

Solving optimal reactive power problem by hurricane search optimization algorithm

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ABSTRACT

In this paper proposed hurricane search optimization (HSO) algorithm is proposed to solve optimal reactive power problem. An upward motion of air is caused due to release of heat which creates a low-pressure zone and by the rotation of the earth that is set into spin. In this spiraling airflow when energy is high then hurricane is created. Projected HSO algorithm design is based on the examination of the horizontal wind structure in a hurricane and how the wind parcels the progression in the neighboring atmosphere. A mixture of wind models has been developed for past few years to Backtesting and to compute hurricane exterior wind fields. Proposed HSO algorithm has been tested in standard IEEE 30, 57bus test systems and simulation results show the projected algorithm reduced the real power loss considerably.

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1. INTRODUCTION

Reactive power problem is important for economic operations of power system. To solve the problem numerous types of methods [1-16] have been utilized. This paper proposes hurricane search optimization (HSO) algorithm to solve the problem. Over tropical and subtropical oceans with warm core hurricane is a low-pressure zone will be formed. A large amount of energy from the sun is received by the tropical and subtropical oceans. In the form of water vapor this energy is let into the environment. Towards the center, winds are primarily amplified in exponential mode, subsequently plunge quickly towards quiet. Towards the center pressure diminish exponentially and within the hurricane eye it settle down in a reasonably plane region of lowest pressure. A swirling flow can be described in parametric mode of a Rankine vortex model. Center of the flow is in solid rotation mode in the inner radial region. Whereas the outer region is liberated of vorticity and a swirling flow can be described in parametric mode of a Rankine vortex model. Center of the flow is in solid rotation mode in the inner radial region. Proposed HSO algorithm has been tested in standard IEEE 30, 57 bus test systems and simulation results show the projected algorithm reduced the real power loss considerably.

2. PROBLEM FORMULATION

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

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

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

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

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

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

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

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

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

3. HURRICANE SEARCH OPTIMIZATION ALGORITHM

Over tropical and subtropical oceans with warm core hurricane is a low-pressure zone will be formed. A large amount of energy from the sun is received by the tropical and subtropical oceans. In the form of water vapor this energy is let into the environment. An upward motion of air is caused due to release of heat which creates a low-pressure zone and by the rotation of the earth that is set into spin. Towards the center, winds are primarily amplified in exponential mode, subsequently plunge quickly towards quiet. Towards the center Pressure diminish exponentially and within the hurricane eye it settle down in a reasonably plane region of lowest pressure. In hurricane Vortex created on the zenith of the horizontal surface can be approximated by using logarithmic (log) spiral pattern log spirals and it can be defined by:

$$r(\theta) = a \cdot \exp(b \cdot \theta), \begin{cases} x(\theta) = r(\theta) \cos(\theta) + e_x \\ y(\theta) = r(\theta) \sin(\theta) + e_y \end{cases} \quad (10)$$

A swirling flow can be described in parametric mode of a Rankine vortex model.

$$V = V_{\max} \frac{r}{R_{\max}} \text{ if } r < R_{\max} \quad (11)$$

$$V = V_{\max} \left(\frac{R_{\max}}{r} \right)^x \text{ if } r > R_{\max} \quad (12)$$

$$X_i = (x_i^1, \dots, x_i^d, \dots, x_i^n) \text{ for } i=1,2,3,\dots,N \quad (13)$$

$$x_i^j = \begin{cases} r_i(t) \cos(\varphi_{\text{initial}}^i + \varphi_i(t)) + e_j & \text{if } j = k \\ r_i(t) \sin(\varphi_{\text{initial}}^i + \varphi_i(t)) + e_j & \text{if } j = k + 1 \\ e_j & \text{otherwise} \end{cases} \quad (14)$$

$$r_i(t) = R_o \cdot \exp(\text{random} \cdot \varphi_i(t)) \quad (15)$$

In the interval $[0, 2\pi]$ $\varphi_{\text{initial}}^i$ for $i=1, 2, 3, \dots, N$ are arbitrarily engendered.

$$\begin{cases} \varphi_i(t+1) = \varphi_i(t); \text{ if } r_i \leq R_{\max} \\ \varphi_i(t+1) = \varphi_i(t) + \omega \cdot \left(\frac{R_{\max}}{r} \right)^{\text{random}}; \text{ if } r_i > R_{\max} \end{cases} \quad (16)$$

Every time parcel X_i^k alters its position, pressure then P_i weighs against to the eye pressure P_{eye} .

$$P_i = \text{fit}_i(t) = f(x_i^1, \dots, x_i^d, \dots, x_i^n) \quad (17)$$

$$P_{\text{eye}} = \begin{cases} \arg \min_{i \in \{1, \dots, N\}} \text{fit}_i \text{ minimization} \\ - \arg \max_{i \in \{1, \dots, N\}} \text{fit}_i \text{ maximization} \end{cases} \quad (18)$$

Initialization of parameters
 $\overline{ey\bar{e}} \leftarrow \text{random position}$
For $j = 1$: iteration Maximum
For $i = 1$: N

$$r_i = R_o \cdot \text{exponential}(\text{random}() \cdot \varphi_i)$$

$$\overline{X}_i = \overline{ey\bar{e}}$$

$k = i \bmod (n - 1)$; $x_i^k = r_i * \cos(\varphi_i) + e_k$; $x_i^{k+1} = r_i * \cos(\varphi_i) + e_{k+1}$
 When $\text{out}(x_i^k)$ then $\varphi_{i \text{ initial}} = \text{random in } [0, 2\pi]$; when $\text{out}(x_i^{k+1})$ then $\varphi_i = 0$
 Else if $\text{pressure}(\overline{X}_i) < \text{pressure}(\overline{ey\bar{e}})$

$$\overline{ey\bar{e}} := \overline{X}_i$$

Else
 when $r_i < R_{max}$ then $\varphi_i := \varphi_i + \omega$
 Else

$$\varphi_i := \varphi_i + \omega * \left(\frac{R_{max}}{r_i} \right)^{\text{random}()}$$

End
 Return $\overline{ey\bar{e}}$

4. SIMULATION STUDY

HSO algorithms is tested, in IEEE 30 and 57 Bus systems [17]. Comparison results are presented in Table 1 and Table 2.

Table 1. Simulation results of IEEE-30 system

Control variables	Base case	MPSO [18]	PSO [18]	EP [18]	SARGA [18]	HSO
PG (MW)	300.9	299.54	299.54	NR*	NR*	298.98
QG (Mvar)	133.9	130.83	130.94	NR*	NR*	130.73
Reduction in PLoss (%)	0	8.4	7.4	6.6	8.3	14.90
Total PLoss (Mw)	17.55	16.07	16.25	16.38	16.09	14.935

Table 2. Simulation results of IEEE-57 system

Control variables	Base case	MPSO [18]	PSO [18]	CGA [18]	AGA [18]	HSO
Reduction in PLoss (%)	0	15.4	14.1	9.2	11.6	25.39
Total PLoss (Mw)	27.8	23.51	23.86	25.24	24.56	20.741

5. CONCLUSION

In this paper HSO algorithm successfully solved the optimal reactive power problem. A mixture of wind models has been developed for past few years to Backtesting and to compute hurricane exterior wind fields. In hurricane Vortex created on the zenith of the horizontal surface can be approximated by using logarithmic (log) spiral pattern log spirals. Center of the flow is in solid rotation mode in the inner radial region. Proposed HSO algorithm has been evaluated in IEEE 30, 57 bus test systems. The simulation result show that power loss reduction is obtained.

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