

NOVEL TRAIN HEIST OPTIMIZATION AND LOGISTIC CHAOTIC MAP BASED FRESHMAN LEARNING PROCESS INSPIRED ALGORITHM FOR SOLVING THE OPTIMAL POWER FLOW PROBLEM

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Abstract

Train heist based optimization (THO) algorithm is designed based on the really happened train heist in United Kingdom. In the exploration section, robbery gang has been executed the plan has been imitated and mathematically defined. Prior to the execution the robbers plan the conspiracy after multiple examinations on the track. In the exploitation section fled activities of the robbery gang has been emulated and scientifically defined. Even though Leatherslade Farm had been already purchased by the robbery gang, they altered the plan rapidly with minimum stay period in the farm by listening in to the police very high frequency channels. Chaotic communiqué amongst the gang members and Perception of movement may differ among the gang members and the error value in the decision of the movement is defined. Then in this paper Logistic chaotic map based freshman learning process inspired optimization (LCP) algorithm is designed to solve the problem. LCP algorithm is designed by imitating the freshman learning process. Trainer will enhance learning process of freshman day by day. Freshman lives in ambiguous world and monetary predicament may originate at dissimilar phases of freshman's life. Deeds of the freshman learning process are mathematically formulated and population engendered based on the logistic chaos mapping. Trainer will explore the complications and consider a mean point of all complications. Suitable guidance and solutions will be delivered to the freshman by the trainer. Train heist based optimization (THO) algorithm and Logistic chaotic map based freshman learning process inspired optimization (LCP) algorithm are validated in 23 Benchmarking functions and IEEE 30, 354 systems.

Keywords: Terms-Train; Heist; Robbery; Gang; Logistic chaotic map; Freshman learning process

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Introduction

Train heist based optimization (THO) algorithm is designed based on the really happened train heist in United Kingdom in the year 1963. Royal Mail train (Figure 1) started from Glasgow and its destination station is London. When the Royal mail train passages in the west coast main line at 3:15 AM of 8th August 1963 at Bridego Railway Bridge, Buckinghamshire, England; 15 members team led by the gang leader Bruce Reynolds stopped the train by turn off the track greensignal and by utilizing the batteries, red signal had been turned on (Figure 1a) (<https://www.postalmuseum.org/collections/great-train-robbery/>). Then the robbers took £2.61 million money from the High Value Packet coach next to the engine. As the sixteen member of the team a retired train operating driver also hired by the robbery gang, but his identity not had been find out throughout the investigation. Stolen money not recovered equally both the hired retired train operating driver and the informer identities are not established.



Figure 1. Royal mail train and robbed High Value Packet coach
(<https://www.postalmuseum.org/collections/great-train-robbery/>)

During the investigation it had been found that seventeen members of the gang are received an equivalent share of the money, along with two significant informers in the plot. Eleven robbers of the gang sentenced to jail terms up to 30 years by the court. In this work, mathematical formulation had been done which is based on the activities of the robbery gang. In the exploration section how the robbery gang has been executed the plan has been mathematically defined. Prior to the execution the

robbers plan the conspiracy after multiple examinations.

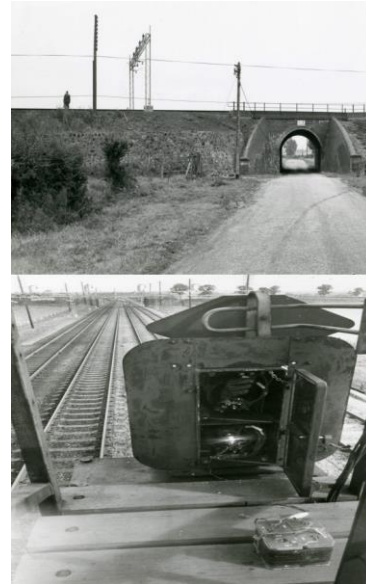


Figure 1a. Bridego Railway Bridge and by utilizing the batteries, red signal had been turned on
(<https://www.postalmuseum.org/collections/great-train-robbery/>)

As per the directions of the gang leader, the members are rapidly altered their activities and their position in the plan also randomly varied. Since few gang members are cautious and observing the High Value Packet coach in charges four postal workers who has been kept under siege. In the exploitation section fled activities of the robbery gang has been mathematically defined.

Even though Leatherslade Farm had been already purchased by the robbery gang, they altered the plan rapidly with minimum stay period in the farm by listening in to the police Very High Frequency channels. They tried to wipe out the finger prints in the Leatherslade Farm before their movement from there and also tried to burn the Leatherslade Farm. Perception of movement may differ among the gang members and the error value in the decision of the movement is defined.

Logistic chaotic map based freshman learning process inspired optimization (LCP) algorithm is designed by imitating the learning process inside the freshman. Complications in learning are customary. Freshman (Figure 2) lives in ambiguous world and monetary predicament may originate at dissimilar phases of freshman's life. Needs of the freshman are has different level of priorities. Each individual prioritize the needs rendering to situations.

Learning pressure, time organization complications, monetary limitations, and psychological health problems are among the topmost tasks that freshman's encounter. Nevertheless, identifying and addressing these glitches in preliminary level can expressively in fluence freshman's overall well-being and all performance. Aloneness, upholding healthy associations and psychological health, intellectual fitness, grief and distressing proceedings, physical disease are generally faced by the common freshman (Juneja *et al.*, 2020).



Figure 2. Freshman training (image representation)

Trainer gives solution to the problems of common freshman has been imitated and scientifically formulated. Trainer identifies the shortcomings of freshman, accordingly put efforts to enhance the learning process. Deeds of the freshman learning process are mathematically formulated and population engendered based on the logistic chaos mapping. Primarily freshman meets the trainer with the problems and seeks guidance. The intensity of the complications differs from one freshman to another. Few freshmen may face multiple complications in the learning process. With huge concentration Trainer will analyze and gives better guidance in terms of solutions to all dissimilar type of complications. Trainer keeps his own mind in the point of neutrality and unbiased approach. Rendering to the intensity of the complications in the learning process, trainer guide the freshman time to time. Freshman conversation with trainer may be continuous or few times it may be intermittent. Few times freshman may hedge form one complication to another in disorder mode. Since freshman may face multiple complications in the learning process. Freshman understanding and adequate solutions given by the trainer plays a key role in diffusing the complications in the process of learning. When freshman not following the guidance given by the trainer, then there may be an

upsurge in the intensity of the problem. Train heist based optimization (THO) algorithm and Logistic chaotic map based freshman learning process inspired optimization (LCP) algorithm validated in 23 Benchmarking functions and IEEE 30, 354 systems.

Problem Formulation

Real power loss reduction is demarcated as,

$$\text{Min } \tilde{F}(\bar{g}, \bar{h}) \quad (1)$$

$$\bar{g} = [VLG_1, \dots, VLG_{Ng}; QC_1, \dots, QC_{Ng}; T_1, \dots, T_{N_T}] \quad (2)$$

$$\bar{h} = [PG_{slack}; VL_1, \dots, VL_{N_{Load}}; QG_1, \dots, QG_{Ng}; SL_1, \dots, SL_{N_T}] \quad (3)$$

$Q_C \rightarrow$ reactive power compensator

$T \rightarrow$ Transformer tap

$V_g \rightarrow$ Generator voltage

$PG_{slack} \rightarrow$ Slack generator

$V_L \rightarrow$ Voltage in transmission lines

$Q_G \rightarrow$ Reactive power generator

Fitness functions are defined as follows,

$$F_1 = P_{Min} = \text{Min} \left[\sum_m^{NTL} G_m [V_i^2 + V_j^2 - 2 * V_i V_j \cos \theta_{ij}] \right]$$

$$F_2 = \text{Min} \left[\sum_{i=1}^{N_{LB}} |V_{Lk} - V_{Lk}^{desired}|^2 + \sum_{i=1}^{Ng} |Q_{GK} - Q_{KG}^{Lim}|^2 \right]$$

$$F_3 = \text{Minimize } L_{Maximum}$$

$$S_L \rightarrow \text{Apparent power } L_{Max} = \text{Max}[L_j]; j = 1; N_{LB}$$

$$\begin{cases} L_j = 1 - \sum_{i=1}^{NPV} F_{ji} \frac{V_i}{V_j} \\ F_{ji} = -[Y_1]^{-1} [Y_2] \end{cases} \quad (4)$$

$$L_{Max} = \text{Max} \left[1 - [Y_1]^{-1} [Y_2] \times \frac{V_i}{V_j} \right]$$

Parity constraints

$$0 = PG_i - PD_i - V_i \sum_{j \in N_B} V_j [G_{ij} \cos[\theta_i - \theta_j] + B_{ij} \sin[\theta_i - \theta_j]] \quad (5)$$

$$0 = QG_i - QD_i - V_i \sum_{j \in N_B} V_j [G_{ij} \sin[\theta_i - \theta_j] + B_{ij} \cos[\theta_i - \theta_j]] \quad (6)$$

NB is the number of buses

PG, QG $\rightarrow$ real and reactive power

Gij, Bij $\rightarrow$ mutual conductance and susceptance

PD, QD → real and reactive load

Disparity constraints

$$P_{gsl}^{\min} \leq P_{gsl} \leq P_{gsl}^{\max} \quad (7)$$

Reactive power generation (QGi)

$$Q_{gi}^{\min} \leq Q_{gi} \leq Q_{gi}^{\max}, i \in N_g \quad (8)$$

Load bus voltage (VLi)

$$VL_i^{\min} \leq VL_i \leq VL_i^{\max}, i \in NL \quad (9)$$

Transformers tap setting (Ti)

$$T_i^{\min} \leq T_i \leq T_i^{\max}, i \in N_T \quad (10)$$

Switchable reactive power compensations (QCi)

$$Q_c^{\min} \leq Q_c \leq Q_c^{\max}, i \in N_C \quad (11)$$

$$|SL_i| \leq S_{L_i}^{\max}, i \in N_{TL} \quad (12)$$

Generator bus voltage (VGi)

$$VG_i^{\min} \leq VG_i \leq VG_i^{\max}, i \in N_g \quad (13)$$

$$F = F_1 + r_1 F_2 + u F_3 = F_1 + \left[\sum_{i=1}^{NL} x_v [VL_i - VL_i^{\min}]^2 + \sum_{i=1}^{NG} r_g [QG_i - QG_i^{\min}]^2 \right] + r_f F_3$$

$$VL_i^{\text{minimum}} = \begin{cases} VL_i^{\max}, & VL_i > VL_i^{\max} \\ VL_i^{\min}, & VL_i < VL_i^{\min} \end{cases} \quad (14)$$

$$QG_i^{\text{minimum}} = \begin{cases} QG_i^{\max}, & QG_i > QG_i^{\max} \\ QG_i^{\min}, & QG_i < QG_i^{\min} \end{cases} \quad (15)$$

Train heist based optimization algorithm

In this paper Train heist based optimization (THO) algorithm is designed based on the really happened train heist in United Kingdom in the year 1963 ([https://en.wikipedia.org/wiki/Great_Train_Robbery_\(1963\)](https://en.wikipedia.org/wiki/Great_Train_Robbery_(1963))) During the investigation it had been found that seventeen full robbery members gang are received an equal share of the money, along with two significant informers in the plot. Eleven robbers of the gang sentenced to jail terms up to 30 years by the court. In this work, mathematical formulation had been done which is based on the activities of the robbery gang. Population of the Train heist based optimization algorithm is produced as follows,

$$H = \begin{bmatrix} H_1 \\ \vdots \\ H_i \\ \vdots \\ H_N \end{bmatrix}_{N \times m} = \begin{bmatrix} h_{1,1} & \cdots & h_{1,m} \\ \vdots & \ddots & \vdots \\ h_{N,1} & \cdots & h_{N,m} \end{bmatrix} \quad (16)$$

$H \rightarrow$ matrix population

$N \rightarrow$ population members

$m \rightarrow$ variables

$$h_{i,j} = \min_j + R(\max_j - \min_j) \quad (17)$$

$\max_j, \min_j \rightarrow$ limits

$R \in [0,1]$

Objective function calculated as,

$$F = \begin{bmatrix} F_1 \\ \vdots \\ F_i \\ \vdots \\ F_N \end{bmatrix}_{N \times 1} = \begin{bmatrix} F(H_1) \\ \vdots \\ F(H_i) \\ \vdots \\ F(H_N) \end{bmatrix}_{N \times 1} \quad (18)$$

In the exploration section how the robbery gang has been executed the plan has been mathematically defined. Prior to the execution the robbers plan the conspiracy after multiple examinations. How to stop the train and which place and time are well planned by the gang. Each member of the gang has been assigned a defined work in the plan. As extensive exploration had been done the robbery gang in order to get succeeds. Especially train stopping procedure as well as place of stopping the train is carefully crafted by the robbery gang. Within 15-20 min the money £2.61 million had been robbed from the train and transported to their vehicle. At first train had been stopped by cut-off the green signal and they put on the red signal by using the battery. Then the gang cut the wires of the telephone which has been placed in the pole for the emergency purpose. When the firemen observed these conditions, has had been assaulted by the gang members. Equally the gang attacked the train driver jack mills were attacked by an iron rod on the head. Both the fireman and train driver fell down in unconscious and semi - unconscious mode. Then the hired sixteenth member of the gang “retired train driver” had tried to operate the train in order to move the train to nearby Bridego Railway Bridge, Ledburn. But the retired train driver doesn't the operating process of the royal mail train. Again the gang by sprinkle the water on the face of the driver jack mill and made him to operate the train up to the Bridego Railway Bridge, Ledburn. Then again the gang hit the head of the jack mill with iron rod and the driver fell down in complete unconscious mode. Immediately

the gang entered into the High Value Packet coach and four postal workers has been kept under siege in forceful mode until the money transferred to their parked vehicles. Gang member's acted swiftly in the minimum time and they continuously altered their position rendering to the conditions. Mathematical formulation of the exploration segment is defined as,

$$H_{i,j}^{L1} = H_{i,j} + R \cdot (G_j - R_1 \cdot H_{i,j}) \quad (19)$$

$H_{i,j}^{L1} \rightarrow$ fresh position of the i th member of the population

$G_j \rightarrow$ location of the train in j th dimension

$R \in [0,1]$

$R_1 \in \{1,2\}$

$$H_i = \begin{cases} H_i^{L1}, & F_i^{L1} \leq F_i \\ H_i, & \text{Else} \end{cases} \quad (20)$$

As per the directions of the gang leader, the members are rapidly altered their activities and their position in the plan also randomly varied. Since few gang members are cautious and observing the High Value Packet coach in charges four postal workers who has been kept under siege. Few are transporting the money from the HVP coach to their private vehicle which had been parked near to the bridge. Then the position variations between the gang members are mathematically defined as,

$$H_{i,j}^k \text{ fresh} = H_{i,j}^k \text{ old} + R * (H_{b,j}^k - H_{i,j}^k \text{ old}) \quad (21)$$

$H_{b,j}^k \rightarrow$ current position of the member

$H_{i,j}^k \text{ fresh} \rightarrow$ fresh position of the member

$R \in [0,1]$

Based on the orders of the gang leader, the members alter their work rapidly to move all the money out of the HVP coach. Each member will learn from other member about the rapidness and work activity of shifting the money within minimum period of the time.

$$H_{i,j}^k \text{ fresh} = H_{i,j}^k \text{ old} + R_2 * (H_{b,j}^k - H_{i,j}^k \text{ old}) - R_3 * (H_{p,j}^k - H_{i,j}^k \text{ old}) \quad (22)$$

$H_{b,j}^k \rightarrow$ current position of the member

$H_{i,j}^k \text{ new} \rightarrow$ fresh position of the member

$H_{p,j}^k \rightarrow$ understanding factor

Members of the gang understand from each other, shifting of the work and position will altered randomly,

$$H_{i,j}^k \text{ fresh} = H_{i,j}^k \text{ old} + R * (H_{b,j}^k - H_{p,j}^k) \quad (23)$$

$H_{b,j}^k \rightarrow$ current position of the member

$H_{i,j}^k \text{ fresh} \rightarrow$ fresh position of the member

$H_{p,j}^k \rightarrow$ understanding factor

Few members of the gang are very spontaneous in their activity and they won't observe the others activity and their concentration will be execution of the assigned work in the plan by the gang leader. This action defined as,

$$H_{i,j}^k \text{ fresh} = C_{i,j}^k \text{ old} * (1 + t(k)) \quad (24)$$

The gang leader continuously direct the members about the course of activity and entire team members will follow the oral orders of the leader,

$$RT \rightarrow [H_1, H_2, \dots, H_{15}] \quad (25)$$

$RT \rightarrow$ robbery team

$H_1, H_2, \dots, H_{15} \rightarrow$ members

After the completion of robbery, the gang leader ordered to High Value Packet coach in charges- four postal workers who has been kept under siege not to move for next 30 minutes. These words of "30 minutes" acted as key for the police in tracing the robbery members. The police approximately calculated the distance of movement covered in 30 minutes; when the robbery gang can move faster mode. This condition is defined as,

$$M_i = \{H_k, F_k > F_i\} \quad (26)$$

$k = 1, 2, 3, \dots, N$

$i = 1, 2, \dots, N$

$M_i \rightarrow$ Movement of the robbery gang

$$H_{i,j}^{L2} = H_{i,j} + R \cdot (H_{i,j} - R_4 \cdot P_{i,j}) \quad (27)$$

$H_{i,j}^{L2} \rightarrow$ fresh position of the gang

$R \in [0,1]$

$R_4 \in \{1,2\}$

$P_{i,j} \rightarrow$ police assumption about the radius of gang movement in the span of 30 minutes

$$H_i = \begin{cases} H_i^{L2}, & F_i^{L2} \leq F_i \\ H_i, & \text{else} \end{cases} \quad (28)$$

In the exploitation section fled activities of the robbery gang has been mathematically defined. Even though Leatherslade Farm had been already purchased by the robbery gang, they altered the plan rapidly with minimum stay period in the farm by listening in to the police VHF channels. They tried to wipe out the finger prints in the Leatherslade Farm before their movement form there and also

tried to burn the Leatherslade Farm. Yet that process is unsuccessful, since the paid member of that activity failed to do so. The robber team altered the vehicles of travel and much tactful movement done by them for without being to be caught by the police. This action is defined as follows,

$$H_{i,j}^{L3} = H_{i,j} + R \cdot (1 - 2 \cdot R) \cdot \frac{\max_j - \min_j}{t} \quad (29)$$

$H_{i,j}^{L3} \rightarrow$ fresh position of the gang
 $R \in [0,1]$
 $t \rightarrow$ iteration counter

$$H_i = \begin{cases} H_{i,j}^{L3}, F_i^{L3} \leq F_i \\ H_i, Else \end{cases} \quad (30)$$

The movement of the gang rendering to conditions are defined as,

$$H_{i,j}^{k,t_l} \text{ fresh} = \begin{cases} H_{b,j}^{k,t_l} \text{ fresh if } R \leq Q_s \\ H_{i,j}^{k,t_l} \text{ old if } R > Q_s \end{cases} \quad (31)$$

$H_{b,j}^{k,t_l} \text{ new} \rightarrow$ new location of the gang
 $Q_s \rightarrow$ conditions
 $R \in [0,1]$

The random movement is defined as,

$$H_{i,j}^{k,t_l} \text{ fresh} = \begin{cases} H_{R,j}^{k,t_l} \text{ if } R \leq P_s \\ H_{i,j}^{k,t_l} \text{ old if } R > P_s \end{cases} \quad (32)$$

$H_{R,j}^{k,t_l} \rightarrow$ Random movement of the gang

Chaotic (Lenin et al., 2023) communiqué amongst the gang members is defined as,

$$\begin{cases} H_{i,j}^{k,t_l} \text{ fresh} = H_{R,j}^{k,t_l} \text{ old} * (1 + R \cdot n) \\ H_{R,j}^{k,t_l} \text{ fresh} = H_{i,j}^{k,t_l} \text{ old} * (1 + R \cdot n) \end{cases} \text{ if } R \leq U_{COM} \quad (33)$$

$U_{COM} \rightarrow$ Chaotic communiqué amongst the gang members

$$\begin{cases} H_{i,j}^{k,t_l} \text{ fresh} = H_{i,j}^{k,t_l} \text{ old} \\ H_{R,j}^{k,t_l} \text{ fresh} = H_{R,j}^{k,t_l} \text{ old} \end{cases} \text{ if } R > U_{COM} \quad (34)$$

Perception of movement may differ among the gang members and the error value in the decision of the movement is defined as,

$$\begin{cases} H_{i,j}^{k,t_l} \text{ fresh} = H_{A_1, A_2}^{k,t_l} \text{ old if } R \leq U_E \\ H_{i,j}^{k,t_l} \text{ fresh} = H_{i,j}^{k,t_l} \text{ old if } R > U_E \end{cases} \quad (35)$$

$E \rightarrow$ Error value

- a. Start
- b. Set the parameters
- c. Engender the population
- d. $h_{i,j} = \min_j + R(\max_j - \min_j)$
- e. Comput the objective function
- f. Apply the exploration section
- g. $H_{i,j}^{L1} = H_{i,j} + R \cdot (G_j - R_1 \cdot H_{i,j})$
- h. $H_i = \begin{cases} H_i^{L1}, F_i^{L1} \leq F_i \\ H_i, Else \end{cases}$
- i. Define the position variations among the gang members
- j. $H_{i,j}^k \text{ fresh} = H_{i,j}^k \text{ old} + R \cdot (H_{b,j}^k - H_{i,j}^k \text{ old})$
- k. Work alteration among the members
- l. $H_{i,j}^k \text{ fresh} = H_{i,j}^k \text{ old} + R_2 \cdot (H_{b,j}^k - H_{i,j}^k \text{ old}) - R_3 \cdot (H_{p,j}^k - H_{i,j}^k \text{ old})$
- m. Update the location of the members
- n. $H_{i,j}^k \text{ fresh} = H_{i,j}^k \text{ old} + R \cdot (H_{b,j}^k - H_{p,j}^k)$
- o. Rendering to time define spontaneous work activity of the members
- p. $H_{i,j}^k \text{ fresh} = C_{i,j}^k \text{ old} * (1 + t(k))$
- q. Gang members controlled by leader
- r. $RT \rightarrow [H_1, H_2, \dots, H_{15}]$
- s. Determine the assumption rate of investigating police
- t. $M_i = \{H_k, F_k > F_i\}$
- u. $H_{i,j}^{L2} = H_{i,j} + R \cdot (H_{i,j} - R_4 \cdot P_{i,j})$
- v. $H_i = \begin{cases} H_i^{L2}, F_i^{L2} \leq F_i \\ H_i, else \end{cases}$
- w. Apply Exploitation segment
- x. $H_{i,j}^{L3} = H_{i,j} + R \cdot (1 - 2 \cdot R) \cdot \frac{\max_j - \min_j}{t}$
- y. $H_i = \begin{cases} H_i^{L3}, F_i^{L3} \leq F_i \\ H_i, Else \end{cases}$
- z. Define the movement of the gang
- aa. $H_{i,j}^{k,t_l} \text{ fresh} = \begin{cases} H_{b,j}^{k,t_l} \text{ fresh if } R \leq Q_s \\ H_{i,j}^{k,t_l} \text{ old if } R > Q_s \end{cases}$
- bb. Determine the Random movement
- cc. $H_{i,j}^{k,t_l} \text{ fresh} = \begin{cases} H_{R,j}^{k,t_l} \text{ if } R \leq P_s \\ H_{i,j}^{k,t_l} \text{ old if } R > P_s \end{cases}$
- dd. Define the chaotic communiqué amongst the gang members
- ee. $\begin{cases} H_{i,j}^{k,t_l} \text{ fresh} = H_{R,j}^{k,t_l} \text{ old} * (1 + R \cdot n) \\ H_{R,j}^{k,t_l} \text{ fresh} = H_{i,j}^{k,t_l} \text{ old} * (1 + R \cdot n) \end{cases} \text{ if } R \leq U_{COM}$
- ff. $\begin{cases} H_{i,j}^{k,t_l} \text{ fresh} = H_{i,j}^{k,t_l} \text{ old} \\ H_{R,j}^{k,t_l} \text{ fresh} = H_{R,j}^{k,t_l} \text{ old} \end{cases} \text{ if } R > U_{COM}$
- gg. Define the error rate in the movement
- hh. End for

- ii. $t = t + 1$
- jj. Output the best solution
- kk. End

Logistic chaotic map based Freshman learning process inspired optimizationalgorithm

Logistic chaotic map based freshman learning process inspired optimization (LCP) algorithm is designed by imitating the training and learning process inside the freshman. Complications in learning are customary. Freshman lives in ambiguous world and monetary predicament may originate at dissimilar phases of freshman's life. Needs of the freshman are has different level of priorities. Each individual prioritize the needs rendering to situations. Learning pressure, time organization complications, monetary limitations, and psychological health problems are among the topmost tasks that freshman's encounter.

In this research paper how a trainer gives solution to the problems of common freshman has been scientifically formulated. Trainer identifies the shortcomings of freshman, accordingly put efforts to enhance the learning process. Deeds of the freshman learning process are mathematically formulated and population engendered based on the logistic chaos mapping,

$$x_{n+1} = rx_n(1 - x_n) \quad (36)$$

$$\begin{aligned} r &\in [0,4] \\ \forall n &\in \{0,1,\dots\} \\ r, x_0 &\in [0,1] \\ x_n &\leq \frac{x_0}{r^{-n} + x_0 n} \\ Q_i &= \delta \cdot Q_{i-1} \cdot (1 - Q_{i-1})(2) \\ 0 &\leq Q_0 \leq 1 \\ i &= 1,2,3,\dots,N \\ \delta &= 4 \end{aligned}$$

In the examination region chaotic value will be mapped and the limits of the region is defined as,

$$Q_i^0 = \min + (\max - \min) \cdot Q_i \quad (37)$$

Rendering to the intensity of the complications in the learning process, trainer guide the freshman time to time. Freshman conversation with trainer may be continuous or few times it may be intermittent. Few times freshman may hedge form one complication to another in disorder mode. Since freshman may face multiple complications in the learning process. In the formulation Lévy flight

strategy has been incorporated. Exploring the complications by the Trainer is defined as,

$$Q_i^{t+1} = \gamma \cdot \left(1 - \frac{t}{\max.iter}\right) \cdot (Q_i^t - Q_b) + Lévy(d) + Q_b \cdot \left(1 - \frac{t}{\max.iter}\right) + (Q_m^t - Q_b) \cdot f\left(\frac{R}{f_j}\right) \cdot f_j \quad (38)$$

$Q_i^t \rightarrow$ Initial exploration of the complication
 $Q_i^{t+1} \rightarrow$ updated exploration of the complication
 $Q_b \rightarrow$ better exploration of the complication
 $Q_m^t \rightarrow$ mean value of exploration

$Lévy(d) \rightarrow$ Lévy dimension

$$Z(i+1) = Q(i) - |e(t)| \times A \times L(d)(5)$$

$$L(s) \sim |s|^{-1-\beta}$$

$$0 < \beta < 2$$

$$L(s, \gamma, \mu) = \begin{cases} \sqrt{\frac{\gamma}{2\pi}} & \text{if } s \leq 0 \\ \exp\left[-\frac{\gamma}{2(s-\mu)}\right] \frac{1}{(s-\mu)^{3/2}} & \text{if } s > 0 \end{cases}$$

$$0 < \mu < s < \infty$$

$$F(k) = \exp[-\alpha|k|^\beta]$$

$$R \in [0,1]$$

Present population mean position is defined as,

$$Q_m^t = \frac{1}{N} \sum_{k=1}^N Q_k^t \quad (39)$$

$$\gamma = 0.2 \left(1 - \frac{t}{\max.iter}\right) \cdot (Q_i^t - Q_m^t)$$

Freshman may face multiple complications in the process of learning. They may not able to express completely because their mind occupied with distress and strain.

$$f_j = \frac{\max - \min}{\alpha}$$

$$\alpha \in [100, 2000]$$

Trainer will explore the complications and consider a mean point of all complications. Then suitable guidance and solutions will be delivered to the freshman. This high level of exploration defined as,

$$Q_i^{t+1} = \begin{cases} \omega \cdot Q_i^t \cdot \exp\left(\frac{-t}{R \cdot \max.iter}\right), R < U \\ \omega \cdot Q_i^t + R_1 \sigma, R \geq U \end{cases} \quad (40)$$

$R_1 \rightarrow$ normal random distribution

$$\sigma \in (1, d)$$

$$R \in [0,1]$$

$U \rightarrow$ mean point of all complications

$$U = 0.6$$

$$d = 1$$

$$\omega = 0.2 \cos\left(\frac{\pi}{2} \left(1 - \frac{t}{\max.iter}\right)\right) \quad (41)$$

Exploring the solutions for the complication is defined as,

$$Q_i^{t+1} = R_1 \exp\left(\frac{Q_L^{t_2} - Q_i^{t_2}}{i^2}\right) \quad (42)$$

$L \rightarrow$ minimum solution to complication

Freshman understanding and acceptable level of the solutions given by trainer plays key role in diffusing the complications in the learning process. When freshman not following the guidance given by the trainer, then there may be an upsurge in the intensity of the problem. Freshman state at this juncture is defined as,

$$Q_i^{t+1} = Q_i^t + \omega \cdot R_3 \cdot (Q_b^t - Q_i^t) \quad (43)$$

$Q_i^{t+1} \rightarrow$ state of learner
 $R_3 \in (1, d)$

Freshman's, who are all not taking the solutions and guidance from the Trainer, and then they may remain in the same state of the complications. This state is defined as,

$$Q_i^{t+1} = (Q_b - Q_i^t)R_1 \quad (44)$$

- a. Start
- b. Generate the population
- c. $Q_i = \delta \cdot Q_{i-1} \cdot (1 - Q_{i-1})$
- d. Define the limits in the examination region
- e. $Q_i^0 = \min + (\max - \min) \cdot Q_i$
- f. Determine the exploration probability based on Levy
- g. $Q_i^{t+1} = \gamma \cdot \left(1 - \frac{t}{\max.iter}\right) \cdot (Q_i^t - Q_b) + Lévy(d) + Q_b \cdot \left(1 - \frac{t}{\max.iter}\right) + (Q_m^t - Q_b) \cdot f\left(\frac{R}{f_j}\right) \cdot f_j$
- h. $Z(i+1) = Q(i) - |e(t)| \times A \times L(d)$
- i. Define the mean position of current population
- j. $Q_m^t = \frac{1}{N} \sum_{k=1}^N Q_k^t$
- k. Define the continuity
- l. $f_j = \frac{\max - \min}{\alpha}$
- m. Determine the range of exploration of the complication
- n. $Q_i^{t+1} = \begin{cases} \omega \cdot Q_i^t \cdot \exp\left(\frac{-t}{R \cdot \max.iter}\right), R < U \\ \omega \cdot Q_i^t + R_1 \sigma, R \geq U \end{cases}$
- o. Define the probability of solutions

- p. $Q_i^{t+1} = R_1 \exp\left(\frac{Q_L^{t_2} - Q_i^{t_2}}{i^2}\right)$
- q. Determine the acceptance rate of freshman
- r. $Q_i^{t+1} = Q_i^t + \omega \cdot R_3 \cdot (Q_b^t - Q_i^t)$
- s. Define the rate of freshman
- t. $Q_i^{t+1} = (Q_b - Q_i^t)R_1$
- u. $t = t + 1$
- v. Output the best solution
- w. End

Results

Validity of Train heist based optimization (THO) algorithm and Logistic chaotic map based freshman learning process inspired optimization (LCP) algorithm are verified in 23 benchmark functions (Tudose *et al.*, 2021), Table 1 define the result THO in 23 benchmark functions.

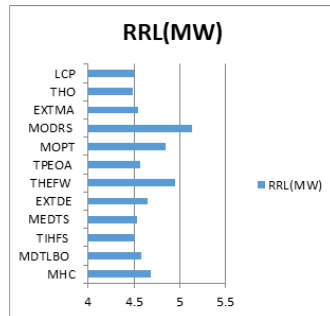
Validity of Train heist based optimization (THO) algorithm and Logistic chaotic map based freshman learning process inspired optimization (LCP) algorithm are verified in IEEE 30 bus system (Illinois Center for a Smarter Electric Grid (ICSEG). Available online: <https://icseg.iti.illinois.edu/ieee-30-bussystem>). Table 2 shows the Real Power Loss (RRL (MW)), Voltage deviation (VFN (PU)) and stability (VSB(PU)). Figure 3 exhibits the valuation.

Table 1. Freshman training (img representation)

F	BICSSA (Tudose <i>et al.</i> , 2021)	AESSA (Tudose <i>et al.</i> , 2021)	THO	LCP
1	6.38×10-12	6.96×10-9	6.30×10-12	6.30×10-12
2	3.08×10-7	5.48×10-6	3.04×10-7	3.04×10-7
3	2.53×10-1	4.35×10-10	2.56×10-1	2.56×10-1
4	6.71×10-7	1.19×10-5	6.69×10-7	6.69×10-7
5	4.110208	4.11726	4.11200	4.11200
6	3.19×10-10	4.50×10-10	3.19×10-10	3.19×10-10
7	2.23×10-5	0.002002	2.21×10-5	2.21×10-5
8	-2877.61	-3052.87	-2872.33	-2872.33
9	1.01×10-12	22.85084	1.00×10-12	1.00×10-12
10	4.79×10-7	0.810233	4.77×10-7	4.77×10-7
11	5.91×10-12	0.33718	5.89×10-12	5.89×10-12
12	2.56×10-12	0.051897	2.54×10-12	2.54×10-12
13	0.000366	0.001099	0.000357	0.000357
14	0.998004	0.998004	0.998001	0.998001
15	0.000307	0.000829	0.000303	0.000303
16	-1.03163	-1.03163	-1.03159	-1.03159
17	0.397887	0.397887	0.397879	0.397879
18	3	3	3	3
19	-3.86278	-3.86278	-3.86270	-3.86270
20	-3.23084	-3.21497	-3.23081	-3.23081
21	-10.1532	-8.80506	-10.1529	-10.1529
22	-10.0486	-8.46635	-10.0479	-10.0479
23	-10.5364	-9.28557	-10.5358	-10.5358

Table 2. Appraisal of values (IEEE30 bus)

Method	RRL(MW)	VVN(PU)	VSB(PU)
MHC (Mandal and Roy, 2013)	4.6862	0.1354	0.1271
MDTLBO (Mouassa <i>et al.</i> , 2017)	4.5777	0.0913	0.1180
TIHFS (Cao <i>et al.</i> , 2019)	4.5135	0.0896	0.1252
MEDTS (Duong <i>et al.</i> , 2020)	4.5284	0.0891	0.1245
EXTDE (Pg <i>et al.</i> , 2022)	4.6482	0.0802	0.1004
THEFW (Abd-El Wahab <i>et al.</i> , 2022)	4.9448	0.1212	0.1232
TPEOA (Habib Khan <i>et al.</i> , 2022)	4.5677	0.1250	0.1135
MOPT (Ali <i>et al.</i> , 2023)	4.8395	1.2663	0.1259
MODRS (Ali <i>et al.</i> , 2023)	5.1328	1.0240	0.1287
EXTMA (Ali <i>et al.</i> , 2023)	4.5464	1.9889	0.1294
THO	4.4910	0.0112	0.1518
LCP	4.4927	0.0129	0.1499

**Figure 3. RRL (MW) evaluation (IEEE30 BUS)**

Validity of Train heist based optimization (THO) algorithm and Logistic chaotic map based freshman learning process inspired optimization (LCP) algorithm are verified in IEEE 354 bus system (PSTCA, Power Systems Test Case Archive, University of Washington, Available: <http://www.ee.washington.edu/research/pstca/>). Table 3 and Figure 4 displays the assessment.

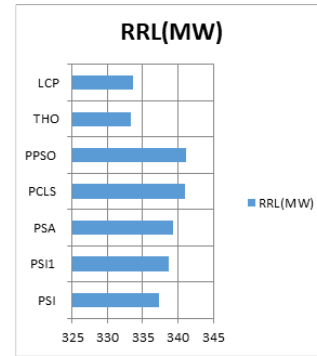
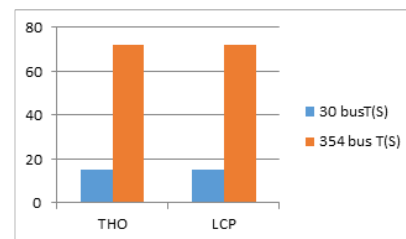
Table 4 and Figure 5 show the time taken by THO, LCP.

Table 3. Appraisal of values (IEEE30 bus)

Method	RRL(MW)	VVN(PU)
PSI (Mouassa and Bouktir, 2019)	337.374	0.4978
PSI1 (Mouassa and Bouktir, 2019)	338.715	0.5117
PSA (Mouassa and Bouktir, 2019)	339.325	0.5216
PCLS (Karthik <i>et al.</i> , 2021)	341.001	0.5354
PPSO (Karthik <i>et al.</i> , 2021)	341.123	0.6395
THO	333.298	0.4237
LCP	333.571	0.4251

Table 4. Appraisal of values (IEEE30 bus)

Method	30 BUST(S)	354 BUS T(S)
THO	15.21	72.19
LCP	15.01	71.93

**Figure 4. RRL (MW) assessment (IEEE354 BUS)****Figure 5. Time taken by THO, LCP**

Discussion of results

Projected Train heist based optimization (THO) algorithm solved the optimal power flow problem competently. Equally Logistic chaotic map based freshman learning process inspired optimization (LCP) algorithm also solve the problem in efficient mode. The simulation results show that both THO and LCP reduced the power loss effectively. In IEEE 30 bus system, obtained power loss values are THO- 4.4910 (MW) and LCP- 4.4927 (MW). In IEEE 354 system obtained power loss values are THO- 333.298 (MW) and LCP - 333.571 (MW). Comparison has been done with the other standard reported algorithms. Over all both the THO and LCP algorithms performed well in solving the problem.

Conclusion

Train heist based optimization (THO) algorithm and Logistic chaotic map based freshman learning process inspired optimization (LCP) algorithm solved the optimal power flow problem skillfully. In the exploration section of THO; the robbery gang has been executed the plan has been imitated and mathematically defined. Prior to the execution the robbers plan the conspiracy after multiple

examinations. Based on the orders of the gang leader, the members alter their work rapidly to move all the money out of the HVP coach. Each member will learn from other member about the rapidness and work activity of shifting the money within minimum period of the time. In the exploitation section, fled activities of the robbery gang has been imitated and scientifically defined. Even though Leatherslade Farm had been already purchased by the robbery gang, they altered the plan rapidly with minimum stay period in the farm by listening in to the police Very High Frequency channels. Chaotic communiqué amongst the gang members and Perception of movement may differ among the gang members and the error value in the decision of the movement is defined. In LCP, trainer gives solution to the problems of common freshman has been imitated and scientifically formulated. Trainer identifies the shortcomings of freshman, accordingly put efforts to enhance the learning process. Deeds of the freshman learning process are mathematically formulated and population engendered based on the logistic chaos mapping. Freshman conversation with trainer may be continuous or few times it may be intermittent. Few times freshman may hedge form one complication to another in disorder mode. Since freshman may face multiple complications in the learning process. Freshman understanding and adequate solutions given by the trainer plays a key role in diffusing the complications in the process of learning. When freshman not following the guidance given by the trainer, then there may be an upsurge in the intensity of the problem. Train heist based optimization (THO) algorithm and Logistic chaotic map based freshman learning process inspired optimization (LCP) algorithm are validated in 23 Benchmarking functions and IEEE 30, 354 systems.

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