A Novel Color Image Encryption Scheme Based on Cellular Neural Network and Chen's Chaotic System

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Abstract

With the explosive development of communication technology, digital images are more widely stored and transmitted on the network as a medium of communication among people. At the same time, the security of the digital image has become the focus of people's attention, and it is also the hotspot and difficulty of current research. Therefore, a novel color image encryption scheme is proposed in this paper by combining the 6-dimensional cellular neural network (CNN) and Chen's hyperchaotic system. In the proposed scheme, the initial keys and switching function generated by the plaintext image are utilized to control the CNN to complete the scrambling operation. Then, using the Chen's hyperchaotic system to diffuse the scrambled image for realizing higher security. Finally, the simulation tests and security performance analyses on the proposed encryption scheme are carried out. Experimental results demonstrate that the proposed scheme has an excellent encryption effect compared with other advanced image cryptography systems.

Full Text

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Figures

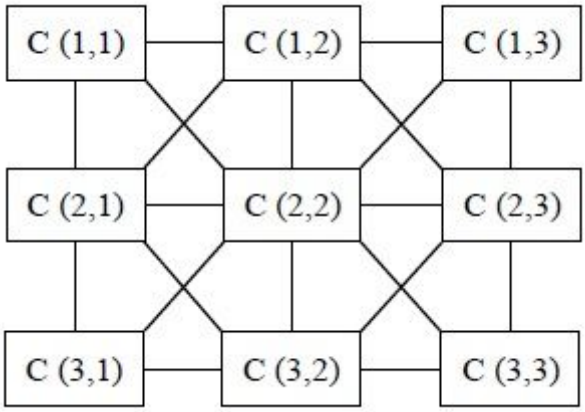

Figure 1

Cellular neural network structure of 3×3

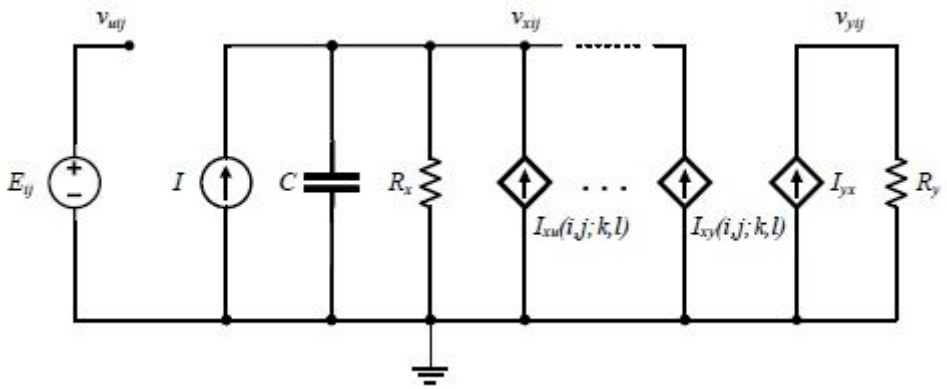

Figure 2

Equivalent circuit diagram of each cell

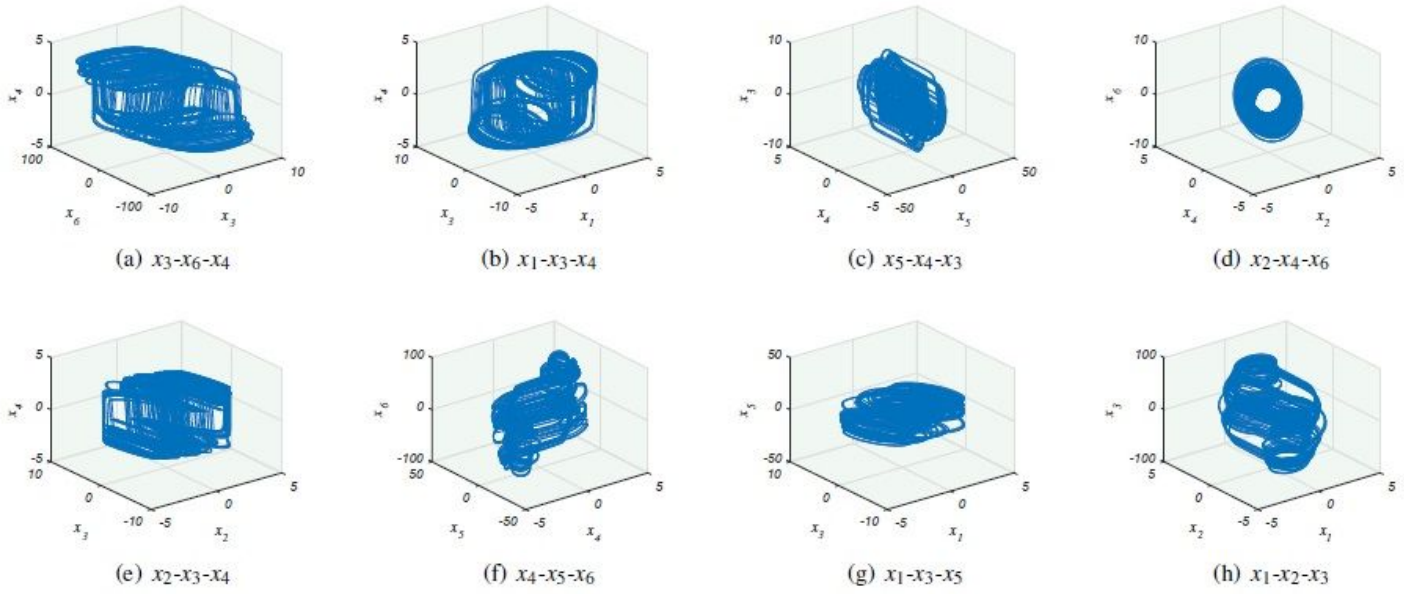

Figure 3

Partial 6th-order CNN chaotic attractor distribution: (a) Distribution in the direction of x3-x6-x4; (b) Distribution in the direction of x1-x3-x4; (c) Distribution in the direction of x5-x4-x3; (d) Distribution in the direction of x2-x4-x6; (e) Distribution in the direction of x2-x3-x4; (f) Distribution in the direction of x4-x5-x6; (g) Distribution in the direction of x1-x3-x5; (h) Distribution in the direction of x1-x2-x3.

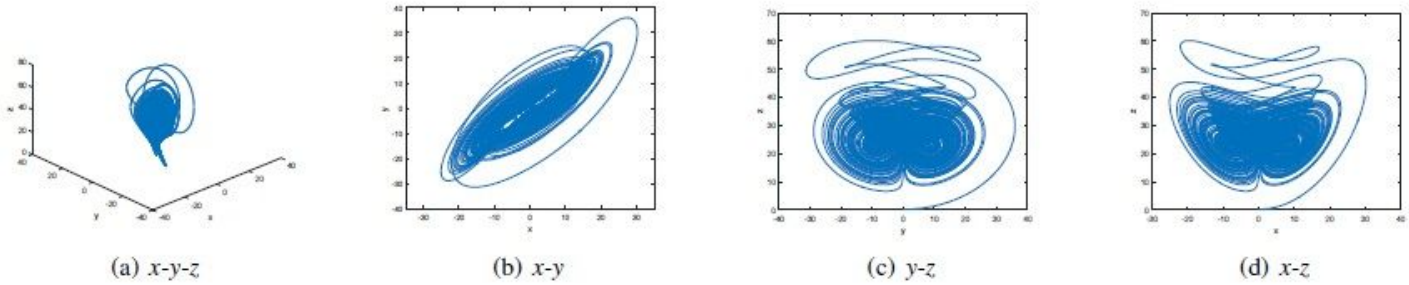

Figure 4

Chaotic attractor of the Chen's system: (a) Distribution in the direction of x-y-z; (b) Plane graph of x-y; (c) Plane graph of y-z; (d) Plane graph of x-z.

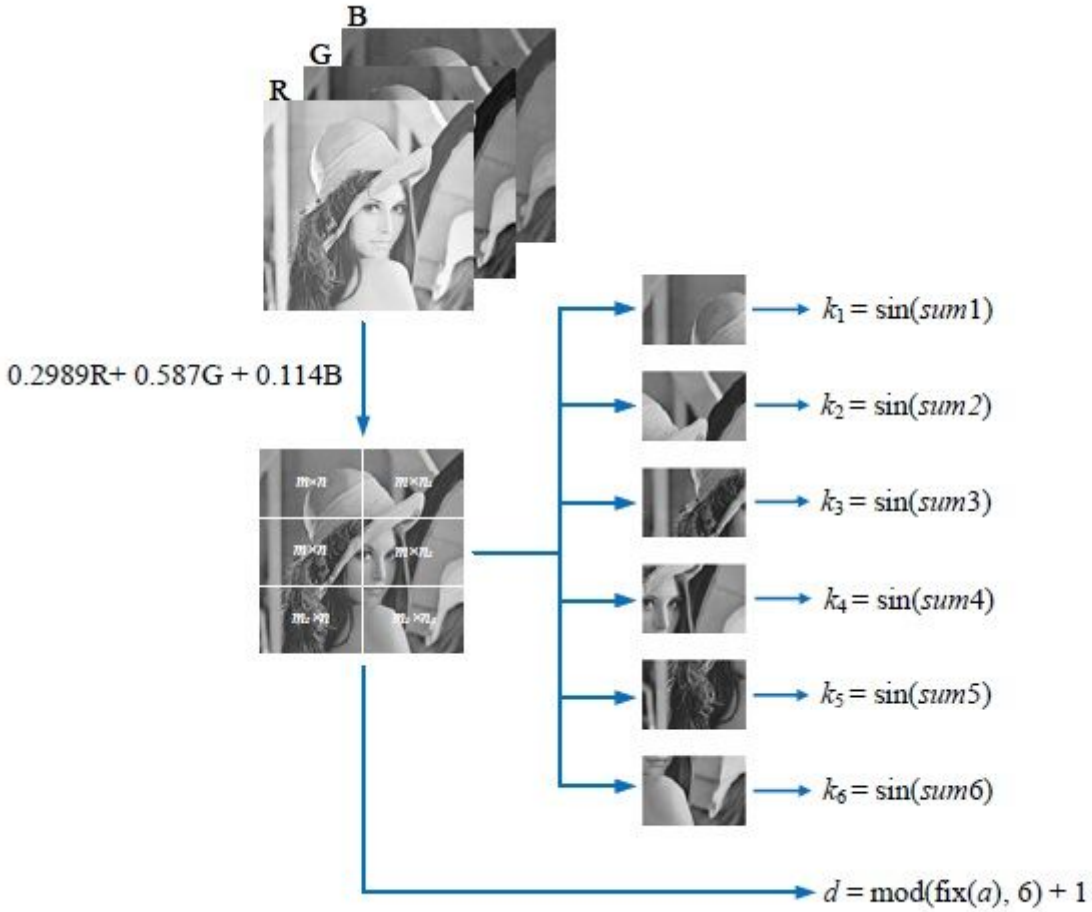

Figure 5

Initial key generation.

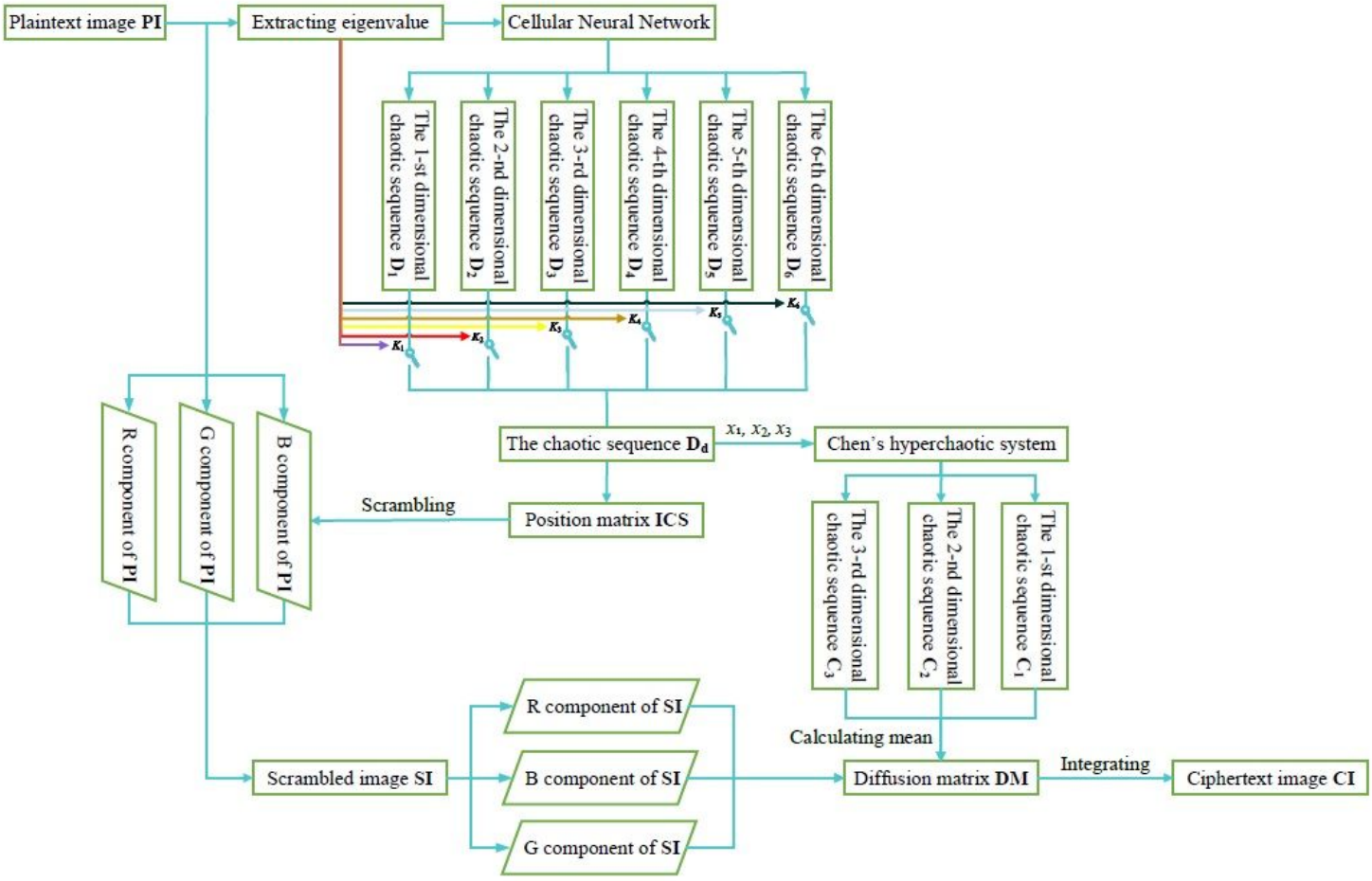

Figure 6

Flow chart of encryption scheme.

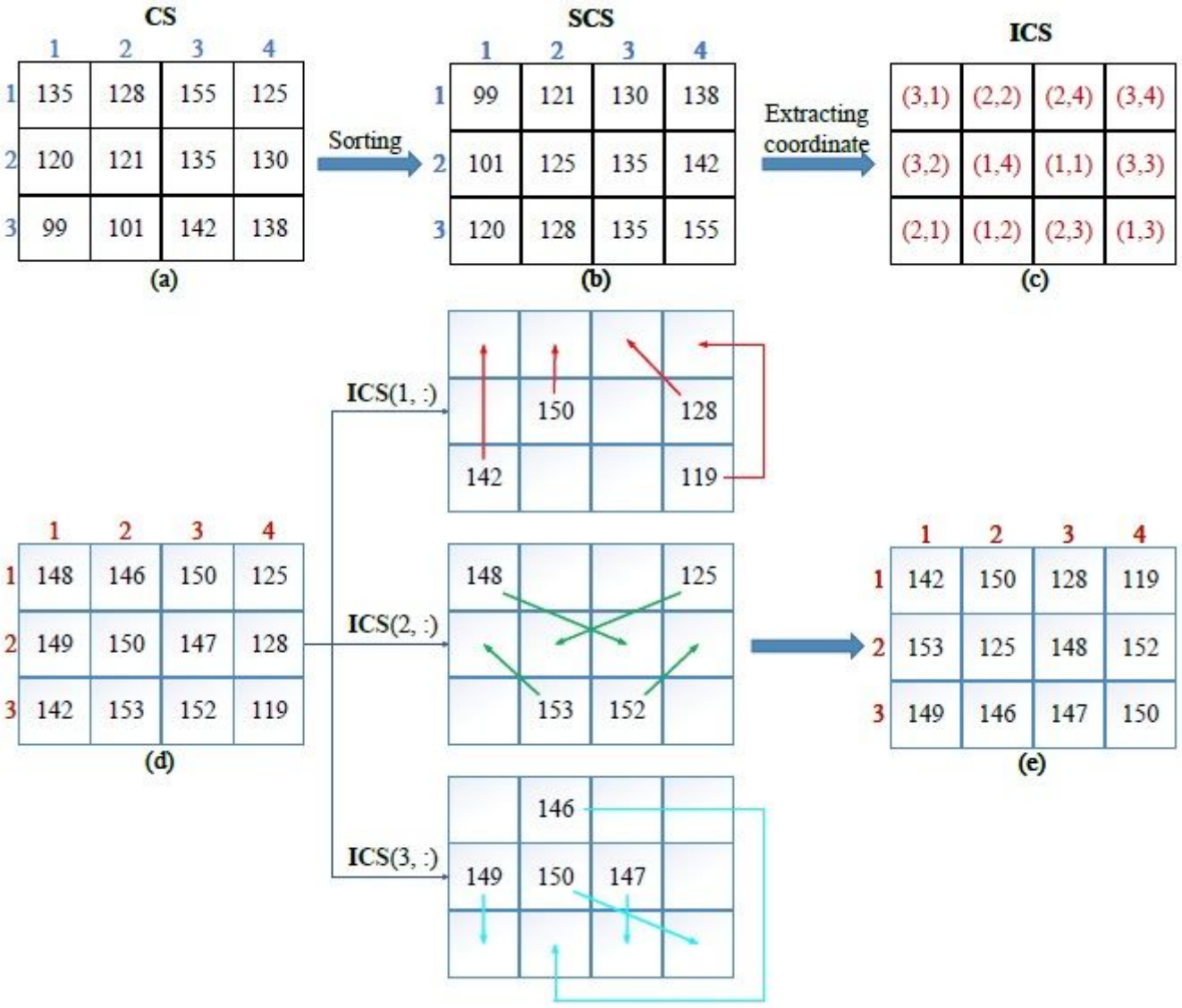

Figure 7

An example of a scrambling algorithm: (a) The 2D chaotic matrix; (b) The sorted chaotic matrix; (c) The position matrix; (d) The plaintext matrix; (d) The scrambled plaintext matrix.

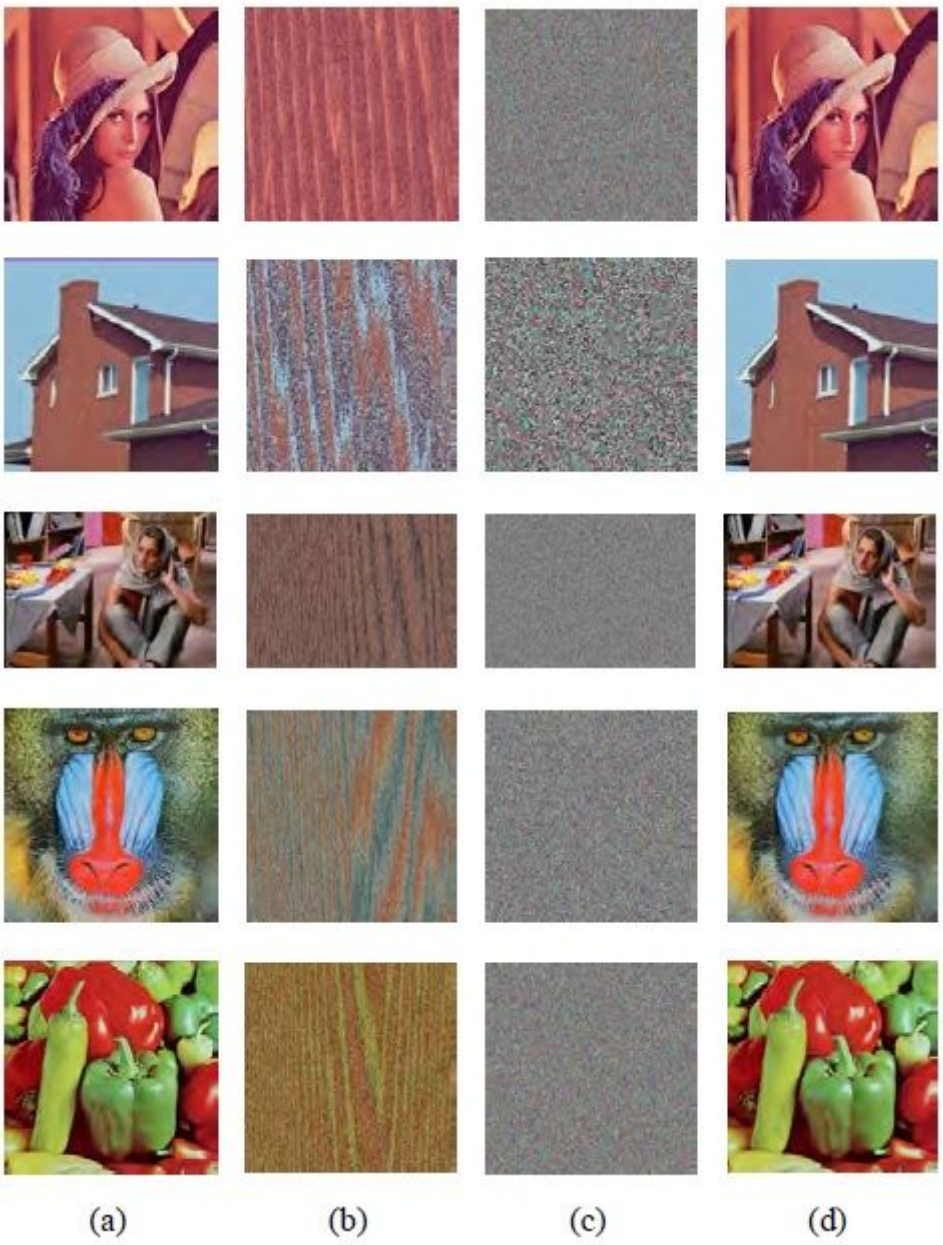

Figure 8

The experimental results of encryption and decryption algorithm: (a) The original plaintext image; (b) The scrambled image; (c) The encrypted ciphertext image; (d) The decrypted image.

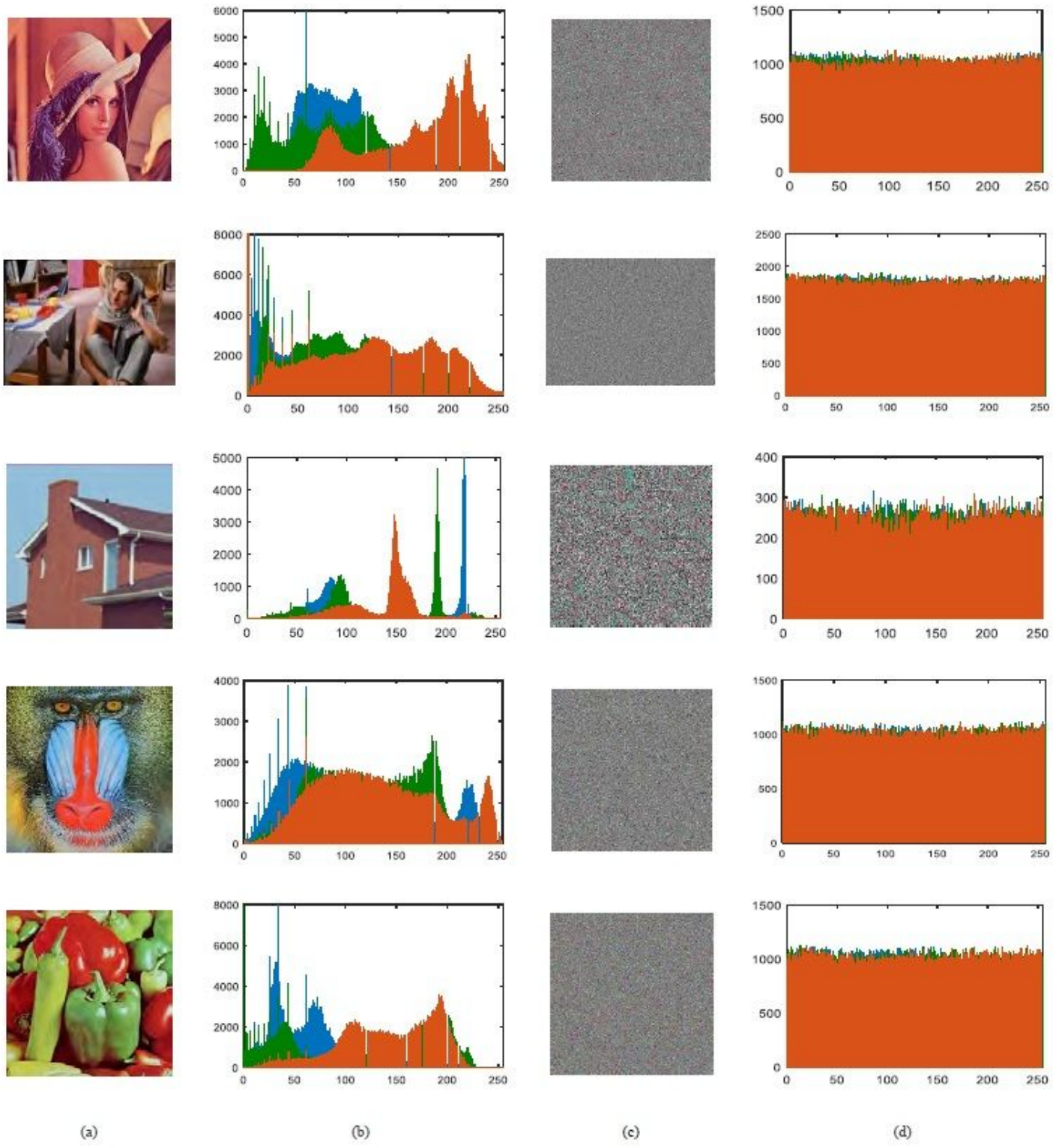

Figure 9

Histogram analysis: (a) The original plaintext image; (b) Histogram of the RGB component of the original plaintext image; (c) The encrypted ciphertext image; (d) Histogram of the RGB component of encrypted ciphertext image.

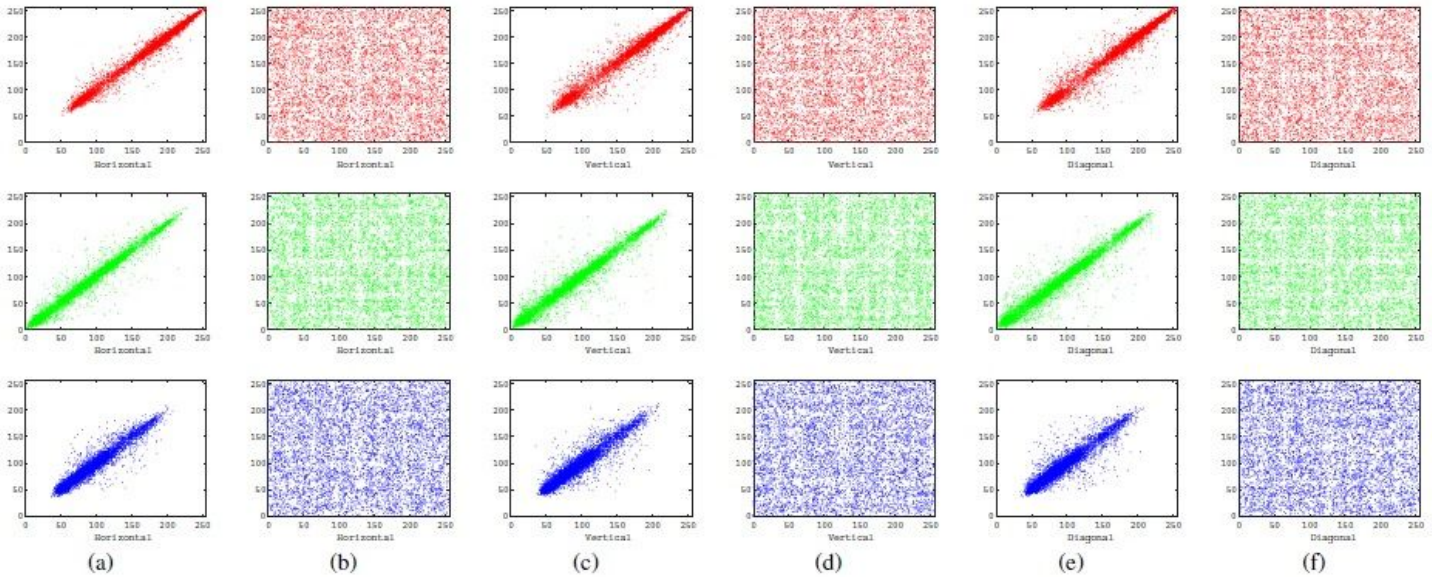

Figure 10

Distribution of horizontal, vertical and diagonal pixel in plaintext image and ciphertext image: (a) Original plaintext image distribution of horizontal; (b) The encrypted ciphertext image distribution of horizontal; (c) Original plaintext image distribution of vertical; (d) The encrypted ciphertext image distribution of vertical; (e) Original plaintext image distribution of diagonal; (f) The encrypted ciphertext image distribution of diagonal.

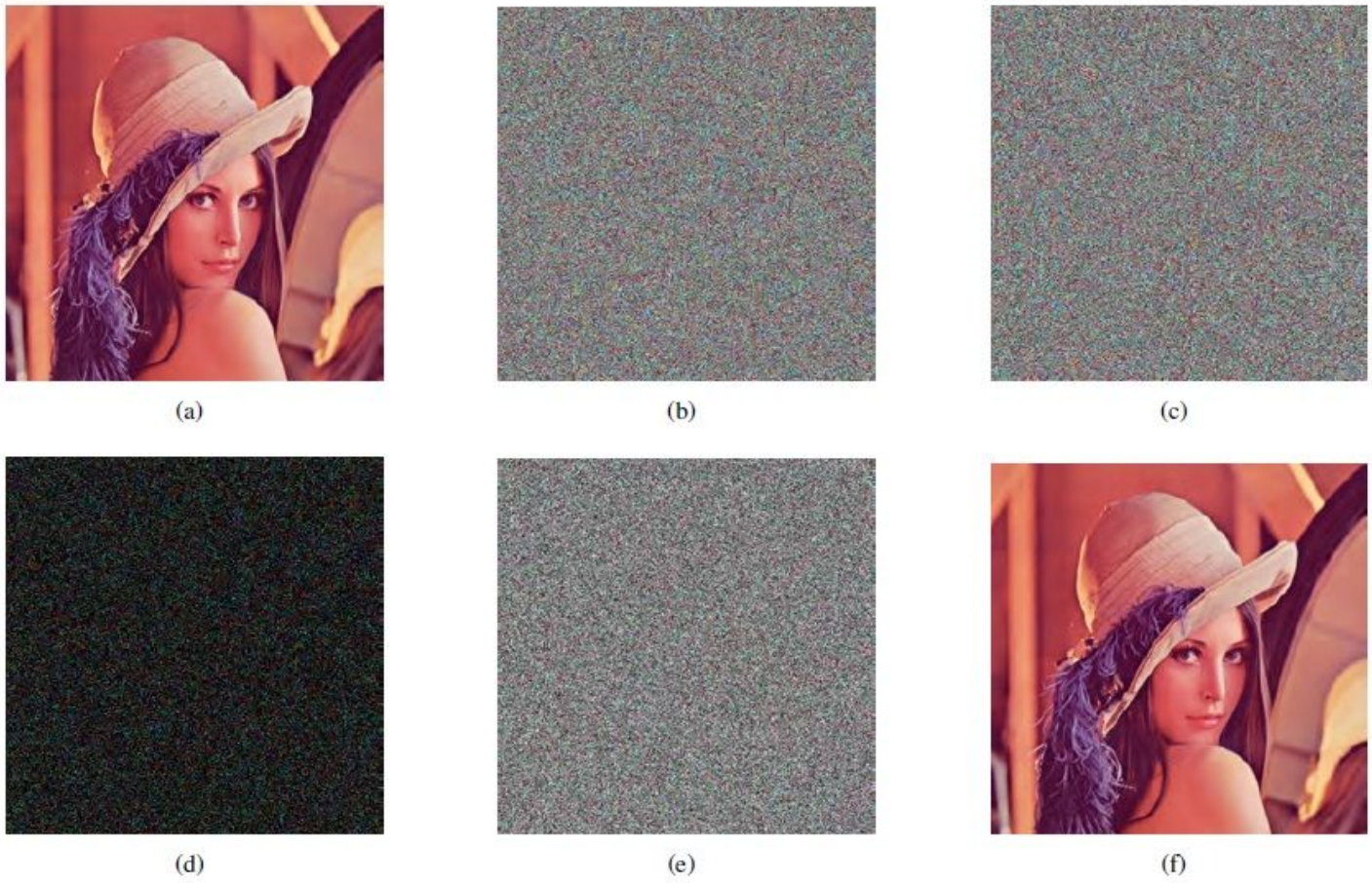

Figure 11

The test results of the key sensitivity analysis: (a) The plaintext image; (b) The correctly encrypted image; (c) The incorrectly encrypted image; (d) The difference between the two encrypted images; (e) The incorrectly decrypted image; (f) The correctly decrypted image.

Figure 12

Experimental results of adding noise: (a) Cipher House image with Pepper & Salt noise of 0.1; (b) Cipher House image with Pepper & Salt noise of 0.15; (c) Cipher House image with Pepper & Salt noise of 0.5; (d) Decrypted image from cipher with Pepper & Salt noise of 0.1; (e) Decrypted image from cipher with Pepper & Salt noise of 0.15; (f) Decrypted image from cipher with Pepper & Salt noise of 0.5; (g) Cipher House image with Gaussian white noise with mean value 0 and variance value 0.01; (h) Cipher House

image with Gaussian white noise with mean value 0 and variance value 0.1; (i) Cipher House image with Gaussian white noise with mean value 0 and variance value 0.01; (j) Decrypted image from cipher with Gaussian white noise with mean value 0 and variance value 0.01; (k) Decrypted image from cipher with Gaussian white noise with mean value 0 and variance value 0.1; (l) Decrypted image from cipher with Gaussian white noise with mean value 0 and variance value 0.15.

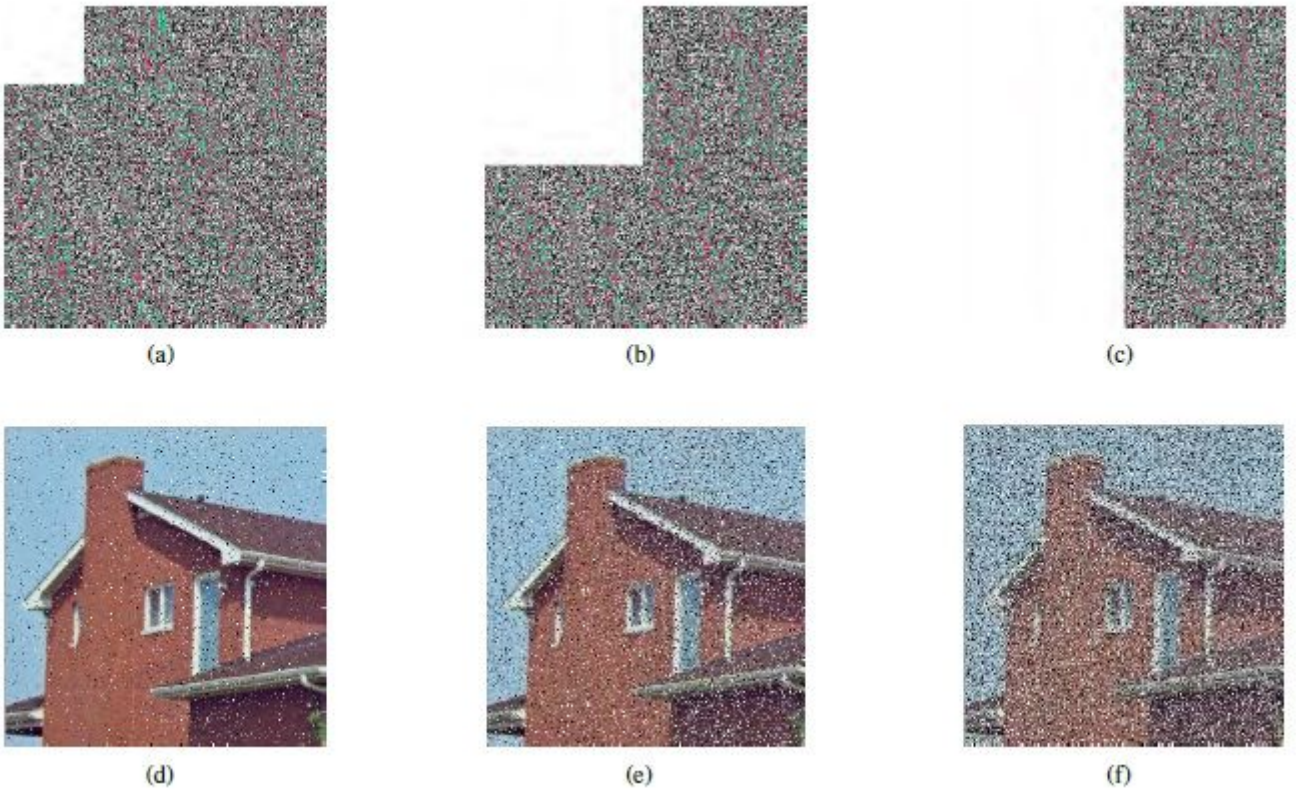

Figure 13

Experimental results of decryption from cropped cipher images: (a) Cipher image with 6.25% cropped; (b) Cipher image with 25% cropped; (c) Cipher image with 50% cropped; (d) Decrypted image from 6.25% cropped cipher; (e) Decrypted image from 25% cropped cipher; (f) Decrypted image from 50% cropped cipher.