Improved Secure IoTs-Based Visual Computing with Image Processing and Artificial Intelligence Techniques for Accurate Predicting of Novel COVID

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Abstract

Secure Internet of Things (IoTs) have evolved into a requirement for electronic healthcare systems. In most cases, health images contain sensitive information about patients that must be protected. Traditional encryption cannot be directly applied to image data due to restrictions in digital data attributes. Additionally, patients may lose the confidentiality of their data when private images are transmitted via a network. Thus, multimedia Artificial Intelligence and image processing are applied to build improved secure IoTs. To guarantee accurate and privately protected e-health services, a secure lightweight key frame extraction approach is essential. Additionally, when taking into account the limitations of real-time e-health systems, it can be challenging to establish a satisfactory degree of security in an economical manner. An encryption scheme that contain a hashing version of the Blum Blum Shub (BBS) generator, namely Hash-BBS (HBBS) is suggested and built to achieve a high grade of integrity and confidentiality in transmission data of COVID-19 CT-images for patients. Also, an AI technique is applied for COVID-19 testing such as adopted a convolutional neural network. Evaluation showed that the proposed framework outperformed alternative security and transfer learning methodologies in secure prediction. Therefore, it can be used to reliably transmit CT-images for COVID-19 patients while meeting strict security and prediction benchmarks.

Keywords: IoT, Privacy, COVID-19, CT Images, Neural Network.

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1 Introduction

Due to the IoTs in the healthcare industry, numerous sensors of medical equipment for use at home are already commonplace. As a result, in an IoT healthcare scenario, users can upload physical health data that generated from medical sensors to assist in making their own medical diagnoses for obtaining advice professional in healthcare (Sun, Y., 2021). Additionally, due to the rapid growth of information technology, these types of self-helped service medical gadgets are becoming more individualized, accurate, and portable (Zhang, Y., 2018). Intelligent medical diagnosis is, thus, a promising and an irresistible development in the field of medicine. Given the growing popularity of IoT healthcare, it will be incredibly easy for patients to receive customized and expert diagnostic reports whenever and wherever they need them (Al-Hashimi, M., 2022). However, strict regulations regarding the privacy of their patients' information make it difficult for doctors to provide effective care. Due to the healthcare information system's security flaws, medical information leaks have become more frequent in recent years (Mosa, A.M., 2022). Therefore, protect the security of the data base of the doctors and current diagnosed patients' information have been very important applications. Intelligent medical diagnosis is hard to use and develop because it is hard to get reliable and accurate medical results, which makes secure searches of doctors' case-databases for related diagnosis reports a trend toward future intelligent medical diagnosis (M Allayla, N., 2022).

Computed Tomography (CT) and Chest X-rays, for example, have been regarded as powerful medical imaging tools for spotting COVID infections. Additionally, the current investigations have validated volumetric CT-thorax imaging for lungs and soft tissues to help doctors distinguish COVID patients (Al-Khafaji, H.M.R., 2022). The primary characteristics of CT scans for COVID patients contain multifocal patchy consolidation, distributed lesions, and Ground-Glass Opacity (GGO) in the peripheral part of lungs (Abed, A.S., 2022). Alongside emerging communication technologies and medical imaging techniques, utilizing the internet to transmit patient information is one way in which healthcare has used these technological advances (Burhan, I.M., 2021). Therefore, it is crucial to safeguard patients' privacy by encrypting any data they send over public computer networks. To complete the necessary tasks of patient data security, cryptographic techniques have a crucial function containing various technologies of medical imaging such as CT and MRI (Jawad, M.R., 2021). In light of the COVID pandemic, this research focuses on medical CT-images as its target. This paper presents an effort to employ sophisticated encryption methods to prevent illegal access to CT-images of patients with deep learning technique for predicting. The encryption algorithm can also be used on any sort of image to meet strict security and privacy standards.

This paper's remaining sections are structured as follows. Sect. 2 talks about the studies that have been done on various encryption techniques also about related works of corona research. In Sect. 3. The proposed framework has been offered. Sect. 4 determine the findings of the experiments and the discussion. In Sect. 5, the results of this research are summarized.

2 Literature Survey

Related Works on Privacy-preserving Healthcare

To address the issue of preserving privacy, many earlier studies introduced some cryptography technologies (Feng, C., 2020) (Yu, K., 2015), such as full holomorphic encryption (FHE) (Gentry, C., 2009), (Rajan, D.P., 2019). These techniques are impractical for large-scale application situations because of the high computing costs necessitated by FHE's limitations. In addition, alternative RSA-based solutions have been presented by other researchers (Ogata, W., 2004). Nevertheless, the RSA signature system is workable under certain conditions. If the RSA known target inversion problem (RSA-KTI) is difficult, then the RSA signature system is secure. Additionally, the privacy data is divided into various parts by the privacy-preserving search technology based on secret sharing (Karnin, E., 1983) and differential privacy (Dwork, C., 2008), regulates the amount of stock purchased in order to meet certain, individualized privacy goals; and When a user requests data retrieval, a user-defined threshold policy translates the privacy data to n copies and then randomly chooses K copies from n sub-data sources. It's inefficient and insecure for real-time communication because of all the extra steps it adds. As a novel cryptographic primitive, searchable encryption (Bellare, M., 2007) enables users to look up keywords in the domain of cipher text. Data is always encrypted on the cloud server, and the server's processing capacity is put to use to recover keywords without compromising users' privacy in these methods. This method not only dramatically enhances retrieval efficiency with the use of a cloud server, but it also protects the privacy of the user in a very effective manner (He, W., 2014). With practice, however, it's not easy to keep your cloud provider from aiding in partial decryption.

In short, these solutions are not appropriate for the secure one-to-one information searching situation in our everyday lives since they introduce a third party or other participants. In this regard, even though numerous novel approaches have consistently been made as new semiconductor, microcontrollers and sensors technologies have been developed in IoT healthcare. Few of researchers have been given security any thought. Figure 1. offers flowchart of preserving privacy In IoTs (Gheisari, M., 2017).

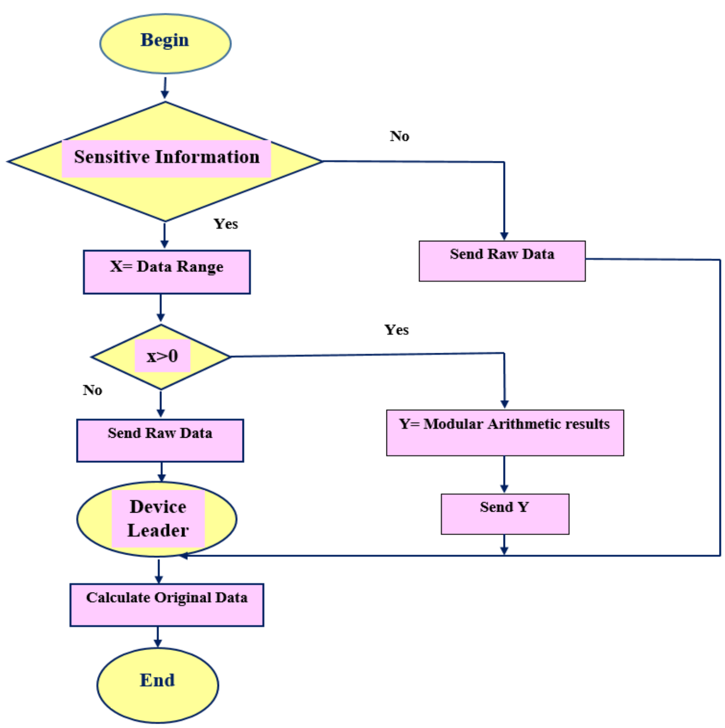

Figure 1: Flowchart of Preserving Privacy In IoTs

Related Works on COVID Research

The study of COVID is doing well at the present time in a number of different fields. Patients afflicted with COVID and other diseases are supported by an array of scalable telehealth services, discussed at length in Reference (Ullah, S.M.A., 2021).

Reference (Islam, M., 2020) this article talks about the different breathing aids and monitoring devices that are often used to help people with coronavirus. The technologies that are being employed to help sick patients breathe are summarized in Reference (Islam, M., 2020). They give a comparative examination of the requirements, difficulties, and potential future directions of the developed devices in order to choose the most cost-effective technologies. In a smart city network, references (Rahman, M.M., 2020) suggest a system that stops the spread of corona by identifying individuals who are not donning a facial mask. With the possibility of CT scans serving as an additional screening tool for corona, In addition to the difficulties with CT interpretation for corona screening, there have been many research done on using CT scans to spot corona. Deep learning is currently frequently utilized in all corona research projects aimed at containing the current pandemic (Asraf, A., 2020) (Muhammad, L.J., 2020), Recently advanced frameworks depend on DL approaches employing several medical imaging modalities, such as X-ray and CT, are summarized in reference (Islam, M.M., 2021). A data-base of hundreds of CT scans from corona positive states was created by Reference (He, X., 2020) and achieved excellent sampling efficiency in a deep learning technique depend on transfer learning (Wu, Z., 2018) and self-supervision (Pan, S.J., 2009). Additionally, scientists have created an AI system that can recognize corona and distinguishing it from other types of pneumonia and from healthy individuals (Zhang, K., 2020). Additionally, reference (Ning, W., 2020) produced a library of 1,521 CT scans of pneumonia patients (containing those with corona), several medical symptoms (a series of symptoms containing cellular and bio-chemical analysis of urine and blood), in addition, established forecasting about the likelihood that each patient will have negative, mild, or severe cases. Reference (Gunraj, H., 2020) suggested a deep CNN structure, COVIDNet-CT, for CT image-depend machine-driven design discovery.

3 Proposed Methodology

Hyper Parameter Settings for Training

Figure 2. Depicts the overall flow diagram of the deep learning-depend COVID identifying framework. The generated model is evaluated based on the training data, and any necessary adjustments are made based on the test data. The framework may be applied to catch the feature from the test, and then it can be used to determine the class targets based on the feature. Finally, the constructed framework is evaluated based on a set of criteria, including sensitivity, accuracy, specificity, and so on. We calculated the gradient using a new set of randomly chosen b CT images and adjusted the network parameters at each iteration. We deviated from the conventional training procedure by placing limits on the training steps rather than the epochs of iteration. We applied stochastic gradient descent (SGD) to choose the hyper parameters. Following an RGB reordering step, a 512 x 512 x 3 image was used as the final input to the suggested model. In terms of data augmentation, we initially customized the corona images for the training set in accordance with the annotated frame, and the images were first scaled up to 512 ×512 pixels, then randomly divided into 480 ×480 pixels, flipped horizontally at random, and then normalized. Simple cropping alterations were made in accordance with the annotation for the test set, then changed their size to 480 480 (Zhao, W., 2021).

COVID-19 Image Encryption

There have been numerous proposals in recent years for encrypting both traditional images, and medical images. CT-images- encryption can be a useful application because of the enormous amount of data and high correlation between neighboring pixels, making stream cipher over block cipher strongly preferred.

When encrypting medical images, the key-stream must have high periodicity and good randomness qualities. Consequently, it is confirmed that medical data is transmitted securely.

In this work, three COVID-19 lung CT scan pictures are encrypted using the key-stream bit-strings created by the suggested HBBS. These images were chosen at random from the public database. These three simple images each have a size of 256 by 256 pixels and each pixel value has an 8-bit representation that ranges from 0 to 255. Three CT plain images entropy values are shown as an example of the study's findings. Our encryption method is intended to secure cryptographic data at a high degree. In Figure 2, we see the four main operations that make up the block diagram of the suggested encryption technique. Each image block is first divided into 8×8 sub-blocks in the suggested framework. Next, the transpose operation is performed on each matrix in the sub-block. S-box substitution operation follows it, and bit permutation has been completed at last. For the purpose of the encryption operation, the HBBS key-stream is further separated into 8×8 sub-keys. Separate plain image blocks are XORed with their respective sub-keys. The final cipher image is constructed by assembling the cypher blocks that have been obtained (Reyad, O., 2021).

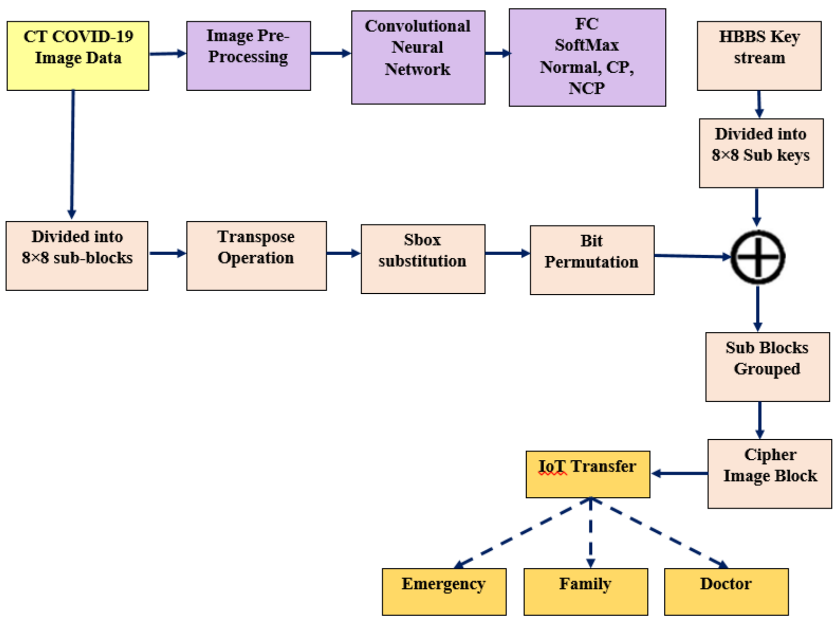

Figure 2: Proposed Framework

4 Results of Experiments

Although performance indicators are helpful for evaluating models, they are unable to explain how the network makes decisions. To this end, we used the Grad-CAM59 visualization method during COVID-19 testing to investigate potential trouble spots in the models, for identifying the most important CT image features for diagnosis, and therefore supporting clinical judgment. Using the detection frame, we first cropped the images as shown in Figure 4, used Grad-CAM to blow them up to 480 ×480 pixels for easier comprehension. The findings of the actual detection match every prediction made by the model utilizing CT scans in Figure 4. The model's results are comparable to what one would expect from a human's average visual cognition abilities in the vast majority of circumstances. This is especially true for common pneumonia, as the framework successfully highlights the disease-affected lung regions and displays them.

In addition, the radiologist can use the color visualization technique provided by Grad-CAM to make quick and secure diagnoses. The model concentrates more on the lower region for the norm scenario. While SARS-CoV-2-related novel coronavirus pneumonia, was detectable in the CT scans as shown in Figure 3, the peripheral texture was what the model focused on most. Further investigation into such a visual heuristic that differs from human visual perception is warranted, to better understand the COVID-19 detection methodology and the features that they deem most diagnostic. A better understanding of the model's efficacy in testing of COVID would be facilitated by the identification of these characteristics, in addition for supporting clinical practitioners in the development of new visual indicators for COVID infections for applying in manual screening using CT scans.

Briefly, Figure 3, Figure 4, and Figure 5 offers the original, Grad-CAM, histogram of original, cipher image, and histogram of cipher image for the three cases respectively; novel coronavirus pneumonia, common pneumonia, and normal. Table 1 and Table 2 offers the specificity and sensitivity for the three cases. The randomness of an image's pixels can be quantified by calculating its entropy, denoted as E (i). Equation (1) can be utilized to compute it. Values of entropy and basic parameters for the three cases of corona of plain and encrypted images using the four key-streams described in Figure 6, 7, and 8, also are listed in Table 3, Tbale4, and Table 5. These entropy levels are quite close to the theoretical value of 8, which means that the probability of occurrence for every encrypted image pixel is the same. As a result, cypher pictures leak very little information and are safe from entropy-based attacks.

$$E(i) = -\sum_{x=0}^{255} (P(i_x) log_2 P(i_x)) \qquad (1)$$

The cipher image must demonstrate a significant difference from the matching plain image. This can be done with two main methods: MAE and MSE. Equation (2) and equation (3) can be used to calculate various MAE and MSE values. In Table 3, Table 4, and Table 5 the MSE and MAE values of the cypher images that were found are shown. High MAE and MSE values confirmed that our encryption approach for sensitive medical images is extremely resistant to the sorts of attacks tested.

$$MAE = \frac{1}{w \times H} \sum_{j=1}^{H} \sum_{x=1}^{W} /(P_{xj} - C_{xj})/ \qquad (2)$$

$$MSE = \frac{1}{w \times H} \sum_{j=1}^{H} \sum_{x=1}^{W} \left(P_{xj} - C_{xj}\right)^2 \qquad (3)$$

Diffusion and ambiguity necessities are quantified with two distinct metrics: UACI and NPCR. Table 3 lists the average UACI and NPCR values for the three plain images, with only a one-bit difference between them. The results demonstrated that for NPCR, the average proportion of altered pixels in an encrypted image is greater than 99.61% and for all key-streams created, UACI scored 33.09%, providing superior resilience against differential attacks.

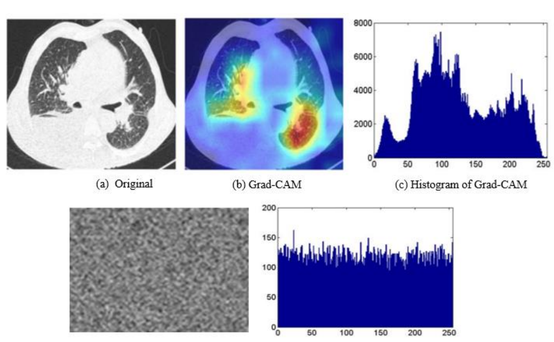

Figure 3: Common Pneumonia Case

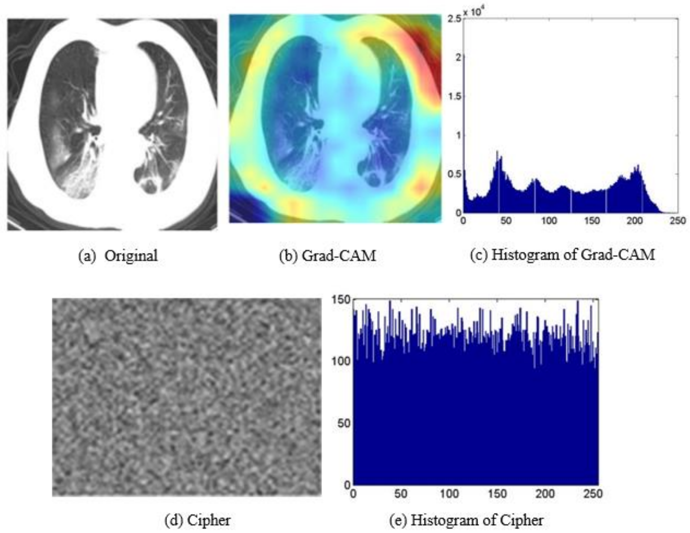

Figure4: Novel Coronavirus Pneumonia Case

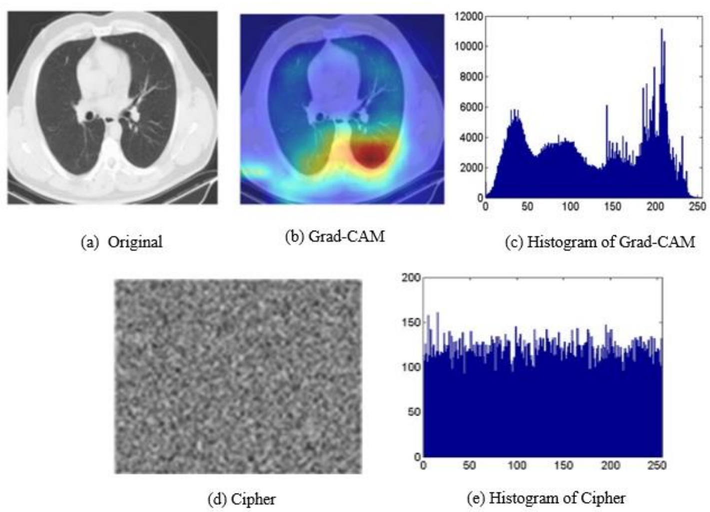

Figure 5: Normal Case

Table 1: Sensitivity

Network	Novel Coronavirus Pneumonia	Common Pneumonia	Normal
Corona-Net CT-1	82.2	87.1	88.4
Corona-Net CT-2 L	87.4	90.2	89.2
Corona-Net CT-2 S	89.7	91.4	91.2
Random(ours)	90.1	90.6	90.4
Bit-S(ours)	92.2	92.8	91.9
Bit-M(ours)	91.9	94.2	94.2

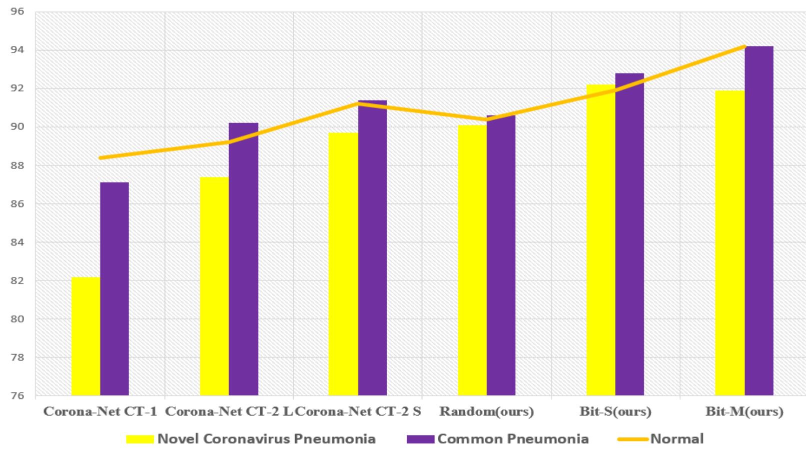

Figure 6: Sensitivity

Table 2: Specificity

Network	Novel Coronavirus Pneumonia	Common Pneumonia	Normal
Corona-Net CT-1	80.3	88.2	88.4
Corona-Net CT-2 L	80.7	89.4	89.3
Corona-Net CT-2 S	89.2	91.3	91.4
Random(ours)	90.7	92.1	92.7
Bit-S(ours)	91.4	92.4	92.8
Bit-M(ours)	91.8	91.7	92.9

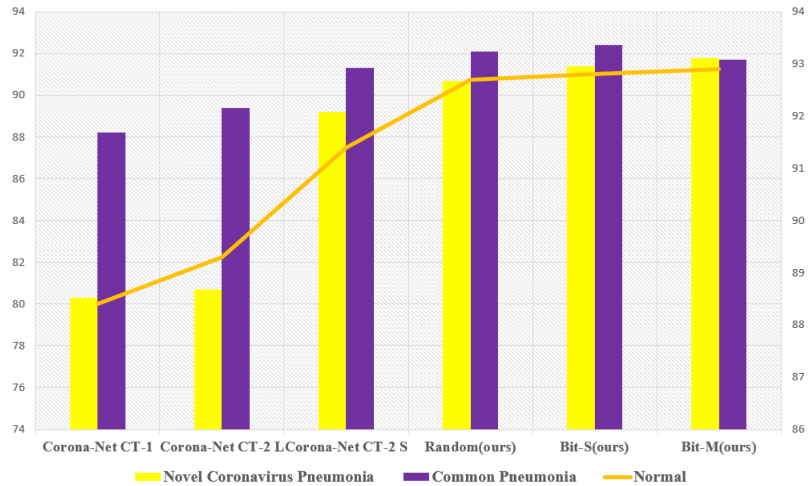

Figure 7: Specificity

Table 3: Basic Parameters for Common Pneumonia Case

Scheme	Entropy	MAE	MSE	NPCR	UACI
Key 1	8.2243	75.92	79.02	99.98	25.12
Key 2	8.0244	75.11	79.77	99.37	25.44
Key 3	8.1427	75.47	79.32	99.48	25.91
Key 4	8.5575	75.88	79.64	99.51	25.99

Table 4: Basic Parameters for Novel Coronavirus Pneumonia Case

Scheme	Entropy	MAE	MSE	NPCR	UACI
Key 1	8.6733	76.02	80.43	99.44	26.11
Key 2	8.1124	76.99	80.95	99.23	26.85
Key 3	8.1117	76.87	80.22	99.97	26.72
Key 4	8.2245	76.94	80.04	99.47	26.77

Table 5: Basic Parameters for Normal Case

Scheme	Entropy	MAE	MSE	NPCR	UACI
Key 1	8.0053	77.09	81.33	99.77	28.12
Key 2	8.1475	77.52	81.75	99.45	28.44
Key 3	8.2514	77.08	81.04	99.87	28.91
Key 4	8.9428	77.42	81.77	99.31	28.99

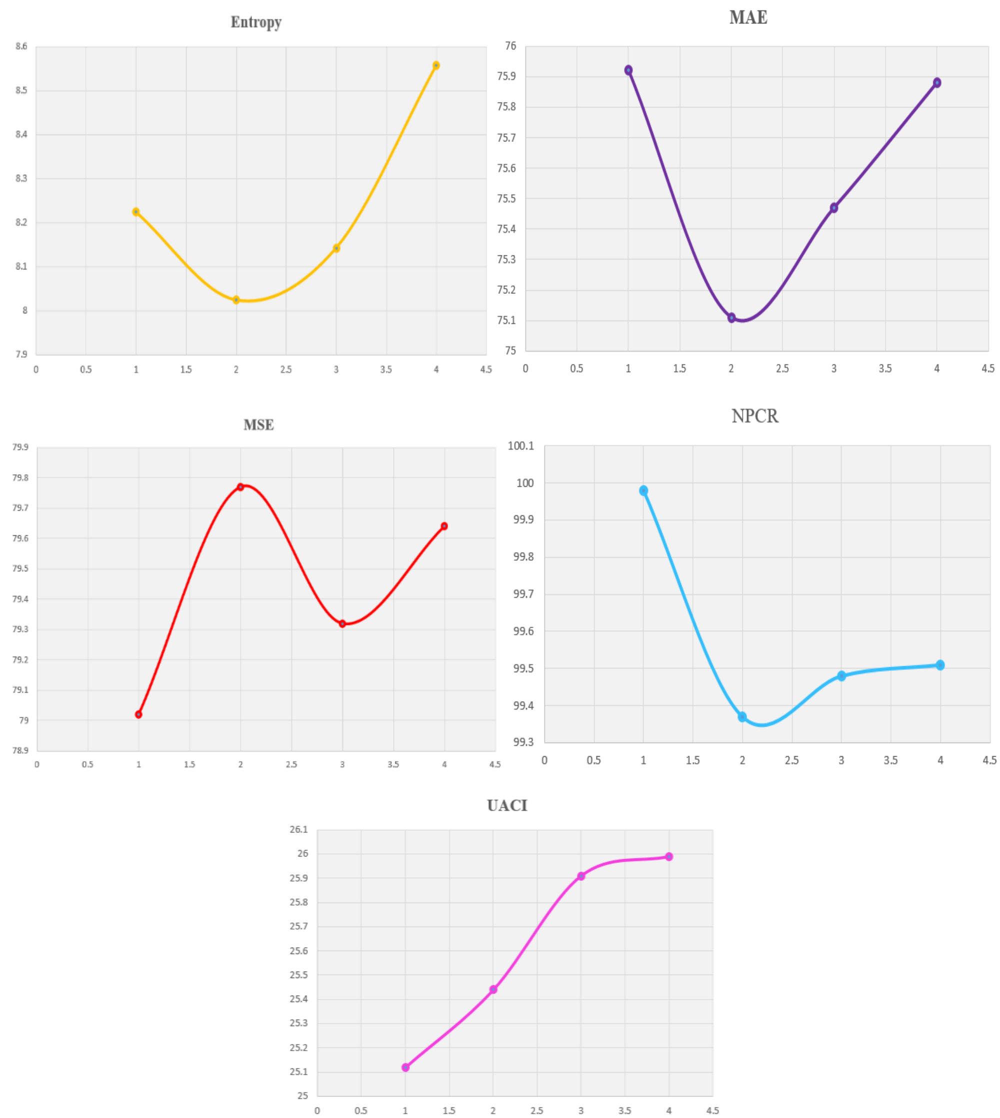

Figure 8: Parameters for Common Pneumonia Case

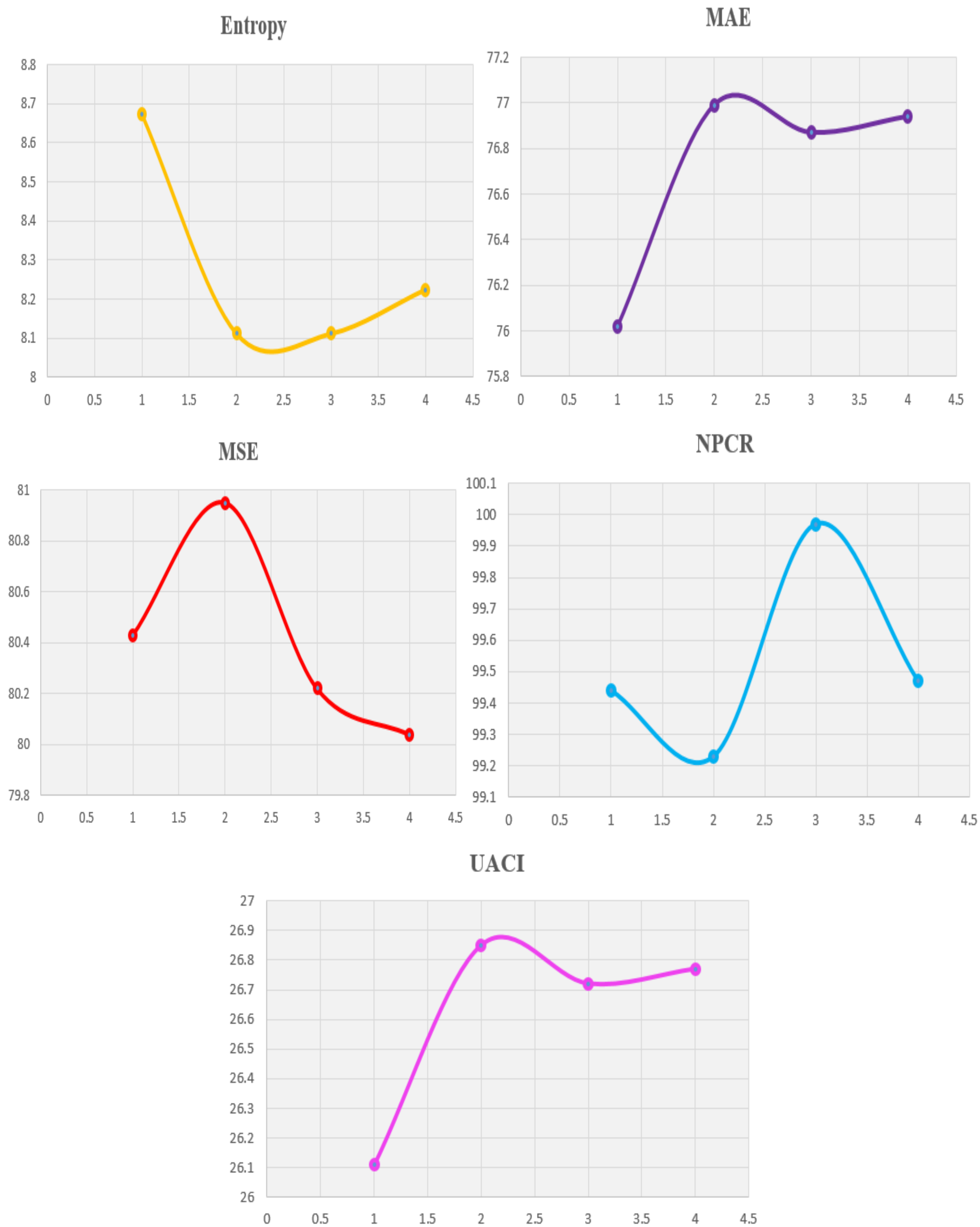

Figure 9: Parameters for Novel Coronavirus Pneumonia Case

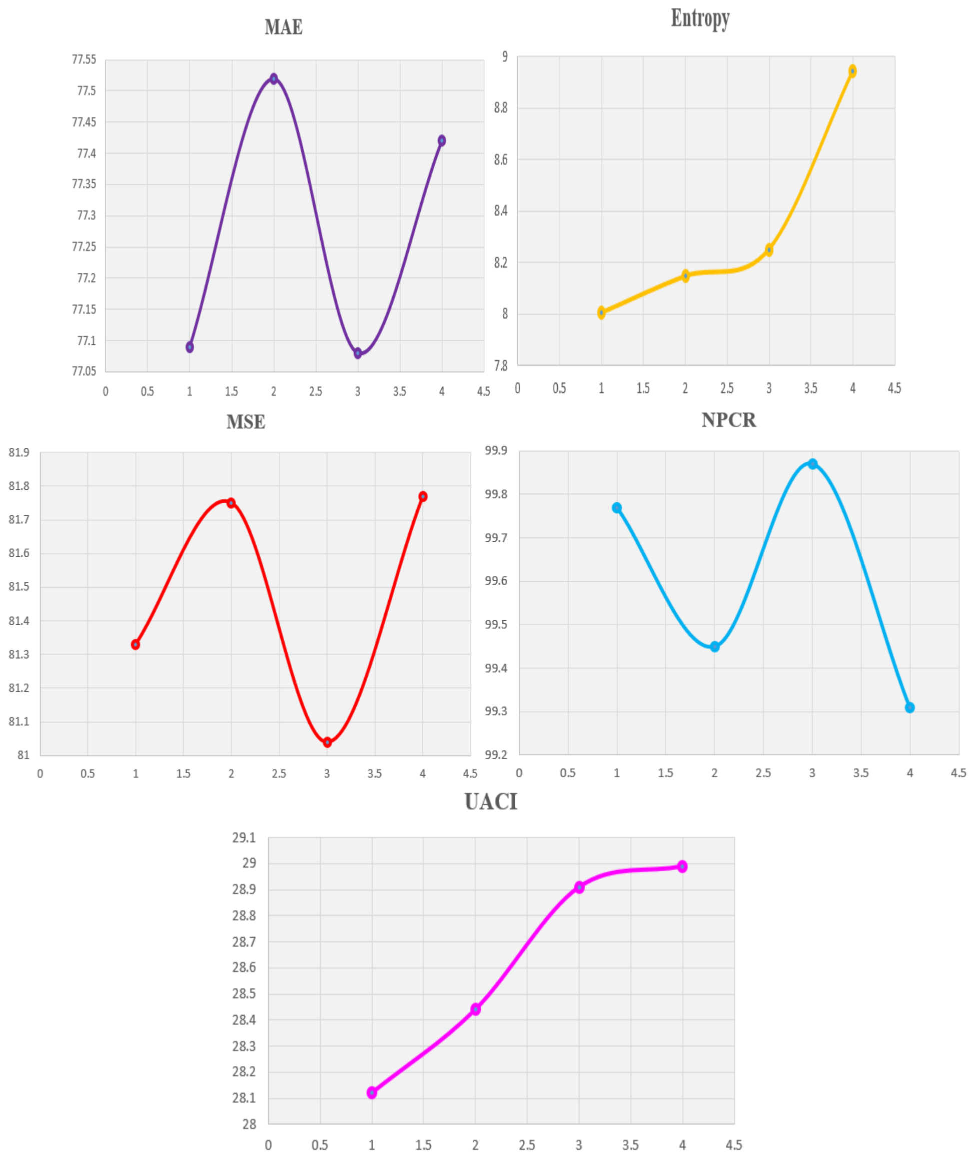

Figure 10: Parameters for Normal Case

5 Conclusions

This paper proposed a new framework that integrate four important technologies; privacy preserving, IoTs, AI and IP to generate effective system, which have high levels of security and prediction depend on the generator of HBBS, hash function, and deep learning. The suggested system is achieved to encrypt COVID CT-images into cipher images for transmitting in secured real-world. Also, for the prediction of cases of COVID for patients, the neural network has been used. We are used three CT COVID images for testing the proposed system in privacy preserving and forecasting. Specificity, sensitivity, MAE, MSE, entropy, NPCR, and UACI have been used as a performance measures for testing the new framework. The findings of evaluating the assessment offered that suggested framework has good efficiency in predicting and identifying case of corona and high security to be suitable for smart telemedicine and medical applications.

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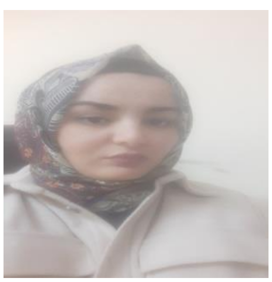

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