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*International Journal of Current Research*
*Vol. 9, Issue, 07, pp.54486-54492, July, 2017*

**INTERNATIONAL JOURNAL OF CURRENT RESEARCH**

**ISSN: 0975-833X**

## REVIEW ARTICLE

# A REVIEW OF EFFICIENT IMAGE ENCRYPTION BASED ON JOINED ALGORITHM

***,[1]Fori Emmanuel, [2]Harrison O. Idakwo and [1]Silas Stephen Neji**

[1]Ruby Springfield College, P O Box 2205, Maiduguri, Borno State
[2]Department of Engineering, Teaching Hospital, University of Maiduguri

**ARTICLE INFO**

*Article History:*
Received 10th April, 2017
Received in revised form
11th May, 2017
Accepted 16th June, 2017
Published online 31st July, 2017

*Key words:*
Cryptography,
Plaintext, Cipher text,
Symmetric, Asymmetric.

**ABSTRACT**

As the use of digital techniques for transmitting and storing images are increasing, it becomes very important issue that how to protect the confidentiality, integrity and authenticity of images over the open network is not toiled with. There are various techniques which are discovered from time to time to encrypt and decrypt images to make them more secure during transmission. This paper reviewed 28 research papers dealing with wide-range of image encryption and decryption techniques that are combined to give a better algorithm. Those encryption techniques are studied and analysed to promote the performance of the encryption methods. Everyday new techniques are evolving hence fast and secure conventional encryption techniques work with high security rate. Each of the new techniques is unique in its own way and this makes it suitable for many applications. The results of the simulations showed that every algorithm has advantages and disadvantages. But the combined techniques are generally faster and the security level is high. Therefore, it is recommended that more complex algorithm should be used to provide high speed and security in cryptosystem and modified versions of various algorithms should also be used to increase the security level.

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**Citation: Fori Emmanuel, Harrison O. Idakwo and Silas Stephen Neji. 2017.** "A review of efficient image encryption based on joined algorithm", *International Journal of Current Research*, 9, (07), 54486-54492.

## INTRODUCTION

It is obvious that individuals nowadays prefer using the internet as the primary medium to transfer data from one end to another (AmbikaOad, 2014). As more and more sensitive information is stored on computers and transmitted over the Internet, we need to ensure information security and safety. Image is also an important part of our information .Therefore it's very important to protect our image from unauthorized access (Komal, 2011). Encryption is well known for such privacy protection. Encryption is the process of transforming information (plaintext) using an algorithm (cipher text) to produce an unreadable data to anyone except those possessing special knowledge, usually referred to as a key. The reverse process of transforming cipher text to plain text is called as decryption. The technique used in encrypting and decrypting is called cryptography. The Key is a numeric or alpha numeric text or may be a special symbol. The Key is used at the time of encryption and at the time of decryption. Therefore, the selection of key in Cryptography is very important since the security of encryption algorithm depends directly on it.

****Corresponding author: Fori Emmanuel***
Ruby Springfield College, P O Box 2205, Maiduguri, Borno S

Cryptography is of three types. They are:

- Secret Key Cryptography (Symmetric): uses a single key for both encryption and decryption.
- Public Key Cryptography (asymmetric): uses two keys, one for encryption and the other for decryption.
- Hash Functions (one way cryptography): have no key since the plain text is not recoverable from the ciphertext.

Image encryption is a technique that convert original image to another form that is difficult to understand. For securely transmission of image content the sender encrypts the image before transmit it to other person. No one can access the content without knowing a decryption key. Image encryption has applications in corporate world, health care, military operations, and multimedia systems (AmbikaOad, 2014). The security of image can be achieved by various types of encryption schemes. There are so many algorithms available to protect image from unauthorized access. In recent years, many image cryptosystems are proposed. Encryption of digital image processing has become more important for Internet data transportation and many methods can be applied for the processing. Everyday new encryption technique is evolving hence fast and secure conventional encryption techniques will always work out with high rate of security (RinkiPakshwar, 2013). And every algorithm has advantages and disadvantages

based on their techniques which are applied on images (AmbikaOad, 2014).

## Literature Review

### An Approach to Image Encryption and Decryption using DFF Transform with Chaos

Rajiv Srivastava, BhartiAhuja, and Rashmi Singh Lodhi (Rajiv Srivastava, 2014), proposed a new technique to encrypt and decrypt the image using discrete fractional Fourier transform and chaos. To encrypt a digital image, an algorithm of two-dimensional DFrFT was used. It was divided into two one dimensional discrete fractional Fourier transforms, then use the periodicity of DFrFT; a continuous use of the appropriate order of DFrFT was maintained to decrypt the encrypted image. In fact, it is a direct result of the property of periodicity of DFrFT. The encryption and decryption steps are as follows:

- Logistic map is applied on original image F and the resulted transformed image is F1.
- Each row vector of the image F1 is transformed by one-dimensional DFrFT, with the transform fractional order being α and the resulted transformed image F2.
- Each column vector of F2 is transformed by another one-dimensional DFrFT, with the transform fractional order being β and the resulted transformed image F3. F3 is regarded as the encrypted image and α, β are taken as the cipher keys.
- Each row vector of F3 is transformed by one dimensional DFrFT, using the transform fractional order α' = (-α) and the transformed image is F2'.
- Each column vector of F2' is transformed by one dimensional DFrFT, using the transform fractional order β' = (-β) and the transformed image is F1'.
- Remove the logistic map from the transformed image F1' and the resulted transformed image is F '. F ' is the decrypted image.

Because chaos function has extreme sensitivity to the initial conditions, the effect of image encryption with DFrFT and chaos is better than in the case of DFrFT. Due to the reality of DFrFT and the confusion properties, the proposed cryptosystem is extremely secure and robust. The algorithm used with DFrFT is Eigen vector decomposition type. Encryption and decryption has been done successfully with almost zero process error and less time to complete the whole process. Various parameters have been analysed like MSE, sensitivity and key space etc.

### Digital Image Encryption Algorithm Based Composition of Two Chaotic Logistic Maps

Ismail Amr Ismail, Mohammed Amin, and HossamDiab (Ismail Amr Ismail, 2010), proposed chaos-based stream cipher, composing two chaotic logistic maps and external secret key for encryption of image. In this an external secret key of 104 bit and two chaotic logistic maps are used to differentiate between the encrypted image and the plain image. Further, the secret key is modified after encrypting of each pixel of the plain image which makes the encrypted image more robust. Then there is a feedback mechanism which increases the robustness of the proposed system (RinkiPakshwar, 2013).

### New algorithm for color image encryption using chaotic map and spatial bit level permutation

Ruiliu, Xiaoping tian (Ruiliu, 2012), proposed a new algorithm for color image encryption using chaotic map and spatial bit-level permutation (SBLP).Firstly, use Logistic chaotic sequence to shuffle the positions of image pixels, then transform it into a binary matrix and permute the matrix at bit-level by the scrambling mapping generated by SBLP. Then use another Logistic chaotic sequence to rearrange the position of the current image pixels. Experimental results show that the proposed algorithm can achieve good encryption result and low time complexity; this makes it suitable for securing video surveillance systems, multimedia applications and real-time applications such as mobile phone services.

### An Image Encryption Algorithm based on Scrambling and Substitution using Hybrid Chaotic Systems

Xiang FeiGuo Xiao-cong (Xiang FeiGuo Xiao-cong, 2011) introduced an image encryption algorithm based on two-dimensional (2D) Logistic map and complicated Chua's system. It uses different ways to scramble a colored image, to get a new encrypted image. And then use the chaotic sequence generated by optimization model of Chua's system to produce new pixel values. The results of the simulation and analysis showed that the new algorithm has good properties of confusion and diffusion, the key space is large and the algorithm is very sensitive to the initial values.

### Image Encryption using Chaotic Maps and DNA Addition Operation and Noise Effects on it

Kuldeep Singh and Komalpreet Kaur (Kuldeep Singh, 2011), compared four (Jiun-In Guo, 2000), chaotic maps in an algorithm. These include: Cross chaotic, Logistic, Ikeda and Henon map and noise effects. These were observed on an image. Firstly, they use the image encryption algorithm to convert original image to encrypted image. Then they apply noise on the encrypted image and then decrypt cipher image with noise back to original image. They have found out that cross chaotic map showed best results than other three chaotic maps.

### Image Encryption Based on the General Approach for Multiple Chaotic Systems

Qais H. Alsafasfeh and Aouda A. Arfoa (Qais, 2011), proposed new image encryption technique based on new chaotic system by adding two chaotic systems: the Lorenz chaotic system and the Rössler chaotic system. From Experimental analysis it shows that the image encryption algorithm has the advantage of large key space and high-level security, high obscure level and high speed.

### Digital image encryption algorithm based on chaos and improved DES

Zhang Yun-peng, Liu Wei, Cao Shui-ping, ZhaiZheng-jun, NieXuan and Dai Wei-di (Zhang Yun-peng, 2009), introduced the combination of image encryption algorithm like chaotic encryption, DES encryption etc. In their algorithm, for making the pseudo-random sequence, logistic chaos sequencer was used; it carries on the RGB with this sequence to the image chaotically, and makes double encryptions with improvement

DES. This algorithm had high security and the encryption speed (AmbikaOad, 2014).

**New Mirror-Like Image Encryption Algorithm and Its VLSI Architecture**

Jiun-In Guo and Jui-Cheng Yen (Jiun-In Guo, 2000), introduced an algorithm in form of a mirror with seven steps. At first, 1-D chaotic system is being verified and its initial point x (0) and sets k = 0. The chaotic system is then used to generate the chaotic sequence and the binary sequence. Image pixels are then rearranged using swap function according to the binary sequence during the remaining four stages.

**An Image Encryption Approach Using a Combination of Permutation Technique Followed by Encryption**

Mohammad AliBaniYounes and AmanJantan (Jiun-In Guo, 2011), introduced a new permutation technique based on the combination of image permutation and a well-known encryption algorithm called RijnDael. In the new technique, the original image was divided into 4 × 4 pixels blocks, which were rearranged into a permuted image using a permutation process, and then the generated image was encrypted using the RijnDael algorithm. The result showed that the correlation between image elements was significantly decreased by using the combination technique and higher entropy was achieved (RinkiPakshwar, 2013).

**A New Combined Symmetric Key Cryptography CRDDBT Using – Relative Displacement (RDC) and Dynamic Base Transformation (DBTC)**

NehalKandele, ShrikantTiwari [12] introduced a new technique of encryption without a predefined key. The input string is fragmented into several parts, with each part encrypted using a different algorithm. Three unique algorithms were used to encrypt the fragmented string on the basis of its orientation. For higher security levels, the key is derived from the two differently determined keys. The outstanding feature of this algorithm is that, a part of the string is manipulated using base conversion; second part of string is deformed by interchanging position and increasing number of repetitions.

**New Image Encryption Technique Based On Combination of Block Displacement and Block Cipher Technique**

KeertiKushwah, SiniShibu (KeertiKushwah, 2013), proposed a new image encryption algorithm. It is already known that security of an algorithm depended on the length of the key that mean the longer the key length, the better the security feature. The proposed algorithm uses 128 bits key length which is expected to provide good security for the proposed algorithm. To access original key or crypto analysis of the proposed key it will require 2128 time its length to break the key which is almost impossible for any hacker. There is no chance to generate floating point error because no such types of mathematical formula have applied on the proposed algorithm. The correlation co-efficient as well as their entropy values for the proposed algorithm was calculated (AmbikaOad, 2014).

**Image Encryption based on the RGB PIXEL Transposition and Shuffling**

Quist-AphetsiKeste (Quist-AphetsiKeste, 2013), proposed a technique of transposition and reshuffling of the RGB values of the image in steps has proved to be really effective in terms of the security analysis. The extra swapping of RGB values in the image file after RGB component shifting has increased the security of the image against all possible attacks available currently.

**Image Encryption Based on Bit-plane Decomposition and Random Scrambling**

Qiudong Sun, Wenying Yan, Jiangwei Huang, Wenxin Ma (Qiudong Sun, 2012), designed the random scrambling method that has more stable scrambling degree than the classical method Arnold transform. At first, they decomposed a grey image into several bit-plane images. Then we shuffled them by a random scrambling algorithm separately. Lastly, we merged the scrambled bit-plane images according to their original levels on bit-planes and gained an encrypted image. Due to each bit-plane image is scrambled by using different scrambling random sequences, the bits located at the same coordinates in different bit-planes will almost not stay on the original positions when each bit-plane is being scrambled separately. For each pixel, it's all bits of grey level; therefore, they may come from those pixels located at different positions. Consequently, the reconstructed grey levels of image are changed unavoidable. It is obvious that our method can do both positions exchange scrambling and grey level change scrambling at the same time (RinkiPakshwar, 2013).

**Technique for Image Encryption using multi-level and image dividing technique**

Chang-Mok Shin, Dong-HoanSeo, Kyu-Bo Chol, Ha Wmn Lee, and SmJmng Kim (Chang-Mok Shin, 2003), proposed an algorithm with multilevel form of image encryption using binary phase Exclusive OR operation and image dividing technique. The same grey level multi-level image is divided into binary images. Then binary picture is regenerated to binary phase encoding and then these images are encrypted with binary random phase images by binary phase XOR operation (Amitava Nag, 2011).

**Color Image Encryption Using Double Random Phase Encoding**

Shuqun Zhang and Mohammad A. (Shuqun Zhang and Mohammed A. Karim, 1999), proposed a new method to encrypt color image using existing optical encryption system for grey-scale image. The proposed single-channel color image encryption method is more compact and robust than the multichannel method. In this new method, the color image is converted to its indexed image format before it is encoded. In the encoding subsystem, image is encoded to stationary white noise with two random phase mask, one in the input plane and the other in the Fourier plane. At the decryption end, the color image is recovered by converting the decrypted indexed image back to its RGB (Red-Green- Blue) format.

**Image Encryption Using Affine Transform and XOR Operation**

Amitava Nag, JyotiPrakash Singh, Srabani Khan, SaswatiGhosh, SushantaBiswas, D. Sarkar and ParthaPratimSarkar (Amitava Nag 2011), proposed a two phase encryption and decryption algorithms that is based on shuffling the image pixels using affine transform and they

encrypted the resulting image using XOR operation. They redistribute the pixel values to different location using affine transform technique with four 8-bit keys. The transformed image then divided into 2 pixels x 2 pixels blocks and each block is encrypted using XOR operation by four 8-bit keys. The total key size used in algorithm is 64 bit. Their results proved that after the affine transform the correlation between pixel values was significantly decreased.

**Lossless Image Compression and Encryption Using SCAN**

S.S. Maniccam and N.G. Bourbakis (Maniccam, 2001), introduced a new algorithm which does two works: lossless compression and encryption of binary and grey-scale pictures. SCAN patterns are used for the compression and encryption schemes. The SCAN is a formal language-based 2D spatial-accessing methodology that generates a wide range of scanning paths or space filling curves (RinkiPakshwar, 2013).

**Image Encryption Using Differential Evolution Approach in Frequency Domain**

Ibrahim S I Abuhaiba and Maaly A S Hassan (Ibrahim, 2011), presented a new effective method for image encryption which employs magnitude and phase manipulation using Differential Evolution (DE) approach. They have carried out key space analysis, statistical analysis, and key sensitivity analysis to demonstrate the security of the new image encryption procedure.

**Hybrid image encryption using multi-chaos-system**

Nien et al. (Nien, 2009), used a hybrid encryption technique for the color image based on the multi-chaotic system. They merged the Pixel-Chaotic-Shuffle (PCS) and Bit-Chaotic-Rearrangement (BCR) methods. First, the PCS, a fast encryption method that can vary the positions of each pixel, is applied to fully eliminate the original image outlines using four third-order chaos's such as Henon, Lorenz, Chua and Rössler chaos maps. Second, the BCR, which uses chaos system to make chaotic codes rearrangement in pixels, are applied. The combination of the PCR and the BCR increases the key space of images to 10180 and completely eradicates the outlines of the encrypted images, blurs the distribution characteristics of RGB-level matrices, and effectively protects against the decryption of exhaustive attack when correlation coefficient is as little as 0.0031.

**Color image encryption based on orthogonal composite grating and double random phase encoding technique**

Y. He, Y. Cao, and X. Lu (He, 2012), introduced a single channel color image encryption technique. The technique is based on orthogonal composite grating and double random phase encoding. A color image first is decomposed into R, G and B components, which subsequently are modulated into an orthogonal composite grating. The deformed composite grating is then encrypted by a typical double random phase encryption technique. It is observed that combining the double random phase encoding and orthogonal composite grating reduces the complexity and cost of encryption. However, in the case of security, the technique falls short, evidence to this conclusion is the near 1 correlation value obtained.

**Color image encryption based on the affine transform and gyrator transform**

H. Chen, X. Du, Z. Liu, and C. Yang (Chen, 2013), proposed a color image encryption algorithm that uses the affine transform in the gyrator transform domains. Firstly, the affine transform is applied on the RGB components of the color image and the real and imaginary parts of their frequency component are extracted. Secondly, the R, G, B image pixel values are interchanged by scrambling using a random angle approach. Then, the resulting image is transformed using the gyrator transform and scrambled again by a second affine transform. Their experimental results showed that PSNR of 7.72dB was attained. This is an indication that high security is attainable.

**A new image cipher in time and frequency domains**

Abdel-Latif A. et al. (Abdel-Latif, 2012), proposed the combination of the linear feedback shift register (LFSR) and chaotic systems in hybrid domains. First, permutation is performed on the input image pixel positions based on 2D chaotic map in the frequency domain. Second, the resultant image is diffused by applying the cryptographic primitive operations combined with the LFSR and chaotic map. On the basis of the result reported in (Lahieb Mohammed Jawad and Ghazali Bin Sulong, 2013), their method can be said to be immune from brute force attacks. It was also observed that a large key space of 2256 was obtained. They also recorded the encryption time of 0.023s, which shows that their method is very fast and appropriate for real-time application. With the entropy value of 7.999, their method can be said to be robust to exhaustive attack and the possibility of threat is minimal.

**A Selective Encryption for Heterogeneous Color JPEG Images Based on VLC and AES Stream Cipher**

The selective encryption technique unlike the full encryption technique, encodes only significant regions in a given image. The main merit of the selective encryption technique is that it can provide equally, privacy and computational requirements without tradeoffs (He, 2012), The advantages of the selective encryption technique are basically in real-time applications, where confidentiality is important and huge amount of data comes into play. In real-time, an important question is usually how to minimize the computational requirements for secure multimedia. Addressing this concern from the partial encryption perspective is one of the fundamental solutions to computational complexity problem. The Partial image encryption techniques are derived from the process of separating information into perceptually sensitive and insensitive data based on perception. The fundamental requirement of a partial encryption scheme is that the encrypted regions must be independent of the unencrypted regions (Lahieb Mohammed Jawad and Ghazali Bin Sulong, 2013).

**Backwards Compatible, Multi-Level Region-of-Interest (ROI) Image Encryption Architecture with Biometric Authentication**

Wong A. and Bishop W. (Wong, 2007), proposed a multi-level ROI image encryption universal architecture, for biometric data. In their work, the multi-level ROI encryption and RC4 were used to encrypt an uncompressed raster image. The idea behind their method is that for an authorized viewer, only the

specified regions can be viewed. In essence, only an authorized person can view the contents of the encrypted image, though this is basically for the biometric system. At the initial step, multiple ROIs are selected for each image, which are then encrypted at three levels of authority using RC4 and fingerprint matching algorithms. We observed that their method can provide image information security, though the key space size (2128) is large, which shows that the method can be sensitive to small change in secret key (Lahieb Mohammed Jawad and Ghazali Bin Sulong, 2013).

**An authenticated image encryption scheme based on chaotic maps and memory cellular automata**

The method proposed by AtiehBakhshandeh and ZibaEslami (AtiehBakhshandeh and ZibaEslam, 2013), provided authentication and encryption to the image based on chaotic maps and linear memory cellular automata (LMCA). The cellular automata are discrete dynamical systems composed of an array of N identical objects called cells. Each cell can hold a state {0,1}.Each cell is updated synchronously according to a local transition function in discrete time steps. The updated state of each cell depends on the input of the function. The input is the previous state of a set of cells, including the cells that are called the neighbourhood (Prasenjit Kumar Das1, 2014).

**A New Image Encryption Approach using the Integration of a Shifting Technique and the AES Algorithm**

Ahmed .B.A., Abdulsamad B. H.B., HamidaA (Ahmed Bashir Abugharsa, 2012), proposed a new encryption technique based on the integration of shift image blocks and basic AES.Here the shifted algorithm is used to divide the image into blocks.Each block consists of number of pixels and these blocks are shuffled by using a shift method that's move the rows and columns of the original image in such a way to produce a shifted image. This shifted image is then used as an input image to the AES algorithm to encrypt the pixels of the shifted image. The main idea is that an image can be encrypted by shifting the rows and columns of original image and not to change the positions of the blocks but by shifting all the rows a number of times depending on the shift table, and then the same number of times for the columns for an arrangement of blocks (NitinRawal, 2013).

**An image Encryption approach using Chaos and Stream Cipher**

AlirezaJolfaei and AbdolrasoulMirghadri (AlirezaJolfaei and AbdolrasoulMirghadri, 2010), here, pixel shuffler and stream cipher unit are used to encrypt an image. Pixel scrambling has two important issues that are useful for image ciphering. It not only rearranges pixel location but also changes the value of each pixel. Confusion is performed by stream cipher itself through nonlinear function operation. Pixel location displacement is appropriate before applying encryption, because unlike the text data that has only two neighbours, each pixel in the image is in neighbourhood with eight adjacent pixels. For this reason, each pixel has a lot of correlation with its adjacent neighbours. However, it is very important to disturb the high correlation among image pixels to increase the security level of encrypted images. In order to dissipate the high correlation among pixels, pixel shuffler is used; in which permutation map is applied in two directions: vertical and horizontal, to decrease adjacent pixel correlation. The proposed scheme's key space is large enough to resist all kinds of brute force attack. This scheme is tenable. High visual degradation can be achieved. No impact is observed on compression efficiency. Encryption ratio is 100%. Speed is fast. It is robust against brute force attack so security level is high (Jolly Shah and Dr.VikasSaxena, 2011).

**Image Encryption using DCT and Stream Cipher**

LalaKrikor, Sami Baba, ThawarArif, and ZyadShaaban (LalaKrikor, 2009), proposed a method based on the idea of decomposing the image into 8X8 blocks; these blocks are transformed from the spatial domain to frequency domain by the DCT. Then, the DCT coefficients correlated to the higher frequencies of the image block are encrypted using Non-linear Shift Back Register. The concept behind encrypting only some selective DCT coefficients is based on the fact that the image details are situated in the higher frequencies while the human eye is most sensitive to lower frequencies than to higher frequency. The proposed algorithm is lossless; hence the images used in such applications are of highly important information, and any amount of information is not allowed. It is tenable as different level of security can be achieved by selecting different bits for encryption. In this scheme, variable visual degradation can be achieved. No impact is observed on compression efficiency so it is compression friendly. Encryption ratio is variable. To increase security, block shuffling methods is applied after encryption (Jolly Shah, 2011).

**Conclusion**

In today's digital world, Image plays an important role they are used in many applications in our day to day lives. Therefore it is necessary to affirm the integrity and confidentiality of the digital image that is being transmitted. The security of digital images has become very essential since the communications of digital products over the open network occur more frequently. In this paper, we reviewed a wide-range of image encryption and decryption algorithms. Those encryption techniques are studied and analysed well to promote the performance of the encryption methods. We brought newly proposed techniques to encrypt and decrypt the image using combined techniques to enhance the security level. Each of the new techniques is unique in its own way and this makes it suitable for many applications. Everyday new techniques are evolving hence fast and secure conventional encryption techniques work with high security rate. The results of the simulations showed that every algorithm has advantages and disadvantages based on their techniques which are applied on images. But the combined techniques are generally faster and the security level is high. We conclude that all techniques are useful for real-time image encryption. Therefore, more complex algorithm should be used to provide high speed and security in cryptosystem. Modified versions of various algorithms should also be used to increase the security level.

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