



Science

REDUCTION OF TRUE POWER LOSS BY IMPROVED ALGORITHM

Dr. K. Lenin *¹

*¹ Professor, Department of EEE, Prasad V.Potluri Siddhartha Institute of Technology, Kanuru, Vijayawada, Andhra Pradesh -520007, India

Abstract

This paper proposes Improved Brain Storm Optimization (IBSO) algorithm is used for solving reactive power problem. predictably, optimization algorithm stimulated by human being inspired problem-solving procedure should be highly developed than the optimization algorithms enthused by collective deeds of ants, bee, etc. In this paper, a new Improved brain storm optimization algorithm defined, which was stimulated by the human brainstorming course of action. In the projected Improved Brain Storm Optimization (IBSO) algorithm, the vibrant clustering strategy is used to perk up the k-means clustering process & exchange of information wrap all ideas in the clusters to accomplish suitable searching capability. This new approach leads to wonderful results with little computational efforts. In order to evaluate the efficiency of the proposed Improved Brain Storm Optimization (IBSO) algorithm, has been tested standard IEEE 30 bus test system and compared to other standard reported algorithms. Simulation results show that Improved Brain Storm Optimization (IBSO) algorithm is superior to other algorithms in reducing the real power loss.

Keywords: Improved Brain Storm Optimization; Optimal Reactive Power; Transmission Loss.

Cite This Article: Dr. K. Lenin. (2018). “REDUCTION OF TRUE POWER LOSS BY IMPROVED ALGORITHM.” *International Journal of Research - Granthaalayah*, 6(8), 105-113. <https://doi.org/10.5281/zenodo.1403827>.

1. Introduction

Power system constancy is related through security, and it refers to steadiness of service, reliability in frequency and specified voltage restrictions. Main task is to sustain the voltage profiles within the limits by increase or decrease in reactive power. Choosing the ideal parameter of reactive power resources is one of the centre ways for the protected function of transmission structure. The scanty regulation of reactive power sources confines the active power transmission, which can be basis for uncontrolled declined in voltage and tension fall down in the load buses. Optimal reactive power dispatch is one among the main subject for the operation and control of power systems, and it should be carried out properly such that system dependability should not get affected. The gradient method [1, 2], Newton method [3] and linear programming [4-7] experience from the complexity of managing the inequality constraints. In recent times widespread Optimization

techniques such as genetic algorithms have been proposed to solve the reactive power flow problem [8,9]. In this paper is Improved Brain Storm Optimization (IBSO) Algorithm used to solve the reactive power problem. In the novel Brain Storm Optimization Algorithm (BSO) [10], a k-means clustering method was espoused to group similar data into numerous groups in the converging procedure. In the projected Improved Brain Storm Optimization (IBSO) algorithm, the vibrant clustering strategy is used to perk up the k-means clustering process. The most important view of the vibrant clustering strategy is that; regularly execute the k-means clustering after a definite number of generations, so that the swapping of information wrap all ideas in the clusters to accomplish suitable searching capability. Proposed algorithm has been evaluated in standard IEEE 30 bus test system. Simulation results show that our proposed Improved Brain Storm Optimization (IBSO) approach outperforms all the entitled reported algorithms in minimization of real power loss.

2. Problem Formulation

Active power loss

The objective of the reactive power dispatch is to minimize the active power loss in the transmission network, which can be described as follows:

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

Where g_k : is the conductance of branch between nodes i and j , Nbr : is the total number of transmission lines in power systems. P_d : is the total active power demand, P_{gi} : is the generator active power of unit i , and P_{gsalck} : is the generator active power of slack bus.

Voltage Profile Improvement

For minimizing the voltage deviation in PQ buses, the objective function becomes:

$$F = PL + \omega_v \times VD \quad (2)$$

Where ω_v : is a weighting factor of voltage deviation.

VD is the voltage deviation given by:

$$VD = \sum_{i=1}^{Npq} |V_i - 1| \quad (3)$$

Equality Constraint

The equality constraint of the problem is represented by the power balance equation, where the total power generation must cover the total power demand and the power losses:

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

This equation is solved by running Newton Raphson load flow method, by calculating the active power of slack bus to determine active power loss.

Inequality Constraints

The inequality constraints reflect the limits on components in the power system as well as the limits created to ensure system security. Upper and lower bounds on the active power of slack bus, and reactive power of generators:

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

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

Upper and lower bounds on the bus voltage magnitudes:

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

Upper and lower bounds on the transformers tap ratios:

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

Upper and lower bounds on the compensators reactive powers:

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

Where N is the total number of buses, N_T is the total number of Transformers; N_c is the total number of shunt reactive compensators.

3. Brain Storm Optimization Algorithm (BSO)

We all have experienced that, when we face a difficult problem which, single person can't solve, a group of persons, particularly with dissimilar environment, get together to brain storm and the problem can frequently be solved with high possibility. Enormous and un-expectable intelligence can happen from interactive teamwork of human beings. One way to help human beings to interactively team up to generate great ideas is to acquire jointly a group of people to brainstorm. A brainstorming procedure normally described as follows,

Rule 1. Acquire jointly a brainstorming group of people with dissimilar background as feasible.

Rule 2. Generate many ideas.

Rule 3. Contain a number of, like 4 or 5, clientele perform as the owners of the problem. To pick up a number of i.e. one from every owner, information as superior ideas for solving the problem.

Rule 4. Use the ideas selected up in the rule 3 with superior possibility than other information as clues, and produce more ideas.

Rule 5. Encompass the owners to choose up several better ideas generated as did in rule 3.

Rule 6. Arbitrarily choose an object and make use of the functions and appearance of the object as clues, & produce more ideas.

Rule 7. Enclose the owners to pick up several healthier ideas;

Rule 8. Optimistically a high-quality solution can be obtained by taking into account or by merging the ideas generated.

In a brainstorming procedure, usually there are a catalyst, a brainstorming cluster of people, and numerous owners of the problem to be solved. The role of the catalyst is to facilitate the idea production (brainstorming) procedure by enforcing the brainstorming cluster to obey the Osborn's [11, 12] original four rules of idea generation in a brainstorming procedure. The catalyst should not be caught up in generating ideas itself, but facilitate the brainstorming procedure only. The rule for selecting catalyst or facilitator is to have a catalyst to have facilitation knowledge, but have less proficiency on the background knowledge connected to the problem to be solved as possible. The purpose of this is to have generated ideas to have less, if not nothing, then biases from the catalyst.

Osborn's Original Rules for Idea Generation in a Brainstorming Process are as follows,

Rule 1. Defer verdict

Rule 2. Everything Goes

Rule 3. Cross-fertilize

Rule 4. Go for capacity

- Rule 1 says that there is no idea can be seen as bad idea. All ideas are high-quality ideas only. It is ill-advised to judge whether a projected idea is a high-quality or dreadful idea. Any decision or censure must be held back until at least the conclusion of the brainstorming process.
- Rule 2 says that everything coming to your mind in the period of the brainstorming process is an idea merit to be pooled and recorded. Don't let any idea or contemplation mistreated.
- Rule 3 says that bunch of ideas be capable and should be based on ideas previously generated. Every generated idea be capable and should dish up as a clue to generate more ideas.
- Rule 4 says that it is essential to generate lot of ideas as possible. We primary go for amount of generated ideas. The superiority will come from quantity obviously. Lacking in generating large quantity of ideas, it is difficult or impossible, to come out ideas with high-quality.

Brain Storm Optimization Algorithm (BSO)

Step 1. Arbitrarily produce n potential solutions (individuals);

Step 2. Huddle n individuals into m clusters;

Step 3. Calculate the n individuals;

Step 4. Grade the individuals in every cluster and document the best individual as cluster centre in each cluster;

Step 5. Arbitrarily generate a value between 0 and 1;

a) If the value is smaller than a predestined probability then,

i. Arbitrarily select a cluster centre;

ii. Arbitrarily generate an individual to substitute the selected cluster centre;

Step 6. Create new individuals,

$$X_{new}^d = X_{selected}^d + \xi * n(\mu, \sigma) \quad (10)$$

where $X_{selected}^d$ is the d^{th} dimension of the individual selected to generate new individual; X_{new}^d is the d^{th} dimension of the individual newly generated; $n(\mu, \sigma)$ is the Gaussian random function with mean μ and variance σ ; the ξ is a coefficient that weights the contribution of the Gaussian random value. ξ can be calculated as

$$\xi = \text{logsig}((0.5 * \text{max_iteration} - \text{current_iteration})/k) * \text{rand} () \quad (11)$$

Where $\text{logsig} ()$ is a logarithmic sigmoid transfer function, max_iteration is the maximum number of iterations, and current_iteration is the current iteration number, k is for changing $\text{logsig} ()$ function's slope, and $\text{rand} ()$ is a random value within (0,1).

- a) Arbitrarily generate a value between 0 and 1;
- b) If the value is less than a probability then,
 - i. Arbitrarily select a cluster with a probability;
 - ii. Create a random value between 0 and 1;
 - iii. If the value is smaller than a predestined probability then,
 - 1) Choose the cluster centre and include random values to it to create new individual.
 - iv. Or else arbitrarily select an individual from this cluster and include random value to the individual to create new individual.
- c) Or else arbitrarily select two clusters to create new individual
 - i. Generate a random value;
 - ii. If it is less than a predestined probability, then the two cluster centres are pooled together and then added with random values to create new individual;
 - iii. Or else, two individuals from every selected cluster are arbitrarily selected has to be combined and added with random values to create new individual.
- d) The newly created individual is compared with the lively individual with the same individual catalogue. The superior one is kept and recorded as the new individual.

Step 7. If n new individuals have been created, then go to step 8 or else go to step 6;

Step 8. Conclude if predestined maximum number of iterations has been reached or else go to step 2.

4. Improved Brain Storm Optimization (IBSO) Algorithm by Vibrant Clustering Approach

In the novel Brain Storm Optimization Algorithm (BSO), a k-means clustering method was espoused to group similar data into numerous groups in the converging procedure. As we all known, the k-means clustering technique is time consuming and requires large time for the computation process. Throughout the evolutionary procedure, BSO carry out the k-means clustering in every generation to cluster ideas. Conversely, it is not essential to use k-means clustering technique to assemblage the ideas into dissimilar groups in every generation. In the projected Improved Brain Storm Optimization (IBSO) algorithm, the vibrant clustering strategy is used to perk up the k-means clustering process. The most important view of the vibrant clustering

strategy is that; regularly execute the k-means clustering after a definite number of generations, so that the swapping of information wrap all ideas in the clusters to accomplish suitable searching capability. Therefore, in our vibrant clustering stratagem, the important point is the size of re-clustering phase. If the re-clustering phase is lofty, the algorithm will get an elevated degree of exploitation and a soaring convergence rate, and the time difficulty of the algorithm will be respectively higher. Conversely, if the re-clustering period is inferior, the algorithm will attain more exploration and diversity, and the run time of the algorithm will be condensed in percentage. So, a suitable re-clustering phase helps to balance the exploitation and exploration of the algorithm, and will attain improved performance than the original BSO algorithm. In this paper, we use a probabilistic parameter $p_vibrant$ to denote the re-clustering period. $p_vibrant$ is a value between 0 to 1.

Algorithm for the implementation of vibrant clustering strategy

Vibrant Clustering

Commence

If $\text{rand}() < P_vibrant$

Implement k-means process

End

End

To regulate the convergence speed as the evolution goes in idea generation, the original BSO algorithm defines a fine-tune factor. Through numerical research, we find that at first the fine-tune factor keeps around 1, while when part the number of generations has been attained, it quickly turns to near 0. This technique to control the size of step can also balance exploration and exploitation at different penetrating generations. Conversely, it just takes effect only for very small interval. Therefore, we bring in a simple vibrant step size stratagem. The vibrant function is described as follows,

$$\xi = \text{random} * \exp\left(1 - \frac{\text{maximum_iteration}}{\text{maximum_iteration} - \text{current_iteration} + 1}\right) \quad (12)$$

Where random is an arbitrary value between 0 and 1. The max_iteration and current_iteration also indicate the maximum number of iterations and current number of iteration, correspondingly.

Commence

Arbitrarily initialize N ideas and estimate their fitness

Set up m cluster centers ($m < N$)

While (end condition not met)

Implement: vibrant Clustering ()

For (i=1 to N)

If $\text{random}() < P_one$

Arbitrarily choose a cluster

If $\text{random}() < P_one_center$

Provide the cluster center plan to X_{selected}

Else

Arbitrarily choose a notion in a cluster to X_{selected}

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End if
Else
Arbitrarily choose two clusters
If random ( ) < P_two_center
Merge the two clusters' center notions to X_selected
Else
Merge two random notions to X_selected
End if
End if
Generate X_new using X_selected with formula (10) and (12)
Recognize X_new if f(X_new) is superior than f(X_i )
End for
End while
End
    
```

5. Simulation Results

Improved Brain Storm Optimization (IBSO) algorithm validity has been verified by testing in standard IEEE 30-bus without considering Voltage stability evaluation. Standard IEEE 30-bus has 41 branches, 6 generator-bus, 4 transformer-tap settings, with 2 shunt reactive compensators buses. 2, 5, 8, 11 and 13 are considered as PV generator buses and Bus 1 is taken as slack bus, others are PQ load buses. In Table 1 Control variables limits are given.

Table 1: Primary Variable Limits (PU)

Name of the Variables	Minimum	Maximum	Class
Generator Bus	0.95	1.1	Continuous
Load Bus	0.95	1.05	Continuous
Transformer-Tap	0.9	1.1	Discrete
Shunt Reactive Compensator	-0.11	0.31	Discrete

In Table 2 gives the power limits of generators buses.

Table 2: Generators Power Limits

Bus number	Pg	Pgminimum	Pgmaximum	Qgminimum	Qgmaximum
1	96.00	49	200	0	10
2	79.00	18	79	-40	50
5	49.00	14	49	-40	40
8	21.00	11	31	-10	40
11	21.00	11	28	-6	24
13	21.00	11	39	-6	24

Table 3 shows the values of control variables. Table 4 narrates the performance of the proposed algorithm. Voltage deviations during the iterations are given in Fig 1 and overall comparison of the results of optimal solution obtained by various methods is given in Table 5.

Table 3: After optimization values of control variables

List of Control Variables	IBSO
V1	1.04120
V2	1.04100
V5	1.01810
V8	1.02720
V11	1.06810
V13	1.04800
T4,12	0.000
T6,9	0.010
T6,10	0.900
T28,27	0.910
Q10	0.100
Q24	0.100
Real power loss	4.2382
Voltage deviation	0.9080

Table 4: Performance of IBSO algorithm

No. of Iterations	34
Time taken (secs)	10.04
Real power loss (MW)	4.2382

Table 5: Comparison of results

Method	Real power loss (MW)
SGA (Wu et al., 1998)	4.98
PSO (Zhao et al., 2005)	4.9262
LP (Mahadevan et al., 2010)	5.988
EP (Mahadevan et al., 2010)	4.963
CGA (Mahadevan et al., 2010)	4.980
AGA (Mahadevan et al., 2010)	4.926
CLPSO (Mahadevan et al., 2010)	4.7208
HSA (Khazali et al., 2011)	4.7624
BB-BC (Sakthivel et al., 2013)	4.690
MCS(Tejaswini sharma et al.,2016)	4.87231
Proposed IBSO	4.2382

6. Conclusion

In this paper Improved Brain Storm Optimization (IBSO) algorithm is used to solve 1 reactive power problem by including various generator constraints. In the projected Improved Brain Storm Optimization (IBSO) algorithm, the vibrant clustering strategy is used to perk up the k-means clustering process. Efficiency of the proposed Improved Brain Storm Optimization (IBSO) algorithm has been demonstrated on standard IEEE 30 bus test system. Simulation results shows that Real power loss has been significantly reduced and voltage profile index within the particular limits.

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*Corresponding author.

E-mail address: gklenin@ gmail.com