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Application of Search Evolution Algorithm for Solution of Optimal Power Flow Problem

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Abstract— In this paper, an easy nature stimulated search method primarily based on differential search set of rules (DSA) has been offered and used for most suitable electricity or power flow (OPF) problem in electricity structures. By the usage of the proposed DSA technique, the power strength machine system parameters along with actual energy or power generations, bus voltages, and load faucet or tap changer ratios and shunt capacitance values are optimized for the certain positive goal functions. The considered goal capabilities are fuel cost minimization, electricity losses minimization, voltage profile improvement, and voltage balance enhancement. Different sorts of single-objective and multi-objective capabilities on IEEE 9-bus and IEEE 30-bus power structures are used to check and confirm the efficiency of the proposed DSA method. By comparing with numerous optimization methods, the results received with the aid of the use of the proposed DSA approach are offered in element. The consequences carried out on this work illustrate that the DSA approach can effectively be used to remedy the non-linear and non-convex problems associated with electricity systems.

Keywords— DSA, OPF, Optimization, Multi-Objective, Objective Functions.

I. INTRODUCTION

In this modern era, due to the increasing demand of power the power system flow should be more effective in planning and operation so that various researchers focused on to optimize best solution for multi-objective power flow problems [1-4]. As we know that the multi-objective functions of power flow problems are an extended form of single objective functions of power flow problems. The main focused motive of various optimization mechanism is that to deduce the whole power generation value with fulfil all the criteria such as providing balance in power between the demand and supply side, Generated powers in terms of active and reactive with respect to the limits of operating constraint and also provide protection for whole power system [5-6].

For solving the multi-objective power flow problem researchers have been considered numerous conflicting functions of objectives and varying levels of trade off which has process of optimization and referred as Multi-Objective Optimization (MOO) [7-8]. As compare to the conventional optimization mechanism or algorithms for single objective problem function the solutions algorithm for solving multi-objective problem functions gives us a better optimal result. The pareto optimal solution is the mechanism of optimization which has optimize optimal power flow at numerous levels of trade off [8]. As know that the pareto optimal mechanism has numerous objectives and these objectives creates point or node in the space of objectives belong to every POS and all points shape referred to as pareto front so that users could have opinion on levels of trade off and their accomplished point of optimal solution for selection of best fitness of power system objectives [8].

There are several mechanisms of optimization available in the market but mainly these optimizations have categorized into two categories groups. First one is programming mechanism based on mathematics and second is heuristic algorithms [9-12].

The programming mechanisms based on mathematics iteration methods are speedy mechanism i.e. minimum computational timing. Whenever these mechanisms are applying to the multi-objective power flow at the huge scale gives us a better result in term of stability and computational time i.e. provide stability in results at every iteration count with taking less computational time. These sorts of mechanism are using derivatives with local optima but for nonconvex issues of global optima these mechanisms do not provide as such results of local optima it means to say that these mechanisms do not provide coverage against nonconvex issues of global optima [13].

The authors were introducing the optimization model-based on function of aggregate and Lagrange which was reduces the cost of fuel and emission from the power system module for two-objective power flow problem [14] [15] [16]. The performance in term of computational speed and rate of convergence, the method was given a tremendous result but for nonconvex problem it became less effective [17] [18] [19].
The genetic and evolutionary algorithms were coming as heuristics approaches for solving the problem of multi-objective power flow [20] [7]. These algorithmic mechanisms are using randomization probing method in place of derivatives to meet the goal of optimal results or solution for multi-objective problems of power flow. Due to the capabilities of identify a better region in the global region for non-convex problem of global optima, it has been more attracted than the programming model but these models has less computational speed so that very few places these models are in used practically.
The rest of this paper is organized as follows: section 2 explains the problem formulation and the proposed method describe in section 3. Simulations and results of multiple DG unit placements are investigated and discussed in Section 4. Finally, Section 5 concludes this paper.

II. PROBLEM FORMULATION

The OPF downside is associate optimization downside that determines the ability output of every on-line generator that may lead to a least value system operational state. The OPF downside will then be written within the following form:

$$\left.\begin{array}{l} Minimize\ f(x) \\ \text{Subject to } g(x)=0 \\ H(x)\le 0 \end{array}\right\}$$

f(x) is that the objective operates, g(x) and H(x) area unit severally the set of equality and difference constraints. X is that the vector of management and state variables.
Cost function:
The objective of the OPF is to reduce the entire system value by adjusting the ability output of every of the generators connected to the grid. The entire system value is sculpturesque because the ad of the value operate of every generator. The generator value curves area unit sculpturesque with swish quadratic functions, given by:

$$f(x)=\sum_{i=1}^{n_g}\left(a_i+b_iP_{gi}+c_iP_{gi}^2\right) \tag{1}$$

Equality Constraints:
The equality constraint is diagrammatic by the ability balance constraint that reduces the ability system to a principle of equilibrium between total system generation and total system masses. Equilibrium is simply met once the entire system generation equals the entire system load and system losses .On other equilibrium is only met when the total system generation equals the total system load (P_D) plus system losses (P_L).

$$\sum_{i=1}^{n_g}\left(P_{gi}-P_D-P_L\right)=0 \tag{2}$$

The exact worth of the system losses will solely be determined by suggests that of an influence flow resolution. the foremost fashionable approach for locating Associate in Nursing approximate worth of the losses is by manner of Kron 's loss formula that approximates the losses as a operate of the output level of the system generators.

$$\sum_{i=1}^{n_g}\sum_{j=1}^{n_g}P_{gi}B_{ij}P_{gi}+\sum_{j=1}^{n_g}P_{gi}B_{io}+B_{oo}=0 \tag{3}$$

Inequality Constraints:
Following area unit the difference constraints

- Upper and lower bounds on the active generations at generator buses

$$P_{gi}^{\min}\le P_{gi}\le P_{gi}^{\max} \tag{4}$$

Upper and lower bounds on the reactive power generations at generator buses and reactive power injection at buses with power unit compensation $Q_{gi}^{\min}\le Q_{gi}\le Q_{gi}^{\max}$ (5)

- Upper and lower bounds on the voltage magnitude at the all the buses

$$V_{gi}^{\min}\le V_{gi}\le V_{gi}^{\max} \tag{6}$$

P_{gi} : Real power injection at i^{th} bus.
Q_{gi} : Reactive power injection at i^{th} bus,
P_D : Total real power demand at all the buses,
V_i : Magnitude of voltage i^{th} bus
G_g : Capacity of the g^{th} DG,
(P_L) : System losses
n_g : Total number of generator buses,
a_i, b_i, c_i : are cost coefficient.

III. PROPOSED METHODOLOGY

DE optimizes a retardant by maintaining a population of candidate solutions and making new candidate solutions by combining existing ones per its easy formulae, so keeping whichever candidate resolution has the simplest score or fitness on the optimization downside at hand. During this manner the optimization downside is treated as a black box that just provides a measure of quality given a candidate solution and also the gradient is therefore not required.

Various objective functions are handled as single-objective optimizations issues that are the fuel price reduction, power losses reduction, voltage profile improvement, and voltage stability improvement. Value-added to it, the MO-OPF optimizations are thought of. For resolution these OPF formulations, and MO-DEA is planned, that relies on a combination between the DE variant (DE/best/1) and therefore the ε-constraint approach.

The notable features of the proposed approach are:

- It is very simple and easy to implement.
- The proposed DE variant is distinguished with a high capability of global search exploitation and faster convergence to optimize the considered OPF objectives.
- The ability to find Pareto-optimal solutions in a single simulation run by incorporating the ε-constraint with adaptive threshold value with the DE variant.
- Each ε-level is forcedly initialized by feeding it with the best individuals from previous level. This process raises the chance for obtaining more economical and technical operating settings.
- Involving the ε-constraint provides Pareto-optimal solutions without computational burden of Pareto ranking and updating or additional efforts to preserve the diversity of the non-dominated solutions.

The best compromise solution is extracted based on fuzzy set theory

Generally proposed methodology consists of three step process:

- Mutation
- Crossover
- Selection

Proposed differential evolution optimization methodology process steps as following (Flow chart Shown in Figure 1):

1. Start the environment.
2. Set the input system data, Branch data, Line data and generator data.
3. Specify differential evolution optimization search algorithm control parameter and penalty terms.
4. Initialize the population for the optimal power flow control variable j = 1.
5. Update the system bus and line data with population and solve the load power flow problem through newton Raphson iteration.
6. Evaluate the generalized fitness function with quadratic penalty terms.
7. Perform differential evolution mutation.
8. Perform differential evolution crossover.
9. Again update the system bus and line data with population and solve the power flow problem through newton iteration.
10. Again evaluate the generalized fitness function with quadratic penalty terms.
11. Perform selection process and form new population.
12. If the value j < Gen then done increment in j i.e. j+1, repeat step from 7.
13. If the value j > Gen, found optimal power flow solution.
14. End the simulation

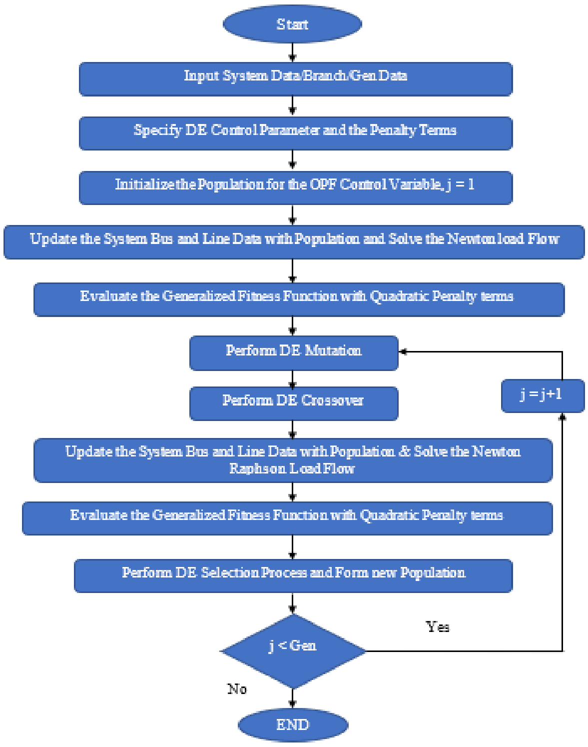

Figure 1: Flow Process Chart for Proposed Mechanism

IV. SIMULATION RESULTS

To evaluate the effectiveness of the proposed approach, the standard IEEE 9-bus and IEEE 30-bus test systems have been considered. Initially, several runs are done with different values of the algorithm's parameters and they are optimally specified.

IEEE-9-bus power system: The IEEE-9-bus power system consists of 9 buses, 9 branches, 3 generators, 3 under-load tap changing transformers.

Newton's method power flow converged in 4 iterations. Converged in 0.05 seconds

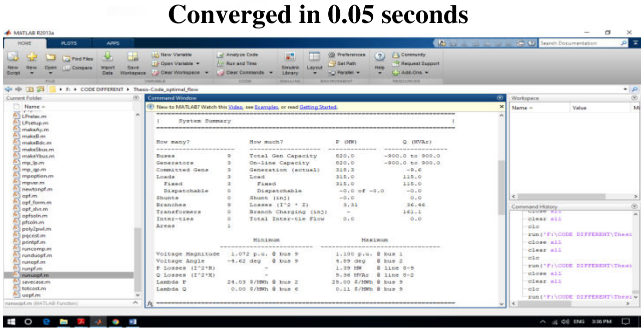

Figure 2: MATLAB command window shows the system summary of proposed methodology for IEEE-9-Power System Bus

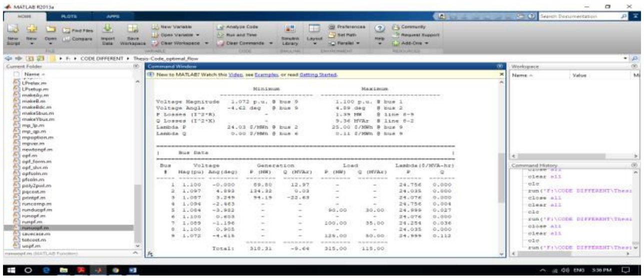

Figure 3: Results window shows the updated bus data for IEEE-9-Power System Bus

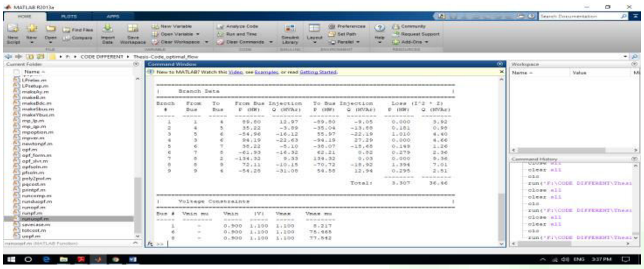

Figure 3: Results window shows the updated bus data for IEEE-9-Power System Bus

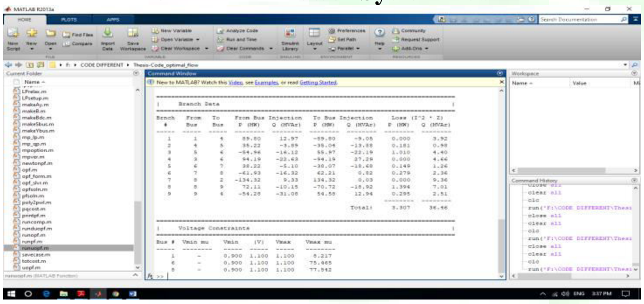

Figure 4: Results window shows the updated Branch data and voltage constraints for IEEE-9-Power System Bus

In Table 1 shows that the system summary of proposed methodology and set the input system, figure 2 shows the system summary and figure 3 depicted the updated bus data with new population and estimate the actual active and reactive load with generated active and reactive load, figure 4 shows that the updated branch data and voltage constraints and also shows the losses both active and reactive losses.

IEEE-30-bus power system: The IEEE 30-bus power system consists of 30 buses, 41 branches,6 generators, 6 under-load tap changing transformers.

Converged in 0.81 seconds

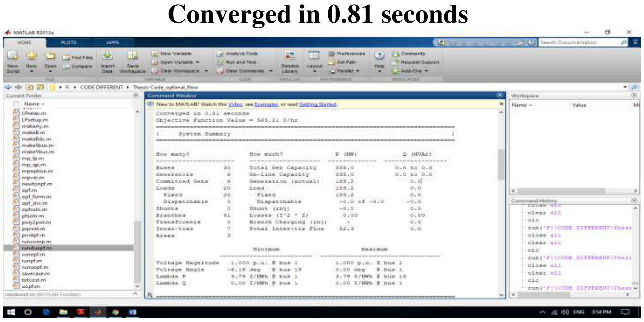

Figure 5: MATLAB command window shows the system summary of proposed methodology for IEEE-30-Power System Bus

Figure 5 shows the system summary and also depicted the updated bus data with new population and estimate the actual active and reactive load with generated active and reactive load and updated branch data and voltage constraints and also shows the losses both active and reactive power losses.

V. CONCLUSION

In this paper, differential search based, optimization method is proposed and successfully applied to solve various types of problems including complex, single and multi-type of objective functions within the constraints regarding to optimal power flow (OPF). The results obtained by using the proposed DSA method, provides better solution performance, robustness and superiority and can effectively be used in large scaled, nonlinear and non-convex problems of power system optimization owing to its high solution quality and rapid convergence speed.

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