibility of the watermark in the watermarked video frame is achieved.

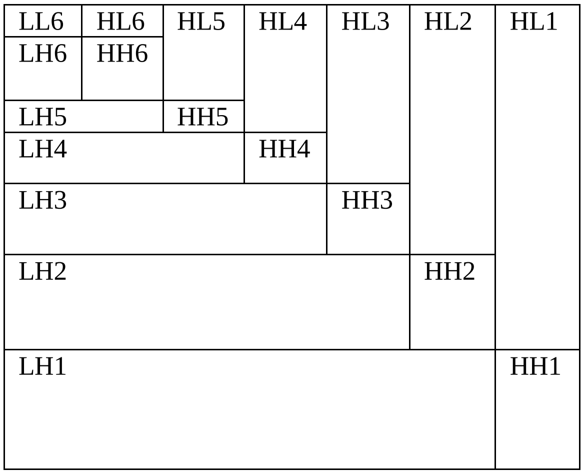

Fig. 1: Watermark embedding order in 6-level DWT sub-bands.

For the intensity histogram difference we're looking for, it can be expressed as,

$$|SD_i| = \sum_{i=1}^{G} |H_i(j) - H_{i+1}(j)| \quad (2)$$

Where $H_i(j)$ is the histogram value for i^{th} frame at level j. G denotes the total number of levels for the histogram. In a continuous video frame sequence, the histogram difference is small, whereas for sudden transition detection, the intensity histogram difference spikes. Even there is a notable movement or illumination changes between neighboring frames, the intensity histogram difference is relatively small compared with those peaks caused by sudden changes. Therefore, the difference of intensity histogram with a proper threshold is effective in detecting sudden transitions in video frames. The threshold value to determine whether the intensity histogram difference indicates a sudden transition can be set to,

$$T_b = \mu + \alpha\sigma \quad (3)$$

Where and are the mean value and standard deviation of the intensity histogram difference. Empirically we estimate that the value of typically varies from 2 to 6.

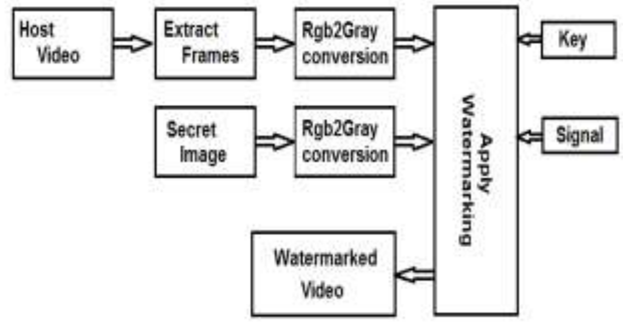

Fig. 2: Steps of proposed watermark embedding process

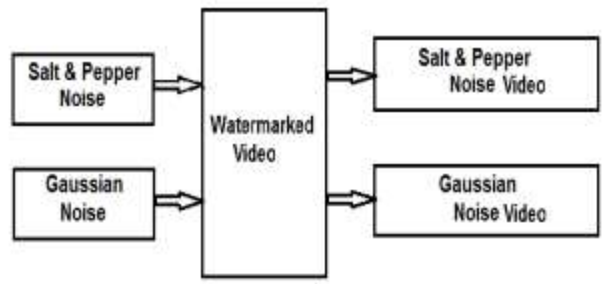

Fig. 3: Steps of Add noise in watermarked video

Before embedding the watermark it should be preprocessed. The watermark is converted into binary image form as w^0(i; j) 2 f0; 1g, for i; j = 0 to M, where M is the number of binary pixel in the image to be encoded. Here the value 0 represents black and 1 represent white value. The binary form of the image w^0(i; j) is then transformed to obtain the vector w(i; j) 2 f1; 1g, where 0 is replaced by 1 and 1 is replaced by 1. Finally two dimensional watermark w(i; j) is changed into one dimensional watermark w(l)(l = 1; 2; :::; L); L is the length of the watermark.

The proposed embedding process is shown in Figure 2. From the block diagram we see that, after separating the video into video shots the system will apply 6L-DWT on the blue channel of RGB frame. In the 6L-DWT coefficients, we embed preprocessed watermark image from the HL4 to HH (as mentioned earlier in Figure 1) sub-band consecutively and then it is transformed into 3-level inverse DWT form. At this stage, for RGB video frame we get the watermarked blue channel which is then combined to other two channels to obtain the watermarked video frame. The relation of embedding is given in Equation 4. Where i and j ranges over selected coefficients in the DWT $_{i;j}{}^0$ and $_{i,j}$ denote the DWT coefficient of the blue channel of the original video frame and the watermarked video

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frame respectively, w_{ij} is the watermark signal and (zeta) is the scaling parameter which value ranges from 0:2 to 0:6 (we found it from our experimental result).

$$\beta'_{i,j} = \beta_{i,j} + \zeta|\beta_{i,j}|w_{i,j} \quad (4)$$

In the case of multiple watermarking, the equation 4 can be repeated up to n times by Equation 5.

$$\beta^{n}_{i,j} = \beta^{n-1}_{i,j} + \zeta|\beta^{n-1}_{i,j}|w^{n-1}_{i,j} \quad (5)$$

C. Watermark detection

Without the original video, authorized detection of the hidden information can be easily accomplished by using the watermarked video and watermark signal. The detector detect whether the watermark is present or not in the watermarked video. Similar to the embedding process, before detecting the watermark the system need to extract the video shots and then select the appropriate identical frame from each video shot. Then the 3-level wavelet transform is performed on the blue channel of the selected frame. Finally compute the average. The proposed watermark detection steps are illustrated in Figure 4.

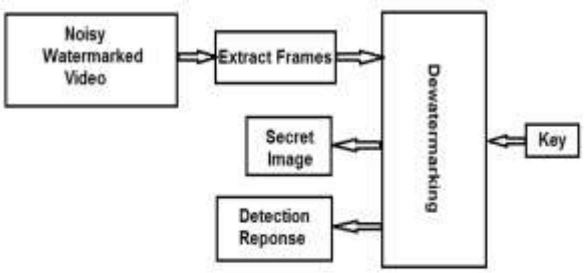


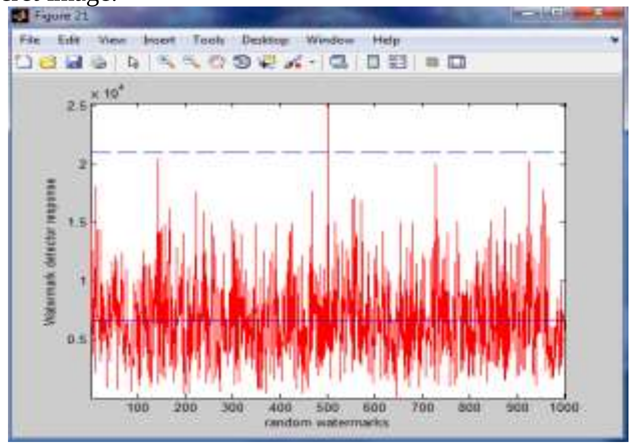
Fig. 4: Steps for Dewater marking.

In Dewatermarking process fist of all insert noisy video and then insert key, then apply Dewatermarking as output we have detection response of detect watermark from noisy video and secret image.

Evaluation and results

To verify the effectiveness (qualities and robustness) of the proposed video watermarking technique, we conduct several experiments with this procedure on several uncompressed video clip.

In this work we load a host video and then extract frames then apply 5 Level DWT and then apply watermarking. In detection of watermark as output we have detection response of added signal in video and secret image.



Detection response of watermarked video

A. Perceptibility

Perceptibility expresses amount of distortion caused by watermark embedding. In other words, it indicates how visible the watermark is. It is measured by peak signal-to-noise ratio (PSNR). The less the value of PSNR is the more perceptible the watermark. The PSNR value represents the average of total identical frames from all video shots. If the PSNR value is 45db or more then It can be said that the quality of the video is almost same to the original video. In our proposed method the PSNR value for all the videos is more than 45db.

B. Noise attack

In order to check the performance of our technique indifferent noise attack we performed some experiment in Matlab. In this test we add two type of noise in watermarked video. One is Gaussian noise and another is salt & peeper noise.

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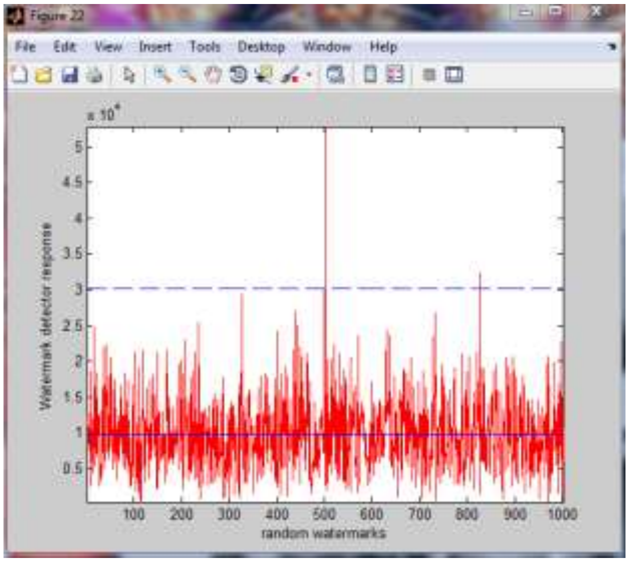
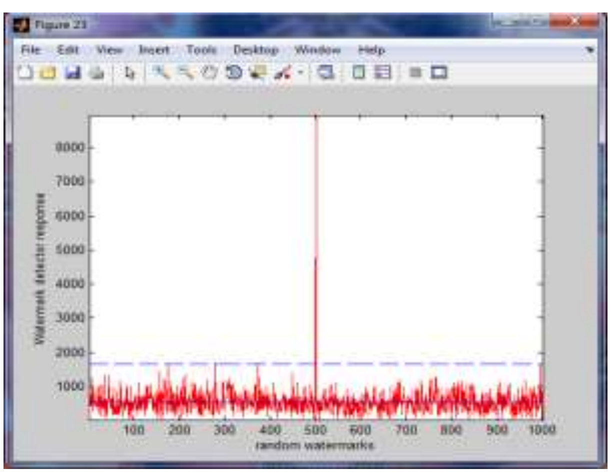


Detection response for noise attacking on watermark

D. Frame dropping

For the existence of the inherent redundancy in video data, there is little change between frames in a shot. So, the frame dropping is often used as an effective video watermark attack, since it leads little or no damage to the video signal. To test the performance of video watermarking procedure against the video frame dropping, we choose 1st video which has 141 frames and randomly dropped 10 frames and finally execute the detector. Here Response of the detector to the frame In this figure the red line indicating the correlation watermark into the identical frame of each video shot if No of identical frame is deleted the system can easily detect the watermark after a large number of frames are dropped.



Detection response of frame dropping case

Level	Original watermarked	Salt & peeper watermarked	Gaussian watermarked
3 level	51.34	37.33	36.33
6 level	53.87	40.05	38.91

Table 1: PSNR Result

Conclusion

In this paper, identical frame based video watermarking technique on 6-level DWT is proposed which is perceptually invisible. In our work there are detect more embedded signal through 3- level watermarking and it also give more PSNR. In future our plan is to minimize the watermark embedding time to improve the performance of the proposed system.

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