



HAL
open science

A Geometrical and Frequential Watermarking Scheme Using Similarities

Patrick Bas, J.-M. Chassery, F. Davoine

► **To cite this version:**

Patrick Bas, J.-M. Chassery, F. Davoine. A Geometrical and Frequential Watermarking Scheme Using Similarities. *Electronic Imaging, Security and Watermarking of Multimedia Content I*, Jan 1999, France. pp.264-272. hal-00166550

HAL Id: hal-00166550

<https://hal.science/hal-00166550>

Submitted on 7 Aug 2007

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

A Geometrical and Frequential Watermarking Scheme Using Similarities

P. Bas^a, J-M. Chassery^a and F. Davoine^b

^aUMR CNRS TIMC, Domaine de la Merci 38706 La Tronche Cedex France

^bUMR CNRS Heudiasyc, BP 20259 60205 Compiègne Cedex France

ABSTRACT

Watermarking schemes are more and more robust to classical degradations. The NEC system developed by Cox,¹ using both original and marked images, can detect the mark with a JPEG compression ratio of 30. Nevertheless a very simple geometric attack done by the program Stirmark can remove the watermark. Most of the present watermarking schemes only map a mark on the image without geometric reference and therefore are not robust to geometric transformation.

We present a scheme based on the modification of a collage map (issued from a fractal code used in fractal compression). We add a mark introducing similarities in the image.

The embedding of the mark is done by selection of points of interest supporting blocks on which similarities are hidden. This selection is done by the Stephens-Harris detector. The similarity is embedded locally to be robust to cropping.

Contrary to many schemes, the reference mark used for the detection comes from the marked image and thus undergoes geometrical distortions. The detection of the mark is done by searching interest blocks and their similarities. It does not use the original image and the robustness is guaranteed by a key.

Our first results show that the similarities-based watermarking is quite robust to geometric transformation such as translations, rotations and cropping.

Keywords: watermarking, similarity, points of interest, fractal scheme

1. INTRODUCTION

1.1. Definition

Watermarking consists in hiding a mark in an electronic document to certify the owner of the document. This document can be audio, image or video. A watermark is needed in order to provide security in case of free diffusion. Basically the embedded mark has to follow two strong constraints:

- invisible
- non-removable

If the first constraint is very sharp, the second one implies many conditions:

The mark had to be robust to image compression, quantization, D-A/A-D conversion, filtering (blurring or sharpening), and geometric transformations such as cropping, translation or rotation. It also implies that the mark must not be removable by an “intelligent” attack (find the location of the mark and subtract it). Consequently if the method is public, it has to use a cryptographic system for the embedding and the detection of the mark.

Further author information: (Send correspondence to P.B.)

P.B: E-mail: Patrick.Bas@imag.fr; WWW: <http://www-timc.imag.fr/~bas/>; Telephone: 33.4.76.54.94.84; Fax: 33.4.76.54.95.49

J.M.C.: E-mail: Jean-Marc.Chassery@imag.fr

F.D: E-mail: Franck.Davoine@hds.utc.fr

1.2. Previous Approaches

Classical embedding schemes consist in adding a mark in the spatial domain² or in a transform domain such as the DCT coefficients,¹ the DFT coefficients,³ the wavelets coefficients.⁴ This mark depends on a key and consequently is unique.

The detection step can be performed by two different ways: it can use an original image or not. Using an original is less practical and can improve piracy.⁵ Classically a correlation is computed between the Reference Mark and the coefficients of the image, the result is given examining a threshold (cf fig1).

In such this scheme the Reference Mark is external. Its inflexibility and not flexible and can be a major drawback.

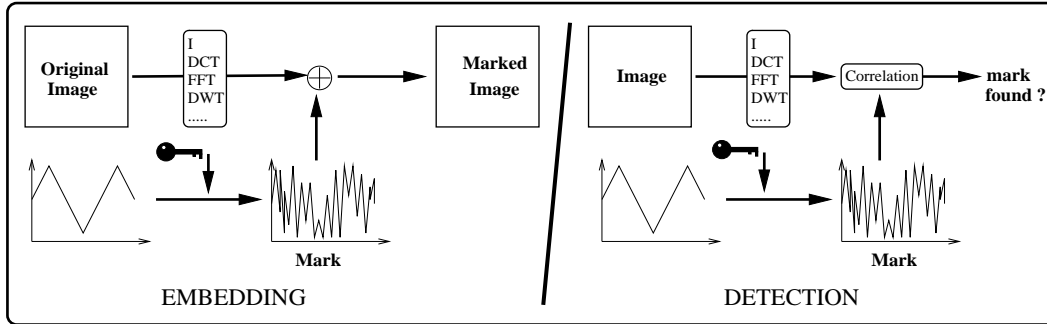


Figure 1. Principle of a classical watermarking scheme: the detection is done using a Reference Mark.

In the case a scheme based on “spread spectrum technics” the detection of the mark can fail just by translating the image of few pixels. It is one of the basic feature of Stirmark software developed by F. Petitcolas using geometrical distortions and filtering to defeat many watermarking schemes.⁶

1.3. Our Scheme

In our scheme the reference mark is *inside* the image. The link between the mark and the image is based on the similarity concept. By this way if the image undergoes geometrical transformations (flipping, translations, rotations), the embedded similarities are affected in the same way (cf fig2).

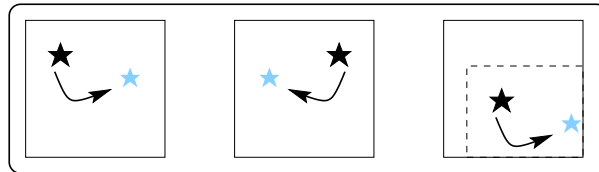


Figure 2.

Similarity inside the image is not affected by geometrical transformations. Similarity will be used as a reference mark

2. USING SIMILARITIES TO EMBED A MARK

2.1. Principle

Our watermarking scheme consists in hiding perfect similarities in the image. The embedding can be done in the spatial domain⁷ or in frequencial domain (DCT⁸). Contrary to previous work,⁹ it does not use the fractal decompressing step and permits to have a better image quality.

As in the fractal compression scheme, a set D of n Domain blocks $\{D_1, D_2, \dots, D_n\}$ is extracted from the image.

Another set R of n Range blocks $\{R_1, R_2, \dots, R_n\}$ is associated to D . D is named as the Domain pool and R the Range pool. A mark W_j ($1 \leq j \leq n$) is embedded by adding a low dynamic version of D_j . Thus the blocks W_j and D_j are similar. The magnitude of W_j is low in order to verify non visibility for the mark W_j . The embedded mark W_j and the marked bloc \hat{R}_j are calculated as follows:

$$W_j = \alpha * Dyn(D_j) = \alpha * \frac{D_j - \bar{D}_j}{\max(D_j - \bar{D}_j)} \quad (1)$$

$$\hat{R}_j = Quant(R_j) + W_j + \frac{s}{2} \quad \text{where} \quad Quant(R_j) = \text{int}\left(\frac{R_j}{s}\right) * s \quad (2)$$

where \bar{D}_j is the mean of D_j , α is a parameter coding the power of the embedding, s is a quantization step. \hat{R}_j represents the embedded blocs issued from similarity between D_j and R_j . The real $\frac{s}{2}$ permits to cancel quantization error during detection. The different steps of the insertion of the similarities are illustrated in figure3.

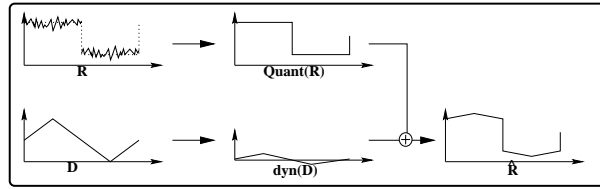


Figure 3. Embedding of similarities. The two blocks R and D permit to create the marked block \hat{R} .

2.2. Selection Of The Domain Pool

The creation of the Domain pool D is performed using the following criteria. The dynamic of D_j blocks must be important (an homogeneous block is always similar to another homogeneous block). Moreover a D_j block has to include geometric features of the image in order to be robust to geometrical transformations.

The proposed solution is based on the Stephen-Harris¹⁰ corner and edge detector. This detector is a classical tool in vision area.¹¹ It is quite robust to rotations and translations (cf fig 4).

In a practical way, on each point $I(x, y)$ of the image we calculate the matrix:

$$M = \begin{pmatrix} \frac{\delta I}{\delta x} \otimes G_w(x, y) & \frac{\delta I}{\delta x \delta y} \otimes G_w(x, y) \\ \frac{\delta I}{\delta x \delta y} \otimes G_w(x, y) & \frac{\delta I}{\delta y} \otimes G_w(x, y) \end{pmatrix}$$

where $G_w(x, y)$ is a gaussian window.

The selection criterion I_c is the combination of the two rotational invariants of the matrix:

$$I_c = Det(M) - kTrace(M)^2$$

A thresholding achieves the selection of points of interest on which we will detect D_j blocks. Fig 4 illustrates such a detection.



Figure 4. Points of interest using the Stephen-Harris detector, the detector is quite robust to translations and rotations.

2.3. Embedding Scheme

The embedding scheme need has to verify the following points:

- Be robust to cropping operations. The similarities must be embedded locally. In the proposed scheme, a similarity is embedded in a $4B \times 4B$ window (B represent a block). It is illustrated in figure 6
- Use a key to embed similarities and prevent piracy. The cryptographic system has not been yet developed.

The embedding scheme is composed of two steps (cf fig 5):

- Firstly the Domain pool is selected using the Stephen-Harris detector. Each point detected corresponds to a block D_j centered on it. A local window is associated to each block D_j .
- Secondly, for each domain block the similarity is inserted in ONE of the 16 blocks of window (the position of the embedded block is constant in the window). This is done using formulas (1) and (2). The marked image is created.

The insertion of similarities can be developed in many transform domains. In our previous work⁷⁸ the embedding was performed in the DCT domain. Unfortunately the DCT coefficients are not invariant using geometric transformation (i.e. the composition of the DCT block is totally changed). Therefore we decided to use representations which preserve the spatial structure of the image. Thus we chose the identity transform (still spatial domain) and the wavelet decomposition (which represents both spatial and frequential information).

2.4. Embedding in the spatial domain

Points of interest are detected on the whole image. The domain pool D is composed of 4 pixels blocks and the window size is 16×16 pixels. Such choice is arbitrary and is mainly based on computational considerations.

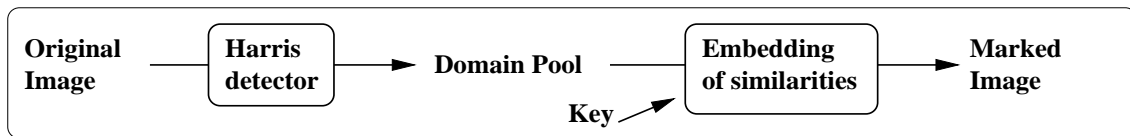


Figure 5. Summary of the embedding scheme: detection of the Domain pool and insertion of similarities

2.5. Embedding in the wavelet domain

In such scheme similarities are embedded in the LL (low resolution) subband of a wavelet decomposition. The level of decomposition can be $LL1$ or $LL2$.

With the subband $LL2$ the embedded information is more concentrated in the low frequencies and thus more robust to compression effects. The detection of interest points is performed in the spatial image and wavelet coefficients are deduced from the position of pixels. The domain pool is composed of 4×4 LL coefficients block (corresponding to 8×8 or 16×16 pixels block in the full image). We have used the Adelson filter-set¹² for wavelet decomposition.

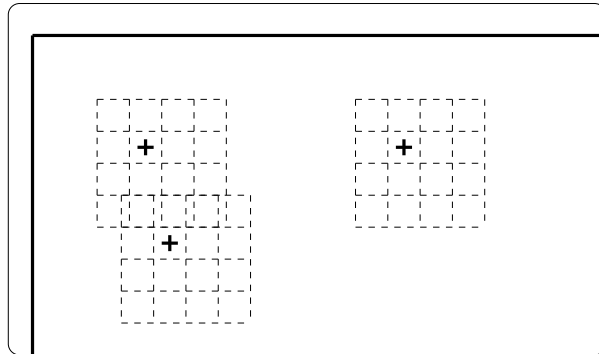


Figure 6. The embedded similarity is locally embedded in a 4×4 block window.

2.6. Detection Scheme

The detection scheme does not use the original image. It is divided in two steps: detection and decision. Let us detail each one of it.

2.6.1. detection

Firstly the Domain pool is constructed using the interest points detector. The Domain block is then generated. Next the block W_j is computed:

$$W_j = \alpha * Dyn(D_j) = \alpha * \frac{D_j - \bar{D}_j}{max(D_j - \bar{D}_j)} \quad (3)$$

And for each block R_i of the 4×4 window, the block \hat{W}_i is calculated:

$$\hat{W}_i = R_i - (Quant(R_i) + \frac{s}{2}) \quad \text{where} \quad Quant(R) = int(\frac{R}{s}) * s \quad (4)$$

Afterward using the root-mean-square criterion between two blocks, for each D_i the most similar block R_j^* is retained.

2.6.2. decision

When a Range block R_i^* is detected, the number of detected blocks for the position i is incremented. Once all R^* had been detected, the decision is taken examining the maximum of detected blocks for the 16 positions of the window. This maximum is compared with a threshold T to determine if the mark is embedded in the image or not.

2.6.3. probability of false-alarm

The threshold T is calculated using the probability of false-alarm P_{fa} (probability to detect a mark which does not exists). We have constructed two arrays simulating different cases attached to two false-alarm values.

nb of Domain blocks	20	40	60	80	100	120	140	160	180
$T (P_{fa} = 10^{-3})$	7	10	13	15	17	20	22	24	27
$T (P_{fa} = 10^{-5})$	9	12	15	18	20	23	26	28	29

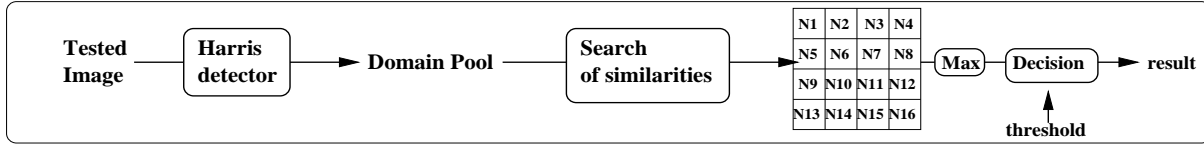


Figure 7. Summary of the detection scheme.

3. RESULTS AND PERSPECTIVES

3.1. Results

The watermarking and detection algorithm have been tested on lena 256×256 . The size of blocks D_j and R_j is 4×4 . In both spatial et wavelet domain parameters $\alpha = 20.0$ and $s = 40.0$.

Fig 8 and fig 9 represent the different detections in the Spatial Domain. Two values are attached to each experiment. The first one corresponds to the number of blocks of interests detected at the good location, the second the total number of blocks of interests. They outline the faculty of our algorithm to be robust to basic geometric transformations and to cropping. However the scheme is still not enough robust to the filtering done by stirmark.

Fig 10 represents the embedding in the wavelet domain usind the $LL2$ subband. The mark is inserted in the whole image and the scheme is quite resistant to Jpeg.

3.2. Perspectives and Future Work

We plan to improve our scheme adding few elements such as:

- improve the points of interest detector to be more robust to compression (use a low-frequency based detector).
- use a cryptographic scheme which is invariant to geometric transformations.
- develop a wavelet-based scheme which is robust to geometric transformations. At this time the quantization of the block R forbids this point.

4. CONCLUSION

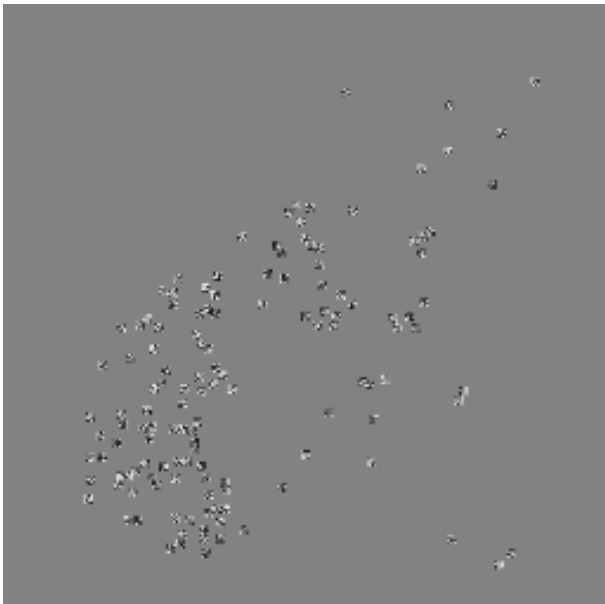
A new scheme has been proposed for image watermarking. The mark is self-generated by the image analysis. More precisely it consists in detection of blocks similarities in a same way that one proposed in a fractal coding. Moreover, in order or provide robustness to classical degradations, the location of the mark embedding is issued from a Harris detector of zones of interest. Such scheme can be developed in spatial domain or in wavelet decomposition scheme. First results are very promising and in perspectives cryptography will be included and more efforts will be devoted to multiresolution representation mode.



Original Image



Marked Image (135/135)



Difference Image



Mirror (67/122)

Figure 8. Results with the spatial embedding scheme. The first number represents the number of domain blocks, the second the number of detected blocks at the same location. Because this number is greater than the threshold T , the mark can be detected.

REFERENCES

1. T. L. I. Cox, J. Killian and T. Shamoan, "Secure spread spectrum watermarking for multimedia," *IEEE Transactions on Image Processing* **6**, pp. 1673–1687, Dec. 1997.
2. D. G. W. Bender and Morimoto, "Techniques for data hiding," in *Proc. SPIE*, vol. 2420, p. 40, Feb. 1995.
3. J. Ruanaidh, F. Boland, and W. Dowling, "Phase watermarking of images," in *Int. Conf. on Image Processing (ICIP)*, IEEE, (Lausanne, Suisse), 1996.



Rotated Image (67/122)



Stirmark1.0 (19/123)



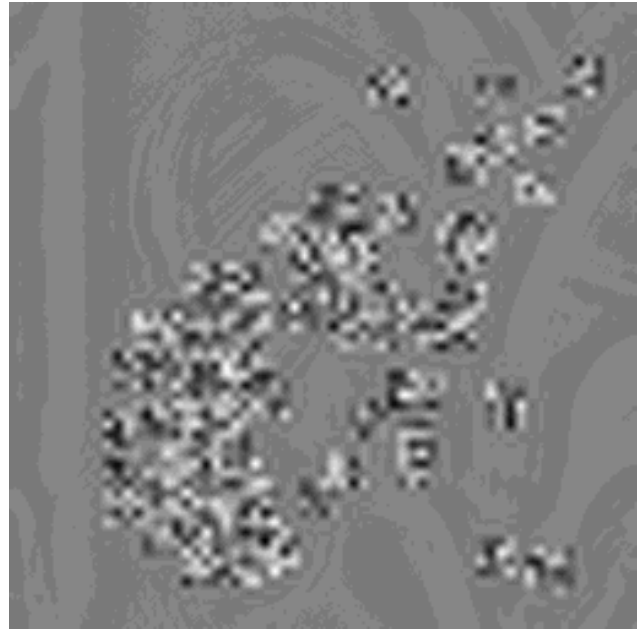
100*100 Crop (33/40)

Figure 9. Results with the spatial embedding scheme. Our algorithm is robust to geometric transformations as cropping and rotations but is not enough robust to filtering (stirmark)

4. D. Kundur and D. Hatzinakos, "Digital watermarking based on multiresolution wavelet data fusion," in *Special Issue on Intelligent Signal Processing*, IEEE, 1997.
5. K. Ratakonda, R. Dugad, and N. Ahuja, "Digital image watermarking: Issues in resolving rightful ownership," in *ICIP*, vol. 2, pp. 414–418, (Chicago), 1998.
6. F. A. Petitcolas, R. J. Anderson, and M. G. Kuhn, "Attacks on copyright marking systems," in *Information hiding: second international workshop*, D. Aucsmith, ed., Lecture notes in computer science, Springer Verlag, Berlin, Germany, 1998.
7. P. Bas, J.-M. Chassery, and F. Davoine, "Self-similarity based image watermarking," *EUSIPCO'98* 4, pp. 2277–2280, 1998.
8. P. Bas, J.-M. Chassery, and F. Davoine, "Using the fractal code to watermark images," *ICIP* 1, pp. 469–473, 1998.
9. F. J. J. Pueate, "Using fractal compression scheme to embed a digital signature into an image," in *SPIE-96 Proceedings*, 1996.
10. C. Harris and M. Stephen, "A combined corner and edge detector," in *4th Alvey Vision Conf*, pp. 147–151, 1988.
11. V. Gouet, P. Montesinos, and D. Pel, "Stereo matching of color images using differential invariants," in *ICIP*, vol. 2, pp. 152–161, (Chicago), 1998.
12. J. L. J.D. Villasenor, B. Belzer, "Wavelet filter evaluation fot image compression," *IEEE Transactions on Image Processing* , 1995.



Marked Image



Difference Image

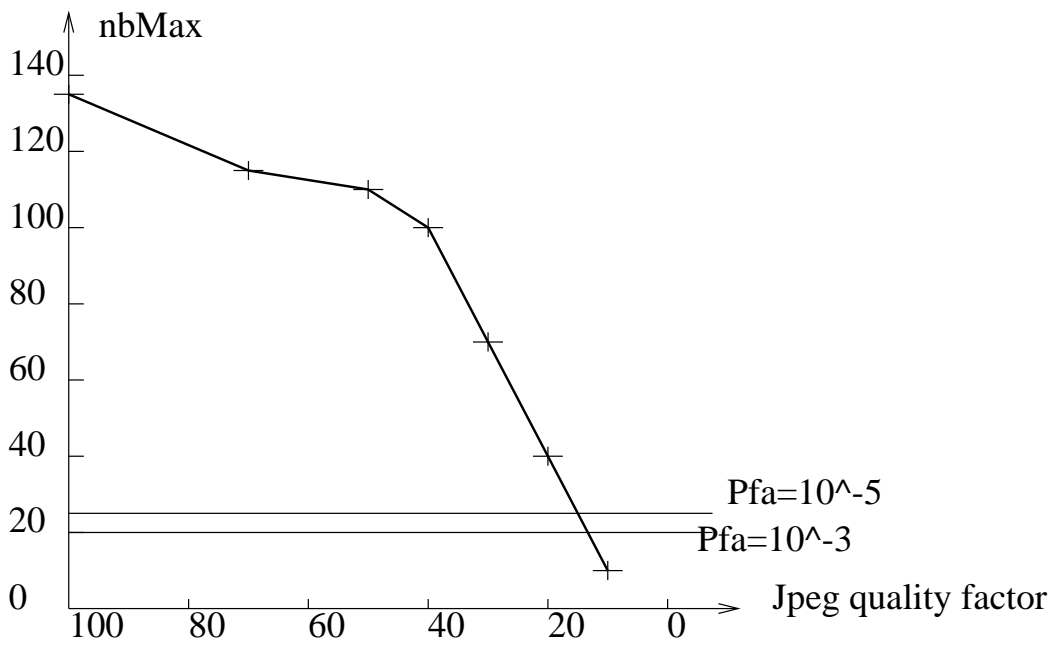


Figure 10. Results with the wavelet based scheme. It is not robust to geometric transformations but it is quite robust to compression (JPEG).