IMAGE WATERMARKING USING THE STEERABLE PYRAMID TRANSFORM

Fadoua DRIRA, Florence DENIS, Atilla BASKURT

LIRIS, Laboratoire d'InfoRmatique en Image et Systèmes d'information
FRE 2672 CNRS, INSA Lyon, UCB Lyon 1, EC Lyon, Univ. Lyon 2
fdrira@liris.cnrs.fr fdenis@liris.cnrs.fr atilla.baskurt@liris.cnrs.fr

ABSTRACT

The protection of intellectual property rights became recently a pressing need especially with the rapid growth of transmission techniques. In this paper, we present as a copyright protection method, a non-blind watermarking technique based on the image content. We choose edges for watermark insertion. Our approach uses the steerable pyramid decomposition: the image is decomposed into a set of subbands and each one is individually marked. Many experiences performed with real images shows the good performance of the proposed method which is resistant to JPEG compression, additive noise and median filtering.

Keywords: content based watermarking, steerable pyramid, edges.

1. INTRODUCTION

Under the development of transmission techniques, data became, volatile and easily processed. Duplication of any digital data, easier than before, made the definition of protection protocols an important issue to prevent illegal use of such content. Consequently, many watermarking techniques have been developed [1]. The digital watermarking defined as an approach to insert an invisible and robust mark in a medium, is the most efficient technique for intellectual property rights protection. In this context, we propose a copyright protection scheme based on watermarking in different oriented subbands. This paper is organized as follows. After a brief introduction of the watermarking concept, we present the proposed method to protect the digital image watermarking. Then, many experimental results are given, showing the performance of this approach. Finally, the advantages of our method are discussed.

2. DIGITAL WATERMARKING

The concept of digital watermarking is defined as embedding a digital signature or a digital watermark in a document to assert its ownership. The insertion step may be performed in spatial [2,3], frequency [4,5,6] or multiresolution [7,8,9] domains. The watermark can then be extracted from the watermarked media to identify the owner. This step can be developed in two different ways: using the original image or not. Each digital watermarking technique must satisfy three essential requirements: perceptual transparency, robustness to attack and capacity of the embedded signature. In fact, the quality of watermarked data must be preserved so that no distortion of the original data should be visible and the perceptual quality of the host media must be the same as the original one. The human visual system may be exploited to improve the mark invisibility [9]. The robustness of the signature is also very important. The embedded signature must be still recoverable and recognizable by the user after many operations including compression and filtering. Moreover, good capacity is very important to prove that the mark should be able to contain significant information.

3. THE PROPOSED WATERMARKING SCHEME USING STEERABLE PYRAMID

3.1 Steerable pyramid

The steerable pyramid proposed by Freeman and Simoncelli [10], is based on steerable filters [11] which could be oriented to any direction defined by the user. Steerable pyramid is a recursive multi-scale and multi-direction decomposition. The bloc diagram of this decomposition is shown in *Fig1* which presents three types of filters: low-pass (L_0)., high-pass (H_0), and pass-bands (B_0... B_K). In fact, both low-pass and high-pass filters separate the image into low and high pass subbands respectively. Then, the lowpass subband is further decomposed in K+1 oriented subbands and a lowpass subband. The latter is then subsampled by a factor 2 and a new decomposition is performed until reaching the scale fixed by the user. The steerable pyramid can be useful in many applications such as orientation analysis, noise removal and enhancement [12], transient detection, texture synthesis, contour detection [13].

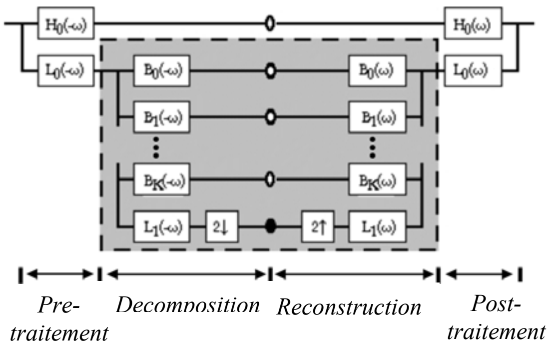


Fig1: Bloc diagram of steerable pyramid decomposition

3.2 Watermark embedding scheme:

Although the low frequency components can survive after reasonable attacks, they are perceptible to the human eye. For, this reason, we choose to insert the watermark on edges extracted from each subband of the pyramid decomposition. The general embedding method can be decomposed into different steps:

1- Image decomposition using steerable pyramid.

2- For each subband:

  a. Thresholding to detect edges;

  b. Finding out 3X3 non overlapping blocs included in thresholded edges;

  c. Additive modification of bloc values related to a certain bit of the signature. The added value depends on the strength of the mark. Each block contains information about one bit of the signature.

3- Image reconstruction by combining the different watermarked subbands.

Let us notice that when the number of 3X3 blocs extracted from a subband is higher than the signature's length, the signature was repeated as many times as possible. Then, we obtain many redundancies through each level of the pyramid but also in each subband.

3.3 Watermark detection scheme

The detection process needs the original image for extracting the signature as well as the presence of the watermarked image. The different steps are:

1- Steerable pyramid decomposition of both the initial image and the marked one.

2- For each subband :

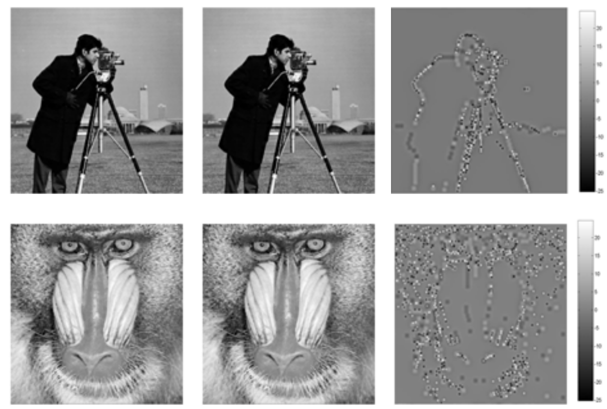
  a. Retrieving marked blocs from the initial image.

  b. Comparison with corresponding marked blocs to extract all signature occurrences.

4- Averaging of all signature occurrences.

4- EXPERIMENTAL RESULTS

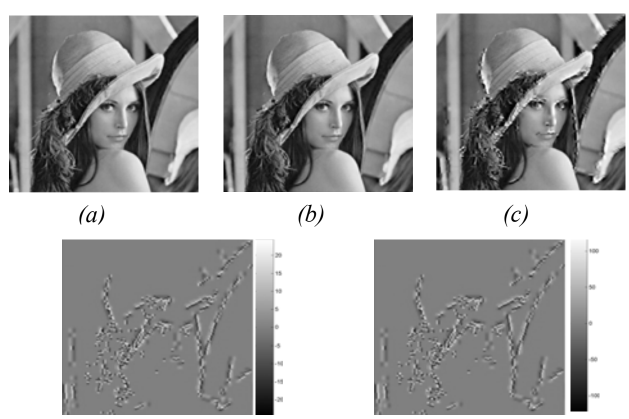
To prove the feasibility of our novel copyright protection scheme, we conduct some experiments. The first test images include "Lena", "Baboons" and "Cameraman" image of size 256x256 and a 119 bits signature, consisting in a logo image. By using the proposed method, the watermark is almost invisible to the human eyes, as shown in *Fig2*. In fact, the choice of the strength of the watermark inserted must assume no distortions inserted. Then, a high parameter (*alpha*) can affect the visual quality of the image (*Fig3*). In general, this parameter depends on the original image used.



(a) *(b)* *(c)*

(a) Initial image 256X256, (scales, directions)=(2,1)
(b) Marked image
(c)Differential image and its associated colorbar

Fig2: Application of the proposed method of "Cameraman" and "Baboons"



(a) *(b)* *(c)*

(d) *(e)*

(a) Initial image Lena 256X256, (scales, directions)= (2,2)
Marked image (b) alpha=20
(c) alpha=100
Differential image and its associated colorbar (d) alpha=20
(e) alpha=100

Fig3: impact of a high value '*alpha'* in degrading the marked image

Moreover, as we previously noticed, the embedding scheme is realized with many redundancies of the signature. In order to estimate this number, we established many measures for different values of scales and directions numbers and for different images. It appears (*Tab1*) that the signature occurrences vary from one image to another and from one parameter (scale, direction) to another. In particular, highly-textured images can be watermarked with many redundancies. The redundancy has many advantages especially in improving the quality of the extracted signature (Fig3) or increasing robustness toward cropping attacks (fig4).

		Watermark redundancies								
	Number of scales	1			2			3		
	Number of directions	1	2	3	1	2	3	1	2	3
Images	*Mandrill*	5	11	13	7	12	13	7	12	13
	Cameraman	2	3	7	3	3	9	3	3	9
	Lena	3	3	6	4	4	7	4	4	7

Tab1: 119 bits signature redundancies

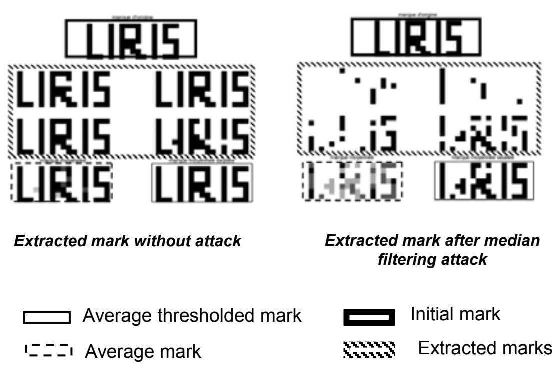


Fig3: Signature extracted with and without attacks
Test on lena image for (scales, directions) = (3,2)

To verify the robustness of the proposed method under standard attacks, we compare its performances with other existing frequency-domain techniques [14] on the Lena image. We choose to insert a random binary sequence of 119 bits length. The table *Tab2* shows PSNR which guarantee no visual degradation of the watermarked image obtained after inserting watermark using the different methods.

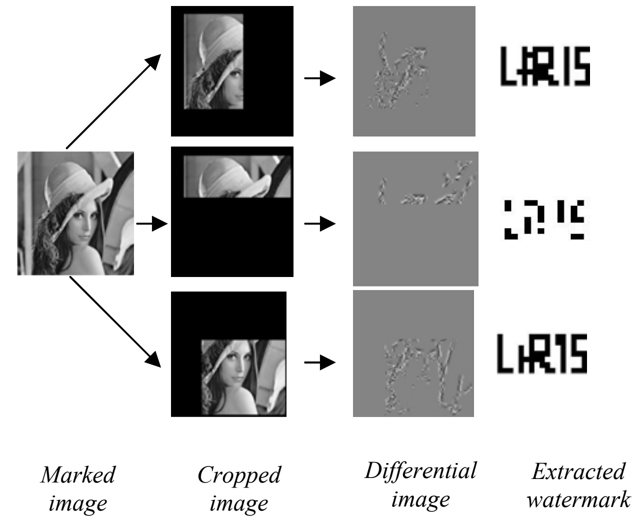


Fig4: Results of cropping attack on 256X256 Lena image (scales, directions) = (2,2)

	Cox's method	Kim's method	Corvi's method	Wang's method	Proposed method
PSNR	40	47	41	35	38

Tab2: PSNR of the different methods tested

All the results depend on the correlation computation. To calculate it, we use the vector projection as defined by:

$$corr\ (X, X') = \frac{X.X'}{\sqrt{X'.X'}}$$

where X is the original watermark and X' is the extracted watermark. For different images and different attack, various numbers of scales and directions have been tested. From these tests (*Fig5*, *Fig6*), we choose the couple (scales=3, directions=2) as gives approximately the most interesting results. After that, comparisons with the other

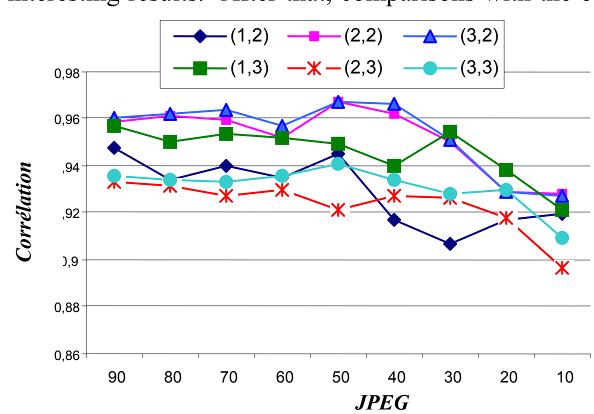


Fig5: JPEG robustness for different values of scales and directions

methods have been carried out. *Fig7*, *Fig8* and *Fig9* summarize the obtained results for many attacks such as JPEG compression, median filtering, salt and pepper noise, cropping, histogram equalisation and gaussien noise.

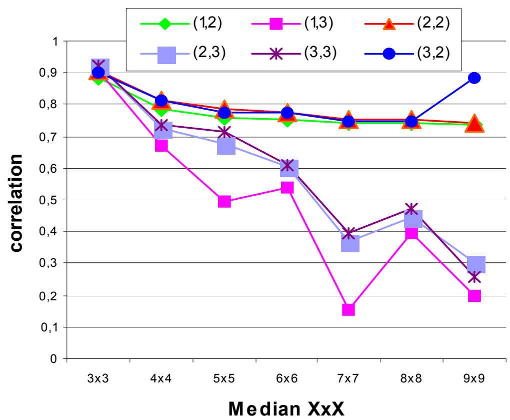


Fig6: Median robustness for different values of scales and directions

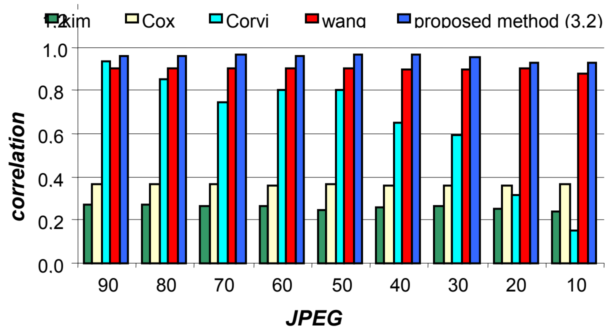


Fig7: Performance comparison for different methods of JPEG robustness

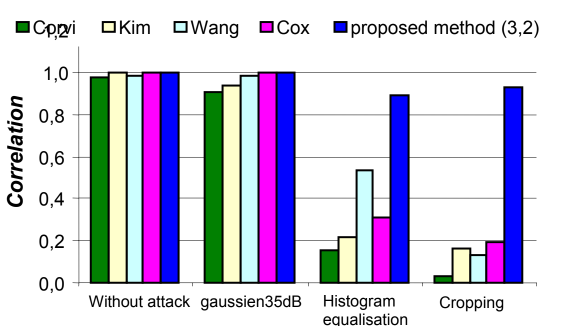


Fig8: Performance comparison for different methods

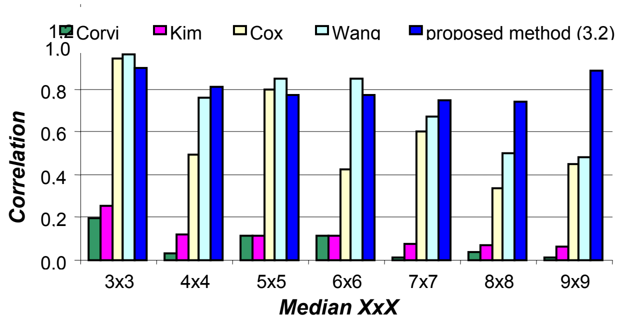


Fig9: Performance comparison for different methods of median robustness

5. CONCLUSION

The proposed method uses edges to insert an additive mark on each subband of a steerable pyramid decomposition. Our results show good robustness to JPEG compression, median filtering, additive noise, cropping and histogram equalisation. Further researches should focus on the automatic choice of the parameters (watermark strength, number of scales and directions) which will guarantee high degree of robustness and best performances.

6. REFERENCES

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