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REDUCTION OF ACTIVE POWER LOSS BY PIONEERING POLL ALGORITHM

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Abstract

This paper projects Pioneering Poll (PP) algorithm, which inspired by poll around the world is used to solve optimal reactive power problem. In Pioneering Poll (PP) algorithm population is general people and each person may be a candidate or a voter. Definite number of people will form dissimilar groups to set up political parties in the solution space. Advertising movement is the fundamental of this Pioneering Poll (PP) algorithm and it contains three core phases: sanguine campaign, disparate campaign and union campaign. During sanguine campaign, the nominee proclaims themselves through accentuate their positive descriptions and potentials. In the disparate campaign, candidates challenge with each other to raise their status and malign their contender. In extraordinary cases, the candidates that have equivalent information can united together in order to increase the possibility of success of the joint party. Campaign positively grounds the people to congregate to a state of solution space that is the comprehensive optimum. All these determinations lead up to poll day (end condition). On poll day, the candidate who is acquiring maximum votes is proclaimed as the conqueror and it matches to the supreme solution that is found for the reactive power problem. The proposed Pioneering Poll (PP) algorithm has been tested in standard IEEE 118 & practical 191 bus test systems and simulation results show clearly about the enhanced performance of the proposed Pioneering Poll (PP) algorithm in reducing the real power loss with voltage profiles are within the limits.

Keywords: Optimal Reactive Power; Transmission Loss; Poll; Sanguine Campaign; Disparate Campaign; Union Campaign.

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1. Introduction

Optimal reactive power problem is to minimize the real power loss and bus voltage deviation. Various numerical methods like the gradient method [1-2], Newton method [3] and linear programming [4-7] have been adopted to solve the optimal reactive power dispatch problem. Both the gradient and Newton methods have the complexity in managing inequality constraints.

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If linear programming is applied then the input- output function has to be uttered as a set of linear functions which mostly lead to loss of accuracy. The problem of voltage stability and collapse play a major role in power system planning and operation [8]. Evolutionary algorithms such as genetic algorithm have been already proposed to solve the reactive power flow problem [9-11]. Evolutionary algorithm is a heuristic approach used for minimization problems by utilizing nonlinear and non-differentiable continuous space functions. In [12], Hybrid differential evolution algorithm is proposed to improve the voltage stability index. In [13] Biogeography Based algorithm is projected to solve the reactive power dispatch problem. In [14], a fuzzy based method is used to solve the optimal reactive power scheduling method. In [15], an improved evolutionary programming is used to solve the optimal reactive power dispatch problem. In [16], the optimal reactive power flow problem is solved by integrating a genetic algorithm with a nonlinear interior point method. In [17], a pattern algorithm is used to solve ac-dc optimal reactive power flow model with the generator capability limits. In [18], F. Capitanescu proposes a two-step approach to evaluate Reactive power reserves with respect to operating constraints and voltage stability. In [19], a programming based approach is used to solve the optimal reactive power dispatch problem. In [20], A. Kargarian et al present a probabilistic algorithm for optimal reactive power provision in hybrid electricity markets with uncertain loads. This paper projects Pioneering Poll (PP) algorithm, which inspired by poll around the world is used to solve optimal reactive power problem. In Pioneering Poll (PP) algorithm population is general people and each person may be a candidate or a voter. Definite number of people will form dissimilar groups to set up political parties in the solution space. Advertising movement is the fundamental of this Pioneering Poll (PP) algorithm and it contains three core phases: sanguine campaign, disparate campaign and union campaign. During sanguine campaign, the nominee proclaims themselves through accentuate their positive descriptions and potentials. In the disparate campaign, candidates challenge with each other to raise their status and malign their contender. In extraordinary cases, the candidates that have equivalent information can united together in order to increase the possibility of success of the joint party. Campaign positively grounds the people to congregate to a state of solution space that is the comprehensive optimum. All these determinations lead up to poll day (end condition). On poll day, the candidate who is acquiring maximum votes is proclaimed as the conqueror and it matches to the supreme solution that is found for the reactive power problem. The proposed Pioneering Poll (PP) algorithm has been tested in standard IEEE 118 & practical 191 bus test systems and simulation results show clearly about the enhanced performance of the proposed Pioneering Poll (PP) algorithm in reducing the real power loss with voltage profiles are within the limits.

2. Objective Function

2.1. Active Power Loss

The objective of the reactive power dispatch problem is to minimize the active power loss and can be written in equations as follows:

$$F = P_L = \sum_{k \in Nbr} g_k \left(V_i^2 + V_j^2 - 2V_iV_j\cos\theta_{ij}\right) \tag{1}$$

Where F- objective function, PL – power loss, gk-conductance of branch,Vi and Vj are voltages at buses i,j,Nbr- total number of transmission lines in power systems.

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2.2. Voltage Profile Improvement

To minimize the voltage deviation in PQ buses, the objective function (F) can be written as:

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

Where VD - voltage deviation, ω_v- is a weighting factor of voltage deviation.

And the Voltage deviation given by:

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

Where Npq- number of load buses

2.3. Equality Constraint

The equality constraint of the problem is indicated by the power balance equation as follows:

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

Where P_G- total power generation, P_D - total power demand.

2.4. Inequality Constraints

The inequality constraint implies the limits on components in the power system in addition to the limits created to make sure system security. Upper and lower bounds on the active power of slack bus (P_g), and reactive power of generators (Q_g) are written as follows:

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

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

Upper and lower bounds on the bus voltage magnitudes(V_i) is given by:

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

Upper and lower bounds on the transformers tap ratios (T_i) is given by:

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

Upper and lower bounds on the compensators (Q_c) is given by:

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

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

 ISSN- 2350-0530(O), ISSN- 2394-3629(P)
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3. Pioneering Poll (PP) algorithm

This Pioneering Poll (PP) algorithm is alike to the poll procedure around the world. Similar numerous other evolutionary algorithms, PP algorithm is depend on an intellectual exploration however restricted solution space using its actuators including optimistic campaign, opposing campaign and alliance campaign.

In $M_{variable}$-dimensional ($M_{variable}$- variables) problem, each people is designed an array of variable values to be optimized. If the people $M_{variable}$ has given by $y_1, y_2, y_3, .., yM_{variable}$ then the people isengraved as an $1 \times M_{variable}$element row vector, which written as,

$$people = [y_1, y_2, y_3, .., yM_{variable}] \quad (10)$$

In the PP, each people must be allocated a fitness value, which is associated to the objective function of the problem. A fitness function is used to calculate the capacity and credentials of peoples. In the optimization problems, the key goal is to find a solution having the least possible cost. Thus, in the PP, the persons who have lesser cost then superior fitness values are allocated to them. The fitness of an individual is found by calculating the fitness function $n$at the$y_1, y_2, y_3, .., yM_{variable}$ the associated objective function. Consequently, we obligate:

$$fitness = n(people) = n(y_1, y_2, y_3, .., yM_{variable}) \quad (11)$$

In maximization problems, the fitness of people is equivalent to the value of problem objective function. However, in our reactive power optimization problem (minimization optimization problem), the people with superior objective function value will get lesser fitness value. It is given by

$$fitness = -n(people) = -n(y_1, y_2, y_3, .., yM_{variable}) \quad (12)$$

To commence the PP, we define a preliminary population of $M_{population}$ peoples. The preliminary population is $M_{variable}$ occupied with arbitrarily created peoples. Each row in the matrix is representative of a people and is being $1 \times M_{variables}$ array of variable values. Then the value of each one is appraised by the fitness function. So at this point, the peoples are approved to the fitness function to weigh their ability. Subsequently creating the preliminary population, we split the entire peoples into some political parties in the solution space. To accomplish this goal, the M_c peoplesarbitrarily are nominated to be candidates and the remaining$M_v$peoples will form the preliminary followers of these candidates. The contender rate, D_r , is the fraction of $M_{population}$ that nominated as the preliminary candidates. Thus, the number of peoples that are nominated as preliminary candidates is given by,

$$M_c = \left[D_r \times M_{population}\right] \quad (13)$$

To pick a proper D_r value, algorithm has been run quite a lot of times. Subsequently investigational study [21], we clinched that 10 –12 % of the population is a fitting value as the preliminary number of candidates in forming preliminary parties. The remaining $M_v = M_{population} - M_c$peoples are the entire number of preliminary followers of the stated candidates.

In PP, the opinions and thinking of the peoples are determined using the fitness function. All the followers are alienated between the candidates based on the similarity of opinions and thinking. Thus, the fitness distance between peoples and candidates are computed to divide peoples among candidates. To do so, Euclidean distance metric is used as similarity measure that is given by,

 ISSN- 2350-0530(O), ISSN- 2394-3629(P)
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$$distance(a_i, b_j) = \sqrt{\sum_{j=1}^{M_c}(Ga_i - Gb_j)^2} \quad (14)$$

Where $M_c$is the number of all candidates,Ga_idesignates the fitness of *i*th voter, Gb_jdesignates the fitness of *j*th candidate, and $distance(a_i, b_j)$ designates the fitness distance between the votera_i and the $b_j$candidate. Each voter is consigned to the party whose the fitness of candidate is flanking to. In other words, peoplea_p is considered as a follower of candidateb_i, if the following grasps,

$$H_i = \{a_p: \|G_{ap} - G_{bi}\| < \|G_{ap} - G_{bi}\| \forall 1 \leq j \leq M_c\} \quad (15)$$

Where $H_i$is the *i*th party, $G_{ap}$and G_{bi}designates the fitness of voter $a_p$and candidateb_i, correspondingly,$\|G_{ap} - G_{bi}\|$is the selected dissimilarity measure between voter a_p and candidateb_i, and it specifies the fitness distance between them, and $M_c$is the number of all candidates. In this each people a_p is assigned to precisely one party H_i.

4. Campaign

Once the preliminary parties are designed, candidates begin their promotion campaign. In campaign trail, the widespread candidates are armoured; the ostracised candidates are faded and may be stoic from the poll ground. As mentioned before, campaign is the core part of the Pioneering Poll (PP) algorithm and comprises three key phases: sanguine campaign, disparate campaign and union campaign.

4.1. Sanguine Campaign

During sanguine campaign, candidates commence to expose their strategies and concepts to voters and attempt to sway the judgments made by voters. Candidates stab to generate a long-lasting impress with the voters. To accomplish this goal, in each party, the $M_s$variable values of the candidate are arbitrarily designated. Following arbitrary numbers are selected to choose the position of variables in followers to be swapped. Then, the designated variables from candidate are swapped with the designated variables of the followers. In this paper, choice rate $(Y_s)$is selected as an arbitrary value in range [0, 1]. In all iteration, the number of variable values that transported from a candidate toward its followers is given by

$$M_s = [Y_s \times Q_c] \quad (16)$$

Where $M_s$indicates the number of designated variables of candidate to be swapped,$Y_s$is the choice rate, and $Q_c$is the total number of variables of candidate.

It is flawless that, in a poll party based on the fitness distance between candidate and its related followers, the efficacy of campaign differs. Consequently, it is rational to consider the effect of fitness distance between candidate and its related followers. To accomplish this goal, we defined fitness distance coefficient (φ_e) as follows,

$$\varphi_e = \frac{1}{distance\ (M_c - M_v) + 1} \quad (17)$$

Where$M_c$and M_v are the fitness of candidate *c* and voter *v*, respectively. In this paper, Euclidean distance metric is used to calculate distance between $M_c and\ M_v$

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In campaign procedure, after choosing $M_s$and calculating $\varphi_e$the value of selected variables from candidate are multiplied in coefficient $\varphi_e$and then swapped with the selected variables of the related followers. In other word, given f_{iold} be the value of ith selected variable of the follower before campaign progression, then after promotion, the new-fangled value of this variable is given as follows:

$$f_{inew} = \varphi_e \times f_{iold} \quad (18)$$

Based on Equation (16), in campaign procedure, the closer followers are much more affected by their related candidate than farther followers.

4.2. Disparate Campaign

Candidates through disparate campaign try to fascinate the followers of other parties toward themselves. It leads to an upsurge in the popularity of popular parties and equally a decrease in the popularity of ostracised parties.

At first in the defender party, the distance of the fitness between the followers and the candidate is calculated. By using Euclidean distance metric, the distance is given by,

$$distance(d_i, e_l) = \sqrt{\sum_{j=1}^{M_v}\left(G_{d_i} - G_{e_l}\right)^2} \quad (19)$$

Where $M_v$is the number of all voters in defender party, $e_l$specifies the candidate of defender party andd_i indicates the ith supporter of the defender party. $G_{d_i}$and$G_{e_l}$are the eligibility of candidate $e_l$and ith supporter, respectively. Then, 10 % of the farthest followers are selected based on the distance measure.

4.3. Union Campaign

Alike to the process of candidate’s coalition in an actual poll, there will be two or more than two candidates in the solution space become very much closer together. In that case, they can join and form a new party. Consequently, some candidates leave the campaign and join to another candidate who is called “head”. The candidate who leaves the poll ground is called “supporter”. The supporter candidates organize to the head one and cheer their followers to follow the head. All of the followers of the supporter candidates become the followers of the head one.

4.4. Ending Phase

Until end condition is satisfied, sanguine campaign, disparate campaign and union campaign are applied to modernize the population. Ultimately a candidate that reaches the maximum votes will announce as the winner and is equivalent to the finest solution, which is found for the problem. In this paper, the maximum iteration number is considered as the stopping state of the Pioneering Poll (PP) algorithm.

4.5. Pioneering Poll (PP) Algorithm for Solving Reactive Power Problem

Start
Create initial population
Calculate fitness for each individual
Form parties: initial candidates and their followers

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Repeat: campaign days
For candidate dimension do
Sanguine campaign
Candidates endorse their plans and discover new strategy
Disparate campaign
Candidates charm the faction from other parties
Union campaign
Candidates will ally on basis of common information
Adaptation of the stipulation of parties
Re-examine the fitness of the candidates
End for
Until population has been converged (poll day)
End

5. Simulation Results

At first Pioneering Poll (PP) algorithm has been tested in standard IEEE 118-bus test system [22].The system has 54 generator buses, 64 load buses, 186 branches and 9 of them are with the tap setting transformers. The limits of voltage on generator buses are 0.95 -1.1 per-unit., and on load buses are 0.95 -1.05 per-unit. The limit of transformer rate is 0.9 -1.1, with the changes step of 0.025. The limitations of reactive power source are listed in Table 1, with the change in step of 0.01.

Table 1: Limitation of reactive power sources

BUS	5	34	37	44	45	46	48
QCMAX	0	14	0	10	10	10	15
QCMIN	-40	0	-25	0	0	0	0
BUS	74	79	82	83	105	107	110
QCMAX	12	20	20	10	20	6	6
QCMIN	0	0	0	0	0	0	0

The statistical comparison results of 50 trial runs have been list in Table 2 and the results clearly show the better performance of proposed PP approach.

Table 2: Comparison results

Active power loss (p.u)	**BBO [23]**	**ILSBBO/ strategy1 [23]**	**ILSBBO/ strategy1 [23]**	**Proposed PP**
Min	128.77	126.98	124.78	118.36
Max	132.64	137.34	132.39	122.28
Average	130.21	130.37	129.22	119.54

Then the Pioneering Poll (PP) algorithm has been tested in practical 191 test system and the following results have been obtained. In Practical 191 test bus system – Number of Generators = 20, Number of lines = 200, Number of buses = 191 Number of transmission lines = 55. Table 3 shows the optimal control values of practical 191 test system obtained by PP method. And table 4 shows the results about the value of the real power loss by obtained by Pioneering Poll (PP) algorithm.

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Table 3: Optimal Control values of Practical 191 utility (Indian) system by PP method

VG1	1.10		VG 11	0.90
VG 2	0.78		VG 12	1.00
VG 3	1.01		VG 13	1.00
VG 4	1.01		VG 14	0.90
VG 5	1.10		VG 15	1.00
VG 6	1.10		VG 16	1.00
VG 7	1.10		VG 17	0.90
VG 8	1.01		VG 18	1.00
VG 9	1.10		VG 19	1.10
VG 10	1.01		VG 20	1.10

T1	1.00		T21	0.90		T41	0.90
T2	1.00		T22	0.90		T42	0.90
T3	1.00		T23	0.90		T43	0.91
T4	1.10		T24	0.90		T44	0.91
T5	1.00		T25	0.90		T45	0.91
T6	1.00		T26	1.00		T46	0.90
T7	1.00		T27	0.90		T47	0.91
T8	1.01		T28	0.90		T48	1.00
T9	1.00		T29	1.01		T49	0.90
T10	1.00		T30	0.90		T50	0.90
T11	0.90		T31	0.90		T51	0.90
T12	1.00		T32	0.90		T52	0.90
T13	1.01		T33	1.01		T53	1.00
T14	1.01		T34	0.90		T54	0.90
T15	1.01		T35	0.90		T55	0.90
T19	1.02		T39	0.90			
T20	1.01		T40	0.90			

Table 4: Optimum real power loss values obtained for practical 191 utility (Indian) system by PP method.

Real power Loss (MW)	**PP**
Min	146.002
Max	149.084
Average	148.026

6. Conclusion

In this paper, Pioneering Poll (PP) algorithm has been successfully solved optimal reactive power problem. In Pioneering Poll (PP) algorithm population is general people and each person may be a candidate or a voter. Definite number of people will form dissimilar groups to set up political parties in the solution space. The proposed Pioneering Poll (PP) algorithm has been tested in standard IEEE 118 & practical 191 bus test systems and simulation results show clearly

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