ORIGINAL ARTICLE

Mathematical design of Sea pirates search, Thetys Vagina swarm, Nucifraga multipunctata, Eunectes notaeus and Otariid Optimization Algorithms for Actual Power Loss Reduction

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Received: 16th August 2023
Revised: 11th September 2023
Accepted: 15th September 2023

OPEN ACCESS

Abstract: Sea pirates search optimization (SPO) algorithm, Thetys Vagina Swarm Optimization (TVO) Algorithm, Nucifraga multipunctata optimization (NMO) algorithm, Eunectes notaeus optimization (ENO) algorithm and Otariid optimization algorithm (OOA) applied for solving the actual power loss problem. Key objective of the paper is Actual power loss reduction, Voltage deviation minimization and stability enhancement. In Sea, pirates search optimization algorithm, the solution excellence assessed, for every pirate fresh position defined which based on fitness functional value. In oceans, Thetys vagina will position in anterior and left behind Thetys vaginas are cohorts. In dimensional examination expanse location of Thetys vagina initialized. In Nucifraga multipunctata optimization the chief exploration segment the Nucifraga multipunctata, instigate to take their preliminary locations, in the examination region. The important stimulation of Eunectes notaeus optimization is the system of identifying the location of the female by the male in the course of the copulating period and the pestering stratagem of Eunectes notaeus. In Otariid optimization algorithm, the area of searching by each individual will be in the extensive mode of covering large area and once the potential prey has identified, an explicit signal and this signal will stimulate all the members of the cluster to move towards the direction of the potential prey. SPO, TVO, NMO, ENO and OOA validated in standard IEEE 30 and 354 bus systems.

Keywords: Sea pirates, Thetys Vagina, Nucifraga multipunctata, Eunectes notaeus, Otariid

Introduction

Sea pirates search optimization (SPO) algorithm, Thetys Vagina Swarm Optimization (TVO) Algorithm, Nucifraga multipunctata optimization (NMO) algorithm, Eunectes notaeus optimization (ENO) algorithm and Otariid optimization algorithm (OOA) applied for solving actual power loss problem. Key objective of the paper is Actual power loss reduction, Voltage deviation minimization and stability enhancement.

In these decades, many methods consecutively applied to solve the Actual power loss reduction. Previously conventional approaches are applied. Swarm and Evolutionary approaches sequentially applied to solve the problem. Quasi-oppositional teaching learning based optimization [1], Ant lion optimizer [2], Improved stochastic fractal search optimization algorithm [3], Effective Metaheuristic Algorithm [4], Hybrid CAC-DE [5], Chaotic Turbulent Flow of Water-Based Optimization Algorithm [6], Adopting Scenario-Based approach [7] applied chronologically. Introduced methods validated in IEEE test systems [8]. Then Multi-objective ant lion optimization algorithm [9], Levy Interior Search Algorithm [10] applied to solve the problem and validated in Power

Systems Test Case [11].

It is very important to balance the exploration and exploitation in the swarm and evolutionary based algorithms. If the balance not properly maintained then the procedure may stuck into the local optimal solutions.

Problem Formulation

Essential functional objective of the Actual Loss dwindling problem systematically demarcated as,

$$\mathrm{Min}\ \tilde{F}(\bar{g},\bar{h}) \tag{1}$$

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

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

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

$$g = [VLG_1,..,VLG_{Ng}; QC_1,..,QC_{Nc}; T_1,..,T_{N_T}] \tag{4}$$

$$h = [PG_{slack}; VL_1,..,VL_{N_{Load}}; QG_1,..,QG_{Ng}; SL_1,..,SL_{N_T}] \tag{5}$$

$Q_c \rightarrow$ 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 defined as follows,

$$F_1 = P_{Min} = \mathrm{Min}\left[\sum_m^{NTL} G_m\left[V_i^2 + V_j^2 - 2 * V_i V_j \cos\emptyset_{ij}\right]\right] \tag{6}$$

$$F_2 = \mathrm{Min}\left[\sum_{i=1}^{NLB}\left|V_{Lk} - V_{Lk}^{desired}\right|^2 + \sum_{i=1}^{Ng}\left|Q_{GK} - Q_{KG}^{Lim}\right|^2\right] \tag{7}$$

$$F_3 = \mathrm{Minimize}\ L_{MaxImum} \tag{8}$$

$S_L \rightarrow$ Apparent power

$$L_{Max} = \mathrm{Max}[L_j]; j = 1; N_{LB} \tag{9}$$

$$L_{Max} = \mathrm{Max}\left[1 - [Y_1]^{-1}[Y_2] \times \frac{V_i}{V_j}\right] \tag{10}$$

Parity constraints

$$0 = PG_i - PD_i - V_i \sum_{j \in N_B} V_j\left[G_{ij}\cos[\emptyset_i - \emptyset_j] + B_{ij}\sin[\emptyset_i - \emptyset_j]\right] \tag{11}$$

$$0 = QG_i - QD_i - V_i \sum_{j \in N_B} V_j\left[G_{ij}\sin[\emptyset_i - \emptyset_j] + B_{ij}\cos[\emptyset_i - \emptyset_j]\right] \tag{12}$$

Disparity constraints

$$P_{gsl}^{min} \le P_{gsl} \le P_{gsl}^{max} \tag{13}$$

$$Q_{gi}^{min} \le Q_{gi} \le Q_{gi}^{max}, i \in N_g \tag{14}$$

$$VL_i^{min} \le VL_i \le VL_i^{max}, i \in NL \tag{15}$$

$$T_i^{min} \le T_i \le T_i^{max}, i \in N_T \tag{16}$$

$$Q_c^{min} \le Q_c \le Q_C^{max}, i \in N_C \tag{17}$$

$$|SL_i| \le S_{L_i}^{max}, i \in N_{TL} \tag{18}$$

$$VG_i^{min} \le VG_i \le VG_i^{max}, i \in N_g \tag{19}$$

$$\text{Multi objective fitness (MOF)} = F_1 + r_i F_2 + u F_3 = F_1 + \left[\sum_{i=1}^{NL} x_v\left[VL_i - VL_i^{min}\right]^2 + \sum_{i=1}^{NG} r_g\left[QG_i - QG_i^{min}\right]^2\right] + r_f F_3 \tag{20}$$

$$VL_i^{minimum} = \begin{cases} VL_i^{max}, VL_i > VL_i^{max} \\ VL_i^{min}, VL_i < VL_i^{min} \end{cases} \tag{21}$$

$$QG_i^{minimum} = \begin{cases} QG_i^{max}, QG_i > QG_i^{max} \\ QG_i^{min}, QG_i < QG_i^{min} \end{cases} \tag{22}$$

Projected Methods

In the projected Sea pirates search optimization (SPO) algorithm, Thetys Vagina Swarm Optimization (TVO) Algorithm, Nucifraga multipunctata optimization (NMO) algorithm, Eunectes notaeus optimization (ENO) algorithm and Otariid optimization algorithm (OOA), both the exploration and exploitation has properly balanced. In Sea, pirates search optimization (SPO) Pirates from olden ages to attack the Container, Bulk, Carrier, Tanker and Passenger Ships to acquire the money, goods and valuable assets. In addition, ships will hijack for the ransom money. Usually the sea pirates will act as groups and a leader will be there. After each successful attempt, they will store the money, valuable items in a hidden known place which only known by group members alone. They valuable items, money and other things will share among them in appropriate predefined time. Many times some member in a particular Sea pirates group will steal certain portion of money or goods, which has been stored in hidden place in secret mode. Then after stealing the member will flee away to unknown place otherwise he may join in the rival group which also doing the same. In that times the group leader will order the members to trace the fled member in order to get back the staled money and assets. Many groups will be there and fight will occur between those groups often, about which group to dominate the sea pirate actions. Few times, there will be revolt within the group to capture the leadership of that particular group. The nations around in that particular sea region will keep vigil and try to arrest the Sea pirates. Yet its uphill task to do so. Since the Sea, pirates know well about the geographical area and attack the ships, escaping and hiding sequentially. In Thetys Vagina Swarm Optimization (TVO) Algorithm strategies of Thetys vagina while scavenging in oceans has emulated to design the Thetys vagina swarm algorithm. In oceans, Thetys vagina will create a manacle and front-runner Thetys vagina will positioned in anterior and left behind Thetys vaginas are cohorts. In dimensional examination expanse location of Thetys vagina initialized. Once a lone Thetys vagina tumbles into the confined (local) optimization, and then the Thetys vagina can hurdle out of the curbed (local) optimization by the actions of front-runner Thetys vagina. But then again if maximum Thetys vagina sinks into the similar circumstance, then entire procedure will be sluggish and trap into local optima. In order to overcome this aspect chaotic map strategy integrated to attain the global optima. Logistic map exploited to engender a chaotic solution in the period of initialization. Then a differential evolution mechanism embedded in the procedure for enhancement of the search. By this approach, a fresh enhanced contender solution can engender for every exploration agent as an escalation contrivance). Behaviour of Nucifraga multipunctata imitated to design the Nucifraga multipunctata optimization (NMO) algorithm. The Nucifraga multipunctata display double distinctive actions that happen at detached phases. In summertime season The Nucifraga, multipunctata explore for kernels and consequent storing in a suitable reserve. In the course of the wintertime, Nucifraga multipunctata will search for the secreted reserves based on search based on the spatial memory stratagem through indicators as locus points. When Nucifraga multipunctata is unable to discover the deposited kernels, they will arbitrarily discover the exploration space to find their nutrition. Nucifraga multipunctata start arbitrarily probing for kernels. This deed called the chief exploration segment. At that point, Nucifraga multipunctata exploit the plenty of kernels and stockpile them away from the pool zone. Nucifraga multipunctata carry the kernels and store it in the appropriate storing locations, typically tall zones deprived of substantial afforestation. During wintertime, Nucifraga multipunctata instigate to search the stockpiled kernels. This performance is subsequent exploration segment. Nucifraga multipunctata do not only arbitrarily examine for their reserves but also use entities nearby the reserves as signs to define their place of storing the kernels. Additionally, Nucifraga multipunctata employ spatial memory as the chief tool to aid for recovering their reserves. Nucifraga multipunctata use numerous substances near a sole reserve and own the aptitude to dredge up the place of the reserve for an extended period. Eunectes notaeus optimization (ENO) algorithm designed based on the regular behaviour of Eunectes notaeus. The important stimulation of ENO is the system of identifying the location of the female by the male in the course of the copulating period and the pestering stratagem of Eunectes notaeus. As soon as the copulating period reaches, male Eunectes notaeus search for the female. Customarily, male Eunectes notaeus are intelligent to recognize the location of female Eunectes notaeus and transfer in the direction of female through tracking pheromone of female Eunectes notaeus produce and it left in the movement. In the course of this procedure, male Eunectes notaeus are intelligent to tracking pheromone of female that specify the existence of the female tracking pheromone of female by continuously pinging the tongue by male Eunectes notaeus. Population member of the procedure is Eunectes notaeus and the candidate solution formed by each Eunectes notaeus. In the exploration segment, female Eunectes notaeus left the pheromone lengthways their lane and sequentially male Eunectes notaeus can recognize their location. Otariid optimization algorithm (OOA) designed by imitating the natural actions of Otariid. During the hunting Otariid will be in foraging period and through this approach Otariid will attain the prey in large amount. Otariid will forage for the prey in individual mode but the hunting will do in cluster mode. The area of searching by each individual will be in the extensive mode of covering large area and once the potential prey had identified, an explicit signal and this signal will stimulate all the members of the cluster to move towards the direction of the potential prey.

Sea Pirates Search Optimization Algorithm

Sea pirates search optimization (SPO) algorithm designed based on the actions of Sea pirates. Pirates from olden ages to now attack the Container, Bulk, Carrier, Tanker and Passenger Ships to acquire the money, goods and valuable assets [12]. In this paper Sea, pirate's actions imitated to design the algorithm. Sea pirates search optimization (SPO) algorithm commenced by arbitrarily priming the location of a sum of n entities in a d-dimensional exploration space as follows,

$$S = \begin{bmatrix} s_1^1 & \cdots & s_d^1 \\ \vdots & \ddots & \vdots \\ s_1^n & \cdots & s_d^n \end{bmatrix} \tag{23}$$

where s is the location of the sea pirates

d is the variable numbers

The preliminary position of the Sea pirate specified as,

$$S^i = LB_j + R \times (UB_j - LB_j) \tag{24}$$

where LB is lower bound

UB is upper bound

S^i location of the i th Sea pirate

$R \in [0,1]$

The forces used by the nations to spoil the actions of the Sea pirates and intelligence level of the forces is specified as,

$$Q = \begin{bmatrix} q_1^1 & \cdots & q_d^1 \\ \vdots & \ddots & \vdots \\ q_1^n & \cdots & q_d^n \end{bmatrix} \quad (25)$$

where q indicate the intelligence of observation

The fitness function defined as,

$$F = \begin{bmatrix} f_1(s_1^1, s_2^1, \ldots, s_d^1) \\ f_2(s_1^2, s_2^2, \ldots, s_d^2) \\ ; \\ f_n(s_1^n, s_2^n, \ldots, s_d^n) \end{bmatrix} \quad (26)$$

where s_d^n specify the d th location of n th Sea pirate

In Sea, pirates search optimization (SPO) algorithm, the solution excellence assessed, for every pirate fresh position defined which based on fitness functional value. Then the position is rationalized once new is superior to the existing one. Each pirate will stay in the present position, when solution excellence is more effectual than the fresh one. Some member in a particular Sea pirates group will steal certain portion of money or goods, which has been stored in hidden place in secret mode. Then after stealing the member will flee away to unknown place otherwise he may join in the rival group which also doing the same. In that times the group leader will order the members to trace the fled member in order to get back the staled money and assets.

$$S_{t+1}^i = GB_t + \left[TE_t\left(B_t^i - U_t^i\right)R_1 + TE_t\left(U_t^i - Q_t^{e(i)}\right)R_2\right]\text{sgn}\,(R - 0.5) \quad (27)$$

$R_3 \geq 0.5$

$R_4 > OP_t$

where s_{t+1}^i signify the location of the Sea pirate

GB_t is the global best location obatined by Sea pirate

U_t^i location of the fled member from the group

B_t^i is the best location attained by the Sea pirate

TE_t Tracing expanse of the Sea pirate

$OP_t$is Opinion probability

$R_1, R_2$and $R_4 \in [0,1]$

$Q_t^{e(i)}$ is the Intellectual actions of the fled member with money to hide away from the searching members

$$e = [(n-1) \cdot R(n,1)] \quad (28)$$

Effectively the fled member himself will alter the strategy of hiding since the other sea pirates will apply different techniques for tracing and capturing the fled member.

$$Q_t^{e(i)} = \begin{cases} s_t^i & \text{if } f(s_t^i) \geq f(Q_t^{e(i)}) \\ Q_t^{e(i)} & \text{if } f(s_t^i) < f(Q_t^{e(i)}) \end{cases} \quad (29)$$

where f define the fitness function

$$TE_t = \beta_0 \cdot e^{\beta_1 \left(\frac{t}{T}\right)_1^{\beta}} \quad (30)$$

where β_0 is the preliminary guess of the Tracing expanse

T and t are maximum and present iterations

β_1 is to control the exploration and exploitation

TE_t large and small values will lead to explore and exploit the spaces

$$OP_t = \delta_0 \cdot \log\left(\delta_1 \left(\frac{t}{T}\right)^{\delta_0}\right) \quad (31)$$

T and t are maximum and present iterations

$\delta_1$control the exploration and exploitation

Big value of OP_t(Opinion probability), will lead to local examination which deepens the search in zones of the examination space. Small value of OP_t(Opinion probability) will decrease the opportunity of penetrating in the locality of present virtuous solutions. Consequently, an upsurge in the value of OP_t(Opinion probability), kindles Sea pirates search optimization (SPO) algorithm to discover the exploration space in global mode and it will diverse the examination in all extents of the exploration space.

$\beta_1 = 2.0$

$\delta_1 = 2.0$

The Sea pirates will try to acquire the money, goods and valuable assets which took away by the fled member in the search operation and at this point the location of the Sea pirates is defined as,

$$S_{t+1}^i = TE_t\left[\left(UB_j - LB_j\right)R + P_j\right] \quad (32)$$

$R_3 \geq 0.5$

$R_4 > OP_t$

where LB is lower bound

UB is upper bound

TE_t Tracing expanse of the Sea pirate

$OP_t$is Opinion probability

$R_1, R_2$and $R_4 \in [0,1]$

In order to amend the exploration and exploitation topographies of Sea pirates search optimization (SPO) algorithm, the examination in supplementary locations are obtained and the fresh location is defined as,

$$S_{t+1}^i = GB_t - [TE_t(B_t^i - U_t^i)R_1 + TE_t(U_t^i - Q_t^{e(i)})R_2] sgn\ (R - 0.5) \quad (33)$$

$R_3 < 0.5$

where s_{t+1}^i signify the location of the Sea pirate

GB_t is the global best location obatined by Sea pirate

U_t^i location of the fled member from the group

B_t^i is the best location attained by the Sea pirate

TE_t Tracing expanse of the Sea pirate

$OP_t$is Opinion probability

$R_1, R_2$and $R_4 \in [0,1]$

$Q_t^{e(i)}$ is the Intellectual actions of the fled member with money to hide away from the searching members

Exploitation raised by narrowed zone inspection with info on the illustrious solution to time in the trivial area of the solution.

$$S_i^t = O_i^t + a * (O_E - O_i^t) + b * (O_m^t - O_n^t) \quad (34)$$

E is excellent solution

$a, b \in R\ (\ )$

$$m, n \in [i - R, i + R] \quad m \neq n \neq i \quad (35)$$

Subsequently the streamlined solution by narrowed zone inspection in the is specified as,

$$O_i^{t+1} = O_i^t + \Psi(O_j^t - O_k^t) \quad (36)$$

$\Psi\ \in R\ (\ )$

a. Start
b. Set the parameters
c. Engender the position of the Sea pirates
d. Initialize GB_t and B_t^i
e. Define the degree of $Q_t^{e(i)}$ rendering to Sea pirates
f. Based on fitness value acquire the location of the Sea pirates
g. while$(t < T)$ do
h. $TE_t = \beta_0 \cdot e^{\beta_1 \left(\frac{t}{T}\right)_1^{\beta}}$
i. $OP_t = \delta_0 \cdot \log\left(\delta_1 \left(\frac{t}{T}\right)^{\delta_0}\right)$
j. if $R \geq 0.5$, then
k. if $R \geq OP_t$, then
l. $S_{t+1}^i = GB_t + [TE_t(B_t^i - U_t^i)R_1 + TE_t(U_t^i - Q_t^{e(i)})R_2] sgn\ (R - 0.5)$
m. otherwise
n. $S_{t+1}^i = TE_t[(UB_j - LB_j)R + P_j]$
o. end if
p. else
q. $S_{t+1}^i = GB_t - [TE_t(B_t^i - U_t^i)R_1 + TE_t(U_t^i - Q_t^{e(i)})R_2] sgn\ (R - 0.5)$
r. end for
s. $S_i^t = O_i^t + a * (O_E - O_i^t) + b * (O_m^t - O_n^t)$
t. $O_i^{t+1} = O_i^t + \Psi(O_j^t - O_k^t)$
u. for $i = 1,2,3, \ldots, n$ do
v. Verify the possibility for fresh locations
w. Appraise the location of the Sea pirates
x. Modernize the location of the Sea pirates
y. Streamline the Opinion probability
z. $Q_t^{e(i)} = \begin{cases} s_t^i & \text{if } f(s_t^i) \geq f(Q_t^{e(i)}) \\ Q_t^{e(i)} & \text{if } f(s_t^i) < f(Q_t^{e(i)}) \end{cases}$
aa. $t = t + 1$
bb. End

Thetys Vagina Swarm Optimization Algorithm

Thetys Vagina Swarm Optimization (TVO) Algorithm based on the Strategies of Thetys vagina while scavenging in oceans has emulated to design the Thetys vagina swarm algorithm. In oceans, Thetys vagina [13] will create a manacle and front-runner Thetys vagina will positioned in anterior and left behind Thetys vaginas are cohorts. In dimensional examination expanse location of Thetys vagina initialized. Location of the front-runner Thetys vagina will altered as,

$$TV_{1,j} = \begin{cases} Q_j + o_1\left(o_2 * \left(UB_j - LB_j\right) + LB_j\right) & o_3 \geq 0 \\ Q_j - o_1\left(o_2 * \left(UB_j - LB_j\right) + LB_j\right) & o_3 < 0 \end{cases} \quad (37)$$

where $TV_{1,j}$ is the location of front − runner Thetys vagina in jth dimension

Q_j is the location of the nutrition spring in the jth dimension

UB_j specify the upper bound jth dimension

LB_j specify the lower bound jth dimension

o_1, o_2 and o_3 are the control parameters

o_2 and $o_3 \in [0,1]$

o_1 parameter is to control the exploration and exploitation

The location of the front-runner Thetys vagina updated based on the nutrition spring.

$$o_1 = 2e^{-}\left(-\frac{4m}{M}\right)^2 \quad (38)$$

where m , M specify the current and maximum iterations

Then the position of the cohort Thetys vaginas specified as,

$$TV_{i,j} = \frac{1}{2} * \left(TV_{i,j} + TV_{i-1,j}\right) \quad (39)$$

$i \geq 2$

where $TV_{i,j}$ specify the position of the ith cohort Thetys vagina in the jth dimension

Once a lone Thetys vagina tumbles into the confined (local) optimization, and then the Thetys vagina can hurdle out of the curbed (local) optimization by the actions of front-runner Thetys vagina. But then again if maximum Thetys vagina sinks into the similar circumstance, then entire procedure will be sluggish and trap into local optima. In order to overcome this aspect chaotic map strategy integrated to attain the global optima. Logistic map exploited to engender a chaotic solution in the period of initialization.

$$P(t+1) = \mu \times P(t) \times (1 - P(t)) \quad (40)$$

where $t = 1,2,3,..,N-1$

$\mu = 4$; t is the present chaotic integer

$P \in [0,1]$

$P \neq 0.25, 0.5$ and 0.75

$$PTV_i = P(t) * TV_i \quad (41)$$

where PTV_i is the chaotic solution

$P(t)$ is the t th chaotic integer

TV_i indicate the i th agent

Then a differential evolution mechanism embedded in the procedure for enhancement of the search. By this approach, a fresh enhanced contender solution can engendered for every exploration agent as an escalation contrivance.

The agent vector in the dimension specified as,

$$TV_i = \left(TV_{i,1}, TV_{i,2}, TV_{i,3}, .., TV_{i,D}\right) \quad (42)$$

In the mutation procedure, the operator applied by choosing dissimilar agents and it defined as,

$$Z_i = TV_{R1} + MSP * (TV_{R2} - TV_{R3}) \quad (43)$$

where Z_i is mutant vector

MSP is mutant scale parameter

$R1 \neq R2 \neq R3 \neq i$

$$MSP = UD(MSP_{min}, MSP_{max}, [1, D]) \quad (44)$$

where UD is uniform distribution

$D \in [0,1]$

$MSP_{min} = 0.20$, $MSP_{max} = 0.80$

In this procedure, a test vector engendered through crossover operative and it defined as,

$$W_{ij} = \begin{cases} Z_{ij}; R < PR_{Cr} \\ TV_{i,j}; \text{otherwise} \end{cases} \quad (45)$$

$PR_{Cr} = 0.10$; $R \in (0,1)$

Rendering to fitness value Picking operative is to pick the best offspring between trial vector and the exploration agent. Subsequently enhanced contender solution will engage, and then convergence speed and precision of the procedure will enrich.

$$TV_i = \begin{cases} W_i; f(W_i) < f(TV_i) \\ TV_i; \text{otherwise} \end{cases} \quad (46)$$

where W_i specify the trial vector

TV_i is the exploration agent

In the proposed Thetys Vagina Swarm Optimization (TVO) Algorithm, a chaotic initialization employed to construct an enhanced introductory populace for the successive optimization procedure. Since the eminence of the preliminary populace controls the convergence swiftness and precision of the procedure. Through chaotic initialization preliminary population created arbitrarily and this, make the algorithm to reach the global optima. Then a differential evolution mechanism embedded in the procedure for enhancement of the search. By this approach, a fresh enhanced contender solution can engendered for every exploration agent as an escalation contrivance.

$$Q_a^j = Q_a^j + (Q_a^i - Q_a^j)(\emptyset - \sigma_j)\varphi \quad (47)$$

$$Q_b^j = Q_b^j + (Q_a^i - Q_b^j)(\emptyset - \sigma_j)\cos\varphi \quad (48)$$

$$Q_c^j = Q_c^j + (Q_c^i - Q_c^j)(\emptyset - \sigma_j)\sin\varphi \quad (49)$$

$\alpha, \beta \in [0,2\pi]$

$\varphi \in [-1,1]$

Population engendered in the limits as follows,

$$TV_{i,j} = LB_j + R \times (UB_j - LB_j) \quad (50)$$

UB_j specify the upper bound jth dimension

LB_j specify the lower bound jth dimension

$R \in (0,1)$

a. Start
b. Engender the position of the exploration agent in the preliminary population arbitrarily
c. $TV_{i,j} = LB_j + R \times (UB_j - LB_j)$
d. Estimate the fitness of every entity in the preliminary population
e. Compute the chaotic solution of the entity in the preliminary population
f. $P(t+1) = \mu \times P(t) \times (1 - P(t))$
g. $PTV_i = P(t) * TV_i$
h. Select the preeminent N solutions from preliminary population
i. Engender the procedure Parameters
j. $o_1 = 2e^{-}\left(-\frac{4m}{M}\right)^2$
k. $\text{if } i == 1, \text{then}$
l. Revive the position of the front-runner Thetys vagina
m. $TV_{1,j} = \begin{cases} Q_j + o_1\begin{pmatrix} o_2 * (UB_j - LB_j) \\ +LB_j \end{pmatrix} & o_3 \geq 0 \\ Q_j - o_1\begin{pmatrix} o_2 * (UB_j - LB_j) \\ +LB_j \end{pmatrix} & o_3 < 0 \end{cases}$
n. Otherwise
o. Revive the position of the cohort Thetys vaginas
p. $TV_{i,j} = \frac{1}{2} * (TV_{i,j} + TV_{i-1,j})$
q. Pick dissimilar agents from the contemporary population, at that time apply the differential evolution mechanism
r. Engender the contender solution of the exploration agent
s. $Z_i = TV_{R1} + MSP * (TV_{R2} - TV_{R3})$
t. $MSP = UD(MSP_{min}, MSP_{max}, [1, D])$
u. $MSP_{min} = 0.20, MSP_{max} = 0.80$
v. $W_{ij} = \begin{cases} Z_{ij}; R < PR_{Cr} \\ TV_{i,j}; \text{otherwise} \end{cases}$
w. Streamline the exploration agent
x. $TV_i = \begin{cases} W_i; f(W_i) < f(TV_i) \\ TV_i; \text{otherwise} \end{cases}$
y. Modify the location of the agent inside the lower and upper bounds
z. $Q_a^j = Q_a^j + (Q_a^i - Q_a^j)(\emptyset - \sigma_j)\varphi$
aa. $Q_b^j = Q_b^j + (Q_a^i - Q_b^j)(\emptyset - \sigma_j)\cos\varphi$
bb. $Q_c^j = Q_c^j + (Q_c^i - Q_c^j)(\emptyset - \sigma_j)\sin\varphi$
cc. Appraise the fitness of each agent in the contemporary population
dd. if the optimum agent is superior than the global optima (Nutrition Location), then modernize the global optima
ee. otherwise
ff. Global optima (Nutrition Location) unchanged
gg. $t = t + 1$
hh. Output the best solution
ii. End

Nucifraga Multipunctata Optimization Algorithm

Behaviour of Nucifraga multipunctata imitated to design the Nucifraga multipunctata optimization (NMO) algorithm. The Nucifraga multipunctata display double distinctive actions that happen at detached phases. In summertime season The Nucifraga, multipunctata explore for kernels and consequent storing in a suitable reserve. In the course of the wintertime, Nucifraga multipunctata will search for the secreted reserves based on search based on the spatial memory stratagem through indicators as locus points. When Nucifraga multipunctata is unable to discover the deposited kernels, they will arbitrarily discover the exploration space to find their nutrition [14]. Nucifraga multipunctata use numerous substances near a sole reserve and own the aptitude to dredge up the place of the reserve for an extended period. Nucifraga multipunctata exploit nutrition reserves to forage themselves and their young ones for up to 180 days. This performance called the additional exploitation segment. In the chief exploration segment, the Nucifraga multipunctata instigate to take their preliminary locations/nutrition places, in the examination region. Each Nucifraga multipunctata instigates by examination the seed case that encompasses the kernels in the preliminary location. If the Nucifraga multipunctata discovers upright kernels, at that moment Nucifraga multipunctata will transport them to the secret backup zone to entomb them in a reserve. If Nucifraga multipunctata unable to discover upright kernels, then further search for kernels will continued.

$$\overrightarrow{Z_i^{t+1}} = \begin{cases} Z_{i,j}^t \ \text{if}\sigma_1 < \sigma_2 \\ \begin{cases} Z_{a,j}^t + \alpha\cdot(Z_{X,j}^t - Z_{Y,j}^t) + \\ \rho.(O^2.\max_j - \min_j) \ \text{if } t \le \frac{T_{max}}{2} \\ Z_{S,j}^t + \alpha\cdot(Z_{X,j}^t - Z_{Y,j}^t) + \\ \rho(O_1 < \varphi). \\ (O^2.\max_j - \min_j)\text{otherwise} \end{cases} \end{cases} \quad (51)$$

Z_i^{t+1} → fresh location of Nucifraga multipunctata

$Z_{i,j}^t$ → jth location of Nucifraga multipunctata in present generation

$\max_j$ and $\min_j$ → limits

X, Y, S → arbitrarily picked indices to aid exploration

$\sigma_1, \sigma_2, O_1, O^2 \in [0,1]$

$Z_{a,j}^t$ → average of the solutions

α → arbitrarily engendered number

$$\rho = \begin{cases} \sigma_3 \ \text{if } O_1 < O_2 \\ \sigma_4 \ \text{if } O_2 < O_3 \\ \sigma_5 \ \text{if } O_1 < O_3 \end{cases} \quad (52)$$

$O_2, O_3 \in [0,1]$

X, Y → indiacte the Nucifraga multipunctata about fresh nutrition locations

σ_1, σ_2 → scaling factors to control the exploration and exploitation

ρ → direction movement of Nucifraga multipunctata to locate the nutrition

Nucifraga multipunctata carry the kernels, which obtained in the primary exploration segment to secret reserve locations. This segment is the primary exploitation segment.

$$\overrightarrow{Z_i^{t+1\,(new)}} = \begin{cases} \overrightarrow{Z_i^t} + \rho\cdot\left(\overrightarrow{Z_{best}^t} - \overrightarrow{Z_i^t}\right)\cdot|L| + \\ O_1\cdot\left(\overrightarrow{Z_X^t} - \overrightarrow{Z_Y^t}\right) \text{if}\sigma_1 < \sigma_2 \\ \overrightarrow{Z_{best}^t} + \rho\cdot\left(\overrightarrow{Z_X^t} - \overrightarrow{Z_Y^t}\right) \text{if}\sigma_1 < \sigma_3 \\ \overrightarrow{Z_{best}^t}\cdot E \text{ otherwise} \end{cases} \quad (53)$$

$\overrightarrow{Z_i^{t+1\,(new)}}$ → new location of the Nucifraga multipunctata in secret reserve zone where kernels are stored

$|L|$ → Levy flight

$\sigma_3 \in [0,1]$

E → reduce linearly from one to zero

E → expand the primary exploitation

The altercation amongst the searching period and the secret reserve zone where kernels are stored is pragmatic rendering to the following formulation to uphold the equilibrium between exploration and exploitation.

$$\overrightarrow{Z_i^{t+1}} = \begin{cases} \begin{cases} Z_{i,j}^t \ \text{if}\sigma_1 < \sigma_2 \\ \begin{cases} Z_{a,j}^t + \alpha\cdot(Z_{X,j}^t - Z_{Y,j}^t) \\ +\rho.(O^2.\max_j - \min_j) \\ \text{if } t \le \frac{T_{max}}{2} \\ Z_{S,j}^t + \alpha\cdot(Z_{X,j}^t - Z_{Y,j}^t) \\ +\rho(O_1 < \varphi). \\ (O^2.\max_j - \min_j)\text{otherwise} \end{cases} \end{cases} \ \text{if } \emptyset > P_1 \\ \begin{cases} \overrightarrow{Z_i^t} + \rho\cdot\left(\overrightarrow{Z_{best}^t} - \overrightarrow{Z_i^t}\right)\cdot|L| \\ +O_1\cdot\left(\overrightarrow{Z_X^t} - \overrightarrow{Z_Y^t}\right) \text{if}\sigma_1 < \sigma_2 \\ \overrightarrow{Z_{best}^t} + \rho\cdot\left(\overrightarrow{Z_X^t} - \overrightarrow{Z_Y^t}\right) \text{if}\sigma_1 < \sigma_3 \\ \overrightarrow{Z_{best}^t}\cdot E \text{ otherwise} \end{cases} \ \text{else} \end{cases} \quad (54)$$

$Z_{i,j}^t$ → jth location of Nucifraga

multipunctata in present generation

$\max_j$ and $\min_j \rightarrow$ limits

$X, Y, S \rightarrow$ arbitrarily picked indices to aid exploration

$\sigma_1, \sigma_2, O_1, O^2 \in [0,1]$

$Z_{a.j}^t \rightarrow$ average of the solutions

$\alpha \rightarrow$ arbitrarily engendered number

$\emptyset \in [0,1]$

$P_1 \rightarrow$ reduce linearly from one to zero

Algorithm for searching period and the secret reserve zone

a. Start
b. Engender N Nucifraga multipunctata
c. Compute the fitness value
d. $t = 1; present\ iteration$
e. $while(t < T)$
f. $for\ i = 1{:}N$
g. $for\ j = 1{:}d$
h. $if\ \emptyset > P_1, //$
   $primary\ exploration\ segment, then$
i. $Upadte\ \overrightarrow{Z_i^{t+1}}$
j. $$\overrightarrow{Z_i^{t+1}} = \begin{cases} Z_{i,j}^t\ if \sigma_1 < \sigma_2 \\ \begin{cases} Z_{a.j}^t + \alpha \cdot (Z_{X.j}^t - Z_{Y.j}^t) \\ +\rho.(O^2.max_j - min_j) \\ if\ t \le \frac{T_{max}}{2} \\ Z_{S.j}^t + \alpha \cdot (Z_{X.j}^t - Z_{Y.j}^t) \\ +\rho(O_1 < \varphi). \\ (O^2.max_j - min_j) otherwise \end{cases} \end{cases}$$
k. $$\overrightarrow{Z_i^{t+1}} = \begin{cases} \overrightarrow{Z_i^{t+1}}\ if\ f(\overrightarrow{Z_i^{t+1}}) < f\left(\overrightarrow{Z_i^t}\right) \\ \overrightarrow{Z_i^t}\ otherwise \end{cases}$$
l. Else/ apply Primary exploitation segment
m. $Upadte\ \overrightarrow{Z_i^{t+1}}$
n. $$\overrightarrow{Z_i^{t+1}} = \begin{cases} \overrightarrow{Z_i^{t+1}}\ if\ f(\overrightarrow{Z_i^{t+1}}) < f\left(\overrightarrow{Z_i^t}\right) \\ \overrightarrow{Z_i^t}\ otherwise \end{cases}$$
o. End if
p. End for
q. $t = t + 1$
r. End

In the wintertime, the Nucifraga multipunctata instigate in examine of their secret reserves where kernels are stored. This segment is second exploration. The Nucifraga multipunctata use a spatial memory stratagem to discover their secret reserves. Nucifraga multipunctata utmost probable use numerous substances as signs for a sole secret reserve.

$$U = \begin{bmatrix} \overrightarrow{U_{1,1}^t} \\ \vdots \\ \overrightarrow{U_{i,1}^t} \\ \vdots \\ \overrightarrow{U_{N,1}^t} \end{bmatrix} \quad (55)$$

$U \rightarrow$ substances as signs nearby secret reserve

The Nucifraga multipunctata will use references (U) to locate the secret reserves where the kernel are stored. If first reference (U) failed then subsequent references (U) will utilized by Nucifraga multipunctata to locate the secret reserves. The first reference (U) engendered as follows,

$$\overrightarrow{U_{1,k}^t} = \overrightarrow{Z_i^t} + \beta \cdot \cos(\theta) \cdot \left(\left(\overrightarrow{Z_X^t} - \overrightarrow{Z_Y^t}\right)\right) \quad (56)$$

$k = 1$

If first reference (U) failed then Nucifraga multipunctata will use second reference (U) to locate the secret reserves where the kernel are stored and it defined as,

$$\overrightarrow{U_{1,k}^t} = \overrightarrow{Z_i^t} + \beta \cdot \cos(\theta) \cdot \left((\overrightarrow{max} - \overrightarrow{min}) \cdot \sigma_3 + \overrightarrow{min}\right) \cdot \overrightarrow{max_2} \quad (57)$$

$$\overrightarrow{max_1} = \begin{cases} 1\ \text{if}\ \overrightarrow{O_2} < P_U \\ 0\ \text{otherwise} \end{cases} \quad (58)$$

$\theta \in [0, \pi]$

$U \in [0,1]$

$\overrightarrow{max}$ and $\overrightarrow{min}$ are the limits

$\beta \rightarrow$ reduce linearly from one to zero

Enhancement of the identification the secret reserves where the kernel are stored by Nucifraga multipunctata through references (U) is mathematically done as follows,

$$\overrightarrow{U_{i,1}^t} = \begin{cases} \overrightarrow{Z_i^t} + \beta \cdot \cos(\theta) \cdot \left(\left(\overrightarrow{Z_X^t} - \overrightarrow{Z_Y^t}\right)\right) \\ +\beta \cdot U\ \text{if}\ \theta = \frac{\pi}{2} \\ \overrightarrow{Z_i^t} + \beta \cdot \cos(\theta) \\ \cdot \left(\left(\overrightarrow{Z_X^t} - \overrightarrow{Z_Y^t}\right)\right)\ \text{otherwise} \end{cases} \quad (59)$$

$$\overrightarrow{U_{i,2}^t} = \begin{cases} \overrightarrow{Z_i^t} + \left(\begin{matrix} \beta \cdot \cos(\theta) \cdot \\ ((\overrightarrow{max} - \overrightarrow{min}) \cdot \sigma_3 + \overrightarrow{min}) \\ +\beta \cdot U \end{matrix} \right) \\ \cdot \overrightarrow{max_2}\ \text{if}\ \theta = \frac{\pi}{2} \\ \overrightarrow{Z_i^t} + \beta \cdot \cos(\theta) \cdot \\ ((\overrightarrow{max} - \overrightarrow{min}) \cdot \sigma_3 + \overrightarrow{min}) \\ \cdot \overrightarrow{max_2}\ \text{otherwise} \end{cases} \quad (60)$$

$$\beta = \begin{cases} \left(1 - \frac{t}{T_{max}}\right)^{2\frac{t}{T_{max}}} & \text{if } O_1 > O_2 \\ \left(\frac{t}{T_{max}}\right)^{\frac{2}{t}} & \text{otherwise} \end{cases} \quad (61)$$

Rendering to the identification of secret reserves, the Nucifraga multipunctata explore and exploit more areas around the secret reserves and location of the Nucifraga multipunctata is updated as follows,

$$\overrightarrow{Z_1^{t+1}} = \begin{cases} \overrightarrow{Z_l^t} \text{ if } f(\overrightarrow{Z_l^t}) < f\left(\overrightarrow{U_{l,1}^t}\right) \\ \overrightarrow{U_{l,1}^t} \text{ otherwise} \end{cases} \quad (62)$$

$\overrightarrow{U_{l,1}^t} \rightarrow$ first reference (U)

With reference to identification of secret reserves, the existing of the kernels in the location defined as,

$$Z_{i,j}^{t+1} = \begin{cases} Z_{i,j}^t \text{ if } \sigma_3 < \sigma_4 \\ Z_{i,j}^t + O_1 \cdot (Z_{best,j}^t - Z_{i,j}^t) \\ +O_2 \cdot \left(\overrightarrow{U_{l,1}^t} - Z_{V,j}^t\right), \text{otherwise} \end{cases} \quad (63)$$

$V \rightarrow$ solution index randomly picked from population

The spatial memory utilized by the Nucifraga multipunctata in the identification of secret reserves defined as,

$$\overrightarrow{Z_1^{t+1}} = \begin{cases} \overrightarrow{Z_l^t} \text{ if } f(\overrightarrow{Z_l^t}) < f\left(\overrightarrow{U_{l,2}^t}\right) \\ \overrightarrow{U_{l,2}^t} \text{ otherwise} \end{cases} \quad (64)$$

$\overrightarrow{U_{l,2}^t} \rightarrow$ second reference (U)

$$Z_{i,j}^{t+1} = \begin{cases} Z_{i,j}^t \text{ if } \sigma_5 < \sigma_6 \\ Z_{i,j}^t + O_1 \cdot (Z_{best,j}^t - Z_{i,j}^t) \\ +O_2 \cdot \left(\overrightarrow{U_{l,1}^t} - Z_{V,j}^t\right), \text{otherwise} \end{cases} \quad (65)$$

The retrieval process by Nucifraga multipunctata defined as,

$$\overrightarrow{Z_1^{t+1}} = \begin{cases} \begin{cases} Z_{i,j}^t \\ Z_{i,j}^t + O_1 \cdot (Z_{best,j}^t - Z_{i,j}^t) \\ +O_2 \cdot \left(\overrightarrow{U_{l,1}^t} - Z_{V,j}^t\right) \end{cases} \\ \text{if } \sigma_7 < \sigma_8 \\ Z_{i,j}^{t+1} = \begin{cases} Z_{i,j}^t \\ Z_{i,j}^t + O_1 \cdot \\ (Z_{best,j}^t - Z_{i,j}^t) \\ +O_2 \cdot \left(\overrightarrow{U_{l,1}^t} - Z_{V,j}^t\right) \end{cases} \text{else} \end{cases} \quad (66)$$

The tradeoff between first and second references (U)defined as,

$$\overrightarrow{Z_1^{t+1}} = \begin{cases} \overrightarrow{Z_1^{t+1}} = \begin{cases} \overrightarrow{Z_l^t} \text{ if } f\left(\overrightarrow{Z_l^t}\right) < f\left(\overrightarrow{U_{l,1}^t}\right) \\ \overrightarrow{U_{l,1}^t} \\ \text{if } f\begin{pmatrix} \overrightarrow{Z_l^t} \text{ if } f\left(\overrightarrow{Z_l^t}\right) < f\left(\overrightarrow{U_{l,1}^t}\right) \\ \overrightarrow{U_{l,1}^t} \end{pmatrix} \\ < f\begin{pmatrix} \overrightarrow{Z_l^t} \text{ if } f\left(\overrightarrow{Z_l^t}\right) < f\left(\overrightarrow{U_{l,2}^t}\right) \\ \overrightarrow{U_{l,2}^t} \text{ otherwise} \end{pmatrix} \end{cases} \\ \overrightarrow{Z_1^{t+1}} = \begin{cases} \overrightarrow{Z_l^t} \\ \text{if } f\left(\overrightarrow{Z_l^t}\right) < f\left(\overrightarrow{U_{l,2}^t}\right) \text{ Otherwise} \\ \overrightarrow{U_{l,2}^t} \end{cases} \end{cases} \quad (67)$$

Algorithm for secret reserves search and retrieval process

a. Start
b. Engender N Nucifraga multipunctata
c. Compute the fitness value
d. $t = 1; present\ iteration$
e. $while(t < T)$
f. Engender U
g. $U = \begin{bmatrix} \overrightarrow{U_{1,1}^t} \\ \vdots \\ \overrightarrow{U_{l,1}^t} \\ \vdots \\ \overrightarrow{U_{N,1}^t} \end{bmatrix}$
h. $\overrightarrow{U_{l,1}^t} = \begin{cases} \overrightarrow{Z_l^t} + \beta \cdot cos(\theta) \cdot \left(\left(\overrightarrow{Z_X^t} - \overrightarrow{Z_Y^t}\right)\right) \\ +\beta \cdot U \ \ if\ \theta = \frac{\pi}{2} \\ \overrightarrow{Z_l^t} + \beta \cdot cos(\theta) \cdot \\ \left(\left(\overrightarrow{Z_X^t} - \overrightarrow{Z_Y^t}\right)\right) \ otherwise \end{cases}$
i. $\overrightarrow{U_{l,2}^t} = \begin{cases} \overrightarrow{Z_l^t} + \begin{pmatrix} \beta \cdot cos(\theta) \\ \cdot \begin{pmatrix} (\overrightarrow{max} - \overrightarrow{min}) \\ \cdot \sigma_3 + \overrightarrow{min} \end{pmatrix} \\ +\beta \cdot U \end{pmatrix} \\ \cdot \overrightarrow{max_2} \ \ if\ \theta = \frac{\pi}{2} \\ \overrightarrow{Z_l^t} + \beta \cdot cos(\theta) \\ \cdot \begin{pmatrix} (\overrightarrow{max} - \overrightarrow{min}) \\ \cdot \sigma_3 + \overrightarrow{min} \end{pmatrix} \\ \cdot \overrightarrow{max_2}\ otherwise \end{cases}$
j. Engender ∅
k. $if\ \emptyset > P_2, //\ second\ exploration$

l. $\overrightarrow{Z_1^{t+1}} =$

$$\begin{cases} \begin{cases} Z_{i,j}^t \\ Z_{i,j}^t + O_1 \cdot \left(Z_{best,j}^t - Z_{i,j}^t\right) \\ +O_2 \cdot \left(\overrightarrow{U_{\iota,1}^t} - Z_{V,j}^t\right) \end{cases} if\ \sigma_7 < \sigma_8 \\ Z_{i,j}^{t+1} = \begin{cases} Z_{i,j}^t \\ Z_{i,j}^t + \\ O_1 \cdot \left(Z_{best,j}^t - Z_{i,j}^t\right) \\ +O_2 \cdot \left(\overrightarrow{U_{\iota,1}^t} - Z_{V,j}^t\right) \end{cases} otherwise \end{cases}$$

m. $\overrightarrow{Z_\iota^{t+1}} = \begin{cases} \overrightarrow{Z_\iota^{t+1}}\ if\ f(\overrightarrow{Z_\iota^{t+1}}) < f\left(\overrightarrow{Z_\iota^t}\right) \\ \overrightarrow{Z_\iota^t}\ otherwise \end{cases}$

n. Else , apply second Exploitation

o. $\overrightarrow{Z_1^{t+1}} =$

$$\begin{cases} \overrightarrow{Z_1^{t+1}} = \begin{cases} \overrightarrow{Z_\iota^t}\ if\ f\left(\overrightarrow{Z_\iota^t}\right) \\ < f\left(\overrightarrow{U_{\iota,1}^t}\right) \\ \overrightarrow{U_{\iota,1}^t} \\ if\ f\begin{pmatrix} \overrightarrow{Z_\iota^t}\ if\ f\left(\overrightarrow{Z_\iota^t}\right) < f\left(\overrightarrow{U_{\iota,1}^t}\right) \\ \overrightarrow{U_{\iota,1}^t} \end{pmatrix} \\ < f\begin{pmatrix} \overrightarrow{Z_\iota^t}\ if\ f\left(\overrightarrow{Z_\iota^t}\right) < f\left(\overrightarrow{U_{\iota,2}^t}\right) \\ \overrightarrow{U_{\iota,2}^t}\ otherwise \end{pmatrix} \end{cases} \\ \overrightarrow{Z_1^{t+1}} = \begin{cases} \overrightarrow{Z_\iota^t} \\ if\ f\left(\overrightarrow{Z_\iota^t}\right) \\ < f\left(\overrightarrow{U_{\iota,2}^t}\right) \\ \overrightarrow{U_{\iota,2}^t} \end{cases} Otherwise \end{cases}$$

p. $\overrightarrow{Z_\iota^{t+1}} = \begin{cases} \overrightarrow{Z_\iota^{t+1}}\ if\ f(\overrightarrow{Z_\iota^{t+1}}) < f\left(\overrightarrow{Z_\iota^t}\right) \\ \overrightarrow{Z_\iota^t}\ otherwise \end{cases}$

q. End if

r. End for

s. $t = t + 1$

t. End

Balancing between the exploration and exploitation done by,

$$\overrightarrow{Z_1^{t+1}} = \begin{cases} \begin{cases} \begin{cases} Z_{i,j}^t \\ Z_{i,j}^t + O_1 \cdot \left(Z_{best,j}^t - Z_{i,j}^t\right) \\ +O_2 \cdot \left(\overrightarrow{U_{\iota,1}^t} - Z_{V,j}^t\right) \end{cases} \\ Z_{i,j}^{t+1} = \begin{cases} Z_{i,j}^t \\ Z_{i,j}^t \\ +O_1 \cdot \left(Z_{best,j}^t - Z_{i,j}^t\right) \\ +O_2 \cdot \left(\overrightarrow{U_{\iota,1}^t} - Z_{V,j}^t\right) \end{cases} \end{cases} if\ \emptyset > P_2 \\ \begin{cases} \overrightarrow{Z_1^{t+1}} = \begin{cases} \overrightarrow{Z_\iota^t}\ if\ f\left(\overrightarrow{Z_\iota^t}\right) < f\left(\overrightarrow{U_{\iota,1}^t}\right) \\ \overrightarrow{U_{\iota,1}^t} \\ if\ f\begin{pmatrix} \overrightarrow{Z_\iota^t}\ if\ f\left(\overrightarrow{Z_\iota^t}\right) < f\left(\overrightarrow{U_{\iota,1}^t}\right) \\ \overrightarrow{U_{\iota,1}^t} \end{pmatrix} \\ < f\begin{pmatrix} \overrightarrow{Z_\iota^t}\ if\ f\left(\overrightarrow{Z_\iota^t}\right) < f\left(\overrightarrow{U_{\iota,2}^t}\right) \\ \overrightarrow{U_{\iota,2}^t}\ otherwise \end{pmatrix} \end{cases} else \\ \overrightarrow{Z_1^{t+1}} = \begin{cases} \overrightarrow{Z_\iota^t} \\ if\ f\left(\overrightarrow{Z_\iota^t}\right) < f\left(\overrightarrow{U_{\iota,2}^t}\right) \\ \overrightarrow{U_{\iota,2}^t} \end{cases} \end{cases} \end{cases} \tag{68}$$

$$\overrightarrow{Z_{\iota,J}^t} = \left(\max_j - \min_j\right).\text{random vector} + \min_j \tag{69}$$

$$\overrightarrow{Z_\iota^{t+1}} = \begin{cases} \overrightarrow{Z_\iota^{t+1}}\ if\ f(\overrightarrow{Z_\iota^{t+1}}) < f\left(\overrightarrow{Z_\iota^t}\right) \\ \overrightarrow{Z_\iota^t}\ otherwise \end{cases} \tag{70}$$

Nucifraga multipunctata optimization (NMO) algorithm

u. Start

v. Engender N Nucifraga multipunctata

w. Compute the fitness value

x. $t = 1; present\ iteration$

y. $while(t < T)$

z. $for\ i = 1{:}N$

aa. $for\ j = 1{:}d$

bb. $if\ \emptyset > P_1, //$

$primary\ exploration\ segment, then$

cc. $Upadte\ \overrightarrow{Z_\iota^{t+1}}$

dd. $$\overrightarrow{Z_i^{t+1}} = \begin{cases} Z_{i,j}^t \ if \sigma_1 < \sigma_2 \\ \begin{cases} Z_{a.j}^t + \alpha \cdot (Z_{X.j}^t - Z_{Y.j}^t) \\ +\rho.(O^2.max_j - min_j) \\ if\ t \le \frac{T_{max}}{2} \\ Z_{S.j}^t + \alpha \cdot (Z_{X.j}^t - Z_{Y.j}^t) \\ +\rho(O_1 < \varphi). \\ (O^2.max_j - min_j) otherwise \end{cases} \end{cases}$$

ee. $$\overrightarrow{Z_i^{t+1}} = \begin{cases} \overrightarrow{Z_i^{t+1}} \ if\ f(\overrightarrow{Z_i^{t+1}}) < f(\overrightarrow{Z_i^t}) \\ \overrightarrow{Z_i^t} \ otherwise \end{cases}$$

ff. Else/ apply Primary exploitation segment

gg. $Upadte\ \overrightarrow{Z_i^{t+1}}$

hh. $\overrightarrow{Z_i^{t+1}} =$

$$\begin{cases} \begin{cases} Z_{i,j}^t \ if \sigma_1 < \sigma_2 \\ \begin{cases} Z_{a.j}^t + \alpha \cdot (Z_{X.j}^t - Z_{Y.j}^t) \\ +\rho.(O^2.max_j - min_j) \\ if\ t \le \frac{T_{max}}{2} \\ Z_{S.j}^t + \alpha \cdot (Z_{X.j}^t - Z_{Y.j}^t) \\ +\rho(O_1 < \varphi) \\ .(O^2.max_j - min_j) otherwise \end{cases} \end{cases} \\ if\ \emptyset > P_1 \\ \begin{cases} \overrightarrow{Z_i^t} + \rho \cdot \left(\overrightarrow{Z_{best}^t} - \overrightarrow{Z_i^t}\right) \cdot |L| \\ +O_1 \cdot \left(\overrightarrow{Z_X^t} - \overrightarrow{Z_Y^t}\right) if \sigma_1 < \sigma_2 \\ \overrightarrow{Z_{best}^t} \quad otherwise \\ +\rho \cdot \left(\overrightarrow{Z_X^t} - \overrightarrow{Z_Y^t}\right) if \sigma_1 < \sigma_3 \\ \overrightarrow{Z_{best}^t} \cdot E\ otherwise \end{cases} \end{cases}$$

ii. $$\overrightarrow{Z_i^{t+1}} = \begin{cases} \overrightarrow{Z_i^{t+1}} \ if\ f(\overrightarrow{Z_i^{t+1}}) < f(\overrightarrow{Z_i^t}) \\ \overrightarrow{Z_i^t} \ otherwise \end{cases}$$

jj. End if

kk. End for

ll. $t = t + 1$

mm. Engender U

nn. $$U = \begin{bmatrix} \overrightarrow{U_{1,1}^t} \\ \vdots \\ \overrightarrow{U_{i,1}^t} \\ \vdots \\ \overrightarrow{U_{N,1}^t} \end{bmatrix}$$

oo. $$\overrightarrow{U_{i,1}^t} = \begin{cases} \overrightarrow{Z_i^t} + \beta \cdot cos(\theta) \cdot \left(\left(\overrightarrow{Z_X^t} - \overrightarrow{Z_Y^t}\right)\right) \\ +\beta \cdot U \ \ if\ \theta = \frac{\pi}{2} \\ \overrightarrow{Z_i^t} + \beta \cdot cos(\theta) \\ \cdot \left(\left(\overrightarrow{Z_X^t} - \overrightarrow{Z_Y^t}\right)\right) \ otherwise \end{cases}$$

pp. $$\overrightarrow{U_{i,2}^t} = \begin{cases} \overrightarrow{Z_i^t} + \left(\begin{array}{c} \beta \cdot cos(\theta) \cdot \\ ((\overrightarrow{max} - \overrightarrow{min}) \cdot \sigma_3 + \overrightarrow{min}) \\ +\beta \cdot U \end{array} \right) \\ \cdot \overrightarrow{max_2} \ if\ \theta = \frac{\pi}{2} \\ \overrightarrow{Z_i^t} + \beta \cdot cos(\theta) \cdot \\ ((\overrightarrow{max} - \overrightarrow{min}) \cdot \sigma_3 + \overrightarrow{min}) \\ \cdot \overrightarrow{max_2} \ otherwise \end{cases}$$

qq. Engender $\emptyset$

rr. $if\ \emptyset > P_2, //\ second\ exploration$

ss. $\overrightarrow{Z_1^{t+1}} =$

$$\begin{cases} \begin{cases} Z_{i,j}^t \\ Z_{i,j}^t + O_1 \cdot (Z_{best,j}^t - Z_{i,j}^t) \\ +O_2 \cdot \left(\overrightarrow{U_{i,1}^t} - Z_{V,j}^t\right) \end{cases} \\ if\ \sigma_7 < \sigma_8 \\ Z_{i,j}^{t+1} = \begin{cases} Z_{i,j}^t \\ Z_{i,j}^t + O_1 \cdot \\ (Z_{best,j}^t - Z_{i,j}^t) \\ +O_2 \cdot \left(\overrightarrow{U_{i,1}^t} - Z_{V,j}^t\right) \end{cases} \quad otherwise \end{cases}$$

tt. $$\overrightarrow{Z_i^{t+1}} = \begin{cases} \overrightarrow{Z_i^{t+1}} \ if\ f(\overrightarrow{Z_i^{t+1}}) < f(\overrightarrow{Z_i^t}) \\ \overrightarrow{Z_i^t} \ otherwise \end{cases}$$

uu. Else , apply second Exploitation

vv. $\overrightarrow{Z_1^{t+1}} =$

$$\begin{cases} \overrightarrow{Z_1^{t+1}} = \begin{cases} \overrightarrow{Z_i^t} \ if\ f\left(\overrightarrow{Z_i^t}\right) < f\left(\overrightarrow{U_{i,1}^t}\right) \\ \overrightarrow{U_{i,1}^t} \\ if\ f \left(\begin{array}{c} \overrightarrow{Z_i^t} \\ if\ f\left(\overrightarrow{Z_i^t}\right) < f\left(\overrightarrow{U_{i,1}^t}\right) \\ \overrightarrow{U_{i,1}^t} \end{array} \right) \\ < f \left(\begin{array}{c} \overrightarrow{Z_i^t} \\ if\ f\left(\overrightarrow{Z_i^t}\right) < f\left(\overrightarrow{U_{i,2}^t}\right) \\ \overrightarrow{U_{i,2}^t}\ otherwise \end{array} \right) \end{cases} \\ \overrightarrow{Z_1^{t+1}} = \begin{cases} \overrightarrow{Z_i^t} \\ if\ f\left(\overrightarrow{Z_i^t}\right) \\ < f\left(\overrightarrow{U_{i,2}^t}\right) \\ \overrightarrow{U_{i,2}^t} \end{cases} Otherwise \end{cases}$$

ww. $$\overrightarrow{Z_i^{t+1}} = \begin{cases} \overrightarrow{Z_i^{t+1}} \ if\ f(\overrightarrow{Z_i^{t+1}}) < f(\overrightarrow{Z_i^t}) \\ \overrightarrow{Z_i^t} \ otherwise \end{cases}$$

xx. End if

yy. End for

zz. $t = t + 1$

aaa. End

Eunectes notaeus optimization (ENO) algorithm

Eunectes notaeus optimization (ENO) algorithm designed based on the regular behaviour of Eunectes notaeus. The important stimulation of ENO is the system of identifying the location of the female by the male in the course of the copulating period and the pestering stratagem of Eunectes notaeus [15]. Population member of the procedure is Eunectes notaeus and the candidate solution formed by each Eunectes notaeus. The primary location of the Eunectes notaeus arbitrarily engendered as follows,

$$Z = \begin{bmatrix} Z_1 \\ \vdots \\ Z_i \\ \vdots \\ Z_N \end{bmatrix}_{N\times m} = \begin{bmatrix} z_{1,1} & \cdots & z_{1,m} \\ \vdots & \ddots & \vdots \\ z_{N,1} & \cdots & z_{N,m} \end{bmatrix}_{N\times m} \quad (71)$$

$$z_{i,d} = \min_d + \mathrm{Random}_{i,d} \cdot (\max_d - \min_d) \quad (72)$$

$i = 1,2,3, \ldots, N$

$d = 1,2,3, \ldots, m$

$\mathrm{Random} \in [0,1]$

$Z \rightarrow$ Eunectes notaeus population matrix

$Z_i \rightarrow$ ith Eunectes notaeus (candidate solution)

$N \rightarrow$ quantity of Eunectes notaeus

$m \rightarrow$ parameters

$\max_d$ and $\min_d \rightarrow$ define the limits

For every Eunectes notaeus the parameter and objective functional values defined as,

$$E = \begin{bmatrix} E_1 \\ \vdots \\ E_i \\ \vdots \\ E_N \end{bmatrix}_{N\times 1} = \begin{bmatrix} E(Z_1) \\ \vdots \\ E(Z_i) \\ \vdots \\ E(Z_N) \end{bmatrix}_{N\times 1} \quad (73)$$

$E \rightarrow$ computed objective functional value

$E_i \rightarrow$ computed objective functional value based on ith Eunectes notaeus

In the exploration segment, female Eunectes notaeus left the pheromone lengthways their lane and sequentially male Eunectes notaeus can recognize their location. Male Eunectes notaeus utilize the tongue for sensing the pheromone and movement of the male Eunectes notaeus will in that specific direction. In the primary segment, position of Eunectes notaeus is rationalized which grounded on the male Eunectes notaeus stratagem in recognizing the female Eunectes notaeus location and stirring near to them for the copulating actions. This tactic tips to huge dislodgments in the location of Eunectes notaeus in the exploration region, which establishes the exploration capability of ENO algorithm in global examination and precise glance to evade the local optima.

$$\text{Female Eunectes notaeus location}^i = \{Z_{k_i} : E_{k_i} < E_i\} \quad (74)$$

$k_i \neq i$

$i = 1,2,3, \ldots, N$

$k_i \in \{1,2,3, \ldots, N\}$

$k_i \rightarrow$ row number of Eunectes notaeus

Pheromone probability function defined as,

$$\mathrm{PPF}_j^i = \frac{O_j^i - O_{max}^i}{\sum_{n=1}^{n_i} O_n^i - O_{max}^i} \quad (75)$$

$\mathrm{PPF}_j^i \rightarrow$ Pheromone probability function

$O_j^i \rightarrow$ objective functional values of ith female Eunectes notaeus

$O_{max}^i \rightarrow$ maximum value

$n_i \rightarrow$ amount of female Eunectes notaeus

In the ENO procedure, it presumed that Eunectes notaeus arbitrarily chooses one of the female Eunectes notaeus and passages in the direction of the female Eunectes notaeus. For this aggregate probability functional value for female Eunectes notaeus computed,

$$A_j^i = XA_j^i + A_{j-1}^i \quad (76)$$

$A_j^i \rightarrow$ aggregate probability functional value of female Eunectes notaeus

$i = 1,2,3, \ldots, N$

$d = 1,2,3, \ldots, m$

$A_0^i = 0$

$$\text{Picked female Eunectes}^i = \text{Female Eunectes notaeus location}_j^i \quad (77)$$

$A_{j-1}^i < \mathrm{Random}_{ij} < A_j^i$

Location of the is modernized as follows,

$$z_{i,d}^{L1} = z_{i,d} + \mathrm{rand}_{i,d} \cdot \left(\text{Picked female Eunectes}_d^i - Q_{i,d} \cdot z_{i,d}\right) \quad (78)$$

$i = 1,2,3, \ldots, N$

$d = 1,2,3, \ldots, m$

$$Z_i = \begin{cases} z_i^{L1}, E_i^{L1} < E_i \\ Z_i, \text{Else} \end{cases} \quad (79)$$

$z_{i,d}^{L1} \rightarrow$ fresh location of ith Eunectes notaeus

$Q_{i,d} \in \{1,2\}$

$rand_{i,d} \in [0,1]$

$E_i^{L1} \rightarrow$ objective functional value

In the Exploitation segment of ENO procedure, hunting or stalking stratagem of Eunectes notaeus in imitated for the formulation of the design. Eunectes notaeus attacks the prey and consume it sequentially. Rendering to this action the location of the Eunectes notaeus updated as follows,

$$z_{i,d}^{L2} = z_{i,d} + (1 - 2rand_{i,d}) \frac{max_d - min_d}{t} \quad (80)$$

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

$d = 1,2,3, \dots, m$

$t = 1,2,3, \dots, T$

$$Z_i = \begin{cases} z_i^{L2}, E_i^{L2} < E_i \\ Z_i, \text{Else} \end{cases} \quad (81)$$

$z_{i,d}^{L2} \rightarrow$ fresh location of ith Eunectes notaeus

$E_i^{L2} \rightarrow$ objective functional value

$rand_{i,d} \in [0,1]$

a. Start

b. Fix the parameters

c. Engender the population

d. $z_{i,d} = min_d + Random_{i,d} \cdot (max_d - min_d)$

e. Compute the objective functional value

f. For $t = 1$ to T

g. For $i = 1$ to N

h. Execute the exploration segment

i. Categorize the female Eunectes notaeus

j. Female Eunectes notaeus location^i = $\{Z_{k_i}: E_{k_i} < E_i\}$

k. Compute the Pheromone probability function

l. $PPF_j^i = \frac{O_j^i - O_{max}^i}{\sum_{n=1}^{n_i} O_h^i - O_{max}^i}$

m. Calculate the aggregate probability functional value

n. $A_j^i = XA_j^i + A_{j-1}^i$

o. Define the pickedfemale Eunectes notaeus

p. Picked female Eunectes^i = Female Eunectes notaeus location$_j^i$

q. $A_{j-1}^i < Random_{ij} < A_j^i$

r. Compute the new location of ith Eunectes notaeus

s. $z_{i,d}^{L1} = z_{i,d} + rand_{i,d} \cdot \left(\text{Picked female Eunectes}_d^i - Q_{i,d} \cdot z_{i,d} \right)$

t. $Z_i = \begin{cases} z_i^{L1}, E_i^{L1} < E_i \\ Z_i, \text{Else} \end{cases}$

u. Apply exploitation segment

v. Compute the new location of ith Eunectes notaeus

w. $z_{i,d}^{L2} = z_{i,d} + (1 - 2rand_{i,d}) \frac{max_d - min_d}{t}$

x. $Z_i = \begin{cases} z_i^{L2}, E_i^{L2} < E_i \\ Z_i, \text{Else} \end{cases}$

y. End for

z. $t = t + 1$

aa. Output the best solution

bb. End

Otariid Optimization Algorithm

Otariid optimization algorithm (OOA) designed by imitating the natural actions of Otariid. During the hunting Otariid will be in foraging period and through, this approach Otariid [16] will attain the prey in large amount. Each entity examinations self-reliantly to cover an area individually and movement determined by the individual. Once a suitable prey found, an explicit signal will given to the Otariid's group, and then sequentially the prey will enfolded by the Otariid. Once the enfolding the prey is completed then attacking period will started. All the Otariid's in the group will attack the prey in the same time and there is no possibility for the prey to escape. Otariid will forage for the prey in individual mode but the hunting will do in cluster mode. The area of searching by each individual will be in the extensive mode of covering large area and once the potential prey has identified, an explicit signal and this signal will stimulate all the members of the cluster to move towards the direction of the potential prey. Then sequentially all the group members will enfold of the prey. In the attacking period, all the members of the cluster will attack on the prey in the same instant. These aspects are imitated and mathematically formulated.

The location of the Otariid defined as,

$$\vec{Z}^{i}_{\delta}(O_m)|\forall\delta\epsilon 2,3,4,..,\varepsilon-1 = \vec{A}_i(O_m)\cdot e^{bf\delta}\cos(2\pi f\delta) + \vec{Z}^{i}_{\varepsilon}(O_m) \quad (82)$$

$O_m \rightarrow$ Otariid

$\vec{Z}^{i}_{\delta}(O_m) \rightarrow$ modernized location of Otariid

$\delta \rightarrow$ position of O_m

$\vec{A}_i(O_m) \rightarrow$ distnace between Otariid and prey

$\varepsilon \rightarrow$ location vector of Otariid

$$\vec{A}_i(O_m) = |\vec{Z}^{i}_{\varepsilon}(O_m) - \vec{Z}^{i}_{a}(O_m)| \quad (83)$$

$$f\delta = 1 - \frac{2*\delta}{\varepsilon} \quad (84)$$

$\vec{Z}^{i}_{a}(O_m) \rightarrow$ primary pposition fo the Otariid

The total number of iterations for foraging, enfolding and attacking defined as,

$$T = T_{FG} + T_{EG} + T_{AG} \quad (85)$$

$T_{FG} \rightarrow$ itertaions for foraging

$T_{EG} \rightarrow$ iterations for enfolding

$T_{AG} \rightarrow$ itertaions for attacking

$$T_{FG} = \left[\frac{T}{3}\right] \quad (86)$$

$$T_{EG} = \left[\frac{T}{3}\right] \quad (87)$$

$$T_{AG} = \left(N - 2 * \left[\frac{T}{3}\right]\right)$$

Preliminary locations of the foraging agents is defined as,

$$z = \min + random * (\max - \min) \quad (88)$$

Enfolding of the prey by the all the Otariid group members is defined as,

$$\vec{Z}_{prey} = location\left[\arg\min_{\forall\delta\epsilon U} - validation[F(O_m)]\right] \quad (89)$$

$U \rightarrow$ set of solutions

$F(O_m) \rightarrow$ fitness funtion of Otariid

$\arg\min_{\forall\delta\epsilon U} - validation[F(O_m)] \rightarrow$ minimization problem

The location of the prey defined as,

$$\vec{Z}_{prey} = \frac{1}{k}\begin{bmatrix}\sum_{i=1}^{k} Z_{ai}\\ \sum_{i=1}^{k} Z_{bi}\\ \cdots\\ \cdots\\ \cdots\\ \sum_{i=1}^{k} Z_{pi}\end{bmatrix} \quad (90)$$

A weight factor introduced to locate the position of the prey and it defined as,

$$\vec{Z}_{prey} = \frac{1}{\sum_{m=1}^{k} W(O_m)}\begin{bmatrix}\sum_{i=1}^{k} W(O_m)\cdot Z_{am}\\ \sum_{i=1}^{k} W(O_m)\cdot Z_{bm}\\ \cdots\\ \cdots\\ \cdots\\ \sum_{i=1}^{k} W(O_m)\cdot Z_{pm}\end{bmatrix} \quad (91)$$

Weight of the foraging agents are computed through the range factor as follows,

$$Range\ (R) = |F(B_y) - F(B_x)| \quad (92)$$

$B_x \rightarrow$ low validation

$B_y \rightarrow$ high validation

$$W(O_m) = \frac{|F(B_y)-F(B_x)|}{Range\ (R)} = \frac{|F(O_m)-F(B_x)|}{|F(B_y)-F(B_x)|} \quad (93)$$

Then the distance [17] between Otariid and the prey defined as,

$$\vec{A}^{i}_{O_m} = |\vec{Q}\cdot\vec{Z}^{i}_{prey} - \vec{Z}^{i}_{O_m}| \quad (94)$$

$$\vec{Z}^{i+1}_{O_m} = \vec{Z}^{i}_{prey} - \vec{S}\cdot\vec{A}^{i}_{O_m} \quad (95)$$

$$\vec{Q} = 2.\vec{q}.\vec{r_1} - \vec{q}$$

$$\vec{S} = 2.\vec{r_2}$$

$$q = 2 - i * \frac{2}{T_{EG}}$$

$\vec{Q}$ and $\vec{S} \rightarrow$ coefficient vectors

$\vec{r_1}$ and $\vec{r_2} \in [0,1]$

$\vec{Q} \in [-1,1]$

In the subsequent period after enfolding the prey by the group of Otariid, attacking will occur over the prey. All the Otariid's will initiate the attack over the prey at single instant and prey unable to escape form the attack since already the prey has been enfolded by the cluster [17] of Otariid's. This phenomenon mathematically defined as,

$$\vec{A}^{i}_{O_m} = |\vec{Z}^{i}_{prey} - \vec{Z}^{i}_{O_m}| \quad (96)$$

a. Start

b. Fix the parameters

c. Define the location of the Otariid

d. $\vec{Z}^{i}_{\delta}(O_m)|\forall\delta\epsilon 2,3,4,..,\varepsilon-1=\vec{A}_i(O_m)\cdot e^{bf\delta}\cos(2\pi f\delta)+\vec{Z}^{i}_{\varepsilon}(O_m)$

e. $\vec{A}_i(O_m)=\left|\vec{Z}^{i}_{\varepsilon}(O_m)-\vec{Z}^{i}_{a}(O_m)\right|$

f. Apply the foraging phase

g. Preliminary locations of the foraging agents are defined

h. $z=\min+\text{random}*(\max-\min)$

i. Apply the Enfolding segment

j. $\vec{Z}_{prey}=\text{location}\left[\arg\underset{\forall\delta\epsilon U}{\min-\text{validation}}[F(O_m)]\right]$

k. Identify the location of the prey

l. $\vec{Z}_{prey}=\frac{1}{k}\begin{bmatrix}\sum_{i=1}^{k}Z_{ai}\\ \sum_{i=1}^{k}Z_{bi}\\ \cdots\\ \cdots\\ \cdots\\ \sum_{i=1}^{k}Z_{pi}\end{bmatrix}$

m. Weight factor is introduced to locate the position of the prey

n. Compute the Weight of the foraging agents by range factor

o. $\text{Range (R)}=\left|F(B_y)-F(B_x)\right|$

p. $W(O_m)=\frac{|F(B_y)-F(B_x)|}{\text{Range (R)}}=\frac{|F(O_m)-F(B_x)|}{|F(B_y)-F(B_x)|}$

q. Determine the distance between Otariid and the prey

r. $\vec{A}^{i}_{O_m}=\left|\vec{Q}\cdot\vec{Z}^{i}_{prey}-\vec{Z}^{i}_{O_m}\right|$

s. $\vec{Z}^{i+1}_{O_m}=\vec{Z}^{i}_{prey}-\vec{S}\cdot\vec{A}^{i}_{O_m}$

t. $\vec{Q}=2.\vec{q}.\vec{r_1}-\vec{q}$

u. $\vec{S}=2.\vec{r_2}$

v. $q=2-i*\frac{2}{T_{EG}}$

w. Apply the attacking segment

x. $\vec{A}^{i}_{O_m}=\left|\vec{Z}^{i}_{prey}-\vec{Z}^{i}_{O_m}\right|$

y. End for

z. $t=t+1$

aa. Output the best solution

bb. End

Simulation Results

Sea pirates search optimization (SPO) algorithm, Thetys Vagina Swarm Optimization (TVO) Algorithm, Nucifraga multipunctata optimization (NMO) algorithm, Eunectes notaeus optimization (ENO) algorithm and Otariid optimization algorithm (OOA) validated in IEEE 30 bus system [8]. Table I shows the Active power loss (ATP (MW)), Electric Voltage abnormality (EVA (PU)) and Equipoise (EVP (PU). Figs 1 to 3 give the valuation of ATP, EVA and EVP.

Table I. Valuation of result

Method	ATP(MW)	EVA(PU)	EVP(PU)
MEDVY [1]	4.5213	0.1038	0.1258
MEDAC [1]	4.6862	0.2064	0.1499
MEDVC [1]	4.6862	0.1354	0.1271
HMDTLBO [2]	4.5777	0.0913	0.1180
MEDALO [2]	4.5142	0.1220	0.1161
MEDABC [2]	4.5275	0.0890	0.1161
HMDFS [3]	4.5135	0.0896	0.1252
MEDFS [4]	4.5284	0.0891	0.1245
MEDDE [5]	4.6482	0.0802	0.1004
CTFWO [6]	4.9448	0.1212	0.1232
IMPA [7]	4.5677	0.1250	0.1135
EBS [22]	4.4910	0.0819	0.1296
SPO	4.4904	0.0812	0.1299
TVO	4.4902	0.0810	0.1312
NMO	4.4900	0.0801	0.1372
ENO	4.4909	0.0832	0.1367
OOA	4.4912	0.0841	0.1351

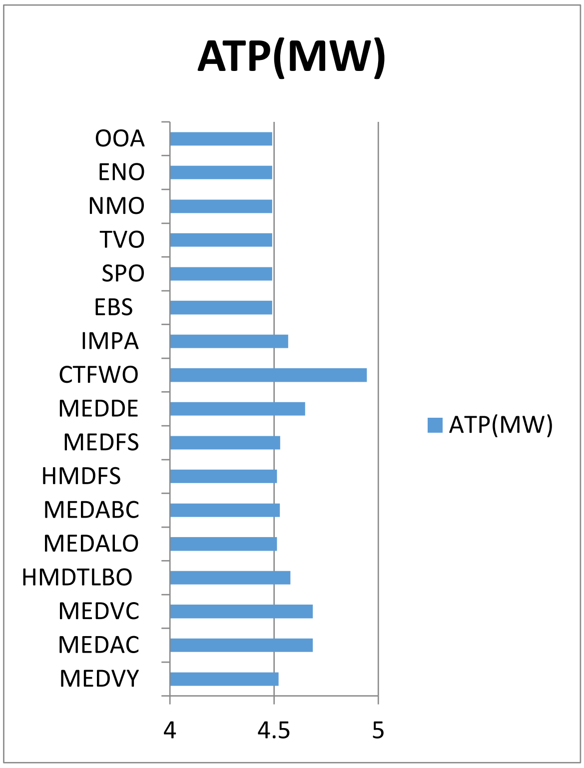

Figure 1. Assessment of ATP

Sea pirates search optimization (SPO) algorithm, Thetys Vagina Swarm Optimization (TVO) Algorithm, Nucifraga multipunctata optimization (NMO) algorithm, Eunectes notaeus optimization (ENO) algorithm and Otariid optimization algorithm (OOA) reduced the actual power loss efficiently.

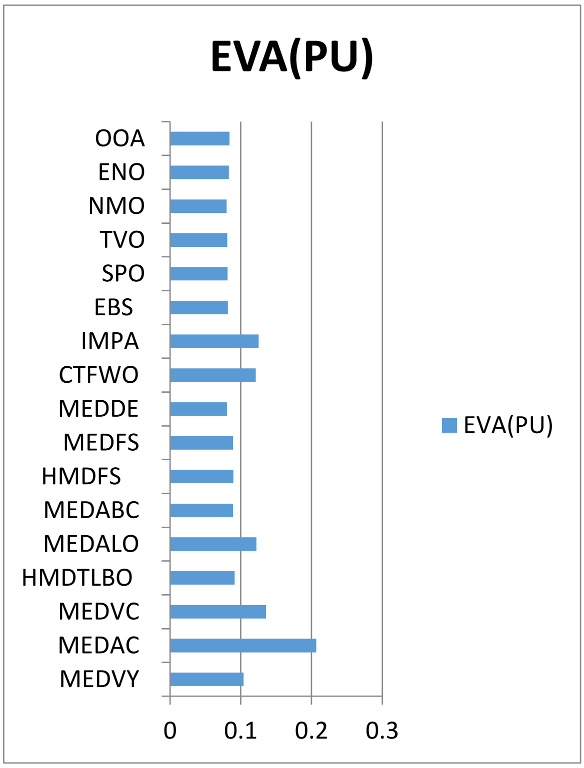

Figure 2. Assessment of EVA

Sea pirates search optimization (SPO) algorithm, Thetys Vagina Swarm Optimization (TVO) Algorithm, Nucifraga multipunctata optimization (NMO) algorithm, Eunectes notaeus optimization (ENO) algorithm and Otariid optimization algorithm (OOA) minimized Voltage deviation and Voltage stability expansion has been achieved.

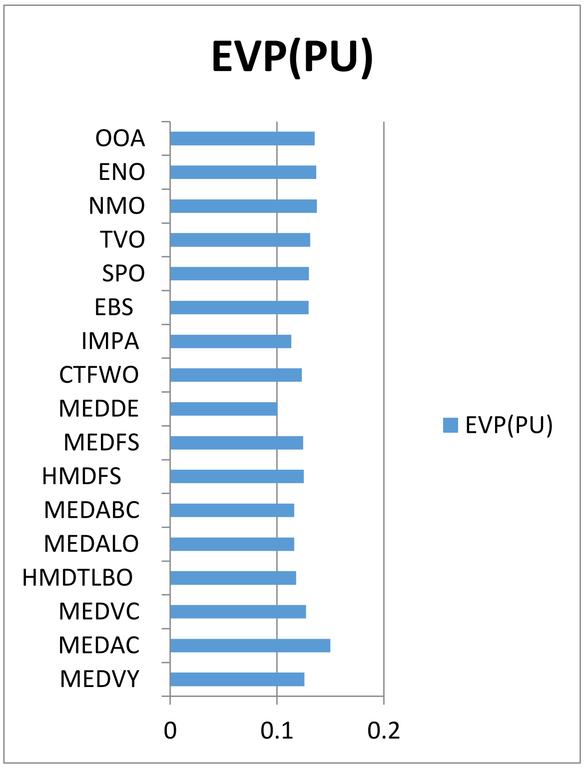

Figure 3. Evaluation of EVP

Sea pirates search optimization (SPO) algorithm, Thetys Vagina Swarm Optimization (TVO) Algorithm, Nucifraga multipunctata optimization (NMO) algorithm, Eunectes notaeus optimization (ENO) algorithm and Otariid optimization algorithm (OOA) validated in IEEE 354 bus test system [11]. Table II shows the Active loss valuation and. Figs 4 and 5 give the appraisal.

Table II. Loss evaluation

Method	ATP(MW)	EVA(PU)
METDISAI [9]	337.374	0.4978
METDISAII [9]	338.715	0.5117
METDISA [9]	339.325	0.5216
METDCLSO [10]	341.001	0.5354
METDPSO [10]	341.123	0.6395
SPO	336.010	0.4461
TVO	336.003	0.4448
NMO	333.108	0.4398
ENO	337.899	0.4501
OOA	337.989	0.4525

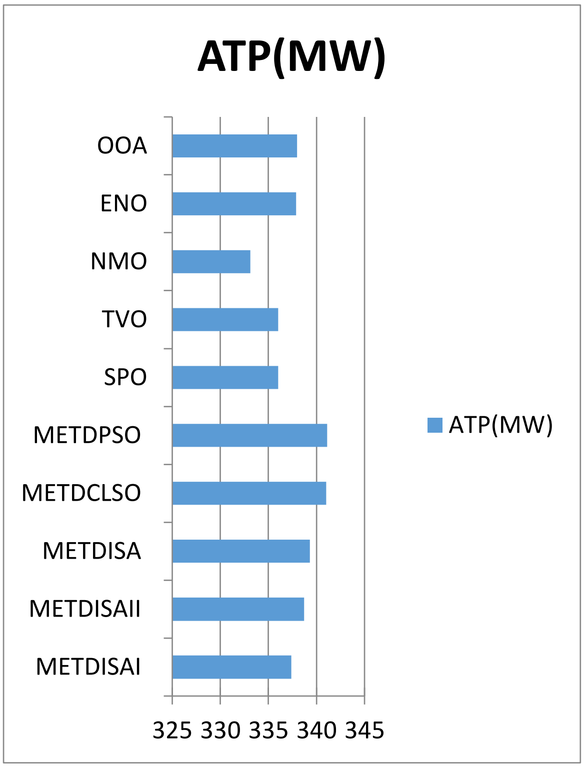

Figure 4. Valuation of ATP

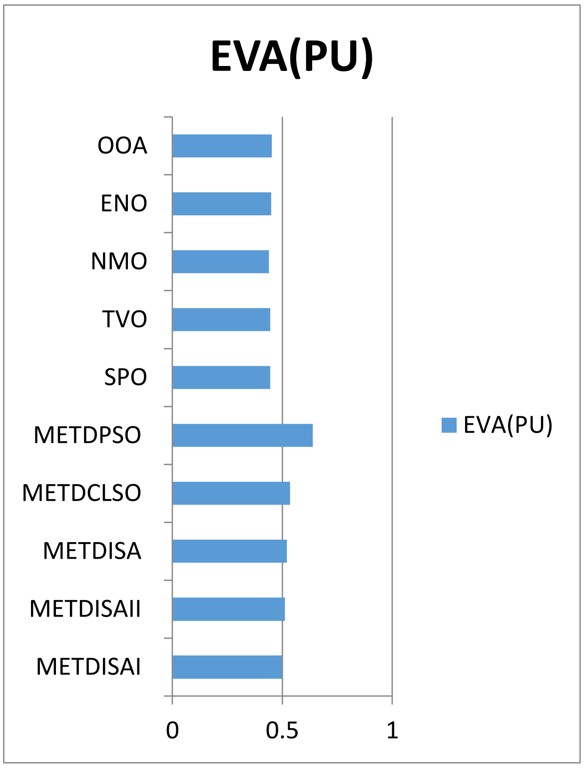

Figure 5. Assessment of EVA

Performance in IEEE 354 bus test system by Sea pirates search optimization (SPO) algorithm, Thetys Vagina Swarm Optimization (TVO) Algorithm, Nucifraga multipunctata optimization (NMO) algorithm, Eunectes notaeus optimization (ENO) algorithm and Otariid optimization algorithm (OOA) is excellent. In big test case systems, also projected algorithms performed well in reducing the power loss and minimization of voltage deviation.

Table III and Fig 6 show the time taken by Sea pirates search optimization (SPO) algorithm, Thetys Vagina Swarm Optimization (TVO) Algorithm, Nucifraga multipunctata optimization (NMO) algorithm, Eunectes notaeus optimization (ENO) algorithm and Otariid optimization algorithm (OOA).

Table III Time taken by SPO, TVO, NMO, ENO, and OOA

Technique	30 bus T(S)	354 bus T(S)
SPO	18.89	82.05
TVO	17.62	80.12
NMO	16.14	76.09
ENO	18.91	81.97
OOA	18.98	82.02

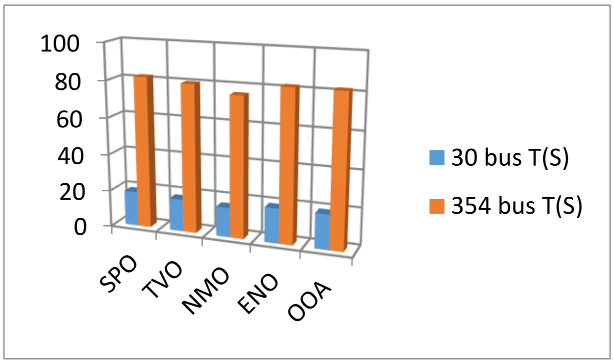

Figure 6. Time taken by SPO, TVO, NMO, ENO, OOA

Conclusion

Sea pirates search optimization (SPO) algorithm, Thetys Vagina Swarm Optimization (TVO) Algorithm, Nucifraga multipunctata optimization (NMO) algorithm, Eunectes notaeus optimization (ENO) algorithm and Otariid optimization algorithm (OOA) solved the problem adeptly. In Sea, pirates search optimization algorithm, the solution excellence assessed, for every pirate fresh position defined which based on fitness functional value. Strategies of Thetys vagina while scavenging in oceans has emulated to design the Thetys vagina swarm optimization algorithm. In dimensional examination expanse location of Thetys vagina initialized. In the chief exploration segment, the Nucifraga multipunctata instigate to take their preliminary locations/nutrition places, in the examination region. Each Nucifraga multipunctata instigates by examination the seed case that encompasses the kernels in the preliminary location In ENO population member of the procedure is Eunectes notaeus and the candidate solution formed by each Eunectes notaeus. In OOA, the subsequent period after enfolding the prey by the group of Otariid's, attacking will occur over the prey. SPO, TVO, NMO, ENO and OOA validated in standard IEEE 30 and 354 bus systems.

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Publisher: Chinese Institute of Automation Engineers (CIAE)

ISSN: 2223-9766 (Online)