



# ICT-Guided Glycemic Information Sharing Through Artificial Neural Telecare Network

Joydeep Dey<sup>1</sup> · Arindam Sarkar<sup>2</sup> · Sunil Karforma<sup>3</sup>

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## Abstract

The revolutionary and retrospective changes in the use of ICT have propelled the introduction of telecare health services in the crucial corona virus pandemic times. There have been revolutionary changes that happened with the advent of this novel corona virus. The proposed technique is based on secured glycemic information sharing between the server and users using artificial neural computational learning suite. Using symmetric Tree Parity Machines (TPMs) at the server and user ends, salp swarm-based session key has been generated for the proposed glycemic information modular encryption. The added taste of this paper is that without exchanging the entire session key, both TPMs will get full synchronized in terms of their weight vectors. With rise in the intake of highly rated Glycemic Indexed (GI) foods in today's COVID-19 lockdown lifestyle, it contributes a lot in the formation of cavities inside the periodontium, and several other diseases likes of COPD, Type I and Type II DM. GI-based food pyramid depicts the merit of the food in the top to bottom spread up approach. High GI food items helps in more co-morbid diseases in patients. It is recommended to have foods from the lower radars of the food pyramid. The proposed encryption with salp swarm-generated key has been more resistant to Man-In-The-Middle attacks. Different mathematical tests were carried on this proposed technique. The outcomes of those tests have proved its efficacy, an acceptance of the proposed technique. The total cryptographic time observed on four GI modules was 0.956 ms, 0.468 ms, 0.643 ms, and 0.771 ms.

**Keywords** Glycemic foods · Glycemic indexed module · Salp swarm key · Statistical tests · Brute force attacks

## Introduction

The emergence of the ICT-based technology friendly systems is a convenient mechanism to interact globally to the doctors/physicians [1–3]. This global pandemic has given rise to the virtual consultations and information sharing through telecare systems. Such online telecare systems

are designed and emerged as a popular tool to share and get the expert opinion/information regarding the diseases, symptoms, clinical reports, etc. This paper emphasizes on the information sharing between various patients and doctors regarding awareness of the high glycemic food values, which is helpful in this peak hours of COVID-19 [4]. Telecare E-health services are primarily supported by the remote Information and Communications Technologies (ICT) [5, 6]. It provides an open platform to give new and innovative ideas to treat the remote patients. To curtail the corona virus transmission, telecare systems are the best-suited options for the non-emergency and non-invasive remote patients [7–10]. The glucose level in the human blood fluctuates rapidly by the effect of foods consumed. Glycemic index (GI) is an integer value assigned to all the food items. More the GI value, more chances to occur cavities. Glycemic index [11] is a fine measuring tool by which we may control to appearance of dental cavities. Oral health reflects the wellness of a person. Glycemic index is a number assigned to a food stuff which gives a perception of conversion of carbohydrates present

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✉ Joydeep Dey  
joydeepmcbu@gmail.com

<sup>1</sup> Department of Computer Science, M.U.C Women's College, Burdwan, India

<sup>2</sup> Department of Computer Science and Electronics, Ramakrishna Mission Vidyamandira, Belur, India

<sup>3</sup> Department of Computer Science, The University of Burdwan, Burdwan, India

in the food into glucose by the body. Low range of values indicates the less impact of that food upon the glucose levels. Different glycemic index can be assigned to two different food stuffs having same amount of carbohydrates. ICT-based platform plays an exposure role to different forums of the community, where fruitful online discussions and conflicts take place. Such technological innovative ways releases the physical pain and mental stress of the patients [12]. Collaborative treatments have fostered the growth of the patient management system in the field of ICT supported Telecare E-health systems. Better health facilities in terms of health care, pain management, psychological boost ups, etc. are possible through such ventures [13].

Imposing security layers on the data before transmission using some key is called cryptography [13–15]. This is one to restrict the external manipulation of the information by the intruders. A variety of techniques are available to generate the shared private key in the domain of online Telecare E-health systems. According to the utility of such cryptographic algorithms, they may be categorized into two groups. They are as follows: first, one is based on the symmetric key cryptography and the remaining one is based on the asymmetric key cryptography. The existing cryptographic algorithms have their several pros and cons from their functional point of views.

The effective method based on cryptography for generation of the shared private key is primarily based on public key cryptography, like Diffie–Hellman key cryptography protocol suite [16]. The approach towards generation of shared key using this suite resolves the issue with elegance. But a huge amount of mathematical paradox is used to decompose the very prime numbers using hard core mathematical jargons and equations. Moreover, the main problem in this protocol is to exchange the secret keys between two nodes of the telecare systems.

The effective method based on asymmetric cryptography is the physical characteristics of the channel are taken into consideration to generate the shared private key rather than mathematical complex calculations. To generate the shared private key using the physical features of the transmission media are based on two parameters. Physical isolation is the first way to generate the shared private key. Another way is to write the shared private key through a wired physical connection cable. RSA public key cryptography is the most frequent and common form of key exchange protocol [17]. The security of RSA algorithm lies on the choice of prime numbers factoring [18, 19]. The product of two very large prime numbers is factored and then it raises the time complexity of the algorithm. Thus, by increasing the length of prime numbers the system's computational cost will be higher. To curtail the said cost, the use of tree parity machines has emerged as a better alternative option in this proposed methodology.

This paper deals with the significance of glycemic information in the era of COVID-19. There is a strong correlation between the COVID-19 and glycemic information. Following points will figure out such significances.

- Mainly in Type I and Type II diabetic patients, they are always in stress regarding their glucose level in plasma. Due to quarantine protocols, they are not able to test those fasting, post-prandial glucose plasma, and HbA1c levels. It creates immense psychological pressures, and hampers their mental wellness [20].
- Lingered diabetic complications can cause cardiovascular diseases. Such patients are more prone to severe corona virus attacks with greater mortality rates [21].
- Controlled sugar levels in diabetic mellitus patients are mandatory thing to resist against the COVID-19 severity. Uncontrolled sugar patients have higher mortality chances if attacked by COVID-19 [22].
- Medicines incurred with COVID-19-positive patients may have some minor effects on the glucose levels of diabetic patients. Such patients need to control and monitor their glucose levels regularly in the post-COVID-19 phase [23].
- Dental diseases are strongly caused through high GI food stuffs, especially in children. Children are more habituated with sticky chocolate in these COVID-19 home quarantine days.
- High glycemic values immensely affect the renal function of the COVID-19 patients [24].
- Pathogenic links are presents between the corona virus and diabetes. COVID-19 affects the plasma homeostasis on glucose level, compromising immunity system, active antigens, etc. [25, 26].
- Due to lockdown restrictions, traditional medical services are restricted. Therefore, patients must follow their diabetic diets and follow the instructions given by their endocrinologists.

Based on the above-stated points, it is very much relevant to spread glycemic information awareness. This paper deals with secured GI sharing to have awareness in the COVID-19 crucial times. Currently, we are dealing with this novel corona virus, and the entire healthcare facilities have changed immensely. The emergent of telemedicine has boosted the medical sciences a lot. It is very much pertinent to treat the remote patients through virtual modes. The scope of the proposed manuscript is immense in the field of healthcare services. The organization of this manuscript has been done as follows. The first section deals with the introduction. The next section contains the important concepts. Literature survey has been given in the third section. The proposed work on glycemic information has been mentioned in the fourth section. The proposed algorithms are given in the fifth



**Fig. 1** a Cavity in teeth (AP view). b Cavity in teeth (lateral view)

section. Experimental results are briefly cited in the sixth section. Conclusions are mentioned in the seventh section. Acknowledgement, funding statements, statements of ethical compliances, and references have been written in the end.

The contributions of this proposed technique can be stated as follows. The formation of glycemic information modules, which are very much contextual in this COVID-19 pandemic crisis are very much significant and needed. Type I and Type II diabetic patients will immensely be benefitted since they are under the maximum COVID-19 threats. A secured mechanism of glycemic information sharing was presented based on tree parity machines (TPMs). The session key has been generated through the salp swarm algorithm in this proposed model. This is a unique idea of key generation though metaheuristic algorithm. No papers were found on salp swarm key generation on glycemic information during the COVID-19 era. Without exchanging the keys, both the TPMs are fully tuned to a similar weight vector, which can be further used as key in AES encryption. Rotational key ciphering has been proposed on the TPM weight vector with efficacy. It has been done to nullify the MITM attacks on the COVID-19 telecare public networks. The statistical skewness on iteration and differences in the iterations has been found to be Computed Skewness (Itr, Diff) = 1.812016 on the TPM. It has shown good real-time data with respect to existing methods. The total cryptographic time on the glycemic information modules were found to be satisfactory.

## Important Concepts

In this section, we have discussed some of the important concepts related to this manuscript.

### Retrospective of Food Habits in Terms of GI

Foods containing high glycemic index are at high risks for the human body. During this pandemic, we need to stay

healthy. Following food items contribute to high glycemic index [27, 28].

- Starchy and refined carbohydrates: foods stuffs such as potato chips, brown breads, and crackers are enemy to the teeth. Starches which are prepared from flour are simple carbohydrates and they do reside at children's mouth and then transformed into simple sugars. Bacteria invasion is on these sugars to produce acid, which then causes tooth decay.
- Candies and sweets: children are very much fond of candies, toffees, chocolates and sweets. These things get stuck inside the pediatric periodontium. Food items such as ice-creams, cookies, cakes, and desserts have maximum amount of sugar to result in cavities.
- Carbonated soft drinks: soft drinks and soda have high amount of carbohydrates and sugar which wear away the enamel coating of the teeth, hence causing them to be fitted with cavities.
- Fruit juice: fruits are the best-suited options for a healthy person. But in some cases they contribute in formation of cavities. Fruits with high glycemic index would come under this category. Ripe bananas, jackfruits and mangoes are good examples of highly rated glycemic indexed foods. In addition, juices have added quantity of sugar, which is even more helpful to cause severe cavities.
- Lemons, citrus fruits and other acidic foods: consuming such foods propels the occurrence of dental cavities.

When the above food items are consumed, the initial resultant is the tooth decay as represented in Fig. 1 [29].

There exhibits a strong link between dental cavities and following chronic diseases. Cavities grow as the more bacterial invasion exists with respect to time frame.

- (a) Aspiration pneumonia: bacteria is inhaled and passed to lungs to cause severe pneumonia, which are non-resistant by the children with affected immune deficit system.

- (b) Respiratory diseases: congestion occurred by the adverse effect of prolonged pediatric cavities. Pulmonologists have found a strong connection between respiratory troubles with cavities.
- (c) Oral cancer: in rural areas, maximum cavities are untreated which results in gum swelling with severe bleeding and pain. If not treated properly, it leads to early stages of oral cancer in human beings.

Public Health Solutions for oral diseases are considered as an effective tool, if these are incorporated with other chronic diseases and also with National Public Health Programmes. The WHO (World Health Organization) and Global Oral Health Programme integrates its philosophy of task with an eye towards chronic disease prevention and health promotion. Main focus is given on developing global medical health policies in the domain of oral health promotion and oral disease prevention. Following are illustrated below:

- Developing oral health policies with effective control of high risks at dental health.
- Developing and implementing various community demographic-based projects for oral health promotion and prevention of oral diseases, with an emphasis more on disadvantageous and poor population group of peoples.
- To encourage national health authorities to implement effective fluoride programmes to prevent dental cavities.
- To provide technical support to countries to strengthen enough their oral health systems and incorporate them into public health.

### Tree Parity Machine Neural Network

A tree parity machine [30, 31] is a type of neural network that consists of three layers of neurons, i.e.,  $N$  number of input neurons,  $K$  number of hidden neurons, and one output neuron. Each input nodes are assigned to a synaptic value in between  $+L$  and  $-L$ , where  $L$  is a positive integer. The function of this TPM is to get synchronized their synaptic links through some processing techniques without exchanging the links. This paper deals with involvement of the TPMs at the server and user end. The pre-requisite criteria of the TPM are the same pseudo random seed given at the both TPMs. Without the exchange of the keys, TPMs do update and synchronize their weight, which resists the Man-In-The-Middle attacks (see Fig. 2).

Metaheuristic means go beyond the heuristic approach. It was proposed by Glover et al. [32] to define a larger perspective of heuristic information to optimize the problem in the search space. Heuristic algorithms may not always generate the optimal solution in proper time. Metaheuristic algorithms have the property of stochasticity. To accelerate

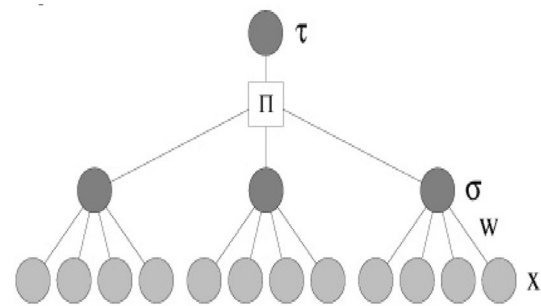


Fig. 2 Sample tree parity machines

the search space and finding the optimum solution, such algorithms are implemented [33, 34].

## Literature Survey

### Works on COVID-19 Glycemic Information

Hosomi et al. [35] had reported that due to quarantine protocols and lockdown restriction, the stress level has increased, and that to raised the Type I Diabetes patients. They have compared the results from pre-pandemic and current pandemic times. In addition, they have found that glycemic food control has worsened in the COVID period due to lifestyle changes. It could be established through HbA1c test for the last 3 months. Biamonte et al. [36] have concluded that the lockdown restrictions had affected the Body Mass Index (BMI) and serum glucose level in Type II Diabetes patients. The parameters such as body weight, BMI, waist circumference, fasting sugar, and HbA1c have accelerated in such patients under their study. All those parameters are very significant in terms of diabetes control and management. Masuda M. et al. [37] had computed that HbA1c plasma levels have abruptly dropped after the declaration of emergency state in Japan in both Type I and Type II diabetes patients. There were several parameters for such drop in HbA1c levels. These are no option to eat outside foods, no physical movements and body wear and tear, less working stress, etc. Rastogi et al. [38] had found that the co-morbid diabetic patients who have restricted outdoor movements have well glycemic control in COVID-19. Co-morbidity may include foot complications, neuropathic foot, and foot deformities. COVID-19 has put psychological impact on the Type II diabetic patients regarding the worsening of their glycemic index. Chowdhury et al. [22] had reviewed 18 papers and found that Type I and Type II diabetes are strongly associated with COVID-19. Such patients are at bigger risk of corona virus. Vinals et al. [39] had found that diabetic patients with Type I are more prone to hypoglycemia in Spain. The strict lockdown imposition had bettered

the glycemic controls in such patients. Brand-Miller et al. [40] had stated that glycemic spikes in patients are related to cardiovascular diseases. Post-prandial hyperglycemia is a common factor of cardiac problem in COVID period. Patients must be judicious to consume the high glycemic indexed foods. Muscogiuri G. et al. [41] had recommended nutritional requirements in the period of COVID-19. Due to lockdown restrictions, physical movements have been restricted. To balance the mental health and proper diet, suitable stuffs are recommended.

### Works Done on Artificial Neural Networks and TPM

Kanter et al. [30] have proposed a tree parity machine that would synchronize with corresponding TPM by updating the learning rules. However, no key exchange takes place between them. Rosen-Zvi et al. [42] have stated that two TPMs generate the same weight vector by updating their links after each iteration.

Dey et al. [43] had used artificial neural networks to predict the interactions of CoV2 and human protein sequences. They had correctly predicted 1326 human proteins of CoV2 through their neural machine-learning techniques. Batra et al. [44] had shown a computational technique which blends machine learning and high-fidelity ensemble docking studies. They had done so to enable quick screening of all possible therapeutic ligands. They had tried to explore the molecular treatments against the novel COVID. Elakkiya et al. [45] had screened the Chest Radiography COVID-19 images through machine learning. They had found 100% accuracy while doing the act of multi-class classifications on their obtained datasets. Apostolopoulos et al. [46] had evaluated the performances of neural network prediction on the medical images. They had worked on 224 COVID-19-positive images. They had found that deep learning has significant biological marks on the COVID-19-positives cases.

Sarkar et al. [47] have proposed a scheme to transport gingivitis intraoral image on E-health arena using tree parity machines. By raising the synaptic depth of the input neurons, the performance can be enhanced against the intruders. In this context, Sarkar [48] had raised the synaptic depth of his proposed TPM structure. Dolecki and Kozera [49] and Santhanalakshmi et al. [50] have compared the performance of synchronization of TPM using Genetic algorithm and Gaussian distribution, respectively. Synchronization time was indeed minimized due to replacement of random weights with corresponding mathematical functions. Moreover, with increase in the number of input and hidden neurons, the chances of counterfeiting the “Majority Flip Attacks” were also made high. Pu et al. [51] had developed an algorithm that deals with true random sequences, generated through artificial neural networks and TPM networks. It had shown

larger complex dynamic perspectives in terms of a better placed encryption tool. Dolecki et al. [52] had proposed a technique to synchronize the TPMs by implementing the Poisson distribution theory.

### Proposed Work

It involves the use of metaheuristic approach to generate the random weight vector of the tree parity machines. This paper has proposed an approach on ICT-based information sharing to different users registered under the specified telecare system of COVID-19. Users can collect different information module from this online telecare system. Following are some of the information modules which are taken as exemplary in this paper by keeping the relevance of glycemic indexed foods in the light of COVID-19.

#### GI Module No. 1: Mathematical equation for cavities

Let the pediatric cavities are caused due to the following equation:

$$F(C) = \sum [F(p) + F(c) + F(TS)]^{f(T)} \quad (1)$$

where  $F(C)$  is the function to evaluate cavity,  $F(p)$  is the function to calculate pathogenic microorganisms inside peri-odontium,  $F(TS)$  is the function to find tooth surface that is susceptible to acid dissolution, and  $F(T)$  is the real-time function.

#### GI Module No. 2: Inference rules : assign GI (glycemic index) rating

The attribute assigned to the glycemic index of all the foods are done with respect to the following inference rules.

```

If [ GI <= 55 ] Then
  Food Quality ← Low ( Good )
Else If [ 56 <= GI <= 69 ] Then
  Food Quality ← Medium ( Average )
Else
  Food Quality ← High ( Bad )
End if

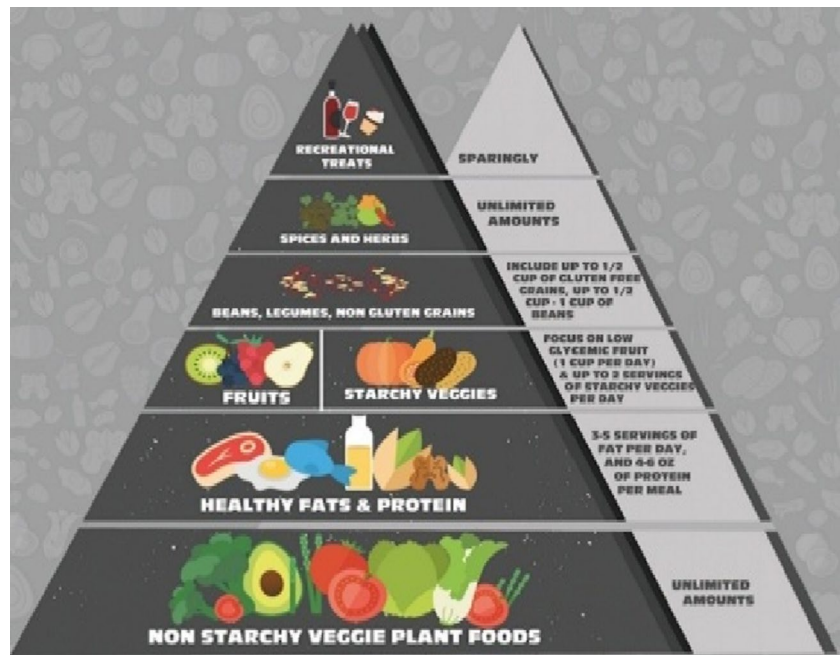
```

Low GI foods are always prescribed the physicians/dieticians because it does not affect the blood cells. It takes less time to decompose the carbohydrate into its absorption format [53].

#### GI Module No. 3: Food pyramid in terms of GI

There are other included parameters which contribute to the assignment of glycemic index to a food item. GI depends upon the preparations of that particular food. The presence of vinegar, lemon juice, fat, and fiber in any preparation lowers the glycemic index number. The longer the food is cooked under processing, higher the glycemic index number. Ripeness of the fruits and vegetables contributes to its GI. More ripen means high GI value. Sample food pyramid is

**Fig. 3** Glycemic indexed food pyramid



given in Fig. 3. Foods kept at the bottom layers are ore necessary in this corona virus period to grow more immunity.

**GI Module No. 4:** Food items with corresponding GI ratings (Table 1).

**Brief Work Flow**

This sub-section deals with the work flow of the proposed technique in brief. The objective of this manuscript is to have secure glycemic information sharing through artificial neural network suits. The generation of glycemic information (GI) modules has been done. In this COVID-19 pandemic crisis, co-morbid patients must be treated and taken care properly. COPD patients, Chronic Kidney Disease (CKD) patients, diabetic patients, etc. are under the highest COVID-19 thresholds. A secured way of glycemic information sharing has been presented here on salp swarm and tree parity machines (TPMs). The session key has been generated through the salp swarm algorithm in this proposed model. Without exchanging the session keys, both the TPMs get a synchronized weight vector through learning rules. Further that weight vector has been used as key in AES [54, 55]. Rotational key ciphering algorithm has been proposed to defend the middle way attacks. It has been implemented to resist the MITM attacks on the COVID-19 telemedicine domain.

**Proposed Algorithmic Structures**

In this section, the proposed algorithms were portrayed in an intelligent way. In the entire approach, the salp swarm algorithm had been modified to find the weight vector of neural networks. The most common problem is the key exchange problem. It has been addressed in this proposed tree parity key synchronization algorithm. Without exchanging the weights, two tree parity machines were synchronized. Different learning rules were followed in that model.

**Table 1** Some of the highly rated glycemic indexed foods

Food items	Corresponding GI value	Corresponding GI ratings
Waffles	76	High
Cake	77	High
Baguette	95	High
White rolls	73	High
Cornflakes	83	High
Rice Krispies	82	High
Weetabix	77	High
Millet	71	High
Watermelon	72	High
Potato	82	High
Date	103	High
Jelly beans	80	High

**Algorithm 1:** Retrospective ICT-based Neural Telecare Information Sharing on Glycemic Information in COVID-19 era.

Salp swarm algorithm [56] is a type of metaheuristic algorithm to find the optimum solution. This paper has proposed to generate the weight vector of the TPM through this salp swarm algorithm. Salps do belong to the *Salphide*

family. The position of the leader salp and followers are updated according to the food source location. This procedure continues till the desired numbers of epochs were reached. A balance between the exploration variable and exploitation variable was done in the following algorithm. Finally, a weight vector is obtained.

**Input(s):** Module of G.I. ( *M.pdf* ), Lower Bounds (LBN), Upper Bounds(UBS)

**Output(s):** Encrypted G.I. Module

// Salp Swarm based Weight Vector generation by Users

SET  $X_i = (X_1, X_2, \dots, X_n)$  such that  $LBN \leq n \leq UBN$

While [! Not Max Turn]

For  $I = 0$  to  $(n - 1)$

Find Fitness( $X_i$ ) // As per optimization problem

End for

$BEST[] = \text{Find Best\_Salp}(X_i)$

Set  $R1 = 2 * e^{\frac{-(4*I)^2}{MITI}}$  //  $I$  means present iteration

For  $I = (X_0)$  to  $(X_{n-1})$

If ( $I = 0$ ) then

If ( $\text{Find\_Rand}(0,1) \geq 0$ ) then

$X_j^1 = FD_j + R1 * \{ (UB_j - LB_j) * R2 + LB_j \}$

Else

$X_j^1 = FD_j - R1 * \{ (UB_j - LB_j) * R2 + LB_j \}$

End if

Else

$X_j^1 = (X_j^i - X_j^{i-1}) * 0.5$

End for

Add Salp upon LBN & UBN to  $BEST[]$

End for

SET Not Max Turn = Not Max Turn - 1

End while

Weight Vector  $\leftarrow BEST[]$

// TPM Synchronization

Call TPM Synchronization ( $BEST[], TPM(S), TPM(U)$ )

// AES Encryption Key Generation from Salp Weight Vector

$AESKEY[128] \leftarrow \text{Call AES KEY FORMATION}(B[])$

// AES Encryption Key

$ENC[] \leftarrow \text{Call AES}(AESKEY[128], M.pdf)$

**Algorithm 1.1:** Tree parity machine synchronization

In this algorithm, there exists a synchronization between the server TPM and user TPM. The weight vectors were made equal after the procedure. Different learning rules were used to achieve such synchronization [58].

**Proposed Algorithm 1.1.1:** Rotational carry ciphering upon weight vector

A coupling was involved between two TPMs, i.e., Server TPM and User TPM. Mutual verification of the weight vector by both TPMs was tightly coupled here. Intermediate encrypted vector generated by the server TPM would be

```

Input(s): No. of Simulation(S), Weight Vector (BEST[ ]),
Production(Server_TPM), Production(User_TPM)
Output(s): Synchronized Weight Vector
While [ S! = 0 ]
    Vector ← Salp Swarm ( LBN , UBN )
    Call Rotational Carry Ciphering (Weight Vector)
    If ( Production(Server_TPM) != Production(User_TPM) ) Then
        Update the Server_TPM & User_TPM by any of the following equation (2).
    End If
    Set S = S + 1
End while
Updating the Weight Vector by any one of the following equation (2).
 $w_i^+ = f ( w_i + \sigma_i x_i \Theta ( \sigma_i \tau ) \Theta ( \tau^S * \tau^U ) )$  ... (2.1) Hebbian Rule
 $w_i^+ = f ( w_i - \sigma_i x_i \Theta ( \sigma_i \tau ) \Theta ( \tau^S * \tau^U ) )$  ... (2.2) Anti - Hebbian Rule
 $w_i^+ = f ( w_i + x_i \Theta ( \sigma_i \tau ) \Theta ( \tau^S * \tau^U ) )$  ... (2.3) Random Walk
 $f(x) = R ; -L \leq R \leq L$ , where L is the range, and
If ( S ≠ U ) Then
     $\Theta(S, U) = 0$ 
Else
     $\Theta(S, U) = 1$ 
End if
    
```

**Table 2** Best noted observation

Column 1	Column 2	Column 3	Column 4
Input nodes(N)	Hidden nodes (K)	Range of weight=L	No. of successful iterations (Itr)
5	10	8	14,605

**Table 3** Statistical computations

Correlation coefficient (L, Itr)	Q1 (on Itr)	Q2 (on Itr)	Q3 (on Itr)	Kurtosis (Itr)	Average deviation (Itr)
0.693244	553	1573	2806	- 1.04108	1236.444

**Table 4** Different set of observations

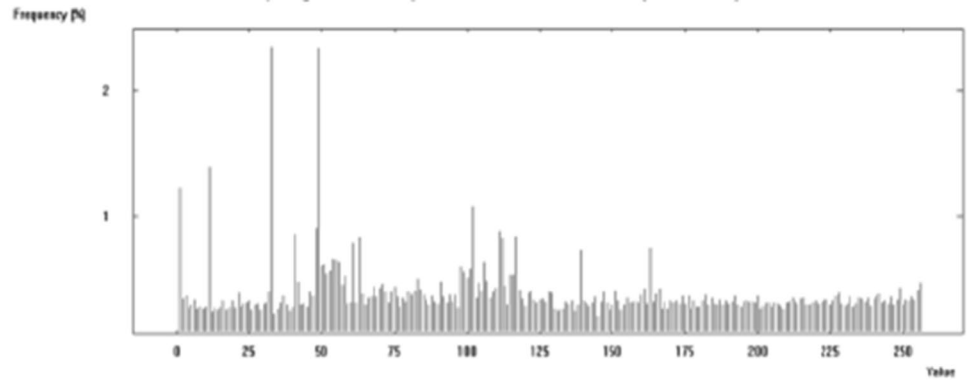
Input neurons	Hidden neurons	Iterations	Range (L)	Difference in iteration
8	3	122	4	00
4	6	401	4	279
8	3	305	5	104
4	6	924	5	619
8	3	377	6	547
4	6	1012	6	635
8	3	875	7	137
4	6	3302	7	2427
8	3	138	8	3164
4	6	853	8	715



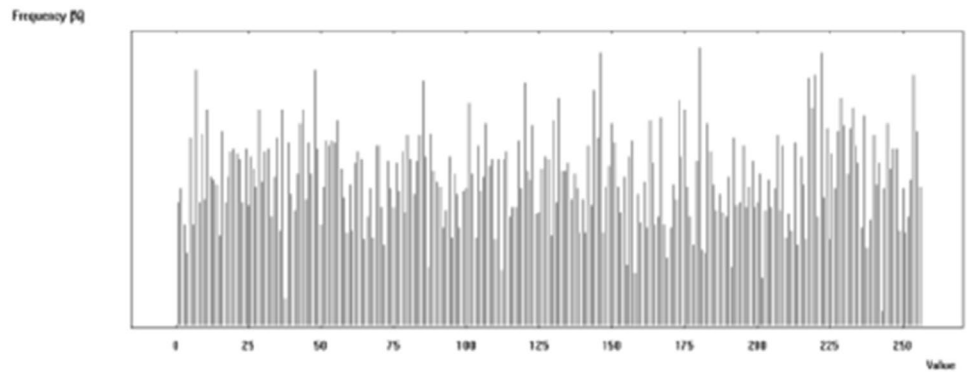
**Table 5** Different set of observations

Sl. No.	Glycemic information module type	Glycemic information module size	Entropy before encryption	Entropy after proposed method
1	Pdf file	309 MB	7.10	7.77
2	Jpeg file	51 KB	5.66	6.90
3	Xls file	235 MB	5.84	7.80
4	Doc file	1125 MB	6.10	7.92
5	Zip file	5 KB	4.29	6.80

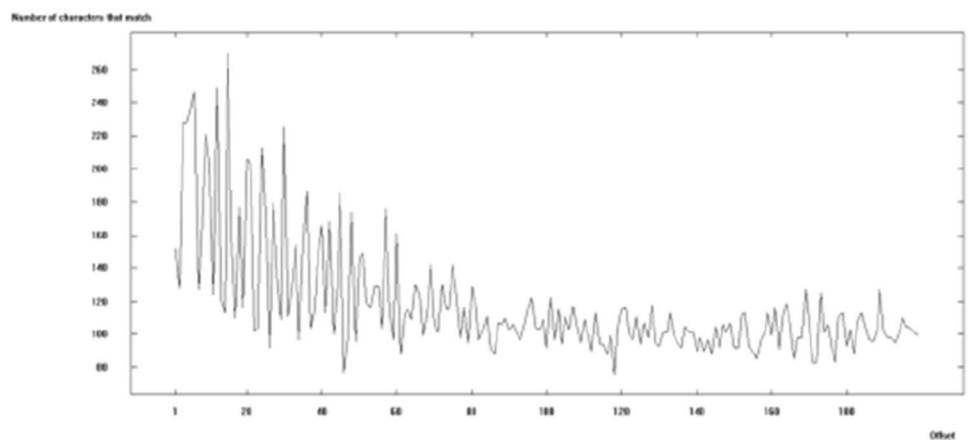
**Fig. 4** Histogram before encryption

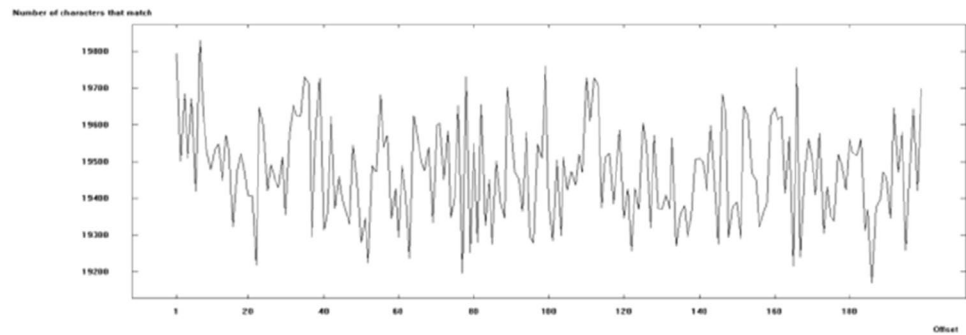


**Fig. 5** Histogram after proposed encryption



**Fig. 6** Autocorrelation before encryption



**Fig. 7** Autocorrelation after proposed encryption**Table 6** Decrypting time by intruders

Input neurons	Hidden neurons	Range of key size	Time in years to crack cipher (time)
10	13	(128,144)	$1.53 \times 10^{31}$
11	12	(128,144)	(in years)
12	11	(128,144)	
13	10	(128,144)	

passed through public channel. The encrypted vector contains the binary value of the number of hidden number of nodes inside the TPMs followed by the proposed rotational carry procedures. Thus, enhanced coupling between these two TPMs exists to achieve complete synchronization. The inverse operation is applied on the user TPM. First half of

the bits extracted from weight vector of TPM(S) followed by a bit left shift with carry, and then subsequent bitwise XOR operation to generate cipher text preceded by the binary value of the hidden layers.

**Requirement(s):** Weight vector  $WA[P]$  of two TPM(S) of length  $P$ .

**Input(s):**  $WA[P]$ : Integer Array

**Output(s):** Encrypted half weight vector of TPM(S).

```

Val1 ← (No. of Hidden nodes)
for i = 0 to ((P/2) - 1)
    PCW[i] ← StringConcat(WA[i])
    Increment i
end for
PCW[P/2 - 1] ← PCW[0]
for i = 1 to ((P/2) - 2)
    PCW[i] ← PCW[i] << 1
    Increment i
end for
PCW[0] ← PCW[0]
for i = 1 to ((P/2) - 2)
    PCW[i] ← (PCW[i] XoR PCW[i + 1])
    Increment i
end for
PCW[P] ← Call StringConcat(Val1, PCW[P/2])
Return ready encrypted transmittable vector

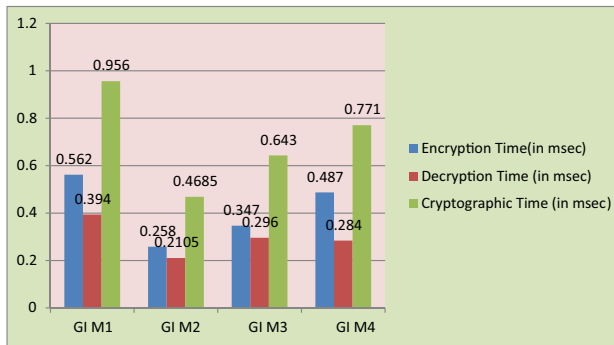
```

**Table 7** Cryptographic time records

Sl. No.	GI module no.	Encryption time (in ms)	Decryption time (in ms)
1	GI M1	0.562	0.394
2	GI M2	0.258	0.2105
3	GI M3	0.347	0.296
4	GI M4	0.487	0.284

**Table 10** Real time on GI M3

Sl. No.	Cryptographic name	Encryption time (in ms)	Decryption time (in ms)
1	RC5	0.753	0.598
2	Blowfish	0.549	0.364
3	Proposed here	0.347	0.296



**Fig. 8** GI-based cryptographic time

**Table 8** Real time on GI M1

Sl. No.	Cryptographic name	Encryption time (in ms)	Decryption time (in ms)
1	RC5	0.741	0.548
2	Blowfish	0.655	0.426
3	Proposed here	0.562	0.394

**Table 9** Real time on GI M2

Sl. No.	Cryptographic name	Encryption time (in ms)	Decryption time (in ms)
1	RC5	0.854	0.652
2	Blowfish	0.605	0.321
3	Proposed here	0.258	0.2105

**Algorithm 1.2:** AES key formation

The weight vector that has been generated through metaheuristic salp swarm algorithm is fed into a message digest algorithm [59, 60, 61]. The output of this algorithm will act as the AES transmission key in the proposed technique between users based in the utility of ICT tools.

**Table 11** Real time on GI M4

Sl. No.	Cryptographic name	Encryption time (in ms)	Decryption time (in ms)
1	RC5	0.686	0.487
2	Blowfish	0.542	0.297
3	Proposed here	0.487	0.284

*Input(s):* Weight Vector :  $B[ ]$   
*Output(s):* AES KEY:  $AK[128]$   
 // Generation of Message Digest  
 $AK[128] \leftarrow MessageDigest(B[ ])$

The resultant of this algorithm will act as the AES encryption key between the server and the users. The MD5 algorithm has been used here because it is more flexible in data operation on 128 bits length. Moreover, AES encryption has been used, and the output of MD5 has been fed into AES. The development of MD5 hash need less time with respect to other has functions. The intelligent matter is that the same key will be generated at both the terminals, thus, avoiding the common key exchange problem. Hence, the proposed technique can manage to defend the Man-In-The-Middle attacks.

**Experimental Results**

The proposed technique has been carried on several combinations of TPMs to reach out its validation. Out of which the following table contains the best observation at random trial with input and hidden neurons as 5 and 10, respectively. The range value is kept at 8 which is imposed on the salp swarm above-stated algorithm. The last column contains the number of synchronization needed between the server TPM and user TPM in terms of iterations required (Table 2).

Based on the data noted in the above Table 2, some of the relevant statistical computations were carried on as given in Table 3.

There exists a good and positive correlation between the range and the number of iterations needed to synchronize. Quartiles are also in good shapes, and kurtosis is also acceptable.

The skewness on the iteration values and differences in the iterations has been evaluated as Computed Skewness (Itr, Diff) = 1.812016. From Table 4, it may be stated that the magnitude in difference in number of iterations vary at a random fashion. Thus, the intruders do not get any concrete pattern of guessing the session key. It is a preventive measure for this proposed technique.

### Entropy Analysis

Entropy of a file is the degree of spreading in terms of 256 ASCII characters. In normal file, usually, it does not contain all 256 characters at uniform distribution. The proposed encryption converts the highly appeared characters to sparsely appeared characters at randomly. The following shows the entropy of the glycemic modules before and after encryption. After encryption, the entropy value is approaching the maximum limit of 8, which is acceptable (Table 5).

### Histogram Analysis

Histogram analysis is the bar graph representation of the character sets in the entire data set. The frequency of those characters is drawn in this diagram. Figures 4 and 5 show the histogram of the glycemic module before and after encryption, respectively.

The proposed technique encrypts the module into uniform distribution. The characters which were getting shorter bar charts before encryption are populated with higher charts here.

### Autocorrelation Analysis

Autocorrelation refers to the degree of match in the patterns within the blocks of data. There should be less autocorrelation in the cipher text. Thus, intruders will be in big dark frame to detect any specific pattern. Autocorrelation of the glycemic modules is reflected before and after encryption in Figs. 6 and 7.

From the above two figures, it is clear that there exists low correlation in cipher text. Thus, it shows the robustness of the proposed technique.

### Brute Force Analysis

This section deals with the calculation of amount of time needed to decrypt the session key by the intruders [62]. Always, intruders fit the cipher text into huge parallel set of neural networks to detect the exact session key. Therefore, the proposed technique has calculated the decrypting time

by the intruders using the super computers of 123 PETA FLOPS capacity (Table 6).

The amount calculated in Table 6 are realistically non-feasible. Therefore, the proposed technique is resistant against the brute force attacks.

### Cryptographic Timing Notes on GI Modules

Cryptographic time is an important criterion in selection secured method. It includes encryption time and decryption time. Minimum interaction time is always recommended for any cryptographic method. The encryption time and decryption time were noted for different GI modules in Table 7.

In Fig. 8, the overall cryptographic time on the proposed GI modules were shown. The results were acceptable in nature.

### Real-Time Comparison with Existing Methods

In this sub-section, a real-time data comparison was made between the proposed technique and RC5 [63] and Blowfish [64] on different GI modules. Tables 8, 9, 10, and 11 have shown the comparative tabulations. The proposed technique has shown better efficacy with respect to the existing methods.

From the above-stated Tables 8, 9, 10, and 11, we can conclude that our proposed technique has better performance with respect to existing techniques in the light of real-time data.

### Conclusion

High glycemic indexed foods are very much harmful to us especially when our immunity needs to get better. High immunity is essential to beat the novel corona virus disease. By the use of ICT in this COVID-19 era, we can get, share, and receive information modules through online telecare systems. This paper had proposed to share online glycemic data modules between the server and users' tree parity machines. They synchronize their weight by different learning rules. The session key was generated through metaheuristic salp swarm algorithm. The statistical skewness on iteration and differences in the iterations has been noted as Computed Skewness (Itr, Diff) = 1.812016 on the TPM.

Different parameter-based tests were carried on to test the acceptance of the proposed technique. Such innovative technique is more suited in food and technology-based E-health Information System [65–67].

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## Declarations

**Conflict of Interest** On behalf of all the authors, the corresponding author states that there are no conflicts of interests.

**Ethics Approval and Consent to Participate** Not applicable.

**Consent for Publication** Not applicable.

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