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Image Encryption Scheme by Applying Heterogeneous Chaotic Neural Network: A Review Article

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Abstract

This paper introduces a new combined pseudorandom sequence generator based on neural network and chaos and a chaotic encryption algorithm based on DNA rules for safe transmission and storage of images. A new heterogeneous chaotic neural network generator that governs the operations of the encryption algorithm is used in the proposed scheme: pixel location permutation, DNA-based bit substitution and a new form of DNA-based bit permutation. By dynamically updating control parameters as well as the number of iterations of the chaotic functions in the neural network, the randomness of the generated chaotic sequence is improved. Many experiments are conducted to demonstrate a high degree of randomness of the proposed chaotic generator, including auto correlation, 0/1 balance and NIST tests. To demonstrate the safety and efficiency of the proposed chaos-based genetic encryption process, experimental results such as pixel correlation coefficients, entropy, NPCR and UACI, etc., as well as security analyses are provided.

Keywords: *Data protection, DNA, Encryption, Image, Media, Safety, Compression..*

I. INTRODUCTION

Media such as images are widely stored and exchanged over the Internet due to the advances in networking and multimedia coding technology. This makes them susceptible to malicious use. In order to ensure confidentiality and avoid unauthorized access to digital information, image protection and encryption have therefore become a highly researched field. Traditional symmetric cyphers are constructed with strong confusion and diffusion properties, such as the Advanced Encryption Standard (AES)[1].

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Figure 1: Illustrates the real and encrypted images [2]

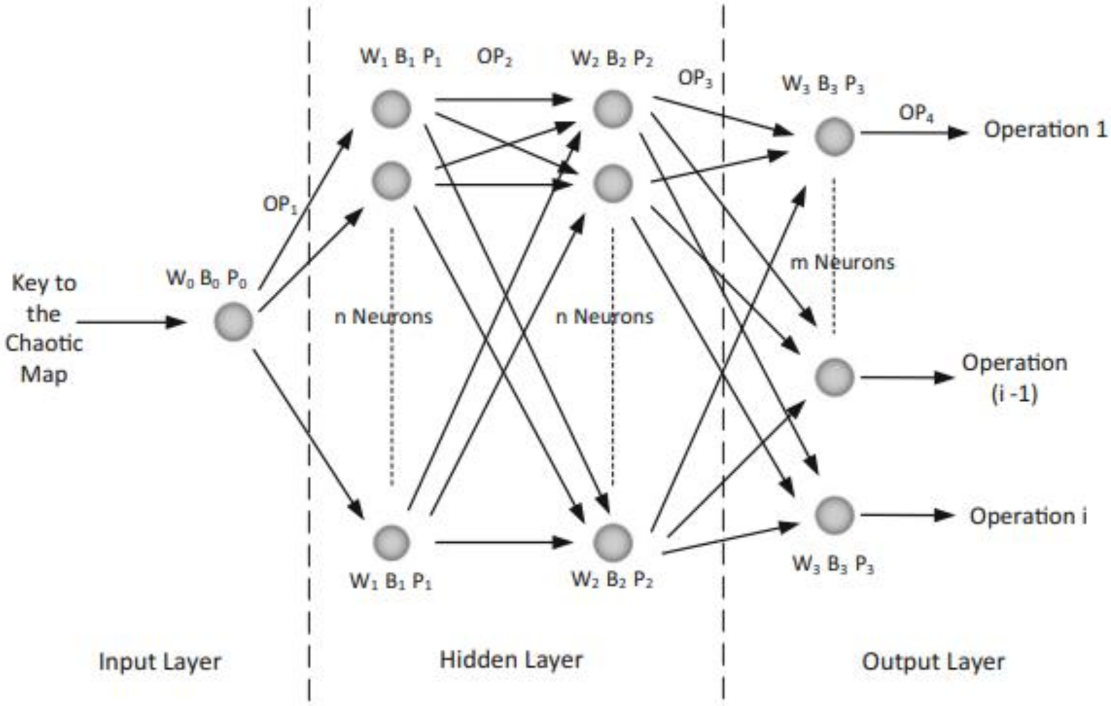

Figure 2: Illustrates the neural network generator architecture [3]

$$MSE = \frac{\sum_{i=1}^{H}\sum_{j=1}^{W}[P(i,j) - E(i,j)]^2}{W \times H}$$

$$MAE = \frac{1}{W \times H}\sum_{i=1}^{H}\sum_{j=1}^{W}|p(i,j) - E(i,j)|$$

$$E(x) = \frac{1}{N}\sum_{i=1}^{N} x_i$$

$$D(x) = \frac{1}{N}\sum_{i=1}^{N}(x_i - E(x))^2$$

$$cov\,(x,y) = \frac{1}{N}\sum_{i=1}^{N}(x_i - E(x))\,(y_i - E(y))$$

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$$r_{xy} = \frac{cov\,(x,y)}{\sqrt{D(x)}\sqrt{D(y)}}$$

$$\sqrt{D(x)} \neq 0, \sqrt{D(y)} \neq 0$$

$$NPCR = \frac{1}{M \times N} \sum_{i=1}^{M} \sum_{j=1}^{N} D(i,j) \times 100\,\%$$

$$UACI = \left[\sum_{i=1}^{M} \sum_{j=1}^{N} \frac{|C1(i,j) - C2(i,j)|}{255} \right] \times \frac{100\%}{M \times N}$$

$$D(y) = \frac{1}{K} \sum_{i=1}^{K} (y_i - E(y))^2$$

The correlation coefficient is another essential constraint to ensure that how much efficient is the encryption algorithm [4].

$$r_{x,y} = \frac{C(x,y)}{\sqrt{D(x)}.\sqrt{D(y)}}$$

Where $C(x,y)$, $D(x)$ and $D(y)$ can be evaluated by using the following equations [5].

$$C(x,y) = \frac{\sum_{i=1}^{K}(x_i - E(x))(y_i - E(y))}{K}$$

$$D(x) = \frac{1}{K} \sum_{i=1}^{K} (x_i - E(x))^2$$

II. LITERATURE REVIEW

Bhattacharyya et al. explored another paper on the topic of a survey of steganography and steganalysis technique in image, text, audio and video as cover carrier. The steady growth in communication technologies and the use of public domain (i.e. the Internet) networks has greatly facilitated data transmission. Such open communication networks, however, have a greater susceptibility to security threats that cause unauthorized access to information. Encryption is traditionally used to understand the confidentiality of communication. This paper provides a critical overview of steganography and analyses the features of different cover media, namely image, text, audio and video, in relation to the fundamental concepts, the advancement of steganographic methods and the creation of the corresponding steganalysis schemes [6].

III. DISCUSSION AND CONCLUSION

A heterogeneous chaotic generator, implemented using neural networks, is suggested in this paper. In the neural network layers, the heterogeneity of the generator is obtained by alternating two separate chaotic maps, Logistic and PWLCM. As shown in the test results, including autocorrelation, cross-correlation, 0/1 equilibrium and NIST tests, the proposed generator is highly random and has strong chaotic properties. Compared to similar works in pseudo-random generators, the 0/1 balance was compared and it was found that our proposed generator gap between the 50-50 0s and 1s distribution was on average 0.004 while similar works achieved at best 0.01. Therefore, on a 0/1 balance, our proposed generator is nearly 10 orders stronger. The NIST was conducted on 100 sequences, and 99.2 passed the exam on an average of 100 sequences, with the lowest being 96. In addition, several chaotic sequences can be generated simultaneously using our proposed generator by varying the number of neurons in the output layer, which allows a number of cryptographic operations with a minimum number of neural network cycles to be performed.

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