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TANGIBLE POWER LOSS DWINDLING BY CANADIAN YUKON COUGAR OPTIMIZATION ALGORITHM

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Abstract

In this paper Canadian Yukon Cougar Optimization Algorithm is applied to solve the power loss lessening problem. Natural deeds of Canadian Yukon Cougar are imitated to model the Canadian Yukon Cougar optimization algorithm. Both male and female Canadian Yukon Cougar switch their positions with reference to the conditions. In the initial population superiority and Migrant classification are done. For each Canadian Yukon Cougar fitness value computed. For superiority matured male Canadian Yukon Cougar fight with other male Canadian Yukon Cougars. Succeeded male will be dominant and defeated male Canadian Yukon Cougars will become as Migrant Canadian Yukon Cougars. In Canadian Yukon Cougar population balance will be there at end of iterations, the amount of existing Canadian Yukon Cougar will be controlled. With reference to the Utmost allowed number of every gender in Migrant Canadian Yukon Cougar; the smallest amount fitness value possessed by Migrant Canadian Yukon Cougar will be removed. Rightfulness of the Canadian Yukon Cougar Optimization Algorithm is corroborated in IEEE 30 bus system (with and devoid of L-index). Actual power loss lessening is reached. Proportion of actual power loss lessening is augmented

Keywords

Optimal reactive power, transmission loss, Canadian Yukon Cougar Optimization Algorithm

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Introduction. In power system reducing genuine power loss is an extensive aspect. Abundant techniques [1–6] and evolutionary methods (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) [7–16] are applied for solving factual power loss lessening problem [17–19]. In this paper, Canadian Yukon Cougar Optimization Algorithm (COA) is applied to solve the factual power loss lessening problem. Natural deeds of Canadian Yukon Cougar are imitated to model the Canadian Yukon COA. Canadian Yukon Cougar naturally lives as group. Canadian Yukon Cougars act as Exterminators to hunt the Quarry. Matured male Canadian Yukon Cougar will fight with other males to obtain the place of superiority. The defeated ones will be as Migrant Canadian Yukon Cougar. Mainly many times there will be switch between occupant and migrant Canadian Yukon Cougars. During hunting the Quarry Exterminators may opt in the opposite position and it has been modelled through opposition-based learning approach. For Migrant Canadian Yukon Cougar it's dissimilar in that a Migrant female Canadian Yukon Cougar mates with one of the male Canadian Yukon Cougar which are chosen arbitrarily for production of offspring. For superiority matured male Canadian Yukon Cougar fight with other male Canadian Yukon Cougars. Succeeded male will be dominant and defeated male Canadian Yukon Cougars will become as Migrant Canadian Yukon Cougars. In Canadian Yukon Cougar population balance will be there at end of iterations, the amount of existing Canadian Yukon Cougar will be controlled. With reference to the Utmost allowed number of every gender in Migrant Canadian Yukon Cougar; the smallest amount fitness value possessed by Migrant Canadian Yukon Cougar will be removed. Sagacity of Canadian Yukon COA is confirmed by corroborated in IEEE 30 bus system (with and devoid of *L*-index). Factual power loss lessening is achieved. Proportion of factual power loss reduction is augmented.

Problem formulation. Power loss minimization is defined by $\min \tilde{F}\left(\overline{d}, \overline{e}\right)$. Subject to

$$A\left(\overline{d}, \overline{e}\right) = 0;\ \ B\left(\overline{d}, \overline{e}\right) = 0;$$

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

$$e = \left[PG_{slack}; VL_1, \ldots, VL_{NL};\ QG_1, \ldots, QG_{NG};\ SL_1, \ldots, SL_{NT}\right].$$

The fitness function $\left(F_1, F_2, F_3\right)$ is designed for power loss (MW) lessening, voltage deviancy, voltage constancy index (*L*-index) is defined by

$$F_1 = P_{\min} = \min\left[\sum_{m}^{N_{TL}} G_m\left[V_i^2 + V_j^2 - 2V_iV_j\cos\text{Ø}_{ij}\right]\right];$$

$$F_2 = \min\left[\sum_{i=1}^{N_{LB}}\left|V_{Lk} - V_{Lk}^{desired}\right|^2 + \sum_{i=1}^{Ng}\left|Q_{Gk} - Q_{Gk}^{Lim}\right|^2\right];$$

$$F_3 = \min L_{\max};$$

$$L_{\max} = \max\left[L_j\right],\ j = 1, \ldots,\ N_{LB};$$

$$L_j = 1 - \sum_{i=1}^{N_{PV}} F_{ji} \frac{V_i}{V_j},$$

$$F_{ji} = -\left[Y_1\right]^1 \left[Y_2\right];$$

$$L_{\max} = \max\left[1 - \left[Y_1\right]^{-1}\left[Y_2\right]\frac{V_i}{V_j}\right].$$

Parity constraints

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

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

Disparity constraints

$$P_{Gslack}^{\min} \le P_{Gslack} \le P_{Gslack}^{\max};\quad Q_{Gi}^{\min} \le Q_{Gi} \le Q_{Gi}^{\max},\ \ i \in NG;$$

$$VL_i^{\min} \le VL_i \le VL_i^{\max},\ i \in NL;\ \ T_i^{\min} \le T_i \le T_i^{\max},\ i \in NT;$$

$$Q_C^{\min} \le Q_C \le Q_C^{\max},\ \ i \in NC;\ \left|SL_i\right| \le S_{L_i}^{\max},\ \ i \in NTL;$$

$$VG_i^{\min} \le VG_i \le VG_i^{\max},\ \ i \in NG;$$

$$MOF = F_1 + r_i F_2 + u F_3 =$$

$$= F_1 + \left[\sum_{i=1}^{NL} x_v \left[VL_i - VL_i^{\min}\right]^2 + \sum_{i=1}^{Ng} r_g \left[QG_i - QG_i^{\min}\right]^2\right] + r_f F_3;$$

$$VL_i^{\min} = \begin{cases} VL_i^{\max},\ VL_i > VL_i^{\max}, \\ VL_i^{\min},\ VL_i < VL_i^{\min}; \end{cases}$$

$$QG_i^{\min} = \begin{cases} QG_i^{\max},\ QG_i > QG_i^{\max}, \\ QG_i^{\min},\ QG_i < QG_i^{\min}. \end{cases}$$

Here *MOF* — multi objective fitness function.

Canadian Yukon Cougar Optimization Algorithm. In this paper, natural deeds of Canadian Yukon Cougar are imitated to model the Canadian Yukon COA. Canadian Yukon Cougar naturally lives as group. Canadian Yukon Cougars act as Exterminators to hunt the Quarry. Matured male Canadian

Yukon Cougar will fight with other males to obtain the place of superiority. The defeated ones will be as Migrant Canadian Yukon Cougar. Mainly many times there will be switch between occupant and migrant Canadian Yukon Cougars. Both male and female Canadian Yukon Cougar switch their positions with reference to the conditions. In the initial population superiority and Migrant classification are done. For each Canadian Yukon Cougar fitness value computed.

In the procedure each Canadian Yukon Cougar represent a solution and it represented as

$$Canadian\ \ Yukon\ \ Cougar = \left[c_1, c_2, c_3, \ldots, c_{N\,\mathrm{var}}\right].$$

Canadian Yukon Cougar fitness value is calculated by

$$Canadian\ \ Yukon\ \ Cougar\ \ fitness\ \ value = f\left(c_1, c_2, c_3, \ldots, c_{N\,\mathrm{var}}\right).$$

During hunting the Quarry, Exterminators may opt in the opposite position and it has been modelled through opposition-based learning approach [20–22, 24–28] and in N variable space $C\left(c_1, c_2, c_3, \ldots, c_{N\,\mathrm{var}}\right)$ is a point $c_i \in \left[a_i, b_i\right]$, where $i = 1, \ldots, c_{N\,\mathrm{var}}$. Then the opposite of C is defined as $\breve{C} = \left(\breve{c}_1, \breve{c}_2, \ldots, \breve{c}_{N\,\mathrm{var}}\right)$, $\breve{c}_i = a_i + b_i - c_i$. *Exterminators* and *Quarry* are being positioned in the space

$$\left(Quarry = \sum \frac{Exterminators\left(c_1, c_2, c_3, \ldots, c_{N\,\mathrm{var}}\right)}{Number\ \ of\ \ Exterminators}\right).$$

Proportion of improvement in fitness of exterminator (*PIE*):

$$Quarry' = Quarry + Random\left(0,1\right) PIE\left(Quarry - Exterminator\right).$$

The new-fangled position of *Exterminators* is defined by

$$Exterminator' = \\ = \begin{cases} Random\left((2Quarry - Exterminator),\ Quarry\right), \\ \qquad (2Quarry - Exterminator) < Quarry, \\ Random\left(Quarry, (2Quarry - Exterminator)\right), \\ \qquad (2Quarry - Exterminator) > Quarry. \end{cases}$$

In the centre point position of the *Exterminator’s* during hunting is defined by

$$Exterminator' = \begin{cases} Random\left(Exterminator, Quarry\right), Exterminator < Quarry, \\ Random\left(Exterminator, Quarry\right), Exterminator > Quarry. \end{cases}$$

```
a. Arbitrarily alienate the Exterminators into subcategories
b. Engender a Quarry
```

```
c. For i = 1: E (E is number of Exterminators)
d. In the direction of the Quarry move the ith Exterminator with orientation to the cluster
e. if novel position of the i-th Exterminator is better than its preceding position
f. Quarry escape form the Exterminator
g. End
h. End
```

When female Canadian Yukon Cougars involve in hunting and its position defined as

$$\begin{gathered}Canadian\ Yukon\ Cougar'\left(F\right)= \\ =F\,Canadian\ Yukon\ Cougar+2\,DistanceRandom\left(0,1\right)\left\{Q_1\right\}+ \\ +\left(-1,1\right)\operatorname{tg}\theta Distance\left\{Q_2\right\},\end{gathered}$$

where Q_1, Q_2 are the starting place of female Canadian Yukon Cougar, $\left\{Q_1\right\}\left\{Q_2\right\}=0;\ \left\{Q_2\right\}=1.$ In cluster G victory rate of Canadian Yukon Cougar is

$$V\left(i,t,G\right)=\begin{cases}1\ best_{i,G}^{t}<best_{i,g}^{t-1}, \\ 0\ best_{i,G}^{t}=best_{i,g}^{t-1}.\end{cases}$$

Utilizing the victory rate, the number of Canadian Yukon Cougar $H_j\left(v\right)$ in superiority j is defined by $H_j\left(v\right)=\sum_{i=1}^{n}V\left(i,t,G\right),\ j=1,\ldots,G.$ Competition Magnitude in superiority is defined by

$$C_j^M=\max\left(2,ceil\left(\frac{H_j(v)}{2}\right)\right),\ j=1,\ldots,G;$$

```
a. For i = 1 to G (G is number of superiority)
b. Compute the Competition Magnitude for the i-th superiority
c. For i = 1 to W (W is the waited female cougar in the i-th superiority)
d. By Competition Magnitude Elect a place for among superiority region
e. Transmit the i-th female cougar in the elect place
f. End
g. End
```

When the Canadian Yukon Cougar move towards the specific region $y\sim U\left(0,2Distance\right)$.

Occupant male Canadian Yukon Cougar (OMC) moves randomly in the space:

```
a. For i = 1 to OMC
b. Choose % W for i-th male Canadian Yukon Cougar to see the region in Arbitrary mode
c. For i = 1 to EP (EP is Elected place in preceding step)
```

```
    d. Move in the direction of j-th place
    e. Preceding best place is inferior to the newly selected place of i-th male Canadian Yukon Cougar then,
    f. Point that unique place as zone
    g. End
    h. End
    i. Current position of the i-th male Canadian Yukon cougar is selected from the best seen location
    j. End
```

In the search space both male and female Canadian Yukon Cougar moves randomly:

```
    a. Migrant Canadian Yukon Cougar move arbitrarily in the exploration space
    b. For i = 1 to NM (NM is the number of Migrant Canadian Yukon Cougar)
    c. Randomly move the i-th Migrant Canadian Yukon Cougar
    d. Preceding best place is inferior to the newly selected place of i-th Migrant Canadian Yukon Cougar then
    e. Modernize the i-th Migrant Canadian Yukon Cougar best position
    f. End
    g. End
```

New-fangled position of the Migrant Canadian Yukon Cougar is defined as

$$Migrant\,Canadian\ Yukon\ Cougar'_{ij} =$$
$$= \begin{cases} Migrant\,Canadian\,Yukon\,Cougar_{ij} & \text{if } \ random_j > PB_i, \\ Random_j & \text{otherwise.} \end{cases}$$

Probability is computed by

$$PB_i =$$
$$= 0,1 + \min\left(0.5\,\frac{Migrant\ Canadian\ Yukon\ Cougar_i - Best_{Migrant\ Canadian\ Yukon\ Cougar}}{Best_{Migrant\ Canadian\ Yukon\ Cougar}}\right),$$
$$i = 1, \ldots, Number\ of\ Migrant\ Canadian\ Yukon\ Cougar.$$

For Migrant Canadian Yukon Cougar it’s dissimilar in that a Migrant female Canadian Yukon Cougar mates with one of the male Canadian Yukon Cougar which are chosen arbitrarily for production of offspring’s:

$$Canadian\,Yukon\,Cougar\,offspring_j 1 =$$
$$= \alpha\,female\,Canadian\,Yukon\,Cougar_j + \sum \frac{1-\beta}{\sum\limits_{i=1}^{OR} V_i}\,male\,Canadian\,Yukon\,Cougar_j^i\ V_i;$$

$$Canadian\,Yukon\,Cougar\,offspring_j 2 =$$
$$= \alpha\,female\,Canadian\,Yukon\,Cougar_j + \sum \frac{1-\beta}{\sum\limits_{i=1}^{OR} V_i}\,male\,Canadian\,Yukon\,Cougar_j^i\ V_i,$$

where *OR* is occupant Canadian Yukon Cougar; α is arbitrarily engendered number with 0.50 mean. Amalgamate novel matured male Canadian Yukon Cougar with old Canadian Yukon Cougars:

```
a. With respect to fitness value classify the male Canadian Yukon Cougars
b. Defeated male Canadian Yukon Cougars will become as Migrant Canadian Yukon Cougars
c. Male Canadian Yukon Cougars will become occupant male Canadian Yukon Cougar
```

For superiority matured male Canadian Yukon Cougar fight with other male Canadian Yukon Cougars. Succeeded male will be dominant and defeated male Canadian Yukon Cougars will become as Migrant Canadian Yukon Cougars:

```
a. For i = 1 to number of Migrant Canadian Yukon Cougars
b. Engender Binary Template; BE [1, SP]
c. SP is number of superiority to binary (0–1)
d. For j = 1 to SP
e. BE = 1
f. For z = 1 to OR (number of occupant males in j-th superiority)
g. If i-th Migrant Canadian Yukon Cougar is better than z-th occupant male Canadian Yukon Cougar in the j-th superiority
h. z-th occupant male Canadian Yukon Cougar will exit out of j-th superiority and it converted to Migrant Canadian Yukon Cougar
i. Sequentially Migrant Canadian Yukon Cougar becomes occupant male progress to further i
j. End
k. End
l. End
m. End
n. End
```

In Canadian Yukon Cougar population balance will be there at end of iterations, the amount of existing Canadian Yukon Cougar will be controlled. With reference to the Utmost allowed number of every gender in Migrant Canadian Yukon Cougar; the smallest amount fitness value possessed by Migrant Canadian Yukon Cougar will be removed

```
a. Start
b. Engender the population of Canadian Yukon Cougar
c. Initialize the superiority Canadian Yukon Cougar
d. Initialize the Migrant Canadian Yukon Cougar
e. Arbitrarily pick the Migrant Canadian Yukon Cougar form preliminary population
f. Classification done in whole population as male and female Canadian Yukon Cougars
g. For each superiority do
h. Each occupant female Canadian Yukon Cougar move in the direction of most excellent position
```

```
i. Mating probability of Canadian Yukon Cougar is computed
j. Defeated Canadian Yukon Cougar will become as Migrant Canadian Yukon Cougar
k. For each Migrant do
l. Both Female and male Migrant Canadian Yukon Cougar move arbitrarily in the exploration space
m. Mating probability between best male and female migrant Canadian Yukon Cougar is computed
n. Migrant Canadian Yukon Cougar arbitrarily attack the superiority Canadian Yukon Cougar
o. For each superiority do
p. Few female Canadian Yukon Cougar will be converted as migrant female Canadian Yukon Cougar
q. Do
r. Each gender of migrant Canadian Yukon Cougar is classified based on fitness value
s. Best female Migrant will occupy the position of empty space in superiority, which has been created by the exit of Female Canadian Yukon Cougar from Superiority to Migrant
t. Smallest amount fitness value possessed by Migrant Canadian Yukon Cougar will be removed
u. Check the end criterion
v. If satisfied stop or else go to step g
w. End
```

Simulation results. With considering L-index (voltage stability), Canadian Yukon COA is substantiated in IEEE 30 bus system [23]. Appraisal of loss has been done with PSO, amended PSO, enhanced PSO, widespread learning PSO, Adaptive Genetic algorithm, Canonical Genetic algorithm, Enriched Genetic algorithm, Hybrid PSO-Tabu Search (PSO-TS), Ant lion (ALO), Quasi-Oppositional Teaching Learning Based (QO-TLBO), Improved Stochastic Fractal Search optimization algorithm (ISFS), Harmony Search (HS), Improved Pseudo-Gradient Search Particle Swarm optimization, Cuckoo search algorithm, Noble, Depraved and Abhorrent (NDA) optimization algorithm and United Kingdom B117 Pandemic Virus algorithm (UPA). Power loss abridged competently and proportion of the power loss lessening has been enriched. Predominantly voltage constancy enrichment achieved with minimized voltage deviancy. Table 1 shows the loss appraisal, Table 2 shows the voltage deviancy evaluation and Table 3 gives the L-index assessment. Figure 1 gives graphical appraisal.

Table 1

Assessment of factual power loss lessening

Technique	Factual power loss, MW
Standard PSO-TS [10]	4.5213
Basic TS [10]	4.6862

End of the Table 1

Technique	Factual power loss, MW
Standard PSO [10]	4.6862
ALO [11]	4.5900
QO-TLBO [12]	4.5594
TLBO [12]	4.5629
Standard GA [13]	4.9408
Standard PSO [13]	4.9239
HAS [13]	4.9059
Standard FS [14]	4.5777
ISFS [14]	4.5142
Standard FS [16]	4.5275
NDA [19]	4.5005
UPA [19]	4.5007
COA	4.5003

Table 2

Evaluation of voltage deviancy

Technique	Voltage deviancy, PU	Technique	Voltage deviancy, PU
Standard PSO-TVIW [15]	0.1038	MPG-PSO [15]	0.0892
Standard PSO-TVAC [15]	0.2064	QO-TLBO [12]	0.0856
Standard PSO-TVAC [15]	0.1354	TLBO [12]	0.0913
Standard PSO-CF [15]	0.1287	Standard FS [14]	0.1220
PG-PSO [15]	0.1202	ISFS [14]	0.0890
SWT-PSO [15]	0.1614	Standard FS [16]	0.0877
PGSWT-PSO [15]	0.1539	COA	0.0834

Table 3

Assessment of voltage constancy

Technique	Voltage constancy, PU	Technique	Voltage constancy, PU
Standard PSO-TVIW [15]	0.1258	TLBO [12]	0.1180
Standard PSO-TVAC [15]	0.1499	ALO [11]	0.1161
Standard PSO-TVAC [15]	0.1271	ABC [11]	0.1161
Standard PSO-CF [15]	0.1261	GWO [11]	0.1242
PG-PSO [15]	0.1264	BA [11]	0.1252

End of the Table 3

Technique	Voltage constancy, PU	Technique	Voltage constancy, PU
Standard WT-PSO [15]	0.1488	Basic FS [14]	0.1252
PGSWT-PSO [15]	0.1394	ISFS [14]	0.1245
MPG-PSO [15]	0.1241	Standard FS [16]	0.1007

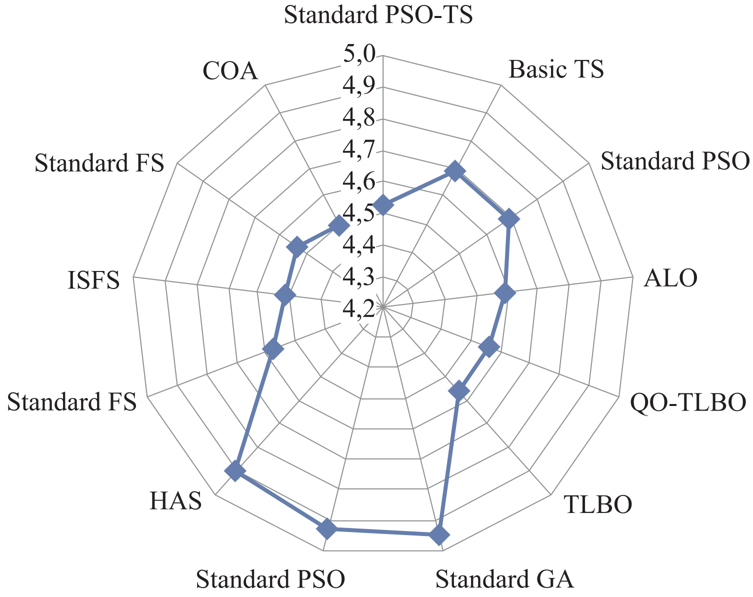

Fig. 1. Appraisal of factual power loss

Then Projected Canadian Yukon COA is corroborated in IEEE 30 bus test system deprived of *L*-index. Loss appraisal is shown in Tables 4. Figure 2 gives graphical appraisal between the approaches with orientation to factual power loss.

Table 4

Assessment of true power loss

Technique	Factual power loss, MW	Proportion of lessening in power loss
Base case value [24]	17.5500	0
Amended PSO [24]	16.0700	8.40000
Standard PSO [25]	16.2500	7.4000
Standard EP [26]	16.3800	6.60000
Standard GA [27]	16.0900	8.30000

End of the Table 4

Technique	Factual power loss, MW	Proportion of lessening in power loss
Basic PSO [24]	17.5246	0.14472
DEPSO [25]	17.5200	0.17094
JAYA [26]	17.5360	0.07977
NDA	14.3900	18.000
UPA	14.5000	17.3700
COA	13.8900	20.8547

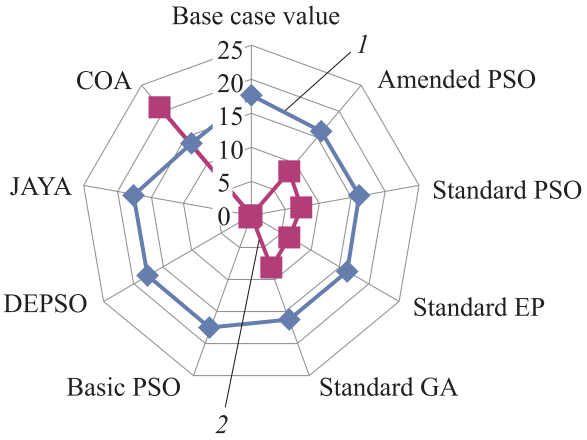

Fig. 2. Appraisal of factual power loss:
1 — factual power loss; *2* — proportion of lessening in power loss

The convergence characteristics of Canadian Yukon COA show in Table 5. The graphical representation of the characteristics shows Fig. 3.

Table 5

Convergence characteristics

Technique	Factual power loss with / without L-index, MW	Time with / without L-index, s	Number of iterations with / without L-index
NDA [19]	4.5005 / 14.39	18.00 / 22.19	16.98 / 27
UPA [19]	4.5007 / 14.50	17.37 / 25.37	19.75 / 31
COA	4.5003 / 13.89	17.39 / 14.16	27 / 24

Conclusion. Canadian Yukon COA abridged the factual power loss ingeniously. Cougar Optimization Algorithm (substantiated in IEEE 30 bus test system. Canadian Yukon COA commendably reduced the power loss and propor-

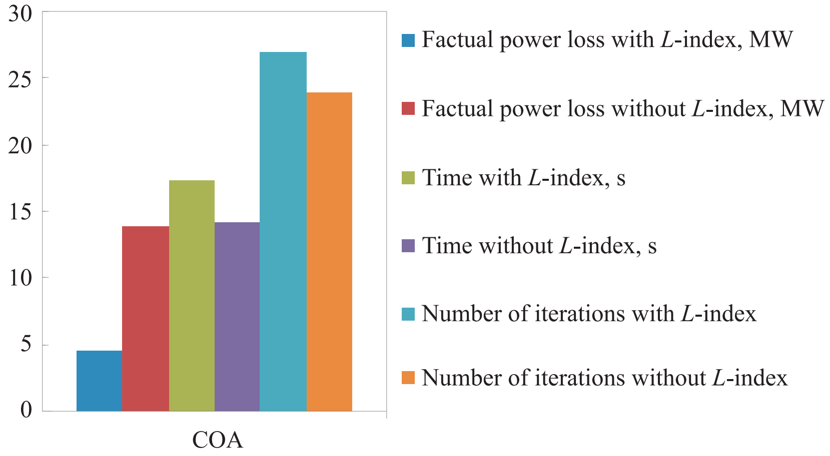

Fig. 3. Convergence characteristics of Canadian Yukon COA

tion of factual power loss lessening has been upgraded. Matured male Canadian Yukon Cougar will fight with other males to obtain the place of superiority. The defeated ones will be as Migrant Canadian Yukon Cougar. Mainly many times there will be switch between occupant and migrant Canadian Yukon Cougars. During hunting the *Quarry Exterminators* may opt in the opposite position and it has been modelled through opposition-based learning approach. For Migrant Canadian Yukon Cougar it's dissimilar in that a Migrant female Canadian Yukon Cougar mates with one of the male Canadian Yukon Cougar which are chosen arbitrarily for production of offspring. For superiority matured male Canadian Yukon Cougar fight with other male Canadian Yukon Cougars. Succeeded male will be dominant and defeated male Canadian Yukon Cougars will become as Migrant Canadian Yukon Cougars. In Canadian Yukon Cougar population balance will be there at end of iterations, the amount of existing Canadian Yukon Cougar will be controlled. With reference to the Utmost allowed number of every gender in Migrant Canadian Yukon Cougar; the smallest amount fitness value possessed by Migrant Canadian Yukon Cougar will be removed. Convergence characteristics show the better performance of the proposed Canadian Yukon COA approach. Assessment of power loss has been done with other customary reported algorithms.

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