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Real power loss reduction by hyena optimizer algorithm

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Article Info	ABSTRACT
	To solve optimal reactive power problem this paper projects Hyena Optimizer (HO) algorithm and it inspired from the behaviour of Hyena. Collaborative behaviour & Social relationship between Hyenas is the key conception in this algorithm. Hyenas a form of carnivoran mammal & deeds are analogous to canines in several elements of convergent evolution. Hyenas catch the prey with their teeth rather than claws – possess hardened skin feet with large, blunt, no retractable claws are adapted for running and make sharp turns. However, the hyenas' grooming, scent marking, defecating habits, mating and parental behaviour are constant with the deeds of other feliforms. Mathematical modelling is formulated for the basic attributes of Hyena. Standard IEEE 14,300 bus test systems used to analyze the performance of Hyena Optimizer (HO) algorithm. Loss has been reduced with control variables are within the limits.

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1. INTRODUCTION

Reactive power problem has been the key in power system operation & control, since it plays major role in secure & economic operation of the power system. Many conventional techniques [1-6] used for solving the problem. But many drawbacks have been found in the conventional methods and mainly difficulty in handling the inequality constraints. Last two decades many evolutionary algorithms [7-18] continuously applied to solve the problem. This paper projects Hyena Optimizer (HO), in which Hyena behaviour imitated to solve the problem. Collaborative behaviour & Social relationship between Hyenas is the key conception in this algorithm [19]. Hyenas a form of carnivoran mammal & deeds are analogous to canines in several elements of convergent evolution. Hyenas catch the prey with their teeth rather than claws – possess hardened skin feet with large, blunt, no retractable claws are adapted for running and make sharp turns. However, the hyenas' grooming, scent marking, defecating habits, mating and parental behaviour are constant with the deeds of other feliforms. Hyenas clean themselves habitually by legs are spread with one leg pointing vertically upward by sitting on the lower back. Conversely, unlike other feliforms, they do not clean their faces. Territories are built by using their anal glands. From any form of attack they defend itself ferociously and capable of producing a number of different sounds consisting of whoops, grunts, groans, lows, giggles, yells, growls, laughs and whines. Mathematical modelling is formulated for the basic attributes of Hyena. Standard IEEE 14,300 bus test systems used to analyze the performance of Hyena Optimizer (HO) algorithm. Loss has been reduced with control variables are within the limits.

2. PROBLEM FORMULATION

Main aim is to minimize the system real power loss & given as,

$$P_{loss} = \sum_{\substack{k=1 \\ k=(i,j)}}^{n} g_{k(V_i^2 + V_j^2 - 2V_i V_j \cos\theta_{ij})} \tag{1}$$

Voltage deviation magnitudes (VD) is,

$$\text{Min (VD)} = \sum_{k=1}^{nl} |V_k - 1.00| \tag{2}$$

Load flow equality constraints:

$$P_{Gi} - P_{Di} - V_{i\sum_{j=1}^{nb} v_j} \begin{bmatrix} G_{ij} & \cos\theta_{ij} \\ +B_{ij} & \sin\theta_{ij} \end{bmatrix} = 0, i = 1,2 \dots., nb \tag{3}$$

$$Q_{Gi} - Q_{Di} - V_{i\sum_{j=1}^{nb} v_j} \begin{bmatrix} G_{ij} & \sin\theta_{ij} \\ +B_{ij} & \cos\theta_{ij} \end{bmatrix} = 0, i = 1,2 \dots., nb \tag{4}$$

Inequality constraints are:

$$V_{Gi}^{min} \leq V_{Gi} \leq V_{Gi}^{max}, i \in ng \tag{5}$$

$$V_{Li}^{min} \leq V_{Li} \leq V_{Li}^{max}, i \in nl \tag{6}$$

$$Q_{Ci}^{min} \leq Q_{Ci} \leq Q_{Ci}^{max}, i \in nc \tag{7}$$

$$Q_{Gi}^{min} \leq Q_{Gi} \leq Q_{Gi}^{max}, i \in ng \tag{8}$$

$$T_i^{min} \leq T_i \leq T_i^{max}, i \in nt \tag{9}$$

$$S_{Li}^{min} \leq S_{Li}^{max}, i \in nl \tag{10}$$

3. HYENA OPTIMIZER ALGORITHM

Hyena optimizer (HO) algorithms imitated form Hyena which is complicated, intelligent [19]. When a new food source is found Hyena produce a typical sound alike to laughing sound of human beings to communicate about the findings. Mating between hyenas engage a number of diminutive sexual intercourse with short intervals, & hyena cubs are born roughly fully developed, with their eyes open with adult markings, closed eyes and small ears. Hyenas do not reiterate food for their young and male hyenas play no part in lift up their cubs. For recognition they use multiple sensory procedures and have been used during he social decision making including relationships. Mathematically modelling of HO algorithm as follows,

Encircling prey
Mathematical model [22]of encircling the prey is;

$$\vec{H}_c = \left| \vec{l} . \vec{S}_Q(y) - \vec{S}(y) \right| \tag{11}$$

$$\vec{S}(y+1) = \vec{S}_Q(y) - \vec{B} . \vec{H}_c \tag{12}$$

Where $\vec{H}_c$ - distance of Hyena with prey, , $\vec{S}_Q$ -position of prey, $\vec{S}$ - position of Hyena.
$\vec{l}$ & $\vec{B}$ are designed as follows:

$$\vec{l} = 2.r\vec{d}_1 \tag{13}$$

$$\vec{B} = 2\vec{c}.r\vec{d}_2 - \vec{c} \tag{14}$$

$$\vec{c} = 5.0 - \left(\text{iteration} * (5.0/\text{max}_{iteration}) \right) \tag{15}$$

Where, Iteration = 1, 2, 3, . . ., Max$_{\text{Iteration}}$
"c"- (5.00 -6.00). rd_1, rd_2 are arbitrary vectors in [0, 1].
Hunting
The following equations are articulate the hunting procedure,

$$\vec{H}_c = |\vec{l} \cdot \vec{S}_c - \vec{S}_c| \tag{16}$$

$$\vec{S}_k = \vec{S}_c - \vec{B} \cdot \vec{H}_c \tag{17}$$

$$\vec{G}_c = \vec{S}_k + \vec{S}_{k+1} + .. + \vec{S}_{K+N} \tag{18}$$

Where $\vec{S}_h$ defines the position of most excellent & count calculated as:

$$D = count_{Numbers} \left(\vec{S}_h, \vec{S}_{h+1}, ... \left(\vec{S}_h + \vec{E} \right) \right) \tag{19}$$

Where $\vec{E}$ is an arbitrary vector in [0.5, 1],
Mathematical modelling of Attacking on prey
Attacking the prey has been mathematically modelled and through that vector h will be specified. Vector $\vec{Z}$ is varied from 5.00 to 0.00 over the course of iterations. Assigned Value |Z| < 1 will oblige & mathematically written as follows,

$$\vec{S}(y + 1) = \frac{\vec{L}_h}{D} \tag{20}$$

According to the position of the finest exploration agent $\overrightarrow{S}(y + 1)$ will modernize the positions & Search for prey is exploration considered in the algorithm. Hyena position in the group indicates the place in vector $\overrightarrow{L}_h$. In this progression of Hyena use $\vec{Z}$ & Factor |Z| > 1 with arbitrary values (1,-1) to move away (random values which are greater than 1 or less than 1) which compel the search agents to move away from the prey.

Step a: Initialize Hyena population.
Step b: primary parameters are chosen.
Step c: agents (fitness value) are calculated.
Step d: In exploration space the premium search agent has been found.
Step e: group of optimal solutions defined sequentially.
Step f: modernize the positions of search agents
Step g: whether any search agent goes beyond the boundary has to be checked in the exploration space and confined to regulate it.
Step h: based on the calculation of modernized search agent fitness value, solution will be revised.
Step i: group of Hyena are modernized based on search agent fitness value.
Step j: stop criterion or else move back to Step e.

Initialize Hyena population & parameters
Fitness of each agent calculated; While (x < Maximum number of iteration) do
Modernize the agent position
End for
Modernize the parameters
Corrective action initiated if violation of search space found
Agent's fitness has been calculated
Update solution
Update the group values; Y=Y + 1
End while
End
Output

4. SIMULATION RESULTS

At first in standard IEEE 14 bus system the validity of the proposed Hyena Optimizer (HO) algorithm has been tested & comparison results are presented in Table 1. Figure 1. Provide the details of Comparison of real power loss.

Table 1. Comparison results

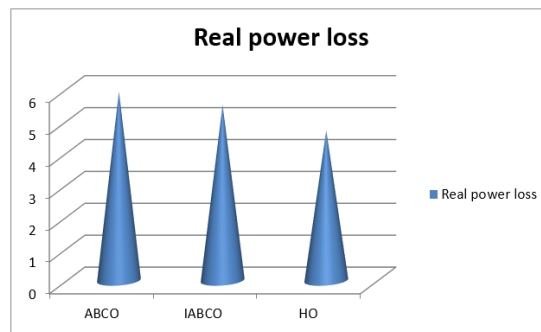| Control variables	ABCO [20]	IABCO [20]	Projected HO
V1	1.0600	1.0500	1.0110
V2	1.0300	1.0500	1.0120
V3	0.9800	1.0300	1.0040
V6	1.0500	1.0500	1.0110
V8	1.0000	1.0400	0.9000
Q9	0.1390	0.13200	0.10000
T56	0.9790	0.96000	0.90000
T47	0.9500	0.9500	0.90000
T49	1.0140	1.00700	1.00000
Ploss (MW)	5.92892	5.50031	4.70108

Figure 1 comparison of real power loss

Then IEEE 300 bus system [18] is used as test system to validate the performance of the Hyena Optimizer (HO) algorithm. Table 2 shows the comparison of real power loss obtained after optimization. Figure 2 gives the comparison of real power values. Real power loss has been considerably reduced when compared to the other standard reported algorithms.

Table 2. Comparison of real power loss

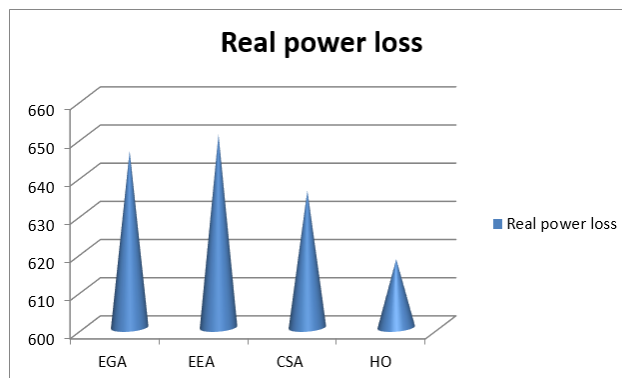| Parameter	Method EGA [21]	Method EEA [21]	Method CSA [22]	Projected HO
PLOSS (MW)	646.2998	650.6027	635.8942	617.8926

Figure 2. Real power loss comparison

5.   CONCLUSION

In this work Hyena Optimizer (HO) efficiently solved the reactive power problem. Deeds of the Hyena has been mathematically modelled successfully & employed to solve the problem. Attacking the prey has been mathematically modelled and through that vector h will be specified. Exploration & exploitation capabilities in the search improved. Standard IEEE 14,300 bus test systems used to analyze the performance of Hyena Optimizer (HO) algorithm. Loss has been reduced with control variables are within the limits.

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