Comparison Between Newton-Raphson Method And Genetic Algorithm Method For Load Flow Problem

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Abstract- *Power flow is the flow of active and reactive power. Basically power flow analysis is used to determine the steady state operating condition of a power system. In short we can find the approximate values of various bus voltages, their phase angle, active and reactive power flows through different branches, generators and loads under steady state condition .[1]Heuristic methods are generally referred as experience based techniques for solving problem, learning and discovery. Heuristics are simple and efficient rules coded by evolutionary processes. In this paper, genetic algorithm (GA), one of such heuristic algorithms have been used to do the power flow analysis in a simple five bus system*

Genetic Algorithm is a method for solving an optimization problem using genetics as the model. More specifically, Genetic Algorithms use the concept of Natural Selection or survival of the fittest to help guide the selection of candidate solutions. Our aim is to use MATLAB to develop a program to optimize load flow problems using the genetic algorithm toolbox. Without the use of a Genetic Algorithm, the load flow equation's solution would rely upon classical analytical optimization techniques. Such techniques are best suited to problems with only a few variables because of the need to develop a mathematical model of the system from which the use of derivatives can be used to find the optimal solution. In comparison, a genetic Algorithm can handle multiple variables and only requires the ability to develop a mathematical model to configure a set of inputs (the variables) in order for the model to produce an optimal output (the voltage profile and cost).

Keywords- Genetic Algorithms(GA), MATLAB

I. INTRODUCTION

Today as the demand for power is increasing day by day Load Flow solution plays an important role as it gives solution of the network under steady state condition subject to certain inequality constraints under which the system operates[13]. It also gives nodal voltages and phase angles and hence the power injection at all the buses and power flows through interconnecting transmission lines[15]. In this work we have used genetic algorithm (GA) technique and MATLAB programming to solve load flow problem for IEEE 5 Bus System. Genetic algorithms are search algorithms based on the mechanics of natural selection and natural genetics they combine survival of the fittest among structures with a structured yet randomized information exchange to form a search algorithm with some of the innovative flair of human search. Genetic algorithm works in following given manner[12]-

1. The algorithm begins by creating a random initial population.
2. The algorithm then creates a sequence of new populations. At each step, the algorithm uses the individuals in the current generation to create the next population. To create the new population, the algorithm performs the following steps:
    a) Scores each member of the current population by computing its fitness value.
    b) Scales the raw fitness scores to convert them into a more usable range of values.
    c) Selects members, called parents, based on their fitness.
    d) Some of the individuals in the current population that have lower fitness are chosen as elite. These elite individuals are passed to the next population.
    e) Produces children from the parents. Children are produced either by making random changes to a single parent mutation or by combining the vector entries of a pair of parents crossover.
    f) Replaces the current population with the children to form the next generation.
3. The algorithm stops when one of the stopping criteria is met.

II. LOAD FLOW SOLUTION

It is a solution of the network under steady state condition subject to certain inequality constraints under which the system operates. These constraints can be in the form of load nodal voltages, reactive power generation of the generator, the tap settings of a tap changing under load transformer.

The load flow solution gives the nodal voltages and phase angles and hence the power injection at all the buses and power flow through interconnecting power channels. Load flow solution is essential for designing a new power system and for planning extension of the exiting one for increased load demand[16].

A load flow solution of a power system requires the following steps:

i. Formation of the network equations.
ii. Suitable mathematical technique for solution of the equations.

III. FORMULATION OF LOAD FLOW EQUATIONS

If the interconnection between various nodes for a given system and the admittance value for each interconnecting circuit are known the admittance matrix may be assembled as follows:

I. The diagonal elements of each node are the sum of the admittances connected to it.
II. The off-diagonal is the negated admittance between the nodes.

- The load flow equation using nodal admittance for n buses is:

$$\begin{bmatrix} I_1 \\ I_2 \\ I_3 \\ \\ I_n \end{bmatrix} = \begin{bmatrix} Y_{11} & Y_{12} & \ldots & Y_{1n} \\ Y_{21} & Y_{22} & \ldots & Y_{2n} \\ Y_{31} & Y_{32} & \ldots & Y_{3n} \\ \\ Y_{n1} & Y_{n2} & \ldots & Y_{nn} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \\ \\ V_n \end{bmatrix}$$

The nodal current equation for n bus system is:

$$Ip = \sum_{q=1}^{n} Ypq * Vq \ , p = 1,2, \ldots \ldots \ldots, n$$

$$Ip = Ypp * Vp + \sum_{q=1}^{n} Ypq * Vq \ , p = 1,2, \ldots \ldots \ldots, n$$

$$Vp = Ip/Ypp - 1/Ypp \sum_{q=1, q \neq p}^{n} Ypq * Vq$$

Now Vp*Ip = Pp - jQp

Or

Ip = (Pp – jQp) / Vp*

Vp=1/Ypp[Pp-jQp/Vp* -],

p=1,2,…………………,n

IV. ITERATIVE METHODS FOR LOAD FLOW SOLUTIONS

As load flow equations are non linear and they can be solved by an iterative method. The iterative methods are -

a. Gauss's method.
b. Gauss-Seidel method.
c. Newton-Raphson method.

V. SOLUTION OF LOAD FLOW PROBLEM USING NEWTON-RAPHSON METHOD

1. Assume a suitable solution for all buses except the slack bus.

2. Let

   Vp=1+j0,

   for p=1,2,…………………n, p≠s,

   Vs=a+j0

3. Set convergence criterion =Є i.e. if the largest of absolute of the residues exceeds Є the process is repeated, otherwise it is terminated.

4. Set iteration count k=0

5. Set bus count p = 1

6. Check if p is a slack bus. If yes, go to step 10.

7. Calculate the real and reactive powers Pp and Qp respectively using:

   $$Pp = \sum_1^n \{ep(eqGpq + fqBpq) + fp(fqGpq - eqBpq)\}$$

   $$Qp = \sum_1^n \{fp(eqGpq + fqBpq) - ep(fqGpq - eqBpq)\}$$

8. Evaluate $\Delta P_p^{\ k} = P_{sp} - P_p^{\ k}$

9. Check if the bus in question is a generator bus. If yes compares Q_p^k with the limits. If it exceeds the limit, fix the reactive power generation to the corresponding limit and treat the bus as a load bus for that iteration and go to next step. If the lower limit is violated set $Q_{psp}=Q_{pmin}$ .If the limit is not violated evaluate the voltage residue $\Delta V_p^2 = V_{p\ spec}^2 - V_p^2$ and go to step 10.

10. Evaluate $\Delta Q_p^k = Q_{sp} - Q_p^k$.

11. Advance the bus count by 1 i.e. p=p+1 and check if all the buses have been accounted. If not go to step 5.

12. Determine the largest absolute value of the residue.

13. If the largest of the absolute value is less than Є go to step 17.

13. Evaluate elements for Jacobian matrix.
14. Calculate voltage increments Δe_p^k and Δf_p^k
15. Calculate new bus voltages
    $e_p^{k+1}=e_p^k+\Delta e_p^k$
    and
    $f_p^{k+1}=f_p^k+\Delta f_p^k$
16. Advance the iteration count k=k+1 and go to step 4.
17. Evaluate bus and line powers and print the results.

VI. SOLUTION OF LOAD FLOW PROBLEM USING GA ALGORITHM

Step 1: Read the line data, bus data

Step 2: Initialize the parameters.

Step 3: Initial population for voltage magnitude is randomly generated between the minimum and maximum limits.

Step 4: Initial population for voltage angles is randomly generated between the minimum and maximum limits and maximum limits

Step 5: Obtain the calculated values of Power by using below mentioned equations:

$$P_i = E_i \sum_{j=1}^{N} (G_{ij} E_j - B_{ij} F_j) + F_i \sum_{j=1}^{N} (G_{ij} F_j + B_{ij} E_j)$$

$$Q_i = F_i \sum_{j=1}^{N} (G_{ij} E_j - B_{ij} F_j) - E_i \sum_{j=1}^{N} (G_{ij} F_j + B_{ij} E_j)$$

Step 6: find out the error by using below mentioned equation:

$$\Delta P_i = P_{i(schadule)} - P_i$$

$$\Delta Q_i = Q_{i(schadule)} - Q_i$$

Step 7: calculate the total error using the equation :

$$\text{Error} = \sum \Delta P_i^2 + \sum \Delta Q_i^2$$

Step 8: find out the fitness value of each population by using the equation :

$$\text{Fit}(i) = \sqrt{\left(\sum \Delta P_i^2 + \sum \Delta Q_i^2\right)} \quad \text{(minimization)}$$

$$\text{Fit1}(i) - 1/(1+\text{Fit}(i)) \quad \text{(maximization)}$$

Step 9: Arrange the population in descending order according to their fitness values.

Step 10: The best chromosomes are directly copied to the next generation population to perform the elitism with a probability of Pe, for both voltage variables and angle variables.

Step 11: Parents are selected in pairs by using the roulette wheel selection technique based on their fitness values.

Step 12: Crossover is performed using the two crossover operators.

Step 13: check the iteration count is greater than iteration maximum or not. If it is greater than iteration count then go to step14.

Step 14: After performing the elitism and crossover operators, the new population is generated from the old population. In this present work mutation operator is eliminated. Go to step 6 to repeat the same procedure.

Step 15: Stop the procedure and print the results.

VII. EXPERIMENTS WITH LOAD FLOW STUDIES

- Simulation is performed on 5 bus system using

  (i) By NR method
  (ii) By GA Algorithm.

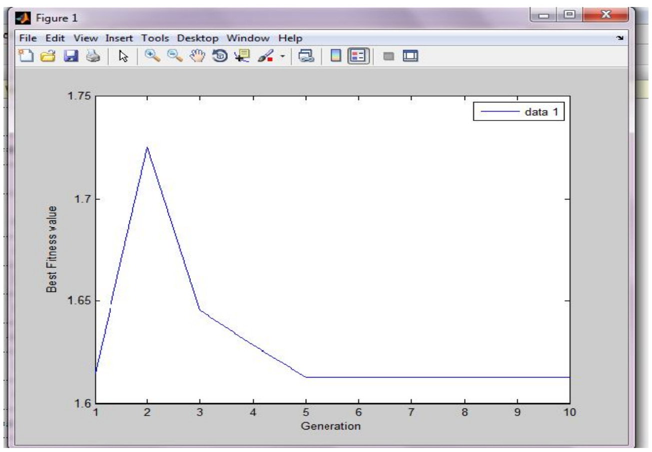

Figure: Graph between Fitness value and Generation

Variable	NR Method	GA Method
V_1	1.02	1.02
V_2	0.97	0.96
V_3	1.04	1.0394
V_4	0.9332	0.9267
V_5	0.9931	0.9931
Θ_1	0	0
Θ_2	-4.2357	-4.2124
Θ_3	1.8904	1.8522
Θ_4	-8.0844	-8.1421
Θ_5	-2.1282	-2.148
P_{Total}	4.444	1.507
Q_{Total}	19.553	6.839

VIII. CONCLUSIONS

Based on the work carried out in this paper following conclusion can be made:

1. In this work Genetic Algorithm has been studied and analyzed its parameters like population size, Initial population, Initial Range, Stopping conditions etc in getting the optimal points and final generation calculated for plotting the graphs. We had also noticed that we are not been able to obtain the results of all the population after each generation or iteration. We were only being able to get best fitness value after every generation.
2. Minimization of both constrained and unconstrained functions has been done using Genetic Algorithm to find global optimum point.
3. We have used the above gathered knowledge in the formulation and implementation of solution methods to obtain the optimum solution of Load Flow problem using Genetic Algorithm is carried out.

The effectiveness of the developed program is tested for IEEE 5-BUS system.

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