

Partition of spaces based algorithm for reduction of real power loss

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ABSTRACT

In this work partition of spaces algorithm is proposed to solve optimal reactive power problem. In this algorithm, for finding the finest outcome based on the concentration of elevated quality and capable points in specific area is considered. State space area are identified and divided into subspaces iteratively and search has been made more comprehensively. Performance of the proposed partition of spaces algorithm is evaluated in standard IEEE 118,300 bus systems and simulated outcome gives better results. Real power loss has been considerably reduced.

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1. INTRODUCTION

Optimal reactive power problem has been key problem in power system, since it plays major role in secure and economic operation of the power system. Many conventional methods [1-6] have been applied for solving optimal reactive power 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. In this paper, partition of spaces algorithm is proposed to solve the reactive power problem. In this approach, elevated quality and capable points of the area is taken. State space are identified and divided into subspaces iteratively and search has been made more comprehensively. Performance of the proposed algorithm is evaluated in standard IEEE 118,300 bus systems simulation results shows the better performance of the proposed algorithm in reduction of real power loss.

2. PROBLEM FORMULATION

The key objective of the reactive power problem is to minimize the system real power loss and given,

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

Voltage deviation magnitudes (VD) is stated as follows:

$$\text{Minimize VD} = \sum_{k=1}^{nl} |V_k - 1.0| \quad (2)$$

Load flow equality constraints:

$$P_{Gi} - P_{Di} - V_i \sum_{j=1}^{nb} V_j \begin{bmatrix} G_{ij} & \cos \theta_{ij} \\ +B_{ij} & \sin \theta_{ij} \end{bmatrix} = 0, i = 1, 2, \dots, nb \quad (3)$$

$$Q_{Gi} - Q_{Di} - V_i \sum_{j=1}^{nb} V_j \begin{bmatrix} G_{ij} & \sin \theta_{ij} \\ +B_{ij} & \cos \theta_{ij} \end{bmatrix} = 0, i = 1, 2, \dots, nb \quad (4)$$

Inequality constraints are:

$$V_{Gi}^{\min} \leq V_{Gi} \leq V_{Gi}^{\max}, i \in ng \quad (5)$$

$$V_{Li}^{\min} \leq V_{Li} \leq V_{Li}^{\max}, i \in nl \quad (6)$$

$$Q_{Ci}^{\min} \leq Q_{Ci} \leq Q_{Ci}^{\max}, i \in nc \quad (7)$$

$$Q_{Gi}^{\min} \leq Q_{Gi} \leq Q_{Gi}^{\max}, i \in ng \quad (8)$$

$$T_i^{\min} \leq T_i \leq T_i^{\max}, i \in nt \quad (9)$$

$$S_{Li}^{\min} \leq S_{Li}^{\max}, i \in nl \quad (10)$$

3. PARTITION OF SPACES ALGORITHM

In this algorithm, for finding the optimal solution based on the concentration of elevated quality and capable points in specific area is considered. With equal sizes the state space are alienated into some subspaces. In the state space uniformly, points are generated arbitrary mode and target function value is calculated. Promising points are chosen with each subspace is determined. Always the chances of finding the optimal solution are higher when promising points are considered as the promising subspaces. The details of the proposed algorithm are as follows:

- Initially whole state space is measured as the capable area.
- Subspaces are created from the state space. Until finally a grid containing $g_{i_1} \times g_{i_2} \times \dots \times g_{i_n}$ subsections in d^{th} dimension ($1 \leq d \leq n$) and is divided into as many as g_d equivalent subintervals. Then, Size of each subinterval,

$$\text{in } d^{\text{th}} \text{ dimension} = \frac{U_d - L_d}{g_d} \quad (11)$$

- Preliminary population are created arbitrarily and that population is considered as the existing population.
- For every point of the existing population of function “f” is computed.
- Q1 - % of points; existing population are regarded as capable points, with the lowest values of function f,
- In each of the subspaces the numbers of capable points are determined and indicate the degree of capable points in the subspace.

$$\text{Capable ranks} = \text{Number of capable points in “s”} \quad (12)$$

- Q2 subspaces are searched more accurately and comprehensively.
 - Extra specific search in the capable subspaces: smaller subspaces are made from the capable subspaces.
 - To search subspaces expansively the number of points generated in each subspace is a linear function and found by [19]:

$$\text{number os points generated in } s = \left(\frac{\text{capable rank}_s}{\sum_{k \in \text{all sub spaces}} \text{capable rank}_k \times \text{population size}} \right) \quad (13)$$

- h. For each point in the new population the value of function f is calculated.
- i. Based on the truncation selection new population are replace the current population.
- j. Q3 percent of the points are arbitrarily selected in new population and customized by adding a Gaussian noise to them it's alike to mutation operation in genetic algorithm.
- k. Evaluation of the stop condition.
- l. The output of algorithm is the most excellent solution generated so far. Trade-off between exploration and exploitation is controlled by the values of parameters Q1, Q2, and Q3.

Partition of spaces algorithm for solving reactive power problem:

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Exploration Space, f
{Inputs:
With boundaries the n-dimensional space - State Space
Function target denoted by "f"
Most excellent solution found by the algorithm is the output
Pop Size, Q1, Q2, Q3, gd for 1 ≤ d ≤ n are initialized
When Pop0 = the initial population; i = 0;points are generated.
Whole exploration space as the skilled area at the commencement; competent Subspaces= State
Space; 1 ≤ d ≤ n for any dimension d
State Space is Partition into gid parts;
When end condition not satisfied
{
Values of Good Points; Quality [, ... Pop Size] = the quality of all the points in Popi
Q1 points with the uppermost superiority = [1... Pop Size]
Number of superior points in each subspace Count = [1, ... Number of Subspaces]
count [1...number os sub spaces] = capable rank [1 ... number os sub spaces]
Q2 percent of the subspaces with highest capable rank = Capable Sub spaces
Dimension d : 1 ≤ d ≤ n for any proficient subspaces "s" ; Promising subspace "s" is
partitioned into gd parts;
Fresh generated subspaces = popi[1 ... pop size]
Most excellent points of
Popi = popi+1[1...pop size];
Gaussian noise is added to Q3 arbitrarily and chosen Popi+1 ; i = i +1;
}
Superior solution found so far will be the out put
Revert to Solution
}
    
```

4. SIMULATION RESULTS

Performance of partition of spaces algorithm evaluated in standard IEEE 118-bus test system [20]. Limitations on reactive power source are listed in Table 1. Table 2 clearly shows better performance of the proposed algorithm. In IEEE 300 bus system, partition of spaces algorithm is verified [20]. Table 3 shows the values of comparison. Figure 1 gives real power loss comparison for IEEE 118 bus test system and Figure 2 shows the active power loss comparison for IEEE 300 bus test system.

Table 1. Reactive power sources limits

BUS NO	5	34	37	44	45	46	48	74	79	82	83	105	107	110
QC	0.00	14.0	0.00	10.0	10.0	10.0	15.0	12.00	20.0	20.0	10.0	20.0	6.00	6.00
MAX														
QC	-40.	0.00	-25.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MIN														

Table 2. Real power loss comparison results

Active power loss (p.u)	Method- BBO [21]	Method- ILSBBO/strategy1 [21]	Method -ILSBBO/Strategy2 [21]	Projected algorithm - Partition of spaces algorithm
Minimum	128.770	126.980	124.780	116.640
Maximum	132.640	137.340	132.390	120.980
Average value	130.210	130.370	129.220	117.560

Table 3 Comparison of loss

Parameter	Method CSA [22]	Method EGA [23]	Method EEA [23]	Partition of spaces
PLOSS (MW)	635.8942	646.2998	650.6027	629.5431

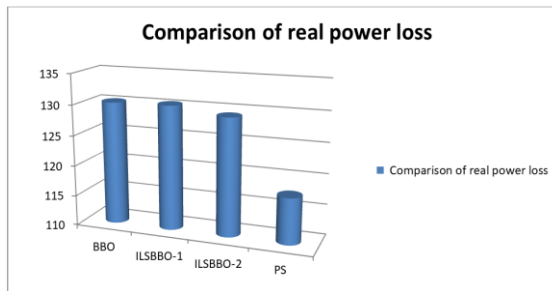


Figure 1. Real power loss comparison

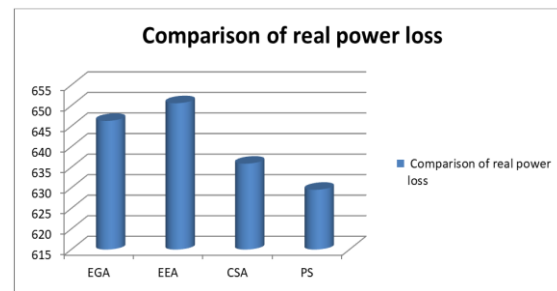


Figure 2. Active power loss comparison

5. CONCLUSION

Partition of spaces algorithm has been efficiently applied for solving reactive power problem. In this approach, elevated quality and capable points of the area is taken. State space are identified and divided into subspaces iteratively and search has been made more comprehensively. Efficiency of the proposed algorithm is evaluated in standard IEEE 118,300 bus systems and simulated outcome gives better results when compared to other reported standard algorithms.

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