MPEG-1 Video Semi-Blind Watermarking Algorithm in the DWT Domain

Ersin Elbasi[α] and Ahmet M. Eskicioglu[β]
[α]The Graduate Center, The City University of New York
365 Fifth Avenue, New York, NY 10016
[β]Department of Computer and Information Science, Brooklyn College
The City University of New York, 2900 Bedford Avenue, Brooklyn, NY 11210
EElbasi@gc.cuny.edu, eskicioglu@sci.brooklyn.cuny.edu

Abstract

A semi-blind image watermarking scheme embeds a pseudo random sequence in all the high pass DWT coefficients above a given threshold T_1. The attacked DWT coefficients are then correlated with the original watermark. For watermark detection, all the coefficients higher than another threshold T_2 ($>T_1$) are chosen for correlation with the original watermark. This idea was extended to embed the same watermark in two bands (LL and HH). The experiments show that for one group of attacks, the correlation with the real watermark is higher than the threshold in the LL band, and for another group of attacks, the correlation with the real watermark is higher than the threshold in the HH band. In this paper, we embed a pseudo random sequence in MPEG-1 using two bands (LL and HH). The chosen attacks are JPEG compression, resizing, adding Gaussian noise, low pass filtering, rotation, histogram equalization, contrast adjustment, gamma correction, cropping, frame dropping, and frame swapping. Our experiments show that for one group of attacks (i.e., JPEG compression, Gaussian noise, resizing, low pass filtering, rotation, and frame dropping), the correlation with the real watermark is higher than the threshold in the LL band, and for another group of attacks (i.e., cropping, histogram equalization, contrast adjustment, and gamma correction), the correlation with the real watermark is higher than the threshold in the HH band. Only for frame swapping, the correlation with the real watermark is higher than the threshold in both of the bands.

1. Introduction

Two-dimensional DWT can be implemented using digital filters and downsamplers. Each level of decomposition produces four bands of data denoted by LL, HL, LH, and HH. The LL subband can further be decomposed to obtain another level of decomposition.

A DWT-based semi-blind image watermarking scheme [1] leaves out the low pass band, and embeds a pseudo random number (PRN) sequence (i.e., the watermark) in the other three bands into the coefficients that are higher than a given threshold T_1. During watermark detection, all the high pass coefficients above another threshold T_2 ($T_2 \geq T_1$) are used in correlation with the original watermark. The algorithms for embedding and detection are as follows:

Watermark embedding

Compute the DWT of an NxN gray scale image I.
Exclude the low pass DWT coefficients.
Embed the watermark (i.e., a PRN sequence) into the DWT coefficients higher than a given threshold T_1: $T = \{t_i\}$, $t'_i = t_i + \alpha|t_i|x_i$, where i runs over all DWT coefficients $> T_1$.
Replace $T = \{t_i\}$ with $T' = \{t'_i\}$ in the DWT domain.
Compute the inverse DWT to obtain the watermarked image I'.

Watermark detection

Compute the DWT of the watermarked and possibly attacked image I^*.
Exclude the low pass DWT coefficients.
Select all the DWT coefficients higher than a given threshold T_2 ($T_2 \geq T_1$).

Compute the sum $Z = \frac{1}{M}\sum_{i=1} y_i t_i^*$, where i runs over all DWT coefficients $> T_2$, M is the number of such coefficients, y_i represents either the real watermark or a fake watermark, t_i^* represents the watermarked and possibly attacked DWT coefficients.

Choose a predefined threshold $T_z = \frac{\alpha}{2M}\sum_{i=1} |t_i^*|$.

If z exceeds T_z, the conclusion is that the watermark is present.

In a recent paper [2], the above idea is extended to embed the same PRN sequence in two bands (LL and HH) using the first level decomposition.

Some of the problems associated with video watermarking are discussed in [3]. Content owners are interested in digital rights management (DRM) systems which can protect their rights and preserve the economic value of digital video. A DRM system protects and enforces the rights associated with the use of digital content. An overview of the concepts and approaches for video DRM and a description of the methods for providing security, including the roles of encryption and video watermarking are given in [4]. 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. Swanson et al [5] presents image, audio, and video data embedding approaches, and the issues associated with copy and copyright protections. Hsu and Wu [6] embed a pseudo random number sequence into both intra and inter frames using DCT with different residual masks in MPEG-1. Simitopoulus et al [7] describe a new technique for MPEG-1/2 compressed video streams. Perceptual models are used in the embedding process to preserve the quality of the video. Qui et al [8] propose a novel H.264/AVC watermarking method. The robust watermark is embedded in the DCT domain and the fragile watermark is embedded into the motion vectors. It is argued that the proposed method can jointly achieve both copyright protection and authentication. Wang et al [9] uses the spatial domain for watermark embedding with much lower computation complexity in MPEG-2. Swanson et al [10] proposes scene-based and video dependent MPEG watermarking. Deguillaume et al [11] proposes a Discrete Fourier Transform (DFT) method for embedding into *I* frames only.

In this paper, we also embed a PRN sequence into *I* frames for two bands (LL and HH). The scaling factor and the threshold values are given in Table 1.

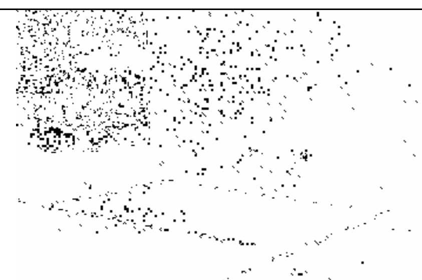
Table 1. Scaling factor α and threshold T

Parameters/Bands	LL	HH
α	0.2	0.8
T_1	10	30
T_2	20	40

A 352x240 sample from the original test sequence, the watermarked image, and their difference are shown in Figure 1.

I frame

Watermarked *I* frame (PSNR = 49.17)



The difference

Figure 1. Embedding two watermarks into an *I* frame

2. Experiments

Matlab was used for all attacks. The chosen attacks were JPEG compression, resizing, adding Gaussian noise, low pass filtering, rotation, histogram equalization, contrast adjustment, gamma correction, and cropping. The attacked images and the Matlab attack parameters are shown in Figure 3.

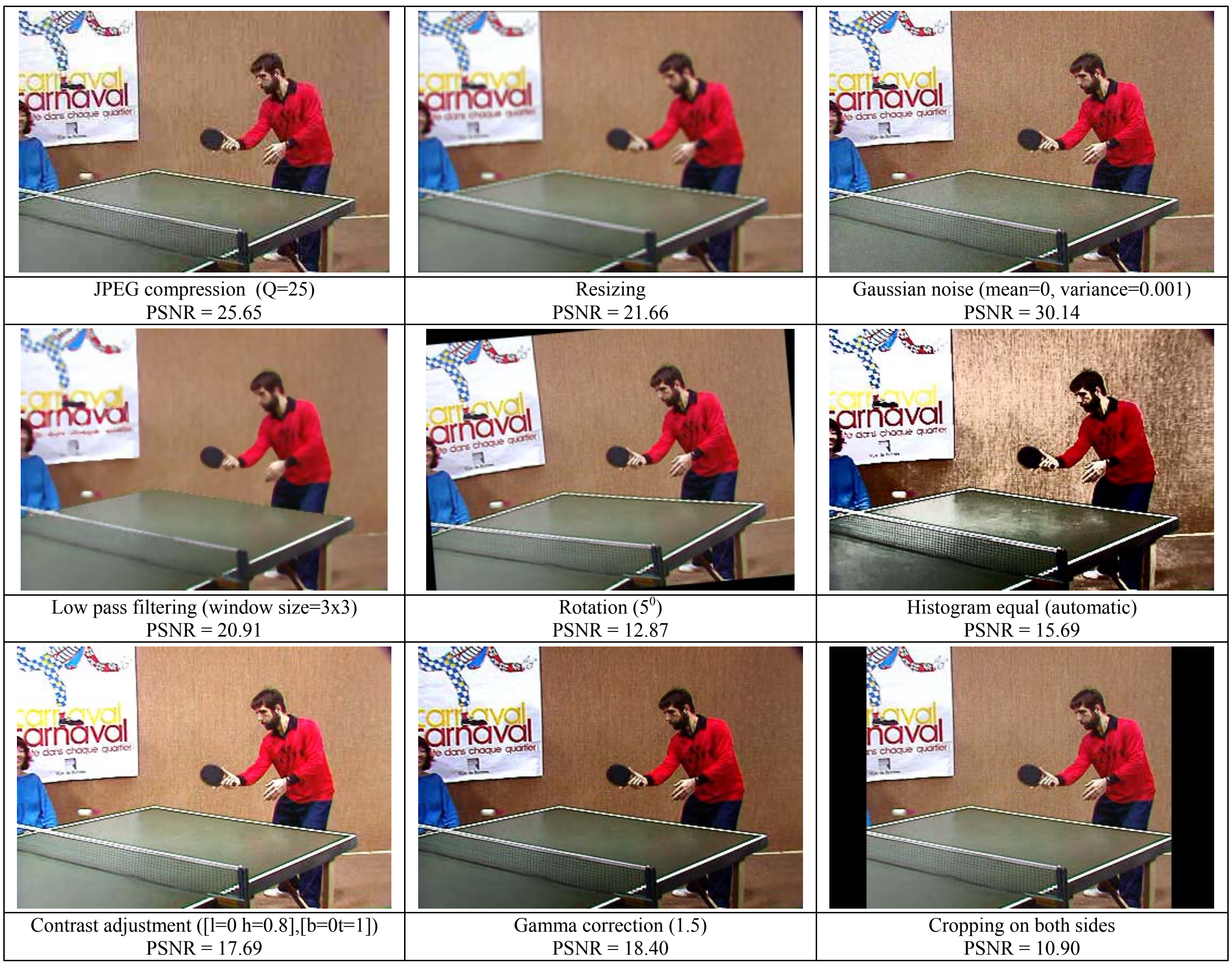
Embedding:

1. Split the video into frames I, B, and P.
2. Convert the NxN RGB I frame to YUV.
3. Compute the DWT of the luminance layer (Y).
4. In each DWT band (LL and HH), embed a PRN sequence to the luminance layer only.
5. Replace the watermarked I frames with original I frames in the original video.

Detection:

1. Split the watermarked (and possibly attacked) video into I, B, and P frames.
2. Convert the NxN RGB I frame to YUV.
3. Compute the DWT of the luminance layer (Y).
4. Calculate the threshold (T_z) and the correlation (Z) for each luminance layer of I frames in each DWT band (LL and HH).
5. In each band, if $Z > T_z$, the watermark is present.

The attacks on a watermarked frame are shown in Figure 2.



JPEG compression (Q=25) PSNR = 25.65

Resizing PSNR = 21.66

Gaussian noise (mean=0, variance=0.001) PSNR = 30.14

Low pass filtering (window size=3x3) PSNR = 20.91

Rotation (5^0) PSNR = 12.87

Histogram equal (automatic) PSNR = 15.69

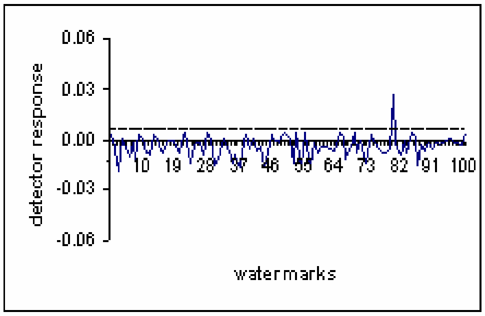
Contrast adjustment ([l=0 h=0.8],[b=0t=1]) PSNR = 17.69

Gamma correction (1.5) PSNR = 18.40

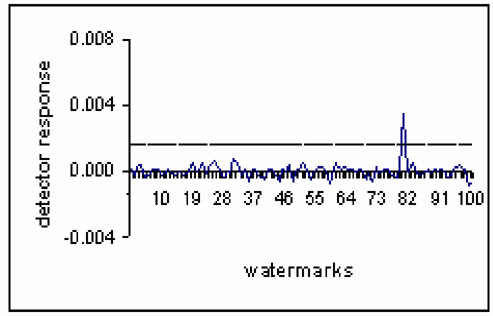
Cropping on both sides PSNR = 10.90

Figure 2. Attacks on a watermarked frame

In Figures 3-14, we display the detector responses for the real watermark, and 99 randomly generated watermarks. In each figure, the correlation with the real watermark is located at 80 on the x-axis, and the dotted line shows the value of the threshold.

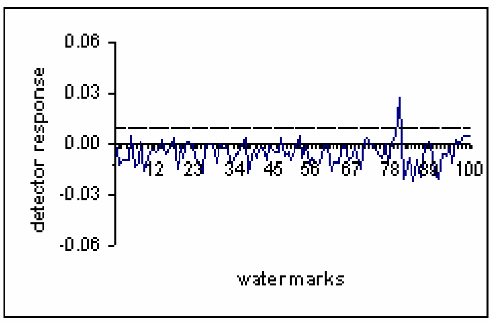


LL band (T=0.0064)

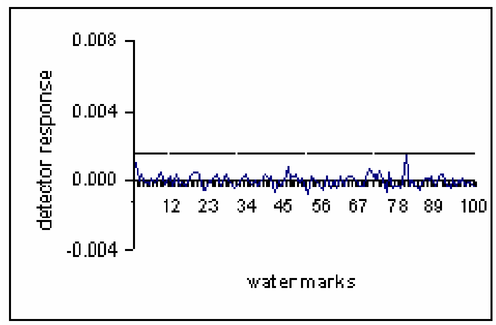


HH band (T=0.0017)

Figure 3. Detector response for unattacked watermarked *I* Frame

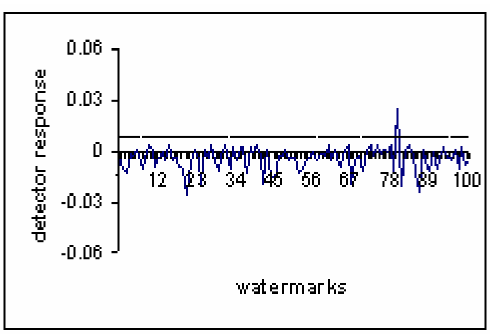


LL band (T=0.0094)

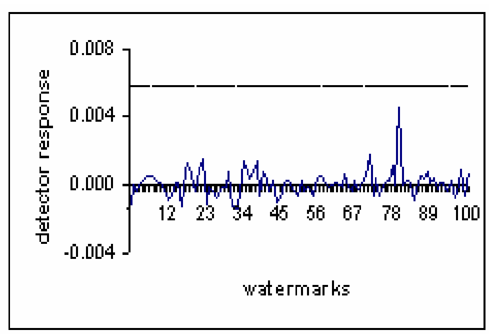


HH band (T=0.0017)

Figure 4. Detector response for JPEG compression: Q=25

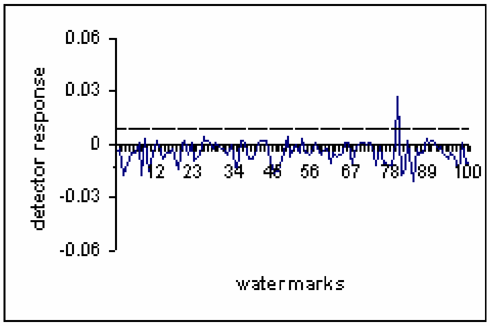


LL band (T=0.0076)

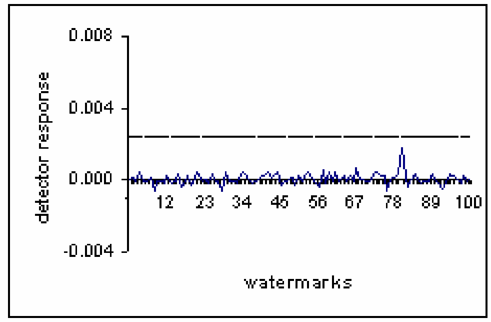


HH band (T=0.0059)

Figure 5. Detector response for Gaussian noise

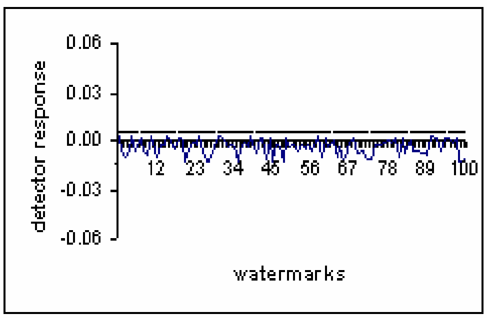


LL band (T=0.0096)

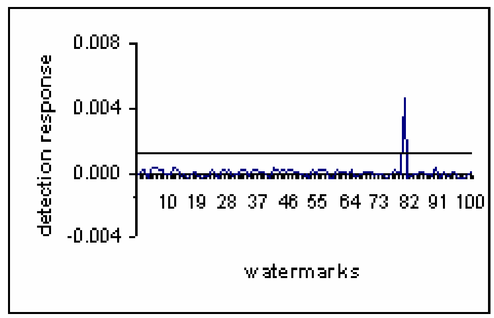


HH band (T=0.0024)

Figure 6. Detector response for resizing

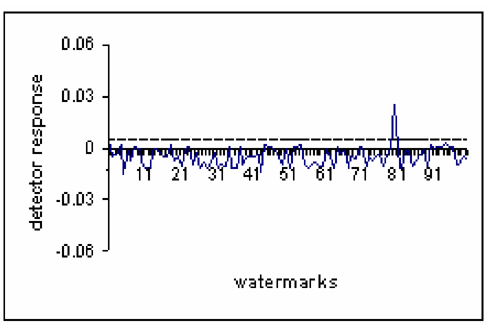


LL band (T=0.0054)

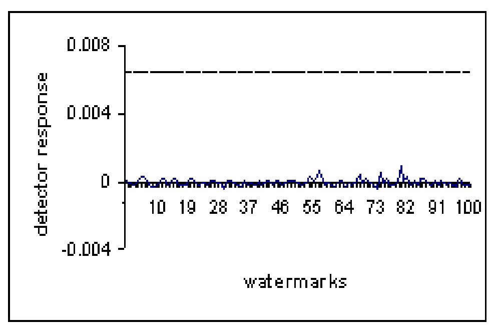


HH band (T=0.0013)

Figure 7. Detector response for cropping

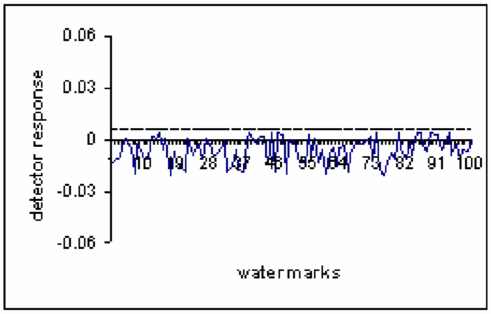


LL band (T=0.0054)

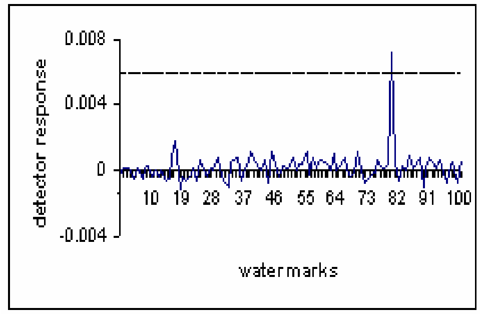


HH band (T=0.0017)

Figure 8. Detector response for low pass filtering

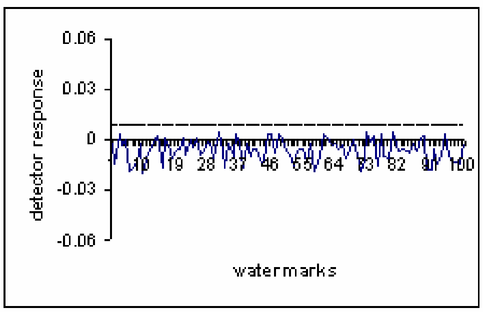


LL band (T=0.0068)

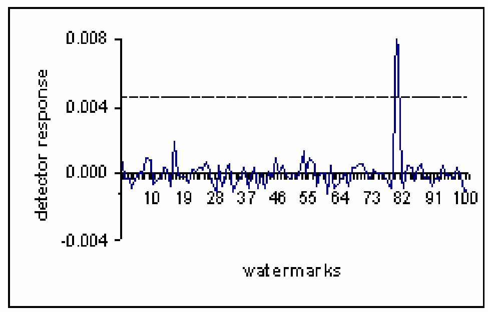


HH band (T=0.0059)

Figure 9. Detector response for histogram equalization

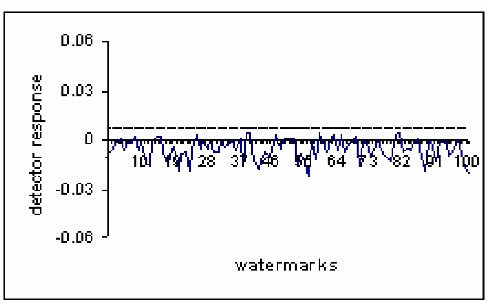


LL band (T=0.0092)

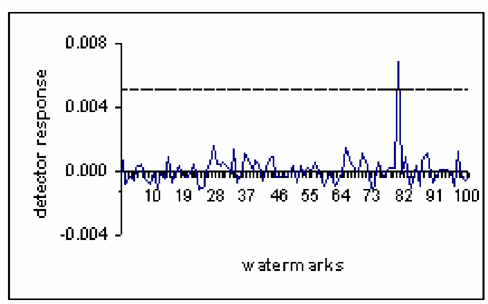


HH band (T=0.0045)

Figure 10. Detector response for contract adjustment

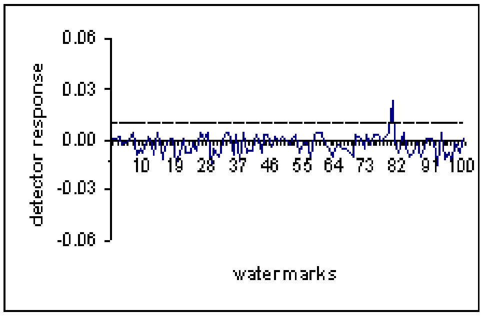


LL band (T=0.0074)

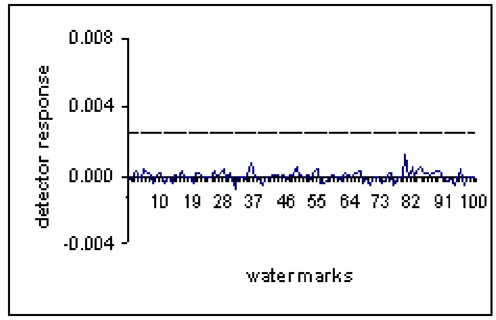


HH band (T=0.0051)

Figure 11. Detector response for gamma correction

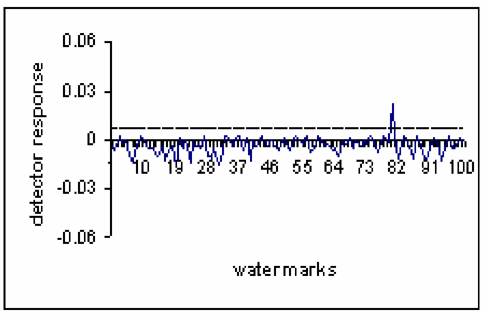


LL band (T=0.0096)

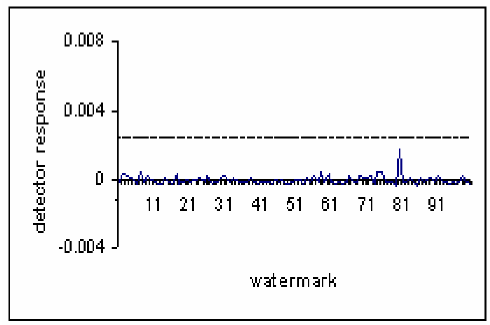


HH band (T=0.0025)

Figure 12. Detector response for rotation (5^0)

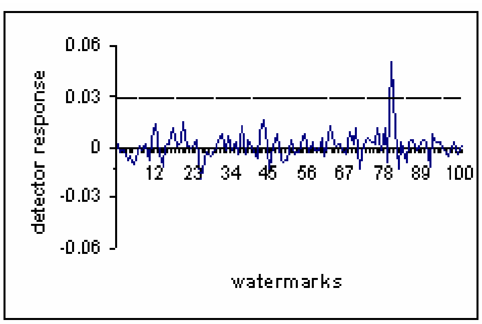


LL band (T=0.0064)

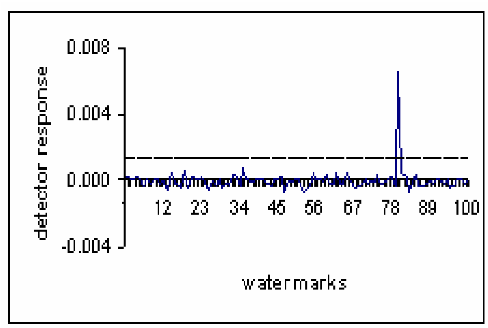


HH band (T=0.0024)

Figure 13. Detector response for frame dropping



LL band (T=0.029)



HH band (T=0.0014)

Figure 14. Detector response for frame swapping

3. Conclusions

In this paper, we presented a semi-blind image watermarking scheme for an MPEG 1 video clip. A pseudo random sequence is embedded in two bands (LL and HH). The chosen attacks were JPEG compression, resizing, adding Gaussian noise, low pass filtering, rotation, histogram equalization, contrast adjustment, gamma correction, cropping, frame dropping, and frame swapping.

Our experiments show that for one group of attacks (i.e., JPEG compression, Gaussian noise, resizing, low pass filtering, rotation, and frame dropping), the correlation with the real watermark is higher than the threshold in the LL band, and for another group of attacks (i.e., cropping, histogram equalization, contrast adjustment, and gamma correction), the correlation with the real watermark is higher than the threshold in the HH band. Only for frame swapping, the correlation with the real watermark is higher than the threshold in both of the bands.

In future research, we plan to use MPEG 2 and MPEG 4 video clips (e.g., akiyo, flower garden, foreman, claire, and salesman).

4. References

[1] R. Dugad, K. Ratakonda, and N. Ahuja, "A New Wavelet-Based Scheme for Watermarking Images," *Proceedings of 1998 International Conference on Image Processing (ICIP 1998)*, Vol. 2, Chicago, IL, October 4-7, 1998, pp. 419-423.

[2] E. Elbasi and A. M. Eskicioglu, "A DWT-based Robust Semi-blind Image Watermarking Algorithm Using Two Bands," *IS&T/SPIE's 18th Symposium on Electronic Imaging, Security, Steganography, and Watermarking of Multimedia Contents VIII Conference*, San Jose, CA, January 15–19, 2006.

[3] G. Doërr and J.-L. Dugelay, "Video Watermarking: Overview and Challenges," Handbook of Video Databases: Design and Applications, B. Furht and O. Marques (editors), CRC Press, 2003.

[4] E. T., Lin, A. M. Eskicioglu, R. L., Lagendijk, and E. J. Delp, "Advances in Digital Video Content Protection," *Proceedings of the IEEE*, Special Issue on Advances in Video Coding and Delivery, Vol. 93, No.1, January 2005.

[5] M. D. Swanson. M. Kobayashi, and A. H. Tewfik, "Multimedia Data-Embedding and Watermarking Technologies," *Proceedings of the IEEE*, Vol. 86, No. 6, June 1998.

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

[7] S. Simitopoulus, S. A. Tsaftaris, N. V. Boulgouris, and M. G. Strintzis, "Digital Watermarking of MPEG-1 and MPEG-2 Multiplexed Streams for Copyright Protection," *2nd International Workshop on Digital and Computational Video (DCV 2001)*, Tampa, FL, February 9, 2001.

[8] G. Qiu, P. Marziliano, A. T. S. Ho, D. He, and Q. Sun, "A Hybrid Watermarking Scheme for H.264/AVC Video," *17th International Conference on Pattern Recognition (ICPR2004)*, Cambridge, UK, August 23-26, 2004.

[9] 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.

[10] M. D. Swanson, B. Zhu, and A. H. Tewfik, "Multiresolution Scene-Based Video Watermarking Using Perceptual Models", *IEEE Journal on Selected Area in Communications*, Vol. 16, No.4, May 1998.

[11] 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, 1999, pp. 113-124.