

# A Visual Cryptography Based Digital Image Copyright Protection

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## ABSTRACT

A method for creating digital image copyright protection is proposed in this paper. The proposed method in this paper is based on visual cryptography defined by Noor and Shamir. The proposed method is working on selection of random pixels from the original digital image instead of specific selection of pixels. The new method proposed does not require that the watermark pattern to be embedded in to the original digital image. Instead of that, verification information is generated which will be used to verify the ownership of the image. This leaves the marked image equal to the original image. The method is based on the relationship between randomly selected pixels and their 8-neighbors' pixels. This relationship keeps the marked image coherent against diverse attacks even if the most significant bits of randomly selected pixels have been changed by attacker as we will see later in this paper. Experimental results show the proposed method can recover the watermark pattern from the marked image even if major changes are made to the original digital image.

**Keywords:** Image Watermark; Pattern; Visual Cryptography; Digital Image; Copyright

## 1. Introduction

The proliferation of digitized images has made the digital images to be modified, distributed, duplicated and accessed easily. It is creating a pressing need to develop copyright protection methods. A watermarking technology is now providing highly attention as a desired method and technology for protecting copyrights for digital data [1-7]. A watermarking has been defined as the practice of embedding identification information in an image, audio, video or other digital media element to provide privacy protection from attackers [8-9]. The identification information is called "watermark pattern" and the original digital image that contains watermark pattern is named "marked image". The embedding takes place by manipulating the contents of the digital image [10]. Also, a secret key is given to embed "watermark pattern" and to retrieve it as well. **Figure 1** gives summarize of standard watermarking embedding scheme.

Basically, if the owner wants to protect his/her image, the owner of an image has to register the image with the copyright office by sending a copy to them. The copyright office archives the image, together with information about the rightful owner. When dispute occurs, the real owner contacts the copyright office to obtain proof that he is the rightful owner. If he did not register the image, then he should at least be able to show the film negative. However, with the rapid acceptance of digital photography,

there might never have been a negative. Theoretically, it is possible for the owner to use a watermark embedded in the image to prove that he/she owns it [11].

A typical image watermark algorithm must satisfy the following two properties: transparency and robustness. Transparency means that the embedded watermark pattern does not visually spoil the original image fidelity and should be invisible. Robustness means the watermark pattern is not easy to detect and remove illegally. Moreover, any modifications of the image values have to be invisible, and the watermark method has to be robust or fragile in order to provide protection against attackers.

In 1994, Noor-Shamir proposed the concept of visual cryptography [12]. The concept nowadays is being developed and/or improved several times for different purposes of applications by authors [13-24]. A good survey on visual cryptography can be found in [25]. Actually, Visual cryptography is describing as a secret sharing scheme extended of digital images, this will be discussed in the next section. Hwang [26] is the first author proposed

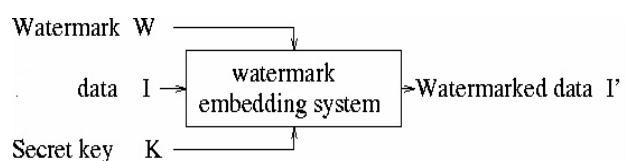


Figure 1. Watermarking embedding scheme.

a method of how to take a benefit of visual cryptography to create digital image copyright protection. According to Hwang method, the watermark pattern does not have to be embedded into the original image directly, which makes it harder to detect or recover from the marked image in an illegal way. [27-30] improved different methods to overcome Hwang method’s shortcomings. We will come to these shortcomings in Section 3.

This paper proposes new digital images copyright protection based on Hwang method. The proposed method is based on visual cryptography defined by Noor-Shamir and Hwang method. Marking images will be conducted without embedding patterns into images. This leaves marked images unchanged with sizes exactly equal to the original ones. This paper is organized as follows. Section 2 reviews the concept of visual cryptography and digital image copyright protection. Section 3 presents our proposed digital image copyright protection method. Section 4 reports some experimental results and makes some discussions concerning our method. Finally, conclusions appear in Section 5.

## 2. Visual Cryptography and related Digital Image Copyright Protection

Naor and Shamir in 1994 proposed the concept of visual cryptography during EUROCRYPT 94. **Figure 2** from [31] demonstrates a simple version of visual cryptography. In their method, they introduced encoding scheme to share a binary image into two shares Share 1 and Share 2. A pixel  $P$  is divided into two subpixels in each of the two shares. If  $P$  is white one of two rows above in **Figure 2** is selected to create Share 1 and Share 2. But, if  $P$  is black one of two rows below in **Figure 2** is selected to create Share 1 and Share 2. A binary image at the end becomes secret image or invisible unless both shares are superposition.

Hwang created the first and typical idea for a digital image copyright protection based on the visual cryptography. The method use a simple (2, 2) visual threshold scheme defined by Naor-Shamir. Referring to Hwang’s algorithm, the owner must select  $h \times n$  black/white image as his/her watermark pattern  $P$  and a key  $S$  which must be kept securely. Then, verification information  $V$  is generated from the original  $k \times 1$  image  $M$  and the watermark pattern  $P$  using the key  $S$ ; as follows:

1) Use  $S$  (the secret key) as the seed to generate  $h \times n$  different random numbers over the interval  $[0, k \times 1]$ . ( $R_i$  represents the  $i$ -th random number).

2) Assign the  $i$ -th pair ( $V_{i1}, V_{i2}$ ) of the verification information  $V$  based on the following **Table 1**:

Collect all the ( $V_{i1}, V_{i2}$ ) pairs to construct the verification information  $V$ . This verification information must be kept by neutral organization. When the owner of an image  $M$  wants to claim the ownership of an image  $M'$  as

pixel		share #1	share #2	superposition of the two shares
□	$p = .5$			
	$p = .5$			
■	$p = .5$			
	$p = .5$			

**Figure 2.** Naor and Shamir’s scheme.

**Table 1.** The rules to assign the value of verification information.

The color of the $i$ -th pixel in watermark pattern is	The left most bit of the $R_i$ -th pixel of Image $M$ is	Assign the $i$ -th pair, ( $v_{i1}, v_{i2}$ ), of verification information $V$ to be
Black	“1”	(0,1)
Black	“0”	(1,0)
White	“1”	(1,0)
White	“0”	(0,1)

a copy of the original image  $M$ , the owner has to provide the secret key  $S$ , and the watermark pattern  $P$  is restored using the image  $M'$  and verification information  $V$  as follows:

1) Use  $S$  as a seed to generate  $h \times n$  different random numbers over the interval  $[0, k \times 1]$ . ( $R_i$  represents the  $i$ -th random number).

2) Assign the color of the  $i$ -th pixel of the watermark pattern  $P'$  based on the image  $M'$  as follows:

Get the left-most bit,  $b$ , of the  $R_i$ -th pixel of image  $M'$ , and if  $b$  is 1 then, assign  $f_i = (1, 0)$ ; otherwise assign  $f_i = (0, 1)$ .

If  $f_i$  is equal to  $i$ -th pair of  $V$  then assigns the color of the  $i$ -th pixel of  $P'$  to be white; otherwise, assign it to be black.

3) If  $P'$  can be recognized as  $P$  through the human, the neutral organization shall adjudge that the image  $M'$  is a copy of  $M$ .

According to the previous method and also the related methods, these methods are strongly related to the values of the most significant bits of pixels selected randomly from the original digital image; therefore, if the most significant bit to some pixels selected randomly has been changed, the modified image  $M'$  will fail to retrieve the watermark pattern  $P$  successfully. Also, since the method does not consider the relationship between pixels and its neighbors, the watermark pattern would not be retrieved, if part of image has been cropped. Moreover, if we have an image  $X$  with some similarities with the original image  $M$ . The watermark pattern  $P$  might be restored successfully, despite the image  $X$  is not the same as the image  $M$ .

### 3. The Proposed Digital Image Copyright Protection

In this section, we present the proposed watermark method. The method actually use the relationship between 8-neighbours pixels of pixel  $P(x, y)$  as a base of embedding algorithm as you will see later. **Figure 3** shows the 8-neighbours of pixel  $P(x, y)$ .

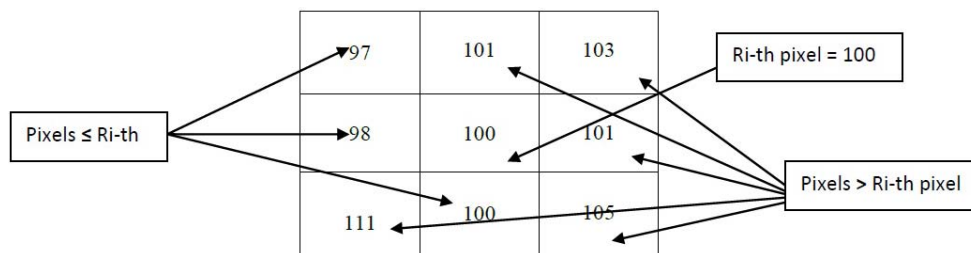
We assume that the owner wants to embed the  $h \times n$  watermark pattern into the image  $M$  that is a  $k \times l$  256 gray-leveled image. The owner embeds the watermark pattern  $P$  into the image  $M$  by generating the secret key,  $S$ , and the verification information,  $V$ , as the following steps.

Step Embedding-1. Select number  $S$  randomly as the secret key of the image  $M$ .

Step Embedding-2. Use  $S$  as the seed to generate  $h \times n$  different random numbers over the interval  $[0, k \times l]$ . Where  $R_i$  is the  $i$ -th random number.)

Step Embedding-3. Calculate the number of  $R_i$ -th pixel's neighbours pixels from its 8-neighbours pixels that are less than or equal to the  $R_i$ -th pixel, this number named,  $Number\_of\_neighbors\_less\_or\_equal\_R_i\text{-th\_pixel}$ . Also, calculate the number of  $R_i$ -th pixel's neighbour pixels from its 8-neighbour pixels that are greater than  $R_i$ -th pixel, this number named  $Number\_of\_neighbor\_greater\_R_i\text{-th\_pixel}$ .

For example, as in **Figure 4**, the  $Number\_of\_neighbors\_less\_or\_equal\_R_i\text{-th\_pixel} = 3$ , because we have three pixels  $\{97, 98, 100\}$  less or equal the  $R_i$ -th pixel, which equals 100. Also,  $Number\_of\_neighbors\_greater\_R_i\text{-th\_pixel} = 5$ , because we have 5 pixels in the following set  $\{101, 103, 101, 105, 111\}$  greater than  $R_i$ -th pixel.



**Figure 4. Example of  $R_i$ -th pixel's neighbors.**

It is obvious, in case the  $R_i$ -th pixel is a border pixel, this pixel do not have a full 8-nighbours. In this case, the available nighbours should be considered and calculate  $Number\_of\_neighbors\_less\_or\_equal\_R_i\text{-th\_pixel}$  and  $Number\_of\_neighbors\_greater\_R_i\text{-th\_pixel}$  same as in step Embedding-3.

Step Embedding-4. Find the  $i$ -th pair  $(vi1, vi2)$  of the verification information  $V$  based on **Table 2**.

Step Embedding-5. Assemble all the  $(vi1, vi2)$  pairs to create the verification information  $V$ .

Note that Step Embedding-5 constructs the verification Information  $V$  based on the watermark pattern  $P$  and the relationship result between  $Number\_of\_neighbors\_less\_or\_equal\_R_i\text{-th\_pixel}$  and  $Number\_of\_neighbors\_greater\_R_i\text{-th\_pixel}$  as shown in **Table 2**, and moreover the proposed method does not make any change into image  $M$  or alter any pixel of image  $M$ .

The verification information  $V$  generated from Step Embedding-5 must be given to the notarial organization. If an image  $M$  is appropriated by somebody as the image  $M'$ , The owner of an image has to provide the secret key  $S$  to the notarial organization. The notarial organization retrieves the verification information  $V$  and the watermark pattern  $P$ , which the owner has registered, and verifies the ownership of the image  $M'$  as follows:

$X - 1, y - 1$	$X - 1, y$	$X - 1, y + 1$
$x, y - 1$	$x, y$	$x, y + 1$
$X + 1, y - 1$	$X + 1, y$	$X + 1, y + 1$

**Figure 3. 8 Neighbours pixels of pixel  $P(x, y)$ .**

**Table 2. The proposed method's rules to assign the value of verification.**

The Color of the $i$ -th pixel in watermark pattern is	The relationship between $Number\_of\_neighbors\_less\_or\_equal\_R_i\text{-th\_pixel}$ and $Number\_of\_neighbors\_greater\_R_i\text{-th\_pixel}$	Assign the $i$ -th pair, $(vi1, vi2)$ , of verification information $V$ to be
Black	$Number\_of\_neighbors\_less\_or\_equal\_R_i\text{-th\_pixel} \leq Number\_of\_neighbors\_greater\_R_i\text{-th\_pixel}$	(0,1)
Black	$Number\_of\_neighbors\_less\_or\_equal\_R_i\text{-th\_pixel} > Number\_of\_neighbors\_greater\_R_i\text{-th\_pixel}$	(1,0)
White	$Number\_of\_neighbors\_less\_or\_equal\_R_i\text{-th\_pixel} \leq Number\_of\_neighbor\_greater\_R_i\text{-th\_pixel}$	(1,0)
White	$Number\_of\_neighbors\_less\_or\_equal\_R_i\text{-th\_pixel} > Number\_of\_neighbors\_greater\_R_i\text{-th\_pixel}$	(0,1)

Step Verification-1. Use  $S$  as the seed to generate  $h \times n$  different random numbers over the interval  $[0, k \times 1]$ . Where  $R_i$  is the  $i$ -th random number.)

Step Verification-2. Assign the color of the  $i$ -th pixel of the watermark pattern based on image  $M'$  as follows:

**If** (*Number\_of\_neighbors\_less\_or\_equal\_Ri-th\_pixel*  $\leq$  *Number\_of\_neighbors\_greater\_Ri-th\_pixel*) **AND** (the  $i$ -th pair,  $(v_{i1}, v_{i2})$ , of verification information  $V = (0,1)$ ) **then**

Assign the color of the  $i$ -th pixel of  $P'$  to be white

**Else If** (*Number\_of\_neighbors\_less\_or\_equal\_Ri-th\_pixel*  $\leq$  *Number\_of\_neighbors\_greater\_Ri-th\_pixel*) **AND** (the  $i$ -th pair,  $(v_{i1}, v_{i2})$ , of verification information  $V = (1,0)$ ) **then**

Assign the color of the  $i$ -th pixel of  $P'$  to be black

**Else If** (*Number\_of\_neighbors\_less\_or\_equal\_Ri-th\_pixel*  $>$  *Number\_of\_neighbors\_greater\_Ri-th\_pixel*) **AND** (the  $i$ -th pair,  $(v_{i1}, v_{i2})$ , of verification information  $V = (1,0)$ ) **then**

Assign the color of the  $i$ -th pixel of  $P'$  to be white

**Else If** (*Number\_of\_neighbors\_less\_or\_equal\_Ri-th\_pixel*  $>$  *Number\_of\_neighbors\_greater\_Ri-th\_pixel*) **AND** (the  $i$ -th pair,  $(v_{i1}, v_{i2})$ , of verification information  $V = (0,1)$ ) **then**

Assign the color of the  $i$ -th pixel of  $P'$  to be black.

Step Verification-3. If  $P'$  equals the original watermark pattern  $P$  or can be recognized as it, then the notarial organization can conclude that image  $M'$  is a copy of  $M$ .

Note that the code written in Step Verification-2 can be concluded directly from **Table 2** which displays the proposed method's rules to assign the value of verification information.

The security of the proposed method is based on the relationship of pixels selected randomly and their 8-neighbor's pixels. This happened because whenever a change is applied into original digital image pixels, the result of the relationship mostly becomes the same. In other words, the relationships between *Number\_of\_neighbors\_less\_or\_equal\_Ri-th\_pixel* and *Number\_of\_*

*neighbors\_greater\_Ri-th\_pixel* will not be affected by some major changes in image pixels' bits. Experimental results in the next section will reflect that fact.

## 4. Experimental Results

The proposed algorithms are studied using Matlab 7. Images used are  $256 \times 256$  pixels images Lina, Baboon and F-16 (shown in **Figure 6**). In Matlab 7, we made some changes in the three images before applying the proposed method. The changes are applied in the most significant bits of randomly selected pixels. Also, we did make changes in images quality using Adobe Photoshop CS 5 by applying diverse compressions in the three images. The watermark pattern used in the experiment is "cheng" in **Figure 5**. From the results shown in **Table 3**, we find that the watermark pattern "cheng" get some noise but still can be recognized even if the three images have been compressed and the size of those files is changed.

## 5. Conclusion

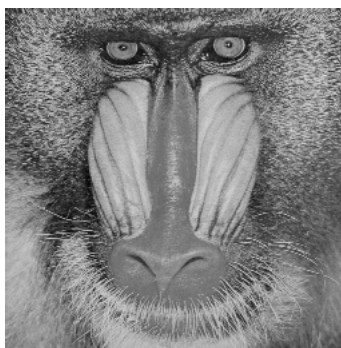
This paper presents a digital image copyright protection method using watermarking technology. The method proposed in this paper does not require that the watermark pattern to be embedded in to the original digital image. Instead, Verification information is generated which will be used to verify the ownership of the image. This leaves the marked image equal to the original image. The proposed method is tested and shows that a watermark pattern can be retrieved easily from marked image even the image is attacked by major changes in pixels bits.



Figure 5. The watermark pattern "cheng".



(a) Lena



(b) Baboon














(c) F-16


Figure 6. Three images of our Experiments.

**Table 3. Experimental results.**












(a) Use the proposed method to embed "Cheng" into "Lena"

The Marked Image	The Digital Image Quality with Adobe Photoshop CS 5	The Recovered Watermark Pattern "Cheng"
	0/low (the size of compressed file is 10,463 Bytes)	
	1/low (the size of compressed file is 12,501 Bytes)	
	2/low (the size of compressed file is 13,830 Bytes)	
	3/middle (the size of compressed file is 15,643 Bytes)	
	4/middle (the size of compressed file is 17,344 Bytes)	
<i>Marked Image = Original Image</i>	5/middle (the size of compressed file is 17,139 Bytes)	
	6/high (the size of compressed file is 19,113 Bytes)	
	7/high (the size of compressed file is 24,385 Bytes)	
	8/maximal (the size of compressed file is 30,930 Bytes)	
	9/maximal (the size of compressed file is 39,177 Bytes)	
	10/maximal (the size of compressed file is 48,199 Bytes)	

(b) Use the proposed method to embed “Cheng” into “Baboon”

The Marked Image	The Digital Image Quality with Adobe Photoshop CS 5	The Recovered Watermark Pattern “Cheng”
	0/low (the size of compressed file is 17,930 Bytes)	
	1/low (the size of compressed file is 22,112 Bytes)	
	2/low (the size of compressed file is 23,856 Bytes)	
	3/middle (the size of compressed file is 27,115 Bytes)	
	4/middle (the size of compressed file is 30,103 Bytes)	
<i>Marked Image = Original Image</i>	5/middle (the size of compressed file is 27,992 Bytes)	
	6/high (the size of compressed file is 33,120 Bytes)	
	7/high (the size of compressed file is 38,004 Bytes)	
	8/maximal (the size of compressed file is 44,759 Bytes)	
	9/maximal (the size of compressed file is 53,992 Bytes)	
	10/maximal (the size of compressed file is 62,951 Bytes)	

(c) Use the proposed method to embed “Cheng” into “F-16”

The Marked Image	The Digital Image Quality with Adobe Photoshop CS 5	The Recovered Watermark Pattern “Cheng”
	0/low (the size of compressed file is 9850 Bytes)	
	1/low (the size of compressed file is 11,451 Bytes)	
	2/low (the size of compressed file is 12,344 Bytes)	
	3/middle (the size of compressed file is 13,949 Bytes)	
	4/middle (the size of compressed file is 16,278 Bytes)	
<i>Marked Image = Original Image</i>	5/middle (the size of compressed file is 14,929 Bytes)	
	6/high (the size of compressed file is 17,930 Bytes)	
	7/high (the size of compressed file is 21,125 Bytes)	
	8/maximal (the size of compressed file is 25,920 Bytes)	
	9/maximal (the size of compressed file is 32,852 Bytes)	
	10/maximal (the size of compressed file is 40,877 Bytes)	

The watermark pattern cannot be retrieved from the marked image unless the key is given, and the key is only known by the owner. Also, the watermark pattern cannot be retrieved from the marked image unless the secret key and the verification information are given.

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