

REAL POWER LOSS REDUCTION BY RHINOTIA HEMISTICTUS BASED JACKAL OPTIMIZATION ALGORITHM FOR ELECTRICAL TRANSMISSION NETWORK

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Abstract

This paper projects Rhinotia hemistictus based Jackal (RJ) optimization algorithm for solving real power loss reduction problem. Core objective of the paper is power loss reduction. Jackal Optimization (JO) algorithm is modelled based on the hunting actions of Jackal. Naturally Jackals hunt the prey in a group. A leader jackal in the group will lead and other Jackals will follow during hunting. Inadequate multiplicity of Jackals in certain circumstances, make the method to settle in confined optimal state. To avoid the local optima and premature convergence Rhinotia hemistictus actions has been integrated to improve the performance of the Jackal algorithm. Natural actions of exploring food by Rhinotia hemistictus are imitated and it has been assimilated in the algorithm. In the proposed approach the forerunner Jackal utilize the sense of hearing to progress in the global search capability and diminish excessive explorations. Random and adaptive parameter applied in the procedure to control the Exploration and exploitation. Then a modernizing strategy which grounded on the cosine function is used to control the process of the RJ algorithm for evading the local optima. Legitimacy of Proposed Rhinotia hemistictus based Jackal (RJ) optimization algorithm is corroborated in IEEE 30bus test system and outcomes show the projected RJ algorithm condensed the factual power loss splendidly.

Keywords: Transmission loss, reduction, Rhinotia hemistictus, Jackal

Introduction

Power loss reduction is very important in Electrical systems. In industries and domestic sectors electrical power plays one among main role in determining the output. Ample numeric procedures and evolutionary approaches (Ant lion optimizer, Hybrid PSO-Tabu search, quasi-oppositional teaching learning based optimization, harmony search

algorithm, stochastic fractal search optimization algorithm, improved pseudo-gradient search particle swarm optimization, Effective Metaheuristic Algorithm, Seeker optimization algorithm, Diversity-Enhanced Particle Swarm Optimization) are applied for solving Factual power loss lessening problem (Azar, 2010a, 2010b, 2012; Azar and Serrano, 2014,

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2015a, 2015b, 2015c, 2015d, 2016a, 2016b, 2017; Azar and Vaidyanathan, 2015a, 2015b, 2015c, 2016; Azar and Zhu, 2015; Mekki *et al.*, 2015; Vaidyanathan and Azar, 2015a, 2015b, 2015c, 2016a, 2016b, 2016c, 2016d, 2016e, 2016f, 2016g, 2016h; Vaidyanathan *et al.*, 2015a, 2015b, 2015c; 2017a, 2017b, 2017b; Zhu and Azar, 2015; Boulkroune *et al.*, 2016a, 2016b; Ghodelbourk *et al.*, 2016; Ouannas *et al.*, 2016, 2017a, 2017b, 2017c, 2017d, 2017e, 2017f, 2017g, 2017h, 2017i, 2017j; 2017k; Meghni *et al.*, 2017a, 2017b, 2018; Azar *et al.*, 2017a, 2017b, 2017c, 2017d; Grassi *et al.*, 2017; Singh *et al.*, 2017; Wang *et al.*, 2017; Soliman *et al.*, 2017; Tolba *et al.*, 2017; Soltani *et al.*, 2020). In this paper, Rhinotia hemistictus based Jackal (RJ) optimization algorithm is proposed for solving the power loss lessening problem. Jackal Optimization (JO) algorithm is based on the Jackal hunting procedure. Naturally Jackal will apply Ringing, quest, and bout towards the prey. These actions are imitated and modeled. To evade the local optima and premature convergence Rhinotia hemistictus actions has been combined to expand the performance of the Jackal algorithm. Rhinotia hemistictus uses its appendages and olfactory pairs to examine an unidentified atmosphere to ascertain the areas with the strongest aroma of nutrition. In every phase, Rhinotia hemistictus grade the aroma with the appendages and then it chooses the progression of the ensuing footstep. Curiously, the Rhinotia hemistictus does not move capriciously in some pathway but stops consequently every footstep and uses the sense of aroma to upgrade the recognition of the direction before creating the successive decree. Forerunner jackal will regulate the prey distance by the sound observed from its ears. This action is very analogous to the actions of Rhinotia hemistictus movement. Random and adaptive parameter applied in the process to regulate the Exploration and exploitation and control parameter modernizing strategy which grounded on the cosine function is used to control the algorithm for dodge the local optima. Proposed algorithm can be applied in others areas of engineering and medical diagnosis field. Proposed Rhinotia hemistictus based Jackal (RJ) optimization algorithm has been appraised in IEEE 30 bus test system. Outcomes illustrate about the superior performance of the projected RJ algorithm in decreasing the power loss.

Problem Formulation

Mathematical formulation of Factual power loss diminution is defined as,

$$F = P_L = \sum_{k \in N_{br}} g_k (V_i^2 + V_j^2 - 2V_i V_j \cos \theta_{ij}) \quad (1)$$

$$F = P_L + \omega_v \times \text{Voltage Deviation} \quad (2)$$

Then

$$\text{Voltage Deviation} = \sum_{i=1}^{N_{pq}} |V_i - 1| \quad (3)$$

Parity constraints is defined as,

$$P_G = P_D + P_L \quad (4)$$

Disparity constraints is defined as,

$$P_{gslack}^{\min} \leq P_{gslack} \leq P_{gslack}^{\max} \quad (5)$$

$$Q_{gi}^{\min} \leq Q_{gi} \leq Q_{gi}^{\max}, i \in N_g \quad (6)$$

$$V_i^{\min} \leq V_i \leq V_i^{\max}, i \in N \quad (7)$$

$$T_i^{\min} \leq T_i \leq T_i^{\max}, i \in N_T \quad (8)$$

$$Q_c^{\min} \leq Q_c \leq Q_c^{\max}, i \in N_C \quad (9)$$

Rhinotia Hemistictus Based Jackal Optimization Algorithm

Jackal Optimization (JO) algorithm is based on the Jackal hunting process. Jackal hunt in a group and a forerunner will lead the group during the hunting. Ringing, quest, and bout are applied towards the prey by the Jackals. In the defined algorithm Jackals are categorized into α , β and γ . Forerunner jackal is designated as α . Three appropriate contestant solutions in the region of the exploration space are α , β and γ . Jackal ringing procedure of is described as,

$$\vec{R} = |\vec{\mu} \otimes \vec{S}_p(n) - \vec{S}(n)|, \quad (10)$$

$$\vec{S}(n+1) = \vec{S}_p(n) - \vec{\lambda} \otimes \vec{R} \quad (11)$$

where n present iteration number $\vec{\mu}$ and $\vec{\lambda}$ are coefficient vectors, $\vec{S}_p(n)$ symbolize the location of the prey at n th iteration $\vec{S}(n)$ indicate the location of jackal at n th iteration $\vec{S}(n+1)$ location of Jackal at $(n+1)$ iteration $\vec{R}$ indicate the difference between Jackal and prey

$$\vec{\lambda}(\text{coefficient vector}) = 2\vec{u} \otimes \overrightarrow{Rand_1} - \vec{u} \quad (12)$$

$$\vec{\mu}(\text{coefficient vector}) = 2 \otimes \overrightarrow{Rand_2} \quad (13)$$

$$\vec{u} = 2 - 2 \left(\frac{n}{\text{maximum iteration}} \right) \quad (14)$$

where $\overrightarrow{Rand_1}$ and $\overrightarrow{Rand_2} \in [0,1]$, $\vec{u}$ convergence factor

In the procedure of the quest the forerunner jackal α will lead the other Jackals to seizure the prey and the updating of the location by other jackals are defined as below,

$$\overrightarrow{R_\alpha} = |\vec{\mu}_1 \otimes \overrightarrow{S_\alpha}(n) - \vec{S}(n)| \quad (15)$$

$$\overrightarrow{R_\beta} = |\vec{\mu}_2 \otimes \overrightarrow{S_\beta}(n) - \vec{S}(n)| \quad (16)$$

$$\overrightarrow{R_\gamma} = |\vec{\mu}_3 \otimes \overrightarrow{S_\gamma}(n) - \vec{S}(n)| \quad (17)$$

where $\overrightarrow{S_\alpha}(n)$, $\overrightarrow{S_\beta}(n)$ and $\overrightarrow{S_\gamma}(n)$ indicates the present position of α , β , and γ Jackals.

$$\overrightarrow{S_1} = \overrightarrow{S_\alpha}(n) - \vec{\lambda}_1 \otimes \overrightarrow{R_\alpha} \quad (18)$$

$$\overrightarrow{S_2} = \overrightarrow{S_\beta}(n) - \vec{\lambda}_2 \otimes \overrightarrow{R_\beta} \quad (19)$$

$$\overrightarrow{S_3} = \overrightarrow{S_\gamma}(n) - \vec{\lambda}_3 \otimes \overrightarrow{R_\gamma} \quad (20)$$

$$\vec{S}(t+1) = \frac{\overrightarrow{S_1} + \overrightarrow{S_2} + \overrightarrow{S_3}}{3} \quad (21)$$

$\vec{\mu}$ (random) and $\vec{\lambda}$ (adaptive) vectors will control the exploration and exploitation

if $|\vec{\lambda}| > 1$ then search will be enhanced towards the prey (increasing exploitation)

if $|\vec{\lambda}| < 1$ then convergence will be enhanced in faster mode

where $\vec{\mu}$ will avoid the local optima by controlling the distance between Jackal and prey

JO Algorithm

- Begin
- Engender the population
- Parameters $\vec{\alpha}$, $\vec{\mu}$, and $\vec{\lambda}$ are defined
- Each exploration agent fitness value computed
- Determine $\overrightarrow{S_\alpha}$, $\overrightarrow{S_\beta}$ and $\overrightarrow{S_\gamma}$
- while ($n < \text{maximum iteration}$)
- For each exploration agent update the position

$$\vec{S}(t+1) = \frac{\overrightarrow{S_1} + \overrightarrow{S_2} + \overrightarrow{S_3}}{3}$$
- End for
- $\vec{\alpha}$, $\vec{\mu}$ and $\vec{\lambda}$ values are updated
- Agent's fitness values are computed
- $\overrightarrow{S_\alpha}$, $\overrightarrow{S_\beta}$ and $\overrightarrow{S_\gamma}$ are updated
- $n = n + 1$
- End while

n. out put ($\vec{S}_\alpha$)

Then in this paper Rhinotia hemistictus strategy has been integrated with the Jackal Optimization (JO) algorithm. Rhinotia hemistictus uses its tentacles and olfactory pairs to investigate an unidentified atmosphere to discover regions with the sturdiest aroma of sustenance. In every phase, Rhinotia hemistictus degree the aroma with the tentacles and then it decides the course of the subsequent footstep. Remarkably, the Rhinotia hemistictus does not move arbitrarily in some track but halts subsequently every footstep and uses the sense of aroma to improved recognition of the objective direction before constructing the subsequent pronouncement. Forerunner jackal α will determine the prey distance by the sound observed from ears. This action is very similar to the activities of Rhinotia hemistictus movement. Then a modernizing strategy which grounded on the cosine function is used to control the process of the RJ algorithm for evading the local optima. The upgrading done in the exploration behavior of Forerunner jackal α as follows,

$$\overrightarrow{Direction} = \frac{Rand(Q,1)}{\|Rand(Q,1)\|} \quad (22)$$

where Rand is random functional range of -1 and 1, Q is exploration space dimension.

Based on the sound observed by the ears of Forerunner jackal α on the both left and right sides the exploration defined as,

$$\vec{S}_\alpha^{left}(n) = \vec{S}_\alpha(n) - Diameter(n) \otimes \overrightarrow{Direction} \quad (23)$$

$$\vec{S}_\alpha^{right}(n) = \vec{S}_\alpha(n) + Diameter(n) \otimes \overrightarrow{Direction} \quad (24)$$

$$Diameter(n) = \frac{Step\ after\ hearing\ (hs(n))}{ratio\ of\ step\ after\ hearing\ (rhs)} \quad (25)$$

where $\vec{S}_\alpha(n)$ initial position of Forerunner jackal α $\vec{S}_\alpha^{left}(n)$. Fresh position of Forerunner jackal α exploring left side at nth iteration $\vec{S}_\alpha^{right}(n)$. Fresh position of Forerunner jackal α exploring right side at nth iteration.

Then the updating of step is done by,

$$hs(n+1) = \eta \otimes hs(n) + 0.010 \quad (26)$$

where η symbolize the attenuation rate.

With reference to hearing and exploration action, the new-fangled position of Forerunner jackal α is defined as,

$$\vec{S}_\alpha^{new}(n) = \vec{S}_\alpha(n) + hs(n) \otimes \overrightarrow{Direction} \otimes \text{Sign}\left(f\left(\vec{S}_\alpha^{left}(n)\right) - f\left(\vec{S}_\alpha^{right}(n)\right)\right) \quad (27)$$

With reference to the sound the Forerunner jackal α will update the location by,

$$\vec{S}_\alpha^{new}(n) = \begin{cases} \vec{S}_\alpha^{new}(n) & f\left(\vec{S}_\alpha^{new}(n)\right) \leq \vec{S}_\alpha(n) \\ \vec{S}_\alpha(n) & f\left(\vec{S}_\alpha^{new}(n)\right) > \vec{S}_\alpha(n) \end{cases} \quad (28)$$

Convergence factor $\vec{u}$ of the cosine function is defined as,

$$\vec{u} = 2 \cdot \cos\left(\frac{\pi}{2} \otimes (n/\text{maximum iteration})^4\right) \quad (29)$$

RJ Algorithm

- Begin
- Engender the population
- Parameters hs , Diameter, $\overrightarrow{Direction}$, $\vec{\alpha}$, $\vec{\mu}$ and $\vec{\lambda}$ are defined
- Each exploration agent fitness value computed
- Determine $\vec{S}_\alpha$, $\vec{S}_\beta$, and $\vec{S}_\gamma$
- while ($n < \text{maximum iteration}$)
- For each exploration agent update the position

$$\vec{S}(t+1) = \frac{\vec{S}_1 + \vec{S}_2 + \vec{S}_3}{3}$$
- End for
- Modernize parameter $\vec{u}$

$$\vec{u} = 2 \cdot \cos\left(\frac{\pi}{2} \otimes (n/\text{maximum iteration})^4\right)$$
- $\vec{\mu}$ and $\vec{\lambda}$ values are updated

- Agent's fitness values are computed
- Modernize the direction of Forerunner jackal α

$$\overrightarrow{Direction} = \frac{\text{Rand}(Q, 1)}{\|\text{Rand}(Q, 1)\|}$$

- Modernize the diameter

$$\text{Diameter}(n) = \frac{\text{Step after hearing}(hs(n))}{\text{ratio of step after hearing}(rhs)}$$
- Reform the Step

$$hs(n+1) = \eta \otimes hs(n) + 0.010$$
- Compute the new position of Forerunner jackal α

$$\vec{S}_\alpha^{new}(n) = \vec{S}_\alpha(n) + hs(n) \otimes \overrightarrow{Direction} \otimes \text{Sign}\left(f\left(\vec{S}_\alpha^{left}(n)\right) - f\left(\vec{S}_\alpha^{right}(n)\right)\right)$$
- Modernize the position of Forerunner jackal α

$$\vec{S}_\alpha^{new}(n) = \begin{cases} \vec{S}_\alpha^{new}(n) & f\left(\vec{S}_\alpha^{new}(n)\right) \leq \vec{S}_\alpha(n) \\ \vec{S}_\alpha(n) & f\left(\vec{S}_\alpha^{new}(n)\right) > \vec{S}_\alpha(n) \end{cases}$$
- End for
- Update the $\vec{S}_\beta$ and $\vec{S}_\gamma$
- $n = n + 1$
- End while
- out put ($\vec{S}_\alpha$)

Simulation Results

Legitimacy of the proposed Rhinotia hemistictus based Jackal (RJ) optimization algorithm has been corroborated in IEEE 30 bus test system. Table 1 show the limits and appraisal of results are presented in Table 2. Convergence characteristics of Jackal Optimization (JO) algorithm and Rhinotia hemistictus based Jackal (RJ) optimization algorithm are shown in Table 3. Figures 1 and 2 shows the assessment of loss and Convergence characteristics. Projected Rhinotia hemistictus based Jackal (RJ) optimization algorithm compared with standard particle swarm optimization, modified particle swarm optimization, standard Evolutionary programming and JAYA algorithm (Base case value Hussain, (2018);

Table 1. Limits

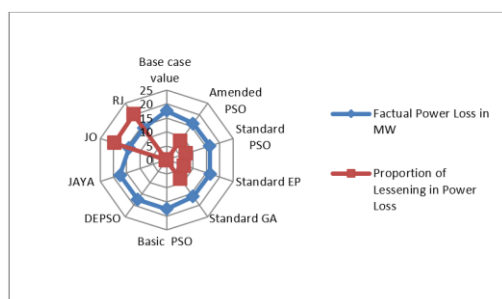
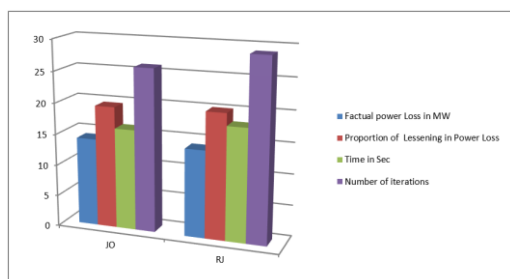
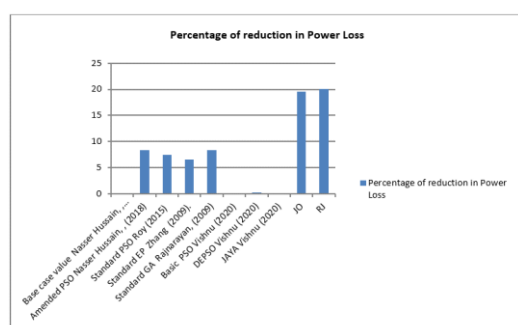
IEEE Bus	Parameter	Min (PU)	Max (PU)
30	Generator Voltage	0.95	1.1
	Transformer Tap	0.9	1.1
	VAR Source	0	0.20
	Bus	Q Min (PU)	Q Max (PU)
	1	0	10
	2	-40	50
	3	0	40
	6	-6	24
	8	-6	24

Table 2. Assessment of true power loss

Method	Factual Power Loss in MW	Proportion of Lessening in Power Loss
Base case value Hussain (2018)	17.5500	0.0000
Amended PSO Hussain (2018)	16.0700	8.40000
Standard PSO Pandya and Roy (2015)	16.2500	7.4000
Standard EP Dai <i>et al.</i> (2009).	16.3800	6.60000
Standard GA Subbaraj and Rajnarayanan (2009)	16.0900	8.30000
Basic PSO Vishnu and Kumar (2020)	17.5246	0.14472
DEPSO Vishnu and Kumar (2020)	17.52	0.17094
JAYA Vishnu and Kumar (2020)	17.536	0.07977
JO	14.12	19.54
RJ	14.03	20.05

Table 3. Convergence characteristics of Jackal Optimization (JO) algorithm and Rhinotia hemistictus based Jackal (RJ) optimization algorithm

IEEE 30 Bus system	Factual power Loss in MW	Proportion of Lessening in Power Loss	Time in Sec	Number of iterations
JO	14.12	19.54	16.16	26
RJ	14.03	20.05	18.09	29

**Figure 1. Appraisal of Factual Power Loss****Figure 2. Convergence characteristics (X- axis; method and Y-axis: value)****Figure 3. Comparison of the percentage of power loss reduction**

Amended PSO Hussain, (2018); Standard PSO Pandya and Roy (2015); Standard EP Dai *et al.* (2009); Standard GA Subbaraj and Rajnarayanan, (2009); Basic PSO Vishnu and Kumar (2020); DEPSO Vishnu and Kumar (2020); JAYA Vishnu and Kumar (2020)). Performance of Rhinotia hemistictus based Jackal (RJ) optimization algorithm is better than the other algorithms in

lessening the power loss. Figure 3 shows the Comparison between the methods with reference to percentage of power loss reduction.

Conclusions

In this paper Rhinotia hemistictus based Jackal (RJ) optimization algorithm splendidly solved the power loss lessening problem. Naturally Jackal actions of Ringing, quest, and bout towards the prey are imitated and modeled. To evade the local optima and premature convergence Rhinotia hemistictus actions has been united to magnify the performance of the Jackal algorithm. Rhinotia hemistictus uses its appendages and olfactory pairs to scrutinize an anonymous atmosphere to ascertain the areas with the sturdiest odour of nutrition. In every phase, Rhinotia hemistictus rank the aroma with the appendages and then it chooses the progression of the ensuing footstep. Inquisitively, the Rhinotia hemistictus does not move impulsively in some pathway but stops subsequently every footstep and uses the sense of aroma to upgrade the recognition of the way before generating the consecutive decree. Forerunner jackal will regulate the prey distance by the sound observed from its ears. This action is very similar to the actions of Rhinotia hemistictus movement. Random and adaptive parameter applied in the method to regulate the Exploration and exploitation and control parameter modernizing strategy which grounded on the cosine function is used to control the algorithm for dodge the local optima. Projected Rhinotia hemistictus based Jackal (RJ) optimization algorithm abridged the factual power loss meritoriously. Proportion of Power loss diminution is enriched. Percentage of power loss reduction achieved by JO and RJ are 19.54, 20.05 respectively. In future this work can be extended to apply in large and practical systems. Mainly to other areas of power system optimization problem like Economic dispatch problem, Unit commitment problem etc., Projected Rhinotia hemistictus based Jackal (RJ) optimization algorithm can be applied.

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