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Application of Chaos and Fractals in Image Stegnography – A Review

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Abstract: In modern steganography the data is embedded in text, image, audio and video file. The review focus on Image SteganographicDomain and this paper gives a detailed analysis of Chaos and Fractals in Image Steganography. This review paper is good enough for the initiator to start their work in this field.The review clearly showsthat Chaos and Fractal Techniques play an important role in Data Hiding having enough capacity, good image quality, security, imperceptibility and survivability.

Keywords: *Chaos, Fractal, Data Hiding, Steganography.*

1. INTRODUCTION

Steganography has recently emerged as an important sub-discipline of information security with the capability of providing secrecy in the internet. Steganography strives for high security and capacity, which often entails that the hidden information is fragile. Design of secure and survivable stego-system is a challenging task.

In modern steganography, secret data are embedded in text, image, audio and video files. The proposed work is in the Image Steganographic Domain and gives a detailed analysis of Chaos and Fractals in Image Steganography. In chapter 2 , analyze the security objectives and the performance analysis of Chaos in Image Steganography. In chapter 3, analyze the various security measures of the Fractals and the performance analysis of Fractal in Image Steganography are discussed. In chapter 4, analyze the security objectives of both Chaos and Fractal techniquesin the specific Image Steganographic Domain and the overall performance are also discussed. In chapter 5 conclude the proposed work.

2. CHAOS IN IMAGE STEGANOGRAPHY

K. Ganesan, B. Venkatalakshmiet al[5] applied chaotic encryption technique for data hiding. The random number logic is used to hide the secret data in image. They mainly focused on using LSB conversion.

K.Sathishet al[6]proposed chaos based spread spectrum image steganography (CSSIS) and chaotic modulation in spread spectrum image steganography (SSIS) techniques. CSSIS is used for chaotic encryption and chaotic modulation is used to ensure the secrecy and privacy in commercial consumer electronic products.

Der-Chyuan Lou et al[7]introduced an asymmetric image steganography method based on a chaotic dynamic system and the Euler Theorem which possesses security, imperceptibility and survivability.

Liu Nian-sheng, Guo Dong-hui et al[8]proposed chaotic sequence in transform domain. Different chaotic random sequences are used and multiplied by multiple sensitive images; to spread the spectrum of sensitive images. Multiple sensitive images are hidden as a form of noise. Theoretical analysis and computer simulation result shows that it has high security, imperceptibility and capacity in comparison with the other conventional scheme such as the least significant bit (LSB).

Niansheng Liu et al[10] proposed a new image steganography to increase digital security scheme for the Internet. It is based on chaotic sequences on the discrete wavelet transform (DWT) domain of covert images. The simulation studies revealed that the new hiding technique has high security, imperceptibility and capacity for hidden information in comparison with least significant bit (LSB).

Peipei Liu et al[11] presented a novel image steganography method using chaotic map and human visual model is presented in discrete cosine transform (DCT) domain. Simulation results show that the algorithm has a high capacity and a good invisibility. It is also found to be robust for the common image processing like JPEG compression and cropping.

Niansheng Liu and DonghuiGuo[12] noticed that a new information hiding technique in a still image.A chaotic sequence in the transform domain of covert image technique has increased the security, imperceptibility, capacity and robustness of hidden information.

G.Geetha[13] showed that non-linearity plays a significant role in Cryptographic Algorithms by appealing to chaos and quantum chaos.

Z. Liu and L. Xi[14] proposed a new image watermark algorithm based on chaotic encryption.A secret signal is transmitted to hide the data as a white noise in the carrier image. The advantages of an algorithm are quantitatively analyzed.

Y. Zhang, F. Zuoet al[16]presented a new digital image encryption scheme. Chaotic maps are used to generate the sub-key sequences to enhance the security of the cryptosystem. The simulation result possesses large key space, sensitivity key dependence and good security.

Enayatifar R, FaridniaS,SadeghiH[22] proposed a new technique for image steganography using chaotic signals and provides the security with the PSNR range(42.06).

Lifang Yu**,** Yao Zhaoet al[24]showed that the improved adaptive LSB Steganography based on chaos and genetic algorithm performs well in image quality and provide high capacity.

Tayel.M[39]proposed a new chaos based Steganographic Algorithm for data hiding. Chaos distribution arrangement is used to coordinate the data in the image dimension. The least significant bit(LSB) method is used to embed the data into the images. The chaos coordination technique is used to separate the data from the stego-image. Algorithm proves that it has high security.

Siddharth Singh and Tanveer J. Siddiqui[40]introduced a new robust Arnold transforms and chaotic system algorithm based on the discrete cosine transform (DCT). Chaotic system generates a random sequence to embed data in cover image. The Arnold Cat map method is used to enhance the security of secret data. Algorithm proves that it has high security and robustness against JPEG compression, noise, low pass filtering and cropping attacks.

Melad J. Saeed[43] presented a new technique based on chaotic steganography and encryption text on DCT domain for color images. It satisfies the properties such as imperceptibility, improved mean square error, peak signal to noise ratio, normalized correlation and capacity.

The algorithm developed by Muhammad Bilal et al[44] hides the payload based on a certain relationship between the cover image, chaotic sequence and the payload. The payload is not directly embedded which often left the significant signs of steganography.

Arun A.S. George M. Joseph[45] proposed stegnographic technique based on chaotic image encryption. Steganography is used to hide the data within cover medium and chaotic image encryption techniques uses a triple-key namely session key, initial key and control key are used to encrypt the stego image. This method provides four-layer security to the original message.

NidhiSethi and Sandip Vijay[46] proposed a new technique using chaotic mapping. Chaotic map is used for encryption. The keys used for encryption and authentication are embedded in the encrypted image. The result shows that it resists the various attacks such as differential attack, statistical attack, brute force attack and histogram analysis attack.

Adaptive image steganography mechanism is proposed by Ratnakirti Roy, AnirbanSarkar et al[47], which combine the benefits of matrix encoding and an LSB method to embed the data. Chaotic mapping is used to enhance the security to the payload adopting high imperceptibility and reliability.

S. Ahadpour and M. Majidpour[48] noticed that chaotic maps require high complexity for embedding the secret data. To overcome this difficulty, the authors introduced discrete cross-coupled chaotic maps for identifying the desired location of the different parts of the secret data in the image and arrived with good results. The proposed method has high robustness and resistance against hackers. Analysis revealed the higher PSNR value when compared with other methods.

Amir Anees, AdilMasoodSiddiqui[54]applied chaotic maps in spatial domain for digital images. Chaosapplied effectively in secure communication strengthens the algorithm. Security measures are carried out to survive against various differential attacks (Known message, cover and stego attack).

M. Ghebleh , A. Kanso[55]introduced sweldens' lifting scheme and 3D chaotic map. A robust chaotic algorithm used the discrete wavelet transform (DWT) coefficientsfor embedding the data into a cover image. This algorithm possesses robust imperceptibility and security.

A 3-3-2 LSB insertion method based on chaos shows a substantial improvement in the peak signal to noise ratio (PSNR) and image fidelity (IF), which is explained by DebiprasadBandyopadhyay et al[60].

Dr.S.Bhargavi, Shobha.M et al[61] stated that the logistic chaotic map is used for embedding the secret data into the cover image. The logistic mapping method generates the chaotic sequence to hide the secret data that enhance the security of the image steganography.

Mahdi Aziz, Mohammad H et al[62] proposed cycling chaos based steganographic algorithm, cycling chaos function generate the seed for the pseudorandom number generator and determine the pixel position to store the data. It compares peak signal-to-noise ratio and quality index, which produces good hiding capacity and increased stego-image quality. This algorithm withstands various steganographic attacks.

Shreenandan Kumar, SumanKumarietal[63] applied one dimensional chaotic logistic map technique. This technique is used to generate the pseudo random numbers.Sorted pseudo random numbers index areused for data hiding. This method provides sufficient capacity and security.

3. FRACTAL IN IMAGE STEGANOGRAPHY

Paul Davern, Dr. Michael Scott[1] proposed a novel fractal image compression technique for data hiding. A visual key is mainly used for hiding the secret data and retrieving the hidden data and it is used as a copyright label in the image file. The enhancement of the steganographic methods and the ways to improve the image qualities are described.

Joan Puate, Frederic D. Jordan[2] developed a new fractal coding and decoding scheme, a fractal coder exploits the spatial redundancy within the image. The test was conducted by embedding a 32-bits signature in 'Lena' image' (256x256)to measure the robustness of this technique against JPEG conversion and low pass filtering. This scheme obtained a good result.

Wohlberg B, de Jager G[3]focused on fractal image coding. They conducted surveys and concluded that the fractal compression and alternative techniques have achieved greater success.

Mitra, S.K,Murthy et al[4] proposed a new fractal image compression technique used the Iterated Function System (IFS) probabilities . This technique is very fast in computing the probabilities and coefficients of maps.

M. Pi, M. K. Mandalet al[9] proposed four statistical indices for efficient image retrieval and efficient hierarchical indexing strategy, which is based on the DC and AC component analysis. Experimental results show that proposed indices significantly improve the retrieval rate.

Bouboulis.P[15] introduced two new pseudo random number generators based on iterated function system (IFS). Based on random seed, iterated function is generated and deterministic iteration algorithm (DAI) constructed a set. The pseudo random numbers have been constructed from this set. The generator has a big period, which indicates that it is used in any applications which require random numbers.

Shiguo Lian[17] discussed the feature of the natural image fractals. It is used for the construction of an image authentication scheme to identify whether an image is maliciously tampered(wiping,cuttingand modification, etc.) or not and also it located the tampered regions.

Automatic image authentication and recovery scheme for the altered region of the image is proposed by Shuenn-ShyangWang, Sung-Lin Tsai[18].The effectiveness of the proposed scheme can be identified and recovered in automatic fashion. Applied fractal encoding and decoding for the blocks of ROI is to achieve high-quality image recovery.

Sos S. Agaian , Johanna M. Susmilch[19] proposed a new fractal steganographic method for data hiding. This method is based on the input parameters of an algorithm. The parameters depend on fractal type, no of iteration and simple secret key. This algorithm performs well against a stenographic detection algorithm.

A new steganography technique for hiding images adopts both fractal and wavelet image processing techniques was proposed by El-Khamy and S.E. Khedr, et al[20]. Cover image is used for hiding the secret image . The wavelet domain of the cover image is used to hide the fractal codebook of the secret image. This technique was tested and proved its robustness against additive white Gaussian noise (AWGN).

J. H. Jeng, C. C. Tseng et al[21] argued that the fractal image compression scheme was insensitive of those noises presented in the corrupted image. So they proposed a new robust Huber fractal image compression (HFIC) technique to retain the quality of the retrieved image but the computational cost is high. To overcome this they used particle swarm optimization (PSO) technique to reduce the searching time and retain the quality of the retrieved image.

Chin-Chen Chang, Chi-Lung Chiang et al[23] proposed an approach to hide the secret image into the cover image. For secret image compression they used fractal image compression method and data encryption standard (DES) is used to encrypt the compressed data. Finally, discrete cosine transform (DCT) is used to embed the encrypted data into the secret image to achieve the goal of steganography.

K. Munivara Prasad, V.Jyothsnaet al[25]introduced fractal compression method to improve the capacity of the hidden information, data encryption standard (DES) is used to enhance the security and to improve the imperceptibility of the blind consistency based steganography (BCBS). The Stego-image transformation was carried out from the spatial domain to frequency domain. This approach is used to overcome the subterfuge attack of the existing steganographic approaches. Analysis revealed on capacity, security and imperceptibility.

Huaxiong Zhang, JieHuet al[27] presented the properties of fractal images, explained the sensitive dependence of initial condition and data embedding procedures. An experimental result shows that a steganography scheme based on fractal images has good imperceptibility and it is inaccessible.

A fractal computing method is used to predict image distortion patterns in image steganography were described by Shanyu Tang, Yong Feng Huang[29]. For embedding, successive random addition algorithm is used. The image distortion patterns are then tested and identified using fractal Hurst parameter.Fractal Hurst parameter is used to make the predictions of future trends.

Fadhil Salman Abed[30] proposed a new approach for encoding and data hiding in images. They utilized the features of fractal theories (Iterated Function System) to encode and decode the secret data.The Fractal image compression technique is used to hide the encoded text in a cover image. They used Lena and Baboon images as a cover image with size (256 *256). Experimental results possess good image quality, imperceptibility, fidelity and high hiding capacity.

Ching-Hung Yuen and Kwok-Wo Wong[33] identified the weaknesses of the selective encryption scheme for fractal image coding and suggested some remedial approaches to enhance the security of the scheme. The experimental results proved that some standard test images are decoded successfully and also recognized that it effectively replaced the specific values of the encrypted contrast scaling factor and brightness offset.

Nadia M. G. Al-Saidi et al[34]proposed a method to improve the security of the password authentication. A hashed password string is generated and encrypted using fractal image coding. The verification of client information is recognized by the optical character recognition and to achieve user identity , It uses the server database and compares both passwords . The advantage of using the fractal image coding is to provide security in non-secured communication channel. From the attacker's view point the system was analyzed and discussed.

Fadhil Salman Abed[36]proposed a new hiding method to encode the information by using RSA cryptosystem and the fractal image compression technique is used for hiding the information. These methods enlarged the hiding capacity.

Shifali Singla[37] developed hybrid fractal wavelet method in order to improve the security. This method is used tomeasure the Bit Error Rate (BER) and also calculated the Peak Signal to Noise Ratio (PSNR) of the retrieved image.

R.M Goudar and PriyaPise[38]discussed on discrete cosine transform (DCT) and fractal compression technique for data hiding. They concluded that fractal compression technique improved the hiding capacity, imperceptibility and also used Data Encryption Standard (DES) to enhance the security. Finally, they recommended the use of wavelet based compression techniques for data hiding.

A novel security approach is used to secure the data from various attacks. Sierpinski Gasket Fractal (SGF) cryptographic algorithm is used to encrypt the data. Penultimate Least Significant Bit (PLSB) embedding method is used to embed the data into an image. RupaCh[42] stated that this approach provides stronger security than other conventional approach.

Krishna Chauhan and Anubhuti Khare[49] focused on a Fractal image compression method, this review gives the study of different speedups using Discrete Cosine Transform (DCT) to reduce the searching time.

Fourier coefficient estimation was proposed by Nadia M. G. Al-Saidiet al[50] This technique is used for the image identification purpose. The Fourier analysis is a new point in fractal space. The estimated coefficient of the fractal subset is oulined on a fractal subset in $[0, 1]^m$. This technique is used to improve the accuracy and reduce the space complexity.

TawfiqAbdulkhaleq Abbas and HassaneinKarim Hamza[51]suggested a new effective system for data hiding in images. The Fractal technique is used to detect the features of the regions of the cover image and the proposed algorithm determined the regions for embedding the data. This algorithm possessesthe maximum hiding capacity, increased image quality.

Ahmad Sami Nori, Asmaa M. et al[53] introduced a novel blind image steganographic method for hiding data in fractal images without acquiring any distortion.

Jian Lu, YuruZouet al[57] proposed a Human Visual System (HVS) based fractal watermarking for color images. Orthogonalization fractal color coding method is used to obtain high image quality. The experimental results have robustness against various attacks and imperceptible in image quality.

G.SuryakalaEswari,N.Leelavathy et al[58] pointed that the multiple generation of the fractal images is poor because of the randomness of generation. Also suggested that developers make use of the new non-linear model, changing color scheme, to generate the acceptable fractal image without affecting the embedding capacity.

4. CHAOS AND FRACTAL IN IMAGE STEGANOGRAPGY

Kiani.Kand Arian.M et al[26] proposed chaos and fractal technique forembedding the authentication data. This approach is used to meet the need for authentication, fragility and unalterability.Image authentication is achieved by using fractal watermarking and chaos theory.

MohammadRezaKeyvanpour and FarnooshMerrikh-Bayat[28]developed a new watermarking method using chaos and fractal coding for embedding the watermark bits. This method provides security, invisibility and capacity. The algorithm determines a set of selective blocks for embedding. The result shows thatchaos-fractal coding (CFC) algorithm has a confidential capacity.

Yue Wu and Joseph P. Noonan[31] proposed an algorithm; it uses fractal images as a cover image which is unique and novel. For embedding, chaotic map is used to generate the random-like sequence. The chaotic logistic map guarantees that the embedding position is unknown.The wavelet transform is used to embed the secret data in the edges with less visual distortion.The proposed scheme is tested with different cover images and results demonstrate its effectiveness and robustness.

Thamizhchelvy.K and G.Geetha[32]proposed an alternate to MAC. MAC provides authentication and confidentiality, it does not provide digital signature. The proposed new Message Authentication Image (MAI) algorithm provides confidentiality, authentication and digital signature.

Thamizhchelvy.K and G.Geetha[35] developeda Message Authentication Image (MAI) algorithm to protect against e-banking fraud and the latest e-banking fraud techniques, such as Phishing, Trojans and man-in-the-middle attacks.This MAI Algorithm provides confidentiality, authentication and digital signature.

Ruisong Ye, YuruZou and Jian Lu[41] proposed a novel chaos based image encryption scheme, which consist of permutation and diffusion process. To permute image pixel positions, two shift dynamical systems are used to generate two chaotic orbits. For the diffusion of pixel gray values, another two shift dynamical systems are used to yield two pseudo random gray value sequences. The proposed permutation-diffusion mechanism produced satisfactory security.

Thamizhchelvy. K and G.Geetha[52] proposed the Fractal Generation Method to generate the different types of fractals using chaos theory. Applied some rules to generate the fractals. The different types of fractals are generated for the same data, because of the great sensitivity to the initial condition. It can be used as a digital signature in online applications such as e-Banking and online shopping.

Thamizhchelvy. K and G.Geetha[56] proposed a Fractal Image Generation method for data hiding using chaos. It is very difficult for the steganalyst to break the data. The generated fractal images are watermarked and it can be used as a digital signature for any online applications.

Thamizhchelvy. K and G. Geetha[59] proposed an efficient Image Generation Algorithm. It generates the Message Authentication Image (MAI) by using Fractals and chaos.. The chaotic behavior of the system is also analyzed. This technique can be employed in online transactions like banking, shopping, etc. to avoid phishing and also watermark this Message Authentication Image ingovernment and private identification proofs to achieve authentication.

5. ANNEXURE I

The performance analysis graph and various security objectives for Chaos and Fractal in Image Steganography are listed in Annexure I. Figure 1 shows year wise analysis of Chaos-Fractal in Image Steganography. The survey stated that more number of work done during the period of 2011 to 2015 and moderate number of work done during the period of 2006 to 2010.The overall performance of Chaos-Fractal in Image Steganography is shown in Figure 2.

The various security objectives such as authentication, confidentiality, security, high capacity , image quality, imperceptibility, digital signature and survivability are analysed for Chaos-Fractal in Image Steganography . In Figure 3,surveyshows that Chaos in Image Steganography achieves high security, confidentiality and capacity. In Figure 4,the performance analysis shows that Fractal in Image Steganography achieves good image quality and imperceptibility but fail to produce digital signature.Even though the limited number of work done in Chaos and Fractal together in Image Steganography and it achieves digital signature.Figure 5 graph proves that Chaos and Fractal in Image Steganography provides high Confidentiality,Authentication, Security and Digital Signature.

5.1. Performance Analysis of Chaos and Fractal in Image Steganography

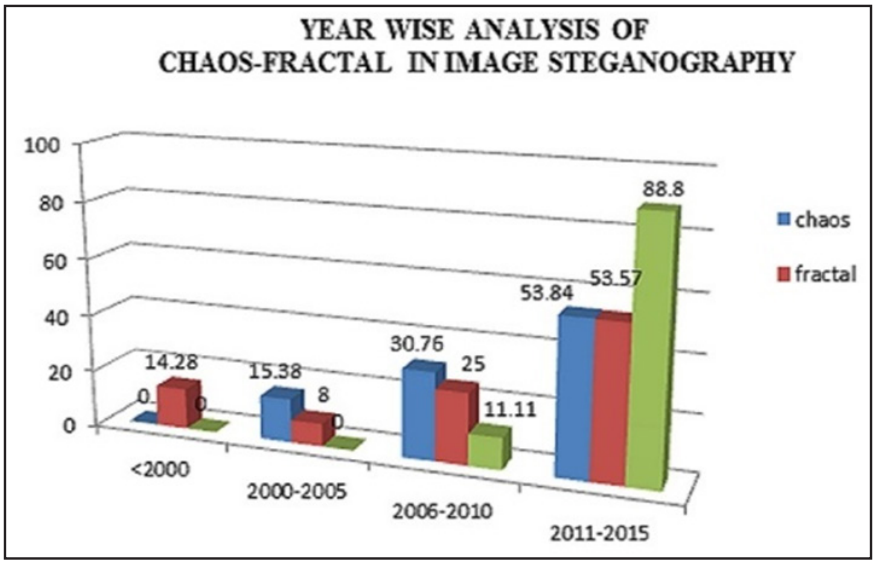

Figure 1: Year Wise Analysis Of Chaos-Fractal In Image Steganography

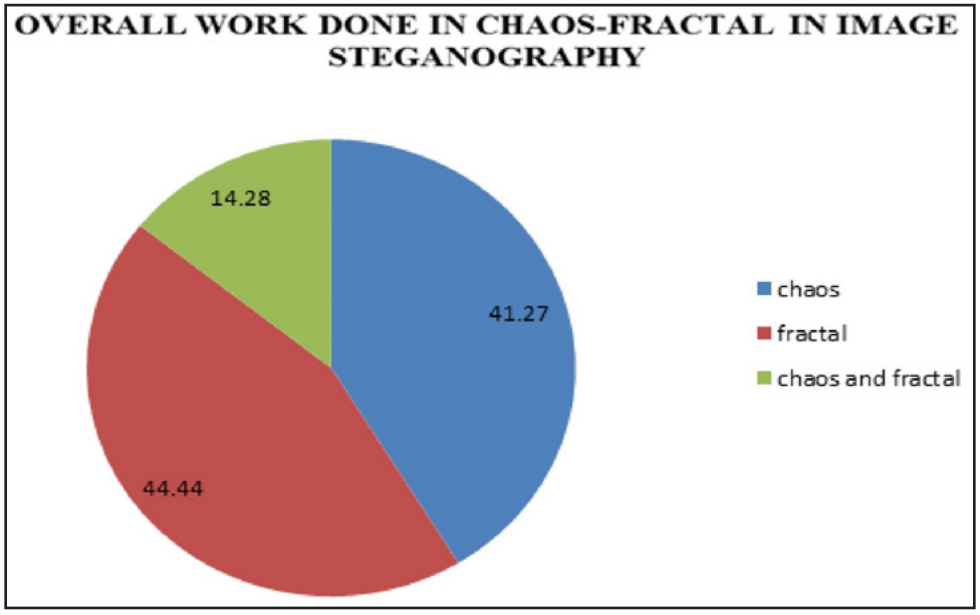

Figure 2: Overall work done in Chaos-Fractal In Image Steganography

5.2. The performance analysis of Chaos-Fractal in Image Steganography-Security objectives

AUTH : Authentication

CON : Confidentiality

CPY : Capacity

IMP: Imperceptability

SUR: Survivability

IQ : Image Quality

DS : Digital Signature

SEC : Security

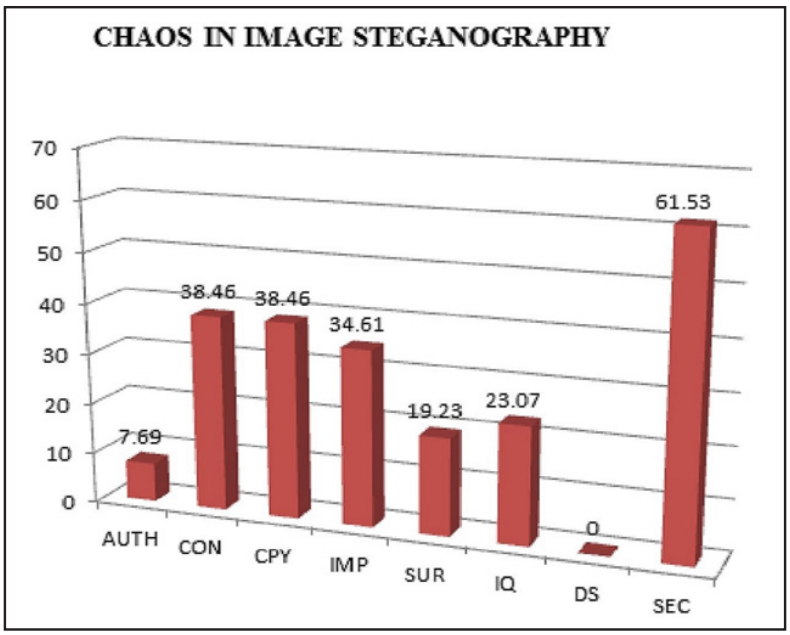

Figure 3

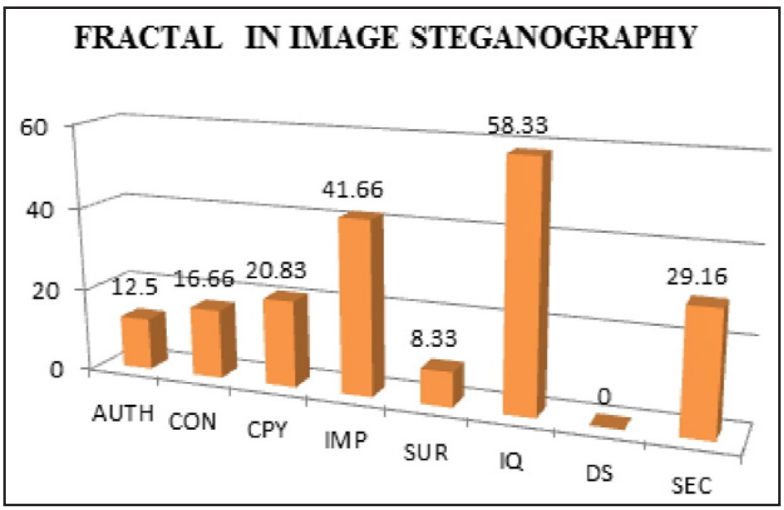

Figure 4

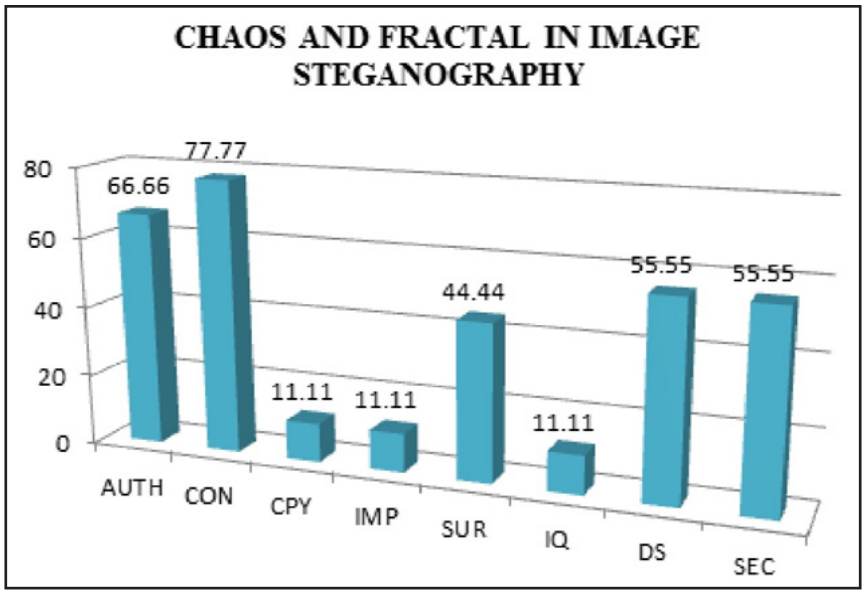

Figure 5

6. CONCLUSION

We reviewed and categorized many papers on Chaos and Fractal in the Image Steganographic Domain. This review paper is good enough for the researchers to precede their work in this field. We noticed that limited amount of work done with Chaos and Fractal,in the specific Image Steganographic Domain. It can be concluded that Chaos and Fractal issuited for data hiding to achieve authentication, confidentiality, security, high capacity, image quality, imperceptibility,survivability and digital signature.

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