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NOVEL MATHEMATICAL DESIGN OF HYBRID SHOEBILL MONODONTIDAE, CONUNDRUM–COMBATTING TERRORIST, *HIERODULA PATELLIFERA*, LEARNING RUSSIAN LANGUAGE BY CHINESE STUDENT INSPIRED PULSATRIX — CROCUTA OPTIMIZATION ALGORITHMS

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Abstract

In this paper, hybrid shoebill monodontidae optimization algorithm, conundrum-combatting terrorist inspired optimization algorithm, *Hierodula Patellifera* optimization algorithm, learning Russian language by Chinese student inspired optimization algorithm, Pulsatrix — Crocuta inspired search optimization algorithm are deigned. Proposed algorithms are applied for solving the electrical real power loss reduction in power transmission system. In the design of hybrid shoebill monodontidae algorithm, monodontidae are considered as search agents and it can passage in search zone by altering their location vectors. Shoebill optimization algorithm stalking stratagem is integrated in the hybrid shoebill monodontidae procedure to enhance exploration segment. The key notion in the scheme of the proposed conundrum optimization procedure is the scientific feigning of the progression of resolving a conundrum by means of an evolutionary optimization. The modernization of the grade is designed by integrating the formulation of strategy on combatting terrorist inspired optimization algorithm in the conundrum–combatting terrorist inspired optimization procedure. *Hierodula Patellifera* optimization algorithm is designed by imitating the activities of *Hierodula Patellifera* like search and confronting the quarry. Learning Russian language by Chinese student inspired optimization algorithm is formulated by imitating the activities of a Chinese student while learning the Russian language. Pulsatrix — Crocuta inspired

Keywords

Monodontidae, conundrum, Hierodula Patellifera, Russian language, Chinese student, Pulsatrix, Crocuta

search optimization algorithm is designed based on the natural searching and hunting activities of the Pulsatrix and Crocuta. Projected algorithms validated in 23 benchmarking functions and IEEE 57 system

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Introduction. Real power loss diminishing [1–8] is a substantial problem in electrical power transmission[1] network [9–13]. Numerous methods Mudskipper optimization algorithm [14], quantum based Mellivora Capensis optimization algorithm [15], alternating optimization approach [16], modified JAYA algorithm [17], Rao-3 algorithm [18], second-order cone programming [19] are applied to solve the real power loss reduction problem. These decades many new algorithms [20, 21] are applied to solve the various problems in engineering and technology. In this paper hybrid shoebill monodontidae (MO) optimization algorithm, conundrum–combatting terrorist inspired optimization (CO) algorithm, *Hierodula Patellifera* optimization (HPO) algorithm, learning Russian language by Chinese student inspired (LCLIS) optimization algorithm, Pulsatrix — Crocuta inspired search optimization (PISO) algorithm are designed and applied to solve the engineering problem. The MO optimization algorithm imitates the deeds of Monodontidae such as whirling, preying and plunge. Shoebill optimization (SO) algorithm [20] stalking stratagem is integrated in the MO procedure to enhance exploration segment. The key notion in the scheme of the proposed CCO procedure is the scientific feigning of the progression of resolving a conundrum by means of an evolutionary optimization. Proposed CO algorithm is a populace grounded procedure that has been established based on conundrum activity feigning. The modernization of the grade is designed by integrating the formulation of strategy on combatting terrorist inspired optimization algorithm [20] in the CO procedure. *Hierodula Patellifera* optimization algorithm is designed by imitating the activities of *Hierodula Patellifera* like search and confronting the quarry. Then the anthropophagy activity of female *Hierodula Patellifera* after the sexual intercourse with male *Hierodula Patellifera* is defined mathematically. Learning Russian language by Chinese student inspired optimization algorithm is formulated by imitating the activities of a Chinese student while learning the Russian language. Every student has aspiration to learn multiple languages in the educating stages. Pulsatrix — Crocuta inspired search optimization algorithm is designed based on the natural searching and hunting activities of the Pulsatrix and Crocuta.

[1] The IEEE 57-bus test system. *ee.washington.edu*: website. Available at: http://www.ee.washington.edu/research/pstca/pf57/pg_tca57bus.htm (accessed: 15.05.2025).

Pulsatrix are characteristically night-time active but extremely well-organized hunters with an amazing acoustic structure and these aspect assistances to discover the target (Prey). Naturally Crocuta hunt in cluster mode while hunting large prey and a leader will lead the cluster. The prey will be surrounded the group of Crocuta and aggressively attack the prey in all directions. The hunting activities of Crocuta have been incorporated into the Pulsatrix procedure to enhance the search capability of the algorithm.

Hybrid shoebill monodontidae algorithm. Monodontidae is imitated to formulate the MO optimization algorithm and SO algorithm [20] stalking stratagem is integrated. Exploration, exploitation and monodontidae plunge are time-honoured in the proposed algorithm, equivalent to the deeds of spin, quarry, and monodontidae plunge, correspondingly. The equilibrium element and possibility of monodontidae plunge in the proposed algorithm is self-adaptive which show momentous protagonists to govern the capability of exploration and exploitation. In addition, Levy flight is presented to augment the universal convergence in the exploitation segment. The MO algorithm imitates the deeds of monodontidae [22] such as whirling, preying and plunge. Each monodontidae is a candidate solution and modernized during optimization. The locations of search agents are defined as follows:

$$M=\begin{bmatrix} m_{1,1} & \dots & m_{1,d} \\ \vdots & \ddots & \vdots \\ m_{n,1} & \dots & m_{n,d} \end{bmatrix},$$

where n, d signifies the population size and dimension of the parameters.

The fitness rate is defined as

$$F_m=\begin{bmatrix} f\left(m_{1,1},\ m_{1,2},\dots,m_{1,d}\right) \\ f\left(m_{2,1},\ m_{2,2},\dots,m_{2,d}\right) \\ \vdots \\ f\left(m_{n,1},\ m_{n,2},\dots,m_{n,d}\right) \end{bmatrix},$$

where F_m define the fitness function.

The MO algorithm is transferred from exploration to exploitation, contingent on the equilibrium factor and it defined as $E_f=E_0\left(1-T/(2T_{\max})\right)$. Here E_f is the equilibrium factor; $E_0\to(0, 1)$; $T, T_{\max}$ define the present and maximum iteration; exploration segment: $E_f>0.50$, exploitation segment: $E_f\le 0.50$; T increase (0, 1) to (0, 0.50).

Exploration segment of MO algorithm is designed by imitating the whirl performance of monodontidae. Then the locations of the monodontidae is modernized as follows:

$$M_{i,j}^{T+1} = M_{i.Lj}^{T} + \left(M_{R.L1}^{T} - M_{i.Lj}^{T} \right),$$
$$\left(1 + R_1\right) \sin\left(2\pi R_2\right), \ j \to even,$$
$$M_{i,j}^{T+1} = M_{i.Lj}^{T} + \left(M_{R.L1}^{T} - M_{i.Lj}^{T} \right),$$
$$\left(1 + R_1\right) \cos\left(2\pi R_2\right), \ j \to odd,$$

where $M_{i,j}^{T+1}$ specify the new location of monodontidae; $M_{i,Lj}^{T}$ indicate the i-th location of monodontidae; $R \to$ random, $R_1, R_2 \in \left[0, 1\right]$.

Exploitation segment of MO algorithm is stimulated from the predatory behaviour of monodontidae. The stratagem of Levy flight is presented in the exploitation segment of MO algorithm to augment the characteristics of convergence: $M_i^{T+1} = R_3 M_b^T - R_4 M_i^T + G_1 \,\mathrm{Levy}\left(M_R^T - M_i^T \right)$, where $R_3, R_4 \in \left[0, 1\right]$; M_b^T specify the excellent positions among monodontidae; M_R^T, M_i^T are the random and current position of monodontidae; $G_1 = 2R_4 \left(1 - T / T_{\max}\right)$; $Y = \mathrm{Levy}\, D$, D is the dimension of the problem, $\mathrm{Levy}\, D = 0.01 u\sigma / \left|v\right|^{1/\beta}$. In order to guarantee the quantity of population size continual, the locations of Monodontidae and step magnitude of monodontidae plunge are expending to institute the rationalized location. The scientific design is articulated as follows: $M_i^{T+1} = R_5 M_i^T - R_6 M_R^T + R_7 M_{step}$, $R_5, R_6, R_7 \in \left[0, 1\right]$; M_{step} is the step magnitude of monodontidae plunge,

$$M_{step} = \left(\max - \min\right) \exp\left(G_2 \frac{T}{T_{\max}} \right), \tag{1}$$

G_2 is step parameter, $G_2 = 2Q_p n$, Q_p is probability of monodontidae plunge, $Q_p = 0.10 - 0.050\left(T / T_{\max}\right)$, $Q_p \to 0.10$ to 0.50.

Shoebill optimization algorithm [21] stalking stratagem is integrated in the procedure to enhance exploration segment and it defined as

$$s_{i,j}^{SB_1} = \begin{cases} s_{i,j} + R\left(\mathrm{Prey}_j - U s_{i,j}\right), \text{ if } O_{SB} < O_i, \\ s_{i,j} + R\left(s_{i,j} - Prey_j\right), \text{ else,} \end{cases}$$

where $s_{i,j}^{SB_1}$ define the new location in exploration segment, $U \in [1, 2]$; Prey_j specify the location of the prey in j-th magnitude;

$$S_i = \begin{cases} s_i^{SB_1}, \; O_i^{SB_1} < O_i, \\ S_i, \; \text{else.} \end{cases}$$

Shoebill optimization algorithm

a. Start
b. Fix the parameter values
c. Create the Monodontidae population
d. Compute the fitness rate
e. While $T \le T_{\max}$ do
f. Acquire the probability of monodontidae plunge
g. Compute the equilibrium factor
h. For each monodontidae (M_i) do
i. if $E_f > 0.50$: exploration segment
j. Engender L_j randomly
k. Pick a monodontidae randomly (M_R)
l. Modernize the location of the i-th monodontidae
m. Else if $E_f \le 0.50$: exploitation segment
n. Streamline the G_1
o. Compute the Levy flight function
p. Modernize the location
q. End if
r. Verify the boundary conditions
s. Compute the fitness value
t. End for
u. For each monodontidae (M_i) do
v. if $E_f(i) \le Q_p$
w. Modernize G_2
x. Compute the M_{step}
y. Formula (1)
z. Modernize the location of the i-th monodontidae
aa. Obtain the present excellent solution
bb. Output the best solution
cc. $t = t + 1$
dd. Output the best solution
ee. End

Conundrum–Combatting terrorist inspired optimization algorithm. In CO algorithm, the key notion is the scientific feigning of the progression of resolving a conundrum by means of an evolutionary optimization. The modernization of the grade is designed by integrating the formulation of strategy on CO algorithm [20] in the procedure. Proposed algorithm is a populace grounded procedure that has been established based on conundrum activity feigning[2]. Consequently, CO procedure fits to the cluster of game grounded procedures. Population of CO algorithm can be scientifically designed by means of a matrix as follows:

$$C = \begin{bmatrix} C_1 \\ \vdots \\ C_i \\ \vdots \\ C_N \end{bmatrix}_{N\times m} = \begin{bmatrix} c_{1,1} & \dots & c_{1,m} \\ \vdots & \ddots & \vdots \\ c_{N,1} & \dots & c_{N,m} \end{bmatrix}_{N\times m},$$

where C is the conundrum population; N, m are the number and parameters of the conundrum.

Assumed that everyone associate of the populace is a projected elucidation to the problem, the rate of the objective utility can be calculated. Consequently, equivalent to the quantity of populace associates, the objective utility is estimated, which the attained standards for the objective functional values and defined as follows:

$$O = \begin{bmatrix} O_1 \\ \vdots \\ O_i \\ \vdots \\ O_N \end{bmatrix}_{N\times m} = \begin{bmatrix} O(C_1) \\ \vdots \\ O(C_i) \\ \vdots \\ O(C_N) \end{bmatrix}_{N\times 1},$$

where O define the attained rate of the objective function; O_i signify the rate of the objective functional value for the i-th conundrum.

Grounded on the assessment of the standards attained for the objective function, the associate that delivers the preeminent rate for the objective function is acknowledged as the preeminent associate of the populace. The preeminent is defined as $P = C_n, O_n = \min(O)$, P is the preeminent associate; C_n define the n-th conundrum with min obj equivalent to O_n.

[2] Vectors. *vecteezy.com*: website. Available at: https://www.vecteezy.com/vector-art/24390847-labyrinth-conundrum-searching-way-many-ways-directions-maze-and-labyrinths-child-game-isolated-vector-set/ (accessed: 15.05.2025).

In the projected CO algorithm, populace associates are rationalized in twofold phases. The principal phase is designed as $SA_i = C_s$, where SA_i specify the supervision associate; $s \in \{1, 2, \ldots, N\}$;

$$dc_{i,d} = \begin{cases} SA_{i,d} - Hc_{i,d}, \ O_s < O_i, \\ c_{i,d} - HSA_{i,d}, \ \text{otherwise}. \end{cases}$$

Here $dc_{i,d}$ is the alterations in the d-th dimensions of i-th conundrum; $SA_{i,d}$ specify the supervision associate in the d-th dimension; O_s define the value of the objective function; H is random number, $H \in [1, 2]$,

$$H = \text{Rotund}\left(1 + R\right), \ \ R \in [0, 1], \quad (2)$$

$$C_i^{new} = C_i + RdC_i \quad (3)$$

is fresh grade of the conundrum,

$$C_i = \begin{cases} C_i^{new}, \ O_i^{new} < O_i, \\ O_i, \ \text{otherwise}, \end{cases}$$

O_i^{new} define the rate of the objective function.

The modernization of the grade is designed by integrating the formulation of strategy on CO algorithm [21] in the procedure as follows:

$$G_i = \left(G_i + 1\right)\left(\left(L_{new} \geq L_{previous}\right) + G_i\left(L_{new} < L_{previous}\right)\right). \quad (4)$$

In the succeeding phase, every associate of the populace appraises its grade by means of conundrum fragments recommended by added associates of the populace. This procedure is scientifically demonstrated as follows:

$$N_C = \text{Rotund}\left(0.50\left(1 - t / T\right)N\right), \quad (5)$$

where N_C define the recommended conundrum fragments; t, T are the counter and maximum iterations;

$$c_{i,d_j}^{new} = c_{U,d_j}, \begin{cases} U \in \{1, 2, 3, 4, \ldots, N\}, \\ j \in \{1, 2, 3, 4, \ldots, N_C\}, \\ d_j \in \{1, 2, 3, 4, \ldots, m\}, \end{cases}$$
$$C_i = \begin{cases} C_i^{new}, \ O_i^{new} < O_i \\ O_i, \ \text{else}, \end{cases} \quad (6)$$

c_{i,d_j}^{new} define the new rate of d_j in the i-th conundrum; c_{U,d_j} is the picked conundrum fragments form U-th conundrum; U is selected randomly.

Subsequently modernizing all associates of the populace rendering to the principal and succeeding phases, an iteration of the procedure is executed and the fresh grade of the associates of the populace is defined.

CO algorithm

a. Start
b. Set the parameter values
c. Produce the primary population
d. Appraise the principal population
e. Modernize the preeminent associate
f. Execute the principal phase
g. Formula (2)
h. Formula (3)
i. Modernize C_i
j. Formula (6)
k. Execute the succeeding phase
l. Formula (5)
m. Formula (4)
n. Modernize C_i
o. $t = t + 1$
p. Output the preeminent solution
q. End

***Hierodula Patellifera* optimization algorithm.** *Hierodula Patellifera* optimization algorithm is designed by imitating the activities of *Hierodula Patellifera* like search and confronting the quarry [23]. Then the anthropophagy activity of female *Hierodula Patellifera* after the sexual intercourse with male *Hierodula Patellifera* is defined mathematically. In this process search defined the exploration and confronting the quarry describes the exploitation of the quarry. Population engendered as follows:

$$z_i^t = \min + \text{random}\big(\max - \min)\big), \tag{7}$$

max, min are upper and lower limits, random ∈ [0, 1].

Hierodula Patellifera search for the quarry and the steps used in this activity is formulated as

$$Z_i^{t+1} = \begin{cases} z_i^t + \sigma_1\left(z_i^t - z_a^t\right) + |\sigma_2| O\left(z_a^t - z_b^t\right), \; r_1 \le r_2, \\ z_i^t O + \begin{pmatrix} z_a^t + r_3 \\ z_b^t - z_c^t \end{pmatrix} (1 - O), \; \text{else}, \end{cases} \tag{8}$$

z_i^t is location of the *Hierodula Patellifera*; σ_1 is number based on Levy; $|\sigma_2|$ is number based on normal distribution; $r_1, r_2, r_3 \in [0,1]$; $z_a^t \neq z_b^t \neq z_c^t \neq z_i^t$; O is binary number,

$$O = \begin{cases} 0, \ r_4 < r_5, \\ 1, \ \text{else}, \end{cases} \quad r_4, r_5 \in [0,1].$$

Ambuscade slayers regularly halt stationary on tree twigs and wait for the quarry to reach the point of confronting expanse until that the *Hierodula Patellifera* visualize patiently without any movement. This action mathematically defined as $Z_i^{t+1} = z_i^t + \alpha\left(Z_e' - Z_a^t\right)$, α is control the location of *Hierodula Patellifera*, $\alpha = \cos(\pi r_6)\rho$, $r_6 \in [0,1]$; $\rho = 1 - t/T$, t, T are current and maximum number of iterations.

The quarry movement in search of the food around the *Hierodula Patellifera* is defined as $Z_i^{t+1} = Z_e' + (r_7 \cdot 2 - 1)\rho z_i^t = \min + r_8(\max - \min))$, $r_7, r_8 \in [0,1]$.

The quarry movement around the *Hierodula Patellifera* reduces as time increases and this aspect mathematically defined as

$$Z_i^{t+1} = \begin{cases} z_i^t + \alpha\left(Z_e' - Z_a^t\right), \ r_9 \le r_{10}, \\ Z_e' + (r_7 \cdot 2 - 1)\rho z_i^t = \min + r_8(\max - \min)), \ \text{else}. \end{cases} \tag{9}$$

A control parameter is defined to regulate this procedure as follows: $H = 1 - (t\%(t/Y))/(t/Y)$, % is remainder factor; Y is integer.

Exploitation segment has been formulated by imitating the confronting the quarry by *Hierodula Patellifera*. At reachable point the *Hierodula Patellifera* attack the quarry swiftly and the velocity of the movement of the *Hierodula Patellifera* towards the quarry is defined as $Velocity_{attack} = 1/\left(1 + e^{c\Delta}\right)$, Δ is gravitational acceleration rate; $c \in \{-1, -2\}$.

The quarry grasping behaviour of the *Hierodula Patellifera* is defined as

$$Z_{i,j}^{t+1} = \frac{Z_{i,j}^t + Z_j^*}{2} + Velocity_{attack} d_{s,i,j}^t, \tag{10}$$

$Z_{i,j}^{t+1}$ is new location of *Hierodula Patellifera*; $d_{s.i,j}^t$ is attacking distance, $d_{s.i,j}^t = Z_j^* - Z_{i,j}^t$, $Z_{i,j}^t$ is quarry location around the *Hierodula Patellifera*; Z_j^* is location of the quarry. When attack of the *Hierodula Patellifera* fail then it alters the direction of the attack and it defined as

$$Z_{i,j}^{t+1} = Z_{i,j}^t + r_{12}\left(Z_{a,j}^t - Z_{b,j}^t\right). \tag{11}$$

Once the attack on the prey is failed means it indicate that the procedure is struck into local optima and this action has to be evaded as follows:

$$Z_{i,j}^{t+1} = Z_{i,j}^{t} + e^{2c}\cos(2\pi c)\left|Z_{i,j}^{t} - Z_{e,j}^{t}\right| + (r_{13}\cdot 2 - 1)(\max - \min). \quad (12)$$

Probability factor is applied to reduced exploration and movement towards the exploitation is defined as

$$P_{factor} = m\left(1 - \frac{t}{T}\right), \quad (13)$$

$$m \in [0,1].$$

In the process of anthropophagy activity, the female *Hierodula Patellifera* will eat the male *Hierodula Patellifera* after sexual intercourse. The attraction of male towards to female *Hierodula Patellifera* is defined as

$$Z_{i,j}^{t+1} = Z_{i,j}^{t} + r_{16}\left(Z_i^t - Z_a^t\right), \quad (14)$$

$$r_{16} \in [0,1].$$

The attraction probability by female *Hierodula Patellifera* is defined as

$$P_F = r_{17}\rho, \quad (15)$$

Then the engendered offspring's is defined as

$$Z_i^{t+1} = Z_i^t O + \left(Z_{11}^t + r_{18}\left(-Z_{11}^t + Z_i^t\right)\right)(1 - O). \quad (16)$$

After the sexual intercourse the female consume the male Hierodula Patellifera and it defined as

$$Z_i^{t+1} = Z_a^t \cos(2\pi c)\rho. \quad (17)$$

HPO algorithm

a. Start
b. Engender "*N*" *Hierodula Patellifera*
c. Formula (7)
d. while ($t < T$)
e. $r_{11} \in [0,1]$
f. Update the control parameter
g. For $i = 1 : N$
h. // Exploration segment //
i. if $r_{11} < Y$%% tracking behaviour
j. Formula (8)

k. if $r_{11} < Y$%% tracking behaviour
l. Else%% ambuscade slayers
m. Formula (9)
n. End if
o. // Exploitation segment //
p. Formula (7)
q. while ($t < T$)
r. $r_4 \in [0,1]$
s. For $i = 1 : N$
t. For $i = 1 : D$
u. $r_2 \in [0,1]$
v. if $r_2 < r_4$, then
w. Formula (11)
x. Else
y. Formula (10)
z. if $r_4 < P_{factor}$, then
aa. Formula (12)
bb. End if
cc. Update the failure of attack probability
dd. Formula (13)
ee. End for
ff. // Anthropophagy activity//
gg. $r_3 \in [0,1]$
hh. For $i = 1 : D$
ii. For $i = 1 : D$
jj. $r_4 \in [0,1]$
kk. if $r_3 < r_4$%% sexual intercourse
ll. Formula (15)
mm. Else if $r_4 < P_f$, %% attraction
nn. Formula (14)
oo. Else%% anthropophagy activity
pp. Formula (17)
qq. End if
rr. Update the attraction probability
ss. Formula (15)
tt. End for
uu. End while
vv. $t = t + 1$

ww. Output the best solution
xx. End

Learning Russian language by Chinese student inspired optimization algorithm. In this paper, LCLIS optimization algorithm is formulated by imitating the activities of a Chinese student while learning the Russian language [24]. Every student has aspiration to learn multiple languages in the educating stages. In LCLIS optimization algorithm population initialization is done as follows:

$$Z = \begin{bmatrix} Z_1 \\ \vdots \\ Z_i \\ \vdots \\ Z_N \end{bmatrix}_{N \times m} = \begin{bmatrix} Z_{1,1} & \dots & Z_{1,m} \\ \vdots & \ddots & \vdots \\ Z_{N,1} & \dots & Z_{m,n} \end{bmatrix}_{N \times m},$$

where Z is LCLIS population matrix; N, m are population number and variables.

Arbitrarily preliminary locations are initialized in the search space as follows: $z_{i,j} = \min_j + R\left(\max_j - \min_j\right)$.

Objective function value is calculated as

$$V = \begin{bmatrix} V_1 \\ \vdots \\ V_i \\ \vdots \\ V_N \end{bmatrix}_{N \times 1} = \begin{bmatrix} V(Z_1) \\ \vdots \\ V(Z_i) \\ \vdots \\ V(Z_N) \end{bmatrix}_{N \times 1}.$$

Each Chinese student will select an educator from existing educators to learn the Russian language. This stratagem tips to LCLIS associates to passage to dissimilar zones of the search space, and this action upholds the exploration:

$$RE_i = \left\{ Z_k \,\middle|\, k \in \{1, 2, \dots, N\} \wedge V_k < V_i \right\} U \left\{ Z_{best} \right\}, \quad (18)$$

RE_i is recommended educator for i-th Indian student; Z_{best} is best associate of the population.

The recommended educator of the Chinese student will start the educating process through various modes and gradually the Chinese student will learn the Russian language:

$$Z_{i,j}^{p1} = z_{i,j} + R\left(RE_{i,j}^{s} - Q z_{i,j} \right), \quad (19)$$

$Z_{i,j}^{p1}$ is new position of the i-th associate; $R \in [0, 1]$; $RE_{i,j}^{s}$ is recommended educator; $Q \in \{1, 2\}$.

If the new positions objective functional value V_i^{p1} higher than previous one, then swapping will be done:

$$Z_i = \begin{cases} Z_i^{p1}, \ V_i^{p1} < V_i, \\ Z_i, \ \text{else}. \end{cases} \tag{20}$$

Chinese students who are in the learning of Russian language will interact with each other about the learned concepts and other additional ideas among themselves. This action is mathematically formulated as

$$Z_{i,j}^{p2} = \begin{cases} z_{i,j} + R\left(z_{l,i,j} - Qz_{i,j}\right), V_{li} < V_i, \\ z_{i,j} + R\left(z_{i,j} - Qz_{l,i,j}\right), \ \text{else}; \end{cases} \tag{21}$$

$$Z_i = \begin{cases} Z_i^{p2}, \ V_i^{p2} < V_i, \\ Z_i, \ \text{else}, \end{cases} \tag{22}$$

$Z_{i,j}^{p2}$ is new position of the i-th associate; $Z_{l,i,j}$ is selected Chinese student interact with another student.

Then the individual Chinese student will try to learn himself/herself. By accessing the errors, weakness and strength the individual Chinese student will learn and practice the Russian language. This activity is mathematically formulated as

$$Z_{i,j}^{p3} = z_{i,j} + \frac{\min_j + R\left(\max_j - \min_j\right)}{t}. \tag{23}$$

$Z_{i,j}^{p3}$ is new position of the i-th associate;

$$Z_i = \begin{cases} Z_i^{p3}, \ V_i^{p3} < V_i, \\ Z_i, \ \text{else}. \end{cases} \tag{24}$$

LCLIS optimization algorithm

a. Start
b. Engender the population
c. For $t = 1$ to T
d. For $i = 1$ to N
e. Apply the education selection phase
f. Formula (18)
g. Formula (19)
h. Formula (20)

i. Execute the Chinese student learning from co-student
j. Formula (21)
k. Formula (22)
l. Individual Chinese student practice himself/herself
m. Formula (23)
n. Formula (24)
o. End for
p. $t = t + 1$
q. Output the Z_{best}
r. End

Pulsatrix — Crocuta inspired search optimization algorithm. Pulsatrix — Crocuta inspired search optimization algorithm is designed based on the natural searching and hunting activities of the Pulsatrix and Crocuta. Pulsatrix are characteristically night-time active but extremely well-organized hunters with an amazing acoustic structure and these aspect assistances to discover the target (Prey). Owing to this exceptional attribute, the sound extents one side of the ear, this is much earlier to the other side ear [25]. Target (prey) can be traced in night time by earshot capability as an alternative of eyesight. The sound engendered by the target (Prey) signal is treated in the Pulsatrix brain in twofold fragments; hence the expanse of target (Prey) is assessed on the base of period (Time internal) and concentration variances of sound wave onset.

Preliminary solutions are engendered as follows:

$$P = \begin{bmatrix} P_{1,1} & \dots & P_{1,d} \\ \vdots & \ddots & \vdots \\ P_{n,1} & \dots & P_{n,d} \end{bmatrix},$$

P is Pulsatrix.

Primary position of the Pulsatrix is defined as

$$P_i = P_L + R\left(P_U - P_L\right), \tag{25}$$

P_U, P_L are upper and lower bounds; $R \in [0, 1]$.

Fitness value of each Pulsatrix is computed as

$$F = \begin{bmatrix} f_1\left(\left[P_{1,1}, \dots, P_{1,d}\right]\right) \\ f_2\left(\left[P_{2,1}, \dots, P_{2,d}\right]\right) \\ \vdots \\ f_n\left(\left[P_{n,1}, \dots, P_{n,d}\right]\right) \end{bmatrix}.$$

The standardized concentration info of ith Pulsatrix is employed to modernize the location and it has been computed as follows:

$$C_i = \frac{f_i - \omega}{e - \omega}, \tag{26}$$

$$\omega = \min_{k \in 1, 2, \ldots, n} f_k; \; e = \max_{k \in 1, 2, \ldots, n} f_k.$$

The expanse (distance) between Pulsatrix and target (Prey) is calculated as follows:

$$D_i = P_i - L_2, \tag{27}$$

L is target (Prey) location.

Silently Pulsatrix move towards the target (Prey) rendering to the sound concentration and it defined as

$$SC_i = \frac{C_i}{D_i^2} + RS, \tag{28}$$

RS is random sound; SC_i is sound concentration.

Naturally target (Prey) move randomly and rendering to that Pulsatrix move in tracking mode. Then the position of the Pulsatrix is defined as

$$P_i^{t+1} = \begin{cases} P_i^t + \beta SC_i \left|\alpha L - P_i^t\right|, \; TP_M < 0.5, \\ P_i^t - \beta SC_i \left|\alpha L - P_i^t\right|, \; TP_M \geq 0.5, \end{cases} \tag{29}$$

TP_M is probability of target (Prey) movement; β is factor control the exploration and exploitation, $\beta \to 1.9$ to 0; $\alpha \in [0, 0.5]$.

The hunting activities of Crocuta [26] have been incorporated into the procedure to enhance the search capability of the algorithm. The prey will be surrounded the group of Crocuta and aggressively attack the prey in all directions.

Initialization of the Crocuta population is engendered with limits:

$$Z_i = R(NP, D)(\max - \min) + \min, \tag{30}$$

$Z_i = [z_1, z_2, z_3, \ldots, z_n]$, $i = 1, 2, 3, \ldots, n$; $R \in [0, 1]$; NP is population number; D is dimension.

In cluster mode Crocuta will chase and encircle the prey P:

$$Z_{new} = \begin{cases} z_{new}, \; \text{if } R(\,) < P, \\ \text{random}, \; \text{else}. \end{cases} \tag{31}$$

The location updated as follows:

$$z_{new} = z + R(\,)\,SR\left(t_{loc}RN - TGPR)\right). \tag{32}$$

Here SR is rate of success in hunting; RN is movement rate; TG is target; PR is rate of prey movement; t_{loc} is location. Then the selection progression is engendered rendering to the position of the prey and it, defined as,

$$Z_i^{k+1} = \begin{cases} \text{update } TG, \text{ if } f(Z) < f(z_{new}), \\ TG = 0, \text{ else}, \end{cases} \tag{33}$$

where $f(Z)$ is fitness value of primary position of the prey; $f(z_{new})$ is fitness value of updated position of the prey. Then the Levy flight has been incorporated into the procedure

$$Z_i^{t+1} = Z_i^t + \text{Levy}(d)\,Z_i^t, \tag{34}$$

$$U^{i,t+1} = U^{i,t} + \alpha\left[\frac{u_1}{(v_1)^{1/\beta}}, \ldots, \frac{u_d}{(v_d)^{1/\beta}}\right],$$

$$u_i \sim N\left(0, \sigma^2\right),\; \sigma = \left(\frac{\Gamma(1+\beta)\sin(\pi/2)}{\Gamma((1+\beta)/2)\,\beta 2^{(\beta-1)/2}}\right)^{1/\beta},$$

$$v_i \sim N\left(0, \sigma^2\right), \sigma' = 1.$$

The hunting activities of Crocuta have been incorporated into the Pulsatrix procedure to enhance the search capability of the algorithm. This incorporation will augment the algorithm to explore extensively to obtain optimal solutions.

PISO algorithm

a. Start
b. Create the Preliminary solutions
c. Define the primary position of the Pulsatrix
d. Formula (25)
e. Compute the fitness value of each Pulsatrix
f. Calculate the concentration rate
g. Formula (26)
h. Determine the distance between Pulsatrix and target (Prey)
i. Formula (28)
j. Rendering to sound concentration, calculate the movement of Pulsatrix
k. Formula (29)

l. With reference to target (Prey) movement calculate the movement of Pulsatrix
m. Formula (29)
n. Integrate the Crocuta search activity
o. Formula (30)
p. Crocuta encircle the prey
q. Formula (31)
r. Update the location
s. Formula (32)
t. Engender the selection progression
u. Formula (33)
v. Apply Levy flight
w. Formula (34)
x. $t = t + 1$
y. Output the best solution
z. End

Engineering application. Electrical real power loss reduction in power transmission system. Real power loss reduction objective function in power grid is defined as

$$\min \tilde{F}\left(\overline{g}, \overline{h}\right), \ M(\overline{g}, \overline{h}) = 0; \ N(\overline{g}, \overline{h}) = 0;$$

$$g = \left[VLG_1, \ldots, VLG_{Ng}; \ QC_1, \ldots, QC_{Nc}; \ T_1, \ldots, T_{NT}\right];$$

$$h = \left[PG_{slack}; \ VL_1, \ldots, VL_{NLoad}; \ QG_1, \ldots, QG_{Ng}; \ SL_1, \ldots, SL_{NT}\right].$$

Fitness functions are defined as follows:

$$f_1 = P_{\min} = \min\left[\sum_{m}^{NTL} G_m \left[V_i^2 + V_j^2 - 2V_i V_j \cos \varnothing_{ij}\right]\right];$$

$$f_2 = \min\left[\sum_{i=1}^{N_{LB}} \left|VL_k - VL_k^{desired}\right|^2 + \sum_{i=1}^{Ng} \left|QG_K - QK_G^{\lim}\right|^2\right];$$

$$f_3 = \min L_{\max},$$

$$L_j = 1 - \sum_{i=1}^{NPV} f_{ji} \frac{V_i}{V_j}, \ f_{ji} = -\left[Y_1\right]^1 \left[Y_2\right]; \ L_{\max} = \max\left[1 - \left[Y_1\right]^{-1} \left[Y_2\right] \frac{V_i}{V_j}\right].$$

Parity constraints:

$$0 = PG_i - PD_i - V_i \sum_{j \in NB} V_j \left[G_{ij} \cos\left[\varnothing_i - \varnothing_j\right] + B_{ij} \sin\left[\varnothing_i - \varnothing_j\right]\right];$$

$$0 = QG_i - QD_i - V_i \sum_{j \in NB} V_j \left[G_{ij} \sin\left[\varnothing_i - \varnothing_j \right] + B_{ij} \cos\left[\varnothing_i - \varnothing_j \right] \right].$$

Disparity constraints $PG_{slack}^{\min} \le PG_{slack} \le PG_{slack}^{\max}$, reactive power generation $QG_i^{\min} \le QG_i \le QG_i^{\max}$, $i \in Ng$, load bus voltage $VL_i^{\min} \le VL_i \le VL_i^{\max}$, $i \in NL$, transformers tap setting $T_i^{\min} \le T_i \le T_i^{\max}$, $i \in NT$, switchable reactive power compensations $QC^{\min} \le QC \le QC^{\max}$, $i \in NC$, $\left| SL_i \right| \le SL_i^{\max}$, $i \in NTL$, generator bus voltage $VG_i^{\min} \le VG_i \le VG_i^{\max}$, $i \in Ng$.

Multi objective fitness function:

$$MOF = f_1 + r_i f_2 + u f_3 =$$

$$= f_1 + \left[\sum_{i=1}^{NL} x_v \left[VL_i - VL_i^{\min} \right]^2 + \sum_{i=1}^{Ng} r_g \left[QG_i - QG_i^{\min} \right]^2 \right] + r_f f_3,$$

Simulation study. Hybrid shoebill monodontidae optimization algorithm, CO algorithm, HPO algorithm, LCLIS optimization algorithm, PISO algorithm verified in 23 benchmark functions (main 7 unimodal, succeeding 6 multimodal, concluding 10 fixed-dimension multimodal) [11], Table 1 displays the result in 23 benchmark functions.

Table 1

Result of MO, CO, HPO, LCLIS, PISO in benchmark functions

Benchmark function	EDESSA [11]	SRDSSA [11]	MO	CO	HPO	LCLIS	PISO
1	$6.38 \cdot 10^{-12}$	$6.96 \cdot 10^{-9}$	$6.20 \cdot 10^{-12}$				
2	$3.08 \cdot 10^{-7}$	$5.48 \cdot 10^{-6}$	$3.02 \cdot 10^{-7}$				
3	$2.53 \cdot 10^{-1}$	$4.35 \cdot 10^{-10}$	$2.41 \cdot 10^{-1}$				
4	$6.71 \cdot 10^{-7}$	$1.19 \cdot 10^{-5}$	$6.62 \cdot 10^{-7}$				
5	4.110208	4.11726	4.11012				
6	$3.19 \cdot 10^{-10}$	$4.50 \cdot 10^{-10}$	$3.03 \cdot 10^{-10}$				
7	$2.23 \cdot 10^{-5}$	0.002002	$2.11 \cdot 10^{-5}$				
8	−2877.61	−3052.87	−2847.08				
9	$1.01 \cdot 10^{-12}$	22.85084	$1.02 \cdot 10^{-12}$				
10	$4.79 \cdot 10^{-7}$	0.810233	$4.3 \cdot 10^{-7}$				
11	$5.91 \cdot 10^{-12}$	0.33718	$5.80 \cdot 10^{-12}$				
12	$2.56 \cdot 10^{-12}$	0.051897	$2.41 \cdot 10^{-12}$				
13	0.000366	0.001099	0.000342				
14	0.998004	0.998004	0.998000				
15	0.000307	0.000829	0.000282				

End of the Table 1

Benchmark function	EDESSA [11]	SRDSSA [11]	MO	CO	HPO	LCLIS	PISO
16	−1.03163		−1.03114				
17	0.397887		0.397820				
18	3						
19	−3.86278		−3.86202				
20	−3.23084	−3.21497	−3.23013				
21	−10.1532	−8.80506	−10.1500				
22	−10.0486	−8.46635	−10.0401				
23	−10.5364	−9.28557	−10.5309				

Proposed algorithms are validated in IEEE 57 bus system. Table 2 show the real power loss (TP, MW), power farcicality (PF, PU) and strength (PS, PU).

Table 2

Evaluation of outcome

Algorithm	TP, MW	PF, PU	PS, PU	Algorithm	TP, MW	PF, PU	PS, PU
TECOA [1]	24.5358	0.6711	0.2757	CTFWO [8]	23.3235	0.58553	0.2561
TEISAI [3]	26.88	1.0642	0.25297	MO	20.92	0.6054	0.2579
THPSO [4]	27.83	1.10	0.30	CO	20.87	0.6048	0.2588
THFO [5]	24.25	1.0179	0.2824	HPO	20.80	0.6043	0.2591
TECGA [6]	25.64	1.091	0.312	LCLIS	20.76	0.6039	0.2594
HCACDE [7]	21.9452	0.6012	0.0948	PISO	20.72	0.6036	0.2598

The time T, s, taken by proposed algorithms (57 bus):

MO	CO	HPO	LCLIS	PISO
27.79	23.25	22.31	22.12	22.08

Conclusion. Hybrid shoebill monodontidae optimization algorithm, CO algorithm, HPO algorithm, LCLIS optimization algorithm, PISO algorithm solved the problem efficiently. Hybrid shoebill monodontidae optimization algorithm imitates the deeds of Monodontidae such as whirling, preying and plunge. In the design exploration segment assurance, the comprehensive examining and the exploitation segment regulate the local examination. In CO procedure every associate of the populace is deliberated as a conundrum in such a manner that the sections of the conundrum govern the parameters of the problem. HPO algorithm is designed by imitating the activities of *Hierodula Patellifera* like search and confronting the quarry. Exploitation segment has been formulated by imitating the confronting the quarry by *Hierodula Patellifera*. In LCLIS Chinese students who are in the learning of Russian language will interact with each other about the learned concepts and other additional ideas among themselves. Pulsatrix — Crocuta inspired search optimization algorithm is designed based on the natural searching and hunting activities of the Pulsatrix and Crocuta. Projected algorithms validated in 23 benchmarking functions and IEEE 57 systems.

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