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New Wateramrking Approach in Radon Field

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Abstract— **The development of the image of technologies and data exchanges is an ever-increasing use with the development of multimedia content through online service. This rapid evolution of technology and its application domain has created the need for new techniques to protect the copyright and data owner identification. Now, Watermarking is considered as an efficient technique to solve these problems. This paper presents a new watermarking method in the Radon field. Our proposed approach is very robust against different attack types as well the properties of the radon area allowing the insertion of a large range of information.**

Keywords— **Discrete Radon transformation, Watermarking, attacks, robustness, Integration Transform (RIT) Circular Integration Transform (CIT)**

I. Introduction

The evolution of technology does not only facilitate the data transfer but it also increases the ability of hacking such information. In this order, several techniques are proposed to protect the data transferred. But they present always errors and limitations in its applications. The first technique developed to protect data online is encryption [1]. Then, the researchers are have developed the steganography method [1]. Finally, they proposed the watermarking technique in 1992 [6]. This last covers the information to be transmitted in a holder in a way to be invisible and correctly reversible (an algorithm allows the correct extraction of watermark). The principle idea of watermarking involves the integration of a message into a digital content. Its algorithm shall be able to respect the three constraints: **imperceptibility**, **robustness** and **the ratio of the watermark**. The attack process applied to watermarking image used to modify and hack the watermark in a first step and find his secret key in a next step. Consequently, this step is very important to improve the watermarking security [14]. So, the watermarking algorithm requires an encryption step in order to increase the security of transferring data. The security process in watermarking algorithm used a privy key or algorithm to encrypt the message.

The digital watermarking came up to solve the problems related to the management of intellectual property of media. But, the development of attacks against watermarking systems has become more sophisticated. In general, the attacks on watermarking systems can be categorized into noise like image processing (compression, noise addition and low-pass filtering…) and geometric distortions (Rotation, translation…). Therefore, the attacks can mislead the watermark detector. A practical digital watermarking scheme must be resistant to a variety of possible attacks [14]. For this reason, various watermarking schemes are proposed for the digital multimedia protection. Most of the schemes perform on the spatial domain [11, 15, 9], or transformation domain such as frequency field [4, 2], multi-resolution field (wavelet field) [8] and Mellin-Fourier field [5, 7, 5 and 15].

Several watermarking domains are proposed to watermark data, but the resistivity of watermarking algorithms against geometric attacks remains low [14]. For this reason, the literature proposes to use the watermarking in Radon field [12]. D. Simitopoulos, DE. Koutsonanos, and M.G.Strintzis proposed in [13] a “Robust Image Watermarking Based on Generalized Radon Transformations”. Other research combines the radon field with other field to insert the watermark [14].

In order to resist against geometrics attacks, we proposed in this pepper a new watermarking algorithm in Radon field when we choose the best coefficient to insert our water in the support. This paper is organized as follows: Section 2 presents an overview of Discrete Radon Transformation (DRT). Section 3 details our watermarking method. In section 4, we study the robustness of this technique against different STIRMARK attacks, and test the ability to detect the embedded watermark in the image. A study of the watermarked image distortions before and after different attacks is also presented.

II. RADON TRANSFORMATION

A. Generalized Radon Transform

In 1917, J. Radon, Austrian mathematician, proved the possibility of reconstructing a function of a space from knowledge of its integration along the hyper-plans in same space. This type of integrations is called “Radon Transform” since. J. Radon has mathematically established the reversibility of this transformed and therefore forms the transition between the native function space and the Radon space, or the space of projections [3]. The generalized Radon transformation of a function $f(x, y; z)$ is defined at [12], as the integral along a curve expressed by the form $W(x, y; z)$.

$$\breve{f}(z) = \int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} f(x, y)\delta(W(x, y; z))dxdy \qquad (1)$$

Where $z = (z_1, z_2, \ldots, z_n)$ presents the vector of the transform domain.

To resist to scaling and rotation attacks, the literature proposed two types of Radon transformation there are **Radial**

Integration Transform (RIT) used to cope with rotation attacks and the **Circular Integration Transform (CIT)** used to deal cope with scaling attacks [14].

1) Radial Integration Transform (RIT)

The RIT represents an integration along a straight line. It is defined at [14] by this equation:

$$R_f(\theta)=\int_0^{+\infty} f(x_0+u\cos\theta, y_0+u\sin\theta)du \tag{2}$$

Where f(x, y) is presented by the integral along a straight line that begins from the origin (x_0, y_0) and has an angle θ with respect to the horizontal axis:

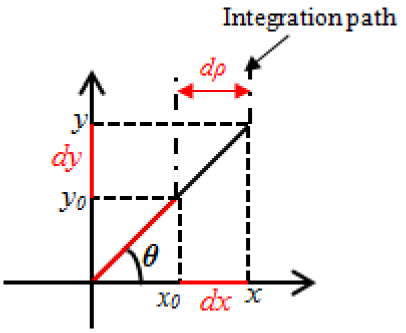

Fig. 1. Radial Integration Transform

Where *dρ*, *dx* and *dy* represents the integrations paths.

This first type of Radon Transformation is characterized by his scaling and rotation properties. So, if $g(x, y)=f(sx, sy)$ is the image scaling by s integration path in both directions, The RIT of $g(x,y)$ has given the following relationship [12]:

$$R_g(\theta)=\frac{1}{s}R_f(\theta) \tag{3}$$

Also if $f(r,\phi)$ presents a polar form image and $g(r,\phi)=f(r,\phi-\phi_a)$ is the image rotated by ϕ_a around the (r,ϕ) system origin, Then the relationship between g and f is defined by [12]:

$$R_g(\theta)=R_f(\theta-\phi_a) \tag{4}$$

The RIT of the rotated image is translated by ϕ_a .

2) Circular Integration Transform (CIT)

The CIT represents an integration along a circle. It is defined at [14] by this equation:

$$C_f(\rho)=\int_0^{2\pi} f(x_0+\rho\cos\theta, y_0+\rho\sin\theta)\rho d\theta \tag{5}$$

Where *f(x, y)* represents the function to be integrated on the circle defined by its center (x_0, y_0) and radius ρ .

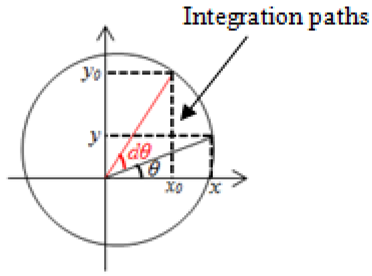

Fig. 2. Circular Integration Transform

$d\theta$ is the integration path.

This second type of Radon Transformation is same characterized by its scaling and rotation properties. So, if $g(x, y)=f(sx, sy)$ is the image scaling by *S* integration path in both directions, The RIT of g(x, y) shall give the following relationship [12]:

$$C_g(\rho)=\frac{1}{s}C_f(s\rho) \tag{6}$$

Also, if $f(r,\phi)$ presents a polar form image and $g(r,\phi)=f(r,\phi-\phi_a)$ is the image rotated by ϕ_a around the (r,ϕ) system origin. The relationship between g and f will be defined by [12]:

$$C_g(\rho)=C_f(\rho_a) \tag{7}$$

Consequently, the CIT of an image is independent of rotation.

B. Discrete Radon Transform (DRT)

The discreet RIT transformation of an image I(x, y) is defined at [12]: by this equation:

$$R(t\Delta\theta)=\frac{1}{J}\sum_{j=1}^{J} I(x_0+j\Delta s.\cos(t\Delta\theta), y_0+j\Delta s.\sin(t\Delta\theta) \tag{8}$$

Where $\Delta\theta$ represents the constant step size for the angle θ and Δs is the scaling constant step sizes. J represents the number of points between the origin and the end of the image on the radius with orientation θ , and $t=1,\ldots\ldots,\frac{360}{\Delta\theta}$.

Also, the Discreet CIT transformation of the image *I(x, y)* is defined at [12] by this equation:

$$C(k\Delta\rho)=\frac{1}{T}\sum_{t=1}^{T} I(x_0+k\Delta\rho.\cos(t\Delta\theta), y_0+k\Delta\rho.\sin(t\Delta\theta) \tag{9}$$

Where $\Delta\theta$ represents the constant step size for the angle θ and Δs is the scaling constant step sizes, $k\Delta\rho$ represents the radius of the smallest circle that encircles the image, and $k=1,\ldots\ldots,\frac{360}{\Delta\theta}$.

The Radon transformation of the image $I(x, y)$ of size $[M\ N]$ results in an image $R(\rho,\theta)$ of a size equal to $[N_p\ N_t]$ witch continued real coefficient in the radon field. With:

$$N_p = \sqrt{N^2 + M^2} + 1 \text{and } N_t = \max(\theta) \qquad (10)$$

III. PROPOSED WATERMARKING METHOD

In this paper, we propose a new watermarking approach in Radon field. The watermarking in this field allows the insertion of height size marks because the DRT increase the support size (see equation 10).

Our method consists in inserting the watermark in the higher coefficients of radon field for tows reasons. The first one, these coefficients are set around of the centre of projection. So they will be well recovered from the inverse radon transformed and they are more resistant against geometric transformation. The second one, it contains the important detail of transformed images. Consequently, they are much resistant against several attack types such as compression attacks.

In the following of the paper, we note by we note by Q the original watermark, *Q'* the decrypted watermark, *W the* embedded watermark, *W'* the recovered encrypted watermark, *I the* Original image (support), *R* the Original image in Radon domain, *Rw:* Watermarking image in Radon domain, *Iw* the watermarking image in spatial domain, *(x, y)* the coordinates of the original image in the spatial domain, (ρ,θ) *:* the coordinates of the original image in the radon domain and *k, l* are the bits to be coded, *[M N]*is the image Size, *[Mq Nq]* represent the size of Q and *G* is the gain factor

A. Watermark embedding process

The main concept of the image watermark embedding process is shown in the following figure:

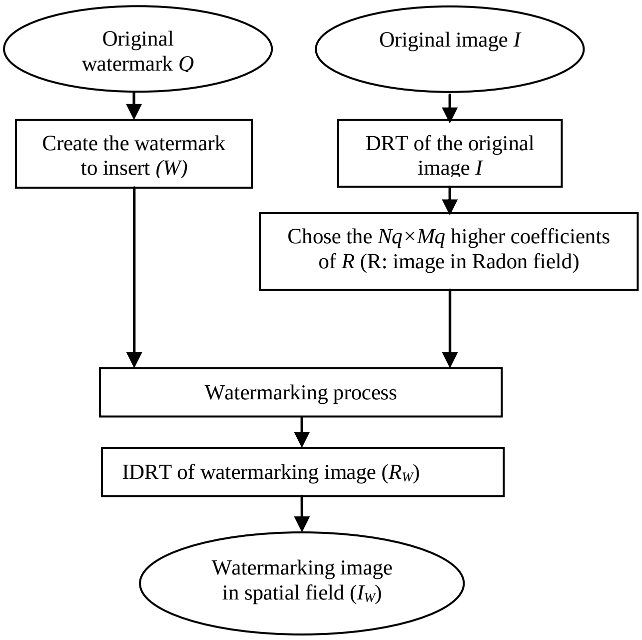

Fig. 3. Watermark embedding process

Step 1: Create the watermark (W):

In this step, we defined the watermark by $\{+1,-1\}$ bits. Then, we transformed the watermark to vector form. We used a secret key to encrypt the generated watermark. For this step, we used the following equation:

$$W(k) = Q(k) \oplus key(k) \qquad (11)$$

Step 2: DRT of the original image *I*

In this step, we used the Circular Integration Transformation where we used an integration path equal to 1°.

Step 3: Chose the $Nq\times Mq$ higher coefficients of *R* (*R*: image in Radon domain):

In this step we transformed the image matrix to vector *Vs* in descending order. Then we selected the value number $Nq\times Mq$ Cm from this vector, so:

$$Cm(Mq \times Nq) = Vs(Mq \times Nq) \qquad (12)$$

Step 4: Watermarking process:

In this step, we sweep the image and we compare the image intense with Cm. The insertion algorithm is presented by the following figure:

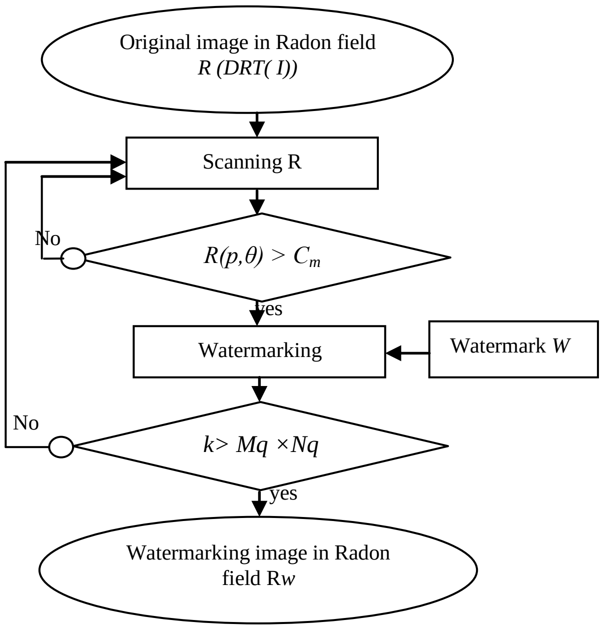

Fig. 4. Watermarking process

To insert the watermark in the *W(k)* in the chose coefficient, we used the folloing equation

$$Rw(\rho,\theta) = R(\rho,\theta) + G.W(k) \qquad (13)$$

Step 5: Transformed the watermarking image to Inverse DRT to create the watermarking image *Iw* in spatial domain.

Step 6: The output image represents the watermarking image in spatial field

B. *Recovered watermark process*

In the order to recover our inserted watermark, we used the following algorithm:

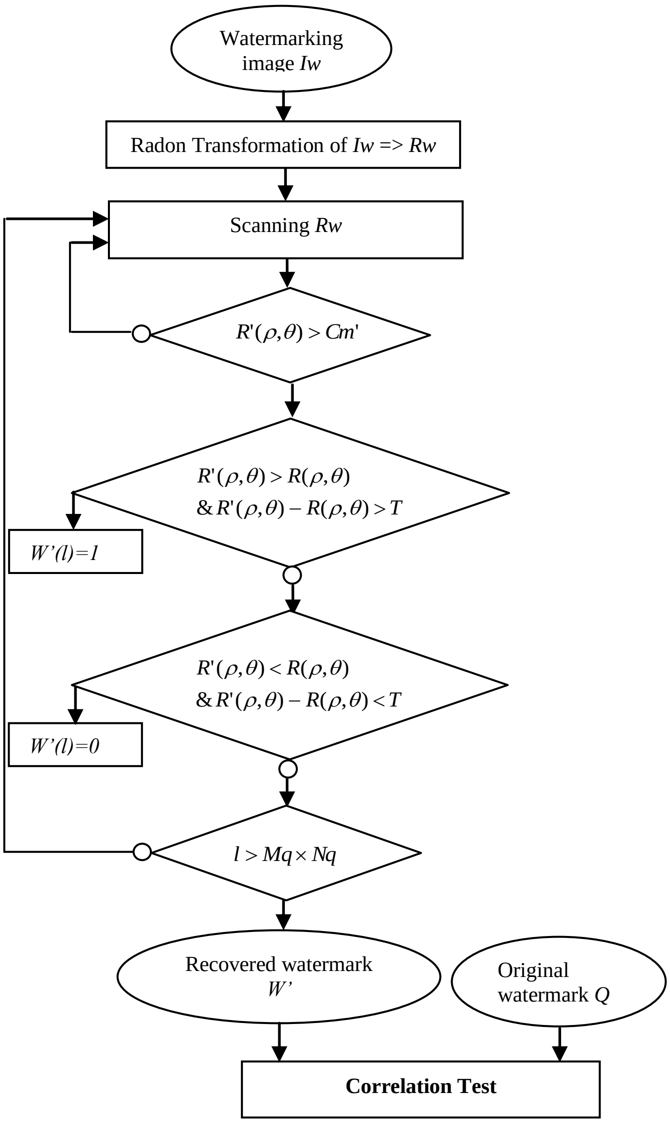

Fig. 5. Recovred entecrypted watermark process

Where Cm' represents the $Nq \times Mq$ higher coefficients of *Rw'* (The Radon Transformation of the watermarking image). To calculate *Cm'*, we applied **step 2** and **step 3** to *Rw'* image.

Finally, to recover our original watermark we used the next equation:

$$Q'(l) = W'(l) \oplus key(l) \tag{14}$$

Where $key(l)$ is similar to the pricy key used in Watermark embedding algorithm.

IV. Experimental Result

To evaluate the performance of the proposed watermarking scheme, we used the next image defined by its size *256×256* and the following watermark defined by *32×32* size. To apply the DRT to original image we used a $\theta_{max} = \pi$ and the path $\Delta\theta = 1$. Then, we inserted the watermark in the original image.

To calculate the performance of our approach we used the normalized cross-correlation C between the recovered and the original watermark. It is defined by the formula showed below [10]:

$$C = \frac{\sum_{i=1}^{Mq}\sum_{1}^{Nq} Q\,Q'}{\sqrt{\left[\sum_{1}^{Mq}\left(\sum_{1}^{Nq} Q^2\right)\sum_{1}^{Mq}\left(\sum_{1}^{Nq} Q'^2\right)\right]}} \tag{15}$$

To keep a more quantitative measure of visual imperceptibility in the watermarking image, we used the peak signal to noise ratio (*PSNR*) metric. This measure serves well for the watermark visibility estimation. Its equation is defined by [10]:

$$PSNR = 10\log 10 \frac{255 \times 255}{MSE} \tag{16}$$

Where MSE is calculated by the following equation:

$$MSE = \frac{1}{Nq \times Mq} \sum_{i=1}^{Nq \times Mq} \left(Q_i - Q'_i\right)^2 \tag{17}$$

The visual results are presented in the followings figures

Fig. 6. Original image

Fig. 7. Wtermarking image

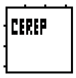

Fig. 8. Original Watermark

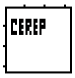

Fig. 9. Recovered Watermark

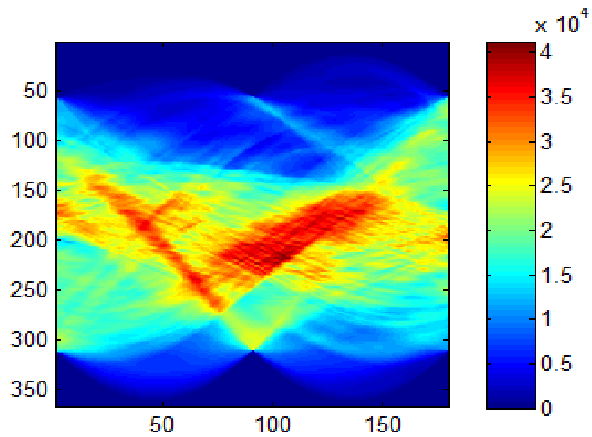

Fig. 10. Original image in Radon domain

Where the ***PSNR = 38.79 dB*** without attacks application. Well as the correlation between the recovered watermark and the original watermark is equal to 1 **(correlation =1)**. So, no differences detected between the original and the recovered watermark.

To study the robustness of our algorithm different type of **STIRMARK ATTACKS** are applied to the watermarking image. The correlation between the recovered and original watermark is defined in the following tables.

TABLE I:

RESISTANCE OF OUR METHOD TO THE STIRMARCKS ATTACKS

STIRMARK ATTACKS	Correlation
Conv_2	1
Median_3	0.9784
Median_5	0.9384
PSNR_0	0.9804
PSNR_50	1
PSNR_100	1
Noise_0	1
Noise_20	0.9571
Noise_40	0.7532
JPEG_50	0.8500
JPEG_60	0.8977
JPEG_70	0.9329
JPEG_80	0.9930
JPEG_90	1
JPEG_100	1
RESC_90	0.9800
RESC_75	0.9898
RNDDIST_1	1
LATESTRNDDIST	1
RML_10	1
RML_40	0.9783
AFFINE_1	1
AFFINE_8	0.9951
ROT_5	0.9934
ROT_0.75	0.9934
ROT_1	1
ROT_-1	0.9987
ROT_-5	0.9419
ROTCROP_0.5	1
ROTCROP_-0.5	0.9993
ROTCROP_-1	0.9866
ROTSCALE_0.25	1
ROTSCALE_-0.25	0.9992
ROTSCALE_0.5	1
ROTSCALE_0.75	1
ROTSCALE_-0.75	0.9941
ROTSCALE_1	0.9899
ROTSCALE_-1	0.9818

This table shows the effectiveness of our method to resist against different STIRMARK attacks. The correlation between the recovered and original watermark shows a low error between them for different types of attack. We note that the resistivity of the proposed approach against geometric attacks is better than that against the common image processing attacks. This efficiency is related to the properties of the Discreet Radon Transformation. Also, the effectiveness of our method to resist against common image processing attacks is related to the coefficients which are/and selected from the image in Radon field. The highest coefficients in the Radon field contain the significant information of the original image that allows it to be withstanding against common image processing attacks. Well, these coefficients are located around the centre of projection and used in the transformed Radon that allows being resilient against the geometrical attacks.

V. CONCLUSIONS

Watermarking is a technology used for various data hiding applications. It is used to provide the copyright ownership described in the previous sections, additional information (small bit-streams) can be embedded in an image using a variation of the proposed watermarking technique (data hiding).A robust image watermarking approach in Radon field for copyright protection is proposed in this paper. The proposed scheme is based on the properties of the RIT Generalized Radon Transformation. The proposed algorithm selects the maximum coefficient in Radon domain to insert the watermark. This method presents a more effectiveness to withstand against the common image treatment. Also, it presents a good robustness against the common image processing and the geometric transformation attacks.

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