Telecardiological COVID-19 (2nd) Wave: Metaheuristic-Key Guides Protected Encryption of Heterogeneous Cardiac Reports

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Abstract:

The epic COVID-19 had pushed the clinical sciences for another new allied branch as telemedicine services. In the field of COVID-19 (2nd) wave telemedicine, Internet and nature propelled algorithms helped to impart private data of various cardiovascular reports to various cardiologists for better treatment, perspectives, and opinion. Such heterogeneous cardiovascular reports are to be gotten so as to re-establish the patients' protection. Metaheuristic-key has been proposed through metaheuristics calculation followed by the standard AES 128 bits encryption. Cardiovascular infections (CVDs) are heart sickness identified with blockage of arteries and veins. Heart co-morbid patients are at the most elevated danger of COVID-19. Such patients are to be analyzed and treated appropriately within the restrictions of lockdown. This paper presents a got protected directing of the heterogeneous cardiovascular reports of the patients. Such were to be applied on the proposed metaheuristic-key followed by AES encryption. Making the heterogeneous reports into non-meaningful organization for the gatecrashers is the vital target of the proposed method. A few numerical tests were carried on the proposed strategy, and getting worthy outcomes. To translate the proposed metaheuristic-key through quickest figuring computing framework, the measure of time required has been calculated as 8.5×10^{52} years. Along with these fine lines, pushing the COVID-19 telecardiology framework with more got and remarkable credits on the society.

Keywords: *COVID-19 (2nd) Wave Telecardiology, Cardiac Reports, Metaheuristic-key, Harmony Search Algorithm*

1. INTRODUCTION

The second flood of COVID has massively influenced the human world. The quantity of COVID-19 positive cases is expanding quickly [1]. With the wide improvements in the high level clinical sciences, maintainability of lossless and got information inside the public correspondence is a foundation issue. Telemedicine is appropriate for serving the patients from their isolates [2-3]. Keeping the patients 'privacy condition under most elevated thought, the development of combinational method of metaheuristics and cryptography, is a superior arrangement approach for telehealth benefits in this worldwide COVID-19 crisis. This paper deals with the cardiac patients, whose treatments could remotely be done through telecardiology. A kind of coronary illness [4] which includes the narrowing or blockage of the arteries and veins is called Cardiovascular Diseases (CVDs). There are various sorts of CVDs like coronary artery disease, cardiovascular stroke, cardiovascular breakdown, hypertensive chronic obstructive pulmonary disease, cardiomyopathy, cardiac arrhythmia, and so forth. In COVID-19 telecardiology, online transmission of heterogeneous patients' information would be conveyed over the remote organizations. The principle worries in such COVID-19 (II^{nd} wave) Telecardiological frameworks are that interlopers devour the private information while going through the public stations and routers. Consequently, they harm the information as well as make counterfeit cases for repaid strategies to the own associations. In the said association, execution of safety on the classified cardiovascular information is to be devised. This paper has proposed to produce a Metaheuristic-key on the metaheuristics harmony search approach. Later on this Metaheuristic-key would be utilized as encryption key to scramble the heterogeneous cardiac reports of COVID-19 telecardiology. A symmetric method known as Advanced Encryption Standards (AES) depends on replacement – stage activity [5]. It is a proficient and tied down component to send information to the destination. It utilized key size of various variations like 128 bits, 192 bits, and 256 bits [6]. Here, the Metaheuristic-key created through proposed procedure will be utilized as 128 bits keys with ten rounds of tasks in the AES strategy to encode heterogeneous cardiological reports of COVID-19 second wave.

Advanced optimization issues do have non-linear function restricted inside the arrangement of constraints. The decision factors are tuned to get the best plan. Metaheuristic harmony search was made by Geem et al. in the time of 2001 [7]. In their looking through technique, an outfit of musician work together tunes their notes to make an in vogue concordance. To secure the best note, they do blend together their notes in like melodious manner. The idea of the sharp solid depends upon the optimum vector [8]. They can deliver a note from their instruments inside the range in sporadic plan. Furthermore, they may choose to sound a note from their recently used memory. At last they may mix together a note browsed their memory. Accordingly, after decisive cycle the best course of action would be recuperated [9].

Electro Cardio Graph [10-11] is an assessment cycle to record the electrical activities of the human heart. It is something like a constant connection of polarization and depolarization of every one of the four chambers of the heart muscle. The essential pieces of ECG are P-wave, QRS complex and T-wave. P wave shows the chamber inception through SA node, QRS depicts the ventricular incitation and T-wave tends to the recovery state to restart again, as shown in the following figure 1.

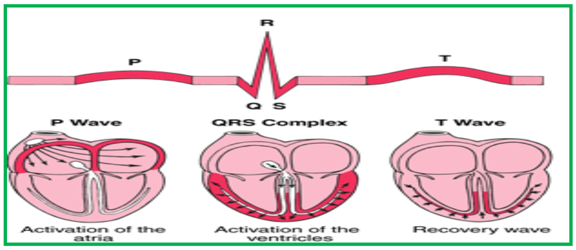

Figure 1: Normal, Fast, Slow, and Irregular Heartbeat

Complete Blood Count (CBC) of a cardiac patient can analyze the portrayal towards the heart problems, assuming if any. It incorporates the accompanying kinds of blood serum parts like RBC, WBC (cell and differential), PCV, Thrombocyte tally, Hb rate, MCV, MCH, MCHC, MPV, and so forth. A height in the WBC cells is an indication of Cardio Vascular Diseases (CVDs) [13]. Pathogenesis of various RBC, WBC and thrombocyte checks are profoundly associated with heart illnesses. An affiliation has been found between high WBC boundaries and high mortality in patients, who are suffering from Coronary Syndrome [14] and Acute Myocardial Infraction [15-18]. High scopes of all sub-kinds of WBCs preferences of eosinophils, monocytes, neutrophils, and lymphocytes have direct connection with Chroni Heart Diseases (CHDs) [19-22]. Besides, the remainder of the segments of CBC preferences of RBC and platelet checks, hemoglobin rate and hematocrit esteems, are additionally unequivocally connected with CHDs [23]. A relative classification between the ordinary CBC reports and CBC of CVDs patient has been introduced in the accompanying table 1.

Table 1: Comparison of normal CBC and CVD patient's CBC

Blood Serum Components	Normal reading	CVDs reading	Normal Range	Measuring Units
WBC Count	5.6	14.8	4.0-11.2	10^9 *per litre*
RBC Count	5.10	3.98	4.18-5.63	10^{12} *per litre*
Haemoglobin	14.3	12.6	M:13.5-17.5 F: 12-15.5	*Gram per deci Litre*
Platelets	3.0	3.1	1.5-3.5	10^{12} *per litre*
Mean Platelets Volume	9.9	10.58	9.6-12.9	*fL*
Lymphocyte	34	17	15-45	*Per microL*
Monocyte	6	14.6	2-12	*Per microL*
Neutrophils	55	36	40-75	*Per microL*
Eosinophils	3	2	2-6	*Per microL*
Basophils	0	0	0-1	*Per microL*
Haematocrit	40.1	41.2	35.6-46.6	%
Mean Corpuscular Volume	88.5	91.26	80.0-100.0	*fL*
Mean Corpuscular Hb			27.5-35.2	*pg*
Red Cell Distribution with Standard Deviation			37.1-48.9	*fL*
Red Cell Distribution with Covariance			11.7-14.1	%

Sari D.M. et al. [24] had clarified that remotely situated heart recovery (HBCR) is an option of focus based cardiovascular restoration (CBCR) because of COVID-19 lockdown obliges. Heart patients are not permitted to go to the recovery communities genuinely to decrease their COVID-19 assaults. Under such critical second wave of pandemic, HBCR has arisen as a treatment choice to treat distantly. Patients are spurred to benefit this office and they can be checked securely. Besnier F. et al. [25] had proposed a perspective that locally situated cardiovascular restoration should be multiplied in clinical practices and heart research. There are immense benefits of this sort of CR. The utilization of telemedicine, internet, mobiles have sped up the implantation of such CR in a superior manner. Babu A.S. et al. [26] had clarified that during the COVID-19 time, distant cardiovascular recoveries can play the lead job to treat the COPD patients. Since the heart patients are at the most noteworthy danger zone of COVID-19 attacks, so they are propelled to get their restorations securely from their isolates. O'Doherty A. F. et al. [27] had overview that whether exercise situated cardiovascular restoration should proceed and the innovative reaction in such manner. Their discoveries had shown that activity should proceed even in COVID-19 time as well.

This manuscript has been organized in the following manner. Section 1 contains the introduction and related survey works. Section 2 has the proposed technique. Section 3 presents the experimental mathematical observations. Section 4 has a lucid comparative statement. Section 5 contains the conclusion. Acknowledgement, Funding Source and Ethical Statements are added at the end.

2. PROPOSED TECHNIQUE

To investigate the plausible arrangement of optimum solution, a methodology has been taken on the metaheuristic harmony search to produce a Metaheuristic-key on COVID-19. The instatement of amicability memory content is stochastically done on the arrangement of practical arrangements inside the limitations of the well designed problem. An enhancement capacity will be characterized on the issues to amplify or limit the assets with more noteworthy results. To make another arrangement, the information put away in the harmony memory will be improvized like artists [28-29]. The proposed calculation to produce such Metaheuristic-key might be summed up underneath.

PROPOSED ALGORITHM

$\boldsymbol{INPUT(S)}$: $, HMCR: Convergence\ Rate,\ \ Rate: Pitch\ Adjustment\ Rate,$
$ITR: Iteration\ number, CD: Cardiac\ Data$
$\boldsymbol{OUTPUT(S)}$: $Encrypted\ Cardiac\ reports$
$ITR\ =\ 0$
$NEXT = 0$
$a = Rnd[0,4]$
$y = Rnd[0,1]$
$Len = Input\ (\text{“}Enter\ Size\ of\ \ Harmony\ Memory\text{”})$

```
For I = 1 TO Len
   HM[I] = Find Sol( low,up )
End for
  Merge Sort ( HM[Len])
While ( ITR != MAXIMUM ITERATION )
      K[NEXT] = HM[0]
      Temp1 = a * y(1 - y) Mod 2
      IF ( Temp1 <= HCMR ) THEN
        IF ( NEXT != Len ) THEN
           K[NEXT] = Rnd( HM[++NEXT], ... ,HM[Len])
           NEXT = Next + 1
        ELSE
           K[NEXT] = Find Sol( low,up )
           NEXT = Next + 1
        END IF
       Temp2 = a * y(1 - y) Mod 2
      IF[ Temp2 <= Rate ] THEN
           K[NEXT] = HM[ NEXT]
           NEXT = Next + 1
      ELSE
           K[NEXT] = Find Sol( low,up )
           Set NEXT = Next + 1
      END IF
      IF ( f( K[NEXT]) > f( HM[NEXT]) THEN
           UPDATE ( HM,HM[NEXT])
      END IF
      Set ITR = ITR + 1
       Merge Sort ( HM[Len])
End while
METAHEURISTIC - KEY[128] = K[ 0 ... 127 ]
Call AES ( METAHEURISTIC - KEY,CD)
```

3. EXPERIMENTAL MATHEMATICAL OBSERVATIONS

This proposed technique has been implemented in MATLAB version 7.6 (R2008a) with Intel i3:2.0 GHz processor, 6 GB RAM, and Windows 10 operating system. Heterogeneous data preserved transmission were considered to flourish the robustness issues. The key generated from the metaheuristic based harmony search. It must be resistant against attacks such as exhaustive key attacks, occlusion attacks, chosen plain signal attack, etc. This technique generates the session key formed through the musically improvised algorithm.

3.1. SECRET KEY SPACE ANALYSIS

In this proposed scheme using harmony search guided session key has been proposed. IBM Summit at Oak Ridge, U.S. in 2018 had invented the fastest supercomputer operating on 123 PFLOPS i.e. 123×10^{15} floating point computing operations per second. Following table 2 shows the amount of time in years needed to guess the proposed Metaheuristic-key by the intruders. The key point is that it has no symmetry with respect to the key length. So, it protects the exact combination of Metaheuristic-key by the intruders. Hence, the proposed technique is more suitable for heterogeneous reports transmissions in COVID-19 telecardiology especially for the remote patients.

Table 2: Time needed to crack the proposed key

Size of Metaheuristic- Key	No. of possible Combinations	Time needed to decipher
08 bits	2^8	6.4×10^{20}
16 bits	2^{16}	1.7×10^{17}
32 bits	2^{32}	1.2×10^{12}
56 bits	2^{56}	1.3×10^5
128 bits	2^{128}	8.5×10^{52}

3.2. ENTROPY ANALYSIS

Information entropy worth of cardiovascular reports will have in the middle of zero bit for each character to eight pieces for every character. It displays the similarly spread character esteems [30-31]. Patient's clinical reports on different boundaries were encoded utilizing proposed Metaheuristic-key based AES encryption. Following table 3 has examination between the entropy of plain cardiovascular related reports and entropy after Metaheuristic-key encryption.

Table 3**:** Entropy values calculation

SL. NO.	METAHEURISTIC-KEY	DATA TYPE*	CARDIAC REPORT ENTROPY	ENTROPY POST-ENCRYPTION	MAXIMUM ENTROPY
1	MSK#101	CBC	6.18	7.93	8.0
2	MSK#102	CXRY	7.54	7.95	8.0
3	MSK#103	ECG	6.35	7.98	8.0
4	MSK#104	LP	6.97	7.89	8.0
5	MSK#105	HM	7.06	7.91	8.0

*CBC=COMPLETE BLOOD COUNT, CXRY=DIGITAL CHEST X-RAY, ECG=ELECTRO CARDIO GRAM, LP=LIPID PROFILE, HM= HOLTER MONITORING

3.3. PROPOSED THROUGHPUT

Using telemedicine, cardiac patients can take part in ECG, LP, CXRY, etc transferring with their cardiologists. Lower interaction time is needed on telecardiological COVID-19. The encryption time and decryption time has been observed and noted in the following table 4.

Table 4: Proposed Encryption & Decryption duration

SL.NO.	Report	No. of Sample(Elements)	Encryption Time(sec)	Decryption Time(sec)
1	CBC	177	0.9414	0.2968
2	ECG	256	0.8581	0.3677
3	LP	147	0.6553	0.3247
4	CXRY	1045	1.2780	0.7681

3.4. HISTOGRAM, FLOATING FREQUENCY, AUTOCORRELATION EFFECTS

Histogram, floating character frequency and autocorrelation are the critical measurements for groupings of the code messages [32]. Consistency in such diagrams addresses the strength of the proposed method. From figure 2 to 10, it very well might be tracked down that the charts were linked at fixed x-pivot focuses. It implies the plain clinical information reports are not consistently spread all through the characters recurrence. COPD Patients' LP, ECG, and HM were acquainted with draw the accompanying histogram, floating character frequency, and autocorrelation outlines.

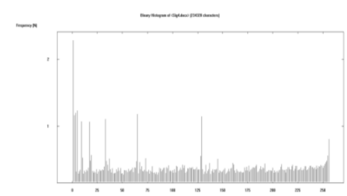

Figure 2 : Histogram of LP

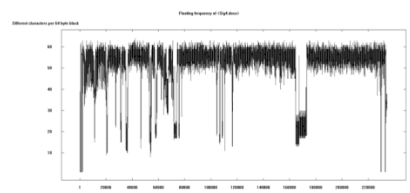

Figure 3: Floating Frequency of LP

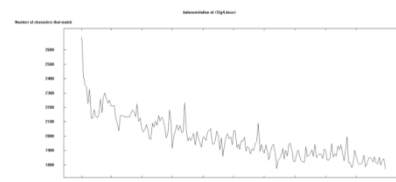

Figure 4 : Autocorrelation of LP

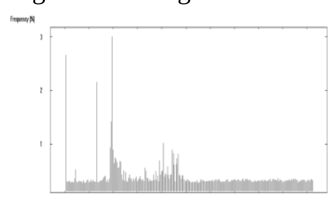

Figure 5 : Histogram of ECG

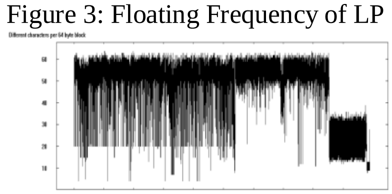

Figure 6: Floating Frequency of ECG

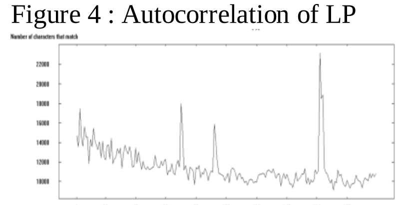

Figure 7 : Autocorrelation of ECG

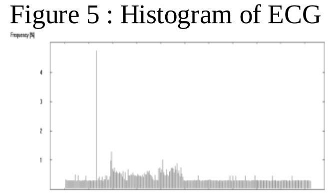

Figure 8: Histogram of HM

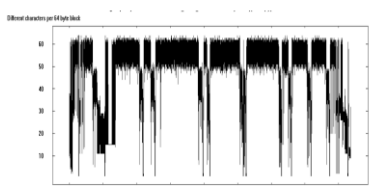

Figure 9: Floating Frequency of HM

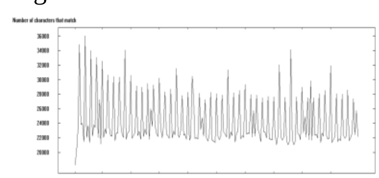

Figure 10 : Autocorrelation of HM

With the same derived Metaheuristic-key, the histogram, floating character frequency, and autocorrelation has been again plotted on the same LP, ECG, and HM cardiac reports. These graphs can be found in the following figures 11 to 19.

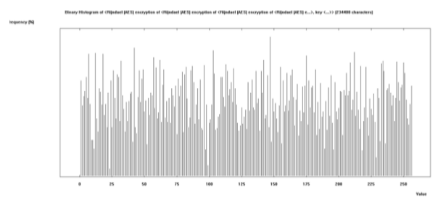

Figure 11: Histogram of Metaheuristic-key Encrypted LP

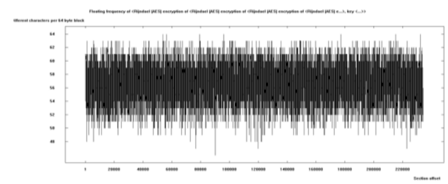

Figure 12: Floating Frequency of Metaheuristic-key Encrypted LP

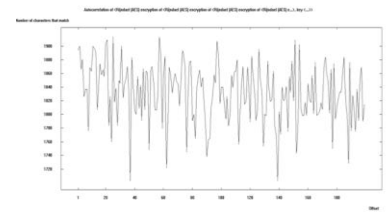

Figure 13: Autocorrelation of Metaheuristic-key Encrypted LP

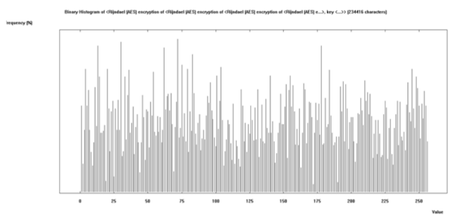

Figure 14: Histogram of Metaheuristic-key Encrypted ECG

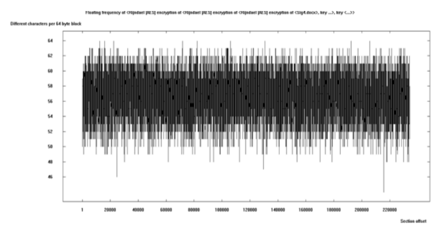

Figure 15: Floating Frequency of Metaheuristic-key Encrypted ECG

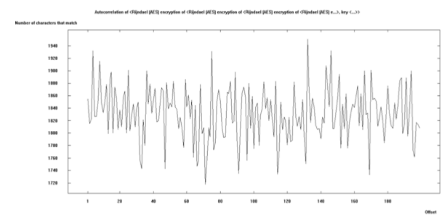

Figure 16: Autocorrelation of Metaheuristic-key Encrypted ECG

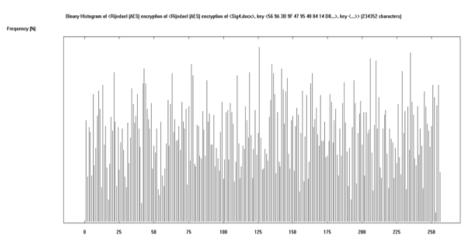

Figure 17: Histogram of Metaheuristic-key Encrypted HM

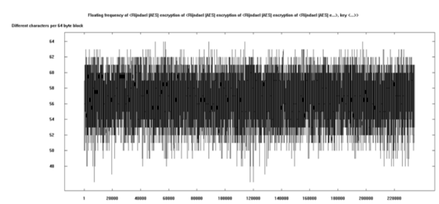

Figure 18: Floating Frequency of Metaheuristic-key Encrypted HM

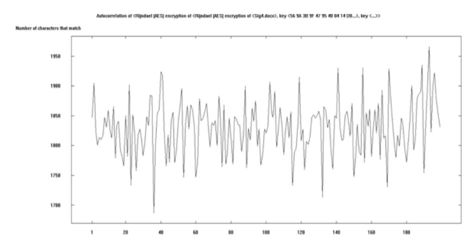

Figure 19: Autocorrelation of Metaheuristic-key Encrypted HM

4. LUCID COMPARISON

It is very needful to infer a conclusion on the efficacy of the proposed technique with respect to the earlier research works. In the following table 6, a comparative format to indicate the comparison between the proposed technique and earlier published papers has been presented in lucid manner.

Table 6: Tabular Comparison with earlier works

Attributes	Reference Paper[33]	Reference Paper[34]	Reference Paper[35]	Proposed Here
Cardiology Data	No	Yes	No	Yes
COVID-19 Telecardiology	No	No	No	Yes
Cardiac Data Live Sense	No	No	No	No
Cardiac Data Encryption	Yes	Yes	Yes	Yes
Analysis on Session Key Space	No	No	No	Yes

Standard Histogram Graph	No	No	No	Yes
Standard Autocorrelation Graph	No	No	No	Yes
Information Entropy Analysis	No	No	No	Yes
Standard Floating Frequency Graph	No	No	No	Yes
Cryptographic Time	Yes	No	No	Yes
Comparative Study	No	No	No	Yes

5. CONCLUSION

All the COVID-19 (2nd wave) telemedicine should guarantee the part of patients' information privacy and protection [36-38]. In no way, shape or form, the information ought not to be compromized to the outer interlopers. The proposed procedure is more powerful and gotten as far as assaults in the remote medium. Stochastically, a Metaheuristic-key has been produced here to scramble various sorts of clinical reports of heart patients during COVID-19 (2nd) wave times. It is more valuable in the domain on COVID - 19 telecardiology frameworks. Patients can benefit the office to speak with their cardiologists with got information interchanges. Histogram, floating character frequency and autocorrelation investigation by the assistance of proposed Metaheuristic-key demonstrate the productivity of this proposed procedure. To decode the proposed Metaheuristic-key through fastest computing machines, the amount of time required is $8.5\times\ 10^{52}$ in years.

ACKNOWLEDGEMENT

The author do extend his gratitude to Dr Salim Ahmad [B.H.M.S. – Kolkata], Consultant Physician, Assistant Teacher in Nutrition, Vidyasagar Uchcha Vidyalaya, Purba Bardhaman, West Bengal, and Former Guest Lecturer, Department of Nutrition, M.U.C. Women's College, Burdwan, West Bengal, for receiving cardiac related information support.

FUNDING SOURCE:

No research funds were received by the author.

COMPLIANCE WITH ETHICAL STANDARDS:

Not applicable.

CONFLICT OF INTEREST:

There is no conflict of interest.

ETHICAL APPROVAL:

This article does not contain any studies with human participants or animals performed by the author.

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