

IMAGE WATERMARKING USING MOJETTE TRANSFORMC. Benachour¹, A. Hazzab^{2*}, A. Bassou³¹Tahri Mohamed University of Bechar, Algeria²Laboratoire Commande Analyse et Optimisation des Systèmes Electro-Énergétiques (CAOSEE), Tahri Mohamed University of Bechar, Algeria³Laboratoire Traitement de l'Information et Télécommunication (LTIT), Tahri Mohamed University of Bechar, Algeria

Received: 08 January 2018 / Accepted: 30 June 2018 / Published online: 01 September 2018

ABSTRACT

Copyright protection of digitized information has become one of the challenges for researchers. For this reason, several techniques are being implemented to resolve this problem, and watermarking is the most adequate with its methods. This paper represents a new approach to digital image watermark based on the Mojette Transform. This approach is to select a pixel block of the original image, where the hidden message insertion will be made. Each message bit is inserted into a different pixel. The results have been encouraging, especially as regards the imperceptibility, detection robustness and capacity of hidden message.

Keywords: Watermarking, Mojette Transform, Copyright, Imperceptibility, robustness, Marked image.

Author Correspondence, e-mail: c_benachour@yahoo.frdoi: <http://dx.doi.org/10.4314/jfas.v10i3.17>

1. INTRODUCTION

In recent years, the Internet has witnessed a rapid growth. This fact, associated with the developments of computers, makes multimedia data piracy easier, which presents a challenge in the field of numerical copyright protection. Digital watermarking, which can be defined as embedding a hidden message into data, has drawn a lot of attention as a possible solution to this problem. In the perspective of watermarking, imperceptibility, robustness, embedding capacity and security are of major concerns [1]. Conventionally, digital watermarking is implicitly known as a perceptually unobtrusive signal which is difficult to remove and is inserted in audio/visual data [2]. Digital watermarking automations are mainly categorized into two types, one is the spatial domain and the other technique is the frequency domain [3]. The watermark is typically embedded by alteration in pixel values or frequency coefficients. Digital watermarking is primarily used in checking data integrity and documents authentication, whereby an embedded mark can help identify the sender or the copyright authenticity. Watermarks are usually designed to be at the same time authenticative and verifiable.

Therefore, there is an crucial necessity for the protection of digital content copyright against piracy and illegal manipulation. Numerous watermarking systems have been proposed as promising and efficient answers to these concerns. Most of the available research papers have focused on developing new paradigms for watermark embedding; however, the watermarking community recently recognized the need to develop a guiding theory to delimit the fundamental parameters of available and yet-to-develop watermarking systems [4].

There are several techniques that can be implemented for watermarking. These include DCT, DWT and so on. [5] In this paper, we present a new method which utilizes the Mojette transform as a watermark in the Mojette domain, and that can dissimulate watermark in a imperceptible and robust manner.

The proposed watermarking system is presented in the form two algorithms; the first is concerned with watermark embedding, and the second is about watermark extraction. The performances of the watermarking system are assessed by means of examples of experimental results. The remaining part of the paper is devoted to results discussion followed by a conclusion.

2. THE MOJETTE TRANSFORM

The Mojette Transform is a mathematical transform that has gone through about 20 years of research history [6]. Software and hardware applications of the Mojette transform exist in the literature such as [7], [8]. In these works, a probable implementations of the above-mentioned software and hardware solution mixed together in a real time milieu was also introduced [9]. The Mojette Transform (MOT) originated in France where J-P. Guédon named an old French class of white beans, which were used in teaching computing basics of arithmetics to children using simple addition and subtraction [6]. Guédon named the transform alluding to the analogy of beans and bins. The bins encompass the sum of pixel values of the respective projection line of an image or a matrix [6]. The Mojette transform involves two parts; the direct and the inverse Mojette transform, as illustrated below:

2.1 Direct Mojette Transform (MT)

The Mojette Transform is a kind of discrete Radon transform [10]. This transform needs many angles such as :

$$\theta = \arctan\left(\frac{q}{p}\right) \quad (1)$$

where (p, q) are integers restricted to $PCD(p,q) = 1$. For an image at each angle, we can acquire a group of projections. Every projection is called a bin. The process of the transform can be described by the following $M_{p,q}$ operator :

$$M_{p,q}f(k, l) = \sum_{k=-\infty}^{+\infty} \sum_{l=-\infty}^{+\infty} f(k, l) \Delta(b + kq - lp) \quad (2)$$

Where

$$\Delta(b) = \begin{cases} 1, & \text{if } b = 0 \\ 0, & \text{if } b \neq 0 \end{cases} \quad (3)$$

And $M_I f(k, l)$ denoted the set of I projections: $M_I f = \{M_{p_i, q_i} f; i \in \{1, 2, \dots, I\}\}$. In another way, given an image and an angle, its projections are acquired by adding together the gray value of the pixels along the straight lines of $m + qk - lp = x$ (see Figure 1).

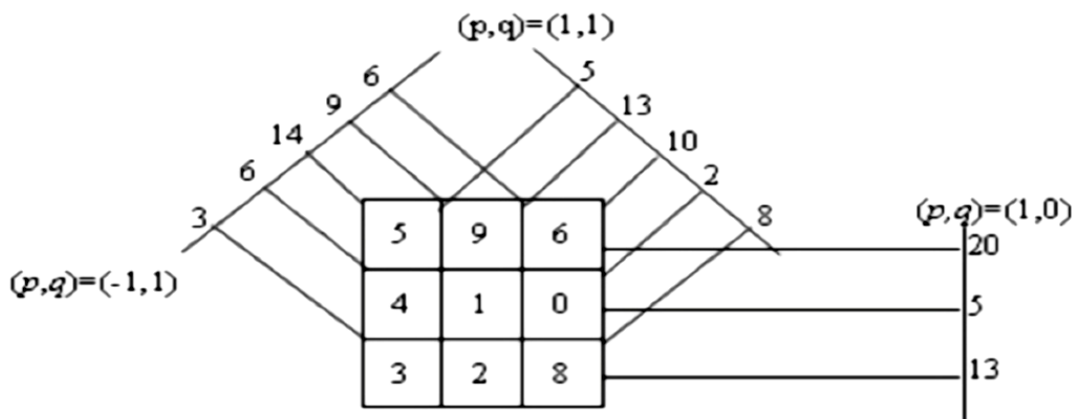


Fig.1. The direct Mojette transform for a 3×3 support and 3 projections

The use of the name Mojette transform is due to the well-posed nature of this linear transform and its explicit discrete nature, so as to avoid confusion with the various regularized versions of the Radon transform. Among the direct consequences of this sampling is that the number of bins of the projection indexed by (p, q) depends both of the projection angle and of the block dimensions. For example, a $P \times Q$ rectangular block has its (p, q) projection comprising B bins with $B = (Q - 1)/|p| + (P - 1)/|q| + 1$. [6]

2.2 Inverse Mojette Transform

The inverse Mojette transform is the process of inverse the projections into the origin gray values of pixels. There have many ways to implement the inverse Mojette transform and we usually use the simplest one: first, select a projection which contains only one pixel; second, select the projections which contain this pixel and subtract the gray value of this pixel from these projections. Then do the above steps repeatedly until all the pixels are retrieved[6]. This is shown in Figure 2.

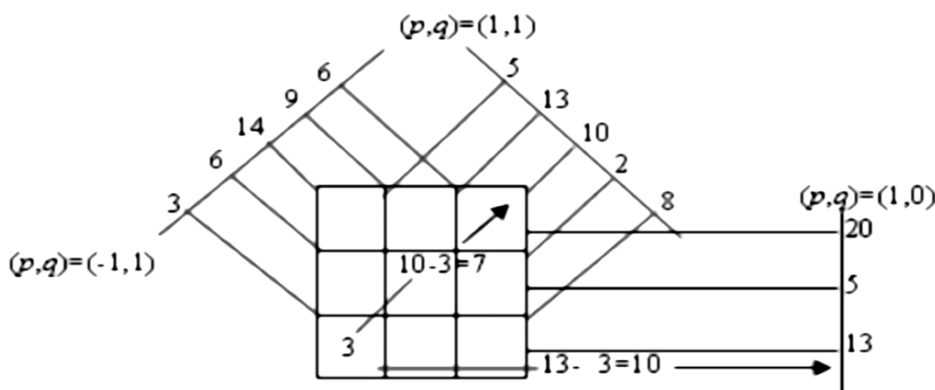


Fig.2. The process of the inverse Mojette transform

3. THE PROPOSED WATERMARKING SYSTEM

The approach is based on the Mojette transform applied on a block b of pixels sized $N_b \times M_b$ of a given image I_o sized $N \times M$. This block has an initial pixel $[I_b, J_b]$ where projections start successively for $p=1$ and $q=1..20$ with a step $=1..4$. The number of projections varies: $NProj = 1..10$.

3.1 Embedding watermark Scheme

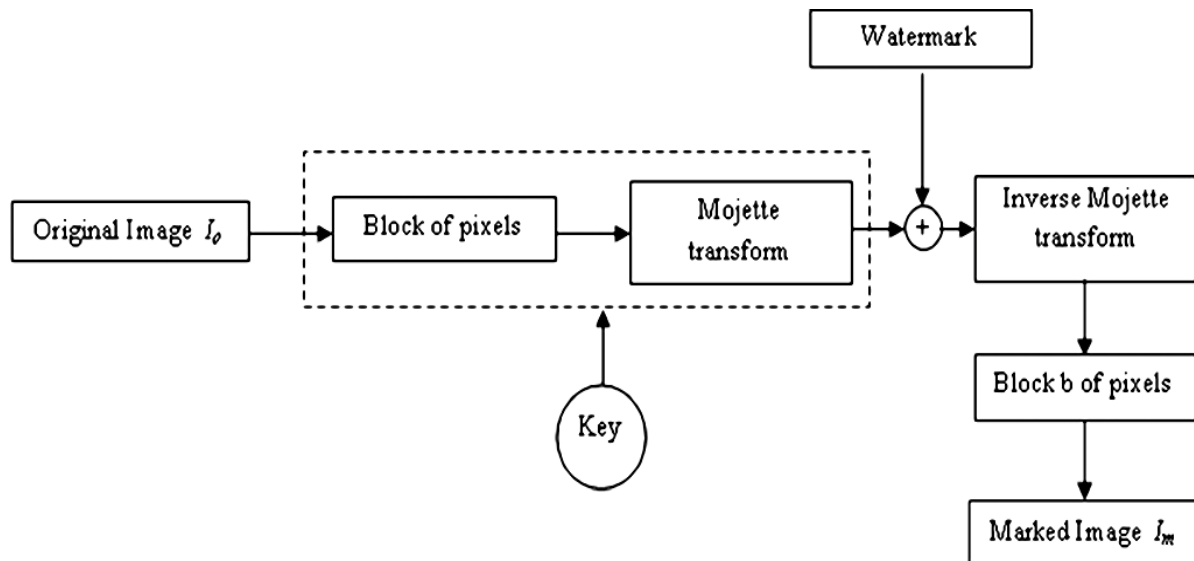


Fig.3. The Embedding watermark Scheme

3.2 Embedding watermark algorithm

Step 1: Loading the original image I_o

Step 2: Choosing the size of the block b $N_b \times M_b$

Step 3: Locating the block on original image I_o beginning from pixel $[I_b, J_b]$

Step 4: Giving the increment step for q

Step 5: Giving the q value for $p=1$

Step 6: Applying the Mojette transform on the block

Step 7: Selecting the embedding watermark positions (bins are sorted according the number of pixels participating in the summation in a descending order)

Step 8: Embedding watermark with a maximum of 64 Bit (each message bit is inserted in one of the pixels of each sorted bin so that all message bits are embedded)

Step 9: Applying the Inverse Mojette transform on the block

Step 10: Output of the marked image I_m

3.3 Extracted watermark Scheme

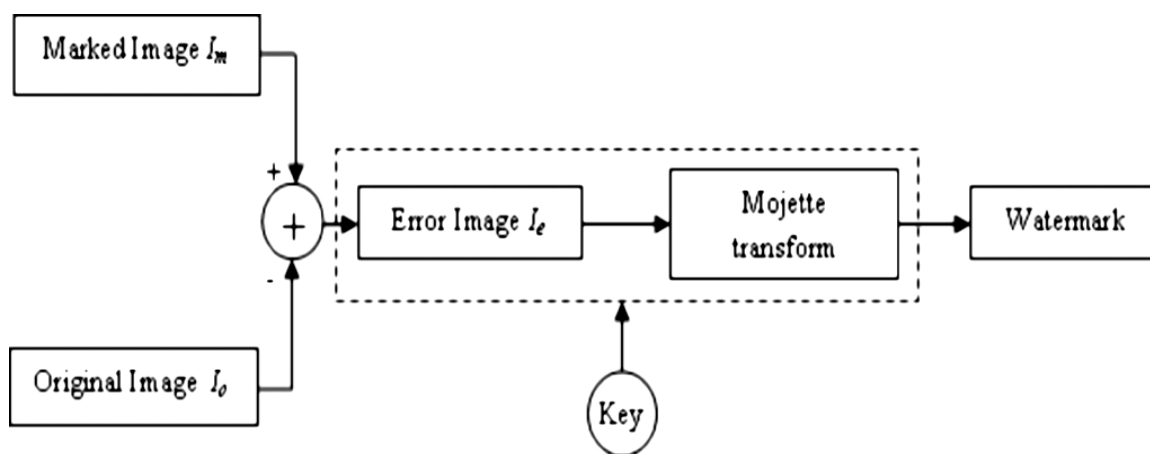


Fig.4. The Extracted watermark Scheme

3.4 Algorithm of Extracted watermark

- Step 1:** Calculating error image $I_e = I_m - I_o$
- Step 2:** Applying the Mojette transform on error image I_e
- Step 3:** Output of the watermark

4. RESULTS AND DISCUSSION

As mentioned earlier, the algorithm of this approach is applied on a block sized 32×32 of Lena image 512×512 starting from pixel $[201, 201]$, $p= 1$, $q=1..20$, with q steps=1..4. The number of projections varies $NProj=1..10$. Hence, the achievable possibilities are presented in Figure 5.

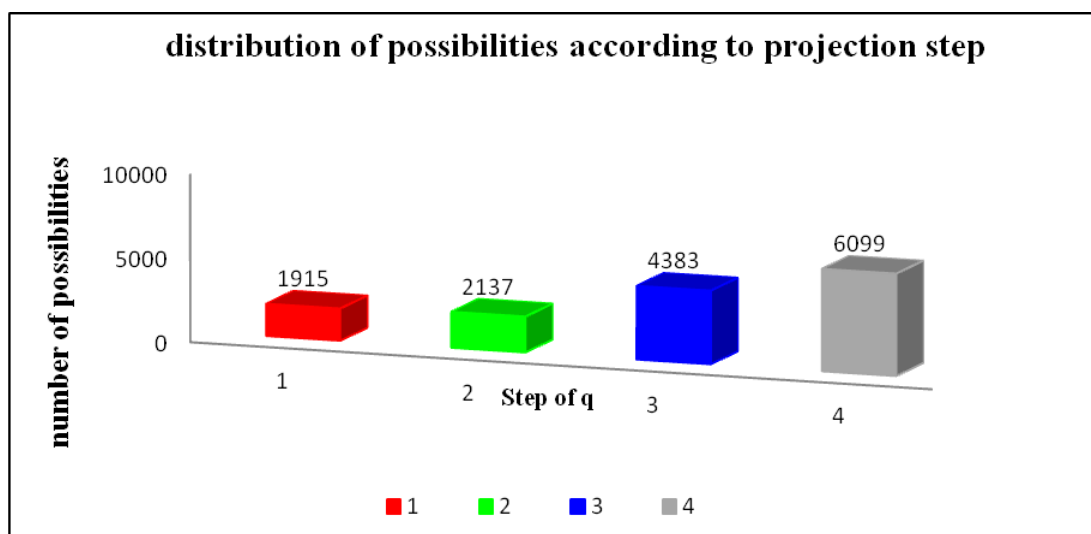


Fig.5. Histogram: Distribution of possibilities according to projection steps

Results presented on the histogram show that the increase of q step provokes a rise in the number of possibilities of numerical tattooing, hence it can be said that there is a strong correlation between the number of possibilities and the q step with a correlation coefficient $r = 0,9619157$.

In the experimental phase, the number of results obtained on Lena image 512×512 (Figure 6) is quite significant. Therefore, four cases with different parameters ($N_b, M_b, I_b, J_b, q, NProj, step$) and $p=1$ are presented below in which each black frame in the marked images represents the marked block:



Fig.6. Original Image I_o

Case 1 :

$N_b = 9$ $M_b = 25$ $I_b = 201$ $J_b = 201$ $q = 20$, $NProj = 2$, $step = 1$



Fig.7. (a) the original block (b) the marked block with projection at angles (1,20) and (1,21)
(c) the error block (d) the marked image

PSNR = 45,994

Case 2 :

$N_b = 18$ $M_b = 19$ $I_b = 201$ $J_b = 201$ $q = 16$, $NProj = 2$, $step = 2$



Fig.8. (a) the original block.(b) the marked block with projection at angles (1,16) and (1,18)
(c) the error block (d) the marked image

PSNR = 50,847

Case 3:

$N_b = 22$ $M_b = 23$ $I_b = 201$ $J_b = 201$ $q = 20$, $NProj = 2$, $step = 3$



Fig.9. (a) the original block.(b) the marked block with projection at angles (1,20) and (1,23).(c)the error block (d) the marked image

PSNR = 57,111

Case 4:

$N_b = 22$ $M_b = 23$ $I_b = 201$ $J_b = 201$ $q = 20$, $NProj = 2$, $step = 4$



Fig.10. (a) the original block (b) the marked block with projection at angles (1,20) and (1,24)
(c) the error block (d) the marked image

PSNR = 57,111

The parameters of the four cases are presented in the Table 1. These results show that there a strong correlation between the q step and the PSNR with a correlation coefficient $r=0,9480605$.

Table 1. The parameters of the four cases

$N_b \times M_b$	$[I_b, J_b]$	p	q	$NProj$	Step of q	PSNR
9×25	[201, 201]	1	20	2	1	45,994
18×19	[201, 201]	1	16	2	2	50,847
22×23	[201, 201]	1	20	2	3	57,111
22×23	[201, 201]	1	20	2	4	57,111

In all possible experimental results obtained, the choice of the four resulting cases is made on the basis that their $PSNR$ is maximal for each case. Each marked bloc in a black frame in the marked image is imperceptible to the naked eye. This algorithm is robust enough to detect the

hidden message, the message detection key is composed of several parameters: block size $N_b \times M_b$ pixel > 64 , the initial pixel of the block $[I_b, J_b]$, the number of projections N_{Proj} , the value q , and the q step. Moreover, the insertion of each hidden message bit is done randomly within the summed pixel in each bin, starting from bins with the largest number of summed pixels, in such a way that all the bits of the hidden message are inserted. The position of pixels containing message bits is unknown. Hence message extraction is done by the subtraction of the original image I_o of the marked image I_m , $I_e = I_m - I_o$. In this algorithm, the message capacity is inferior or equal to 64 bits. If the bit rate is equal to 1, then the inserted value is 1, and if the bit rate is equal to 0, then the inserted value is -1, so that their sum of the inserted values is equal to 0.

5. CONCLUSION

A new watermarking method based on the Mojette transform that can hide specific information in the original image is presented in this paper. Experimental results show the effectiveness of the method once a meaningful watermark is successfully constructed. Most of the possibilities for image watermarking have been investigated taking into account three criteria: (a) invisibility; the message is imperceptible to the naked eye, (b) robustness which is determined by the key which consists in block size and location, the number of projections as q step and (c) message capacity in which we considered a maximum of 64 bits.

6. ACKNOWLEDGEMENTS

This work would not have seen the light without the precious help and assistance of many people, starting with TAHRI Mohamed University staff who provide researchers with the necessary means to promote research. Special thanks are due to the CAOSEE and LITT laboratories without whose assistance and equipment, this work would not have seen the light. Authors are also grateful to the IEEE Signal Processing Magazine for enabling the publication of the present work, and to reviewers for devoting time to evaluate this research paper. Finally, special thanks go to Dr. T. GHOMRI, from the department of English, for his valuable proofreading.

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How to cite this article:

Benachour C, Hazzab A, Bassou A. Image watermarking using mojette transform. *J. Fundam. Appl. Sci.*, 2018, *10(3)*, 239-250.