3-D Image Information Hiding Based on Improved Fast Fourier Transform

Jubao Qu[a], Hongtao Liang[b]

School of mathematics and computer, Wuyi University, Wuyishan, Fujian 354300, China

[a]Qjbok@qq.com, [b]Lianght@qq.com

Keywords: 3-D Image Information, Improved Fast Fourier Transform

Abstract: Based on the randomness and disorder of three-dimensional image, a hidden image information is encrypted by three-dimensional chaotic scrambling. Then, the encrypted information is embedded into the three-dimensional image by two-dimensional discrete Fourier transform. Without changing the original visual effect of the image, a good hiding effect is achieved. The experimental results show that the algorithm can effectively resist strong external attacks, has good robustness, and has a certain practical value.

1. Introduction

With the development of network technology, image-based information hiding technology has become the focus of current research. Literature [1] points out that image information hiding refers to hiding a meaningful secret information in another image to obtain a secret image, and then publicly transmit the secret image. Literature [2] points out that because the secret image data only changes locally, and this change is not easily perceived by human vision, and does not affect the visual effect and use value of the original image, it is difficult for illegal users to judge whether secret information exists from public information, thus reducing the possibility of secret information being attacked. Literature [3] points out that in order to improve the security of the system, encryption technology can be combined with information hiding technology, that is, secret information is encrypted by encryption technology first, and then hidden into the carrier image. Literature [4] points out that for further security, three-dimensional image can also be used as the encrypted image, which will play a role. Better concealment effect, because the three-dimensional image data often have strong randomness and disorder, making encryption and decryption more difficult. Based on this idea, this paper uses three-dimensional chaotic mapping to encrypt and scramble useful information, and then uses fast Fourier transform (FFT) to hide hidden information into three-dimensional images. The simulation results show that the method has good security and application value.

2. Dynamic state equation of three-dimensional chaotic system

In HSV space, the digital image is expressed by H, S and V channels. In order to enhance the security of encryption methods and the subsequent image encryption process, the dynamic state equation of three-dimensional chaotic system is selected. Qi mapping is referred to in document [5]:

$$\left.\begin{aligned} \dot{x} &= \alpha(y-x)+yz, \\ \dot{y} &= \beta x + y - xz, \\ \dot{z} &= xy - \gamma z, \end{aligned}\right\} \tag{1}$$

Among them, α,β,γ is the control parameter of the chaotic system, and there are five equilibrium points in the whole Qi map. This paper chooses the chaotic state of $\alpha = 40, \beta = 2.765, \gamma = 84$. Setting up the matrix needed for the subsequent operation of image hiding from three dimensions, there are:

  DOI: 10.25236/icscbd.2018.008

$$\left.\begin{aligned} H &= [1024 \times \frac{x_i}{x_{\max} - x_{\min}}] \quad \bmod \quad 512, \\ S &= [1024 \times \frac{y_i}{y_{\max} - y_{\min}}] \quad \bmod \quad 512, \\ V &= [1024 \times \frac{z_i}{z_{\max} - z_{\min}}] \quad \bmod \quad 512, \end{aligned}\right\} \tag{2}$$

Among them: H, S and V represent the results of data processing in the three dimensions of x, y and z of Q_i chaotic system; mod represents the operation of modulus extraction; x_i, y_i and z_i represent the first data in the three dimensions; x_{max}, y_{max} and z_{max} represent the maximum values in the x, y and z dimensions of intercepted chaotic sequence; x_{min}, y_{min} and z_{min} represent the x, z dimensions of intercepted chaotic sequence, respectively. The minimum value in the y, z dimension.

According to the method of formula (2), the data sequence with the same number of pixels to be processed is intercepted from the chaotic sequence and mapped into a matrix. Assuming that the width and height of the processed image are expressed by W*H, the mathematical formula of the matrix is mapped from the data sequence to the matrix.

$$\left.\begin{aligned} H_{W \times H} &= H_n, \\ S_{W \times H} &= S_n, \\ V_{W \times H} &= V_n, \end{aligned}\right\} \tag{3}$$

Among them: H_{W*H}, S_{W*H}, V_{W*H} represent the result of mapping H_n, S_n and V_n into matrices respectively, that is, the result of arranging them in rows and columns. Hn represents the data sequence with the same total number of pixels of the original image intercepted from the X dimension of Q_i map. In this paper, the 1024 data of the chaotic sequence is intercepted, because the size of the image to be processed is 512px×512px. The total length intercepted on X dimension is 1024+512*512 when x*512px is used. S_n and V_n, which are the same on the other two dimensions, represent the same data sequence of the total number of original image pixels intercepted from the two dimensions of Q_i mapping y and Z respectively.

3. two-dimensional fast fourier transform

Two-dimensional fast Fourier transform is used to hide image information from chaotic scrambling information. Fast Fourier Transform (FFT) can greatly reduce the number of multiplications required by computer to calculate discrete Fourier Transform (DFT). Especially, the more the number of sampling points N is transformed, the more significant the computation cost of FFT algorithm is saved.

In reference [6], the formula of two-dimensional discrete Fourier positive transformation is as follows:

$$F(u,v) = \sum_{x=0}^{N-1}\sum_{y=0}^{N-1} f(x,y) \cdot e^{[-j\frac{2\pi}{N}(ux+vy)]} \qquad u,v = 0,1,\cdots N-1 \tag{4}$$

The formula of two-dimensional inverse discrete Fourier transform is as follows:

$$F(x,y) = \frac{1}{N^2}\sum_{u=0}^{N-1}\sum_{v=0}^{N-1} f(u,v) \cdot e^{[j\frac{2\pi}{N}(ux+vy)]} \qquad x,y = 0,1,\cdots N-1 \tag{5}$$

4. Stealth Processing of Secret Image

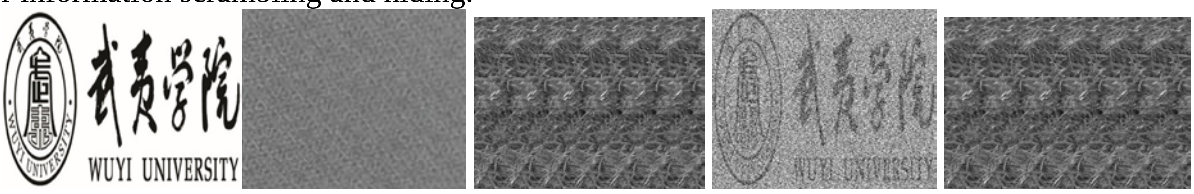
It has irreplaceable advantages to use three-dimensional stereo image to process the encrypted information. Three-dimensional stereo image is a kind of description of three-dimensional objects through the principle of interlaced depth perception of binocular vision. Although the images look disorderly and disorderly, they are actually orderly. When binocular vision is observed with parallel or dispersed lines of sight, it will produce a three-dimensional stereo effect with a certain depth of field. Figure 3 is a three-dimensional illustration of two small animals. Secret image information is encrypted and scrambled by using three-dimensional chaotic map to further improve the security of information. Even if the pre-processed secret image information is detected, the decoder can not obtain the secret image. The corresponding pre-processed encryption algorithm steps are as follows:

Step 1: Enter the image needed to be encrypted with WXH size. image 1(a) is the calibration of Wuyi College.

Step 2: Using the three-dimensional chaotic mapping formula (1), (2), (4), the image information is scrambled and the chaotic sequence image is obtained, as shown in image 1(b).

Step 3: Using two-dimensional fast Fourier transform formula (4), (5), the scrambled secret information is put into the 3D stereo image 1(c), and the 3D stereo image is obtained as shown in image 1(e).

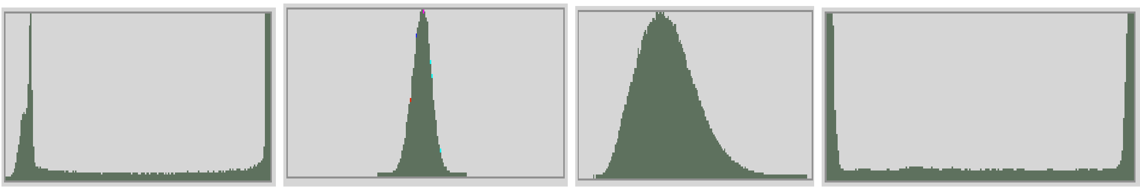
The extraction process of hidden image is the inverse process of the above steps. It needs to know the encrypted key to decrypt correctly. image 1(d) is to extract the secret image information after adding strong interference to the hidden image. Although there is still noise, the information of the original image can still be seen. Figure 2 is a histogram of three-dimensional image before and after information scrambling and hiding.



(a) (b) (c) (d) (e)

(a) Waiting for secret information. (b) Secret information after scrambling. (c) Three dimensional image. (d) Information extraction after salt and pepper interference. (e) Three-dimensional image after embedding secret information

Figure 1. Scrambling and hiding of 3-D image information.



(a) (b) (c) (d)

(a) Histogram of information to be hidden. (b) The histogram of secret information after scrambling. (c) Three-dimensional stereo image histogram. (d) Extraction of information histogram after salt and pepper interference.

Figure 2. 3-D image information scrambling and hiding before and after histogram.

5. Analysis of experimental results

In order to further measure the effect of image hiding, we use peak signal-to-noise ratio (PSNR) and root mean square error (RMSE) to measure the objective fidelity between carrier image and mixed image. Peak signal-to-noise ratio (PSNR) is used as the objective fidelity criterion of image. The larger its value, the better the fidelity of mixed image is. The smaller the root mean square error is, the more similar the two images are. Table 1 lists the comparison between the hidden image and the processed image, the comparison between the carrier image and the mixed image, the comparison between the error key recovery image and the hidden image, and the comparison between the correct key recovery image and the hidden image.

Table 1. Analysis of experimental results.

Serial number	Compare	PSNR	RMSE
1	Figure 1(a) and figure 1(b)	24.936 845	12.596 365
2	Figure 1(b) and figure 1(c)	28.236 897	15.878 912
3	Figure 1(c) and figure 1(e)	51.546 258	0.614 547
4	Figure 1(a) and figure 1(d)	40.254 154	0.309 601

The experimental results in Table 1 show that the RMSE of the carrier image is smaller than that of the mixed image, and the PSNR is larger than 30 (when PSNR > 30, the human eye can not distinguish), which shows that the hiding effect of the image is very good; the correct key recovery image and the decrypted image are subjected to strong interference (salt, pepper, mean filtering, clipping, median filtering, etc.) For example, although the extracted secret information is mixed with noise and has less distortion, it still has a great similarity, which shows that the algorithm can restore the hidden image tenaciously and has good robustness.

6. Conclusion

This algorithm makes full use of the texture characteristics and imperceptibility of the three-dimensional image, encrypts a common image information by three-dimensional chaotic scrambling, and then uses two-dimensional discrete Fourier transform to insert the encrypted information into the three-dimensional image. Without changing the original visibility of the image, it obtains a better hidden image. Tibetan effect. The experimental results show that it can effectively resist external destructive attacks and has good security. The image extracted after the attack is still clear and visible, which shows that it has strong anti-attack ability and has certain application value.

Acknowledgments

This work was financially supported by The Key Laboratory of Cognitive computing and intelligent information processing of Fujian Education Innovation, Fujian Provincial Higher Education Innovation and Entrepreneurship Education Reform Project(sjzy2017002), Fujian Provincial University "Curriculum Thought" Education and Teaching Reform Project(KC18087), Fujian Provincial Natural Science Foundation Project(2017J01406).

References

[1] Zeng Xianting,Ping Lingdi,Li Zhuo. Lossless data hiding Scheme using adjacent pixel difference encephalased on scanpath .Journal of Multimedia,145(2015) 145-152.

[2] Venkat Narayana Rao T, Govardhan Dr A. Syed Jahangir Badashah.Improved lossless embedding and extraction a data hiding mechanism.International Journal of Computer Science and Information Technology 134(2016) 75-86.

[3] Lin C, Tai W L, Chang C. Multilevel reversible data hiding Based on histogram modification of difference images. PatternRecognition, 241 (2008) 3582-3591.

[4] Zou J C, WardR, Qi D X. A novel digital image scrambling Method based on Fibonacci sequence. IEEE International Symposium on Circuits and Systems. Vancouver: IEEE, 214(2013) 965- 968.

[5] Ding W, Yan W Q, Qi D X. Digital image scrambling. ProGress in Natural Science, 116 (2001) 456-460.

[6] ZHANG J S, TIAN L, TAI H M.A. new watermarking Method based on chaotic maps. IEEE International Conference on Multimedia and Expo, Taipei Taiwan, 39(2014) 345-348.