

# DNA Computing for Secure Image Transmission: A Review

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**Abstract:** *The advent of advances in mobile computing technology in the recent era has led to generation of large voluminous traffic data over unsecured networks. Among them, image is the most significantly used data in numerous application fields such as medical, defense, rescue operations etc. comprises of crucial and confidential information. Thus, image security is the utmost need of the hour to protect the confidentiality and integrity of the information from the modern technology assisted adversaries. The bulk data capacity, strong correlation among pixels and high data redundancy features of image thereby making DNA cryptography is one of the suitable choices over conventional cryptographic techniques. DNA cryptography is one of the most emerging techniques in the era of cryptography using Bio-molecular computations which offer massive parallelism, large storage space and energy efficient operations. The current paper presents a systematic review on DNA based image cryptographic techniques. Furthermore, the emphasis will also be laid on crucial findings that demand future addressal.*

**Keywords:** Bio-molecular computation, DNA cryptography, Image cryptography

## 1. Introduction

In the 21<sup>st</sup> century, the exponential rise in mobile computing technology and internet users have led to boost up the use of social media platforms like facebook, twitter, whatsapp, Instagram etc., but also has increased the security threats to the user information that transferred in the form of personal information, trade, professional, state and official secrets over the unsecured networks. Subsequently, with the availability of advanced computing technology, there is a potential rise in adversaries' methods to break the system in order to steal the crucial information and also to destroy the authenticity and data integrity. Thus, in today's scenario, protection of information is a challenging task for the modern computing technology- based devices. Along with the success of mobile communication technology, there is a subsequent rise in multimedia- based applications as multimedia image and video services. Among these, image poses a significant importance as images are more lucrative in interpretation with faster transmission [1-3].

Thus, image security becomes the utmost need for the modern computing technology. From the ancient period rulers to the modern period governments have been keenly interested in keeping secrecy and maintaining the integrity of the data from the adversaries. The techniques such as cryptography and steganography are widely used from the middle of the 20<sup>th</sup> century to secure the digital information. Cryptography technique just encodes the plain text while steganography involves hiding the plain text from the adversaries. As far as availability, accessibility and usability of multimedia based applications is concerned, image cryptography gained a lot of attention among the researchers nowadays. Image cryptography is a process of confusion and diffusion of pixels of an image from an intelligent form to an unintelligent form. Undoubtedly, there exist a lot of traditional cryptographic techniques such as RSA, DES, AES, IDEA, Blowfish, ECC etc. on the basis of number theory and posses large computational time, but these are not suitable for digital images due to some intrinsic properties of

images viz as their capacity for large amount of data, data redundancy in pixels and higher pixel correlation. These intrinsic features make traditional approaches obsolete in concern of digital image security and create a vacuum. This opportunity to be taken over by chaos based cryptography to some extent due to high sensitivity to the initial seeds, pseudo randomness and ergodicity of chaos function but implementation complexity and limited functionality over digital images makes chaos based approach results to be constrained within certain boundaries [4-11]. For such digital images, DNA computing provides a genetic information based latest innovation in the cryptographic field called DNA based image cryptography. DNA cryptography exploits the DNA molecules base pair for encoding and decoding of the pixels of an image by using different mapping rules, which is further operated by performing numerous DNA operations such as DNA Addition, DNA Subtraction, DNA exclusive-or etc. over the encoded pixels of an image. It has been observed that bio-molecular computation provides a vast range of DNA encoding and decoding schemes along with numerous operations which help to generate robust, proficient and elegant DNA based cipher for image which is hard to break using conventional approaches. Numerous attempts have been made in the DNA computing field in the past decade or so, and the achievements have been incredibly promising [12-26].

## 2. DNA based Image Cryptography

Conventional cryptographic techniques are not suitable for providing promising solutions for securing digital image information due to the inherent properties of images. So, DNA computing provides a promising solution for securing image information by adding the fragrance of fruitful security analysis results with extreme key sensitivity, larger key space and resilience against differential cum statistical attack [42-43].

During DNA based image cryptography, firstly pixels of an image are converted into binary numbers. Subsequently, these binary numbers are encoded into different DNA base pairs by using different mapping rules. Secondly, encoded pixels are diffused by operating numerous DNA operations with the help of DNA based external keys. Lastly, DNA based cipher image is generated by decoding the operated

encoded pixel in the previous step [44-45]. The block diagram of DNA based image cryptography is shown in figure 1. Numerous DNA operations such as DNA addition, DNA subtraction, DNA ex-or, DNA complement etc., along with eight different mapping rules of Watson - Crick Model are extensively used to provide the essence of the additional dynamicity.

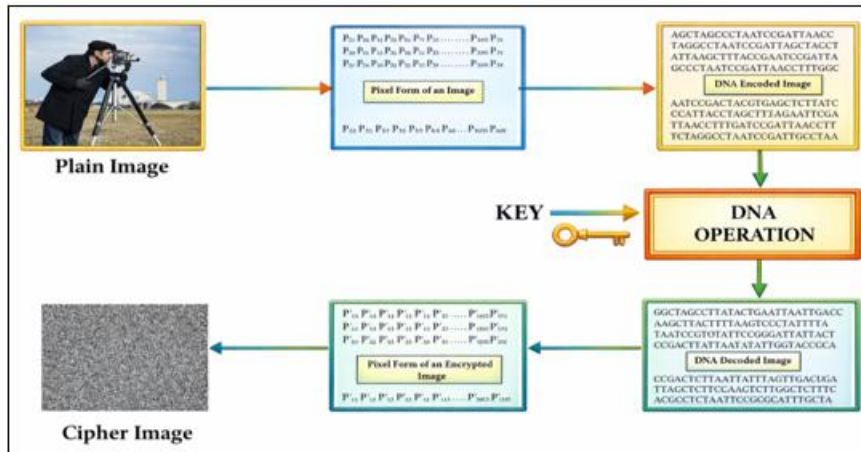


Figure 1: Block diagram of DNA based Image Encryption

### 3. Literature Review

To fully understand the most recent advances in this field, a comprehensive examination of current DNA-based image encryption techniques has been accomplished. To strengthen image security, several researchers have suggested

techniques based on chaotic systems, hybrid cryptography, and DNA computing. Table 1 summarizes the main contributions of this research in terms of methodology, key features, benefits, and limits for better comparison and comprehension.

Table 1: Comparative Analysis of DNA based Image Encryption Techniques

S. No	Author & Year (Ref.)	Methodolog	Key Features	Advantages	Limitations
1	R. Soni et al. (2012) [46]	DNA Cryptography	Bimolecular computation	Bio-inspired security; flexible encoding	Lacks real-time validation
2	L. Liu et al. (2012) [47]	DNA + Logistic Chaos	RGB separation, DNA encoding, logistic map	Large key space (~10 <sup>56</sup> )	High computational cost
3	Q. Zhang et al. (2013) [48]	DNA XOR + Hyper Chaos	Hyper-chaotic scrambling + DNA XOR	Resistant to attacks	Complex implementation
4	A. U. Rehman et al. (2014) [49]	DNA Cipher	Permutation + dynamic key	Strong security	Time consuming
5	R. K. Jangid et al. (2014) [50]	DNA + Hill Cipher	Hybrid classical + DNA	Improved security	Key dependency
6	T. Hu et al. (2016) [51]	DNA + Chaos	XOR + insertion/deletion	Attack resistant	Complex
7	Ayesha Kusoom et al. (2016) [52]	Selective DNA	MSB/LSB + logistic map	Efficient	Partial security
8	Xiuli Chai et al. (2017) [53]	Chaos + DNA	2D logistic + permutation	High sensitivity	Parameter complexity
9	M. Kar et al. (2018) [54]	DNA + Lorenz	6D chaos + DNA ops	High randomness	High cost
10	X. Zhang et al. (2018) [55]	Feistel + DNA	Dynamic encoding	Strong security	Complex
11	Ref. [56]	DNA + CML	DNA + cyclic shift	Efficient	Less clarity
12	Ju et al. [57]	DNA + Henon-Sine	Hybrid chaos	Large key space	Complex init
13	S. Bendaoud et al. (2019) [58]	ECC + DNA	Dual encryption	Very secure	High load
14	Alireza Arab et al. (2019) [59]	Chaos + AES	Modified AES	Fast	Hybrid complexity
15	A. Balazi et al. (2019) [60]	Chaos + DNA	SHA-256 + DNA	Real-time	Delay
16	X. Wang & S. Chen (2020) [61]	Chaos Scrambling	Spiral scrambling	High sensitivity	Chaos dependent
17	S. Gang et al. (2020) [62]	DNA + DWT	DWT + FSM	Multi-level security	Slow
18	M. G. A. Malik et al. (2020) [63]	DNA + Chaos	RGB + DNA	Multimedia use	Overhead
19	N. Iqbal et al. (2021) [64]	Chaos + DNA + Chess	4D chaos	Better randomness	Complex
20	M. Uddin et al. (2021) [65]	DNA Scrambling	Dynamic encoding	Fast	Limited testing
21	B. Akhiwati & L. Parthiban (2021) [66]	Chaos + DNA	DNA + chaos	Attack resistant	Key complexity

#### 4. Key Findings from Literature Review

A comprehensive review of recent literature highlights significant advancements in mobile computing technologies that have transformed multimedia-based platforms for transmitting images and videos over unsecured networks. Images, being a critical medium for sensitive information such as medical records and defense data, have made security a major research concern. Traditional cryptographic techniques often fall short due to the unique characteristics of image data. Consequently, DNA-based cryptography has emerged as a promising alternative for enhancing image security.

However, several research gaps remain. Limited studies exist in the broader domain of DNA cryptography despite its potential for solving complex computational problems. Most existing work focuses on text encryption, with comparatively less attention given to multimedia data. Current approaches often integrate conventional cryptography with bio-computing rather than relying solely on DNA-based methods. Although DNA cryptography offers high unpredictability, efficiency improvements are still needed. Additionally, there is insufficient research on DNA-based key generation and key exchange mechanisms. Future work should emphasize hybrid models combining DNA computing with chaos theory for image encryption. Moreover, existing DNA-based methods require stronger validation against established cryptographic standards, particularly in terms of confusion and diffusion properties.

#### 5. Conclusion

Finally, it can be concluded that DNA based cryptography offers a plethora of potential application in the field of image encryption, owing to some inherent traits of DNA molecules thereby making it suitable for cryptography such as accumulation of large data by the DNA molecule, high efficiency and less power consumption. Generally, DNA cryptography applications have yet to demonstrate their value in terms of safety, speed, and complexity. It offers a far more secure, quick and statistically complex technique in contrast to its conventional counterparts. Although, it can also be observed that a blend of DNA based image cryptography with chaos function provides a promising results on the cost of computational time with complexity. Consequently, author analyzed that literature review findings of DNA based cryptographic applications along with safety, computation time and implementation feasibility issues need further addressable in future.

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