Secure Hybrid Watermarking Technique In Medical Imaging

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Abstract: Medical imaging organizations currently face a significant problem with stealing of medical data. Watermarking is a powerful tool that can be used to authorize the hidden information in cover image. The unique features associated with watermarking are authorization and copyright protection. Because of its unique characteristics, watermarking associated with medical data hiding gives more robustness in medical imaging. In spite of this adding security to watermarking in medical imaging, gives more protection for medical information. This paper explored two main fields that, the encryption of medical images using DNA Encoding and Spatiotemporal Chaos Algorithm and the embedding of medical images in cover image using hybrid transformation of NSCT, RDWT and SVD. The goal of this study was to develop a methodology to improve the robustness, imperceptibility and security for medical information without implementing a physical model, thus saving time, money and reducing the risks associated with hacking partners. For this paper, I used patient health document as one watermark and his medical image as another watermark. The theoretical model has demonstrated that it is possible to use this type of technique and apply it to a complex digital image transmission. The correlation observed before and after encryption and embedding procedures. Experimental results show how robustness and imperceptibility and security of medical images are improved.

Keywords: - encryption, embedding, watermarking, PSNR, NSCT, SVD, chaos algorithm, DNA encoding

1. INTRODUCTION

In online transmission of data, data ownership, authentication and protection factors play a very important role in secure transmission of data. Data may in the form of array of characters, image and video. So many transform techniques are developed and advised for watermarking mechanism. Several reversible transforms like Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT) can be used. Discrete wavelet transform is one of the techniques which is generally used in watermarking algorithms. This technique leads to several methods of embedding multiple watermarks into the low frequency and high frequency bands of discrete wavelet transform [4]. In authenticated watermarked multimedia transmission, maintain sufficient robustness against all possible unintentional attacks [17]. It is ensuring that any watermarking algorithm is developed to strengthen robustness of watermarking over attacks such as gamma correction, jpeg compression, cropping, salt & pepper noise, gaussian noise, speckle noise, sharpening, motion blur, median filtering, histogram equalization, contrast/brightness adjustment, resizing, and rotation. Robustness, imperceptibility and embedding capacity are the preliminary requirements of any watermarking technique [24].

In these days, it is very important to maintain safe transmission and reception of the patient's medical and personal data. This is obtained by implementing an innovative encryption mechanism for safe and completeness of the patient's diagnostics information. Cryptography is one of the best techniques of hiding information by encrypting the data such that only the authenticated persons can only access and can decrypt the original information [44]. Medical imaging technique is a method of generating perceptible delegation of the internal body for diagnosis and treatment functions with the help of digital media. This is very useful in clinical analysis and medical intervention as well as visual representation of the function of some organs or tissues (physiology). Medical imaging methodologies brings out hidden architectures of human body and further can improve diagnose and treatment suggestions. Medical imaging also authorizes a directory of normal anatomy and physiology to accomplish a possibility to identify abnormalities. Even if removed organs and tissues are also be usually revealed and these techniques are treated as an element of pathology rather than medical imaging. The term, medical imaging, includes various radiological imaging techniques such as: X-ray radiography, Fluoroscopy, Magnetic resonance imaging (MRI), Medical ultrasonography or ultrasound, Endoscopy, Elastography, Tactile imaging, Thermography, Medical photography and nuclear medicine functional imaging techniques e.g. positron emission tomography (PET) and single-photon emission computed tomography (SPECT) [44].

To achieve better digital image watermarking scheme, it is very important to learn about different transformation techniques and also singular value decomposition techniques. In most of the algorithm the watermark is not embedded directly on the wavelet coefficients but rather than on the elements of singular values of the cover image's DWT sub bands [45]. Transmission of authenticated information like documents, images, audios, and videos on internet channel has turned into simple with the help of digital watermarking. At the beginning, watermark embedding and retrieving process techniques using discrete wavelet transform coefficients, distance measurement, and cryptographic techniques are applied in digital image watermarking systems [46]. To preserve the imperceptibility and robustness the combination of redundant discrete wavelet transforms and singular value decomposition provides the better results to accomplish more embedding capability in the original cover image and watermarked image with no shift-invariant [47]. Replacing the contourlet transform with Non-subsampled contourlet transform combination with DWT and RDWT proved improvement in frequency selectivity and regularity when compared to existing digital watermarking systems [48]. Here the secret message is a confidential patient's medical data concealed in a medical image which is transmitted. We need to prevent the hidden information secure by preventing others from knowing and to remove such suspicion in having hidden information we use stenography techniques. This paper aims to improve security of medical data transmission based on a hybrid encryption algorithm to get a highly secure healthcare system.

This paper is organized into five section which including this section; Section 2 illustrate related

works; Section 3 explains the proposed methodology and the algorithms implemented; Section 4 provides
the experimental results; Section 5 summarizes the conclusions.

Relative Work

Pardhasaradhi P et. al., proposed an algorithm which is based on wavelet image fusion [7], which shows good results in the direction of enhancement and fusion of image with the help of wavelet transform techniques. Wen, Heping et. al., suggested a technique for an image encryption based on DNA encoding and spatiotemporal chaos (IEA-DESC) [1], which helps in analysing some security aspects for various unintentional attacks. This paper mainly deals with pixel diffusion and permutation to overcome some inherent security defects. Nagaraju, G. et. al., proposed a reversible secured image encryption methodology for medical images [2], which the experimental results shows that how the efficiency of medical image encryption is improved using wavelet transformation. Chai, X. et. al., presented a paper on hyperchaotic system, cellular automata (CA) and DNA sequence-based image encryption scheme [3], which simulation results illustrated that how this technique having robustness and secure enough to face some geometrical and signal processing attacks in the transmission of watermarked images. This paper reveals the idea of using SHA 256 hash functions for secret key and two DNA rule matrices for encoding the cover image and chaotic sequences for generating two-dimensional (2D) CA. Tripathi D.P., et. al., suggested different image enhancement techniques [10] which measures the phase-transition temperatures using polarizing microscopy technique. This paper proposes the crystalline phases in the pure and nano-doped LC compound and simulation results part shows how this technique is highly robust over existing image enhancement methods. Gehani, A. et. al., recommended an algorithm on DNA-based, molecular cryptography systems [9], which presents how DNA model cryptography is depends on one-time-pads. The mentioned encryption schemes in this paper are mainly substitution method and XOR which provides relatively improvement in security among some existing steganography methods. Chai, X. et. al., proposed a new way of encrypting a color image using cryptosystem based dynamic DNA and chaos [42], which shows how a four-wing hyperchaotic system is very useful in providing pseudo-random chaotic sequences, and how to compute initial values using SHA 384 hash function of the plain image and with the help of external parameters, and finally experimental results reveals that how one-time-pad encryption policy makes the proposed technique efficiently robust against different geometrical and signal processing attacks.

G. Nagaraju, et. al., presented a paper on watermarking mechanism [22], which shows that embedding of patient's personal information in patient's medical image after encryption. Simulation results shows that improvement in security in watermarked image transmission from information hackers. Sun, S. suggested a paper on novel image encryption scheme using pixel-level scrambling, bit-level scrambling, and DNA encoding [25], which shows that in watermarking mechanism, how the security of the cryptosystem is improved. Simulation results and analysis of different watermarks illustrates that the suggested encryption technique is highly secured and robust enough for different geometrical and signal processing attacks. G. Nagaraju, et. al., recommended an algorithm on transform domain based secured image watermarking [32], which gives that how the efficiency of the image watermarking is improved with combining two transforms, discrete cosine transform and discrete wavelet transform. A simple encryption algorithm is also adopted for security. The experimental results show that how this watermarked image transmission technique robust enough for different practical attacks happened in channel. Gundu R.P., et. al., proposed a measurement model for obtaining the position of a stationary emitting source for Line-of-Sight (LOS) [14], which mentions that the comparison of three different optimization techniques in terms of convergence rate and also comparison of error values obtained from two different scenarios. Performance results show that with Monte Carlo simulation how the efficiency of the algorithm is improved. Wagdarikar A.M.U., et. al., presented a paper on improved optimization techniques for video watermarking [20], which mainly deals with embedding of data watermark in video with Chronological-Moth Search (Chronological-MS) optimization technique. Simulation results shows that the suggested algorithm shows that the performance is highly improved with Chronological-MS optimization. Aparna P., et. al., suggested an efficient medical image watermarking mechanism using biometric based algorithm [23], which is mainly used in electronic healthcare applications. In this paper the authors mentioned that apart from watermarking algorithm the fingerprint biometric is very useful for authentication, confidentiality, and reliability of the system. Noorbasha F., et. al., implemented an algorithm on high secured low power advance encryption standard (AES) implementation with DNA cryptography [26], which presented secure dual rate register with AES-128 which gives better results for the cryptography systems against different unintentional signal processing attacks. Design methodology of this algorithm shows that it is very useful in practical applications. G. Nagaraju, et. al., recommended an innovative secured image watermarking technique for medical images with patient details [18], which presented that the combination of NSCT and RDWT transforms with SVD gives best performance in robustness against different geometrical and signal processing attacks. Experimental results show that this enhanced algorithm is vulnerable in imperceptibility, safety in security and solid in unintentional attacks. Gajula S., et. al., proposed an interesting algorithm on medical image watermarking with CLA-HE & DWT, SVD transforms [30], which presented that the combination of these techniques gives best in best performance in medical image transmission. Simulation results illustrates that this algorithm is performing good values in terms of PSNR and MSE. Divya Shivani J.L., et. al., presented a paper on an enhanced digital watermarking mechanism based on shuffled SVD and RDWT [34], which mentions the problem of false-positive-attack on RDWT and SVD. In this paper the design methodology illustrates that how this technique is giving more imperceptibility and robustness against different geometrical and signal processing attacks. Aparna P., et. al., suggested an efficient digital image watermarking mechanism in healthcare systems using the combination of compression and cryptography algorithms [38], which deals with tumer part seperation with region growing algorithm, encryption performed using SHA-256 and elliptical curve cryptography technique, compression performed by an arithmetic coding algorithm and finally embedding procedure is done using different transformed techniques. Performance results shows that improvement in efficiency parameters like PSNR and NC.

Most of the algorithms are concentrating on either robustness, imperceptibility, embedding capacity or security or any two of them. This paper mainly concentrating on improvement in these four parameters.

Major Contributions Of The Work

Before developing the proposed method, it is necessary to carry out a feasibility study on watermark techniques. So, this paper mainly concentrated on fusion of DNA encoding based encryption and transform domain-based watermarking techniques. The main motto of proposed compound techniques in our method is as follows:

- The Shift-invariant, multi-scale, and rich directional information properties of NSCT provides good development in many image processing applications [29].
- The shift variant problem of DWT is definitely resolved by using RDWT [29].
- Singular Value Decomposition method in image processing applications gives its best due to its

special mathematical effects of singular values that provide outstanding stability.

- However, SVD [27] is computationally extortionate when it is applied solely to images. So, the compound method (SVD and RDWT) is a better chance to make up for the problem and improve the robustness of our suggested technique.
- DNA based encryption [1] is using for securing medical images, sensitive patient data and digital information. In IEA-DESC, pixel diffusion, DNA encoding, DNA-base permutation and DNA decoding are performed successively to generate cipher-images from the plain-images [1].

To prove the security performance of the proposed encryption technique at its best, the calculation of the performance metrics such as the Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE), Structural Similarity (SSIM), Normal Correlation (NC), Universal Quality Index (UQI), the Number of changing pixel rates (NPCR), and Unified mean modified intensity (UACI) were carried out.

2. PROPOSED METHODOLOGY

Our proposed methodology be found in encryption and embedding procedures. Here three images are taken for experimental purpose. One is any cover image in which the medical data is hidden. The remaining two are watermark images having medical data. One watermark image having the information of medical data like Chest CT scan image, Abdomen CT scan image, Kidney stones scan image, PET- scan image, Breast MRI image, Brain MRI image, Ultrasound image, Hand X-ray image etc. Second watermark consists of patient health record like patient's name, patient's age, patient's gender, patient's present location, patient's Aadhaar number, patient's contact number, patient's disease, its location in body, severity, preferred treatment, hospital name, hospital address, doctor details, patient's reference number, date in which the data collected, and hospital logo etc. A cipher watermark image is obtained by applying a special image encryption algorithm of DNA Encoding and Spatiotemporal Chaos on the normal watermark image. This encryption procedure is applied for both watermarks. Later, these two cipher watermark images are embedded into cover image with the help of proposed technique which uses a fusion of NSCT, RDWT and SVD for the watermark process of integration and extraction. Encryption and embedding procedures are explained as follows.

4.1 Illustration of Image Encryption Algorithm- DNA Encoding and Spatiotemporal Chaos (IEA-DESC)

4.1.1. Cipher Key

The cipher key of IEA-DESC consists of X0, μ, K0, N0, α, β, ε and L, where X0, μ, and K0 are the parameters of the logistic map, α, β, ε and L are the parameters of new chaotic algorithm-based coupled
map lattice, and N0 is the span of removed pattern for terminating destructive temporary outcomes.

4.1.2. Encoding Procedure

The encoding body of IEA-DESC are 8-bit grayscale images of size M X N. A flow chart for IEA-DESC algorithm is shown in Figure 1, where W, W', and Wc are the watermark image, the diffused image, and the cipher- watermark image, respectively. This encoding procedure consists of four fundamental stages: pixel Morphing, DNA encoding, Row and Column permutation, and DNA decoding.

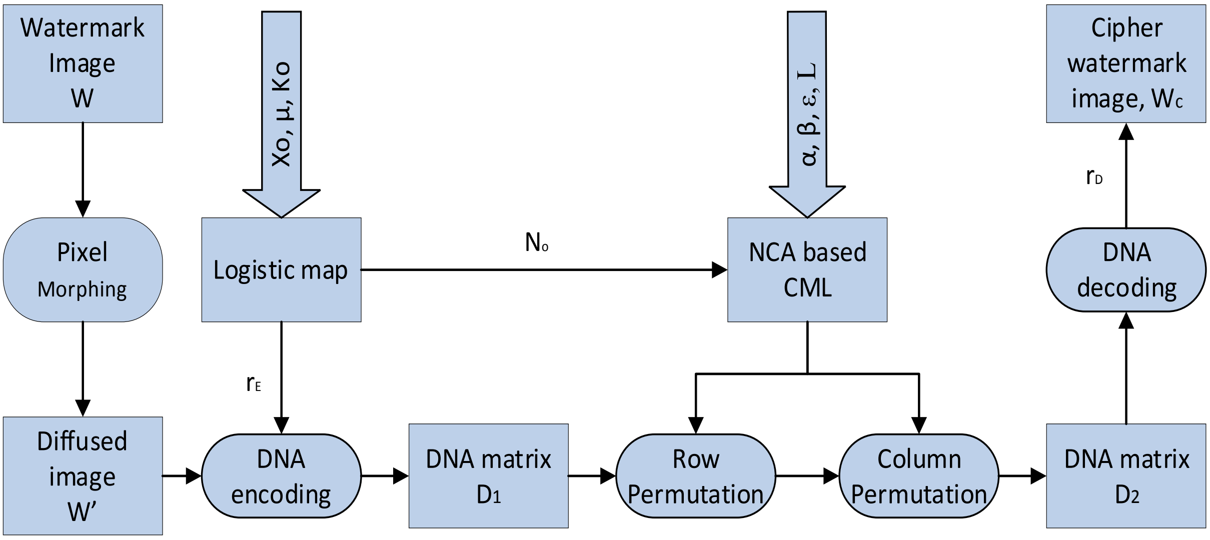


Figure 1. Flow diagram of the image encryption algorithm based on DNA encoding and spatiotemporal chaos (IEA-DESC).

The specific explanations of IEA-DESC [1] are illustrated below:
Step 1. Pixel Morphing:
By converting the watermark-image P into the corresponding sequence $\{p_1, p_2, . . . , p_{MXN}\}$ in circular scanning order. Thus, the morphed image P_0 of size M X N is obtained from the diffused sequence $\{p_1', p_2', ……., p'_{MXN}\}$. Here a medical image and patient health document image are considered as watermark images which are shown in Figure 2.

Step 2. DNA Encoding:
Calculating the summation of the watermark-image pixels, the K_0-th emphasis value xK_0 is attained by the fundamental value x_0 and the control parameter m. The DNA encoding rule r_E, is further resolved by

$$r_E = \lfloor x_{K_0} \times 8 \rfloor + 1,$$

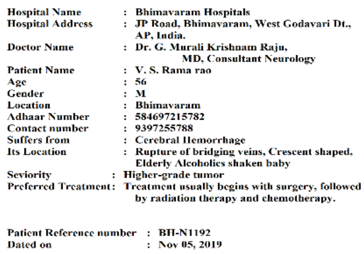
where $r_E \in [1, 8]$, and $\lfloor a \rfloor$ rounds the element a to the nearest integer towards minus infinity. Then, by the rE-th encoding rule in Table 1, the diffused image P_0 of size MXN is firstly transformed into the analogous binary matrix of size MX8N, and then encoded as the DNA matrix D_1 of size MX4N.

Step 3. Row and Column Permutation:
Intially, by emphasize and then removed the front N0 values under the fundamental value x0 and the control parameter m, a sequence $\{a_1, a_2, . . . , a_{4N}\}$ of length 4N is obtained. Here, the sequence $\{a_1, a_2, . . . , a_{4N}\}$ is taken as an fundamental value of the spatiotemporal chaos called NCA-based CML. Thus, by emphasizing under the values α, β, ε and L, a real matrix X of size MX4N is achieved.

Step 4. DNA Decoding:
The DNA matrix D_2 of size MX4N is initially translated as the analogous binary matrix of size MX8N, and then transformed into the cipher-image W_C of size M X N.

4.1.3. Decryption Process

From the reverse steps of encryption procedure, we achieved decryption for the proposed algorithm. Initially, the cipher-watermark image W_C is transformed into the DNA matrix D_2 by the r_D-th encryption rule. Then, the DNA matrix D_1 is derived from the DNA matrix D_2 after the reverse-permutation. Later, the DNA matrix D_1 is decrypted as the morphed image P0 with the r_E-th decrypting rule. At last, the watermark-image W is retrieved by reverse-diffusion.



Hospital Name	:	Bhimavaram Hospitals
Hospital Address	:	JP Road, Bhimavaram, West Godavari Dt., AP, India.
Doctor Name	:	Dr. G. Murali Krishnam Raju, MD, Consultant Neurology
Patient Name	:	V. S. Rama rao
Age	:	56
Gender	:	M
Location	:	Bhimavaram
Adhaar Number	:	584697215782
Contact number	:	9397255788
Suffers from	:	Cerebral Hemorrhage
Its Location	:	Rupture of bridging veins, Crescent shaped, Elderly Alcoholics shaken baby
Seviority	:	Higher-grade tumor
Preferred Treatment	:	Treatment usually begins with surgery, followed by radiation therapy and chemotherapy.
Patient Reference number	:	BH-N1192
Dated on	:	Nov 05, 2019

Fig 2. Watermark images (a) Medical image (watermark 1), (b) Patient's information image (watermark 2)

4.2. Illustration of Image Embedding Algorithm- Fusion of NSCT, RDWT and SVD techniques

The suggested technique uses a fusion of NSCT, RDWT and SVD for watermark embedding and extraction process. Using a compound of these two transforms takes the algorithm in getting retrieved watermarked images of good quality. Firstly, the cover image or the original image is modified using the downsampling process to derive the downsampled components. The entropy values of these down sampled components are determined and Non-subsampled counter let transform is applied on the highest entropy components. For high-frequency sub-band of NSCT decomposed image, RDWT is applied. Later, on selected sub-bands of RDWT transformed components, SVD is applied. Similarly, both cipher watermark images are modified using NSCT decomposition followed by RDWT and SVD. The process of cipher watermark embedding is carried by using the modified SVD coefficients with help of gain factor 'α'. The watermark recovery process is done by applying NSCT-RDWT and SVD fragmentation on the decrypted watermarked image to get the recovered watermark components from modified SVD coefficients. Finally, the inverse of NSCT-RDWT and SVD is applied to the recovered components to obtain the recovered cipher watermark images separately. Flow diagram of our proposed scheme is presented in Fig. 3.

3. EXPERIMENTAL RESULTS

Efficiency assessment experimental results of the suggested techniques are examined using non-medical cover images of 1024 × 1024 size. In addition, two watermarks of size 512 × 512 (image of patient's thorax) and 512 × 512 (patient's health information) are used for experimental calculations. The patient's health information watermark consists of patient health record like patient's name, patient's age, patient's gender, patient's present location, patient's Aadhaar number, patient's contact number, patient's disease, its location in body, severity, preferred treatment, hospital name, hospital address, doctor details, patient's reference number, date in which the data collected, and hospital logo etc., however the second watermark containing information of medical data like Chest CT scan image, Abdomen CT scan image, Kidney stones scan image, PET- scan image, Breast MRI image, Brain MRI image, Ultrasound image, Hand X-ray image etc. The performance of the proposed algorithm was carried out using the MATLAB R2018b software running on a personal computer with 1.80 GHz Intel (R) Core (TM) i5 CPU, 8 GB RAM and 1TB hard disk with Windows 10 as the operating system. The quality of the proposed secure watermarking algorithm is determined using some peculiar statistical parameters. These parameters correlate the original cover image and the watermarked image, watermark image and retrieved watermark image. The experimental results were evaluated based on seven statistical metrics; the Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE), Structural Similarity (SSIM), Normal Correlation (NC), Universal Quality Index (UQI), the Number of changing pixel rates (NPCR), and Unified mean modified intensity (UACI).

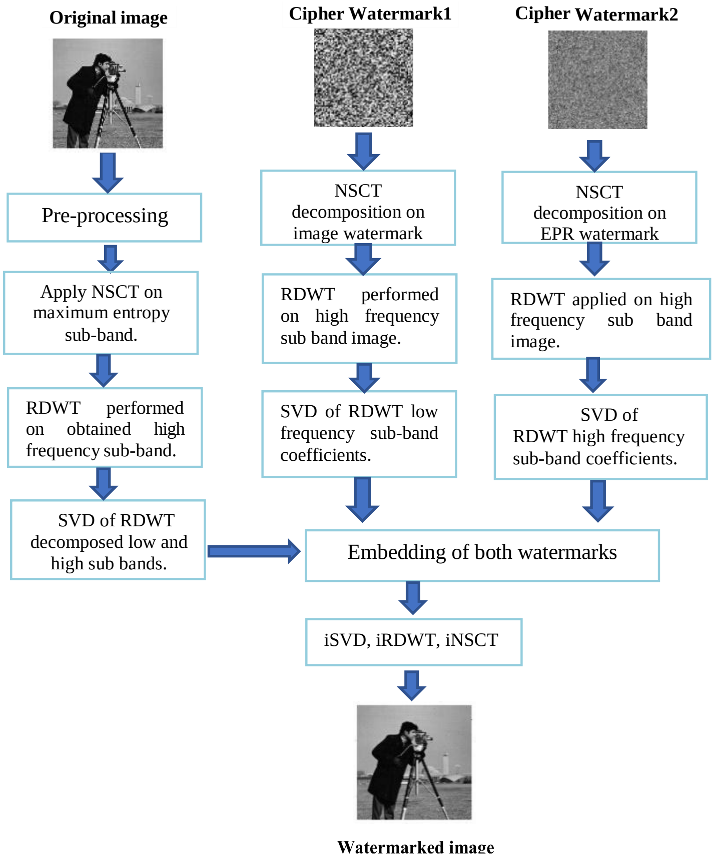


Figure 3. Flow diagram of our proposed embedding scheme

The peak signal-to-noise ratio (PSNR) is the ratio between the maximum value of signal component to the value signal's noise component. In watermarking mechanism PSNR is the parameter to measure the quality robustness of reconstructed images that have been watermarked

$$\mathrm{PSNR}(C, C^*) = 10\lg\frac{C_{\max}^2}{\mathrm{MSE}},$$

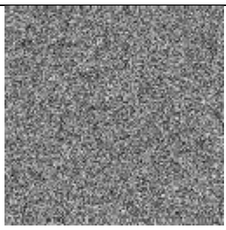
$$\mathrm{MSE} = \frac{1}{M^2}\sum_{i=1}^{M}\sum_{j=1}^{M}(C_{i,j} - C_{i,j}^*)^2,$$

where MSE is the mean square error between cover image and watermarked image and Cmax is the maximum pixel value in the cover image. SSIM is defined by

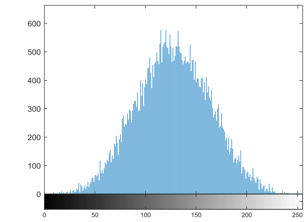
$$\mathrm{SSIM}(C, C^*) = \frac{\mu_C \mu_{C^*} + d_1}{\mu_C^2 + \mu_{C^*}^2 + d_1} \cdot \frac{\sigma_{CC^*} + d_2}{\sigma_C^2 + \sigma_{C^*}^2 + d_2},$$

where μ_C and μ_{C^*} are the average of C and C^*, σ^2_C and $\sigma^2_{C^*}$ are the variance of C and C^*, σ_{CC^*} is the covariance of C and C^*, d_1 and d_2 are two variables which are used to stabilize the division with a weak denominator. Normalized correlation (NC) is often used to evaluate the robustness of the original and extracted watermarks, which is defined by

$$\mathrm{NC} = \frac{\sum_{i=1}^{N} \sum_{j=1}^{N} W_{i,j} W_{i,j}^*}{\sqrt{\sum_{i=1}^{N} \sum_{j=1}^{N} W_{i,j}^2} \sqrt{\sum_{i=1}^{N} \sum_{j=1}^{N} {W_{i,j}^*}^2}},$$

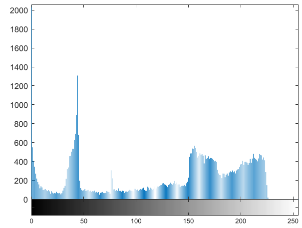


(a) Cipher- watermark 1 image



(b) Histogram

(c) Recovered watermark 1 image

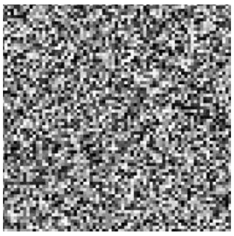


(d) Histogram

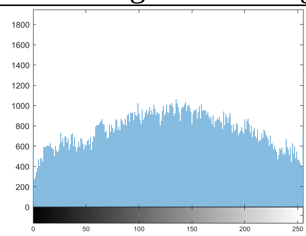
Figure 4. Encrypting and decrypting results of Watermark 1.

To get good imperceptibility, we consider watermarked images to have PSNR greater than or equal to 30 and extracted watermark should have PSNR above 37. UQI and NC must be greater than 0.91 to have good visibility of the watermark.

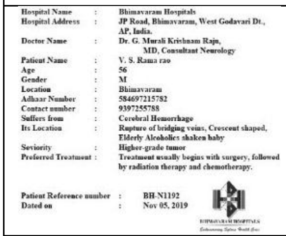
To differentiate the two watermarks, the first watermark which is patient's medical image is calculated as "NC_1" and the second watermark which patient's health document image is calculated as "NC_2". Encrypted watermark image and its histogram, decrypted watermark image and its histogram for both watermarks are shown in Figure 4 and Figure 5.



(a) Cipher- watermark 2 image

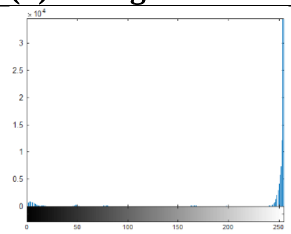


(b) Histogram



Hospital Name	:	Bhimavaram Hospitals
Hospital Address	:	JP Road, Bhimavaram, West Godavari Dt., AP, India.
Doctor Name	:	Dr. G. Murali Krishnam Raju, MD, Consultant Neurology
Patient Name	:	V. S. Rama rao
Age	:	56
Gender	:	M
Location	:	Bhimavaram
Adhaar Number	:	584697215782
Contact number	:	9397255788
Suffers from	:	Cerebral Hemorrhage
Its Location	:	Rupture of bridging veins, Crescent shaped, Elderly Alcoholics shaken baby
Seviority	:	Higher-grade tumor
Preferred Treatment	:	Treatment usually begins with surgery, followed by radiation therapy and chemotherapy.
Patient Reference number	:	BH-N1192
Dated on	:	Nov 05, 2019

BHIMAVARAM HOSPITALS



(c) Recovered watermark 2 image	**(d) Histogram**

Figure 5. Encrypting and decrypting results of Watermark 2.

After observing the results as shown in Table 1, for embedding of two watermarks with size 512 x 512 in a cover image with size of 1024 x1024, we locate that good estimation of PSNR, NC1, and NC2 are 43.62dB, 0.9976, and 0.9991, respectively.

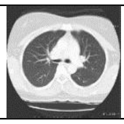
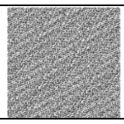
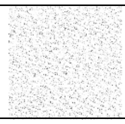
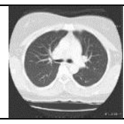
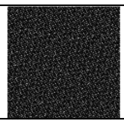
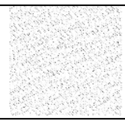
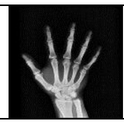
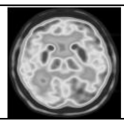
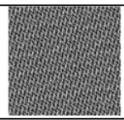
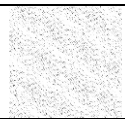
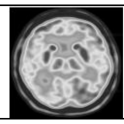
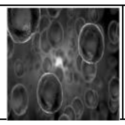
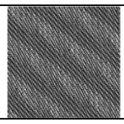
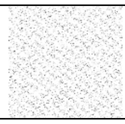
Host image	**Watermark 1**	**Encrypted Watermark 1**	**Watermark 2**	**Encrypted Watermark 2**	**Retrieved Watermark 1**	**Retrieved Watermark 2**
Scaling factor = 0.01, PSNR (in dB) = 40.28, NC1 = 0.9966, NC2 = 0.9983, NPCR = 0.9960, UACI = 0.3469.						
						
Scaling factor = 0.1, PSNR (in dB) = 41.77, NC1 = 0.9976, NC2 = 0.9983, NPCR = 0.9960, UACI = 0.3469.						
						
Scaling factor = 0.5, PSNR (in dB) = 39.31, NC1 = 0.9974, NC2 = 0.9991, NPCR = 0.9960, UACI = 0.3468.						
						
Scaling factor = 0.9, PSNR (in dB) = 43.62, NC1 = 0.9963, NC2 = 0.9983, NPCR = 0.9959, UACI = 0.3467.						
						

Table 1. Evaluation metrics for different scaling factors and watermarks of same size.

For different cover images, the efficiency of suggested technique is tabulated in Table 2. The best PSNR is observed for “Cell” image with a value of 55.33dB. 45.29dB, 41.62dB and 38.96dB are PSNR values for Lena, Barbara and Coins images respectively. All these results give better imperceptibility. However, the NC values maintains almost constant values which are greater than 0.9 in all cases. This shows that improvement in recovery capability of our proposed algorithm.

Cover Image	**PSNR (in dB)**	**NC1 (Watermar1)**	**NC2 (Watermark2)**	**UACI**	**NPCR**
Lena	45.29	0.9394	0.9732	0.4025	0.9963
Barbara	41.62	0.9912	0.9731	0.4315	0.9972
Cells	55.33	0.9896	0.9726	0.3471	0.9960
Coins	38.96	0.9876	0.9732	0.4128	0.9974

Table 2. PSNR, NC, NPCR, UACI values for various host images

After retrieving the cipher watermark from the watermarked image and thereafter decrypting the cipher watermark to get the recovered watermark, calculations of cover PSNR, watermark PSNR, normal correlation coefficient, universal quality index, structural similarity index, mean square error are carried out and tabulated in Table3. Here Lena, Barbara, Cell, Coins images are used as cover images and patient's medical images as watermark1 and patient's health information as watermark2. These calculations are taken from these images after applying our proposed algorithm for different values of scaling factor-alpha. In Table 3, it is observed that the best optimized value for Cover PSNR is obtained for 'Lena image', best optimized value for watermark1 PSNR is obtained for 'Lena image'. best optimized value for watermark2 PSNR is obtained for 'Barbara image', best optimized value for NC is obtained for 'Lena image', best optimized value for UQI is obtained for 'Lena image', best optimized value for SSIM is obtained for 'Barbara image', best optimized value for IMMSE is obtained for 'Lena image' are obtained.
A graph is plotted between the PSNR and alpha values which shows the how the peak signal to noise ration depends on the value of optimized alpha values. Here Y-axis indicates the PSNR values for both cover image (Lena image) and watermark image1 (Patient's medical image) and X-axis shows different alpha values as shown in figure 6.

Cover and Watermark Images	**'α'**	**Cover PSNR**	**Watermark PSNR**	**NC**	**UQI**	**SSIM**	**IMMSE**
Lena image and watermark 1	0.002	**75.74007**	8.65657	0.774381	0.665831	**0.999999**	**0.001734**
	0.032	**52.00271**	30.2313	**0.994019**	**0.993845**	**0.999728**	**0.410024**
	0.162	**37.9049**	**44.49911**	**0.999762**	**0.999761**	**0.993326**	**10.53394**
	0.192	36.48324	**41.17723**	**0.999558**	**0.999523**	**0.99090**	14.61356
	0.292	32.87408	31.25972	**0.995208**	**0.995105**	**0.980586**	33.54843
Barbara image and watermark 2	0.002	**74.7874**	8.111453	0.420643	0.390189	**0.999999**	**0.002159**
	0.052	**45.26402**	34.53673	**0.997821**	**0.997773**	**0.99870**	**1.934989**
	0.102	**39.41978**	**40.04075**	**0.999372**	**0.999364**	**0.995169**	**7.431949**
	0.162	35.47088	29.89717	**0.993644**	**0.993543**	**0.988693**	18.44983
	0.182	34.50807	27.63588	**0.989598**	**0.989338**	0.986196	23.02891
Cell image and watermark 1	0.002	**72.178**	10.15241	0.607123	0.586861	**0.999997**	**0.003938**
	0.032	**47.52955**	30.05151	**0.99406**	**0.99388**	**0.99921**	**1.148486**
	0.062	**41.82191**	**35.87943**	**0.998465**	**0.998414**	**0.997151**	**4.274542**
	0.132	35.44671	23.36127	0.972836	0.972252	0.988875	18.55278
	0.162	33.95098	19.81446	0.945348	0.942172	0.985071	26.18077
Coins image and watermark 2	0.002	**69.78383**	12.56955	0.68974	0.685369	0.999995	0.006834
	0.052	**41.76589**	**33.39552**	**0.997266**	**0.997176**	**0.99713**	**4.330037**
	0.102	36.09264	22.92726	0.969799	0.969257	0.990366	15.98883
	0.132	34.27344	18.37633	0.9261	0.921571	0.986248	24.30727
	0.152	33.47065	15.91562	0.886553	0.873767	0.983849	29.24258

Table 3. PSNR, NC, UQI, SSIM, IMMSE values for different cover and watermark images

The PSNR is taken on the Y-axis and alpha values are taken on the X-axis. From the graph, we can observe that the PSNR of cover image gradually decreases with the increasing alpha value. However, the PSNR of the watermark image increases till a particular value and then decreases gradually. The optimized values for Figure 6 are $PSNR_{cover}$ = 37.9dB, $PSNR_{watermark1}$ = 44.499dB with α = 0.162.

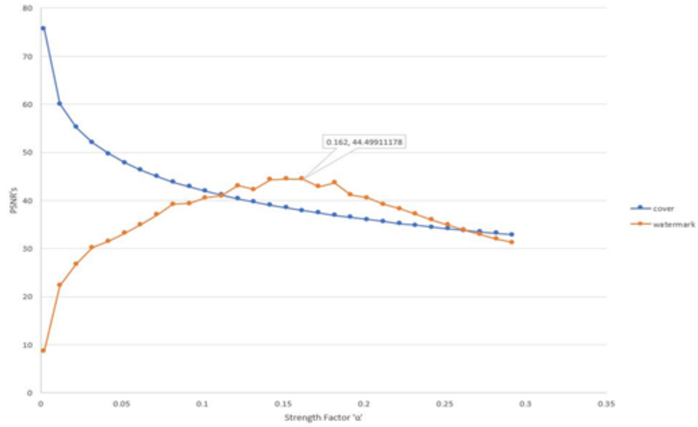


Figure 6: Graph between PSNR and alpha values for Lena image and watermark 1

In another example, as shown in Figure 7, Y-axis indicates the PSNR values for both cover image (Barbara image) and watermark image2 (Patient's health information image) and X-axis indicates different alpha values. The PSNR is taken on the Y-axis and alpha values are taken on the X-axis. From the graph, we can observe that the PSNR of cover image gradually decreases with the increasing alpha value. However, the PSNR of the watermark image increases till a particular value and then decreases gradually. The optimized values for Figure 7 are $PSNR_{cover}$ = 39.42dB, $PSNR_{watermark1}$ = 40.04dB **with α = 0.102.**

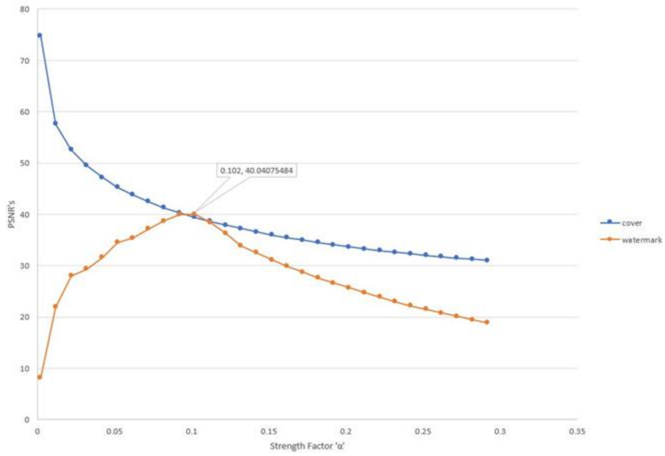


Figure 7: Graph between PSNR and alpha values for Barbara image and watermark 2

In another example, as shown in Figure 8, Y-axis indicates the PSNR values for both cover image (Cell image) and watermark image2 (Patient's medical image) and X-axis indicates different alpha values. The PSNR is taken on the Y-axis and alpha values are taken on the X-axis. From the graph, we can observe that the PSNR of cover image gradually decreases with the increasing alpha value. However, the PSNR of the watermark image increases till a particular value and then decreases gradually. The optimized values for Figure 8 are $PSNR_{cover}$ = 41.82dB, $PSNR_{watermark1}$ = 35.88dB **with α = 0.062.**

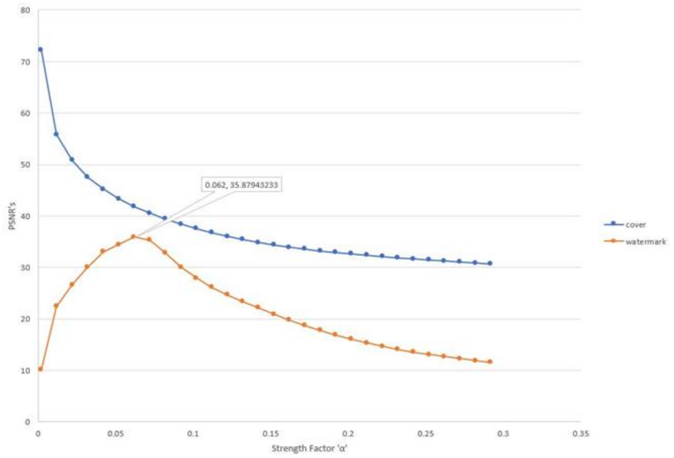


Figure 8: Graph between PSNR and alpha values for Cell image and watermark 1

In another example, as shown in Figure 9, Y-axis indicates the PSNR values for both cover image (Coins image) and watermark image2 (Patient's health information image) and X-axis indicates different alpha values. The PSNR is taken on the Y-axis and alpha values are taken on the X-axis. From the graph, we can observe that the PSNR of cover image gradually decreases with the increasing alpha value. However, the PSNR of the watermark image increases till a particular value and then decreases gradually. The optimized values for Figure 9 are $PSNR_{cover}$ = 41.77dB, $PSNR_{watermark1}$ = 33.4dB with α = 0.052.

4. CONCLUSION

Experimental results show how the robustness, imperceptibility and protection mechanism are improved in this proposed watermarking algorithm. Using of DNA based spatiotemporal chaos for image encryption avoids significant problem with stealing of medical data, so that the risks associated with hacking partners are also resolved. Our proposed watermarking algorithm for image hiding is also proven for good authorization and copyright protection. Because of unique characteristics of our proposed algorithm, watermarking associated with medical data encryption gives more robustness and security in medical imaging. The theoretical experimental results have demonstrated that it is possible to use this type of technique and apply it to a complex digital image transmission. Future studies of secure watermarking digital imaging mechanism can deal with multiple transformations for embedding watermark and multiple encoding techniques for encrypting the watermark.

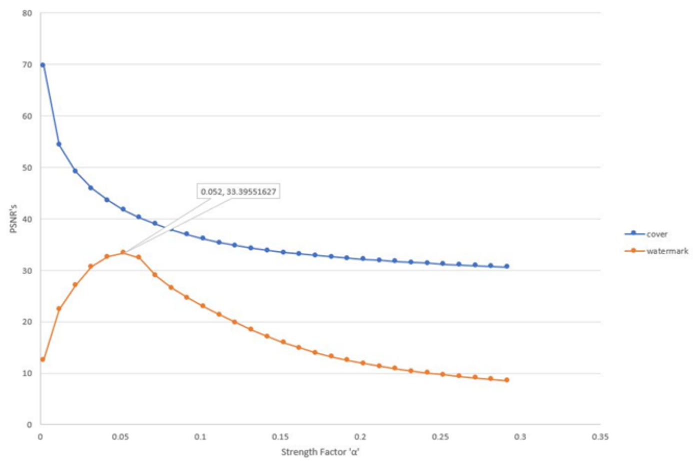


Figure 9: Graph between PSNR and alpha values for Coins image and watermark 2

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