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Real power loss diminution by predestination of particles wavering search algorithm

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ABSTRACT

In this work Predestination of Particles Wavering Search (PPS) algorithm has been applied to solve optimal reactive power problem. PPS algorithm has been modeled based on the motion of the particles in the exploration space. Normally the movement of the particle is based on gradient and swarming motion. Particles are permitted to progress in steady velocity in gradient-based progress, but when the outcome is poor when compared to previous upshot, immediately particle rapidity will be upturned with semi of the magnitude and it will help to reach local optimal solution and it is expressed as wavering movement. In standard IEEE 14, 30, 57,118,300 bus systems Proposed Predestination of Particles Wavering Search (PPS) algorithm is evaluated and simulation results show the PPS reduced the power loss efficiently.

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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 [7-15] 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 work, Predestination of Particles Wavering Search (PPS) algorithm has been applied to solve optimal reactive power problem. PPS algorithm has been modeled based on the motion of the particles in the exploration space. Particles will arbitrarily move in the exploration space in many algorithms which has been already applied to many optimization problems. In the PPS algorithm particles are distributed in the exploration space consistently. In an atom how the electrons positioned in the centre accordingly particles are in the exploration space. Normally the movement of the particle is based on gradient and swarming motion [16, 17]. When the gradient method failed then swarming is executed by inducing the particle shift towards the global most excellent position by modernizing the velocity. Validity of the Proposed Predestination of Particles Wavering Search (PPS) algorithm has been tested in standard IEEE 14, 30, 57,118, 300 bus systems and results show the projected PPS reduced the power loss effectively.

2. PROBLEM FORMULATION

Objective of the problem is to reduce the true power loss:

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

Voltage deviation given as follows:

$$\mathbf{F = P_L + \omega_v \times Voltage\ Deviation} \tag{2}$$

Voltage deviation given by:

$$\mathbf{Voltage\ Deviation \quad = \sum_{i=1}^{Npq} |V_i - 1|} \tag{3}$$

Constraint (Equality)

$$\mathbf{P_G = P_D + P_L} \tag{4}$$

Constraints (Inequality)

$$\mathbf{P_{gslack}^{min} \le P_{gslack} \le P_{gslack}^{max}} \tag{5}$$

$$\mathbf{Q_{gi}^{min} \le Q_{gi} \le Q_{gi}^{max}, i \in N_g} \tag{6}$$

$$\mathbf{V_i^{min} \le V_i \le V_i^{max}, i \in N} \tag{7}$$

$$\mathbf{T_i^{min} \le T_i \le T_i^{max}, i \in N_T} \tag{8}$$

$$Q_c^{min} \le Q_c \le Q_C^{max}, i \in N_C \tag{9}$$

3. PREDESTINATION OF PARTICLES WAVERING SEARCH ALGORITHM

Predestination of Particles Wavering Search (PPS) algorithm has been modeled based on the motion of the particles in the exploration space. Particles will arbitrarily move in the exploration space in many algorithms which has been already applied to many optimization problems. In the PPS algorithm particles are distributed in the exploration space consistently. In an atom how the electrons positioned in the centre accordingly particles are in the exploration space. Normally the movement of the particle is based on gradient and swarming motion. Particles velocity has been initiated as follows,

$$velocity_i^0 = \left[\frac{y_{best} - y_i^0}{2}\right] \tag{10}$$

Particles are permitted to progress in steady velocity in gradient-based progress, but when the outcome is poor when compared to previous upshot, immediately particle rapidity will be upturned with semi of the magnitude and it will help to reach local optimal solution and it is expressed as wavering movement. Particle moves from point of slope y_1 to y_2 then it end's in negative fitness slope and when the particle velocity is multiplied by the value -0.50, subsequently the particle moves from y_2 to y_3 then sequentially it end's in positive fitness slope, through this motion particle reach y_4 afterwards a negative fitness slope attained again by the particle then once again by -0.50 the particle velocity will be multiplied. Next at y_5 particle will attain, now the particle fitness will be positive slope, then in the same way particle continues its motion and it reach the point y_6. Once particle reaches the local optimal point $y_{optimal}$ then the velocity will be reversed again. When the gradient method failed then swarming is executed by inducing the particle shift towards the global most excellent position by modernizing the velocity as given below,

$$velocity_i^{t+1} = velocity_i^t + \left[\frac{y_{best} - y_i^t}{2}\right] \tag{11}$$

When the progress develop into constructive subsequently particle prolong to discover any more local optimal solution, and this procedure persist until maximum number of evaluation has been attained. Predestination of Particles Wavering Search (PPS) algorithm defined as follows,

```
Step 1 In the exploration space Initiate the particle's position with reference to boundary limits
Step 2: i=1; k =1
Step 3: Iterative procedure:
    With respect to upper and lower boundaries particle positions are initiated
    While (i < = sum of particles)
        Particles possible combinations has to be discovered
        For c=1: sum of combinations
            With respect to positions and combinations alter the positions of the particle $y_i$ as elevated values
            i ++
        End for
        k ++
        if (k > dimensions) / when no boundary combinations are found then leave the loop /
            Break
        End if
    End while
Step 4: Between two particles which has been already initiated some more particles are present, then factor based procedure is applied to reorganize the particle positions
    Particles number are factorized
    f=factor (n) ; n = sum of particles ; f is an array to store the factor values
    Iterative procedure:
    While (i <= n)
        For c=1: sum of factors (with reference to length of "f")
            For j=1: dimensions (p)
                For i = 1:f(c)
                    $y_i(j) = minimum(j) + k^*(maximum(j) - minimum(j))/(f(c) + 1)$
                    i++
                End
            End
            if i >n then when no boundary combinations are found then leave the loop
                Repeat step 4 with Minimum and Maximum are exchanged
                Break
            End if
        End for
    End while
```

Then with suitable parameters projected Predestination of Particles Wavering Search (PPS) algorithm is applied to solve the optimal reactive power problem as shown below,

```
Step 1: Initialization of parameters
Step 2: In the exploration space Initiate the particle's position with reference to boundary limits
Step 3: Particles fitness values are computed and most excellent particle will be identified
Step 4: Velocity of the particles are initialized through $velocity_i^0 = \left[\frac{y_{best} - y_i^0}{2}\right]$
Step 5: Iterative procedure
    While (computation number < maximum number of computation)
        For i = 1; sum of particles
            By augmenting the velocity to the present position determine new-fangled position
            With reference to new-fangled position particle fitness should be calculated
            Augmentations of computation counter, and then modernize global most excellent solution
            When (slope = = unknown) then modernize slope of the particle with reference to new fitness to be positive or negative; Otherwise when (slope = = positive)
                When (new-fangled fitness inferior than previous fitness); Then modernize velocity by $" - \frac{velocity}{2}"$ ; modernize the slope with reference to new-fangled fitness to be negative; otherwise (slope = = negative)
                When (new-fangled fitness inferior than the previous fitness)
                    Then modernize velocity by
                    $velocity + (global\ most\ excellent\ position - present\ position/2)$
                    Update slope to be unknown
```

```
End if
End for
End while
Step 6: Global most excellent particle position found with fitness value
Step 7; Output the result
```

4. SIMULATION RESULTS

In standard IEEE 14 bus system the validity of the projected Predestination of Particles Wavering Search (PPS) algorithm has been tested, Table 1 shows the constraints of control variables Table 2 shows the limits of reactive power generators and comparison results are presented in Table 3.

Table 1. Constraints of control variables

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

Table 2. Constrains of reactive power generators

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

Table 3. Simulation results of IEEE−14 system

Control variables	Base case	MPSO [18]	PSO [18]	EP [18]	SARGA [18]	PPS
$VG-1$	1.060	1.100	1.100	NR*	NR*	1.012
$VG-2$	1.045	1.085	1.086	1.029	1.060	1.013
$VG-3$	1.010	1.055	1.056	1.016	1.036	1.019
$VG-6$	1.070	1.069	1.067	1.097	1.099	1.024
$VG-8$	1.090	1.074	1.060	1.053	1.078	1.003
Tap 8	0.978	1.018	1.019	1.04	0.95	0.904
Tap 9	0.969	0.975	0.988	0.94	0.95	0.903
Tap 10	0.932	1.024	1.008	1.03	0.96	0.920
$QC-9$	0.19	14.64	0.185	0.18	0.06	0.145
PG	272.39	271.32	271.32	NR*	NR*	271.60
QG (Mvar)	82.44	75.79	76.79	NR*	NR*	74.75
Reduction in PLoss (%)	0	9.2	9.1	1.5	2.5	24.67
Total PLoss (Mw)	13.550	12.293	12.315	13.346	13.216	10.206

NR*-Not reported

Then the projected Predestination of Particles Wavering Search (PPS) algorithm has been tested, in IEEE 30 Bus system. Table 4 shows the constraints of control variables, Table 5 shows the limits of reactive power generators and comparison results are presented in Table 6.

Table 4. Constraints of control variables

System	Variables	Minimum (PU)	Maximum (PU)
IEEE 30 Bus	Generator Voltage	0.95	1.1
	Transformer Tap	o.9	1.1
	VAR Source	0	0.20

Table 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

Table 6. Simulation results of IEEE −30 system

Control variables	Base case	MPSO [18]	PSO [18]	EP [18]	SARGA [18]	PPS
$VG-1$	1.060	1.101	1.100	NR*	NR*	1.013
$VG-2$	1.045	1.086	1.072	1.097	1.094	1.014
$VG-5$	1.010	1.047	1.038	1.049	1.053	1.061
$VG-8$	1.010	1.057	1.048	1.033	1.059	1.005
$VG-12$	1.082	1.048	1.058	1.092	1.099	1.024
VG-13	1.071	1.068	1.080	1.091	1.099	1.043
Tap11	0.978	0.983	0.987	1.01	0.99	0.904
Tap12	0.969	1.023	1.015	1.03	1.03	0.912
Tap15	0.932	1.020	1.020	1.07	0.98	0.906
Tap36	0.968	0.988	1.012	0.99	0.96	0.905
QC10	0.19	0.077	0.077	0.19	0.19	0.064
QC24	0.043	0.119	0.128	0.04	0.04	0.103
PG (MW)	300.9	299.54	299.54	NR*	NR*	298.62
QG (Mvar)	133.9	130.83	130.94	NR*	NR*	130.74
Reduction in PLoss (%)	0	8.4	7.4	6.6	8.3	18.41
Total PLoss (Mw)	17.55	16.07	16.25	16.38	16.09	14.319

NR*-Not reported.

Then the proposed Predestination of Particles Wavering Search (PPS) algorithm has been tested, in IEEE 57 Bus system. Table 7 shows the constraints of control variables, Table 8 shows the limits of reactive power generators and comparison results are presented in Table 9.

Table 7. constraints of control variables

System	Variables	Minimum (PU)	Maximum (PU)
IEEE 57 Bus	Generator Voltage	0.95	1.1
	Transformer Tap	o.9	1.1
	VAR Source	0	0.20

Table 8. Constrains of reactive power generators

System	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

Table 9. Simulation results of IEEE−57 system

Control variables	Base case	MPSO [18]	PSO [18]	CGA [18]	AGA [18]	PPS
VG 1	1.040	1.093	1.083	0.968	1.027	1.024
VG 2	1.010	1.086	1.071	1.049	1.011	1.013
VG 3	0.985	1.056	1.055	1.056	1.033	1.033
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	1.030
VG 9	0.980	1.054	1.048	0.991	1.051	1.014
VG 12	1.015	1.054	1.046	1.004	1.057	1.042
Tap 19	0.970	0.975	0.987	0.920	1.030	0.953
Tap 20	0.978	0.982	0.983	0.920	1.020	0.934
Tap 31	1.043	0.975	0.981	0.970	1.060	0.920
Tap 35	1.000	1.025	1.003	NR*	NR*	1.012
Tap 36	1.000	1.002	0.985	NR*	NR*	1.004
Tap 37	1.043	1.007	1.009	0.900	0.990	1.005
Tap 41	0.967	0.994	1.007	0.910	1.100	0.990
Tap 46	0.975	1.013	1.018	1.100	0.980	1.010
Tap 54	0.955	0.988	0.986	0.940	1.010	0.973
Tap 58	0.955	0.979	0.992	0.950	1.080	0.962
Tap 59	0.900	0.983	0.990	1.030	0.940	0.961
Tap 65	0.930	1.015	0.997	1.090	0.950	1.003
Tap 66	0.895	0.975	0.984	0.900	1.050	0.952
Tap 71	0.958	1.020	0.990	0.900	0.950	1.003
Tap 73	0.958	1.001	0.988	1.000	1.010	1.004
Tap 76	0.980	0.979	0.980	0.960	0.940	0.961

Table 9. Simulation results of IEEE−57 system (*Continued)*

Control variables	Base case	MPSO [18]	PSO [18]	CGA [18]	AGA [18]	PPS
Tap 80	0.940	1.002	1.017	1.000	1.000	1.003
QC 18	0.1	0.179	0.131	0.084	0.016	0.172
QC 25	0.059	0.176	0.144	0.008	0.015	0.160
QC 53	0.063	0.141	0.162	0.053	0.038	0.142
PG (MW)	1278.6	1274.4	1274.8	1276	1275	1270.12
QG (Mvar)	321.08	272.27	276.58	309.1	304.4	272.33
Reduction in PLoss (%)	0	15.4	14.1	9.2	11.6	23.36
Total PLoss (Mw)	27.8	23.51	23.86	25.24	24.56	21.305

NR*-Not reported.

Then the Predestination of Particles Wavering Search (PPS) algorithm has been tested, in IEEE 118 Bus system. Table 10 shows the constraints of control variables and comparison results are presented in Table 11.

Table 10. Constraints of control variables

System	Variables	Minimum (PU)	Maximum (PU)
IEEE 118 Bus	Generator Voltage	0.95	1.1
	Transformer Tap	o.9	1.1
	VAR Source	0	0.20

Table 11. Simulation results of IEEE−118 system

Control variables	Base case	MPSO [18]	PSO [18]	PSO [18]	CLPSO [18]	PPS
VG 1	0.955	1.021	1.019	1.085	1.033	1.013
VG 4	0.998	1.044	1.038	1.042	1.055	1.042
VG 6	0.990	1.044	1.044	1.080	0.975	1.024
VG 8	1.015	1.063	1.039	0.968	0.966	1.003
VG 10	1.050	1.084	1.040	1.075	0.981	1.012
VG 12	0.990	1.032	1.029	1.022	1.009	1.021
VG 15	0.970	1.024	1.020	1.078	0.978	1.034
VG 18	0.973	1.042	1.016	1.049	1.079	1.042
VG 19	0.962	1.031	1.015	1.077	1.080	1.034
VG 24	0.992	1.058	1.033	1.082	1.028	1.010
VG 25	1.050	1.064	1.059	0.956	1.030	1.031
VG 26	1.015	1.033	1.049	1.080	0.987	1.050
VG 27	0.968	1.020	1.021	1.087	1.015	0.902
VG31	0.967	1.023	1.012	0.960	0.961	0.901
VG 32	0.963	1.023	1.018	1.100	0.985	0.913
VG 34	0.984	1.034	1.023	0.961	1.015	1.002
VG 36	0.980	1.035	1.014	1.036	1.084	1.001
VG 40	0.970	1.016	1.015	1.091	0.983	0.960
VG 42	0.985	1.019	1.015	0.970	1.051	1.001
VG 46	1.005	1.010	1.017	1.039	0.975	1.002
VG 49	1.025	1.045	1.030	1.083	0.983	1.003
VG 54	0.955	1.029	1.020	0.976	0.963	0.920
VG 55	0.952	1.031	1.017	1.010	0.971	0.961
VG56	0.954	1.029	1.018	0.953	1.025	0.954
VG 59	0.985	1.052	1.042	0.967	1.000	0.963
VG 61	0.995	1.042	1.029	1.093	1.077	0.970
VG 62	0.998	1.029	1.029	1.097	1.048	0.982
VG 65	1.005	1.054	1.042	1.089	0.968	1.001
VG 66	1.050	1.056	1.054	1.086	0.964	1.002
VG 69	1.035	1.072	1.058	0.966	0.957	1.050
VG 70	0.984	1.040	1.031	1.078	0.976	1.034
VG 72	0.980	1.039	1.039	0.950	1.024	1.020
VG 73	0.991	1.028	1.015	0.972	0.965	1.013
VG 74	0.958	1.032	1.029	0.971	1.073	1.014
VG 76	0.943	1.005	1.021	0.960	1.030	1.005
VG 77	1.006	1.038	1.026	1.078	1.027	1.006
VG 80	1.040	1.049	1.038	1.078	0.985	1.003
VG 85	0.985	1.024	1.024	0.956	0.983	1.014
VG 87	1.015	1.019	1.022	0.964	1.088	1.013
VG 89	1.000	1.074	1.061	0.974	0.989	1.042
VG 90	1.005	1.045	1.032	1.024	0.990	1.031
VG 91	0.980	1.052	1.033	0.961	1.028	1.000
VG 92	0.990	1.058	1.038	0.956	0.976	1.031

Table 11. Simulation results of IEEE−118 system (*Continued*)

Control variables	Base case	MPSO [18]	PSO [18]	PSO [18]	CLPSO [18]	PPS
VG 99	1.010	1.023	1.037	0.954	1.088	1.003
VG 100	1.017	1.049	1.037	0.958	0.961	1.001
VG 103	1.010	1.045	1.031	1.016	0.961	1.010
VG 104	0.971	1.035	1.031	1.099	1.012	1.001
VG 105	0.965	1.043	1.029	0.969	1.068	1.050
VG 107	0.952	1.023	1.008	0.965	0.976	1.012
VG 110	0.973	1.032	1.028	1.087	1.041	1.014
VG 111	0.980	1.035	1.039	1.037	0.979	1.000
VG 112	0.975	1.018	1.019	1.092	0.976	1.091
VG 113	0.993	1.043	1.027	1.075	0.972	1.000
VG 116	1.005	1.011	1.031	0.959	1.033	1.001
Tap 8	0.985	0.999	0.994	1.011	1.004	0.943
Tap 32	0.960	1.017	1.013	1.090	1.060	1.000
Tap 36	0.960	0.994	0.997	1.003	1.000	0.951
Tap 51	0.935	0.998	1.000	1.000	1.000	0.933
Tap 93	0.960	1.000	0.997	1.008	0.992	1.002
Tap 95	0.985	0.995	1.020	1.032	1.007	0.970
Tap 102	0.935	1.024	1.004	0.944	1.061	1.001
Tap 107	0.935	0.989	1.008	0.906	0.930	0.942
Tap 127	0.935	1.010	1.009	0.967	0.957	1.000
QC 34	0.140	0.049	0.048	0.093	0.117	0.002
QC 44	0.100	0.026	0.026	0.093	0.098	0.021
QC 45	0.100	0.196	0.197	0.086	0.094	0.163
QC 46	0.100	0.117	0.118	0.089	0.026	0.120
QC 48	0.150	0.056	0.056	0.118	0.028	0.042
QC 74	0.120	0.120	0.120	0.046	0.005	0.110
QC 79	0.200	0.139	0.140	0.105	0. 148	0.102
QC 82	0.200	0.180	0.180	0.164	0.194	0.150
QC 83	0.100	0.166	0.166	0.096	0.069	0.123
QC 105	0.200	0.189	0.190	0.089	0.090	0.151
QC 107	0.060	0.128	0.129	0.050	0.049	0.133
QC 110	0.060	0.014	0.014	0.055	0.022	0.001
PG(MW)	4374.8	4359.3	4361.4	NR*	NR*	4362.10
QG(MVAR)	795.6	604.3	653.5	NR*	NR*	610.11
Reduction in PLOSS (%)	0	11.7	10.1	0.6	1.3	13.84
Total PLOSS (Mw)	132.8	117.19	119.34	131.99	130.96	114.418

NR*-Not reported.

Then IEEE 300 bus system [18] is used as test system to authenticate the good performance of the Predestination of Particles Wavering Search (PPS) algorithm. Table 12 shows the comparison of real power loss obtained after optimization.

Table 12. Comparison of real power loss

Parameter	Method EGA [20]	Method EEA [20]	Method CSA [21]	PPS
PLOSS (MW)	646.2998	650.6027	635.8942	610.3371

5. CONCLUSION

In this work Predestination of Particles Wavering Search (PPS) algorithm successfully solved the optimal reactive power problem. In the PPS algorithm particles are distributed in the exploration space consistently. In an atom how the electrons positioned in the centre accordingly particles are in the exploration space. Normally the movement of the particle is based on gradient and swarming motion. Particles are permitted to progress in steady velocity in gradient-based progress, but when the outcome is poor when compared to previous upshot, immediately particle rapidity will be upturned. In standard IEEE 14, 30, 57,118, 300 bus systems Predestination of Particles Wavering Search (PPS) algorithm have been tested and power loss has been reduced efficiently.

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