

NOVEL CHIMPANZEE MATING INSPIRED OPTIMIZATION ALGORITHM FOR REAL POWER LOSS REDUCTION

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Abstract

Abstract; Chimpanzee Mating Inspired Optimization (CPO) Algorithm is applied to solve the power loss lessening problem. Major objectives are reduction of power loss and voltage deviation minimization. Various mating actions of Chimpanzee have been imitated to formulate the algorithm. Mating of Male Chimpanzee with single and multiple females are considered in the design. Few Chimpanzees may stay alone and some may wander as like nomad. These situations are included in the formulations of the algorithm. Chimpanzee Mating Inspired Optimization (CPO) Algorithm is verified in G01 - G24 benchmark functions, IEEE 300, 354 bus test systems and Practical system - WDN 220 KV (Unified Egyptian Transmission Network (UETN)). In Practical UETN the value obtained by CPO is Power loss (MW) - 29. 708, Voltage deviation (PU) - 0.5808.

Keywords: Optimization, Power, Transmission Loss, Chimpanzee Mating

Introduction

Real power Loss dwindling complications are evaluated as one of the special atmospheres for imparted and accurate action of congregation. It is excellent by precise incorporation of the structure apparatus castoff to deal with up the power flow with the objective of shrinking the losses and growth the power carcass of the congregation. Ahirwar *et al.* 2021 applied MODE algorithm, Arya *et al.* 2019 employed GSA method, Kapse *et al.* 2018 utilized HGAPSO Scheme. Verma *et al.* 2021 applied TLBO process, Selvam *et al.* 2016 utilized enriched TLBO, Jena *et al.* 2016 applied Group Optimization, Jain *et al.* 2018 employed PSO, Koshti *et al.* 2013 used Adapted Bare Bones

methodology, Ghosh *et al.* 2021; Singh *et al.* 2021 applied BHA, Raghuwanshi *et al.* 2019 employed K-ELM, Nagarajan *et al.* 2020 applied LIS method, Mohamed *et al.* 2022 used Abou El-Ela *et al.* 2019 applied new algorithm. Many researchers (Talebitooti and Zarastvand, 2018; Masood *et al.*, 2021, 2022; Kanagasabai (2020a); Najafi *et al.*, 2022; Kanagasabai (2020b); Najafi *et al.*, 2014; Kanagasabai (2020c); Sanagooy *et al.*, 2021; Veeramani *et al.*, 2021; Taghvaei and Safa, 2021; Ikpe *et al.*, 2020, Ikpe *et al.*, 2023; Omelchenko *et al.*, 2021) around the globe used utilized different algorithms to solve the engineering problems. In this paper Chimpanzee Mating Inspired Optimization

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(CPO) Algorithm is applied to solve the power loss lessening problem. Major objectives are reduction of power loss and voltage deviation minimization. Various mating actions of Chimpanzee have been imitated to formulate the algorithm. Mating of Male Chimpanzee with single and multiple females are considered in the design. Few Chimpanzees may stay alone and some may wander as like nomad. These situations are included in the formulations of the algorithm. The following categories are considered to design the algorithm.

- Mating of Male Chimpanzee with a single female.
- Mating of Male Chimpanzee with multiple females.
- Chimpanzee staying alone
- Few cases Mating of Male Chimpanzee may wander as nomads.

Proposed Chimpanzee Mating Inspired Optimization (CPO) Algorithm is corroborated in G01-G24 benchmark functions, IEEE bus test systems and in Practical Unified Egyptian Transmission Network.

Problem Formulation

Main Objective function of the problem is demarcated as,

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

$$M(\bar{g}, \bar{h}) = 0 \quad (2)$$

$$N(\bar{g}, \bar{h}) = 0 \quad (3)$$

Then the control ($\bar{g}$) and dependent ($\bar{h}$) vectors are defined as,

$$\bar{g} = [VLG_1, \dots, VLG_{Ng}; QC_1, \dots, QC_{Nc}; T_1, \dots, T_{Nt}] \quad (4)$$

$$\bar{h} = \begin{bmatrix} PG_{slack}; VL_1, \dots, VL_{Nload}; QG_1, \dots, \\ QG_{Ng}; SL_1, \dots, SL_{Nt} \end{bmatrix} \quad (5)$$

$Q_c \rightarrow$ 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,

$$F_1 = P_{Min} = \text{Min} \left[\sum_m^{NTL} G_m [V_i^2 + V_j^2 - 2 * V_i V_j \cos \theta_{ij}] \right] \quad (6)$$

$$F_2 = \text{Min} \left[\sum_{i=1}^{N_{LB}} |V_{Lk} - V_{Lk}^{desired}|^2 + \sum_{i=1}^{Ng} |Q_{GK} - Q_{KG}^{Lim}|^2 \right] \quad (7)$$

$$F_3 = \text{Minimize } L_{Maximum} \quad (8)$$

$$S_L \rightarrow \text{Apparent power } L_{Max} = \text{Max}[L_j]; j = 1; N_{LB} \quad (9)$$

$$\begin{cases} L_j = 1 - \sum_{i=1}^{NPV} F_{ji} \frac{V_i}{V_j} \\ F_{ji} = -[Y_1]^{-1} [Y_2] \end{cases} \quad (10)$$

$$L_{Max} = \text{Max} \left[1 - [Y_1]^{-1} [Y_2] \times \frac{V_i}{V_j} \right] \quad (11)$$

Parity constraints

$$0 = PG_i - PD_i - V_i \sum_{j \in N_B} V_j [G_{ij} \cos[\theta_i - \theta_j] + B_{ij} \sin[\theta_i - \theta_j]] \quad (12)$$

$$0 = QG_i - QD_i - V_i \sum_{j \in N_B} V_j [G_{ij} \sin[\theta_i - \theta_j] + B_{ij} \cos[\theta_i - \theta_j]] \quad (13)$$

Disparity constraints

$$P_{gsl}^{\min} \leq P_{gsl} \leq P_{gsl}^{\max} \quad (14)$$

$$Q_{gi}^{\min} \leq Q_{gi} \leq Q_{gi}^{\max}, i \in N_g \quad (15)$$

$$VL_i^{\min} \leq VL_i \leq VL_i^{\max}, i \in N_L \quad (16)$$

$$T_i^{\min} \leq T_i \leq T_i^{\max}, i \in N_T \quad (17)$$

$$Q_c^{\min} \leq Q_c \leq Q_c^{\max}, i \in N_c \quad (18)$$

$$|SL_i| \leq S_{Li}^{\max}, i \in N_{TL} \quad (19)$$

$$VG_i^{\min} \leq VG_i \leq VG_i^{\max}, i \in N_g \quad (20)$$

$$\begin{aligned} \text{Multi objective fitness (MOF)} &= F_1 + r_1 F_2 + \\ u F_3 &= F_1 + \left[\sum_{i=1}^{NL} x_v [VL_i - VL_i^{\min}]^2 + \right. \\ &\left. \sum_{i=1}^{Ng} r_g [QG_i - QG_i^{\min}]^2 \right] + r_f F_3 \end{aligned} \quad (21)$$

$$VL_i^{\text{minimum}} = \begin{cases} VL_i^{\max}, VL_i > VL_i^{\max} \\ VL_i^{\min}, VL_i < VL_i^{\min} \end{cases} \quad (22)$$

$$QG_i^{minimum} = \begin{cases} QG_i^{max}, & QG_i > QG_i^{max} \\ QG_i^{min}, & QG_i < QG_i^{min} \end{cases} \quad (23)$$

Chimpanzee Mating Inspired Optimization Algorithm

Various mating actions of Chimpanzee have been imitated to formulate the algorithm. Mating of Male Chimpanzee with single and multiple females are considered in the design. Few Chimpanzees may stay alone and some may wander as like nomad. These situations are included in the formulations of the algorithm. The following categories are considered to design the algorithm

- Mating of Male Chimpanzee with a single female
- Mating of Male Chimpanzee with multiple females
- Chimpanzee staying alone
- Few cases Mating of Male Chimpanzee may wander as nomads

In first case male Chimpanzee inclines to Mating with only one female. Each male assesses the eminence of the females by means of a probabilistic methodology to pick one of female for Mating. Eminent Female possesses sophisticated probability of being designated for mating actions by male and sequentially offspring will emerge.

$$\vec{O}_i = \vec{O} + PCW * \vec{R} * (\vec{O}^i - \vec{O}) \quad (24)$$

where PCW signify the Period changeable weight
 $\vec{R} \in [0,1]$
 $(\vec{O}^i - \vec{O})$ define the magnitude of the problem

$$d = e \quad (25)$$

$$e \in [1, n]$$

When R_1
 $> \text{Mutation Regulating Element (MRE)}$, then

$$O_{offspring}(d) = \text{Min}(d) - R_2 * (\text{Max}(d) - \text{Min}(d)) \quad (26)$$

$R_1, R_2 \in [0,1]$
 Min, Max are the lower and upper limits
 $MRE \in [0,1]$

Second case male Chimpanzee Mating with multiple females. Then the production of the offspring is demarcated mathematically as follows,

$$\vec{O}_i = \vec{O} + PCW * \sum_{j=1}^{n_1} \vec{R}_j * (\vec{O}_j^i - \vec{O}) \quad (27)$$

$$\begin{aligned} g &= h \\ h &\in [1, n] \end{aligned} \quad (28)$$

When R_1
 $> \text{Mutation Regulating Element (MRE)}$, then

$$\begin{aligned} O_{offspring}(g) &= \text{Min}(g) - R_2 * (\text{Max}(g) - \text{Min}(g)) \\ R_2 &\in [0,1] \end{aligned} \quad (29)$$

In the third case Chimpanzee may opt to stay alone,

$$\vec{O}_i = \vec{O} + PCW * \sum_{k=1}^{n_1} \vec{R}_k * (\vec{O}_k^i - \vec{O}) \quad (30)$$

$$u = v \quad (31)$$

$v \in [1, n]$
 When R_1
 $> \text{Mutation Regulating Element (MRE)}$, then

$$\begin{aligned} O_{offspring}(u) &= \text{Min}(u) - R_3 * (\text{Max}(u) - \text{Min}(u)) \\ R_3 &\in [0,1] \end{aligned} \quad (32)$$

When $R_1 > \text{Mutation Regulating Element} - \text{Rare case}(MRE_{RC})$, then

$$O_{offspring}(i) = O(i) + \varphi * (R_4 - R_5) * O(i) \quad (33)$$

φ specify the step size
 MRE_{RC} indicate the
 Mutation Regulating Element – Rare case

$$\begin{aligned} R_4, R_5 &\in [0,1] \\ \vec{O}_i &= \vec{O} + PCW * \vec{R}_6 * (\vec{O}^i - \vec{O}) \end{aligned} \quad (34)$$

where PCW signify
 the Period changeable weight
 $\vec{R}_6 \in [0,1]$
 $(\vec{O}^i - \vec{O})$ define the magnitude of the problem

$$\begin{aligned} x &= z \\ z &\in [1, n] \end{aligned} \quad (35)$$

When R_1
 $> \text{Mutation Regulating Element (MRE)}$, then

$$O_{\text{offspring}}(x) = \text{Min}(x) - R_7 * (\text{Max}(x) - \text{Min}(x)) \quad (36)$$

$$R_6, R_7 \in [0,1]$$

Min, Max are the lower and upper limits
 $\text{MRE} \in [0,1]$

Certain cases male and female Chimpanzee may wander as nomads. This aspect is scientifically defined as,

$$O'_{ij} = \begin{cases} O_{ij}, & \text{if } \text{Random}_j > P_i \\ \text{Random}_j, & \text{otherwise} \end{cases} \quad (37)$$

$$P_i = 0.10 + \min\left(0.50, \frac{W_N - C_N}{C_N}\right) \quad (38)$$

where P_i specify the possibility
 W_N specify the male and
female wandering as nomads
 C_N is the male and
female wandering as nomads
– involved in copulate actions

In the case of a wandering nomad male Mating with the female, then the offspring generation is mathematically defined as,

$$\text{offspring}_i = \gamma * \text{female}_j + \sum \frac{1-\gamma}{\sum_{i=1}^{NR} Q_i} * \text{male}_j^i * Q_i \quad (39)$$

where Q_i is 1 when wandering
nomad male copulate with the female
or else it is 0

Figure 1 shows the Flowchart of Chimpanzee Mating Inspired Optimization (CPO) Algorithm.

- a. Start
- b. Set the parameters
- c. Engender the population
- d. Define the size of the problem
- e. Set the number of male and female Chimpanzee
- f. Categorize the individuals
- g. Define the percentage of the each category
- h. Identify the type of male and female
- i. Set the value of the Mutation Regulating Element
- j. Engender the solution randomly
- k. Compute the quality of the each individual
- l. Grade the individual based on the evaluation
- m. Categories c and d are considered as females
- n. Categories a and b are considered as males
- o. Define the percentage of each category
- p. Offspring's are engendered

- q. $\vec{O}_i = \vec{O} + PCW * \vec{R} * (\vec{O}^i - \vec{O})$
- r. $O_{\text{offspring}}(d) = \text{Min}(d) - R_2 * (\text{Max}(d) - \text{Min}(d))$
- s. $\vec{O}_i = \vec{O} + PCW * \sum_{j=1}^{n_1} \vec{R}_j * (\vec{O}_j^i - \vec{O})$
- t. $O_{\text{offspring}}(g) = \text{Min}(g) - R_2 * (\text{Max}(g) - \text{Min}(g))$
- u. $\vec{O}_i = \vec{O} + PCW * \sum_{k=1}^{n_1} \vec{R}_k * (\vec{O}_k^i - \vec{O})$
- v. $O_{\text{offspring}}(u) = \text{Min}(u) - R_3 * (\text{Max}(u) - \text{Min}(u))$
- w. $O_{\text{offspring}}(i) = O(i) + \varphi * (R_4 - R_5) * O(i)$
- x. $\vec{O}_i = \vec{O} + PCW * \vec{R}_6 * (\vec{O}^i - \vec{O})$
- y. $O_{\text{offspring}}(x) = \text{Min}(x) - R_7 * (\text{Max}(x) - \text{Min}(x))$
- z. if the quality offspring's are better, then apply swap
- aa. Otherwise retain the same
- bb. Verify the status of wandering nomad male and female

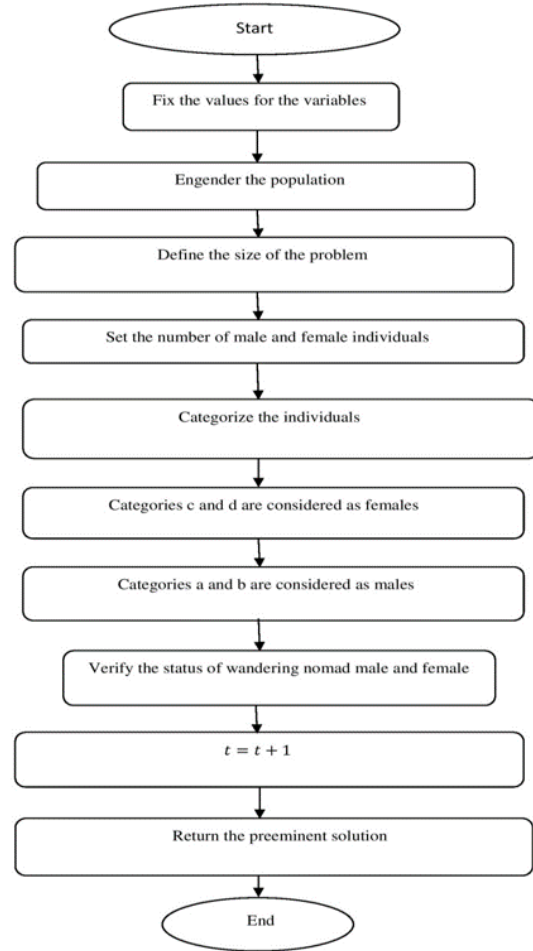


Figure 1. Flowchart of Chimpanzee Mating Inspired Optimization (CPO) Algorithm

cc. $O'_{ij} = \begin{cases} O_{ij}, & \text{if } \text{Random}_j > P_i \\ \text{Random}_j, & \text{otherwise} \end{cases}$
 dd. $P_i = 0.10 + \text{minimum}\left(0.50, \frac{W_N - C_N}{C_N}\right)$
 ee. $\text{offspring}_i = \gamma * \text{female}_j + \sum_{i=1}^{NR} \frac{1-\gamma}{Q_i} * \text{male}_j^i * Q_i$
 ff. $t = t + 1$
 gg. Output the best solution.
 End.

Computation complexity

$$\begin{aligned} O(P) &= O(O) + O(i) + O(f) + O(s) \\ &\quad O(1) \\ &\quad O(b * d) \\ &\quad O(U * f * n) \\ &\quad O(U * a * b * d) \\ O(Q) &= O(1 + b * d + U * f * b + U * a * b * d) \end{aligned}$$

Results and discussion

Proposed Chimpanzee Mating Inspired Optimization (CPO) Algorithm verified in G01–G24 benchmark functions (Roy *et al.*, 2021).

$$\begin{aligned} F(x) &= 5 \sum_{i=1}^4 x_i - 5 \sum_{i=1}^4 x_i^2 - \sum_{i=5}^{13} x_i \\ F(x) &= - \left| \frac{\sum_{i=1}^n \cos^4(x_i) - 2 \prod_{i=1}^n \cos^2(x_i)}{\sqrt{\sum_{i=1}^n i x_i^2}} \right| \\ F(x) &= -(\sqrt{n})^n \prod_{i=1}^n x_i \\ F(x) &= 5.35x_3^2 + 0.83x_1x_5 + 37.2x_1 - 40.792.1 \\ F(x) &= 3x_1 + 0.00000 x_1^3 + 2x_2 \\ &\quad + \left(\frac{0.000002}{3}\right) x_2^3 \\ F(x) &= (x_1 - 10)^3 + (x_2 - 20)^3 \\ F(x) &= x_1^2 + x_2^2 + x_1x_2 - 14x_1 - 16x_2 \\ &\quad + (x_3 - 10)^2 + 4(x_4 - 5)^2 \\ &\quad + (x_5 - 3)^2 + 2(x_6 - 1)^2 \\ &\quad + 5x_7^2 + 7(x_8 - 11)^2 \\ &\quad + (x_9 - 10)^2 + (x_{10} - 7)^2 + 45 \\ F(x) &= -\sin^3(2\pi x_1)\sin(2\pi x_2)/x_1^3(x_1 + x_2) \\ F(x) &= (x_1 - 10)^2 + 5(x_2 - 12)^2 + x_4^3 \\ &\quad + 3(x_4 - 11)^2 + 10x_5^6 + 7x_6^2 \\ &\quad + x_7^4 - 4x_6x_7 - 10x_6 - 8x_7 \\ F(x) &= x_1 + x_2 + x_3 \\ F(x) &= x_1^2 + (x_2 - 1)^2 \end{aligned}$$

$$\begin{aligned} F(x) &= -100(-(x_1 - 5)^2 - (x_2 - 5)^2 \\ &\quad - (x_3 - 5)^2)/100 \\ F(x) &= e^{x_1x_2x_3x_4x_5} \\ F(x) &= \sum_{i=1}^{10} x_i \left(c_i + \ln \frac{x_i}{\sum_{j=1}^{10} x_j} \right) \\ F(x) &= 1000 - x_1^2 - 2x_2^2 - x_3^2 - x_1x_2 - x_1x_3 \\ F(x) &= 0.0001y_{14} + 0.1365 + 0.000023y_{13} \\ &\quad + 0.0000015y_{16} + 0.03y_{12} \\ &\quad + 0.0043y_5 + 0.0001 \frac{c_{15}}{c_{16}} \\ &\quad + 37.48 \frac{y_2}{c_{12}} - 0.00000058y_{17} \\ F(x) &= f_1(x_1) + f_2(x_2) \\ F(x) &= -0.5(x_1x_4 - x_2x_3 + x_3x_9 - x_5x_9 + x_5x_8 \\ &\quad - x_6x_7) \\ F(x) &= \sum_{j=1}^5 \sum_{i=1}^5 c_{ij} x_{(10+i)} x_{(10+j)} \\ &\quad + 2 \sum_{j=1}^5 d_j x_{(10+j)}^3 - \sum_{i=1}^{10} b_i x_i \\ F(x) &= \sum_{i=1}^{24} a_i x_i \\ F(x) &= x_1 \\ F(x) &= x_1 \\ F(x) &= -9x_5 - 15x_8 + 6x_1 + 16x_2 \\ &\quad + 10(x_6 + x_7) \\ F(x) &= -x_1 - x_2 \end{aligned}$$

FUC - Function

Then projected algorithm is corroborated in IEEE 300, 354 bus test systems and Practical system - WDN 220 KV (Unified Egyptian Transmission Network (UETN)). Loss lessening, power divergence curtailing and power constancy index augmentation has been attained.

Projected Chimpanzee Mating Inspired Optimization (CPO) Algorithm corroborated in IEEE 300 bus system (IEEE 300 bus). Table 2 shows the loss appraisal and voltage aberration evaluation. Figures 2 and 3 show the loss and voltage aberration analysis.

Table 1. Relative outcome of G01–G24 benchmark functions

B. Function		BAPSO (Roy <i>et al.</i> , 2021)	BABO (Roy <i>et al.</i> , 2021)	BADE (Roy <i>et al.</i> , 2021)	BAABC (Roy <i>et al.</i> , 2021)	BHTS (Roy <i>et al.</i> , 2021)	BATLBO (Roy <i>et al.</i> , 2021)	BJAYA(Roy <i>et al.</i> , 2021)	CPO
FUC.G01 (-15.00)	Best	-15	-14.977	-15	-15	-15	-15	-15	-15
	Mean	-14.71	-14.967	-14.55	-15	-15	-10.782	-15	-15
FUC.G02 (-0.803619)	Best	-0.669158	-0.7821	-0.472	-0.803598	-0.7517	-0.7835	-0.803605	-0.803621
	Mean	-0.41996	-0.7642	-0.665	-0.792412	-0.6437	-0.6705	-0.7968	-0.7976
FUC.G03 (-1.0005)	Best	-1	-1.0005	-0.99393	-1	-1.0005	-1.0005	-1.0005	-1.0004
	mean	0.764813	-0.3957	-1	-1	-0.9004	-0.8	-1	-1
FUC.G04 (-30.665.539)	Best	-30,665.539	-30,665.539	-30,665.539	-30,665.539	-30,665.539	-30,665.539	-30,665.539	-30,665.521
	mean	-30,665.539	-30,411.865	-30,665.539	-30,665.539	-30,665.539	-30,665.539	-30,665.539	-30,665.521
FUC.G05 -5126.486	Best	5126.484	5134.274	5126.484	5126.484	5126.486	5126.486	5126.486	5126.382
	Mean	5135.973	6130.5289	5264.27	5185.714	5126.5152	5126.6184	5126.5060	5126.5051
FUC.G06 (-6961.814)	Best	-6961.814	-6961.8139	-6954.434	-6961.814	-6961.814	-6961.814	-6961.814	-6961.809
	Mean	-6961.814	-6181.746	-6954.434	-6961.813	-6961.814	-6961.814	-6961.814	-6961.803
FUC.G07 -24.3062	Best	24.37	25.6645	24.306	24.33	24.3104	24.3101	24.3062	24.3047
	Mean	32.407	29.829	24.31	24.473	24.4945	24.837	24.3092	24.3074
FUC.G08 (-0.095825)	Best	-0.095825	-0.095825	-0.095825	-0.095825	-0.095825	-0.095825	-0.095825	-0.095839
	Mean	-0.095825	-0.095824	-0.095825	-0.095825	-0.095825	-0.095825	-0.095825	-0.095839
FUC.G09 -680.6301	Best	680.630	680.6301	680.630	680.634	680.6301	680.6301	680.6301	680.6309
	Mean	680.630	692.7162	680.630	680.634	680.6329	680.6336	680.6301	680.6309
FUC.G010 -7049.28	Best	7049.481	7679.0681	7049.548	7053.904	7049.4836	7250.9704	7049.312	7049.307
	Mean	7205.5	8764.9864	7147.334	7224.407	7119.7015	7257.0927	7052.7841	7052.7829
FUC.G011 -0.7499	Best	0.749	0.7499	0.752	0.75	0.7499	0.7499	0.7499	0.7451
	Mean	0.749	0.7499	0.752	0.75	0.7499	0.7499	0.7499	0.7451
FUC.G012 (-1)	Best	-1	-1	-1	-1	-1	-1	-1	-1
	Mean	-0.998875	-1	-1	-1	-1	-1	-1	-1
FUC.G013 (-0.05394)	Best	0.085655	0.62825	0.385	0.76	0.37319	0.44015	0.003625	0.003510
	Mean	0.569358	1.09289	0.872	0.968	0.66948	0.69055	0.003627	0.003510
FUC.G014 (-47.764)	Best	-44.9343	54.6679	-45.7372	-44.6431	-47.7278	-46.5903	-47.7322	-47.7318
	Mean	-40.871	175.9832	-29.2187	-40.1071	-46.4076	-39.9725	-46.6912	-46.6878
FUC.G015 -961.715	Best	961.715	962.664	961.715	961.7568	961.715	961.715	961.715	961.709
	Mean	965.5154	1001.4367	961.7537	966.2868	961.75	962.8641	961.715	961.709
FUC.G016 (-1.9052)	Best	-1.9052	-1.9052	-1.9052	-1.9052	-1.9052	-1.9052	-1.9052	-1.9047
	Mean	-1.9052	-1.6121	-1.9052	-1.9052	-1.9052	-1.9052	-1.9052	-1.9047
FUC.G017 -8853.5396	Best	8857.514	9008.5594	8854.6501	8859.713	8853.5396	8853.5396	8853.5396	8853.5322
	Mean	8899.4721	9384.26	8932.0444	8941.9245	8877.9175	8876.5071	8872.5402	8853.5322
FUC.G018 (-0.86603)	Best	-0.86603	-0.65734	-0.86531	-0.86603	-0.86603	-0.86603	-0.86603	-0.86588
	Mean	-0.8276	-0.56817	-0.86165	-0.86587	-0.77036	-0.86569	-0.86602	-0.86588
FUC.G019 -32.6555	Best	33.5358	39.1471	32.6851	33.3325	32.7132	32.7916	32.6803	36.6151
	Mean	36.6172	51.8769	32.768	36.0078	32.7903	34.0792	32.7512	36.6149
FUC.G020 -0.204979	Best	0.24743	1.26181	0.24743	0.24743	0.24743	0.24743	0.24139	0.24126
	Mean	0.97234	1.43488	0.26165	0.80536	0.25519	1.22037	0.24385	0.24375
FUC.G021 -193.274	Best	193.7311	198.8151	193.7346	193.7343	193.7264	193.7246	193.5841	193.2381
	Mean	345.6595	367.2513	366.9193	275.5436	256.6091	264.6092	193.7219	193.2439
FUC.G022 -236.4309	Best	-258.74	-267.15	-249.12	-243.43	-272.78	-248.78	-242.45	-242.27
	Mean	-255.55	-254.44	-249.46	-251.33	-265.66	-252.56	-239.05	-239.01
FUC.G023 (-400.055)	Best	-105.9826	2.3163	-72.642	-43.2541	-390.6472	-385.0043	-391.5192	-391.5149
	Mean	-25.9179	22.1401	-7.2642	-4.3254	-131.2522	-83.7728	-381.2312	-381.2332
FUC.G024 (-5.5080)	Best	-5.5080	-5.5080	-5.5080	-5.5080	-5.5080	-5.5080	-5.5080	-5.5045
	Mean	-5.5080	-5.4982	-5.5080	-5.5080	-5.5080	-5.5080	-5.5080	-5.5045

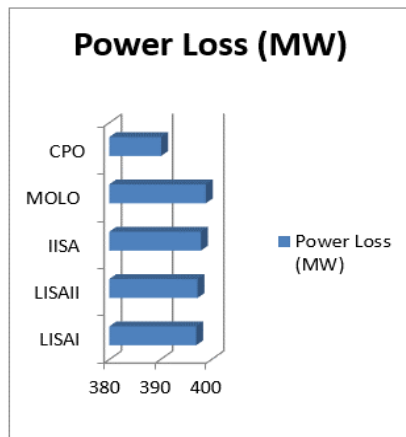
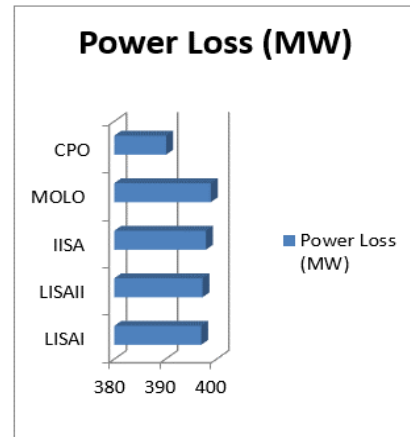
**Figure 2. Analysis of loss value (X- axis; Power loss (MW), Y- axis; methods)****Figure 3. Analysis of voltage aberration (X- axis; voltage aberration (PU), Y- axis; methods)**

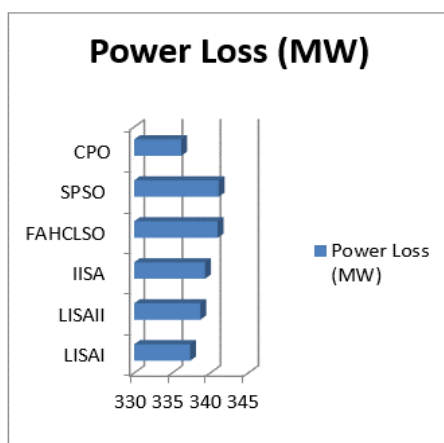
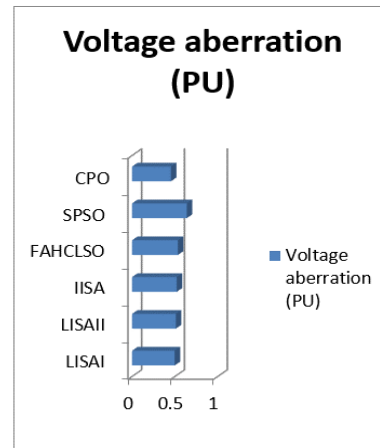
Table 2. Loss appraisal

Method	Power Loss (MW)	Voltage aberration (PU)
LISAI (Nagarajan <i>et al.</i> , 2020)	396.983	5.9324
LISAI (Nagarajan <i>et al.</i> , 2020)	397.236	5.9416
IISA (Singh <i>et al.</i> , 2021)	397.902	5.9613
MOLO (Singh <i>et al.</i> , 2021)	398.853	6.0169
CPO	390.132	5.8175

Then projected Chimpanzee Mating Inspired Optimization (CPO) Algorithm is corroborated in IEEE 354 bus system (IEEE 354 bus). In Table 3 shows the loss appraisal and voltage aberration evaluation. Figures 4 and 5 show the loss and voltage aberration analysis.

Table 3. Loss appraisal

Method	Power Loss (MW)	Voltage aberration (PU)
LISAI (Nagarajan <i>et al.</i> , 2020)	337.374	0.4978
LISAI (Nagarajan <i>et al.</i> , 2020)	338.715	0.5117
IISA (Nagarajan <i>et al.</i> , 2020)	339.325	0.5216
FAHCLSO (Singh <i>et al.</i> , 2021)	341.001	0.5354
SPSO (Singh <i>et al.</i> , 2021)	341.123	0.6395
CPO	336.199	0.4539

**Figure 4. Loss value analysis (X- axis; Power loss (MW), Y- axis; methods)****Figure 5. Voltage aberration analysis (X- axis; Voltage aberration (PU), Y- axis; methods)**

Then Proposed Chimpanzee Mating Inspired Optimization (CPO) Algorithm validated in practical Unified Egyptian Transmission Network (Abou El-Ela *et al.*, 2019). Table 4 shows the loss appraisal and voltage aberration evaluation. Figures 6 and 7 show the loss and voltage aberration analysis.

Table 5 show the time taken by Chimpanzee Mating Inspired Optimization (CPO) Algorithm, when corroborated in IEEE 300, 354 bus test systems and practical Unified Egyptian Transmission Network (Abou El-Ela *et al.* 2019).

Table 4. Loss appraisal

Method	Power loss (MW)	Voltage aberration (PU)
BASPSO (Mohamed <i>et al.</i> , 2021)	32.314	0.5800
BBBA (Mohamed <i>et al.</i> , 2021)	33.875	0.6327
IBMBBA (Mohamed <i>et al.</i> , 2021)	30.786	0.6751
CPO	29.708	0.5808

Table 5. Time taken by CPO

Method	IEEE 300 bus Time (S)	IEEE 354 bus Time (S)	WDN 220 KV Time (S)
CPO	80.89	93.95	29.99

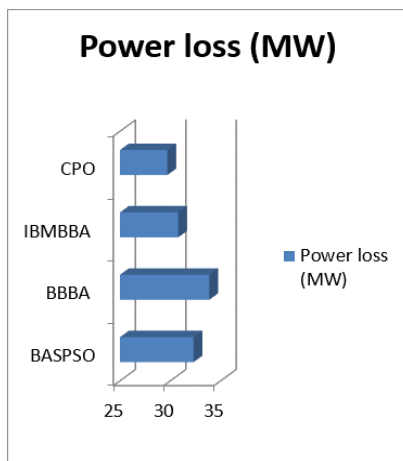


Figure 6. Analysis of value of loss (X- axis; Power loss (MW), Y- axis; methods)

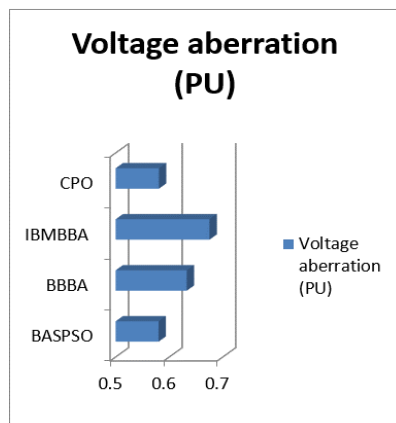


Figure 7. Analysis of aberration of voltage (X- axis; Voltage aberration (PU), Y- axis; methods)

Conclusion

Proposed Chimpanzee Mating Inspired Optimization (CPO) Algorithm abridged the loss ingeniously. Various mating actions of Chimpanzee have been imitated to formulate the algorithm. Mating of Male Chimpanzee with single and multiple females are considered in the design. Few Chimpanzees may stay alone and some may wander as like nomad. These situations are included in the formulations of the algorithm. The following categories are considered to design the algorithm; Mating of Male Chimpanzee with a single female, Mating of Male Chimpanzee with multiple females, Chimpanzee staying alone and in few cases Mating of Male Chimpanzee may wander as nomads. These are scientifically modeled and algorithm

successfully solved the power loss reduction problem. Chimpanzee Mating Inspired Optimization (CPO) Algorithm is verified in G01-G24 benchmark functions, IEEE bus test systems and in Practical Unified Egyptian Transmission Network the value obtained by CPO is Power loss (MW) - 29.708, Voltage deviation (PU) - 0.5808. Loss lessening, power divergence curtailing has been attained.

Limitations

Projected Chimpanzee Mating Inspired Optimization (CPO) Algorithm took time to reduce the power loss. Still the algorithm can be tuned such that time may be reduced further.

Future scope of work

Projected Chimpanzee Mating Inspired Optimization (CPO) Algorithm can be applied to other areas of engineering and technology. Even in medical imaging and cancer detection projected CPO algorithm can be applied in near future.

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