

High efficiency embedding and anti-clipping digital watermark algorithms based on the LSB, watermark separation and image interpolation

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Abstract. Traditional arithmetic of LSB is only replaces the least bit which is retaining the image more better but a waste of memory. Furthermore LSB can not cut out. In order to improve the LSB digital image watermarking method, in this paper, an algorithm based on *image interpolation* and *spatial separation* watermarking is proposed. The watermark's high and low frequency separation method is used in the treatment of watermark, and then the image interpolation is performed to improve the anti-cutting performance. The use of *linear transformation* and embedded *the back of the qr code* also improve the security of the algorithm. Experimental results show that to replace the last two bits and image interpolation techniques take effects to LSB.

1. Introduction

At present, most researches on digital watermarking technology focus on frequency domain, so, on the contrary there is less research on spatial domain. The main reason is the available information of spatial domain is little. And the bits of embedded is limited, the watermark has poor robustness. It can not resistant to rotation, cutting. Once embedded to another image, it's easily to be founded and without any security^[1]. LSB is the main way of spatial method for image hiding. Principle of it is to make the image like what it not be hid with another image, with this principle we can use the information we want to hide to replace the least important bits of pixels in the image of the carrier image. As a arithmetic which can hide bulk information, LSB is still widely used in many field for it's easily understand and operation^[2]. Basing on these questions we raise a method base on image interpolation and LSB. For LSB, in order to promote The efficiency of embedding, changing the last two bits of the image, and it doesn't influence the quality of itself. Information hiding is an important branch of information security, we often use streaming media redundancy hides information and then realize the covert transmission of information. To dispose of hidden information which basing on digital watermarking technology has big problem. The times we scrambling is very important, too few the effect is not ideal and too many is much complex^[3]. There we put forward a new way to solve these problem. Refer to the back shape principle of qr code, we put the watermark at any bit, if we want to find it, we just find the back shape. And we make the high frequency part and low frequency part of the watermarking separated, which enhance the anti-clipping performance and the robustness.

2. Embedding and extraction process of watermark

The first step of embedding watermark is separating the high frequency part and the low frequency



part. After that using the method of linear change to make the watermark complicated. Later using image interpolation to change the watermark basing on LSB which replace the last two bits. Thus we have finished the process of embedded. Finally cutting the image and extract watermark.

3. Spatial separation watermark embedding method based on LSB

3.1. The prepare process for watermark

Generally the pre - processing for watermark is using the way of Scrambling to meet the need of confidentiality. But it has a high requirement to the data. The more data we have, the more computer has to deal with, and the time we spend will much longer. Also will happen while we recovering watermark. Because of these reasons we *separating watermark* and using the method of *linear transformation* dealing with watermark.

First, separating watermark to two part, the *high and low frequency part*. And then making them be scrambled though *linear transformation*. *Linear transformation* not only can scramble, but also reduce the data computer deal with. Remove the process of iterative. Though this new algorithm we promote the efficiency and the security of watermark.

Second, the back of the qr code make embedding and extraction are random. In this way, the position of watermark embedding can be found precisely. And, random embedding also improves security.

3.2. Watermark processing algorithm

(1) .Converting watermark images to binary and separating the watermark in airspace. we will get the high and low frequency parts. As shown in figure 3.1-3.2.



Fig.3.1



Fig.3.2



Fig.3.3

Fig.3.3 is the original watermark.

(2) .Linear transformation of watermark image.

The watermark needed scrambling before embedded. Arnold, permutation transform and Fibonacci are common replacement methods. After these scrambling image visual effect are different. But it's a big calculation. Based on the above considerations, we choose the method of *linear transformation*. It is known from the matrix theory of linear algebra, the transformation of two matrices can be expressed as:

$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} x \\ y \end{pmatrix} \times \begin{pmatrix} a & b \end{pmatrix} \quad (a)$$

The right multiplication is the column transformation and the left multiplication is the line transformation. So the mapping of the linear transformation is shown as follows:

$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} e & f \end{pmatrix} \times \begin{pmatrix} x \\ y \end{pmatrix} \times \begin{pmatrix} a & b \end{pmatrix} + \begin{pmatrix} m \\ n \end{pmatrix} \quad (b)$$

Simplified into,

$$A' = P * A * Q + C \quad (1)$$

$$B' = P * B * Q + C \quad (2)$$

The watermark image after *linear transformation* are shown in figure 3.4-3.5.



Fig.3.4



Fig.3.5

Part A is the high frequency and B is the low frequency. The pattern of P and Q is same with A and B. C is a constant matrix. Though *linear transformation* image scrambling is done.

(3) *Image interpolation* for watermark. In order to enhance the cutting resistance.

(4). Finally, adding the *back to the glyph* for watermark.

4. Image interpolation for watermark

4.1. Interpolating the image with the nearest neighbors

In the field of image processing, image interpolation technology is a basic and common image processing technology^[4]. It can construct a corresponding high resolution image based on a given low resolution image. Traditional image interpolation techniques mainly include *nearest neighbor interpolation*, bilinear interpolation and bicubic interpolation. *Nearest neighbor interpolation* has a small calculation, but the resulting image is discontinuous, where the gray level change may appear obvious jagged^[5]. But the nearest neighbor algorithm is a simplest interpolation method which is suitable for the design requirements of this algorithm. It doesn't need calculate, we just give the pixel which to be worked out using the most nearest pixel.

As shown in figure 4.

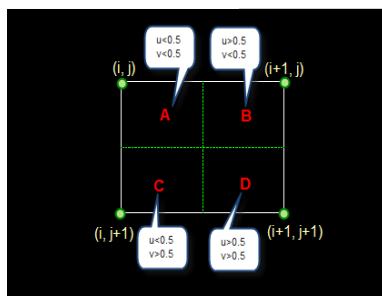


Fig.4

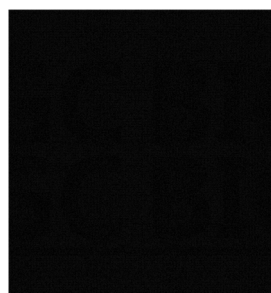


Fig.4.1

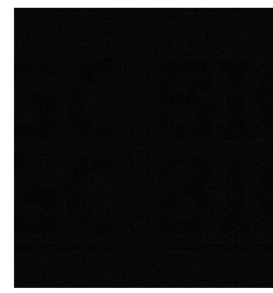


Fig.4.2

If $(i+u, j+v)$ located in A, we give the pixel of (i, j) . B, C, D is the same with A.

4.2. Image interpolation steps.

First expand the watermark image. Second is to calculate the pixel value of the extended neighboring element. Finally, the watermark image is interpolated by the nearest element method. As shown in figure 4.1-4.2.

5. Watermark embedding of LSB method based on the back shape.

To enhance the safety of watermarking, borrowing the principle of the back - shape of QR code. With the beginning of meeting the back shape and end with also meeting it. The starting position of the embedding is random. The embedding of the back glyph is for the image of the carrier. This is the last

step of watermark embedding which is adding back shapes at the beginning and ending. Thus, it is convenient to extract watermark.

5.1. The embedding process

The first embedded bit is selected randomly on the carrier diagram. In order to enhance the embedding efficiency, LSB method is embedded in the lowest two bits.

Fig5.1 is the image of back shape. Fig 5.2 is carrier image and Fig 5.3 is the synthetic images .

254	254	254	254	254
254	254	254	254	254
254	10	10	10	254
254	10	0	10	254
254	10	10	10	252
252	252	252	252	253



Fig5.1

Fig5.2

Fig5.3

6. Watermark extraction process.

First, scanning the carrier image to find out the back shape. According the location of back shape to ensure where the watermark is. Second, extracting the watermark and converting binary to decimal. Finally, using linear inverse transformation to recover the watermark. The extracted watermark is shown in Fig6.1.

BIGC
BIGC

Fig6.1

7. Cutting treatment.

Cutting The embedded image and then extracting the watermark. The result as shown in Fig7.1 (No interpolation) and Fig7.2(interpolation).

Recovered Watermark

BIGC
BIGC

Fig7.1

BIGC :
BIGC :

Fig7.2

8. Conclusion.

After linear transformation and image interpolation, the watermark is difficult to recognition, which is enhance the security of digital watermark obviously. The use of LSB algorithm does not have a great impact on the quality of carrier the image. Changing the last two bits not only reduce the quality of carrier image but also promote the efficiency of embedding and save the space. The most obvious improvement is the noise produced by the tailoring became more concentrated after the watermark

separation. And watermark interpolation reduces the noise produced by the cut. So we can conclude from the experiment that high efficiency embedding and anti-clipping digital watermark algorithms based on the LSB, watermark separation and image interpolation has obvious anti-clipping effect.

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