IJREAT International Journal of Research in Engineering & Advanced Technology, Volume 1, Issue 6, Dec-Jan, 2014
ISSN: 2320 - 8791
www.ijreat.org

Video Watermarking using Wavelets

Senthil Veerasamy[1], Bhaskaran Raman[2]

[1]Department of MCA, Thiagarajar School of Management, Madurai, Tamilnadu, India

[2]School of Mathematics, Madurai Kamaraj University, Madurai, Tamilnadu, India

Abstract

Abstract— Digital image, audio and video are now widely distributed on the internet. The increasing importance of digital media, however, brings new challenges as it is now easy to duplicate and even manipulate multimedia content. Digital Watermarking technology plays an important role in securing the business as it allows placing an imperceptible mark in the digital video data to identify the legitimate owner, track unauthorized users or detect malicious tampering of the digital video.

Keywords: *Digital video watermarking, Wavelets, Attack Analysis..*

1. Introduction

One way to protect multimedia data against illegal recording and retransmission is to embed a signal called digital signature or copyright label or watermark that completely characterize the person who applied it and therefore marks it as being his intellectual property. The basic idea of digital watermarking is to create a metadata containing information about a digital content to be protected and hide it within that content. A Watermarking system consists of two components, Watermark Embedder and Watermark Detector , Watermark embedder combines the cover work Co, an original copy of digital media and payload P, a collection of bits representing metadata to be added to the cover work and creates the watermarked cover Cw. The difference between C0 and Cw is embedding distortion, which will be small enough to be noticed. Watermark Detector either extracts the payload P from the corrupted watermarked cover Ĉw (the corruption may be by various intentional or unintentional distortions) or it produces some kind of confidence measure indicating how likely it is for a given payload P to be present in Cw [1,2,3,4,5].

Robustness refers to the ability to detect the watermark after any kind of distortions introduced by standard or malicious data processing, i.e. the watermark shall be very difficult to erase without destroying the content. Robustness, in general, is restricted to common signal processing operations like linear and nonlinear filtering, lossy compression, statistical averaging, data reduction and geometrical distortions. Depending on the application and watermarking requirements, the list of distortions and attacks to be considered includes, but is not limited to: Common signal processing operations such as Digital to Analog, Analog to Digital conversion, resampling, requantization, dithering distortion, color scan, print-scan, analog TV transmission. Signal enhancement operations such as sharpening, contrast enhancement, color correction, gamma correction, filtering operations such as Linear filtering includes low pass, high pass and band pass filtering and nonlinear filtering includes median, morphological filtering. Additive and multiplicative noise includes noises such as Gaussian, Salt and Pepper, speckle and passion etc. Many lossy compression schemes such as JPEG, H.261, H.263, MPEG can potentially degrade the data's quality through irretrievable loss of data. Geometric distortions are specific to images and videos and include operations such as translation, rotation, scaling and shearing. Data reduction includes cropping, clipping and histogram modification. Data composition includes logo insertion and scene composition. Multiple watermarking, Collusion attacks, Statistical averaging, Stirmark attack, Mosaic attacking and Video editing attack such as Cut & splice, cut-insert-splice, fade-out-dissovle and are the other kinds of attacks [6,7,8,9,10].

1.1. Wavelet Transforms

Wavelet Transform is a new tool for predicting performance and optimizing design. It employs an approach to problems where mathematical process models, efficient algorithm for computer numerical solutions, and for computation intensive real-time applications. Also, Wavelet Transform provides windows varying property, i.e. to isolate signal discontinuities one would like to have some short basis functions. The sophisticated mechanism derived from Discrete Wavelet Transform coding studies is introduced to take into account several of Human Visual System phenomena, such as gray level sensibility, isofrequency and non-isofrequency masking and noise sensibility around edges. When we decompose a data set using wavelets, if the details are small, they might be omitted without substantially affecting the main features of the data set. The idea of *threshold* is set of all coefficients that are less than a particular value which is called the threshold to zero. Research in *human perception* indicates that the retina of the eye splits an image into several components, which circulate from the eye to the cortex in differently tuned channels (frequency bands). These channels can only be excited by the component of a signal with similar characteristics. The processing of signals in different channels is independent. Studies have shown that each of these channels has a bandwidth of approximately one octave. Similarly, in a multi-resolution decomposition, the image is separated into bands of approximately equal bandwidth on a logarithmic scale. It is therefore expected that use of the discrete wavelet transform will allow the independent processing of the resulting components without significant perceptible interaction between them.

1.2. Quality measures in Digital Watermarking

There are various quality measures defined in literature, the watermark robustness directly depends on the embedding strength, which in turn influences the visual degradation of the image. Measures such as *difference distortion metrics*; *correlation distortion metrics and perceptual quality metrics* are the most popular distortion criteria used in the digital watermarking. The difference distortion metrics include *maximum difference, average absolute difference, norm average absolute difference, mean square error, normalized mean square error, L^p-norm, Laplacian MSE, Signal to Noise Ratio, Peak Signal to Noise Ratio and Image Fidelity.* Correlation based distortion metrics includes *normalized cross correlation* and *correlation quality. Structured content, global sigma signal to noise ratio* and *sigma signal to noise ratio* are also used as quality metrics. *Mean Structural Similarity Index (MSSIM)* and *Visual Signal to Noise Ratio (VSNR)* are quality measures used by recent researchers. We have used the quality measures such as mean square error, signal to noise ratio, peak signal to noise ratio, normalized correlation, Mean Structural Similarity Index and Visual Signal to Noise Ratio in this work and are defined as follows.

1.2.1 Mean Square Error - Mean Square Error is one of the quality measures, which is oldest, widely used, simplest to calculate and have clear physical meaning. MSE is defined as follows in equation (1.1).

$$MSE = \frac{1}{N}\sum_{i=1}^{N} E^2 = \frac{\|E\|^2}{N} \qquad (1.1)$$

where E = WV – V, WV is the watermarked video and V is the original video.

1.2.2. Peak Signal to Noise Ratio - *The quality measure PSNR has been used to evaluate the fidelity of the watermarked image after embedding the logo. The PSNR is defined as in equation (1.2)*

$$PSNR = 10\log_{10}\left(\frac{255^2}{MSE}\right) \qquad (1.2)$$

1.2.3. Normalized Cross Correlation - Normalized cross correlation (NCC) has been used extensively for many machine vision applications and it is the most common way to find a template in an image. The equation (1.3) is used to find the normalized correlation coefficients.

$$NCC = \frac{\sum H_{m,n} WH'_{m,n}}{\sum H^2_{m,n}} \qquad (1.3)$$

1.2.4. Mean Structural Similarity Index - Mean Structural Similarity Index Measure (MSSIM), indicates the relative change in structural information of a watermarked video with respect to the original video sequences. MSSIM has been defined in [101] and is as follows:

$$S(x,y) = l(x,y) * c(x,y) * s(x,y) \qquad (1.4)$$

where l(x,y) is local patch luminance, c(x,y) is contrast sensitivity and s(x,y) is local patch structure, and are defined as in equations (1.5), (1.6) and (1.7).

$$l(x,y) = \frac{2\mu_x\mu_y + C_1}{\mu_x^2 + \mu_y^2 + C_1} \qquad (1.5)$$

$$c(x,y) = \frac{2\sigma_x\sigma_y + C_2}{\sigma_x^2 + \sigma_y^2 + C_2} \qquad (1.6)$$

$$s(x,y) = \frac{\sigma_{xy} + C_3}{\sigma_x\sigma_y + C_3} \qquad (1.7)$$

where μ is Mean, σ is Standard Deviation and C_1, C_2, C_3 are small positive constant to stabilize each term. MSSIM index can obtain the maximum value of 1 that indicates no change in structure between the observed and the reference frame of video sequence. One of the advantage of using MSSIM is that it has effective normalization power for various types of image structures and distortions.

1.2.5. Visual Signal to Noise Ratio - *The Visual Signal to Noise Ratio (VSNR) is one of the recent visual quality measures. It performs competitively with other visual fidelity measures, and is efficient in terms of computational complexity and memory requirements and it operates on physical luminance and visual angle and can accommodate different viewing conditions as described in equation (1.8).*

$$VSNR = 20\log_{10}\left(\frac{C(I)}{\alpha d_{pc} + (1-\alpha)\frac{d_{gp}}{\sqrt{2}}}\right) \qquad (1.8)$$

where C(I) denotes the Root Mean Square contrast of the original image as defined below in equation (1.9),

$$C(I) = \frac{\sigma_{L(I)}}{\mu_{L(I)}}. \qquad (1.9)$$

2. Digital Video Watermarking

Digital Video Watermarking is one of the promising techniques for protection of ownership content in Digital Rights Management. Applications such as copy control, broadcast monitoring, fingerprinting, video authentication and others are playing major role in video watermarking. There exists a complex trade-off between capacity, fidelity and robustness parameters in any digital watermarking systems. Digital video watermarking can be seen as the exploitation of the features of the compression algorithm in order to hide information but video coding and video watermarking are two conflicting technologies. If the watermark is inserted in the compressed stream, it will reduce computation needs. Common attacks on video data include illegal access and tampering. In Robust digital video watermarking an unauthorized detection can be used for three purposes, namely, (i) it can provide protocol assistance to robust watermarking, (ii) it can provide a fair evaluation of the robustness and security of a given watermarking technology during benchmarking and (iii) it can identify which watermarking technology is being used and help select an appropriate attacking strategy. Embedding the watermark information in the lower and higher wavelet frequency bands, is robust enough against attack on the watermark in motionless or motion regions of video sequence.

2.1. Review of Literature

There are several procedures in watermark embedding and extraction in digital videos, A framework for characterizing the tradeoffs between robustness, distortion of the host image and the capacity using Quantization Index Modulation (QIM) and Dither Modulation discussed by Chen et al [7,11]. S.P. Maity et al [5,15,16,17], selects the perceptually significant region of the cover by using Walsh Transforms also they select the coefficients using Biorthogonal wavelet and using successive interference cancellation to embed and extract the watermark to improve the robustness and embedding capacity they also proposed n-level lifting based DWT data hiding scheme for quality access control of images. A method that employs the Dual Tree Complex Wavelet Transforms (DT-CWT) to embed a watermark in high textured areas of the video frames discussed by Lino Coria1 et al [13], Mark Pickering et al [14]. Jing Zhang et al [48] proposed a method of robust video watermarking scheme of H.264/AVC. The authors of Pik Wah Chan et al [72] proposed a novel Scheme for hybrid digital video watermarking and discussing various issues related to evaluation and experimentation of video watermarking. Lino Coria1 et al [13] propose a hybrid digital video-watermarking scheme based on the scene change analysis with error correction code and robustness analysis to geometrical distortions. Gwena. El. Doerr et al [12] discuss the guide tour of Video watermarking provides detailed literature and methods in current video watermarking strategies. Zhou Wang et al [18,19,20] explains the importance of structured distortion measurement in video quality assessment and they explain the objective image quality measures whose important roles in various image-processing applications. In this proposed work, we used the non-blind and blind method of watermark extraction to analyze the robustness for different modalities of videos such as .AVI, .MOV, and .FLV using Canny edge detection operator and with the Wavelet Transforms. We describe our proposed method of video watermark embedding and extraction process with the analysis of results to check the robustness.

3. Proposed Work

The novelty of our method is use of edge detection operator; Edge detection is a process of identifying and locating sharp discontinuities in a frame of a given video. The discontinuities are abrupt changes in pixel intensity, which characterize boundaries of objects in a scene of video. We use the Canny edge detection operator in our work to select the suitable coefficients of each frame of the video. The improvement of our proposed watermark embedding algorithm includes steps such as read the video, convert the video into frames and then convert the selected frames into YCbCr color components. Then we apply discrete wavelet transform to Y component of all the frames. This is followed by Canny edge detection operation into the second level LL sub-band of each frame. Wherever the edge pixel value is 1, we add the watermark data into LL coefficients and repeat the process until all watermark values are embedded. Finally we take the inverse discrete wavelet transform of each selected frames and then convert all these frames into a video called as watermarked video. The step-by-step method of this embedding process is described as follows and the extraction process is simply reverse of it.

3.1. Embedding Scheme

- Read the video (V) and the watermark logo (L) and convert into frames (VF)
- Convert the watermark logo into one-dimensional (OL) and multiply it by the embedding factor α and convert all frames into YCbCr color components (YVF)
- Apply the 2nd level DWT into Y component of each frame (YVF')
- Apply Canny edge detection into the 2nd level LL sub-band of each frame -YVF''
- If edge pixel=1 (YVF''(i, j) = = 1) then add the watermark bit into the LL coefficients (YVF''(i,j) = YVF''(i,j) + OL'(k))
- Repeat the above step until all the watermark bits are embedded and take inverse discrete wavelet transform (IYVF) .

Image fidelity is degraded with the increase in payload capacity and embedding strength. The higher value of embedding strength, at the cost of greater visual distortion, increases robustness against signal processing operations.

For relatively dark and busy or textured regions, the local gain factor alpha (α) increases the embedding power for higher robustness. For relatively bright and smooth regions where human eyes are more readily able to spot any distortions α should be decreased to minimize the distortions. To consider and achieve this, we use the α value as 0.0625 in dark region and 0.03125 for bright region. Also since the video size is large, we can choose the payload capacity depending on the applications. In our case we choose advertisement videos of as watermarks, which will be embedded in all the frames of the video sequence.

4. Robustness Analysis

Nearly two hundred video file formats are available in digital world; in our work we take video types such as Audio Video Interleave (.avi), Movie (.mov) and Flash Video (.flv) because of common availability and support for all the platforms. Our tested sample videos are High, Medium and Slow in motion and the duration is twenty seconds. The Figure 1 shows the extracted watermark video frames from the tested watermarked video frames using Biorthogonal wavelet and Canny edge detection operator. We also used the histogram analysis to check the visual differences between the original and watermarked frames, figure 1shows the histogram analysis of our sample video frames, the graph shows that the original and watermarked seems to be the same for all the tested video sequences.

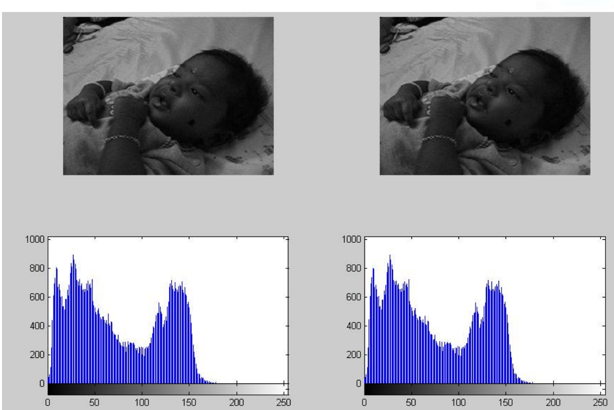

Figure 1. Histogram analysis of original and watermarked frame

There are various distortion quality measures are defined in literature, the measures such as Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR), Mean Structural Similarity Index (MSSIM) and Visual Signal to Noise Ration (VSNR) as described in Chapter 1. We use all these measure for testing the distortion quality between the watermarked video with original video. The graph in Figure 2 shows the results of Mean Structured Similarity Index Measure (MSSIM) between the original and watermarked frames of different video sequences, and all these cases, the MSSIM values are also close to 1, which indicates that similarity between the original and watermarked frames are very high. Also to test the robustness of our method against the JPEG compression, we apply the JPEG compression of different compression ratios such as 95, 90, 80, 70, 50, 30 and 10 in the watermarked video sequences. The extracted watermarks from these compressed frames are displayed in Figure 3, the visibility of the extracted watermarks are poor if there is high compression ratio i.e. further clarity in visibility is required in cases such as compression ratios of 95 and 90. Even with the different reduced quality ratios, our method provides reasonable robustness against the compression attacks. The rewatermarking attacks are highly dangerous when two people are claiming the same digital content as their own.

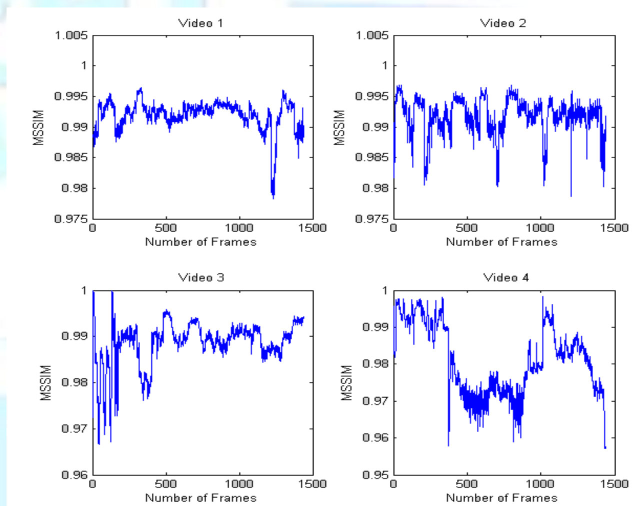

Figure 2. MSSIM between original and watermarked video

To prove the ownership between these two embedded watermarks, only one is embedded first whereas the second is a re-watermarked one. We test robustness of our method against this re-watermarking attack, we embed similar second watermark in the same position of the watermarked content. Even when the similarity of the second watermark video is close to the first one, our method can distinguish these two. We tested our method with various video sequences of different duration; it has reasonable degree of robustness against the rewatermaring attacks. Also our proposed method has effective robustness against the frame dropping attack. The alternate frames are dropped from the video sequence and watermarks are extracted from these frames by Biorthogonal wavelet are shown in Figure 4.

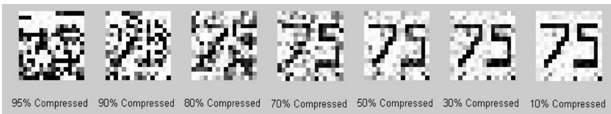

Figure 3. Watermarks extracted from the compressed video frames

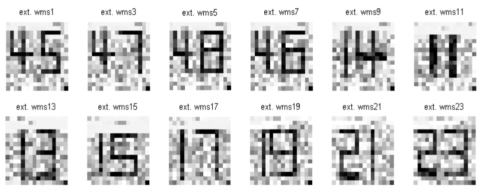

Figure 4. Watermarks extracted from the frame drop attack

5. Conclusion

In this work, we have proposed a scheme, which embeds and extracts the advertisement video as a watermark in videos, using various types of wavelets and edge detection operator. The scheme embeds the watermark in the luminance component of the frames of video, the proposed method is working very well for extracting the video watermarks with good visibility and also robust to different kinds of attacks. We also observe that the .avi videos are highly suitable for watermark embedding to maintain the robustness and security because of more memory requirement. In future the proposed work is to be tested to other multimedia content and also to test other kinds of attacks to prove the tamper resistance and authenticity.

References

[1] A. Piva, M. Barni, F. Bartolini and V. Cappellini, “DCT based watermark recovering without resorting to the uncorrupted original image”, proceeding of IEEE internation conference on image processing, vol 1, pp 520-523, 1997.

[2] A.B. Watson, “DCT quantization matrices visually optimized for indivisual images”, Proceedings of SPIE conference on human vision, visual processing, and digital display IV, 1997.

[3] A.B. Watson, G.Y. Yang, J.A. Soloman and J. Villasanor, “Visibility of wavelet quantization noise”, IEEE transactions on image processing, 6, pp 1164-1175,1997.

[4] Alasdair Mcandrew, “Digital image processing with Matlab, Cengage Learning, 2009.

[5] Amit Phadikar, S.P. Maity and Malay K Kundu, “Quantization based Data hiding scheme for efficient Quality Access Control of Images using DWT via Lifting”, Proceeding of IEEE conference on Computer Vision Graphics and Image Processing, pp. 265-272,2008.

[6] Anil K. Jain, ”Fundamentals of Digital Image Processing”, Tenth Indian Printing, Prentice Hall of India, 2003.

[7] B. Chen, G.W. Wornell, “ Digital watermarking and information embedding using dither modulation”, Proceeding of IEEE workshop multimedia signal processing, pages 273-278, 1998.

[8] Bernd Jahne, Horst Haubecker , “Computer Vision and Applications”, Elsevier publications, 2007

[9] C H. Lee, Y K. Lee “An adaptive digital image watermarking technique for copyright protection”, IEEE Transactions on Consumer Electronics, Vol. 45, Issue 4,pp. 1005 - 1015, Nov 1999.

[10] C.I. Podichuk and W. Zeng, “Image adaptive watermarking using visual models”, IEEE journal on selected areas in communications, Vol. 16, pp 525-539,1998.

[11] Chen and Wornell, “Dither Modulation and Quantization Index Modulation: New methods for Digital Watermarking and Information Embedding”, Proceeding of IEEE workshop on Multimedia signal Processing, pp 273-278, 1998.

[12] Gwenear Doerr, Jean-Luc Dugelay, “A Guide tour of Video Watermarking”, Signal Processing: Image Communication, Elsevier, 18, pp 263-282, 2003.

[13] Lino Coria1, Panos Nasiopoulos, Rabab Ward and Mark Pickering, “An Access Control Video Watermarking Method that is Robust to Geometric Distortions”, Journal of Information Assurance and Security, vol. 2. pp. 266-274, 2007.

[14] Mark Pickering, Lino E. Coria and Panos Nasiopoulos, “A Novel Blind Video Watermarking Scheme for Access Control Using Complex Wavelets” Proceeding of IEEE conference on consumer electronics, 2007.

[15] S.P. Maity and M.K. Kundu “Information theoretic approach to spatial image watermarking”, Proceeding of international conference on Computer Vision, Graphics (ICCVG-2002), Poland, 524-429, September 2002.

[16] Santi P. Maity, Malay K. Kundu and Mrinal Kr. Mandal, “Capacity Improvement in Spread Spectrum Watermarking using Biorthogonal Wavelet”, Proceeding of 48th international Midwest symposium on circuits and systems, pp 1426-1429, 2005.

[17] Zhou Wang , Alan C. Bovik , “Mean Square Error : Love it or Leave it?”, IEEE signal processing magazine, pp 98-117, Jan. 2009.

[18] Zhou Wang , Alan C. Bovik, “A Universal Image Quality Index”, IEEE Signal Processing Letter, Vol xx, pp. 81-84, March 2002.

[19] Zhou Wang, Ligang Lu and alan C Bovik, “Video Quality Assessment Based on Structural Distortion measurement”, Signal Processing: Image Communication, Vol. 19, No.2, pp 121-132, Feb. 2004.