UNSYNCHRONIZED ANN & GENETICS GUIDED TELECARDIOLOGY SECURITY REINFORCEMENT IN THE LIGHT OF COVID-19

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Abstract

In this COVID-19 crucial stage, cryptographic developments help to convey secret information inside the digital telemedicine frameworks. The novel corona virus had broken all configurations of our life. In the clinical medical sciences, patients are encouraged to select the remote based telemedicine services. Cardiac patients are especially defenseless to this COVID-19. Patients having Chronic Obstructive Pulmonary Diseases (COPDs) as co-morbidity are enthusiastically prescribed to remain protected at their remote isolations. Through such telecardiology, they might impart their basic data with various cardiovascular experts. This will diminish their odds of getting COVID-19 positive because of no actual developments outside homes. Patients experiencing such significant COPDs are to be analyzed and treated appropriately via cardiologists. Contemporary imperfections on patients' private data are an open challenge in such telecardiology. Electronic cardiac data are very much vulnerable in nature. Along these lines, it is exceptionally critical to force a high level security strategy in such COVID-19 telecardiology. In this paper, we have generated session key based on unsynchronized artificial neural networks and genetic algorithm. Two unsynchronized ANNs were considered to have two intermediate keys. These keys were genetically crossover to form the session key. Furthermore, that session key would e used in the secret share generation process. Entropy values observed with respect to the secret share were nearly closed to eight. Histogram, floating frequency, and autocorrelation, etc were generated by the proposed technique with well-distributed in shapes. The functional time in the form of encryption and decryption were evaluated in this paper for different secret shares. Patients' medical data are very much under severe risk of intrusion. Lastly, secret shares were transmitted through RSA. This framework acts against various security conducts in correspondence network particularly where online clinical exchanges have overflowed colossally in this COVID-19 period.

Keywords: *COVID-19 telecardiology, Unsynchronized ANN, Session Key, Secret Sharing, Functional time*

1. Introduction

Clinical online benefits may be described as the exhibition of providing treatments to patients' wellbeing through digital modes. This may be accomplished with Internet services and computers. Such are regularly regulated by the specialists under a clinical consideration system. Right when these organizations are given through Internet enabled centers, this goes under the telemedicine. Such change has arisen altogether with the appearance of COVID-19. The novel Ccorona virus has constrained us to move from Out Patient Department (OPD) visits to virtual visits. Therefore, the patients encountering non-invasive cases may be managed remotely through the telemedicine support. The objectives of social distance, lockdown conventions, disinfection, and so on ought to be kept up the mass people to try against this perilous COVID-19. In any case, through COVID-19 teleprescriptions, such patients can be relieved from their secured far off regions anytime. Similarly, noscomial diseases can be made to zero for such patients. In light of this pandemic, clinics, medical care facilities and specialists' chambers have moved from genuine offline modes to virtual conversation modes through Internet empowered gadgets. Specialists, clinical staffs, attendants, specialized staffs, patients, clinical benefits staffs, etc are then less introduced to COVID-19 when they join under the umbrella of telemedicine. In this perspective, the most recent things in clinical consideration industry are the protected digitization of clinical benefits systems [1].

With the wide improvements in the high level clinical area, manageability of lossless and got information correspondence is a foundation issue. Putting the patients’ privacy statement viable, the rise of cryptography strategy is a superior arrangement approach for achieving the social helpful turns of events. In this manuscript, we have considered cardiological issues in the period of COVID-19. During the current pandemic time, cardiac patients were restricted within their homes to prevent themselves from COVID-19. They were recommended to use telemedicine for non-invasive cases. Such cardiac patients’ sensitive data need to be encrypted to resist against different kinds of intrusions. A class of heart illness / diseases that includes the limiting or blockage of the supply arteries or veins is known as Cardiovascular Diseases (CVDs) [2]. There are diverse CVDs like coronary artery diseases (CADs), cardiovascular stroke, cardiovascular breakdown, hypertensive coronary illness, heart arrhythmia, and so on. Heart patients are at the highest threshold of COVID-19 assaults. Their invulnerability has been compromised because of drawn out Chronic Obstructive Pulmonary Diseases (COPDs). In the telecardiology, online transmission of patients' information would be imparted over the public networks [3-6]. During the time of COVID-19, the rise of COVID-19 telecardiology has supported a huge number of cardiovascular patients. They have taken virtual visits from their cardiologists. The main worries in such COVID-19 telecardiology are that interlopers hush up well enough to get the information while information going through the public paths. Accordingly, they harm the information as well as make counterfeit cases for repaid approaches to the patients. In the said association, execution of safety on the classified information is to be contrived. This paper has proposed unsynchronized ANN and genetics guided session key generation followed by secret shares formation [7]. Harder intricacies were added to reinforce its belongings.

Electro Cardio Graph is a method which records the electrical activities done by the heart [8-9]. It is a continuous process of polarization and depolarization of the heart muscle within its four cabinets. Four cabinets are: left autrium, right autrium, left ventricle, and right ventricle. The significant components of an ECG are P-wave, QRS complex and T-wave. P wave is the atrium activation with SA node, QRS is the ventricular activation and T-wave is the recovery state to restart again. It has been shown in figure 1.

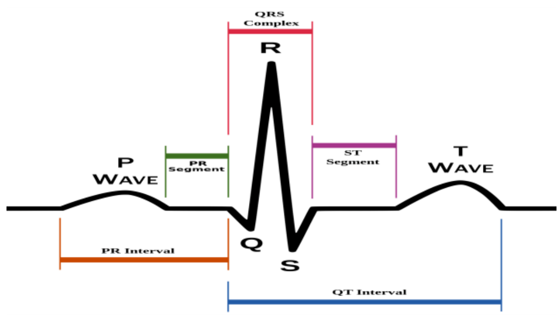

Figure 1: Components of ECG

The manuscript has been composed as follows. The section 1 has the introduction. Related works were discussed in section 2. The section 3 presents the proposed algorithm. Section 4 deals with different results which were carried in this proposed technique. Validation has been mentioned in section 5. Conclusions were added at section 6. Acknowledgement, Ethical Statements, and References were written at the end.

2. Related Works

This section presents the related papers on telecardiology. Amicable services were rendered by the telecardiology fraternity in this corona virus pandemic [10]. Telecardiology is the most suited method to treat non-invasive COPD patients from their homes. Nan J. et al. [11] had referred to the productivity of COVID-19 telecardiology for ST Segment Elevation Myocardial Infarction (STEMI). In the crisis hours of lockdown and social isolation, STEMI patients can remotely be taken care of with telemedicine administrations. Authors had not proposed any patients' security methods in this unreasonable utilization of advanced world. Neubeck L. et al. [12] had assessed the papers identified with computerized heath care on COPD during worldwide pandemic time. They had attempted to have proof of telemedicine impacts during the quarantine time frame for the patients having cardiovascular sickness. The information security concerns were also not referenced in their review. Scherrenberg M. et al. [13] had checked on that Cardiac Rehabilitation (CR) focuses in Belgium had to give online recoveries to control the COVID-19 transmission. It could speed up the internet based CR working examination and practices. They had not expressed any safety measures in this pandemic. Mill J.C. et al. [14] had surveyed the act of remote patient monitoring (RPM) in this pandemic period. They had investigated the utility of wearable to screen the cardiovascular status. Telecardiology has been more lightened-up by the cameo of COVID-19. Nonetheless, the information from such wearable devices was especially helpless against the interlopers. Offiah G. et al. [15] had investigated an example study on patients visiting emergency clinics versus patients selected telemedicine on cardiac division. Their discoveries had shown less cardiovascular examinations caused. Telecardiology upholds have diminished the treatment cost and time. Be that as it may, the real evaluation of the patients is impossible utilizing telecardiac framework which was a greater restriction in this context. Gonzalez G. M. et al. [16] had talked about the upsides of telecardiac medicine in this corona virus time. Dangers implied in such heart medicines were mentioned in their review. Advanced telemedical care administrations can be a way of treating persistent heart patients from a distance. Nan J. et al. [17] had thought about the results of patients having ST Segment Elevation Myocardial Infarction (STEMI) and percutaneous coronary mediation (PCI) and utilized the telemedicine application. Their review time was running between August 2019 to March 2020 in a Chinese clinic. The utilization of telemedicine application had abbreviated the treatment time. However, the advanced dangers were brought about in such patients. Chowdhury D. et al. [18] had given an outline of telecardiology in kids. They have additionally referred to the quick changes made in the heart practices to teach the distant medicines in this COVID-19 period. The strategy for adjusted staffing has assisted with checking the framework from far off areas. In any case, the remote checking needs an appropriate reconnaissance system. This was not found in their work. Tersalvi G. et al. [19] had directed the future extents of the telecardiology in the period of COVID-19. Lockdown execution can forestall the infection transmission. It blocks the COPD patients to go to OPD visits in hospitals. To ensure their smooth medicines, telecardiology is the most secure system to go for. Patients can for all intents and purposes talk with their cardiologists. They have clarified the genuine difficulties happened in telecardiology modalities despite the fact that there exists a lack of information security. Mill J. et al. [20] had audited the information backing and straightforwardness required in the telemedicine during this basic COVID-19 stage. The COVID-19 has guided another aspect in remote patient monitoring (RPM). It incorporates implantable gadgets and wearable gadgets both in the space of telecardiology. Patients can be examined securely from their homes through mechanized ready framework. Accordingly, any crisis cardiac conditions can be effortlessly taken care of.

3. Proposed Methodology

3.1 Proposed Algorithm

This proposed algorithm has been broken into four sub-modules. These are: Intermediate Key Generation, Session Key Generation, Secret Share generation, and Transmission of shares. Such modules have been discussed in the following algorithms.

$\boldsymbol{ALGORITHM}\ \mathbf{1}$: $\boldsymbol{ANN}$ & $Genetic\ Algorithm\ Guided\ Telecardiological\ Security\ Reinforcement$
$\boldsymbol{Input(s)}$: $Patients'\ Cardiac\ Data\ (P1.PDF)$

$\boldsymbol{Output(s)}$: $n\ number\ of\ Transmitted\ Ciphered\ Shares$
$\boldsymbol{Module(s)}$:
$Module\ 1.\ Call\ Intermediate\ Keys\ (ANN1, ANN2)$ // $Intermediate\ keys\ generation$
$Module\ 2.\ Session\ Key = Call\ Genetic\ Algorithm\ ()$ // $Genetic\ Algorithm$
$Module\ 3.\ Call\ Secret\ Share\ generation\ ()$ // $Secret\ Share\ generation$
$Module\ 4.\ Call\ Transmission\ of\ shares\ ()$ // $Transmission\ to\ n\ users$

All the above modules were explained in details.

$\boldsymbol{ALGORITHM\ 1.1}$: $\boldsymbol{Intermediate\ Keys\ Generation}$

In this algorithm, unsynchronized tree parity machines were used. Both the TPM will generate different unsynchronized weight vector. The synchronization process is not required in this method, thus curtailing time complexity. During the medical transactions, online key intrusion can be reduced.

Input(s): $ANN1(N1, K1, L1), ANN2(N1, K1, L1)$
Output(s): $Intermediate\ Keys\ Generation$
// $Intermediate\ Key1\ Generation\ ANN1$
$x_{i,j} = Input(-1, +1)$
$w2_{i,j} = Random(-L1, +L1)$
$For\ i\ =\ 1\ to\ N1$
$For\ j\ =\ 1\ to\ K1$
$h_i =\ h_i + (w_{i,j} * x_{i,j})$
$End\ for$
$If\ (\ h_i\ =\ 0)\ then$
$h_i = 0$
$Else\ if\ (\ h_i > 0)\ then$
$h_i = +1$
$Else$
$h_i =\ -1$
$End\ if$
$For\ i\ =\ 1\ to\ K1$
$O_S[LEN1] =\ Product(h_i)$
$End\ for$

// $Intermediate\ Key2\ Generation\ ANN2$
$x_{i,j} = Input(-1, +1)$
$w_{2i,j} = Random(-L2, +L2)$
$For\ i\ =\ 1\ to\ N2$

$For\ j\ =\ 1\ to\ K2$
$h_i =\ h_i + (w_{i,j} * x_{i,j})$
$End\ for$
$If\ (\ h_i\ =\ 0)\ then$
$h_i = 0$
$Else\ if\ (\ h_i > 0)\ then$
$h_i = +1$
$Else$
$h_i =\ -1$
$End\ if$
$For\ i\ =\ 1\ to\ K2$
$O_R[LEN2] =\ Product(h_i)$
$End\ for$

$\boldsymbol{ALGORITHM\ 1.2}$: $\boldsymbol{Session\ Key\ Generation}$

Session key is the secret key for encryption which may be used for a data transaction or session. Usually it remains valid for a little period of time. In this module, genetic operation has been used. It has been done in the following algorithm. It is the most vital component of any cryptographic system.

$\boldsymbol{Input(s)}$: Intermediate Key1($O_S[LEN1]$), Intermediate Key2($O_R[LEN2]$)
$\boldsymbol{Output(s)}$: $Session\ Key\ (SK)$
$X_1 =$ Input(Enter any random number:)
$X_2 =$ Input(Enter another random number:)
$If(X_1 > X_2)$ then
$Interchange(X_1, X_2)$
$End\ if$
$For\ i =\ 0\ to\ X_1$
SK[i] =$O_S[i]$
$End\ for$
$For\ i =\ X_1\ to\ X_2$
SK[i] = SK[i] + $O_R[i]$
$End\ for$
$For\ i =\ X_2\ to\ LEN1$
SK[i] = $SK[i] + O_S[i]$
$End\ for$

$\boldsymbol{ALGORITHM\ 1.3}$: $\boldsymbol{Secret\ Share\ Generation}$

The craft of camouflaging information into different parts in another idea has been proposed in this paper. Indeed, those different parts are being treated as individual offers [21]. In

COVID-19 telecardiology, the patients' information is being destroyed into various camouflaged parts. Leave it alone n number of beneficiaries getting the various offers. Interestingly, threshold number of the fractional shares are obligatory to rebuild the first patients' information. Every one of the proposed offers will have a lot of missing paired pieces. The algorithmic methodology has been referenced in the accompanying calculation.

$\boldsymbol{Input(s)}: Medical\ Data(D.PDF), Session\ Key\ (SK), Mask\ Matrix\ (Mask\ Mat[n][10])$
$\boldsymbol{Output(s)}: Final\ Secret\ Shares$

N= Input(" Enter number of recipients")

$For\ I =\ 0\ to\ N$

$Final\ Secret[I][\ ] = XOR\ (\ SK[LEN1], Data\ D)$

$End\ for$

$\boldsymbol{ALGORITHM\ 1.4}: \boldsymbol{Transmission\ of\ Shares}$

In this module, we have used RSA encryption to transmit the secret shares to the recipients. The following algorithm will illustrate the said thing.

$\boldsymbol{Input(s)}:\ FinalShares$
$\boldsymbol{Output(s)}: Secured\ transmission\ by\ RSA$
$Set\ N = 5$

Pub_{N1}= Input(" Enter the public key of recipient 1 ")
Pub_{N2}= Input(" Enter the public key of recipient 2 ")
Pub_{N3}= Input(" Enter the public key of recipient 3 ")
Pub_{N4}= Input(" Enter the public key of recipient 4 ")
Pub_{N5}= Input(" Enter the public key of recipient 5 ")

$For\ I =\ 0\ to\ N$

$Ciphered[I][\ ] = RSA\ (\ FinalShare[I], Pub_{N(I)})$

$End\ for$

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4. Result Sections

The proposed methodology had been implemented in a computer having Intel Core i5 processor, Microsoft Windows 10 (64 bits) OS, 16 GB RAM and 2TB of secondary memory. The results of the proposed technique were presented in a beautiful manner. The key generated by the unsynchronized neural networks and genetic algorithm had been diffused with the medical data to have the secret shares. It should show resistant against intrusions. It has been designed to boost up the security features of the telecardiology. We have focused on the entropy value analysis, session key analysis, histogram, floating frequency, autocorrelation analysis, and functional time.

4.1 Entropy Value Analysis

Entropy value of cardiological data of the COPD patients will have in between of zero bits for each character to eight bits for each character. It shows the similarly in spreading the characters. Patient's data on horde boundaries were scrambled utilizing the proposed session key. Following tables 1-2 will contain the entropy values of different shares on two session keys.

Table 1**:** Entropy on Session Key SK@1

Session Ke Id	Secret Shares Id	Highest Entropy	Entropy of Post-Encryption	Entropy of Pre-Encryption
SK@1	SS#1	8.0	7.50	6.61
SK@1	SS#2	8.0	7.42	6.74
SK@1	SS#3	8.0	7.68	7.83
SK@1	SS#4	8.0	7.89	7.87
SK@1	SS#5	8.0	7.45	7.91

Table 2**:** Entropy on Session Key SK@2

Session Ke Id	Secret Shares Id	Highest Entropy	Entropy of Post-Encryption	Entropy of Pre-Encryption
SK@2	SS#1	8.0	7.556	6.61
SK@2	SS#2	8.0	7.48	6.74
SK@2	SS#3	8.0	7.59	7.83
SK@2	SS#4	8.0	7.77	7.87
SK@2	SS#5	8.0	7.43	7.91

4.2 Histogram, Floating Frequency, and Autocorrelation Graph

Histogram, floating frequency and autocorrelation are the vital measurements for arrangements of the proposed cipher texts. Consistency in such diagrams addresses the strength of the proposed procedure. From figures 2 to 4, it could be tracked down that the diagrams were aggregated at fixed x-axis focuses. It implies the plain clinical information reports are not consistently spread all through the characters recurrence inside the plain text record of the patient.

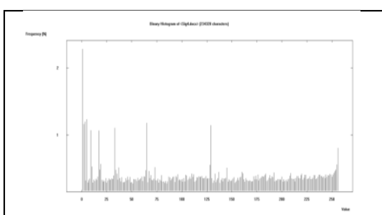

Figure 2 : Histogram of Cardiac Data

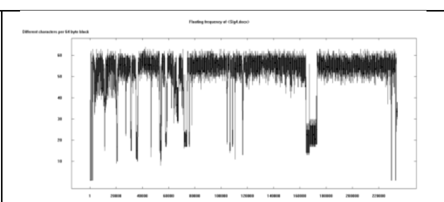

Figure 3: Floating Frequency of Cardiac Data

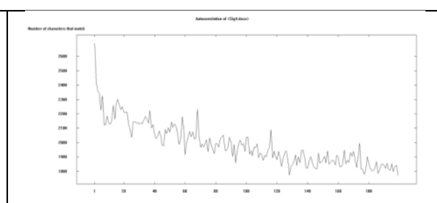

Figure 4 : Autocorrelation of Cardiac Data

Using those two session key (SK@1 and SK@2), the histogram, floating frequency, and autocorrelation were drawn on the same cardiac data. It has been mentioned in the following figures 5-10.

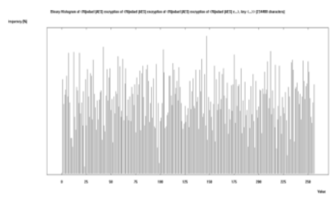

Figure 5: Histogram of Post-Encryption on SK@1

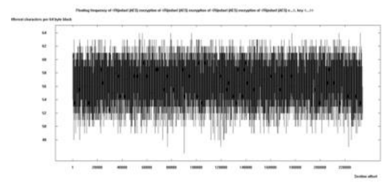

Figure 6: Floating Frequency of Post-Encryption on SK@1

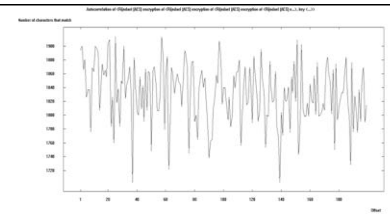

Figure 7: Autocorrelation of Post-Encryption on SK@1

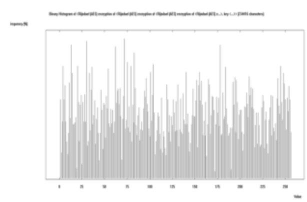

Figure 8: Histogram of Post-Encryption on SK@2

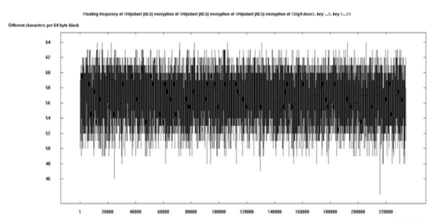

Figure 9: Floating Frequency of Post-Encryption on SK@2

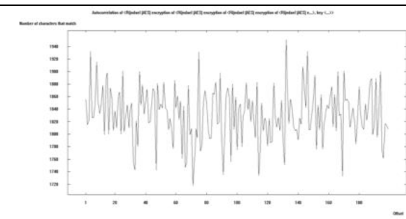

Figure 10: Autocorrelation of Post-Encryption on SK@2

4.3 Session Key Analysis

In this proposed methodology, session key has been formed by the unsynchronized ANN and genetic operation. Further the secret shares of telecardiology data were generated. It has been done to protect the patients' data privacy in the light of COVID-19.

The quickest supercomputer has been designed in Japan that works on 415 PFLOPS [22]. In any telemedicine network, it is commanded to confirm the time needs to unravel the proposed session key. Following table 3 contains the measure of time in years expected to disentangle the proposed session key. The most fascinating important point is that it has no balance between the session key length and the time required. Along these lines, it protects the specific blend of the session key against the excellent gatecrashers. Thus, the proposed method is more reasonable for data communication in COVID-19 telecardiology for the distant COPD patients [23].

Table 3: Time needed to crack the proposed key

Size of Session Key	No. of combinations	Time needed to Decode (in years)
8 bits	2^{8}	4.4×10^{20}
16 bits	2^{16}	6.7×10^{17}
32 bits	2^{32}	7.2×10^{12}
56 bits	2^{56}	9.3×10^{5}
128 bits	2^{132}	10.5×10^{52}

4.4 Functional Time

Utilizing on the web transmission, patients can impart their medical data with their cardiologists. Least cooperation time is wanted for such framework on digital field. The encryption time and decoding time were determined for various shares and were noted in the accompanying tables 4-5.

Table 4: Functional Time on Session Key SK@1

Session Key Id	Secret Shares Id	Encryption Time(sec)	Decryption Time(sec)
SK@1	SS#1	0.9182	0.2269
	SS#2	0.8598	0.3544
	SS#3	0.6560	0.3104
	SS#4	1.0578	0.7022
	SS#5	0.7459	0.4392

Fig 11: Functional Time on SK@1

Table 5: Functional Time on Session Key SK@2

Session Key Id	Secret Shares Id	Encryption Time(sec)	Decryption Time(sec)
SK@2	SS#1	0.9057	0.4469
	SS#2	0.8268	0.3904
	SS#3	0.6541	0.3625
	SS#4	1.0358	0.6897
	SS#5	0.7474	0.4458

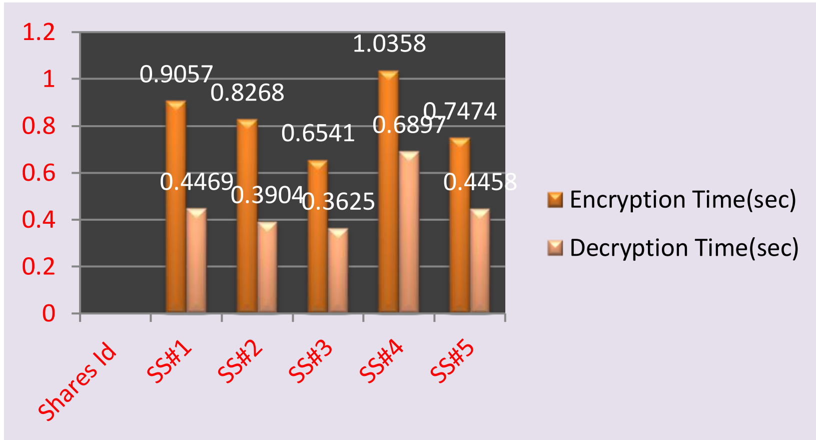

Fig 12: Functional Time on SK@2

5. Validation

This section presents the validation of the proposed technique on Telecardiology during the COVID-19 period [24]. The idea of mixing unsynchronized tree parity machines with genetic operation to have the session key. That session key has been used to generate the secret shares. Entropy values presented in the above stated table 1 with correspondence to the secret share were nearly closed to 8.0. The maximum allowed entropy is 8.0. Histogram, floating frequency, and autocorrelation, etc were generated by using the proposed technique's session keys. All such graphs were well-distributed in shapes. The functional time in the form of encryption and decryption were evaluated in this paper for different secret shares. Patients' medical data are very much under severe risk of intrusion. Lastly, secret shares were transmitted through RSA. Avoidance of data risks involved in social engineering and networking in terms of patients' privacy can be achieved through this proposed technique. Since it counters different attacks like Man-In-The-Middle attacks, etc, so the data modifications in COPD treatments are minimized. Clinical cardiological data protection against intrusion was the central theme in this proposed technique. It reflects the affirmation probability of moderate varieties made in the general wellbeing science due to COVID-19.

6. Conclusion

The novel corona virus has brought drastic changes in the field of medical sciences. Telemedicine services are more blossomed so that patients can be treated from their quarantines. Patients' data secrecy is to be given utmost care [25-27]. Unsynchronized session key has been generated in this paper for the purpose of encrypting different medical data of cardiac patients. Genetic crossover was also made to ensure more robust key. Furthermore, secret shares were generated on the medical data using the proposed session key. Lastly, those shares were transmitted through RSA to different users of the system. Data security is inevitable in telecardiology during the days of COVID-19. Patients can opt for the facility to communicate with their cardiologists reinforced data privacy. Histogram, floating frequency, and autocorrelation analysis was carried out on the proposed technique. Session key analysis on different range of session keys was performed here. The proposed functional time with respect to different shares were also calculated.

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