

Perspectives on Multidisciplinary Research in Science and Technology: *Concepts and Statistical Approaches*

Mrs. DIMPLE JUNEJA
Dr. VIKAS SINGH
Dr. P. PUSHPA
Mrs. ANNIE.D



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Mrs. DIMPLE JUNEJA

Research Scholar, Department of Education,
Mohanlal Sukhadia University
Udaipur, Rajasthan, India

Dr. VIKAS SINGH

Head, Department of Chemistry
National Post Graduate College
Lucknow, India.

Dr. P. PUSHPA

Assistant Professor, Department of Mathematics
St. Peter's Institute of Higher Education and Research
Chennai

Mrs. ANNIE.D

Assistant Professor, Department of English
The Quaide Milleth College for Men
Medavakkam, Chennai, India.

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PREFACE

The pursuit of knowledge in the twenty-first century is defined by the convergence of diverse disciplines. Traditional boundaries between fields of science, engineering, mathematics, and technology are steadily dissolving, giving rise to a multidisciplinary approach that offers both depth and breadth in addressing contemporary challenges. This book, *Perspectives on Multidisciplinary Research in Science and Technology: Concepts and Statistical Approaches*, reflects this dynamic evolution by bringing together research contributions that blend conceptual foundations with analytical and computational methods.

One of the central themes of this volume is the use of quantitative and statistical approaches to decode complex real-world problems. From analyzing economic patterns in the food and beverage sector to exploring algorithmic strategies for traffic and energy optimization, the chapters illustrate how data-driven insights can guide practical decision-making. Such statistical and computational perspectives not only enhance prediction and efficiency but also strengthen the link between theoretical research and societal applications.

At the same time, the book underscores the importance of mathematical frameworks and graph-theoretic explorations, which remain the backbone of computational sciences. Studies on domination numbers, solvability in combinatorial games, and chromatic properties of graphs highlight how abstract mathematical concepts continue to shape modern applications in cryptography, optimization, and network systems. These works

remind us that innovation is deeply rooted in rigorous conceptual foundations.

Another significant dimension of the book lies in its focus on emerging technologies such as Artificial Intelligence (AI) and metaheuristic algorithms. By demonstrating how machine learning can transform workforce performance prediction or how swarm intelligence methods like krill herd and flower pollination algorithms optimize energy dispatch, the book showcases the transformative power of intelligent systems. Such advances are not merely technical triumphs but also harbingers of sustainable solutions to pressing global concerns.

The book also ventures into biomedical research and computational drug discovery, reflecting the growing synergy between life sciences and computational modeling. Chapters dedicated to in silico multi-targeting of cancer pathways and structure-based drug design highlight how multidisciplinary collaboration can accelerate therapeutic innovation. These contributions bridge chemistry, biology, and informatics, exemplifying how science can directly contribute to improved healthcare outcomes.

Altogether, this collection of fourteen chapters serves as a testament to the integrative spirit of modern research. By uniting perspectives from statistics, mathematics, computer science, engineering, and life sciences, the book provides a platform for scholars, researchers, and practitioners to appreciate the interconnectedness of knowledge. It is our hope that the insights offered herein will not only advance academic inquiry but also inspire further multidisciplinary collaborations that address the challenges and opportunities of our rapidly evolving world. We

would like to extend our sincere thanks to our publisher, **Scientific Research Reports, Chennai**, India, for their dedicated efforts in preparing this book, which provides enriched content.

Wishes and Regards,

Mrs. DIMPLE JUNEJA

Research Scholar (Education) from Mohanlal Sukhadia University, Udaipur, Rajasthan.

Dr. VIKAS SINGH

Department of Chemistry, National Post Graduate College, Lucknow.

Dr. P. PUSHPA

Department of Mathematics, St. Peter's Institute of Higher Education and Research, Chennai.

Mrs. ANNIE.D

Department of English, The Quaide Milleth College for Men, Medavakkam, Chennai.

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A Flower Pollination Algorithm Approach or Optimal Reactive Power Dispatch

**S.Vijayaraj^a, M.K.Soundarya^b, R.Chandrasekaran^c,
K.Parthasarathy^d**

^{a*} Assistant Professor, Department of EEE, VISTAS, Chennai

^b Assistant Professor, Department of Civil Engineering, VISTAS, Chennai

^c Assistant Professor, Department of Bio-Medical Engineering, VISTAS, Chennai

^d Assistant Professor, Department of EEE, Indian Naval Academy, Kozhikode, India

Abstract

This paper proposes an effective and robust evolutionary optimization technique, known as the Flower Pollination Algorithm (FPA), to address the Optimal Reactive Power Dispatch (ORPD) problem in power systems. The performance of the proposed FPA is evaluated using the standard IEEE 30-bus test system, where control variables include bus voltages, transformer tap settings, and reactive power sources. The objective functions considered are the minimization of active power transmission losses, total voltage deviation, and enhancement of the voltage stability index. The results obtained using FPA are compared with those from other recently developed evolutionary algorithms reported in the literature. Simulation outcomes demonstrate that FPA provides superior performance in terms of solution quality, effectiveness, and convergence speed, making it a promising tool for solving the ORPD problem.

Keywords Optimal Reactive Power Dispatch; Flower Pollination

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Algorithm; Loss Minimization; Voltage Stability; ORPD;

1. Introduction

The Optimal Reactive Power Dispatch (ORPD) problem is recognized as one of the more challenging optimization tasks in power system operation. Reactive power sources include generators, synchronous condensers, capacitor banks, static compensators, and tap-changing transformers. The primary goal in reactive power optimization is to determine the appropriate levels of reactive power generation at various locations in the system to optimize a given objective function.

In essence, the ORPD problem involves the efficient utilization of generator voltage magnitudes, transformer tap settings, and reactive power source outputs to minimize transmission losses and enhance the system's voltage stability. This results in a complex, nonlinear optimization problem.

Historically, several mathematical methods have been applied to address this issue, including the gradient method [1–2], Newton's method [3], and linear programming approaches [4–7]. However, these conventional techniques often encounter limitations, particularly in handling inequality constraints and maintaining accuracy. For instance, the gradient and Newton methods struggle with constraint handling, while linear programming requires linear approximation of nonlinear relationships, which may lead to reduced accuracy.

To overcome these limitations, global optimization techniques such as Genetic Algorithms (GAs) have been explored [8–9]. GAs, inspired by the process of natural selection, are stochastic search methods that have been effectively applied to solve the voltage-constrained reactive power dispatch problem. These algorithms determine the

optimal settings of generator voltages, transformer taps, and reactive source outputs, aiming to reduce transmission losses and improve voltage stability. Test results using the IEEE 30-bus system have shown that GAs can achieve near-optimal solutions with lower computational burden and consistent performance [10].

In the present study, the Flower Pollination Algorithm (FPA) is employed to solve the ORPD problem with a focus on improving computational efficiency and convergence behavior. The algorithm is tested on the IEEE 30-bus standard power system. The performance of the proposed FPA approach is benchmarked against other computational intelligence techniques, and the simulation results demonstrate its superior performance in terms of convergence speed and solution quality.

2. Problem Formulation

ORPD problem is, mainly, concerned with either minimisation of PLoss or that of TVD or improvement of VSI, satisfying various equality and inequality constraints.

2.1. Minimisation of Ploss

The general formulation of Ploss minimisation problem may be expressed as follows

$$\begin{aligned}
 &\text{minimize } J_1(x_1, x_2) \\
 &= \text{minimize } P_{\text{loss}} \\
 &= \sum_{K=1}^{NL} [G_k(V_p^2 + V_q^2 - 2V_p V_q \cos \delta_{pq})]
 \end{aligned} \tag{1}$$

subject to

$$\begin{cases} g(X_1, X_2 = 0) \\ h(X_1, X_2 \leq 0) \end{cases} \tag{2}$$

where $J_1(x_1, x_2)$ is the active power transmission loss minimisation function, X_1 is the vector of dependent variables consisting of load voltages $(V_{L1}, \dots, V_{LN_{PQ}})$ generators' reactive powers $(Q_{G1}, \dots, Q_{GN_{PV}})$ and transmission line loadings $(S_{L1}, \dots, S_{LN_L})$ X_2 is the vector of control variables consisting of generators' voltages $(V_{G1}, \dots, V_{GN_{PV}})$ transformers' tap settings $(T_1, \dots, T_{N_T})$ and reactive power injections $(Q_{C1}, \dots, Q_{CN_C})$, G_k is the conductance of branch k , V_p, V_q are voltages of the p th and the q th buses, respectively and δ_{pq} is the voltage angle difference between buses p and q . Therefore X_1 and X_2 may be expressed as

$$X_1 = [V_{L1}, \dots, V_{LN_{PQ}}, Q_{G1}, \dots, Q_{GN_{PV}}, S_{L1}, \dots, S_{LN_L}] \quad (3)$$

$$X_2 = [V_{G1}, \dots, V_{GN_{PV}}, T_1, \dots, T_{N_T}, Q_{C1}, \dots, Q_{CN_C}] \quad (4)$$

where NPV is the number of generator buses, NPQ is the number of load buses, NL is the number of transmission lines, NT is the number of tap setting transformer branches and NC is the number of capacitor banks.

2.2. Minimisation of TVD

The general formulation of TVD minimisation objective may be stated as in (5)

$$\text{minimize } J_2(x_1, x_2) = \text{minimize TVD} = \sum_{p=1}^{N_{PQ}} |V_p - V_p^{\text{ref}}| \quad (5)$$

where $J_2(x_1, x_2)$ is the TVD minimisation objective function, V_p is the voltage at bus p and V_p^{ref} is the desired value of the voltage magnitude of the p th bus, taken as 1 pu.

2.3. Improvement of VSI

The general objective of VSI improvement problem may be stated as in (6)

$$\begin{aligned} \text{Minimise } J_3(X_1, X_2) &= \text{Minimise } (L_{\max}) \\ &= \min[\max(L_K)], \quad K=1, 2, \dots, N \end{aligned} \quad (6)$$

where L_k is the voltage stability indicator (L-index) of the k th node. The value of L_k may be written as

$$L_k = \left| 1 - \sum_{p=1}^{NPV} m_{qp} \frac{V_p}{V_q} < \{\lambda_{pq} + (\theta_p - \theta_q)\} \right| \quad (7)$$

where M_{qp} are the (p, q) th components of the sub-matrices obtained from partial inversion of Ybus matrix.

The value of M_{qp} is given by (8)

$$M_{qp} = -[Y_{qq}]^{-1}[Y_{qp}] \quad (8)$$

where λ_{pq} is the phase angle of M_{qp} , θ_p , θ_q are phase angles of the p th and the q th bus voltages, respectively, Y_{qq} is the self-admittance term of the q th bus and Y_{qp} is the mutual admittance between the q th and p th buses.

2.4. Equality constraints

Constraints representing the load flow equations given by (9)

$$\begin{cases} P_{Gp} - P_{Lp} = \sum_{q=1}^{NB} V_p || V_q (G_{pq} \cos \delta_{pq} + B_{pq} \sin \delta_{pq}) \\ Q_{Gp} - Q_{Lp} = \sum_{q=1}^{NB} V_p || V_q (G_{pq} \sin \delta_{pq} - B_{pq} \cos \delta_{pq}) \end{cases} \quad (9)$$

where P_{Gp} , Q_{Gp} are injected active and reactive powers, at the p th bus, respectively, P_{Lp} , Q_{Lp} are active and reactive power demands,

at the pth bus, respectively, G_{pq} , B_{pq} are transfer conductance and susceptance, between the pth and the qth buses, respectively and NB is the number of buses.

3. Inequality constraints

3.1. Generator constraints

For all the generator voltages (including slack bus), real and reactive power outputs (including slack bus) must be restricted within their lower and upper limits as stated in (10)

$$\begin{cases} V_{G_p}^{\min} \leq V_{G_p} \leq V_{G_p}^{\max}, p = 1, 2, \dots, N_{PV} \\ V_{G_p}^{\min} \leq Q_{G_p} \leq Q_{G_p}^{\max}, p = 1, 2, \dots, N_{PV} \end{cases} \quad (10)$$

3.2. Transformer constraints

Transformer tap settings must be within their specified lower and upper limits as presented in (11)

$$T_{G_p}^{\min} \leq Q_{G_p} \leq Q_{G_p}^{\max}, p = 1, 2, \dots, N_T \quad (11)$$

3.3. Shunt VAR compensator constraints

Reactive power outputs of shunt VAR compensators must be restricted within their lower and upper limits as written in (12)

$$Q_{C_p}^{\min} \leq Q_{C_p} \leq Q_{C_p}^{\max}, p = 1, 2, \dots, N_C \quad (12)$$

3.4. Security constraints

These include the constraints on voltages at load buses and transmission line loadings. Each of these constraints must be within their lower and upper operating limits, as expressed in (13) and (14), respectively

$$V_{L_P}^{min} \leq V_{L_P} \leq V_{L_P}^{max}, p = 1, 2, \dots, N_{PQ} \quad (13)$$

$$S_{L_P} \leq S_{L_P}^{max}, p = 1, 2, \dots, N_L \quad (14)$$

4. Nature-inspired Flower Pollination Algorithm

The flower reproduction is ultimately through pollination. Flower pollination is connected with the transfer of pollen, and such transfer of pollen is related with pollinators such as insects, birds, animals etc. some type of flowers depend only on specific type of insects or birds for successful pollination. Two main forms of pollination are A-biotic and biotic pollination. 90% of flowering plants are belonging to biotic pollination process. That is, the way of transferring the pollen through insects and animals. 10% of pollination takes A-biotic method, which doesn't need any pollinators. Through Wind and diffusion help pollination of such flowering plants and a good example of A-biotic pollination is Grass [10, 11]. A good example of pollinator is Honey bees, and they have also developed the so-called flower constancy. These pollinators tend to visit exclusively only certain flower species and bypass other flower species. Such type of flower reliability may have evolutionary advantages because this will maximize the transfer of flower pollen. Such type of flower constancy may be advantageous for pollinators also, because they will be sure that nectar supply is available with their some degree of memory and minimum cost of learning, switching or exploring. Rather than focusing on some random, but potentially more satisfying on new flower species, and flower dependability may require minimum investment cost and more likely definite intake of nectar [12]. In the world of flowering plants, pollination can be achieved by self-pollination or crosspollination. Cross-pollination means the

pollination can occur from pollen of a flower of a different plant, and self-pollination is the fertilization of one flower, such as peach flowers, from pollen of the same flower or different flowers of the same plant, which often occurs when there is no dependable pollinator existing.

Biotic, crosspollination may occur at long distance, by the pollinators like bees, bats, birds and flies can fly a long distance. Bees and Birds may behave as Levy flight behaviour [13], with jump or fly distance steps obeying a Levy allotment. Flower fidelity can be considered as an increment step using the resemblance or difference of two flowers. The biological evolution point of view, the objective of the flower pollination is the survival of the fittest and the optimal reproduction of plants in terms of numbers as well as the largely fittest. The flower reproduction is done through pollination process. Flower pollination is connected with the relocation of pollen and such transfer of pollen is related with pollinators such as insects, birds, animals etc.

The major two pollination are A-biotic and biotic pollination. 90% of flowering plants are belonging to biotic pollination process. That is, the way of transferring the pollen through insects and animals. 10% of pollination takes Abiotic method, which doesn't need any pollinators. . Through Wind and diffusion help pollination of such flowering plants and a good example of A-biotic pollination is Grass. A very good example of pollinator is Honey bees, and they have also developed the so-called flower constancy. These pollinators tend to visit exclusively only certain flower species and bypass other flower species. Such type of flower reliability may have evolutionary advantages because this will maximize the transfer of flower pollen .

4.1. Rules for Flower Pollination Algorithm

1. Biotic and cross-pollination is considered as global pollination

process with pollen- carrying pollinators performing Levy flights.

2. Abiotic and self-pollination are considered as local pollination.

3. Flower constancy can be considered as the reproduction probability is proportional to the similarity of two flowers involved.

4. Local pollination and global pollination is controlled by a switch probability $Pa \in [0, 1]$. Due to the physical proximity and other factors such as wind, local pollination can have a significant fraction pa in the overall pollination activities.

4.2. Mathematical representation of Flower Pollination Algorithm

The first rule plus flower constancy can be represented mathematically as

$$x_i^{t+1} = X_i^t + L(X_i^t - g_*) \quad (15)$$

where X_i^t is the pollen i or solution vector X_i at iteration t , and g_* is the current best solution found among all solutions at the current generation/iteration.

4.3. Levy distribution is given by

$$L \sim \frac{\lambda \Gamma \sin\left(\frac{\pi\lambda}{2}\right)}{\pi} \frac{1}{S^{1+\lambda}}, (S \gg S_0 > 0) \quad (16)$$

where L is the strength of the pollination should be greater than zero, $\Gamma(\lambda)$ is the gamma function and this distribution is valid for large steps $s > 0$.

The local pollination can be represented as

$$x_i^{t+1} = X_i^t + \varepsilon(X_j^t - X_k^t) \quad (17)$$

where, X_j^t and X_k^t are pollens from the different flowers of the same plant species. This essentially mimic the flower constancy in a limited

neighbourhood. Mathematically, if X_j^t and X_k^t comes from the same species or selected from the same population, this become a local random walk if we draw from a uniform distribution in $[0,1]$.

4.4. Switch probability or proximity probability (pa)

Most flower pollination activities can occur at both local and global scale. In practice, adjacent flower patches or flowers in the not-so-far-away neighbourhood are more likely to be pollinated by local flower pollens than those far away. For this, we use a switch probability (Rule 4) or proximity probability pa to switch between common global pollination to intensive local pollination. In this simulation we used $pa=0.6$ and $pa=0.8$ to analyse the simulation result.

4.5. Pseudo code of Flower Pollination Algorithm (FPA)

Objective min or max $f(x)$, $x = (x_1, x_2, \dots, x_d)$

Initialize a population of n flowers/pollen gametes with random solutions

Find the best solution g_* in the initial population

Define a switch probability $Pa \in [0, 1]$.

while ($t < \text{MaxGeneration}$)

for $i = 1$ to n (all n flowers in the population)

if $\text{rand} < pa$,

Draw a (d -dimensional) step vector L which obeys a Levy distribution

Global pollination via $x_i^{t+1} = X_i^t + L(X_i^t - g_*)$

else

Draw ε from a uniform distribution in $[0,1]$

Randomly choose j and k among all the solutions

Do local pollination via $x_i^{t+1} = X_i^t + \varepsilon(X_j^t - X_k^t)$

end if

Evaluate new solutions

If new solutions are better, update them in the population

end for

Find the current best solution g_*

end while

5. Simulation Results

FPA based results of the ORPD problem for Ploss, TVD and L-index minimisation objective of this test system is presented in Table 1. These results are compared with those offered by the algorithms such as KHA and CKHA.

Table 1: Best control variable settings for power loss, TVD and L-index minimisation

Control variables	KHA [18]	CKHA [18]	Proposed FPA For Loss Minimization	Proposed FPA For TVD Minimization	Proposed FPA For L-index Minimization
V_{G1}	1.05	1.05	1.05	1.05	1.05
V_{G2}	1.0381	1.0473	1.0278	1.0256	1.02389
V_{G5}	1.011	1.0293	1.0293	1.0238	1.0229
V_{G8}	1.025	1.035	1.028	1.016	1.012
V_{G11}	1.05	1.05	1.05	1.05	1.05
V_{G13}	1.05	1.05	1.05	1.05	1.05
T_{11}	0.9541	0.9916	0.9686	0.9548	0.9489
T_{12}	1.0412	0.9538	1.9538	1.9486	1.9369
T_{15}	0.9514	0.9603	0.9331	0.9327	0.9347
T_{36}	0.9541	0.967	0.948	0.948	0.946
QC_{10}	0.0089	0.0092	0.0092	0.0091	0.0097
QC_{12}	0	0	0	0	0
QC_{15}	0.0141	0.0153	0.0148	0.0139	0.0127
QC_{17}	0.0498 9	0.0497	0.0495	0.0492	0.0492
QC_{20}	0.0314	0.0302	0.0301	0.03	0.03

QC_{21}	0.0345	0.05	0.045	0.033	0.041
QC_{23}	0.0241	0.0134	0.0234	0.0231	0.0238
QC_{24}	0.05	0.05	0.05	0.05	0.04
QC_{29}	0.0107	0.0121	0.0111	0.0118	0.0116
Ploss, MW	3.65	3.24	3.21	3.52	3.71
TVD, pu	1.3415	1.3364	1.3856	1.3356	1.3589
L-index, pu	0.1425	0.1402	0.1416	0.1437	0.1376

6. Conclusion

In this paper, the Flower Pollination Algorithm (FPA) is proposed as a solution to the Optimal Reactive Power Dispatch (ORPD) problem in power systems characterized by varying levels of dimensionality and complexity. To evaluate the effectiveness and robustness of the proposed approach, it is applied to the standard IEEE 30-bus power system. The simulation results obtained using FPA are compared with those produced by other well-known techniques recently reported in the literature. The comparison clearly demonstrates that the proposed FPA offers improved efficiency, greater flexibility, and enhanced stability, making it a promising tool for solving complex ORPD problems.

References

- [1] O.Alsac, and B. Scott, "Optimal load flow with steady state security", IEEE Transaction. PAS -1973, pp. 745-751.
- [2] Lee K Y ,Paru Y M , Ortiz J L –A united approach to optimal real and reactive power dispatch , IEEE Transactions on power Apparatus and systems 1985 PAS-104 1147-1153
- [3] A.Monticelli , M .V.F Pereira ,and S. Granville , "Security constrained optimal power flow with post contingency corrective rescheduling" , IEEE Transactions on Power Systems PWRS-2, No. 1, pp.175-182.,1987.
- [4] Deeb N ,Shahidehpur S.M ,Linear reactive power optimization in a large power network using the decomposition approach. IEEE Transactions on power system 1990 5(2) 428-435
- [5] E. Hobson ,'Network consrained reactive power control using linear

programming, ‘ IEEE Transactions on power systems PAS -99 (4) ,pp 868-877, 1980

[6] K.Y Lee ,Y.M Park , and J.L Ortiz, “Fuel –cost optimization for both real and reactive power dispatches” , IEE Proc; 131C,(3), pp.85-93.

[7] M.K. Mangoli, and K.Y. Lee, “Optimal real and reactive power control using linear programming” , Electr.Power Syst.Res, Vol.26, pp.1-10,1993.

8] S.R.Paranjothi ,and K.Anburaja, “Optimal power flow using refined genetic algorithm”, Electr.Power Compon.Syst , Vol. 30, 1055- 1063,2002.

[9] D. Devaraj, and B. Yeganarayana, “Genetic algorithm based optimal power flow for security enhancement”, IEE proc-Generation.Transmission and. Distribution; 152, 6 November 2005.

[10] D.Devaraj ,’ Improved genetic algorithm for multi – objective reactive power dispatch problem’ European Transactions on electrical power 2007 ; 17 569-581

[11] C.A. Canizares , A.C.Z.de Souza and V.H. Quintana , “ Comparison of performance indices for detection of proximity to voltage collapse ,” vol. 11. no.3 , pp.1441-1450, Aug 1996

[12] B.Gao ,G.K Morison P.Kundur ,’voltage stability evaluation using modal analysis ‘ Transactions on Power Systems ,Vol 7, No .4 ,November 1992.