Robust Encryption System Based Watermarking Theory by Using Chaotic Algorithms: A Reviewer Paper

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Abstract: In the previous decade, the mixing between chaotic supposition and cryptography frames considers a significant field of data security. Chaos-based image encryption is given a lot of attention in the exploration of data security moreover a great deal of picture encrypting calculations have been proposed concerning chaotic maps. Because of some invariable highlights of media like information limit and high information excess, the encryption of images not quite the same as that of texts; accordingly it is hard to deal with them by conventional encryption strategies. This paper presents a short review of robust digital watermarking systems that used chaotic algorithms such as Logistic, Tent, Baker, Hyper, Fibonacci, and Arnold maps for encryption of the data presented in several years.

Keywords: Logistic, Tent, Baker, Hyper, Fibonacci, Arnold.

1. Introduction

Versus the advancement of electronic devices and Web propels, a computerized substance can be adequately gotten to by methods for different transmission channels, for instance, Internet, remote frameworks. As a result of focuses of interest of computerized substance, flawlessly recreated and effectively changed, numerous issues have gotten more pressing than in simple occasions, for example, copyright assurance and substance confirmation. A watermark can be classified into two types depending on its capacity: the specific vigorous watermark for copyright protection, and delicate watermark for honesty check[1].

Some procedures should be possible either consecutively or arbitrarily. Arbitrarily picked pixels for covering up in the spread picture give preferable security over a successive
way. In our proposed conspire spread picture, pixels are select arbitrarily by utilizing the chaotic arrangement created by the chaotic map. chaotic implies a state of disorder. In science, a map is an advancement work that gives a type of chaotic behavior. A discrete-time dynamical framework is called a map too[2].

Chaos signals are viewed as useful for practical use since they have significant qualities, for example, they are exceptionally delicate to introductory stipulations and framework parameters, they have a fake-irregular property and non-periodicity as the turbulent waves ordinarily commotion, and so on. Subsequently, the aggregation of chaotic theory and cryptography constitutes a significant field of data security. The qualities of chaotic signs make chaos framework a fantastic and strong crypto-framework against any statistical aggression [3].

Chaos-based picture encryption is given a lot of consideration in the examination of data security and a great deal of picture encryption calculations will depend on the chaotic form. There have been numerous watermarking encryption calculations dependent on chaotic maps like the Standard map, the Logistic map, the tent map, the Baker map, and some other types which present in this paper. The watermarking encryption systems are summarized as follows: host media are entered to encryption algorithms which are here chaotic algorithms to embed the information and give a high performance of security, efficiency, and robustness to it. On the other side, the extraction of the information follows the inverse same algorithm that mad in the embedding site and deduce the information with high quality. "Figure.1" shows the general block diagram for the watermarking system.

First of all, section1 of this paper gives an introduction about the watermarking and chaotic algorithms, section2 highlight survey to the maps that the researcher trending in watermarking encryption algorithms and the conclusion and references in the last section.

2. Chaotic Maps
This section, highlight the chaotic maps used in the embedding algorithms.

2.1 Logistic map
Chaotic maps are utilized for image encryption which includes highlights like non-deterministic, irregular, periodicity, and so on. the common one is a 1D logistic map, which was discovered in 1976 by Robert May[4]. Mathematically, the logistic map was written as seen in "Equation (1)"

\[ x_{n+1} = \beta(x_n - x_n^2) \]  (1)

Where \( x_0 \) is a number somewhere in the range of zero and one which is the initial value. The estimations for the parameter \( \beta \) are dependent on the user which generates chaotic

![Figure 1](image-url)
sequence and take place amidst 3 and 4. The random arrangement generated from equation (1) exhibits chaotic properties and used for encrypting the image. The basis of β value is:

1- $0 < \beta < 1$, the characteristics will be in a steady-state.
2- $1 < \beta < 3$, the characteristics will be rapidly increasing
3- $3 < \beta < 3.44949$, the populace will be moved toward perpetual motions between two qualities.
4- $3.44949 < \beta < 3.54409$ (around), from practically all underlying conditions the populace, will move toward perpetual motions among four qualities
5- With $\beta$ expanding past 3.54409, from practically, all underlying conditions will be moved toward motions among 8 qualities.
6-When $\beta \approx 3.56995$ (succession A098587 in the OEIS) the case is considered as the beginning of bedlam. The bifurcation chart of a calculated guide is pictured in ”Fig.2″. The guide is in confused state when $3.57 < \beta \leq 4$ [4,5,6]. The disorderly state is shown by a concealed region. Right now express, the subsequent qualities seem arbitrary even though the framework deterministic [4].

![Figure 2 Bifurcation chart of a logistic map (Wikipedia)](image_url)

Researchers [4-26] have used the logistic map in them watermarking algorithms to encrypt their information which was (image, audio, and text) as shown in "table 1". They were demonstrated How to be careful at the determination of the capacity seed in the generation of chaotic-watermarks. Dependence the on strength range alone isn't sufficient to decide the phantom properties of the watermarks created from the logistic map. The studies were introduced to show that although this method gives an effective strong watermarking procedure however it comes up short if the customer is unwise to choose capacity essential for the logistic map.
### Table 1: Review of the Logistic map

| References                        | Technique Used in the algorithm | Applicatios | Parameters evaluated                              |
|-----------------------------------|---------------------------------|-------------|--------------------------------------------------|
| Kunal Kumar [4]                   | 2D Logistic map                 | image       | Number of Pixel Change Rate (NPCR)               |
| Saswati Trivedy [5]               | logistic map                    | image       | The PSNR values                                 |
| Rinaldi Munir [6]                 | Logistic Map                    | image       | PSNR                                             |
| Aidan Mooney [7]                  | Logistic map                    | image       | power spectral density (PSD)                     |
| Botta [8]                         | Logistic+ Arnold map            | image       | ---                                              |
| Qiaolun Gu [9]                    | Logistic map                    | image       | PSNR and Accuracy Rate AR                       |
| Sajjad Shaukat [10]               | Logistic map                    | image       | Entropy and GLCM                                 |
| Sriti Thakur [11]                 | Logistic map and DWT, DCT, SVD. | image       | NC and SSIM                                      |
| Song Wei [12]                     | logistic map                    | image       | Peak signal noise ratio (PSNR) and bit error ratio (RPSN) |
| Xianyong Wu [13]                  | logistic and Chebyshev map      | image       | PSNR (dB) and BER (%)                           |
| S. Thakur [14]                    | logistic map + NSCT, RDWT and SVD | image       | PSNR, NCNC, NPCR and UACI                       |
| Yassine Himeur [15]               | logistic map + DWT-SVD          | Video       | Video comparison Ratio CR                        |
| Mariya Fatema [16]                | Arnold and logistic             | image       | PSNR, SSIM, and MSE                              |
| Hegui Zhu [17]                    | hyper-chaotic and 2D Logistic map | image       | NPCR and UACI                                   |
| Ola N. Kadhim [18]                | 1D Logistic Map                 | image       | PSNR and MSE                                    |
| Gurjit Singh Walia [19]           | Logistic and LUDO scan scheme.  | image       | PSNR and MSE                                    |
| Milad Yousefi [20]                | modified logistic map           | image       | PSNR and MSE                                    |
| Zhao Dawei [21]                   | Wavelet and Logistic map        | image       | PSNR                                             |
| Mahavir Shantilal [22]            | Laplace Detector And Logistic Map | image       | laplacian of Gaussian (LoG)                      |
| Shabir A. Parah [23]              | Logistic and DCT                | image       | PSNR                                             |
| Mamta Rani [24]                   | complex logistic map            | image       | Generation of fractals                           |
| Hailiang Shi [25]                 | DWT-SVD and logistic map        | Image       | PSNR and CC                                      |
| Chittaranjan Pradhan [26]         | 2D Logistic and (ECC) in the DWT domain | image       | PSNR                                             |

#### 2.2 Tentmap

The tentmap is one of the least difficult chaotic maps. It has a single dimension and a multi-definition function straight guide. The disorderly practices of the tent map were concentrated diagnostically as far as the invariant thickness and the force range, all through its chaotic region. It was understood: as the climax greatest is brought down, progressive band-parting changes in the disorganized locale and gather to the progress point into the non-clamorous area. Tentmap is topologically conjugate and along these lines its practices are right now under the cycle. It is given as in "Equation(2)":
\[ a_{n+1} = f_\mu(a_n) = \begin{cases} \mu a_n & \text{for } a_n < \frac{1}{2} \\ \mu(1 - a_n) & \text{for } \frac{1}{2} \leq a_n \end{cases} \quad (2) \]

Where \( \mu \) is a positive genuine steady =2 for instance, the effect of the function \( f_\mu \) is the resulting interval choosing as (0,1/2) or (0,1). While, \( a_0 \) assumes to be a new ensuing position, \( a_n \) is generating sequence in (0,1). Higher thickness demonstrates an expanded likelihood of the (a) variable procuring that esteem for the given estimation of the \( \mu \) parameter as shown in "Fig. 3".

Researchers[27-33] have used the tent map to encrypt their information through a system which has two principle phases: watermark embedding and extraction as indicate in "Table 2".

| References | Technique Used in the algorithm | Applications | Parameters evaluated |
|------------|--------------------------------|--------------|-----------------------|
| Joshua C. Dagadu[27] | Tent map and IWT | Medical image | Correlation coefficient, entropy, SSIM, PSNR, BER, NPCR |
| Hassan Elkamchouchi[28] | Tent map | image | PSNR, MSE |
| Sukalyan Som[29] | Tent and Logistic maps | image | MSE, PSNR, NPCR, UACI, entropy |
| Toshiki Habutsu[30] | Tent Map | Plaintext | Information rate R |
| Yicong Zhou[31] | Tent - Sine Map | image | Correlation, entropy |
| R. Parvaz[32] | Tent - Sine Map | image | Correlation, entropy, NPCR and UACI |
| Jianhua Song[33] | Tent Mapping and SVD | image | PSNR, NC |

2.3 Baker map:
It is named after a plying activity that pastry specialists applied to a mixture: the batter is sliced down the middle, and the two parts are stacked on each other and packed. The disorganized Bakermap is notable to the image-processing network as a material of encryptions. It is a change based apparatus, which plays out the randomization of a square
matrix dimensions by changing the pixel positions in the light of a mystery key. It allows a pixel to another pixel position in a goal way.

The Geometrical portrayal of a baker map change is as per the following: The Phasespace (set of every conceivable condition of a dynamical framework) arrange.

"Equation (4)" shows the general formula of the Baker’s map:

$$B_{\text{folded}}(q, d) = \begin{cases} (2q, d/2) & \text{for } 0 \leq q \leq 0.5 \\ (2 - 2q, 1 - d/2) & \text{for } 0.5 \leq q \leq 1 \end{cases}$$

(3)

Researchers [34-40] performed 1D, 2D and 3D baker map algorithms to encrypted the information. Chaotic Baker map is utilized as a pre-preparing layer to expand the security level, "Table 3" show their studies.

### Table 3: Review of Baker’s map

| References          | Technique Used in the algorithm | Applications | Parameters evaluated       |
|---------------------|--------------------------------|--------------|----------------------------|
| Waleed Al-Nuaimy [34]| Baker map and SVD              | Audio        | SNR                        |
| Mazleena Salleh [35]| Baker map                      | Image        | ----                       |
| Ahmed Elshamy [36]  | Baker map                      | Image        | MSE, PSNR                  |
| Muhammad Asif [37]  | Baker Map                      | Plaintext    | Bit Independent Criterion, Differential Approximation Probability |
| Ruisong Ye [38]     | Baker Map - DWT                | Image        | PSNR, NC                  |
| Fengling Han, [39]  | Improve Baker Map              | Image        | Histograms                |
| Ruisong Ye [40]     | improved Baker map             | Image        | PSNR                      |

2.4 Hyper-chaotic map

Cai GL et al. proposed a three-dimensional chaotic framework in 2007 as shown in "Equation (4)"

$$\begin{align*}
\dot{x} &= a_1(y - x) \\
\dot{y} &= a_2x + a_3y - xz \\
\dot{z} &= x^2 - a_4z
\end{align*}$$

(4)

Where $a_1$, $a_2$, $a_3$ and $a_4$ are framework parameters. At the point when "$a_1 = 20", "a_2 = 14", "a_3 = 10.6":, and "$a_4 = 2.8", the framework is confused. Its greatest Lyapunov type is "2.355". This value is greater than that of Lorenz system (1.497) and Chen system (1.0742). As we as a whole know, large Lyapunov type implies quick directions division rate. Researchers [41-45] used the Hyper-chaotic map with other algorithms to produce a novel way for encryption as indicated in "Table 4".

### Table 4: Review of Hyper-chaotic map

| References          | Technique Used in the algorithm | Applications | Parameters evaluated       |
|---------------------|--------------------------------|--------------|----------------------------|
| Xiaopeng Wei [41]   | hyper-chaotic maps             | Image        | NPCR , UACI                |
| Xuanping Zhang [42] | hyper-chaotic map              | Image        | Histogram analysis         |
| Yueping Li [43]     | hyper-chaotic map and permutation | Image      | Histogram analysis         |
| Lihua Gong [44]     | hyper-chaotic map and DfRRT    | Image        | Correlation coefficients, Histogram analysis |
| Abolfazl Niyat, [45]| hyper-chaotic map and cellular automata | Image  | Histograms, Entropy, Correlation coefficients, |
2.5 Fibonacci-chaotic map

The Fibonacci numbers 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, have been denominated by French-mathematician EdouardLuc in nineteenth-century after Leonard Fibonacci of Pisa, probably the best mathematician of the Middle Ages, who alluded to them in his book LiberAbaci (1202) regarding his hare issue. Fibonacci succession has interested the two novices and expert mathematicians for a considerable length of time because of their inexhaustible applications, and their pervasive propensity for happening in thoroughly astounding and irrelevant spots. Fibonacci numbers applied by the researcher [46-54] as in "Table 5" for data security from the year 2004 onwards. The Fibonacci numbers were generated by "Equation(5)" as follows:

\[
   f_a = \begin{cases} 
   0 & \text{if } a < 1 \\
   1 & \text{if } a = 1 \\
   f_{a-1} + f_{a-2} & \text{if } a > 1 
   \end{cases}
\]

(5)

| References     | Technique               | Applications       | Parameters evaluated |
|----------------|-------------------------|--------------------|----------------------|
| Min-Jen Tsai[46] | Fibonacci+ DWT          | Image              | Correlation          |
| S. Ponni Sathya[47] | Fibonacci+ DWT+ SVD   | Video              | PSNR and NCC         |
| Jiancheng Zou[48]  | Fibonacci map           | Image              | -----                |
| Ali Akbar Attari[49] | Fibonacci+ DWT       | audio              | BER                  |
| Mehdi Fallahpour[50] | Fibonacci map           | audio              | SNR and ODG          |
| Baisa L. Gunjal[51]  | Fibonacci+ DWT+SVD     | Image              | PSNR, NC             |
| Yicong Zhou[52]    | Fibonacci P-code        | Image              | Histogram            |
| Nan Jiang[53]      | Fibonacci and Arnold maps | Image              | -----                |
| Ehsan Nezhadarya[54] | Fibonacci+ DWT+SVD    | Video              | PSNR and NCC         |

Table 5: Review of Fibonacci map

2.6 Arnold map

Arnold's catmap denominated after the effect show of Vladimir Arnold in the 1960s, who utilizing an image of a cat. it is a chaotic map from the torus into itself. The 2-dimensional Arnold's cat map is given by the "equation(6)".

\[
   \begin{bmatrix} 
   d^- \\
   q^- 
   \end{bmatrix} = \begin{bmatrix} 
   1 & 1 \\
   2 & 1 
   \end{bmatrix} \begin{bmatrix} 
   d \\
   q 
   \end{bmatrix} \mod N, \text{ Where } d,q \in \{0,1,2,\ldots,N-1\}
\]

(6)

Arnold transform is utilized as a pre-treatment organization for watermarking, which makes the importance of full image as an inane one. It is a basic worry to have the spatial relationship diminished between the host image and the watermarked image. Wherein, d,q is the pixels organizes of the original image: so that d,q are the pixels organizes after iterative calculations mingling; N is the size of the image. The inverse converting of the "equation (6)" can be attained in "equation (7)"

\[
   \begin{bmatrix} 
   d \\
   q 
   \end{bmatrix} = \begin{bmatrix} 
   2 & -1 \\
   -1 & 1 
   \end{bmatrix} \begin{bmatrix} 
   d^- \\
   q^- 
   \end{bmatrix} \mod N, \text{ d,q}^- \in \{0,1,2,\ldots,N-1\}
\]

(7)

The chaoticArnold map is employed to make the watermarking robust for different types of multimedia attacks as in the researchers [55-71] as indicated in "Table 6".
Table 6: Review of Arnold map

| References             | Technique Used in the algorithm | Applications | Parameters evaluated |
|-----------------------|---------------------------------|--------------|----------------------|
| Zhu Xi’an[55]         | Arnold map and DWT.             | image        | SNR, NC              |
| Min Li[56]            | Arnold map                      | image        | ----                 |
| D. Vaishnavi [57]     | Arnold map                      | image        | PSNR, NC             |
| Abdallah Soualmi      | Arnold map                      | image        | PSNR, NC, SSIM       |
| Chen Wei-bin[59]      | Arnold + Henon map              | image        | ----                 |
| Wangsheng             | Arnold + logistic map           | image        | histogram            |
| Fang[60]              | Arnold map, DWT, SVD, and LU Decomposition | image | SR, PSNR             |
| Onur Jane [61]        | DCT-Arnold.                     | image        | PSNR, NC and WAR     |
| Mehdi Khalili[62]     | Arnold map+ DCT                 | image        | NC ratio (RPSN)      |
| Mohammad              | Arnold map                       | image        | ----                 |
| Keyvanpour[64]        | Arnold and DCT                  | image        | PSNR, NC             |
| Pradhan[65]           | A. Arnold and DWT, DCT          | image        | PSNR, NCC            |
| Esam Hagras[66]       | Arnold and DCT                  | image        | PSNR, NC             |
| Jianhua Song[67]      | Arnold and SVD                  | image        | PSNR                 |
| Xiaohu Ma[68]         | Arnold map                      | image        | Compression quality  |
| Ruisong Ye[69]        | Arnold and Logistic map         | image        | PSNR                 |
| Changjiang Zhang[70]  | Arnold and DCT                  | image        | MSE                  |
| Qian-chuan Zhong[71]  | Arnold and DCT                  |              |                      |

3. Conclusion
In this reviewer paper, first, the basics of some types of chaotic sequence which is used in the data encryptions systems are constructed. You can see that different researchers generate the chaos sequence and used it with other algorithms to produce a robust, efficient, and secured encrypted system. Some researchers encrypt text, other encrypt images, audio, and video, with attention to the conditions of its use, chaotic map gave great results in information security.

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