International Journal of Swarm Intelligence Research
Volume 13 • Issue 1

A Hybrid GWO-PSO Technique for the Solution of Reactive Power Planning Problem

Manjulata Badi, Alliance University, Bangalore, India
https://orcid.org/0000-0003-3196-8383
Sheila Mahapatra, Alliance University, Bangalore, India
Bishwajit Dey, Gandhi Institute of Engineering and Technology (GIET) University, Gunupur, India
Saurav Raj, Marathwada Campus, Jalna, India.*
https://orcid.org/0000-0002-1875-3903

ABSTRACT

Over the years, the optimization in various areas of power systems has immensely attracted the attention of power engineers and researchers. RPP problem is one such area. This is done by the placement of reactive power sources in the weak buses and thereafter minimizing the operating cost of the system which is directly dependent on the system transmission loss. The work proposed in this article utilizes FVSI method to detect the weak bus. GWO-PSO is proposed in the current work for providing optimal solution to RPP problem. To test the efficacy of the proposed technique, comparative analysis is then performed among the variants of PSO and hybrid GWO-PSO. The optimal solution rendered by the proposed method is compared with other heuristic algorithms. The proposed method of GWO-PSO generates a reduction of 4.25% in operating cost for IEEE 30 bus and 5.99% for New England 39 bus system. The comparison thus yields that the GWO-PSO hybrid method is superior in generating optimality, diversity, and is efficient to generate solution strategies for RPP even in a practical power network.

KEYWORDS

Active Power Loss, Fast Voltage Stability Index Method, Grey Wolf Optimization, Particle Swarm Optimization, Reactive Power Planning

1. INTRODUCTION

Reactive power planning (RPP) is considered one of the most onerous problems encountered in interconnected power system operation. The Secure and economic operation of power networks is substantially dependent on the effectual planning of reactive power sources. In the current scenario of an interconnected power network, an increase in transmission loss and congestion of power lines is due to enhanced power demand, unscheduled power flow and curtailment in extension of transmission lines. So, to restore stability margin to previously existing circuits and retain efficient power system operation, reactive power control and planning is extremely crucial. The challenges of RPP involves the decision of determining the exact location and amount of reactive power sources for reducing the

DOI: 10.4018/IJSIR.2022010104
*Corresponding Author

transmission loss and optimizing the cost of VAR sources. Thus, optimal reactive power planning encompasses voltage quality, economic operation and reduction of power system losses.

Optimal placement of capacitor is instrumental in providing reactive power planning solutions as depicted in (Yehia & Ghandour et. al, 1992). The work in research article (Birchfield & Overbye 2018) focuses on power flow convergence and reactive power planning approach in a massive interconnected synthetic grid. In recent years, deregulation of power utilities has elevated the problems associated in controlling a large scale, complex interconnected power network with numerous uncertainties and solution based on the mathematical formulation of these real-time problems may not always yield accurate results which optimize it globally. Therefore, to seek globally optimal solution, modern heuristic algorithms are being implemented for solving reactive power planning problem (Shaheen & El-Sehiemy 2019, Mazzini, Asada & Lage 2018, Shwehdi, Mohamed & Devaraj 2018). Various global optimization techniques like Symbiotic Organisms Search Algorithm, Sine-Cosine algorithm, Dragonfly optimization, Improved Gravitational Search algorithm have gained popularity for implementation in power network optimization problems (Das, Bhattacharya & Ray 2018, Patel & Bhattacharjee 2020, Mahapatra, Jha & Panigrahi 2016, Amroune, Bouktir & Musirin 2018)). The work proposed in (Shen & Liu 2018) presents a multistage solution for dynamic reactive power optimization. The authors in (Bhattacharyya & Raj 2016) implemented numerous bio-inspired algorithms on IEEE 14 and 30 bus test systems for the RPP problem. Authors in the research article (Parida, Singh & Srivastava 2008) presented a hybrid algorithm for providing solution to security-constrained reactive power planning and (Shekarappa, Mahapatra & Raj 2020) proposed voltage constrained RPP. The work presented in (Hong-Zhong, Hao-Zhong & Zheng 2010) depicts an improved PSO algorithm for RPP optimal solution in the test system. The authors (Jeyadevi, Baskar & Iruthayarajan 2011) present a new technique of covariance matrix adapted evolution strategy for optimal reactive power solution.

To ensure that global optimality is attained in the optimization problem involving a large-scale power network, hybrid techniques are introduced which are a combination of two or more algorithms. To provide a solution of transmission line expansion along with RPP solution, Genetic algorithm, Interior point method is used (Mahmoudabadi & Rashidinejad 2013). The authors in (Liu, Ma & Zhang 2000) combined the merits of Genetic Algorithm, Tabu Search and Simulated Annealing to develop a hybrid method which would address the reactive power optimization problem in an improved manner. The authors in (Raj & Bhattacharyya 2018) obtained RPP solution while retaining voltage profile on IEEE 14, 30 and 57 bus test systems by using Grey Wolf Optimization.

These techniques generate improved solutions but have several drawbacks like relatively slow convergence or being trapped in local optima. So, a contemporary approach to tackle multi-objective, divergent power system problems are to combine the best attribute of these algorithms for realizing more effective global optimal solutions. The combination ensures selection of the best so that the solution converges towards global optimality and swiftly improve the secured operation. The work presented in this research article merges the bio-inspired techniques of PSO and meta-heuristic algorithm of GWO to form a hybrid optimization that is implemented for the RPP problem. The optimal reactive power planning solution is also obtained by using six improved PSO variants such as Linearly Decreasing Weight (LDW-PSO), Supervisor-Student Model (SSM-PSO), PSO with time-varying acceleration coefficient (PSOTVAC), Fixed Inertia Weight (FIW-PSO), Constriction Factor (CF- PSO), Improved Self Adaptive PSO (ISA-PSO) and another bio-inspired method of Salp swarm algorithm (SSA).

The important highlights of the proposed work include:

1. Improved performance of PSO which inherently depends on its parameters by preventing premature convergence and stagnation.
2. Population diversity is treated with an adaptable trade-off between exploitation and exploration to enhance the global search ability of the proposed algorithms.