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A Survey For Medical Image Encryption Techniques in Tele-medicine and E-healthcare

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***Abstract*—In this pandemic situation, radiological Images are the biggest source of information in healthcare and, at the same time, one of the foremost troublesome sources to analyze. Clinicians now-a-days must depend to a great extent on therapeutic image investigation performed by exhausted radiologists and some of the time analyze and filter themselves. Due to overflow of patients, transmission of these medical data becomes frequent and maintaining confidentiality turns out to be one of the most important aspects of security along with Integrity and availability. Due to varied features of image data, different algorithms are used to protect data from unauthorized access. This paper basically center on the distinctive cryptographic techniques used for the image encryption and decryption of the medical image data within the field of information security. In addition, a comparative analysis is carried out among the parameters used to measure security of the existing literatures.**

Keywords*—*Information security,Image Encryption,Middle East Respiratory Syndrome (MERS-CoV) , severe acute respiratory illness (SARS-CoV)

I. Introduction

Digital medical images are becoming increasingly vital in modern hospitals for detecting and treating diseases, and as a result, they are attracting greater attention.If unauthorised accesses steal, view, or exploit these confidential photographs, disastrous accidents may ensue. A hacker or a rogue database administrator, for example, could utilise the unauthorised photographs for personal gain, such as medical marketing and false insurance claims, posing a life-threatening risk.As a result, safeguarding medical pictures is critical.

Generally, images utilized in bio medical field are treated as delicate data within the bio data frameworks. To transmit these sorts of medical image through network, a secure encryption calculation is required [18], [19], [20]. Researchers have proposed a part of picture encryption calculation for the final few decades. Information Encryption Standard calculation is most popular algorithm used for encryption which needs minimum time for fetched computations [21], [22], [23], [24]. By applying either symmetric or asymmetric algorithm, a secure image encryption can be exhausted exceptionally viable way[25], [26], [27], [28], [29]. Image encryption is considered exceptionally successful whereas it can give way better result against common attack- known-plain text as well as cipher text attack[30], [31], [32]. In medical image encryption, to upgrade security, Cipher Input Mode is utilized to scramble the image[39], [40], [41], [42]. Many technologies have been developed to safeguard various types of photos, including medical images, up to this point. Among these technologies, encryption is the most intuitive and successful method of transforming images into ones that are not recognised [3], [4].We propose an image encryption technique to overcome the issues with existing medical picture encryption schemes. The well-known substitution-permutation network is used. First, random values are added into the image's surroundings.

In this paper we study some of the methodologies proposed in the recent and a comparative analysis is made among Several techniques depending on the parameters like size of the images, algorithmic techniques that are used and the security parameters (PSNR, SSIM etc) that are used to measure the efficiency of the algorithm.

The remainder of this work is arranged in the following manner. Section 2 introduces the current research for different medical image encryption scheme; Section 3 presents the proposed encryption scheme's simulation results and discusses its properties; Section 4 assesses the comparison of the results for several classical medical image encryption schemes; and Section 5 conclusion of the whole survey work.

II. Literature Survey

Some of the recent contributions on the same field is collected and discussed in the below section.

(Omar.et.al (2021)) [3], the encryption technique proposed for Encrypting chest computed tomography (CT) coronavirus (COVID-19) images into encrypted images to safely transmit real-world data of infected patients. The main point is to obtain integrity and the security of the COVID-19 persistent information employing a modern Hash-based BBS (HBBS) pseudo-random bit generator. This leads to a novel method to create pseudo-random bit-strings in arrange to provide a high level of security based on HBBS generator and hash operations. The proposed method is given to scramble COVID-19CT images to encrypted images for secure actual transmission. Specifically, a secure hash calculation (SHA-256) used to generate a hash value that is used for the agility and haphazardness of freed pseudo-random bits that generate various key streams. In this paper, the key stream bit string generated by the proposed HBBS is used to encrypt four COVID-19 images of chest CT scan, namely 'front', 'lung', 'side' and ' top side. These Images are randomly selected from public data sets [33] these four generic images are of size 256 × 256, with each pixel value representing a number between 0 and 255 at 8 bits. These encryption techniques provide a high level of encryption. Designed to provide secure encrypted data The original and encrypted image is shown in figure 1 using three HBBS keystream values. These entropy values are very similar to the theoretical value = 8, indicating that all encrypted image pixels are likely to occur. As a result, password image data leaks can be ignored and protected from entropy-based attacks.

(Barsha Bose, 2020) [4] This paper proposes encryption of medical images in order to achieve security over insecure network. The medical images of the patient's data are encrypted before transmission and the encryption process involves non-systematic cyclic coding. The work has been performed Cyber attacks in the frequency and spatial domains are also as expected with the results of the unaffected correlation coefficient. The proposed method is suitable for encrypting multiple medical images in the field of very high speed remote care.In this study, medical images was encrypted using the well-known circular coding and convolution coding. In general, there are two types of circular coding: non-systematic and systematic circular coding. They have used unsystematic circular coding. A well-known generator polynomial was selected in the encoding and decoding process. The first selected image was multiplied by the generator polynomial for encryption and decrypted at the receiving end using the reverse process. Their work was mainly in the frequency domain. Therefore, cyber attacks in some spatial domains are ineffective. In the proposed method, the decoding of a particular image depends on the choice of the appropriate generative polynomial. To verify the safety of the tour technique, they applied it to a selective ciphertext attack, which is the method of the very popular cyberattack. The correlation coefficient is one of the effective tools for measuring the effectiveness of image encoding processing. In both cases, the correlation coefficient gives a satisfactory result.

(Arindam Sarkar 2020) [12] This paper addresses the security risks in the use of telehealth during this COVID-19 pendamic scenario where telehealth plays an important role in e-health.This paper presents a guide to the original secret sharing system, TPM (Tree Parity Machine), for patient privilege-based security sharing. The proposed method produces compelling results showing that this method achieves a high level of protection, reliability, and efficiency and can be compared to existing secret sharing methods. Became clear. This system is a highly secure online information transmission module that can be integrated with all existing telemedicine systems. Analysis of histogram: Histogram analysis was performed in which both initial and encrypted clinical signals were accessed by the proposed program. If this method is successful, it will be displayed as a uniform distribution along with a random histogram of similar values. If the histogram is uniform, the cryptographic algorithm has excellent statistical properties. Figures 2,3 show histograms of general and encrypted information, respectively. Since the histogram of the encrypted information is uniform, the proposed method is robust against histogram-based statistical attacks.

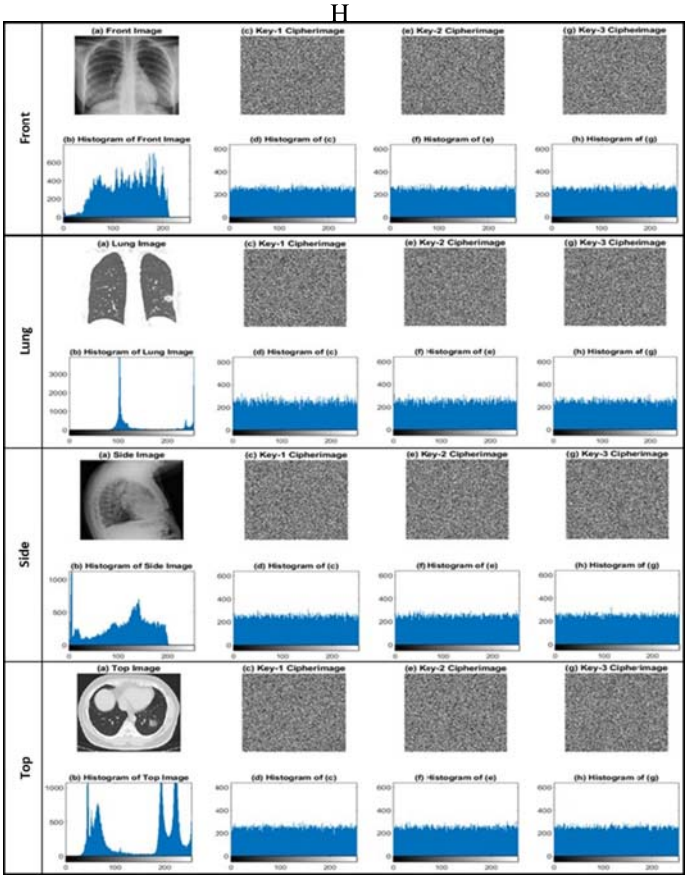

Fig. 1. Histogram of 4 CT normal images and corresponding cipher images. It contains 3 key streams: Key-1, Key-2, Key -3. using the state of the art method [3]

(Xiuli Chai, 2019) [5] This paper provides a new medical image encryption technology that combines Latin Square and a chaos system. A permutation and diffusion architecture is adopted. Using Latin rectangles and general image information to provide general images and permutations based on Latin squares (PPILS), mixing general image pixels into other rows and columns for strong correlation between adjacent

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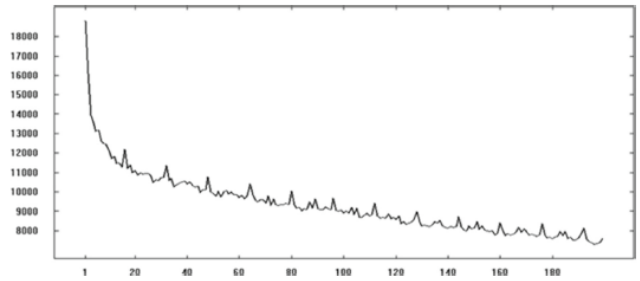

Fig. 2. Autocorrelation of the plaintext signal using using the state of the art method [11]

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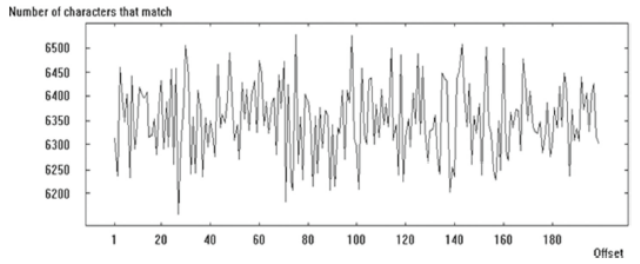

Fig. 3. Autocorrelation of the encrypted signal using using the state of the art method [11]

pixels It effectively weakens the relationship and makes the other images different. Permutation effect. To enhance the effectiveness of encryption, we propose bidirectional adaptive diffusion with little change in the normal image over the pixels of the encrypted image. Since the chaos sequences used for permutation and diffusion are generated by the 4D memristive chaos system and the initial values are calculated with the SHA 256 hash value of a normal image, the proposed algorithm is known general text and can withstand selective permutation attacks.

The flowchart of the proposed encryption algorithm

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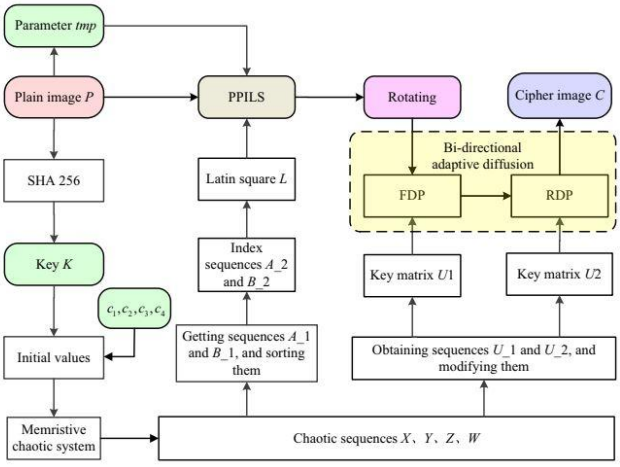

Fig. 4. Autocorrelation of the plaintext signal using using the state of the art method [11]

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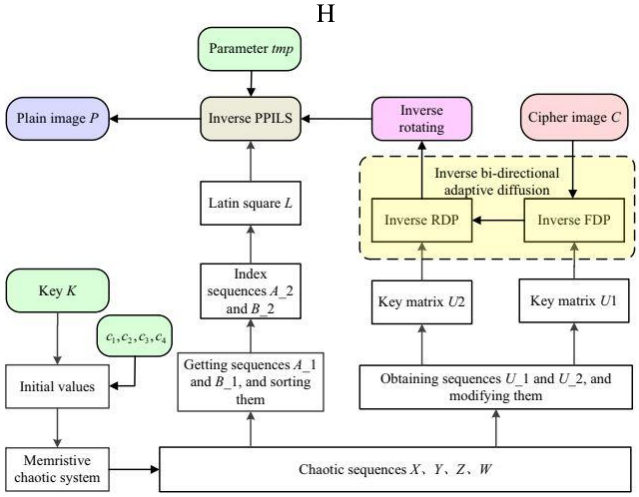

Fig. 5. Autocorrelation of the encrypted signal using using the state of the art method [11]

in [5] is shown in Figure 6 For the general image, first mix the general image with in a permutation based on Latin Square (PPILS), then rotate the permutation image 180 degrees clockwise to the next bi-direction adaptive diffusion. Is to change the pixel value in order to generate the encrypted image.of each step in the encryption process. Before decryption, the secret key K, parameter c1, c2, c3, c4, tmp should be sent to the receiver through the secure communication channel. The decryption process is illustrated in Figure 5

Xiaoyi Zhou,2021 [8] This paper mainly focuses on the security issues which have increased due to the increasing demand of the Telemedicine during this COVID-19 period. This paper proposes novel Reversible watermarking (RRW) algorithm based on the discrete wavelet transform to remove the limitations over embedded capacity, robustness and imperceptibility. The author explains the principle of reversibility using the Haar wavelet transform and discusses the use of some Zernike moment coefficients for image correction. they elaborated the steps of embedding and extracting in the robust reversible watermarking scheme and presents the experimental results of this scheme for watermark reversibility, robustness, imperceptibility, and embedding capacity. The proposed methodology is capable of preventing common and geometric attacks. Despite of having high embedding capacity, the algorithm is able to produce distortion free images. The paper contributes towards improving the security of medical images in tele-medicine and e-healthcare.

(Fares Kahlessenane, 2020) [10] The paper proposes a blind and robust approach in the field of Telemedicine and e-health care. The strategy comprises of the patient's information which are embedded with the image acquisition data. The clinical reading for both the original image and the watermarked image should be similar and the whole experiment has been accomplished in frequency domain. As a result spatial domain attacks can be avoided. The four transforms are utilized in their experiment 1. Discrete wavelets transform. .2. Non-subsampled Contourlet transform 3. Non-subsampled

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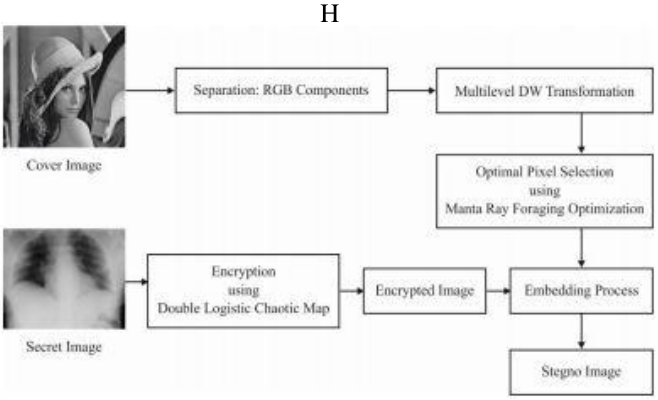

Fig. 6. Block diagram of the EIS-SDT model proposed in [44]

shearlet transform. 4. Discreet cosine transform. Further, Schur decomposition was combined with these four transform and the watermark bits were integrated in the upper triangular matrix.

(V. Pavithra, 2018) [2] This paper presents an investigation into the encryption technology used in medical imaging. In this paper, we introduce a comparative study of medical image encryption and expand the scene that is obvious to researchers by examining various existing statistics such as PSNR (maximum signal-to-noise ratio) and MSE (mean squared error). Encryption technology for medical images. This includes analyzing the security level, requirements, and purpose of medical image encryption. This investigation is helpful for researchers comparing the various cryptographic techniques implemented so far.

(Subhaluxmi Sahoo, 2020) In this paper, the author proposed a methodology in the spatial domain where COVID-19 X-Ray images are experimented [43]. In this approach, Dual Encryption is employed on the input Image data in addition with the generation of the Baconian Ciphers by using Encrypted DNA technique. This data was then inserted into the LSB of the image using logical operations. The insertion was performed in the LSB window of the image with the lowest average intensity. The final image is then reconstructed in the bit plane. The author has used Normalized Cross relation (NCC), Root Mean Square difference (RMD), and Average Difference (AD) for analysing the correlation between the original and the cipher image.

(Sultan Alkhliwi, 2021) [44]This paper proposes a novel encryption technique keeping an eye to achieve a secured data Transmission in this COVID-19 pendamic situation. The encryption process involves image steganography model(EIS-SDT) using a multilevel discrete wavelet transform. Further, Manta Ray Foraging Optimization (MRFO) algorithm has been employed for optimal pixel selection. To gain additional level of security, Double Logistic Chaotic map is used in the EIS-SDT model. Performance analysis like MSE and PSNR are used to measure the security of the proposed algorithm. Figure 6 shows the workflow included in the EISSDT model. Initially, the cover image is decomposed using a multi-level DWT, and the optimal pixel is selected by the MRFO algorithm. In addition, the secret image is encrypted by applying the DLCM model. The resulting Stego image reconstruction process is reversibly transferred to different hospitals.

III. Results Comparison

The various parameters used in different literature are taken into considerations to create the Table 1. The main factors of comparisons are Size of the image/Signals, the strategy or algorithms used and the security parameters those are used to quantify the strength of the algorithms. The primary aim of most of the literature are to provide algorithms which are robust, secured even in unsecured network and preserving quality of the images throughout the encryption and decryption process. So for evaluating the image with these factors, the different metrics used in some of the literature are illustrated in the table 1.

IV. Conclusion

Due to the on rise demand of the transmission of the patient's data over network, it is very much important to study the encryption techniques that can be used in this pandemic situation to ensure not only the security but also time-effectiveness. In medical imaging apart from security, data integrity also plays a vital role as chance of data loss is always there during Encryption and decryption process and as a result it may lead to false diagnosis of the patient. In this paper, a detailed review is discussed of the encryption techniques which involve COVID-19 medical images and the various information accompanying it.

References

[1] Basu Sanhita, Sushmita Mitra and Nilanjan Saha. "Deep learning for screening covid-19 using chest x-ray images", In 2020 IEEE Symposium Series on Computational Intelligence (SSCI), pp. 2521-2527. IEEE, 2020.

[2] Pavithra, V.,and C. Jeyamala, "A survey on the techniques of medical image encryption", In 2018 IEEE International Conference on Computational Intelligence and Computing Research (ICCIC), pp. 1-8. IEEE, 2018.

[3] Mohammad, Omar Farook, Mohd Shafry Mohd Rahim, Subhi Rafeeq Mohammed Zeebaree, and Falah YH Ahmed. "A survey and analysis of the image encryption methods", International Journal of Applied Engineering Research 12, no. 23, pp: 13265-13280, 2017.

[4] Bose Barsha, Diptana Dey, Anupam Sengupta, Nikita Mulchandani, and Anirban Patra, "A Novel Medical Image Encryption using Cyclic Coding in Covid-19 Pandemic Situation", In Journal of Physics: Conference Series, vol. 1797, no. 1, p. 012035. IOP Publishing, 2021.

[5] Chai Xiuli, Jitong Zhang, Zhihua Gan, and Yushu Zhang. "Medical image encryption algorithm based on Latin square and memristive chaotic system", Multimedia Tools and Applications 78, no. 24, pp: 35419-35453, 2019.

[6] Chen Lei, and Shihong Wang, "Differential cryptanalysis of a medical image cryptosystem with multiple rounds", Computers in biology and medicine 65, pp: 69-75, 2015.

[7] Cohen, Joseph Paul, Paul Morrison, Lan Dao, Karsten Roth, Tim Q. Duong, and Marzyeh Ghassemi, "Covid-19 image data collection: Prospective predictions are the future." arXiv preprint arXiv:2006.11988, 2020.

[8] Zhou Xiaoyi, Yue Ma, Qingquan Zhang, Mazin Abed Mohammed, and Robertas Damaševičius, "A Reversible Watermarking System for Medical Color Images: Balancing Capacity, Imperceptibility, and Robustness", Electronics 10, no. 9, pp: 1024, 2021.

[9] Paul Aditya Jyoti. "Recent Advances in Selective Image Encryption and its Indispensability due to COVID-19", arXiv preprint arXiv:2011.13740, 2020.

[10] Kahlessenane Fares, Amine Khaldi, Redouane Kafi, and Salah Euschi, "A robust blind medical image watermarking approach for telemedicine applications", Cluster Computing, pp: 1-14, 2021.

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TABLE I. COMPARISON ANALYSIS AMONG 6 STATE OF THE ART METHODS BASED ON SIZE OF IMAGE AND SECURITY PARAMETERS LIKE PSNR , MSE, UACI ETC.

References	Author	Image size	Algorithm used	Security parameters
[3]	Omar et al.	256 X 256	BBS	Correlation coefficient, Entropy, PSNR, MSE, NPCR, UACI
[4]	Barsa.et.al	512 X 512	Non Systematic Cyclic coding	Correlation coefficient, PSNR
[12]	Arindam Sarkar,2020			Correlation, Information Entropy
[5]	Xiuli Chai 2019	256 × 256, 512 × 512, 400 × 400	Permutation based on plain image and Latin square (PPILS)	Correlation coefficient, Histogram Analysis, NPCR, UACI
[8]	Xiaoyi Zhou,2021	512 × 512	Novel Reversible watermarking (RRW)	MSE,PSNR
[10]	Fares Kahlessenane, 2020	1024 × 1024	Blind and Robust Approach	PSNR, SSIM,NVC,STD,NCC
[43]	Subhaluxmi Sahoo, 2020	352x262,352x288,348x288, 334x288,337x288	DNA based Double Encryption Technique	Normalized cross-correlation (NCC), Root mean square difference (RMD), and Average difference (AD)
[44]	Alkhliwi, 2021		EIS-SDT	PSNR, MSE

[11] Reyad Omar, and Mohamed Esmail Karar, "Secure CT-image encryption for COVID-19 infections using HBBS-based multiple key-streams", Arabian Journal for Science and Engineering 46, no. 4, pp: 3581-3593,2021.

[12] Sarkar Arindam, and Moumita Sarkar, "Tree parity machine guided patients' privileged based secure sharing of electronic medical record: cybersecurity for telehealth during COVID-19", Multimedia Tools and Applications 80, no. 14, pp: 21899-21923, 2021.

[13] Shashikiran B. S., K. Shaila and K. R. Venugopal, "Minimal Block Knight's Tour and Edge with LSB Pixel Replacement Based Encrypted Image Steganography", SN Computer Science 2, no. 3, pp: 1-9, 2021.

[14] Bhowmik Anirban, Joydeep Dey and Sunil Karforma, "A novel Double Tier Cryptographic System (nDTCS) to Reinforce Patients' Privacy in Contemporary COVID-19 Telemedicine", 2021.

[15] Bokolo, Anthony Jnr. "Application of telemedicine and eHealth technology for clinical services in response to COVID-19 pandemic." Health and Technology 11, no. 2, pp: 359-366, 2021.

[16] Bokolo, Anthony Jnr. "Exploring the adoption of telemedicine and virtual software for care of outpatients during and after COVID-19 pandemic." Irish Journal of Medical Science (1971-), pp: 1-10, 2020.

[17] Kapoor Aditya, Santanu Guha, Mrinal Kanti Das, Kewal C. Goswami, and Rakesh Yadav, "Digital healthcare: The only solution for better healthcare during COVID-19 pandemic", Indian Heart Journal,2020.

[18] Kotian RP, Faujdar D, Kotian SP, D'souza B., Knowledge and understanding among medical imaging professionals in India during the rapid rise of the covid-19 pandemic, Health and Technology, pp:1-6, 2020.

[19] Rothe C., Schunk M., Sothmann P., Bretzel G., Froeschl, G., Wallrauch, C., et al., Transmission of 2019-nCoV infection from an asymptomatic contact in Germany. New England Journal of Medicine, 382(10), 970–971, 2020.

[20] Jordan, R. E., Adab, P., Cheng, K. K. (2020). Covid-19: risk factors for severe disease and death. BMJ,368,m1198.

[21] Kadir, M. A. (2020). Role of telemedicine in healthcare during COVID-19 pandemic in developingcountries. Telehealth and Medicine Today.

[22] Thiagarajan K. Covid-19: India is at centre of global vaccine manufacturing, but opacity threatens publictrust BMJ 2021; 372 :n196 doi:10.1136/bmj.n196.Covid-19: Indian health officials defend approval of vaccine. BMJ2021;372:n52.pmtid:33414156.

[23] L.B. Zhang, Z.L. Zhu, B.Q. Yang et al., Cryptanalysis and improvement of an efficient and secure medical image protection scheme, Math. Probl. Eng. 2015 (2015).

[24] Tamilarasi, K., Jawahar, A.: Medical data security for healthcare applications using hybrid lightweight encryption and swarm optimization algorithm. Wirel. Pers. Commun. 114(3),1865–1886 (2020). https://doi.org/10.1007/s11277-020-07229-x

[25] Balasamy, K., Ramakrishnan, S.: An intelligent reversiblewatermarking system for authenticating medical images usingwavelet and PSO. Clust. Comput. 22(2), 4431–4442 (2019).https://doi.org/10.1007/s10586-018-1991-8

[26] Boussif, M., Aloui, N., Cherif, A.: DICOM imaging water-marking for hiding medical reports. Med. Biol. Eng. Comput.58(11), 2905–2918 (2020). https://doi.org/10.1007/s11517-020-02269-8

[27] Kahlessenane, F., Khaldi, A., Kafi, R., Euschi, S.: A DWT basedwatermarking approach for medical image protection. J. AmbientIntell. Hum. Comput. (2020). https://doi.org/10.1007/s12652-020-02450-9

[28] Balu, S., Nelson Kennedy Babu, C., Amudha, K.: Secure andefficient data transmission by video steganography in medicalimaging system. Clust. Comput. 22(2), 4057–4063 (2019).https://doi.org/10.1007/s10586-018-2639-4

[29] Khaldi, A.: Diffie–Hellman key exchange through steganographied images. Law State Telecommun. Rev. 10(1), 147–160(2018). https://doi.org/10.26512/lstr.v10i1.21504

[30] Gul, E., Ozturk, S.: A novel triple recovery information embedding approach for self-embedded digital image watermarking.Multimedia Tools Appl. 79(41), 31239–31264 (2020). https://doi.org/10.1007/s11042-020-09548-4

[31] Senthilnathan, T., Prabu, P., Sivakumar, R., Sakthivel, S.: Anenhancing reversible data hiding for secured data using shuffleblock key encryption and histogram bit shifting in cloud environment. Clust. Comput. 22, 12839–12847 (2019). https://doi.org/10.1007/s10586-018-1765-3

[32] Khaldi, A.: Steganographic techniques classification according toimage format. Int. Ann. Sci. 8(1), 143–149 (2020). https://doi.org/10.21467/ias.8.1.143-149

[33] Cohen, J.P.; Morrison, P.; Dao, L.: COVID-19 image data collection. arXiv, vol. IV, p. 2003.11597 (2020)

[34] Devanna, H., Satish Kumar, G.A.E., Giri Prasad, M.N.: A spatio-frequency orientational energy based medical image fusion using non-sub sampled contourlet transform. Clust. Comput. 22,11193–11205 (2019). https://doi.org/10.1007/s10586-017-1351-0

[35] Hu, H.-T., Chang, J.-R.: Efficient and robust frame-synchronizedblind audio watermarking by featuring multilevel DWT andDCT. Clust. Comput. 20(1), 805–816 (2017). https://doi.org/10.1007/s10586-017-0770-2

[36] Fares, K., Amine, K., Salah, E.: A Robust blind color imagewatermarking based on Fourier transform domain. Optik 208,164562 (2020).https://doi.org/10.1016/j.ijleo.2020.164562.

[37] Kavitha, C., Sakthivel, S.: An effective mechanism for medicalimages authentication using quick response code. Clust. Comput.22(2), 4375–4382 (2019). https://doi.org/10.1007/s10586-018-1905-9.

[38] Rayachoti, E., Tirumalasetty, S., Prathipati, S.C.: SLT basedwatermarking system for secure telemedicine. Clust. Comput. 23,3175–3184 (2020). https://doi.org/10.1007/s10586-020-03078-2.

[39] Chowdhury, M.E.H., Rahman, T., Khandakar, A., Mazhar, R.,Kadir, M.A., Mahbub, Z.B., Islam, K.R.: Can AI help inscreening viral

and COVID-19 pneumonia? IEEE Access 8,132665–132676 (2020). https://doi.org/10.1109/ACCESS.2020.3010287.

[40] Rajkumar, R., Vasuki, A.: Reversible and robust image water-marking based on histogram shifting. Clust. Comput. 23,12313–12323 (2019). https://doi.org/10.1007/s10586-017-1614-9.

[41] Salah, E., Amine, K., Redouane, K., Fares, K.: A Fourier transform based audio watermarking algorithm. Appl. Acoust. 172,107652 (2021). https://doi.org/10.1016/j.apacoust.2020.107652.

[42] Balasamy, K., Suganyadevi, S.: A Fuzzy based ROI selection forencryption and watermarking in medical image using DWT andSVD. Multimedia Tools Appl. (2020). https://doi.org/10.1007/s11042-020-09981-5.

[43] S. Sahoo and S. S. Sahoo, "A new COVID-19 medical image steganography based on dual encrypted data insertion into minimum mean intensity window of LSB of X-ray scans," 2020 IEEE 17th India Council International Conference (INDICON), 2020, pp. 1-6, doi: 10.1109/INDICON49873.2020.9342067.

[44] Sultan Alkhliwi, "Encryption-based Image Steganography Technique for Secure Medical Image Transmission During the COVID-19 Pandemic" IJCSNS International Journal of Computer Science and Network Security, VOL.21 No.3, March 2021