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A Review on Video Watermarking and Its Robust Techniques

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Abstract

There has been a rapid growth in internet and technology that lead to increase in the data exchange and use of digital media. Hence, there is a need of copyright protection of the digital media. Digital video watermarking is a modern and widely used technique for protecting the digital media by embedding the additional data along with the video signal. A number of video watermarking techniques are proposed. This paper reviews various schemes that exploit different ways of embedding a robust watermark in order to maintain the quality of original video signal and also review their robustness against several attacks.

Keywords: *Video Watermarking, Discrete Wavelet Transform, Principal Component Analysis, Binary Watermark.*

1. Introduction

There has been an explosive growth in use of internet and World Wide Web and also in multimedia technology and it's applications recently. This has facilitated the distribution of the digital contents over the internet. Digital multimedia works (video, audio and images) become available for retransmission, reproduction, and publishing over the Internet. A large amount of digital data is duplicated and distributed without the owner's consent. This arises a real need for protection against unauthorized copy and distribution. Hence it became necessary to build some secure techniques for legal distribution of these digital contents. Digital Watermarking has proved to be a good solution to tackle these problems. It discourages the copyright violation and help to determine the authenticity and ownership of the data.

In the literature, different schemes are proposed to achieve more robustness and imperceptibility. In 2007, Hanane H.Mirza et al. [3] propose a new digital video watermarking scheme based on Principal Component Analysis. A video file is a continuous collection of static images, and each image is composed of three color channels, the proposed algorithm embed a watermark in the three color channels RGB of an input video file. An imperceptible watermark is embedded into the three different RGB channels of the video frame separately using PCA transform. The main advantage of this approach is that the same or multi-watermark can be embedded into the three color channels of the image in order to increase the robustness of the watermark. Furthermore, using PCA transform allows to choose the suitable significant components into which to embed the watermark. The preliminary results show a high robustness against most common video attacks, especially frame dropping, cropping and rescaling for a good perceptual quality.

In 2008, E. Chrysochos et. al. presented a new robust watermarking scheme. The algorithm is based on a chaotic function and a correlation method for detection, operating in the frequency domain. The scheme is blind and comparing to other chaos related watermarking methods, experimental results exhibit satisfactory robustness against a wide variety of attacks such as filtering, noise addition, geometric manipulations and JPEG compression with very low quality factors. The scheme also outperforms traditional frequency domain embedding both in terms of robustness and quality.

In 2009, Sadik. A.M .Al-Taweel et. Al. [13] proposed a novel DWT-based video watermarking algorithm based on a three-level DWT using Haar filter which is robust against geometric distortions such as Downscaling, Cropping, and Rotation. It is also robust against Image processing attacks such as low pass filtering (LPF), Median filtering, and Weiner filtering. Furthermore, the algorithm is robust against Noise attacks such as Gaussian noise, Salt and Pepper attacks. The embedded data rate is high and robust. The

experimental results show that the embedded watermark is robust and invisible. The watermark was successfully extracted from the video after various attacks.

Salwa A.K Mostafa et. al. [4] presents a novel technique for embedding a binary logo watermark into video frames. PCA is applied to each block of the two bands (LL – HH) which result from Discrete Wavelet transform of every video frame. The watermark is embedded into the principal components of the LL blocks and HH blocks in different ways. The scheme is tested by applying various attacks. Experimental results show no visible difference between the watermarked frames and the original frames and show the robustness against a wide range of attacks such as MPEG coding, JPEG coding, Gaussian noise addition, histogram equalization, gamma correction, contrast adjustment, sharpen filter, cropping, resizing, and rotation. The proposed scheme is an imperceptible and a robust hybrid video watermarking scheme. Combining the two transforms improved the performance of the watermark algorithm.

In 2011, Sanjana Sinha et. al. [2] proposed a comprehensive approach for watermarking digital video by using a hybrid digital video watermarking scheme based on Discrete Wavelet Transform (DWT) and Principal Component Analysis (PCA). PCA helps in reducing correlation among the wavelet coefficients obtained from wavelet decomposition of each video frame thereby dispersing the watermark bits into the uncorrelated coefficients. The video frames are first decomposed using DWT and the binary watermark is embedded in the principal components of the low frequency wavelet coefficients. The imperceptible high bit rate watermark embedded is robust against various attacks that can be carried out on the watermarked video, such as filtering, contrast adjustment, noise addition and geometric attacks.

Manish Choubisa et. al. [7] proposed algorithm of digital watermarking technique based on DCT (Discrete Cosine Transformation) using permuting the image. Through adjusting the block DCT coefficient of the image the watermarks are invisible. The images are first permuted and then converting into block allowing to 8×8 pixel and thus the watermark images are embedded through adjusting their DCT coefficient. The proposed scheme proved that the method has strong robust.

In 2012, Poulami Ghosh et. al. [14] proposed a novel watermarking technique where both visible and invisible watermarks are embedded in a video. Digital data can be copied easily without any degradation in quality, so the protection of the data is necessary. Digital watermarking is a technology to embed additional information into the host signal to ensure security and protection of multimedia data. The video frames contain both the watermarks, so it is more robust to attacks. The watermarking scheme described here deals with embedding and extraction of the watermarks. Discrete Wavelet transform (DWT) is used to embed the invisible watermark and Peak Signal to Noise Ratio (PSNR) is calculated to measure efficiency of this method. In this technique we are including both visible and invisible watermark which gives an extra edge in the copyright protection. As we are using compound mapping to embed the visible watermark it helps to increase the robustness of the video. The proposed algorithm works well on gray scale and on video of uncompressed .avi format and could be done in colored videos further.

Nisreen I Yassin et. al. [1] introduced a comprehensive approach for digital video watermarking, where a binary watermark image is embedded into the video frames. Each video frame is decomposed into sub-images using 2 level discrete wavelet transform then the Principle Component Analysis (PCA) transformation is applied for each block in the two bands LL and HH. The watermark is embedded into the maximum coefficient of the PCA block of the two bands. The proposed scheme is tested using a number of video sequences. Experimental results show high imperceptibility where there is no noticeable difference between the watermarked video frames and the original frames. The proposed scheme shows high robustness against several attacks such as JPEG coding, Gaussian noise addition, histogram equalization, gamma correction, and contrast adjustment.

Nikita Kashyap et. al. [6] have implemented a robust image watermarking technique for the copyright protection based on 3-level discrete wavelet transform (DWT). In this technique a multi-bit watermark is embedded into the low frequency sub-band of a cover image by using alpha blending technique. The insertion and extraction of the watermark in the grayscale cover image is found to be simpler than other transform techniques. The proposed method is compared with the 1-level and 2-level DWT based image watermarking methods by using statistical parameters such as peak-signal-to-noise-ratio (PSNR) and mean square error (MSE). The experimental results demonstrate that the watermarks generated with the proposed algorithm are invisible and the quality of watermarked image and the recovered image are improved.

Kshama S. Karpe et. al. [12] presents a novel technique for embedding a binary logo watermark into video frames, based on Discrete Wavelet Transform (DWT) and Principal Component Analysis (PCA). PCA is applied to each block of two bands (LL–HH) which results from DWT of every video frame. The video frames are first decomposed using DWT and the binary watermark is embedded in the principal components of the low frequency wavelet coefficients. Results show that there is visible difference between watermarked.

U.Mehraj Ali, et. al. [5] proposed a wavelet based watermarking technique with the combination of PCA transform. DWT is more computationally efficient than other transform methods like DFT and DCT. Due to its excellent spatio-frequency localization properties, the DWT is very suitable to identify areas in the host video frame where a watermark can be embedded imperceptibly. PCA is basically used to hybridize the algorithm as it has the inherent property of removing the correlation amongst the data i.e. the wavelet coefficients and it helps in distributing the watermark bits over the sub-band used for embedding thus resulting in a more robust watermarking scheme that is resistant to almost all possible attacks. The watermark is embedded into the luminance component of the extracted frames as it is less sensitive to the Human Visual System (HVS).

Gaurav Bhatnagar et. al. [8] proposed a wavelet packet transform (WPT)-based robust video watermarking algorithm. A visible meaningful binary image is used as the watermark. First, sequent frames are extracted from the video clip. Then, WPT is applied on each frame and from each orientation one sub-band is selected based on block mean intensity value called robust sub-band. Watermark is embedded in the robust sub-bands based on the relationship between wavelet packet coefficient and its 8-neighbour (*D*8) coefficients considering the robustness and invisibility. Experimental results and comparison with existing algorithms show the robustness and the better performance of the proposed algorithm.

2. Video Watermarking Techniques

Different digital video watermarking algorithms have been proposed. Video watermarking techniques are classified according to their working domain. Some techniques embed watermark in the spatial domain. This is done by modifying the pixel values in each frame extracted from the video. These methods are not robust to attacks and common signal distortions. In contrast, other techniques embed the watermark in the frequency domain, which are more robust to distortions.

2.1 Spatial Domain

The spatial domain watermarking techniques embed the watermark by modifying the pixel values of the host image/video directly. Least Significant bit (LSB) technique is the most frequently used method. In this technique, the LSB of each pixel is used to embed the watermark or the copyright information. This technique is the most-straight forward method and uses the entire cover image to store the watermark, which enables a smaller object to be embedded multiple times. In case of attacks destroying data, a single surviving watermark can be considered a success. They are robust to attacks like cropping, noise, lossy compression, etc. But an attack that is set on a pixel to pixel basis can fully uncover the watermark, which is the major drawback of the system.

The main advantages of pixel based methods are that they are conceptually simple and have very low computational complexities and therefore are widely used in video watermarking where real-time performance is a primary concern. However, they also exhibit some major limitations. The need for absolute spatial synchronization leads to high susceptibility to de-synchronization attacks; lack of consideration of the temporal axis results in vulnerability to video processing and multiple frame collusion; and watermark optimization is difficult using only spatial analysis techniques.

2.2 Frequency Domain

In frequency domain techniques, the watermark is embedded by modifying the transform coefficients of the frames of the video sequence. The most commonly used transforms are the Discrete Fourier Transform (DFT), the Discrete Cosine Transform (DCT), and the Discrete Wavelet Transform (DWT).The watermark is embedded distributively in overall domain of an original data. Here, the host image/video is first converted into frequency domain by transformation techniques. The transformed domain coefficients are then altered to store the watermark information. The inverse transform is finally applied in order to obtain the watermarked image/video. Several researches concentrated on using DWT because of its multi resolution characteristics, it provides both spatial and frequency domain characteristics so it is compatible with the Human Visual System (HVS). Also the recent

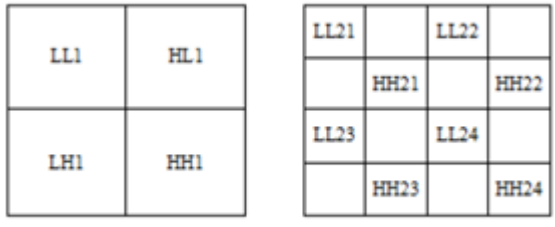
trend is to combine the DWT with other algorithms to increase robustness and invisibility.

3. Proposed Watermarking Scheme:

In this paper, we propose an imperceptible and robust video watermarking algorithm based on DWT and PCA. DWT is more computationally efficient than other transform methods because of its excellent localization properties which provide the compatibility with the Human Visual System (HVS). More robustness could be achieved by embedding the watermark into higher levels of wavelet transform. In our work we propose this hybrid scheme by considering multilevel DWT and then applying PCA to it.

3.1 Discrete Wavelet Transform

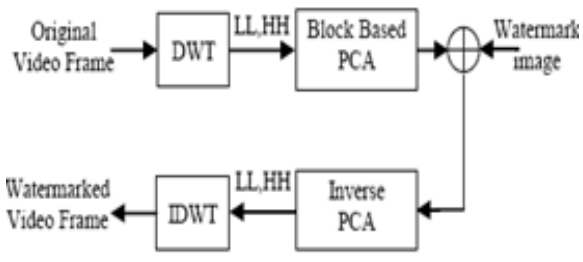
The Discrete Wavelet Transform (DWT) is used in a wide variety of signal processing applications. 2-D discrete wavelet transform (DWT) decomposes an image or a video frame into sub-images, 3 details and 1 approximation. The approximation sub-image resembles the original on 1/4 the scale of the original. The 2-D DWT is an application of the 1-D DWT in both the horizontal and the vertical directions. DWT separates 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. Embedding the watermark in low frequencies obtained by wavelet decomposition increases the robustness with respect to attacks that have low pass characteristics like filtering, lossy compression and geometric distortions while making the scheme more sensitive to contrast adjustment, gamma correction, and histogram equalization. Since the HVS is less sensitive to high frequencies, embedding the watermark in high frequency sub-bands makes the watermark more imperceptible while embedding in low frequencies makes it more robust against a variety of attacks.
The DWT (Discrete Wavelet Transform) separates an image into a lower resolution approximation image (LL) as well as horizontal (HL), vertical (LH) and diagonal (HH) detail components. The process can then be repeated to compute multiple "scale" wavelet decomposition. One of the many advantages over the wavelet transform is that that it is believed to more accurately model aspects of the HVS as compared to the FFT or DCT. This allows us to use higher energy watermarks in regions that the HVS is known to be less sensitive to, such as the high resolution 32 detail bands LH, HL, HH). Embedding watermarks in these regions allow us to increase the robustness of our watermark, at little to no additional impact on image quality.



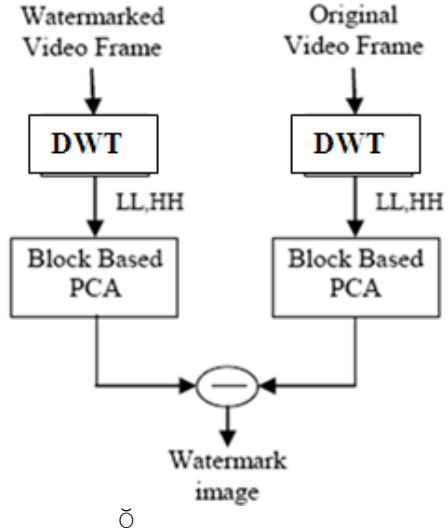
3.2 Principal Component Analysis

Principal component analysis (PCA) is a mathematical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of uncorrelated variables called principal components. The number of principal components is less than or equal to the number of original variables. PCA is a method of identifying patterns in data, and expressing the data in such a way so as to highlight their similarities and differences. Since patterns in data can be hard to find in data of high dimension, where the advantage of graphical representation is not available, PCA is a powerful tool for analyzing data.
The other main advantage of PCA is that once these patterns in the data have been identified, the data can be compressed by reducing the number of dimensions, without much loss of information. It plots the data into a new coordinate system where the data with maximum covariance are plotted together and is known as the first principal component. Similarly, there are the second and third principal components and so on. The maximum energy concentration lies in the first principal component.

The following block diagrams show the embedding and extraction procedure of the watermark. In the proposed method the binary watermark is embedded into each of the video frames by the decomposition of the frames into DWT sub bands followed by the application of block based PCA on the sub-blocks of the low frequency sub-band. The watermark is embedded into the principal components of the sub-blocks. The extracted watermark is obtained through a similar procedure.



1



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4. Conclusion

In this paper we revised various proposed video watermarking algorithm and their robustness factor. A robust video watermarking scheme is proposed using multi level DWT in conjunction with the PCA transform. Embedding the watermark in low frequencies obtained by wavelet decomposition increases the robustness against attacks like filtering, lossy compression and geometric distortions while making the scheme more sensitive to contrast adjustment, gamma correction, and histogram equalization. Embedding the watermark in high frequency sub-bands makes the watermark more imperceptible while embedding in low frequencies makes it more robust against a variety of attacks.

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