An Evolutionary-Analytical Method for Improving Convergence in 63/20 kV Substation Emplacement

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Abstract: - Several methods are used for emplacement of subtransmission substations. This paper introduces a new heuristic way that is named as improved Lagrange method and shows that the new way has the better convergence and consequently the less investment cost and compares it with two previous methods, complete counting and Lagrange [1].

Key-Words: - Evolutionary technique– Substation emplacement – Lagrange method - Optimization

1. Introduction

Need to electrical energy in agriculture and industry parts in Iran as a developing country is grown increasingly and the optimum emplacement of many necessary subtransmission substations and feeding network has been converted to an important problem of utility companies.

In this paper we see a new combinational method, consist of analytical and evolutionary techniques that has a better convergence. Due to large investments in high voltage networks, the investment cost is one of the most important goals and so it's assumed as a goal function with voltage bounds as inequality constraints and load flow equations as equality constraints.

Number of load flow studies used in substation emplacement is decreased by Lagrange method. This is very important, because there are many alternatives, which examined by the expert planner for every network plan and each alternative needs to many power flow calculations and this needs to many times, but with using of the combinational method, in addition to time reduction, a better convergence also is obtained, so that the goal function is more minimized.

2. Optimization methods used in power system problems

In power system problems, different goal functions are defined for performing optimal planning such as economic dispatch, loss minimization, congestion management and investment cost minimization [1-4]. Also there are multiple mathematical solutions for nonlinear problems of power system such as Lagrange and Newton methods that using of them is limited by discrete variables in goal functions and nonlinear nature of those methods; thus the power system problems are solved by some new evolutionary ways such as Genetic, PSO and ACO algorithms.

Interior point method [5] and GA [6] have been used for economic dispatch and reactive power planning [7-10].

After review of power system optimization papers, we find out that, the substation emplacement with investment cost goal, has been discussed only in one paper by Lagrange method [11].

Thus we can see that, there is two known methods for emplacement problem and a new one, also will be introduced at this paper and comparison will be implemented between three above mentioned methods.

3. Problem formulation

Suppose a rectangular area for substation emplacement with length x and width y. if the Lagrange method is used then we have following relations that k, f and d are the number of stages, number of divisions and accuracy respectively.

$$r = \sqrt{x^2 + y^2} \tag{1}$$

$$k = \frac{\ln \frac{r}{2d}}{\ln \frac{f}{2}} \tag{2}$$

$$f \cong 3.77 \tag{3}$$

Basic difficulty of Lagrange method usage in discrete substation emplacement is its convergence in which time the study points are selected near together. Although the distance of the points in practical cases is not very little, but it is necessary to finding a better way for improving convergence in unpredicted cases.

This paper uses a special software (Electrical Network Planning Program or ENPP [12]) with more advanced tools for simplifying the study by defining floating points. Fig.1 shows the flowchart of the heuristic method. It uses the Lagrange optimization and doubles the study time but improves the convergence of solution. We named it as improved Lagrange method.

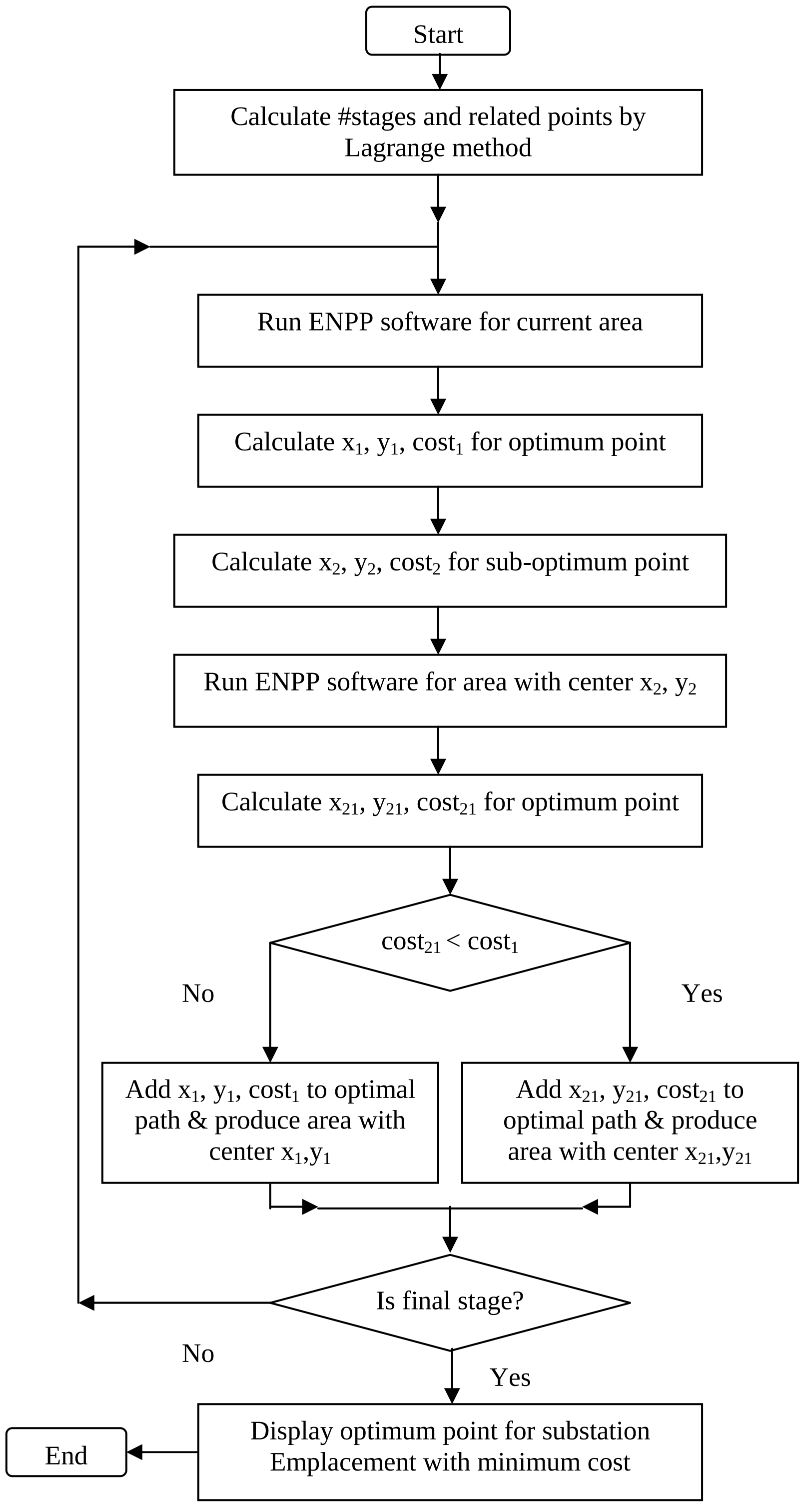

Figure 1 – Flowchart of the heuristic method

4. Case Study

Comparison of the methods in a substation emplacement problem is given in Table 1. We can see that the improved Lagrange method has the least investment cost but the number of its related load flows has doubled.

Table 1 –Results of substation emplacement using different methods

Method	# Load Flows	Network Minimum Voltage (p.u)	Minimum Investment Cost
Complete Counting	**561**	**0.95**	**581.0898**
Lagrange	**150**	**0.95014**	**581.1682**
Improved Lagrange	**300**	**0.95002**	**580.4774**

5. Conclusion

Assume the number of divisions in length and width is equal. So the selection of different methods will depend on r/d ratio. We can see that the number of load flows in Lagrange, improved Lagrange and complete counting methods are obtained from following relations with N_L, N_{IL} and N_{CC} respectively.

$$N_L = 25\times[\frac{\ln\frac{r}{2d}}{\ln\frac{3.77}{2}}] \quad (4)$$

$$N_{IL} = 50\times[\frac{\ln\frac{r}{2d}}{\ln\frac{3.77}{2}}] \quad (5)$$

$$N_{CC} = ([\frac{r}{d}]+1)^2 \quad (6)$$

In the Fig.2 we can see that the complete counting method is better than improved Lagrange until r/d less than 12 but for above 12 improved Lagrange is appropriate because it has the less spent time and more convergence.

There is some evolutionary techniques such as PSO, ACO and GA that they are finally suggested for solving emplacement problem at the future researches.

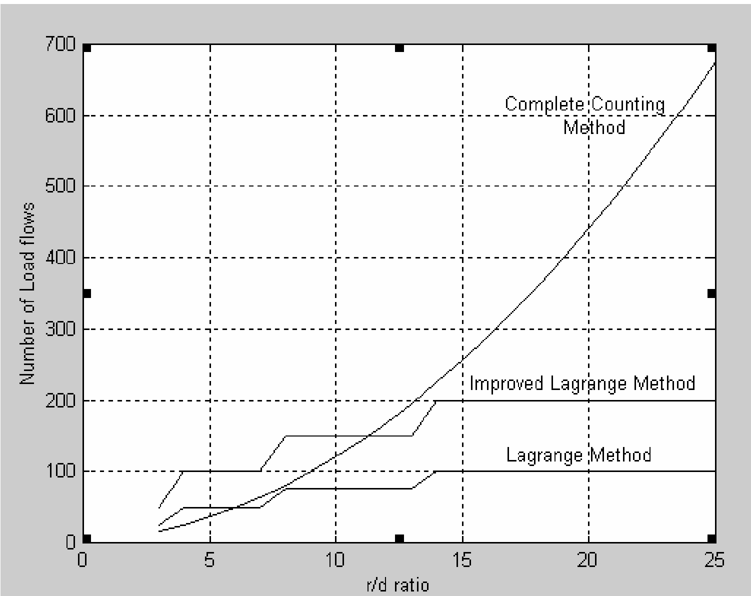

Figure 2 – Selection of emplacement method

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