A Novel Merchant Optimization Algorithm for Solving Optimal Reactive Power Problem

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K. Lenin

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Abstract: *In this paper Merchant Optimization Algorithm (MOA) is proposed to solve the optimal reactive power problem. Projected algorithm is modeled based on the behavior of merchants who gain in the market through various mode and operations. Grouping of the traders will be done based on their specific properties, and by number of candidate solution will be computed to individual merchant. First Group named as "Ruler candidate solution" afterwards its variable values are dispersed to the one more candidate solution and it named as "Serf candidate solution" In standard IEEE 14, 30, 57 bus test systems Merchant Optimization Algorithm (MOA) have been evaluated. Results show the proposed algorithm reduced power loss effectively.*

Keywords: *Optimal reactive power, Transmission loss, Merchant Optimization Algorithm*

1. Introduction

Reactive power problem plays a key role in secure and economic operations of power system. Optimal reactive power problem has been solved by variety of types of methods ([1-6]) . Nevertheless numerous scientific difficulties are found while solving problem due to an assortment of constraints. Evolutionary techniques ([7-16]) are applied to solve the reactive power problem, but the main problem is many algorithms get stuck in local optimal solution & failed to balance the Exploration & Exploitation during the search of global solution. In this paper Merchant Optimization Algorithm (MOA) has been proposed to solve the optimal reactive power problem. Projected algorithm is modeled based on the behavior of merchants who gain in the market through various mode and operations. Initial point of the projected algorithm all the merchants will possess same properties and in subsequent iterations properties will be updated. Then grouping of the traders will be done based on their specific properties, and by number of candidate solution will be computed to individual merchant. Subsequent to grouping of candidate solutions, then the most excellent candidate solution of each group named as "Ruler candidate solution" afterwards its variable values are dispersed to the one more candidate solution and it named as "Serf candidate solution". In standard IEEE 14, 30, 57 bus test systems [17] the proposed Merchant Optimization Algorithm (MOA) is evaluated. Simulation study shows the projected algorithm reduced power loss effectively.

2. Problem Formulation

True power loss reduction is main objective of the problem:

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

Voltage deviation given as follows:

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

Voltage deviation given by:

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

Constraint (Equality)

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

Constraints (Inequality)

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

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

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

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

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

3. Merchant Optimization Algorithm

Merchant Optimization Algorithm (MOA) has been modeled based on the behavior of merchants who gain in the market through various mode and operations.

Initialization of population through candidate solution (CS) is done through various variables and given by,

$$variousvariables = \{vv_1, vv_2, .., vv_n, G\} \quad (10)$$

Subsequent to the formation of the population the merit is computed through the objective function and with reference to the problem merit will be defined.

Initial point of the projected algorithm all the merchants will possess same properties and in subsequent iterations properties will be updated. Then grouping of the traders will be done based on their specific properties, then by following equation the number of candidate solution will be computed to individual merchant,

$$Totalnumber_i = 2 + round\left[\frac{Q_i}{\sum_{j=1}^{T} Q_J} \times (G - 2\times T)\right] \quad (11)$$

Subsequent to grouping of candidate solutions, then the most excellent candidate solution of each group named as "Ruler candidate solution" afterwards its variable values are dispersed to the one more candidate solution and it named as "Serf candidate solution" by,

$$\sum_{j=1}^{Ck}\left(\sum_{i=1}^{R}(\text{candidate solution\_Serf\_j(random)(n))} = \text{candidate solution\_Ruler\_k(random)(n)))}\right) \quad (12)$$

"Serf candidate solution" is improved by,

$$\sum_{i=1}^{R}(\text{candidate solution}_{Serf(R)} = \text{candidate solution}_{Serf(R)} + + k \times random(\text{candidate solution}_{Serf(R)})) \quad (13)$$

To "Ruler candidate solution" most excellent candidate solution are imported which has been arbitrarily chosen,

$$\sum_{j=1}^{T}\sum_{i=1}^{R}(\text{candidate solution\_Ruler\_j(random(n))} = = \text{candidate solution\_Ruler\_k(random(n)))} \quad (14)$$

$$K = = \{a | a \neq j \text{ and } a \text{ is an integer random value in } 1 \le a \le n\} \quad (15)$$

Merchant group's properties has been updated by,

$$properties_i = \left\{\sum_{j=1}^{B} OF(j) | \text{candidate solution}(j,P) = P_i\right\} \quad (16)$$

a. Initialization of parameters
b. Candidate population initiated
   For I=1 to B
   For j=1 to n
   Candidate solution (I,j) = an arbitrary in defined level
   For I=1 to T
   Modernize the total number (I) by
c. Objective function called
   For I=1 to B
   Candidate solution (I). Gain = Returned value form the objective function
d. Candidate solution grouping
   TMP =NB
   For I=1 to B
   $k = random(light(TMP)$,
   Candidate solution (I,n + 1) = k,
   TMP(k) - TMP(k) – 1
   if TMP(k) == 0 then TMP(:,k) = [ ]
e. Altering the candidate solution using
   For I=1 to T
   Ruler = most excellent candidate solution of the "I" group
   For J=1 to B
   Dispense "Ruler candidate solution" values to "Serf candidate solution" only if objective function value enhanced or else disregard the alteration
f. Altering the candidate solution using
   For I=1 to B
   Modernize the "Serf candidate solution" only if objective function value enhanced or else disregard the alteration
g. Altering the candidate solution using
   Modernize the "Ruler candidate solution" only if objective function value enhanced or else disregard the alteration
h. Modernization of the properties
   Merchant properties are updated by
   Stop if the end criterion is satisfied or else go to step "d"
i. Output the best solution

4. Simulation Results

In standard IEEE 14 bus system validity of Merchant Optimization Algorithm (MOA) has been tested, Tab. 1 gives the constraints of control variables, Tab. 2 provides the limits of reactive power generators. Tab. 3 shows the comparison results.

Tab. 1. Control variables limits

System	Variables	Minimum (PU)	Maximum (PU)
IEEE 14 Bus	Generator Voltage	0.95	1.1
	Transformer Tap	0.9	1.1
	VAR Source	0	0.20

Tab. 2. Reactive power generators limits

System	Variables	Q Minimum (PU)	Q Maximum (PU)
IEEE 14 Bus	1	0	10
	2	-40	50
	3	0	40
	6	-6	24
	8	-6	24

Tab. 3. Simulation results of IEEE −14 system

Control variables	Base case	MPSO [18]	PSO [18]	EP [18]	SARGA [18]	MOA
VG−1	1.060	1.100	1.100	NR*	NR*	1.024
VG−2	1.045	1.085	1.086	1.029	1.060	1.038
VG−3	1.010	1.055	1.056	1.016	1.036	1.037
VG−6	1.070	1.069	1.067	1.097	1.099	1.023
VG−8	1.090	1.074	1.060	1.053	1.078	1.035
Tap 8	0.978	1.018	1.019	1.04	0.95	0.940
Tap 9	0.969	0.975	0.988	0.94	0.95	0.942
Tap 10	0.932	1.024	1.008	1.03	0.96	0.946
QC−9	0.19	14.64	0.185	0.18	0.06	0.131
PG	272.39	271.32	271.32	NR*	NR*	271.90
QR (Mvar)	82.44	75.79	76.79	NR*	NR*	75.91
Reduction in PLoss (%)	0	9.2	9.1	1.5	2.5	25.40
Total PLoss (Mw)	13.550	12.293	12.315	13.346	13.216	10.108

NR* - Not reported.

Then the proposed Merchant Optimization Algorithm (MOA) is evaluated in standard IEEE 30 Bus system. Tab. 4 gives the constraints of control variables, Tab. 5 shows the limits of reactive power generators and in Tab. 6 comparison of real power loss has been given.

Tab. 4. Constraints of control variables

System	Variables	Minimum (PU)	Maximum (PU)
IEEE 30 Bus	Generator Voltage	0.95	1.1
	Transformer Tap	0.9	1.1
	VAR Source	0	0.20

Tab. 5. Constrains of reactive power generators

System	Variables	Q Minimum (PU)	Q Maximum (PU)
IEEE 30 Bus	1	0	10
	2	-40	50
	5	-40	40
	8	-10	40
	11	-6	24
	13	-6	24

Tab. 6. Simulation results of IEEE −30 system

Control variables	Base case	MPSO [18]	PSO [18]	EP [18]	SARGA [18]	MOA
VG−1	1.060	1.101	1.100	NR*	NR*	1.023
VG−2	1.045	1.086	1.072	1.097	1.094	1.030
VG−5	1.010	1.047	1.038	1.049	1.053	1.021
VG−8	1.010	1.057	1.048	1.033	1.059	1.042
VG−12	1.082	1.048	1.058	1.092	1.099	1.045
VG-13	1.071	1.068	1.080	1.091	1.099	1.037
Tap 11	0.978	0.983	0.987	1.01	0.99	0.941
Tap 12	0.969	1.023	1.015	1.03	1.03	0.943
Tap 15	0.932	1.020	1.020	1.07	0.98	0.930
Tap 36	0.968	0.988	1.012	0.99	0.96	0.941
QC 10	0.19	0.077	0.077	0.19	0.19	0.090
QC 24	0.043	0.119	0.128	0.04	0.04	0.122
PG (MW)	300.9	299.54	299.54	NR*	NR*	297.73
QC (Mvar)	133.9	130.83	130.94	NR*	NR*	131.44
Reduction in PLoss (%)	0	8.4	7.4	6.6	8.3	18.88
Total PLoss (Mw)	17.55	16.07	16.25	16.38	16.09	14.241

Then the Proposed Merchant Optimization Algorithm (MOA) has been tested, in IEEE 57 Bus system. Tab. 7 shows the constraints of control variables, Tab. 8 shows the limits of reactive power generators and comparison results are presented in Tab. 9.

Tab. 7. Constraints of control variables

	Variables type	Minimum value (PU)	Maximum value (PU)
IEEE 57 Bus	Generator Voltage	0.95	1.1
	Transformer Tap	0.9	1.1
	VAR Source	0	0.20

Tab. 8. Constrains of reactive power generators

	Variables	Q Minimum (PU)	Q Maximum (PU)
IEEE 57 Bus	1	-140	200
	2	-17	50
	3	-10	60
	6	-8	25
	8	-140	200
	9	-3	9
	12	-150	155

Tab. 9. Simulation results of IEEE −57 system

Control variables	Base case	MPSO [18]	PSO [18]	CGA [18]	AGA [18]	MOA
VG 1	1.040	1.093	1.083	0.968	1.027	1.020
VG 2	1.010	1.086	1.071	1.049	1.011	1.022
VG 3	0.985	1.056	1.055	1.056	1.033	1.023
VG 6	0.980	1.038	1.036	0.987	1.001	1.012
VG 8	1.005	1.066	1.059	1.022	1.051	1.024
VG 9	0.980	1.054	1.048	0.991	1.051	1.021
VG 12	1.015	1.054	1.046	1.004	1.057	1.030
Tap 19	0.970	0.975	0.987	0.920	1.030	0.900
Tap 20	0.978	0.982	0.983	0.920	1.020	0.901
Tap 31	1.043	0.975	0.981	0.970	1.060	0.924
Tap 35	1.000	1.025	1.003	NR*	NR*	1.012
Tap 36	1.000	1.002	0.985	NR*	NR*	1.026
Tap 37	1.043	1.007	1.009	0.900	0.990	1.025
Tap 41	0.967	0.994	1.007	0.910	1.100	0.917
Tap 46	0.975	1.013	1.018	1.100	0.980	1.024
Tap 54	0.955	0.988	0.986	0.940	1.010	0.932
Tap 58	0.955	0.979	0.992	0.950	1.080	0.930
Tap 59	0.900	0.983	0.990	1.030	0.940	0.941
Tap 65	0.930	1.015	0.997	1.090	0.950	1.042
Tap 66	0.895	0.975	0.984	0.900	1.050	0.913
Tap 71	0.958	1.020	0.990	0.900	0.950	1.022
Tap 73	0.958	1.001	0.988	1.000	1.010	1.034
Tap 76	0.980	0.979	0.980	0.960	0.940	0.941
Tap 80	0.940	1.002	1.017	1.000	1.000	1.020
QC 18	0.1	0.179	0.131	0.084	0.016	0.133
QC 25	0.059	0.176	0.144	0.008	0.015	0.141
QC 53	0.063	0.141	0.162	0.053	0.038	0.101
PG (MW)	1278.6	1274.4	1274.8	1276	1275	1272.10
QC (Mvar)	321.08	272.27	276.58	309.1	304.4	272.23
Reduction in PLoss (%)	0	15.4	14.1	9.2	11.6	26.57
Total PLoss (Mw)	27.8	23.51	23.86	25.24	24.56	20.412

NR* - Not reported.

5. Conclusion

In this paper Merchant Optimization Algorithm (MOA) solved the optimal reactive power problem effectively. Projected algorithm is modeled based on the behavior of merchants who gain in the market through various mode and operations. Initially all the merchants will possess the same properties and in subsequent iterations properties will be updated. Then grouping of the traders has been done based on their explicit properties. Proposed Merchant Optimization Algorithm (MOA) has been tested in standard IEEE 14, 30, 57 bus test systems and simulation results show the projected algorithm reduced the real power loss. Percentage of real power loss reduction has been improved.

AUTHOR

Kanagasabai Lenin – Department of Electrical and Electronics Engineering, Prasad V. Potluri Siddhartha Institute of Technology, Vijayawada, India, e-mail: gklenin@gmail.com.

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